



Instruction

Z-Wave 500 Series Appl. Programmers Guide v6.8x.0x

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REVISION RECORD

Doc. Rev	Date	By	Pages affected	Brief description of changes
1	20160407	JFR	All	Based on INS13478-5 - Z-Wave 500 Series Appl. Prg. Guide v6.71.01.
1	20170621	PSH	4.1.1	Updated to SDK version 6.80.00 Specified that 16KB EEPROM will not work on controller nodes Removed ZW_UART0_zm5202_mode_enable from text
1	20170714	JSI	3.10.4	Added information of Smart Start additions to protocol usage of Critical RAM.
1	20170719	JFR	7 & 8	Updated protocol versions etc. & references.
2	20170926	JSI	4.3.1.2, 4.3.1.4, 4.3.1.8, 4.3.1.11, 4.3.1.12, 4.3.2.27, 4.3.2.28, 4.4.1.1, 4.4.1.1.2 4.4.2, 4.2.1	Updated ApplicationInitSW and ApplicationPoll according to SDK 6.80 enhancements. Added description of the two new Smart Start status updates, Added description of new functionality ApplicationNetworkLearnCompleted, ZW_Power_Management_Init and ZW_NetworkLearnModeStart Added ADD_NODE_SMART_START description Added ZW_AddNodeDskToNetwork Added multicast FLIRS wakeup functionality to functionality list
3	20170927	JFR	4.3.1.2	Wacthdog is default disabled
4	20171107	COLSEN	4.3.9	Added TimerLong API.
4	20180202	EFH	4.11	Added detailed description of changing RF transmission power setting
5	20180306	BBR	All	Added Silicon Labs template
6	20180530	JFR	All	Minor clarifications
7	20180614	JSI/JFR	4.3.3.2.6	Added TRANSMIT_COMPLETE_VERIFIED and Updated S2_TXOPTION_VERIFY_DELIVERY description
8	20180717	JFR	3.4	Clarified exceptions wrt. updating LWR when receiving a successful routed/direct request from another node.
9	20180816	JFR	4.3.2.29	Added ZW_NetworkManagementSetMaxInclusionRequestIntervals description.
9	20181009	JFR	7	Updated protocol versions etc.
10	20181222	JFR	7 4.3.1.13 4.3.17.1	Updated protocol versions and added serial API version etc. Clarified how to enable ApplicationRfNotify function. 50Hz was erroneously mentioned twice in bKeepOff formulas.
11	20190816	JOROSEVA	4.3.1.8	Corrected description of Serial API packet for UPDATE_STATE_NODE_INFO_SMARTSTART_HOMEID_RECEIVED
11	20190927	JFR	4.3.1.13 & 7	Updated ApplicationRfNotify and protocol versions etc.
12	20200416	JFR	7	Updated protocol versions etc.
13	20200421	SCBROWNI	All	Review

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1 ABBREVIATIONS

Abbreviation	Explanation
ACK	Acknowledge
AES	The Advanced Encryption Standard is a symmetric block cipher algorithm. The AES is a NIST-standard cryptographic cipher that uses a block length of 128 bits and key lengths of 128, 192 or 256 bits. Officially replacing the Triple DES method in 2001, AES uses the Rijndael algorithm developed by Joan Daemen and Vincent Rijmen of Belgium.
ANZ	Australia/New Zealand
AODV	Ad hoc On-Demand Distance Vector (AODV) Routing.
API	Application Programming Interface
APR	Application Priority Route
ASIC	Application-Specific Integrated Circuit
CR	Carriage Return, move the position of the cursor to the first position on the same line.
DLL	Dynamic Link Library
DUT	Device Under Test
ECB	Electronic CookBook (block cipher mode)
ERTT	Enhanced Reliability Test tool
EU	Europe
FET	Field-Effect Transistor
FLiRS	Frequently Listening Routing Slave. Communication to a FLiRS node can be established by a wakeup beam.
GNU	An organization devoted to the creation and support of Open Source software
HK	Hong Kong
HW	Hardware
IGBT	Insulated Gate Bipolar Transistor
IL	Israel
IN	India
IR	InfraRed
ISR	Interrupt Service Routines
JP	Japan
KR	South Korea
LF	Line Feed, Move cursor to the next line
LRC	Longitudinal Redundancy Check
LS	Less significant
LWR	Last Working Route
MS	Most significant
MTP	Many Times Programmable memory
MY	Malaysia
NAK	Not Acknowledged
NLWR	Next to Last Working Route
NVM	Non-Volatile Memory
NVR	Non-Volatile Read memory (cannot write)
NWI	Network Wide Inclusion (add node out of direct range)
NWE	Network Wide Exclusion (remove node out of direct range)
OTA	Over The Air (e.g., making a firmware update wireless)
OTW	Over The Wire (e.g., making a firmware update via the serial API interface)
PA	Power Amplifier
POR	Power On Reset
PRBS	Pseudo-Random Binary Sequence
PRNG	Pseudo-Random Number Generator
PWM	Pulse Width Modulator
RF	Radio Frequency
RFRNG	Radio Frequency Random Number Generator

Abbreviation	Explanation
RU	Russian Federation
SDK	Software Developer's Kit
SFR	Special Function Registers
SIS	SUC ID Server
SoC	System-on-Chip
SOF	Start Of Frame
SPI	Serial Peripheral Interface
SUC	Static Update Controller
UPnP	Universal Plug and Play
US	United States
WUT	Wake Up Timer
XML	eXtensible Markup Language

2 INTRODUCTION

2.1 Purpose

The Application Programming Guide gives guidance for developing Z-Wave application programs, which use the Z-Wave application programming interface (API) to access the Z-Wave Protocol services and 500 Series SoC resources. For host processor application development using the serial API, refer also to [2].

For details about working in the 500 Series environment, refer to [14].

The document is also an API reference guide for programmers.

2.2 Audience and Prerequisites

The audience is Z-Wave partners and Silicon Labs involved in application development. The application programmer should be familiar with the PK51 Keil Development Tool Kit for 8051 micro controllers.

2.3 Key words to Indicate Requirement Levels

The guidelines outlined in IETF RFC 2119 “Key words for use in RFCs to Indicate Requirement Levels” [17] apply:

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

3 Z-WAVE SOFTWARE ARCHITECTURE

Z-Wave software relies on polling of functions, command complete callback function calls, and delayed function calls.

The software is split into two groups of program modules: Z-Wave basis software and Application software. The Z-Wave basis software includes system startup code, low-level poll function, main poll loop, Z-Wave protocol layers, and memory and timer service functions. From the Z-Wave basis point of view the Application software include application hardware and software initialization functions, application state machine (called from the Z-Wave main poll loop), command complete callback functions, and a received command handler function. In addition to that, the application software can include hardware drivers.

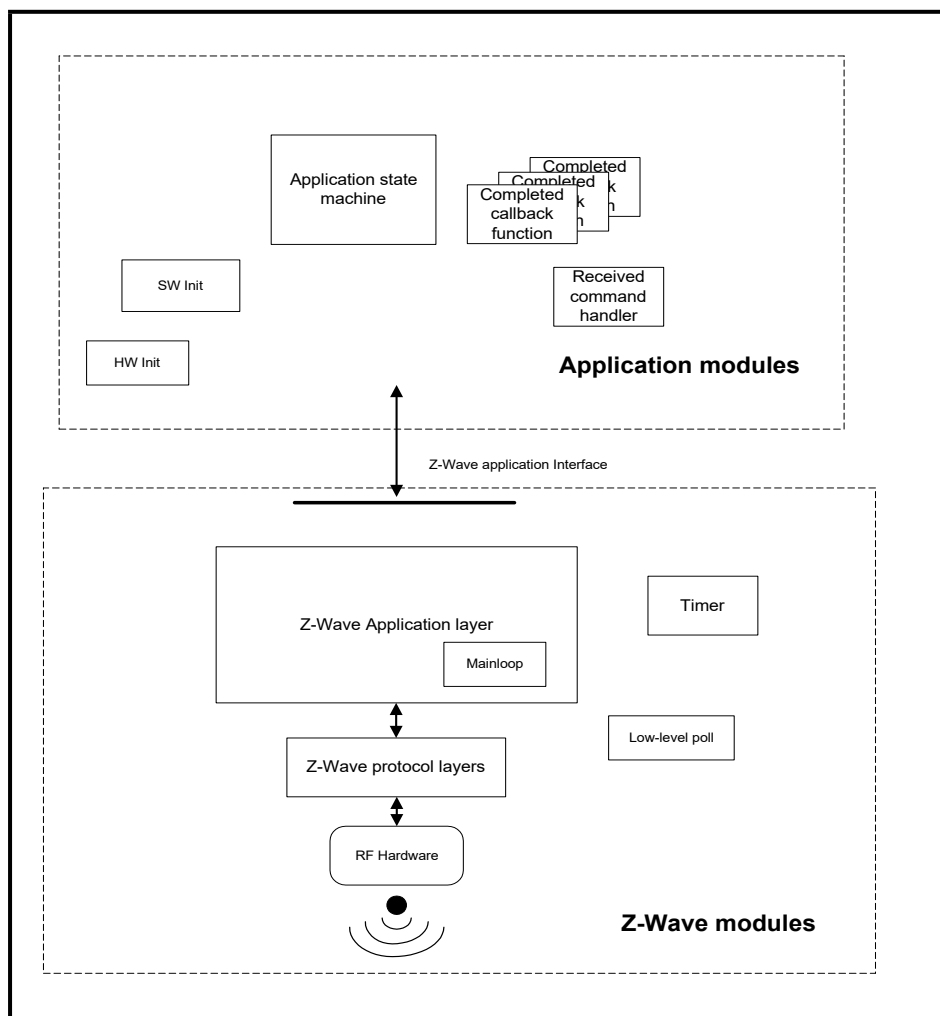


Figure 1. Software Architecture

3.1 Z-Wave System Startup Code

The Z-Wave modules include the system startup function (main). The Z-Wave system startup function first initializes the Z-Wave hardware and then calls the application hardware initialization function **ApplicationInitHW**. Then initializing the Z-Wave software (including the software timer used by the timer module), initializes the NVM if necessary and finally calling the application software initialization function **ApplicationInitSW**. Execution then proceeds in the Z-Wave main loop.

Notice: Initialization of the external NVM is now handled internally by the Z-Wave protocol library. The protocol will now delete and initialize the NVM on bootup if a 16 bit validation field in the NVM is not correct. Therefore the NVM initialization file `extern_epp.hex` is now obsolete.

3.2 Z-Wave Main Loop

The Z-Wave main loop will call the list of Z-Wave protocol functions, including the **ApplicationPoll** function and the **ApplicationCommandHandler** function (if a frame was received) in round robin order. The functions must therefore be designed to return to the caller as fast as possible to allow the MCU to do other tasks. Busy loops are not allowed. This will make it possible to receive Z-Wave data, transfer data via the UART and check user-activated buttons, etc. “simultaneously”. In order not to disrupt the radio communication and the protocol, no application function must execute code for more than 5ms without returning.

For production testing the application can be forced into the **ApplicationTestPoll** function instead of the **ApplicationPoll** function.

3.3 Z-Wave Protocol Layers

When transmission of data to another node is requested, the Z-Wave protocol layer adds a frame header and a checksum to the data before transmission. The protocol layer also handles frame retransmissions, as well as routing of frames through “repeater” nodes to Z-Wave nodes that are not within direct RF communication reach. When the frame transmission is completed, an application-specified transmit complete callback function is called. The transmission complete callback function includes a parameter that indicates the transmission result. The transmission complete callback function indicate also when the next frame can be send to avoid overwriting the transmit queue.

The Z-Wave frame receiver module (within the MAC layer) can include more than one frame receive buffer, so the upper layers can interpret one frame while the next frame is received.

3.4 Z-Wave Routing Principles

The Z-Wave protocol use source routing, which is a technique whereby the sender of a frame specifies the exact route the frame must take to reach the destination node. Source routing assumes that the sender knows the topology of the network, and can therefore determine a route having a minimum number of hops. The Z-Wave protocol supports up to four repeaters between sender and destination node. Routing can also be used to reach FLiRS destination nodes. Source routing allows implementation of a lightweight protocol by avoiding distributed topologies in all repeaters. Nodes containing the topology can also assign routes to a topology-less node enabling it to communicate with a number of destination nodes using routes.

In case sender fails to reach destination node using routes an explorer mechanism can be launched on demand to discover a working route to the destination node in question. The explorer mechanism builds

on AODV routing with adjustments for source routing and memory footprint. Explorer frames implement managed multi-hop broadcast forwarding and returns a working route to sender as result. The application payload piggybacks on explorer frame to reduce latency.

The routing algorithm in controllers store information about successful attempts to reach a destination node avoiding repetition of previously failed attempts. The last successful route used between sender and destination node are stored in NVM and is called Last Working Route(LWR). The LWR list comprises of 232 destination nodes having up to two routes each, called the LWR and the Next to Last Working Route (NLWR). A LWR/NLWR can contain either a direct or a routed route. Updating LWR and NLWR happens in the following situations (if new route != current LWR):

- When receiving a successful explorer frame route, new route becomes LWR and old LWR becomes NLWR.
- When receiving a successful routed/direct request from another node, new route becomes LWR and old LWR becomes NLWR. However, there are two exceptions where the new route does not become LWR. The LWR and NLWR stays unchanged when a speed modified frame (lower speed) or 9.6kbps direct frame are received successfully.
- When receiving a successful acknowledge for a transmitted explorer frame, new route becomes LWR and old LWR becomes NLWR.
- When receiving a successful acknowledge for a transmitted NLWR, NLWR becomes LWR.
- When receiving a successful acknowledge for a transmitted routed/direct frame, new route becomes LWR and old LWR becomes NLWR.

Incase a LWR/NLWR fails the LWR and NLWR are updated as follows:

- If a LWR fails; it is 'exiled' to become the NLWR and the current NLWR (if present) is tried as the next route.
- If a NLWR fails it is removed.

The Application can, instead of having both the LWR and the NLWR entries for a destination node, overload the LWR with an Application Priority Route (APR), which then upgrades the NLWR to LWR status as the protocol now is down to one dynamic LWR for the destination node in question. The APR will after being set always be tried prior to any possible present LWR. The APR can only be removed by the Application. If destination node has an APR defined the updating of the LWR happens in the following situations (if new route != APR AND new route != LWR)

- When receiving a successful explorer frame route, new route becomes LWR.
- When receiving a successful routed/direct request from another node, new route becomes LWR.
- When receiving a successful acknowledge for a transmitted explorer frame, new route becomes LWR.
- When receiving a successful acknowledge for a transmitted routed/direct frame, new route becomes LWR.
- Incase LWR fails it is removed.

The routing algorithm in slaves store information about successful attempts to reach a destination node in response routes after the following principles:

- When receiving a successful explorer frame route, new route becomes a new Response Route.
- When receiving a successful routed/direct request from another node, new route becomes a new Response Route.
- When receiving a successful acknowledge for a transmitted explorer frame, new route becomes a new Response Route.
- When receiving a successful acknowledge for a transmitted routed/direct frame, new route becomes a new Response Route.
- Incase Response Route fails it is removed.

However, the response routes only contains up to two routes to different destination nodes. A response route for a new destination node overwrites the oldest of the two buffered response routes. A new response route for an existing destination overwrites the old response route for that specific destination.

The routing attempts depend on the Z-Wave library and transmit options used in the node, for details refer to section 3.10.

The source routing algorithm does not alter the topology due to failed attempts or store any statistics regarding link quality.

3.5 Z-Wave Application Layer

The application layer provides the interface to the communications environment which is used by the application process. The application software is located in the hardware initialization function **ApplicationInitHW**, software initialization function **ApplicationInitSW**, application state machine (called from the Z-Wave main poll loop) **ApplicationPoll**, command complete callback functions, and a receive command handler function **ApplicationCommandHandler**.

The application implements communication on application level with other nodes in the network. On application level, a framework is defined of Device and Command Classes to obtain interoperability between Z-Wave enabled products from different vendors. For details of the Z-Wave Plus Framework refer to [4]-[5] and [7]-[12]. For details of the old Z-Wave Framework but still interoperable refer to [6]. The basic structure of these commands provides the capability to set parameters in a node and to request parameters from a node responding with a report containing the requested parameters. The Device and Command Classes are defined in the header file `ZW_classcmd.h`.

Wireless communication is by nature unreliable because a well-defined coverage area simply does not exist since propagation characteristics are dynamic and unpredictable. The Z-Wave protocol minimizes these "noise and distortion" problems by using a transmission mechanisms of the frame there include two re-transmissions to ensure reliable communication. In addition are single casts acknowledged by the receiving node so the application is notified about how the transmission went. No precautions can unfortunately prevent that multiple copies of the same frame are passed to the application. Therefore is it very important to implement a robust state machine on application level there can handle multiple copies of the same frame. Below are shown a couple of examples how this can happen:

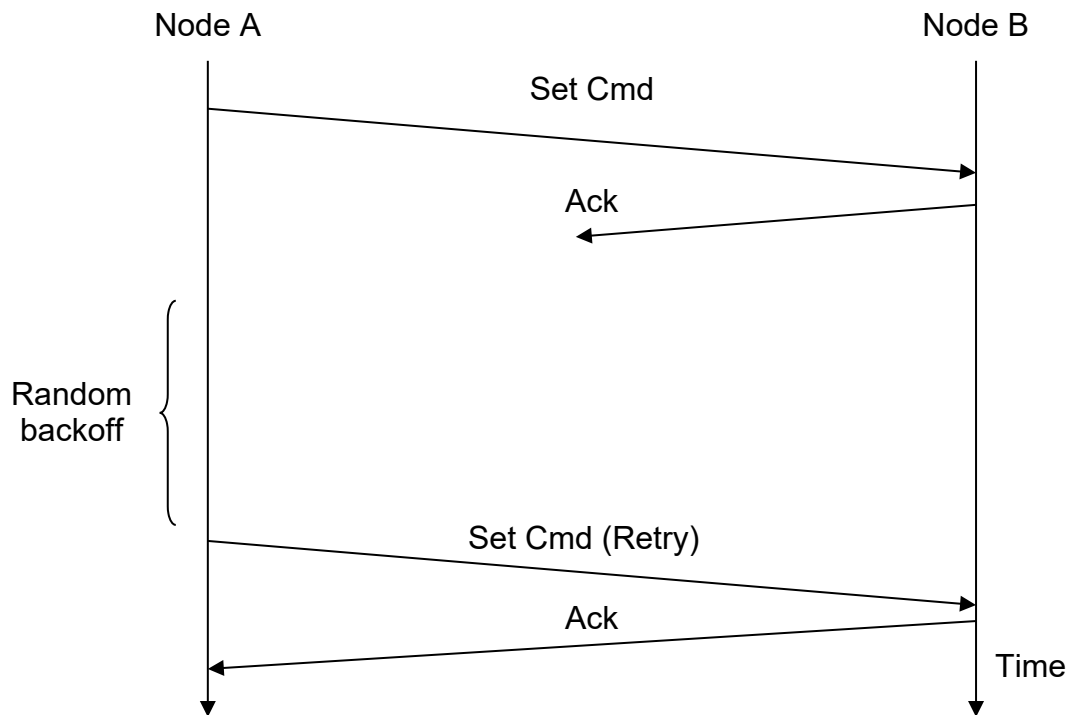


Figure 2. Multiple Copies of the Same Set Frame

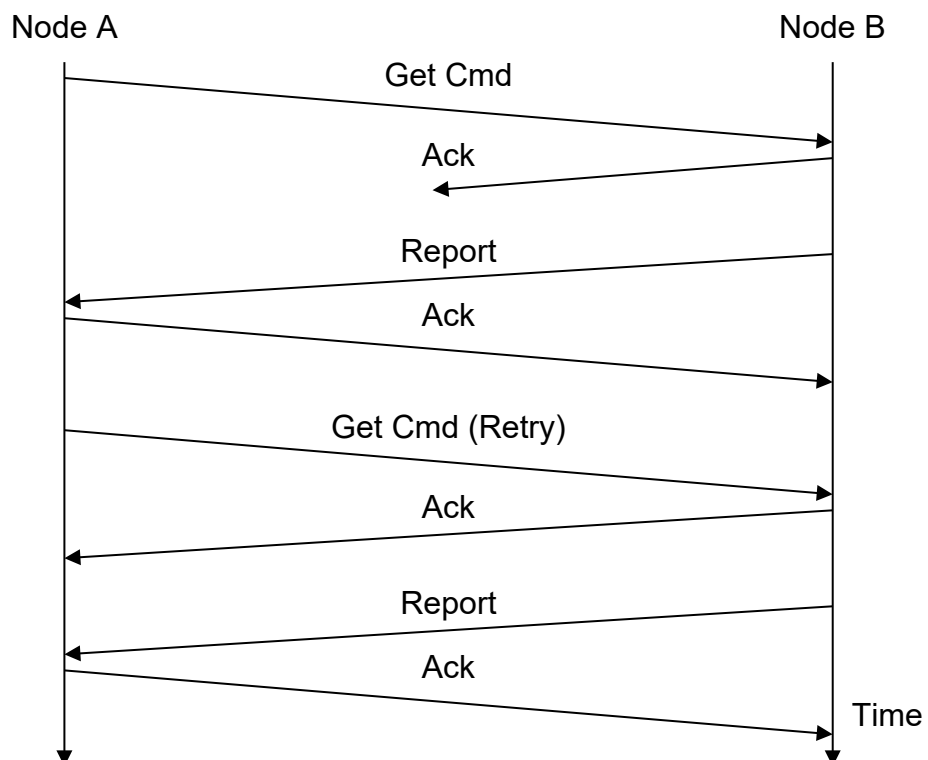


Figure 3. Multiple Copies of the Same Get/Report Frame

The Z-Wave protocol is designed to have low latency on the expense of handling simultaneously communication to a number of nodes in the Z-Wave network. To obtain this is the number of random

backoff values limited to 4 (0, 1, 2, and 3). The figure below shows how simultaneous communication to even a small number of nodes easily can block the communication completely.

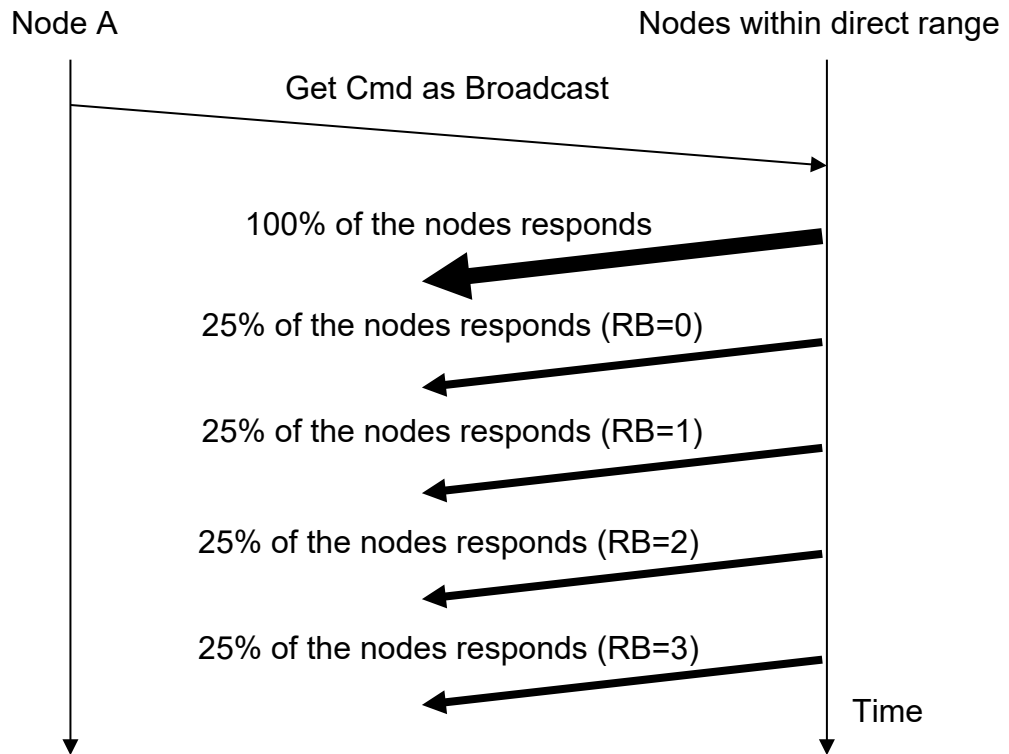


Figure 4. Simultaneous Communication to a Number of Nodes

Avoid simultaneous request to a number of nodes in a Z-Wave network in case the nodes in question respond on the application level.

3.6 Z-Wave Software Timers

The Z-Wave timer module is designed to handle a limited number of simultaneous active software timers. The Z-Wave basis software reserves some of these timers for protocol timeouts.

A delayed function call is initiated by a **TimerStart** API call to the timer module, which saves the function address, sets up the timeout value and returns a timer-handle. The timer-handle can be used to cancel the timeout action e.g., an action completed before the time runs out.

The timer can also be used for frequent inspection of special hardware e.g., a keypad. Specifying the time settings to 50 ms and repeating forever will call the timer call-back function every 50 msec.

3.7 Z-Wave Hardware Timers

The 200/300/400/500 Series Z-Wave SoCs have a number of hardware timers/counters. Some are reserved by the protocol and others are free to be used by the application as shown in the table below:

Table 1. 200/300/400/500 Series Z-Wave SoCs Hardware Timer Allocation

	200 Series	300 Series	400 Series	500 Series
TIMER0	Protocol system clock	Protocol system clock	Available for the application	Available for the application
TIMER1	Available for the application	Available for the application	Used by the protocol	Available for the application
GPTIMER	Available for the application	Available for the application	Available for the application	Available for the application

The TIMER0 and TIMER1 are standard 8051 timers/counters.

3.8 Z-Wave Hardware Interrupts

Application interrupt service routines (ISR) must use 8051 register bank 0. However, do not use USING 0 attribute when declaring ISR's. The Z-Wave protocol uses 8051 register bank 1 for protocol ISR's, see table below regarding application ISR availability:

Table 2. 200/300/400/500 Series Z-Wave SoC Application ISR Availability

200 Series	300 Series	400 Series	500 Series
INUM_INT1	INUM_INT1	INUM_INT0	INUM_INT0
INUM_TIMER1	INUM_TIMER1	INUM_TIMER0	INUM_INT1
INUM_SERIAL	INUM_SERIAL	INUM_SERIAL0	INUM_TIMER0
INUM_SPI	INUM_SPI	INUM_SPI0	INUM_SERIAL0
INUM_TRIAC	INUM_TRIAC	INUM_TRIAC	INUM_SPI0
INUM_GP_TIMER	INUM_GP_TIMER	INUM_GP_TIMER	INUM_TRIAC
INUM_ADC	INUM_ADC	INUM_ADC	INUM_GP_TIMER
		INUM_USB	INUM_ADC
		INUM_IR	INUM_USB
			INUM_IR

The duration of an application interrupt routine must be below 80us.

Refer to ZW020x.h, ZW030x.h, ZW040x.h and ZW050x.h header files with respect to ISR definitions. For an example, refer to UART ISR in serial API sample application.

3.9 Interrupt Service Routines

When using interrupt service routines from one of the hardware interfaces such as ADC, GP timer or UART, one should be aware of certain issues as described in the following sections.

3.9.1 SFR Pages

The 500 Series Z-Wave SoC uses multiple pages of 8051 SFR registers. The page selection is set using SFRPAGE. Consequently the SFRPAGE must be preserved when calling an Interrupt Service Routine (ISR) in your code. In order to do this the intrinsic functions `_push_()` and `_pop_()` must be called. Function `_push_()` must be called when the ISR starts, and `_pop_()` just before returning from the ISR.

For example, the ISR of the ADC should be look as follow:

```
#include <INTRINS.H>

void ADC_int(void) interrupt INUM_ADC
{
    _push_(SFRPAGE)1;

    call api's
    _pop_(SFRPAGE);
}
```

3.9.2 Calling Functions from ISR

The 8051 core of the 500 Series Z-Wave SoC has no register-to-register move. Therefore, the compiler generates register to memory moves instead. Since the compiler knows the register bank, the physical address of a register in a register bank can be calculated. For example, when the compiler calculates the address of register R2 in register bank 0, the address is 0x02. If the register bank selected is not really 0, then the function overwrites this register. This might result in unpredictable behavior of the program. This technique of accessing a register using its absolute address is called absolute register addressing.

In the Z-Wave system the system timer and RF interrupt use register bank 1. The default register bank used for non-interrupt code is register bank 0. Therefore, if a function is called from an ISR it might be looking in the wrong place for its register values.

To solve this problem, one of these solutions can be used:

1. Use the C51's REGISTERBANK directive to specify that a certain function uses the same register bank as the ISR that calls the function. Hence, no code is generated in the function to switch the register bank. For example:

```
#pragma registerbank(1)
void foo (void)
{
}
```
2. Use the NOAREGS directive to specify that the compiler should not use absolute register addressing. This make the function register bank independent so that it may be called from any function that uses a different register bank than the default.

¹ The `_push_` and `_pop_` functions are intrinsic functions and the header file INTRINS.H. Therefore, INTRINS.H should be included in order to be able to use them.

3.10 Z-Wave Nodes

From a protocol point of view, there are five types of Z-Wave nodes: Portable Controller nodes, Static Controller nodes, Bridge Controller nodes, Routing Slave nodes, and Enhanced 232 Slave nodes. All controller based nodes stores information about other nodes in the Z-Wave network. The node information includes the nodes each of the nodes can communicate with (routing information). The Installation node will present itself as a Controller node, which includes extra functionality to help a professional installer setup, configure, and troubleshoot a Z-Wave network. The bridge controller node stores information about the nodes in the Z-Wave network and in addition is it possible to generate up to 128 Virtual Slave nodes.

3.10.1 Z-Wave Portable Controller Node

The software components of a Z-Wave portable controller are split into the controller application and the Z-Wave-Controller basis software, which includes the Z-Wave protocol layers and control of the various data stored into the NVM.

Portable controller nodes include an external NVM in which the non-volatile application data area can be placed. The Z-Wave basis software has reserved the first area of the external NVM.

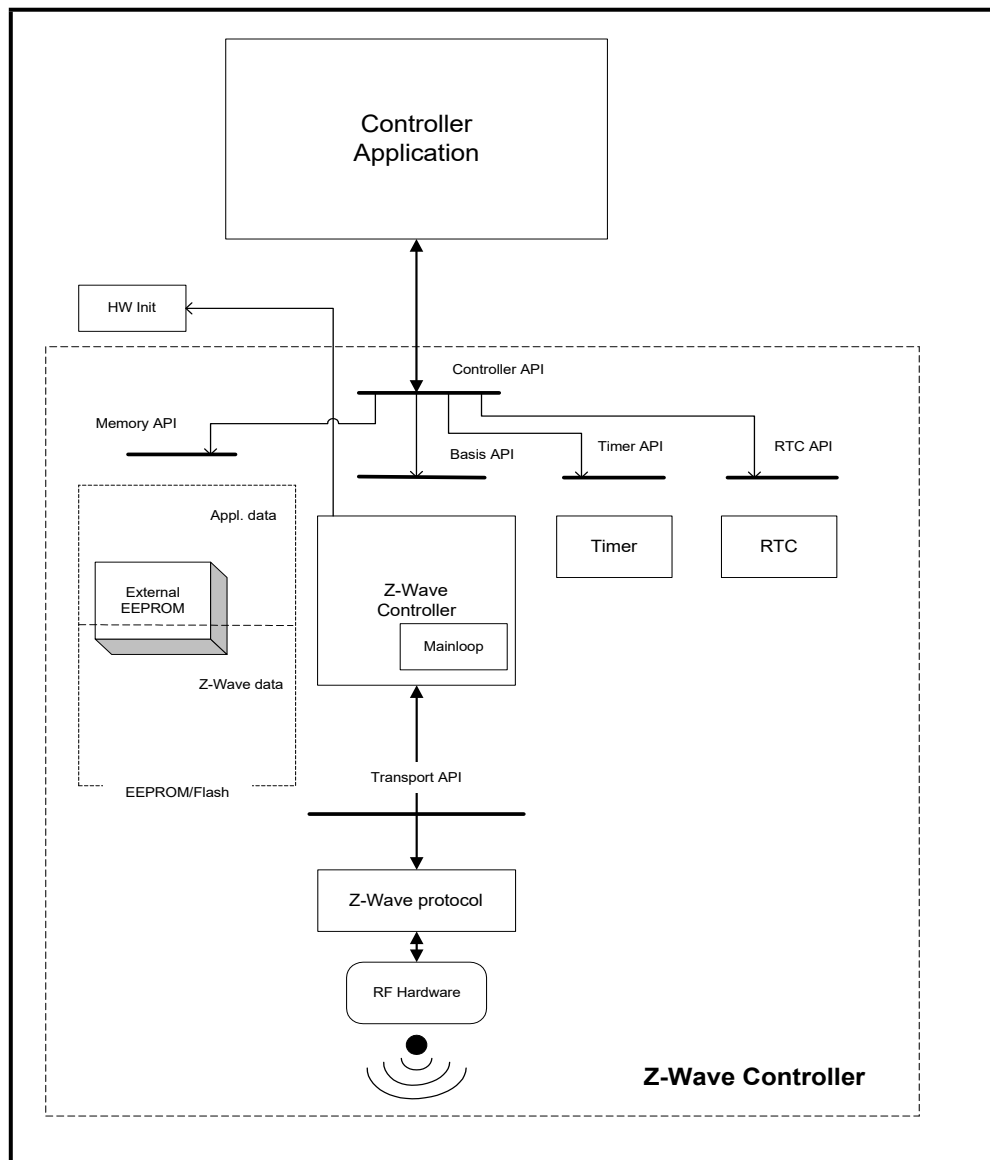


Figure 5. Portable Controller Node Architecture

The Portable Controller node has a unique home ID number assigned, which is stored in the Z-Wave basis area of the external NVM. Care must be taken, when reprogramming the external NVM, that different controller nodes do not get the same home ID number.

When new Slave nodes are registered to the Z-Wave network, the Controller node assigns the home ID and a unique node ID to the Slave node. The Slave node stores the home ID and node ID.

When a controller is primary, it will send any networks changes to the SUC node in the network. Controllers can request network topology updates from the SUC node.

The routing attempts done by a portable controller to reach the destination node are as follows:

- If APR, LWR and NLWR all are non-existing and TRANSMIT_OPTION_ACK set. Try direct with retries.
- If APR exist and TRANSMIT_OPTION_ACK set. Try direct without retries. In case it fails, try the APR. If APR fails then try LWR if it exist and if it also fails then remove the LWR.
- If APR do not exist, LWR exist and TRANSMIT_OPTION_ACK set. Try direct without retries. In case it fails, try the LWR. In case the LWR also fails, 'exile' it to become NLWR and try old NLWR if it exist. if the NLWR also fails, remove it.
- If APR do not exist, LWR do not exist, NLWR exist and TRANSMIT_OPTION_ACK set. Try direct without retries. In case it fails, try the NLWR. In case the NLWR also fails remove it.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. In case TRANSMIT_OPTION_EXPLORE set, a maximum number limits number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_NO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software, the header file "ZW_controller_api.h" also include the other Z-Wave API header files e.g., ZW_timer_api.h.

The following define must be set when compiling the application: ZW_CONTROLLER.

The application must be linked with ZW_CONTROLLER_PORTABLE_ZW*S.LIB (* = 050X for 500 Series Z-Wave modules, etc).

3.10.2 Z-Wave Static Controller Node

The software components of a Z-Wave static controller node are split into a Static Controller application and the Z-Wave Static Controller basis software, which includes the Z-Wave protocol layers and control of the various data stored into the NVM.

The difference between the static controller and the controller described in chapter 3.10.1 is that the static controller cannot be powered down, that is it cannot be used for battery-operated devices. The static controller has the ability to look for neighbors when requested by a controller. This ability makes it possible for a primary controller to assign static routes from a routing slave to a static controller.

The Static Controller can be set as a SUC node, so it can sends network topology updates to any requesting secondary controller. A secondary static controller not functioning as SUC can also request network Topology updates.

The routing attempts done by a static controller to reach the destination node are as follows:

- If APR, LWR and NLWR all are non-existing and TRANSMIT_OPTION_ACK set. Try direct when neighbors with retries.
- If APR exist and TRANSMIT_OPTION_ACK set. Try the APR. If APR fails then try LWR if it exist and if it also fails then remove the LWR and try direct if neighbor.
- If APR do not exist, LWR exist and TRANSMIT_OPTION_ACK set. Try the LWR. In case the LWR fails, 'exile' it to become NLWR and try old NLWR if it exist. if the NLWR also fails, remove it and try direct if neighbor.
- If APR do not exist, LWR do not exist, NLWR exist and TRANSMIT_OPTION_ACK set. Try the NLWR. In case the NLWR fails remove it and try direct if neighbor.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. If enough routes exist try a settable maximum number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_NO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software, the header file "ZW_controller_static_api.h" also includes the other Z-Wave API header files e.g., ZW_timer_api.h.

The following define is being included compiling the application: ZW_CONTROLLER_STATIC.

The application must be linked with ZW_CONTROLLER_STATIC_ZW*S.LIB (* = 050X for 500 Series Z-Wave modules, and so on).

3.10.3 Z-Wave Bridge Controller Node

The software components of a Z-Wave Bridge Controller node are split into a Bridge Controller application and the Z-Wave Bridge Controller basis software, which includes the Z-Wave protocol layer.

The Bridge Controller is essentially a Z-Wave Static Controller node, which incorporates extra functionality that can be used to implement controllers, targeted for bridging between the Z-Wave network and others network (ex. UPnP).

The Bridge application interface is an extended Static Controller application interface, which besides the Static Controller application interface functionality gives the application the possibility to manage Virtual Slave nodes. Virtual Slave nodes is a routing slave node without repeater and assign return route functionality, which physically resides in the Bridge Controller. This makes it possible for other Z-Wave nodes to address up to 128 Slave nodes that can be bridged to some functionality or to devices, which resides on a foreign Network type.

The routing attempts done by a bridge controller to reach the destination node are as follows:

- If APR, LWR and NLWR all are non-existing and TRANSMIT_OPTION_ACK set. Try direct when neighbors with retries.
- If APR exist and TRANSMIT_OPTION_ACK set. Try the APR. If APR fails then try LWR if it exist and if it also fails then remove the LWR and try direct if neighbor.
- If APR do not exist, LWR exist and TRANSMIT_OPTION_ACK set. Try the LWR. In case the LWR fails, 'exile' it to become NLWR and try old NLWR if it exist. if the NLWR also fails, remove it and try direct if neighbor.
- If APR do not exist, LWR do not exist, NLWR exist and TRANSMIT_OPTION_ACK set. Try the NLWR. In case the NLWR fails remove it and try direct if neighbor.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. In case TRANSMIT_OPTION_EXPLORE set, a maximum number limits number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software the header file "ZW_controller_bridge_api.h" also include the other Z-Wave API header files.

The following define is being included compiling the application: ZW_CONTROLLER_BRIDGE.

The application must be linked with ZW_CONTROLLER_BRIDGE_ZW*S.LIB
(* = 050X for 500 Series Z-Wave modules, etc).

3.10.4 Z-Wave Routing Slave Node

The software components of a Z-Wave routing slave node are split into a Slave application and the Z-Wave-Slave basis software, which includes the Z-Wave protocol layers.

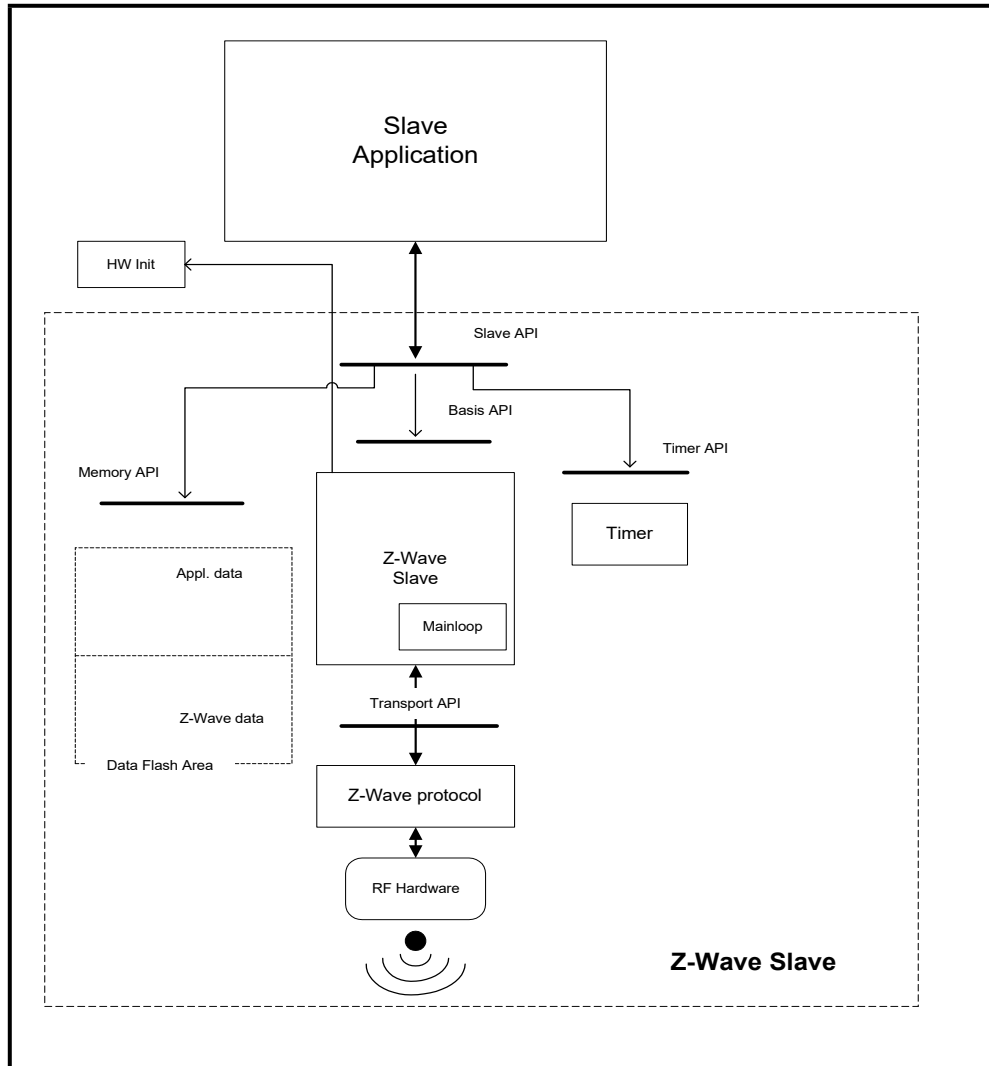


Figure 6. Routing Slave Node Architecture

The routing slave is capable of initiating communication. Examples of a routing slave could be a wall control or temperature sensor. If a user activates the wall control, the routing slave sends an “on” command to a lamp (slave).

The routing slave does not have a complete routing table. Frames are sent to destinations configured during association. The association is performed via a controller. If routing is needed for reaching the destinations, it is also up to the controller to calculate the routes.

Routing slave nodes have an area of 256 bytes MTP (Many Times Programmable memory) for storing data. The Z-Wave basis software reserves the first part of this area, and application data uses the remaining part.

The home ID is set to a randomly generated value and node ID is zero. When registering a slave node to a Z-Wave network the slave node receives home and node ID from the network's primary controller node. These IDs are stored in the Z-Wave basis data area in the flash.

The routing slave can send unsolicited and non-routed broadcasts, singlecasts, and multicasts. Singlecasts can also be routed. Further, it can respond with a routed singlecast (response route) in case another node has requested this by sending a routed singlecast to it. A received multicast or broadcast results in a response route without routing.

A temperature sensor based on a routing slave may be battery operated. To improve battery lifetime, the application may bring the node into sleep mode most of the time. Using the wake-up timer (WUT), the application may wake up once per second, measure the temperature and go back to sleep. In case the measurement exceeded some threshold, a command (e.g., "start heating") may be sent to a heating device before going back to sleep.

The routing attempts done by a routing slave to reach the destination node are as follows:

- If TRANSMIT_OPTION_ACK is set and destination is available in response routes, try response route.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try return routes if any exists for specified destination.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try direct.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set, issue an explore frame as last resort.

The return routes comprises of up to five destinations having up to 4 routes each. Return routes can contain a no repeater route (direct) up to a full 4 repeater route.

The return routes are tried in the order of priority, highest first. The priority of the return routes are dynamically updated when return routes either succeed or fails.

The Application can set a Priority Return Route, which always will have the highest priority and therefor always be tried as the first return route and can only be removed by the Application. The priority return route will when set use one of the available 4 route entries.

New routes/direct are qualified for return route insertion by checking if the destination exist and route/direct do not exist. In that event the new route/direct entry will be placed either in a free route or the one having lowest priority.

A number of limitations are unfortunately necessary with respect to Security S2 due to lack of external NVM:

- All key classes supported but only one can be active after inclusion (add).
- Slave routing based devices will when entering Sleep mode save the “Most Recently Used” (MRU) S2 SPAN entry in critical RAM. The MRU S2 SPAN entry are restored on power up if a valid S2 SPAN entry resides in critical RAM.
- S2 Public-Private key pair resides in Protocol part of NVR and written to NVR at production. Refer to [22] for details.
- Cannot send S2 multicast but do support S2 multicast receive.

The table below show the NVM memory budget of the full routing slave with S0/S2 functionality included is as follows:

#	Functionality	Bytes
1	Home ID, Node ID, magic bytes and SUC return routes.	25
2	Return routes: 5 destinations having 4 full hop routes each 5 destinations x (1 destination byte + 4 x (4 hop bytes + 1 aux. byte))	105
3	Keyclass byte – Which security keyclass is active – Only ONE keyclass can be active at any time, can be either S0, S2 (3 keyclasses)	1
4	S0/S2 Network key	16
5	Critical SPAN nodeID – Identifies the SPAN, which is saved in Critical RAM when going into Sleepmode and reloaded on wakeup from Sleepmode – This means that no resync (S2) is needed for the Critical SPAN nodeID after wakeup from Sleepmode. If equal to ZERO the MRU SPAN entry will be stored/restored.	1

The routing slave NVM is placed in the MTP (Total of 255 Bytes) resulting in 107 Bytes available for the application.

No SPAN/MPAN are saved in NVM, which for a FLiRS node would mean that the node needs to sync every time it wakes up in case it want to communicate with another node. But to minimize the resync after Sleepmode we do save ONE SPAN in Critical RAM (retention RAM).

The Critical RAM is 128 Bytes retention memory – Currently 32 Bytes are allocated for Application and 96 bytes are allocated for protocol. The table below shows the protocol Critical RAM requirement for a Routing Slave with one SPAN entry.

#	Functionality	Bytes
1	Protocol usage: phyRfData, ResponseRoutes, FLiRS, NodeID, HomeID etc.	51
2	1 S2 SPAN	39
3	Smart Start-specific variables	6

The ECDH keypair for routing slaves is stored in the NVR [22] and must be generated and pre-programmed during production. The updated NVR layout must be used when producing a SDK 6.8x based routing slaves. The routing slave cannot detect if the keypair is missing.

When developing application software, the header file “ZW_slave_routing_api.h” also includes the other Z-Wave API header files e.g., ZW_timer_api.h.

The following define will be generated by the headerfile, if it does not already exist when when compiling the application: ZW_SLAVE.

The application must be linked with ZW_SLAVE_ROUTING_ZW*S.LIB (* = 050X for 500 Series Z-Wave modules, etc).

3.10.5 Z-Wave Enhanced 232 Slave Node

The Z-Wave enhanced 232 slave has the same basic functionality as a Z-Wave routing slave node, but offers return route assignment of up to 232 destination nodes instead of 5.

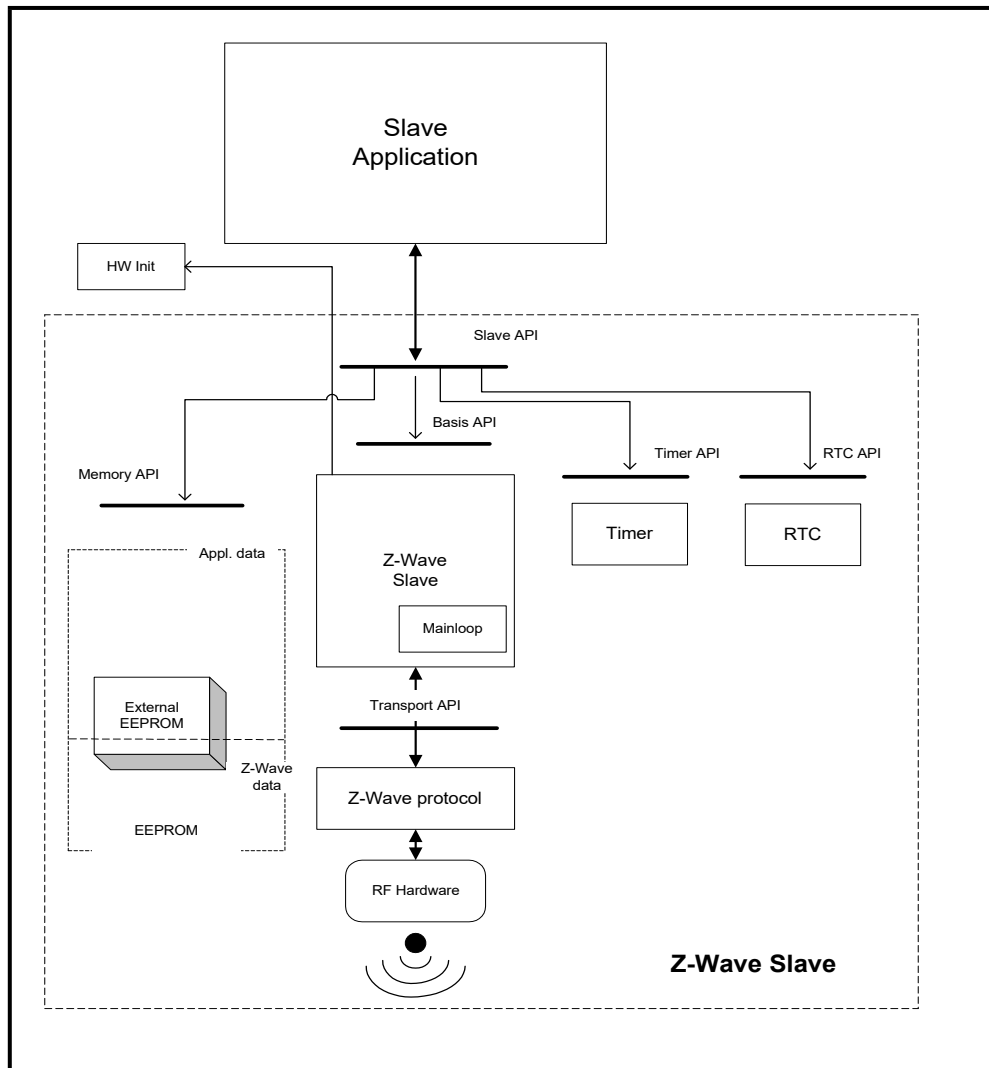


Figure 7. Enhanced 232 Slave Node Architecture

Enhanced 232 slave nodes have an external NVM and a WUT. The Z-Wave basis software reserves the first area of the external NVM: The last area of the NVM is reserved for the application data.

The routing attempts done by an enhanced 232 slave to reach the destination node are as follows:

- If TRANSMIT_OPTION_ACK is set and destination is available in response routes, try response route.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try return routes if any exists for specified destination.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try direct.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set, issue an explore frame as last resort.

The return route comprises of up to 232 destinations having up to four routes each. Return routes can contain a no repeater route (direct) up to a full 4 repeater route.

The return routes are tried in the order of priority, highest first. The priority of the return routes are dynamically updated when return routes either succeed or fails.

The Application can set a Priority Return Route, which always will have the highest priority and therefor always be tried as the first return route and can only be removed by the Application. The priority return route will when set use one of the available 4 route entries.

New routes/direct are qualified for return route insertion by checking if the destination exist and route/direct do not exist. In that event the new route/direct entry will be placed either in a free route or the one having lowest priority.

When developing application software, the header file "ZW_slave_32_api.h" also includes the other Z-Wave API header files e.g., ZW_timer_api.h.

The following define will be generated by the headerfile, if it does not already exist when compiling the application: ZW_SLAVE and ZW_SLAVE_32.

The application must be linked with ZW_SLAVE_ENHANCED_232_ZW*S.LIB (* = 050X for 500 Series Z-Wave modules, etc).

3.10.6 Adding and Removing Nodes to/from the Network

Its only controllers that can add new nodes to the Z-Wave network, and reset them again is the primary or inclusion controller. The home ID of the Primary Z-Wave Controller identifies a Z-Wave network.

Information about the result of a learn process is passed to the callback function in a variable with the following structure:

```
typedef struct _LEARN_INFO_
{
    BYTE  bStatus;           /* Status of learn mode          */
    BYTE  bSource;          /* Node id of the node that send node info */
    BYTE  *pCmd;            /* Pointer to Application Node information */
    BYTE  bLen;             /* Node info length              */
} LEARN_INFO;
```

When adding nodes to the network the controller have a number of choices of how to add, and what nodes to add to the network.

3.10.6.1 Adding a Node Normally

The normal way to add a node to the network is to use `ZW_AddNodeToNetwork()` function on the primary controller, and use the function `ZW_SetLearnMode()` on the node that should be included into the network.

3.10.6.2 Adding a New Controller and Make it the Primary Controller

A primary controller can add a controller to the network and in the same process give the role as primary controller to the new controller. This is done by using the `ZW_ControllerChange()` on the primary controller, and use the function `ZW_SetLearnMode()` on the controller that should be included into the network. Note that the original primary controller will become a secondary controller when the inclusion (add) is finished.

3.10.6.3 SUC ID Server (SIS)

Previously Z-Wave offered a Static Update Controller (SUC) functionality that could be enabled in a static controller. This functionality can no longer be enabled alone but is now an integrated part of the SUC ID Server (SIS). The SIS becomes the primary controller in the network because it always has the latest update of the network topology and capability to include/exclude nodes in the network. When including a controller to the network it becomes an inclusion controller because it has the capability to include/exclude nodes in the network via the SIS. The inclusion controller's network topology is dated from last time a node was included or it requested a network update from the SIS. The SUC and the SIS functionality can not be split and will always be available on the same controller

3.10.7 The Automatic Network Update

A Z-Wave network consists of slaves, a primary controller and secondary controllers. New nodes can only be added and removed to/from the network by using the primary controller. This could cause secondary controllers and routing slaves to misbehave, if for instance a preferred repeater node is removed. Without automatic network updating a new replication (copy) has to be made from the primary controller to all secondary controllers and routing slaves should also be manually updated with the changes. In networks with several controller and routing slave nodes, this process will be cumbersome.

To automate this process, an automatic network update scheme has been introduced to the Z-Wave protocol. To use this scheme a static controller must be available in the network. This static controller is dedicated to hold a copy of the network topology and the latest changes that have occurred to the network. The static controller used in the Automatic update scheme is called the SUC ID Server (SIS).

Each time a node is added, deleted or a routing change occurs, the inclusion controller will send the node information to the SIS. Other controllers can then ask the SIS if any updates are pending. The SIS will then in turn respond with any changes since last time this controller asked for updates. In the controller requesting an update, **ApplicationControllerUpdate** will be called to notify the application that a new node has been added or removed in the network.

The SIS holds up to 64 changes of the network. If a node requests an update after more than 64 changes occurred, then it will get a complete copy (see **ZW_RequestNetWorkUpdate**).

Routing slaves have the ability to request updates for its known destination nodes. If any changes have occurred to the network, the SIS will send updated route information for the destination nodes to the Routing slave that requested the update. The Routing slave application will be notified when the process is done, but will not get information about any changes to its routes.

If an inclusion controller sends a new node's node information and its routes to the SIS while it is updating another controller, the updating process will be aborted to process the new nodes information.

4 Z-WAVE APPLICATION INTERFACES

The Z-Wave basis software consists of a number of different modules. Time critical functions are written in assembler while the other Z-Wave modules are written in C. The Z-Wave API consists of a number of C functions which give the application programmer direct access to the Z-Wave functionality.

4.1 API Usage Guidelines

The following guidelines should be followed when making a Z-Wave application.

4.1.1 Code Space, Data Space and Internal/External NVM

One code bank of 32KB memory in flash is allocated for application development. The data SRAM available for the application is 4KB.

To enable full utilization of the 500 series with respect to future protocol features and OTA firmware update results in the following recommendations for external NVM:

Minimum requirements when selecting external NVM for devices without OTA firmware update support:

- 32KB – Required for slave and controller devices

Minimum requirements when selecting external NVM for devices with OTA firmware update support:

- 128KB – Required for slave devices
- 256KB – Required for controller devices

Initialization of the external NVM is completely handled by the Z-Wave protocol and for details about data layout in external NVM refer to [14]. For selection of external NVM refer also to [21].

4.1.2 Buffer Protection

Some API calls has one parameter that is a pointer to a buffer in the application SRAM area and another parameter that is a pointer to a callback function. When using these API functions in Z-Wave, it is important that the application does not change the contents of the buffer before the last callback from the API function has been issued. If the content of the buffer is changed before that callback, the Z-Wave protocol might perform the function on invalid data.

4.1.3 Overlapping API Calls

In general, it should be avoided to call an API function before the previously started API function is finished and has called the callback function for the last time. Due to the limited resources available for the API not all combinations of API calls will work, some API calls will use the same state machine or the same buffers so if multiple functions is started one or both of the functions might fail.

4.1.4 Error Handling

For purpose of robustness, an application implementation may choose to guard callback API calls with a timer. In this guide, a timeout value for each API call, which uses a callback, is given. In some functions it is necessary to execute some commands in order to recover from a timeout exception. Recovery handling is described for each operation.

4.2 Z-Wave Libraries

4.2.1 Library Functionality

Each of the API's provided in the Developer's Kit contains a subset of the full Z-Wave functionality; the table below shows what kind of functionality the API's support independent of the network configuration:

Table 3. Library Functionality

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Basic Functionality					
Singlecast (non-secure)	X	X	X	X	X
Multicast (non-secure)	X	X	X	X	X
Broadcast (non-secure)	X	X	X	X	X
Controller replication (copy)	-	-	X	X	X
Promiscuous mode	-	-	X	X	X
Random number generator	X	X	X	X	X
Able to act as NWI center	-	-	X	X	X
Able to be included via the NWI mechanism	X	X	X	X	X
Able to issue an explorer frame	X	X	X	X	X
Able to forward an explorer frame	X	X	-	X	X
S0 Security (singlecast)	X	X	-	-	-
S2 Security (singlecase and multicast)	X	X	-	-	-
Send multicast wakeup to FLiRS nodes			X	X	X
Memory Location					
NVM data located in internal MTP	X	-	-	-	-
NVM data located in external FLASH/EEPROM	-	X	X	X	X
Firmware update with automatic NVM data conversion	-	X	X	X	X
Network Management					
Network router (repeater)	X ¹	X ¹	-	X ¹	X ¹
Assign routes to routing slave	-	-	X	X	X
Routing slave functionality	X	X	-	-	-
Access to routing table	-	-	X	-	-
Maintain virtual slave nodes	-	-	-	-	X ²
Able to be a FLiRS node	X	X	-	-	-
Able to beam when repeater	X	X	-	X	X
Able to create route containing beam	X ³	X ³	X	X	X

¹ Only if "always listening"

² Only when secondary controller

³ Only when return routes are assigned by a controller capable of creating routes containing beam

4.2.1.1 Library Functionality without a SIS

Some of the API's functionality provided on the Developer's Kit depends on the network configuration. The table below shows what kind of functionality the API's support without a SIS in the Z-Wave network:

Table 4. Library Functionality without a SIS

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Network Management					
Controller replication (copy)	-	-	X	X	X
Controller shift	-	-	X ¹	X ¹	X ¹
Create new primary controller	-	-	-	-	-
Request network updates	-	-	-	-	-
Request rediscovery of a node	-	-	X ¹	X ¹	X ¹
Remove failing nodes	-	-	X ¹	X ¹	X ¹
Replace failing nodes	-	-	X ¹	X ¹	X ¹
Provide routing table info	-	-	X	X	X

¹ Only when primary controller

4.2.1.2 Library Functionality with a SIS

Some of the API's functionality provided on the Developer's Kit depends on the network configuration. The table below shows what kind of functionality the API's support with a SUC ID Server (SIS) in the Z-Wave network:

Table 5. Library Functionality with a SIS

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Network Management					
Controller replication (copy)	-	-	X	X	X
Controller shift	-	-	-	-	-
Create new primary controller	-	-	-	-	-
Request network updates	X	X	X	X	X
Request rediscovery of a node	-	-	X ¹	X ¹	X ¹
Remove failing nodes	-	-	X ¹	X ¹	X ¹
Replace failing nodes	-	-	X ¹	X ¹	X ¹
Set static ctrl. to SIS	-	-	X ²	X ²	X ²
Work as SIS	-	-	-	X	X
Work as inclusion controller			X	X	X
"I'm lost" – provide help	X ³	X ³	X ³	X ⁴	X
Provide routing table info	-	-	X	X	X

Note that the ability to provide help for "I'm lost" requests is limited to forwarding the request to the SIS. Only the portable controller configured as SIS can actually do the updating of the device.

¹ Only when primary/inclusion controller

² Only when primary controller

³ Only if "always listening"

⁴ The library without repeater functionality cannot provide help or forward help requests.

4.3 Z-Wave Common API

This section describes interface functions that are implemented within all Z-Wave nodes. The first subsection defines functions that must be implemented within the application modules, while the second subsection defines the functions that are implemented within the Z-Wave basis library.

Functions that does not complete the requested action before returning to the application (e.g. ZW_SEND_DATA) have a callback function pointer as one of the entry parameters. Unless explicitly specified this function pointer can be set to NULL (no action to take on completion).

A serial API implementation provide an interface to the major part of interface functions via a serial port. The SDK contains a serial API application [18], which enables a host processor to control the interface functions via a serial port.

4.3.1 Required Application Functions

The Z-Wave library requires the functions mentioned here implemented within the Application layer.

4.3.1.1 ApplicationInitHW

BYTE ApplicationInitHW(BYTE bWakeupReason)

ApplicationInitHW is used to initialize hardware used by the application. The Z-Wave hardware initialization function set all application IO pins to input mode. The **ApplicationInitHW** function **MUST** be called by the Z-Wave main function during system startup. At this point of time the Z-Wave timer system is not started so waiting on hardware to get ready **SHOULD** be done by MCU busy loops.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Application hardware initialized
	FALSE	Application hardware initialization failed. Protocol enters test mode and Calls ApplicationTestPoll

Parameters:

bWakeupReason IN	Wakeup flags:	
	ZW_WAKEUP_RESET	Woken up by reset or external interrupt
	ZW_WAKEUP_WUT	Woken up by the WUT timer
	ZW_WAKEUP_SENSOR	Woken up by a wakeup beam
	ZW_WAKEUP_WATCHDOG	Reset because of a watchdog timeout
	ZW_WAKEUP_EXT_INT	Woken up by external interrupt
	ZW_WAKEUP_POR	Reset by Power on reset circuit

Serial API (Not supported)

4.3.1.2 ApplicationInitSW

BYTE ApplicationInitSW(ZW_NVM_STATUS bNvmStatus)

ApplicationInitSW is used to initialize memory used by the application and driver software before the Z-Wave protocol is started.

ApplicationInitSW return value is used to make the protocol determine if the node should go into Power Down mode and if so; when and which Power Down mode the protocol should use. The application can request power down through the return value in **ApplicationPoll**

ApplicationInitSW MUST be called from the Z-Wave main function during system startup. Notice that watchdog is disabled by default.

Defined in: ZW_basis_api.h

Return value:

BYTE	APPLICATION_NODEINFO_LISTENING	Application is a listening always ON node and Application should always return E_APPLICATION_STATE_ACTIVE in the ApplicationPoll return value.
	APPLICATION_NODEINFO_NOT_LISTENING	Application is a none listening node. When Application indicates E_APPLICATION_STATE_READY_FOR_POWERDOWN in the ApplicationPoll return value the protocol will set the module in WUT powerdown mode according to ZW_Power_Management_Init settings (See 4.3.2.27)
	APPLICATION_FREQ_LISTENING_MODE_250ms	Application is a 250ms FLiRS node. When Application indicates E_APPLICATION_STATE_READY_FOR_POWERDOWN in the ApplicationPoll return value the protocol will set the module in 250ms FLiRS mode.
	APPLICATION_FREQ_LISTENING_MODE_1000ms	Application is a 1000ms FLiRS node. When Application indicates E_APPLICATION_STATE_READY_FOR_POWERDOWN in the ApplicationPoll return value the protocol will set the module in 1000ms FLiRS

mode.

Parameters:

ZW_NVM_STATUS Status of NVM initialization during power-up
bNvmStatus IN

ZW_NVM_INITIALIZED

NVM was empty or invalid during startup and has now been initialized as first time startup.

ZW_NVM_VALID

NVM is valid, that is in normal running condition.

ZW_NVM_UPDATED

NVM has been updated to match the layout of a newly installed firmware. NVM is therefore ready for normal operation.

Serial API (Not supported)

4.3.1.3 ApplicationTestPoll

void ApplicationTestPoll(void)

The **ApplicationTestPoll** function is the entry point from the Z-Wave basis software to the application software when the production test mode is enabled in the protocol. This will happen when **ApplicationInitHW** returns FALSE. The **ApplicationTestPoll** function will be called indefinitely until the device is reset. The device must be reset and **ApplicationInitHW** must return TRUE in order to exit this mode. When **ApplicationTestPoll** is called the protocol will acknowledge frames sent to home ID equal to 0x00000000 and node ID as follows.

Device	Node ID
Slave	0x00
Controllers before Dev. Kit v3.40	0xEF
Controllers from Dev. Kit v3.40 or later	0x01

The following API calls are only available in production test mode:

1. **ZW_EepromInit** is used to initialize the external NVM. Remember to initialize controllers with a unique home ID that typically can be transferred via the UART on the production line.
2. **ZW_SendConst** is used to validate RF communication. Remember to enable RF communication when testing products based on a portable controller, routing slave or enhanced 232 slave.

Defined in: ZW_basis_api.h

Serial API (Not supported)

4.3.1.4 ApplicationPoll

E_APPLICATION_STATE ApplicationPoll(E_PROTOCOL_STATE bProtocolState)

The **ApplicationPoll** function is the entry point from the Z-Wave basis software to the application software modules. The **ApplicationPoll** function is called from the Z-Wave main loop when no low-level time critical actions are active. In order not to disrupt the radio communication and the protocol, the application code **MUST** return within 2ms measured from the call of **ApplicationPoll**.

To determine the ApplicationPoll frequency (see table below) is a LED Dimmer application modified to be able to measure how often ApplicationPoll is called via an output pin. The minimum value is measured when the module is idle, i.e., no RF communication, no push button activation etc. The maximum value is measured when the ERTT application at the same time sends Basic Set Commands (value equal 0) as fast as possible to the LED Dimmer (DUT).

Table 6. ApplicationPoll Frequency

	ZW0201 LED Dimmer	ZW0301 LED Dimm,er	400 Series LED Dimmer	500 Series LED Dimmer
Minimum	7.2 us	7.2 us	80 us	80 us
Maximum	2.4 ms	2.4 ms	180 us	180 us

The above mentioned output pin mapped to the ApplicationPoll **SHOULD** also be used during application testing to ensure that the application code never runs for more than 2ms even in worst-case scenarios; setting the pin high when entering and low when leaving the ApplicationPoll function.

The **ApplicationPoll** function return value is used for requesting power down mode, the application can specify if it is ready for power down or if it needs to be running.

Defined in:

ZW_basis_api.h

Return value:

E_APPLICATION_STATE	E_APPLICATION_STATE_ACTIVE	Application active - not ready for sleep/powerdown
	E_APPLICATION_STATE_READY_FOR_POWERDOWN	Application is ready to System Powerdown and protocol will set module in Power down according to value Application returned at the ApplicationInitSW() call (See 4.3.1.2)

Parameters:

E_PROTOCOL_STATE bProtocolState IN	Current protocol state	
	E_PROTOCOL_STATE_ACTIVE	Protocol active - not ready for sytem shutdown
	E_PROTOCOL_STATE_SHUTDOWN_PENDING	Protocol power down pending - protocol making ready for system shutdown
	E_PROTOCOL_STATE_READY_FOR_SHUTDOWN	Protocol going in powerdown - now ready for system shutdown

Serial API (Not supported)

4.3.1.5 ApplicationCommandHandler (Not Bridge Controller Library)

```
void ApplicationCommandHandler( ZW_APPLICATION_TX_BUFFER *pCmd,  
                               BYTE cmdLength,  
                               RECEIVE_OPTIONS_TYPE *rxopt)
```

The Z-Wave protocol will call the **ApplicationCommandHandler** function when an application command or request has been received from another node. The receive buffer is released when returning from this function. The type of frame used by the request can be determined (single cast, mulitcast or broadcast frame). This is used to avoid flooding the network by responding on a multicast or broadcast. In order not to disrupt the radio communication and the protocol, no application function must execute code for more than 5ms without returning.

Except for the Bridge Controller library, this function **MUST** be implemented by the Application layer.

NOTE: For Controllers the rxopt->securityKey is ALWAYS SECURITY_KEY_NONE.

Defined in: ZW_basis_api.h

Parameters:

rxopt->rxStatus IN	Received frame status flags	Refer to ZW_transport_API.h header file
	RECEIVE_STATUS_ROUTED_BUSY xxxxxx1	A response route is locked by the application
	RECEIVE_STATUS_LOW_POWER xxxxx1x	Received at low output power level
	RECEIVE_STATUS_TYPE_SINGLE xxx00xx	Received a single cast frame
	RECEIVE_STATUS_TYPE_BROAD xxx01xx	Received a broadcast frame
	RECEIVE_STATUS_TYPE_MULTI xxx10xx	Received a multicast frame
	RECEIVE_STATUS_TYPE_EXPLORE xxx10xxx	Received an explore frame
	RECEIVE_STATUS_FOREIGN_FRAME x1xxxxxx	The received frame is not addressed to this node (Only valid in promiscuous mode)
	RECEIVE_STATUS_FOREIGN_HOMEID 1xxxxxxx	The received frame is received from a foreign HomeID. Only Controllers in Smart Start AddNode mode can receive this status.
rxopt->destNode IN	Command destination Node ID	Only valid in promiscuous mode and for singlecast frames.
rxopt->sourceNode IN	Command sender Node ID	
rxopt->rxRSSIVal IN	RSSI measurement of the received frame	This is a signed 8-bit value. Values from RSSI_RESERVED_START to 124 are reserved. All values below RSSI_RESERVED_START are received power in dBms. RSSI_NOT_AVAILABLE - RSSI measurement not available RSSI_MAX_POWER_SATURATED - Receiver saturated. RSSI too

		high to measure precisely
		RSSI_BELOW_SENSITIVITY - No signal detected. The RSSI is too low to measure precisely.
rxopt->securityKey IN	Security key frame was decrypted with.	Refer to ZW_security_api.h header file.
	SECURITY_KEY_NONE	Nonsecure transmission – no decryption done.
	SECURITY_KEY_S2_UNAUTHENTICATED	S2 Unauthenticated key
	SECURITY_KEY_S2_AUTHENTICATED	S2 Authenticated key
	SECURITY_KEY_S2_ACCESS	S2 Access key
	SECURITY_KEY_S0	Security Scheme 0 key
pCmd IN	Payload from the received frame.	The command class is the very first byte.
cmdLength IN	Number of Command class bytes.	

Serial API:

ZW->HOST: REQ | 0x04 | rxStatus | sourceNode | cmdLength | pCmd[] | rxRSSIVal | securityKey

When a foreign frame is received in promiscuous mode:

ZW->HOST: REQ | 0xD1 | rxStatus | sourceNode | cmdLength | pCmd[] | destNode | multiNodeMaskLen [] | multiNodeMask[multiNodeMaskLen] | rxRSSIVal

The destNode parameter is only valid for singlecast frames.

If multiNodeMaskLen is ZERO the next parameter in SerialAPI frame is rssiVal.

4.3.1.6 ApplicationNodeInformation

```
void ApplicationNodeInformation(BYTE *deviceOptionsMask,
                              APPL_NODE_TYPE *nodeType,
                              BYTE **nodeParm,
                              BYTE *parmLength )
```

The Z-Wave Application Layer MUST use the **ApplicationNodeInformation** function to generate the Node Information frame and to save information about node capabilities. All Z-Wave application-related fields of the Node Information structure MUST be initialized by this function. For a description of the Generic Device Classes, Specific Device Classes, and Command Classes refer to [4]-[5] and [7]-[12]. The deviceOptionsMask is a Bit mask where Listening and Optional functionality flags MUST be set or cleared accordingly to the nodes capabilities.

The listening option in the deviceOptionsMask (APPLICATION_NODEINFO_LISTENING) indicates a continuously powered node ready to receive frames. A listening node assists as repeater in the network.

The non-listening option in the deviceOptionsMask (APPLICATION_NODEINFO_NOT_LISTENING) indicates a battery-operated node that power off RF reception when idle (prolongs battery lifetime)..

The optional functionality option in the deviceOptionsMask (APPLICATION_NODEINFO_OPTIONAL_FUNCTIONALITY) indicates that this node supports other command classes than the mandatory classes for the selected generic and specific device class.

Examples:

To set a device as Listening with Optional Functionality:

```
*deviceOptionsMask = APPLICATION_NODEINFO_LISTENING |
                    APPLICATION_NODEINFO_OPTIONAL_FUNCTIONALITY;
```

To set a device as not listening and with no Optional functionality support:

```
*deviceOptionsMask = APPLICATION_NODEINFO_NOT_LISTENING;
```

Note for Controllers: Because controller libraries store some basic information about themselves from **ApplicationNodeInformation** in nonvolatile memory. **ApplicationNodeInformation** should be set to the correct values before Application return from **ApplicationInitHW()**, for applications where this cannot be done. The Application must call **ZW_SetDefault()** after updating **ApplicationNodeInformation** in order to force the Z-Wave library to store the correct values.

A way to verify if **ApplicationNodeInformation** is stored by the protocol is to call **ZW_GetNodeProtocolInfo** to verify that Generic and specific nodetype are correct. If they differ from what is expected, the Application should Set the **ApplicationNodeInformation** to the correct values and call **ZW_SetDefault()** to force the protocol to update its information.

Defined in: ZW_basis_api.h

Parameters:

deviceOptionsMask OUT		Bitmask with options
	APPLICATION_NODEINFO_LISTENING	In case this node is always listening (typically AC powered nodes) and stationary.
	APPLICATION_NODEINFO_NOT_LISTENING	In case this node is non-listening (typically battery powered nodes).
	APPLICATION_NODEINFO_OPTIONAL_FUNCTIONALITY	If the node supports other command classes than the ones mandatory for this nodes Generic and Specific Device Class
	APPLICATION_FREQ_LISTENING_MODE_250ms	This option bit should be set if the node should act as a Frequently Listening Routing Slave with a wakeup interval of 250ms. This option is only available on Routing Slaves. This option is not available on 3-channel systems (the JP frequency).
	APPLICATION_FREQ_LISTENING_MODE_1000ms	This option bit should be set if the node should act as a Frequently Listening Routing Slave with a wakeup interval of 1000ms. This option is only available on Routing Slaves.
nodeType OUT	Pointer to structure with the Device Class:	
	(*nodeType).generic	The Generic Device Class [5]. Do not enter zero in this field.
	(*nodeType).specific	The Specific Device Class [5].

nodeParm OUT	Command Class buffer pointer.	Command Classes [12] supported by the device itself and optional Command Classes the device can control in other devices.
parmLength OUT	Number of Command Class bytes.	

Serial API:

HOST->ZW: REQ | 0x03 | deviceOptionsMask | generic | specific | parmLength | nodeParm[]

The **ApplicationNodeInformation** is replaced by **SerialAPI_ApplicationNodeInformation**. Used to set information that will be used in subsequent calls to `ZW_SendNodeInformation`. Replaces the functionality provided by the `ApplicationNodeInformation()` callback function.

```
void SerialAPI_ApplicationNodeInformation(BYTE deviceOptionsMask,
                                          APPL_NODE_TYPE *nodeType,
                                          BYTE *nodeParm,
                                          BYTE parmLength)
```

The define `APPL_NODEPARAM_MAX` in `serialappl.h` must be modified accordingly to the number of command classes to be notified. Prior to either start or join a Z-Wave network the HOST needs to initially setup the Node Information Frame (NIF) which should define the type of Z-Wave node the SerialAPI module is supposed to be. For the NIF to be stored in the protocol NVM area as well as in the application NVM area the HOST need to perform the following steps:

1. HOST->ZW: send **SerialAPI_ApplicationNodeInformation()** with NIF information
2. HOST->ZW: send **ZW_SetDefault()**

The figure below lists the Node Information Frame structure on application level. The Z-Wave Protocol creates this frame via `ApplicationNodeInformation`. The Node Information Frame structure when transmitted by RF does not include the Basic byte descriptor field. The Basic byte descriptor field on application level is deducted from the Capability and Security byte descriptor fields.

Byte descriptor \ bit number	7	6	5	4	3	2	1	0
Capability	Listening	Z-Wave Protocol-Specific Part						
Security	Opt. Func.	Z-Wave Protocol-Specific Part						
Reserved	Z-Wave Protocol-Specific Part							
Basic	Basic Device Class (Z-Wave Protocol-Specific Part)							
Generic	Generic Device Class							
Specific	Specific Device Class							
NodeInfo[0]	Command Class 1							
...	...							
NodeInfo[n-1]	Command Class n							

Figure 8. Node Information Frame Structure on Application Level

WARNING: Must use `deviceOptionsMask` parameter and associated defines to initialize Node Information Frame with respect to listening, non-listening and optional functionality options.

4.3.1.7 ApplicationSlaveUpdate (only Slave Libraries)

```
void ApplicationSlaveUpdate ( BYTE bStatus,  
                             BYTE bNodeID,  
                             BYTE *pCmd,  
                             BYTE bLen)
```

The Z-Wave protocol MAY notify a slave application by calling **ApplicationSlaveUpdate** when a Node Information Frame has been received. The Z-Wave protocol MAY refrain from calling the function if the protocol is currently expecting node information.

All slave libraries requires this function implemented by the application.

Defined in: ZW_slave_api.h

Parameters:

bStatus	IN	The status, value could be one of the following:
		UPDATE_STATE_NODE_INFO_RECEIVED A node has sent its Node Info while the Z-Wave protocol is idle.
bNodeID	IN	The updated node's node ID (1..232).
pCmd	IN	Pointer of the updated node's node info.
bLen	IN	The length of the pCmd parameter.

Serial API:

ZW->HOST: REQ | 0x49 | bStatus | bNodeID | bLen | basic | generic | specific | commandclasses[]

4.3.1.8 ApplicationControllerUpdate (only Controller Libraries)

```
void ApplicationControllerUpdate (BYTE bStatus,
                                  BYTE bNodeID,
                                  BYTE *pCmd,
                                  BYTE bLen)
```

A controller application MAY use the information provided by **ApplicationControllerUpdate** to update local data structures or to control smart start inclusion.

The Z-Wave protocol MUST notify a controller application by calling **ApplicationControllerUpdate** when a new node has been added or deleted from the controller through the network management features.

The Z-Wave protocol MUST call **ApplicationControllerUpdate** in response to **ZW_RequestNodeInfo** being called by the controller application. The Z-Wave protocol MAY notify a controller application by calling **ApplicationControllerUpdate** when a Node Information Frame has been received. The Z-Wave protocol MAY refrain from calling the function if the protocol is currently expecting a Node Information frame.

ApplicationControllerUpdate MUST be called in a controller node operating as SIS each time a node is added or deleted by the primary controller. **ApplicationControllerUpdate** MUST be called in a controller node operating as SIS each time a node is added/deleted by an inclusion controller.

A controller application MAY send a **ZW_RequestNetWorkUpdate** command to a SIS or SIS node. In response, the SIS MUST return update information for each node change since the last update handled by the requesting controller node. The application of the requesting controller node MAY receive multiple calls to **ApplicationControllerUpdate** in response to **ZW_RequestNetWorkUpdate**.

The Z-Wave protocol MUST NOT call **ApplicationControllerUpdate** in a controller node acting as primary controller or inclusion controller when a node is added or deleted.

Any controller application MUST implement this function.

Defined in: ZW_controller_api.h

Parameters:

bStatus	The status of the update process, value could	
IN	be one of the following:	
	UPDATE_STATE_NEW_ID_ASSIGNED	A new node has been added to the network
	UPDATE_STATE_DELETE_DONE	A node has been deleted from the network
	UPDATE_STATE_NODE_INFO_RECEIVED	A node has sent its node info either unsolicited or as a response to a ZW_RequestNodeInfo call
	UPDATE_STATE_SUC_ID	The SIS node Id was updated
	UPDATE_STATE_NODE_INFO_SMARTSTART_HOMEID_RECEIVED	A Smart Start inclusion request has been received. Only Controllers in Smart Start AddNode mode can receive this status.

	UPDATE_STATE_INCLUDED_NODE_INFO_RECEIVED	A Smart Included Node Information Frame has been received. Only Controllers in Smart Start AddNode mode can receive this status.
bNodeID	The updated node's node ID (1..232).	
IN		
pCmd	IN Pointer of the updated node's node info.	If bStatus equals UPDATE_STATE_NODE_INFO_SMARTSTART_HOMEID_RECEIVED the pCmd points to a buffer containing the Smart Start DSK derived HomeID of the Smart Start node wanting to be included, followed by the node's node info.
		If bStatus equals UPDATE_STATE_INCLUDED_NODE_INFO_RECEIVED the pCmd points to a buffer containing rxStatus (see 4.3.1.9) and the Smart Start DSK derived HomeID of an already included Smart Start node. If INIF received are from a foreign Network rxStatus will have RECEIVE_STATUS_FOREIGN_HOMEID set.
bLen	IN The length of the pCmd parameter.	

Serial API:

ZW->HOST: REQ | 0x49 | bStatus | bNodeID | bLen | basic | generic | specific | commandclasses[]

ApplicationControllerUpdate via the Serial API also have the possibility for receiving the status UPDATE_STATE_NODE_INFO_REQ_FAILED, which means that a node did not acknowledge a ZW_RequestNodeInfo call.

ZW->HOST: REQ | 0x49 | 0x85 | bNodeID | bLen | dskID[4] | ccLen | basic | generic | specific | cmdclasses[ccLen]

If Controller has been put into Smart Start mode by calling **ZW_AddNodeToNetwork** with ADD_NODE_SMART_START, the controller will when a Smart Start inclusion request are received use ApplicationControllerUpdate with **UPDATE_STATE_NODE_INFO_SMARTSTART_HOMEID_RECEIVED** (0x85) to inform the Application that a Smart Start node with the specified characteristics requests for Inclusion.

ZW->HOST: REQ | 0x49 | 0x86 | bNodeID | bLen | rxStatus | dskID[4]

If Controller has been put into Smart Start mode by calling **ZW_AddNodeToNetwork** with ADD_NODE_SMART_START, the controller will when a Smart Start Included Node Information Frame (INIF) are received use ApplicationControllerUpdate with **UPDATE_STATE_INCLUDED_NODE_INFO_RECEIVED** (0x86) to inform the Application that a Smart Start node with the specified characteristics has been powered up.

4.3.1.9 ApplicationCommandHandler_Bridge (only Bridge Controller Library)

```
void ApplicationCommandHandler_Bridge(ZW_MULTI_DEST multi,
                                     ZW_APPLICATION_TX_BUFFER *pCmd,
                                     BYTE cmdLength,
                                     RECEIVE_OPTIONS_TYPE *rxopt)
```

The Z-Wave protocol MUST call the **ApplicationCommandHandler_Bridge** function when an application command has been received from another node to the Bridge Controller or an existing virtual slave node. The Z-Wave protocol MUST NOT reuse the receive buffer until the application has exited this function.

A bridge controller application MUST implement this function.

Defined in: ZW_controller_bridge_api.h

Parameters:

rxopt->rxStatus IN Frame header info:

RECEIVE_STATUS_ROUTED_BUSY xxxxxxx1	A response route is locked by the application
RECEIVE_STATUS_LOW_POWER xxxxxx1x	Received at low output power level
RECEIVE_STATUS_TYPE_SINGLE xxx00xx	Received a single cast frame
RECEIVE_STATUS_TYPE_BROAD xxx01xx	Received a broadcast frame
RECEIVE_STATUS_TYPE_MULTI xxx10xx	Received a multicast frame
RECEIVE_STATUS_TYPE_EXPLORE xxx1xxxx	Received an explore frame
RECEIVE_STATUS_FOREIGN_FRAME x1xxxxxx	The received frame is not addressed to this node (Only valid in promiscuous mode) but are addressed to another node belonging to same HomeID as current node.
RECEIVE_STATUS_FOREIGN_HOMEID 1xxxxxxx	The received frame is received from a foreign HomeID. Only Controllers in Smart Start AddNode mode can receive this status.

rxopt->destNode IN	Command receiving Node ID. Either Bridge Controller Node ID, virtual slave Node ID or if in promiscuous mode Node ID on node belonging to same HomeID as current node.	
	If received frame is a multicast frame then destNode is not valid and multi points to a multicast structure containing the destination nodes.	
rxopt->sourceNode IN	Command sender Node ID.	
rxopt->rxRSSIVal IN	RSSI measurement of the received frame	<p>This is a signed 8-bit value.</p> <p>Values from RSSI_RESERVED_START to 124 are reserved.</p> <p>All values below RSSI_RESERVED_START are received power in dBms.</p> <p>RSSI_NOT_AVAILABLE - RSSI measurement not available</p> <p>RSSI_MAX_POWER_SATURATED - Receiver saturated. RSSI too high to measure precisely</p> <p>RSSI_BELOW_SENSITIVITY - No signal detected. The RSSI is too low to measure precisely.</p>
pCmd IN	Payload from the received frame. The command class is the very first byte.	
cmdLength IN	Number of Command class bytes.	

Serial API:

ZW->HOST: REQ | 0xA8 | rxStatus | destNodeID | srcNodeID | cmdLength | pCmd[] | multiDestsOffset_NodeMaskLen | multiDestsNodeMask | rxRSSIVal

When a foreign frame is received in promiscuous mode:

ZW->HOST: REQ | 0xD1 | rxStatus | sourceNode | cmdLength | pCmd[] | destNode | multiNodeMaskLen [| multiNodeMask[multiNodeMaskLen]] | rxRSSIVal

The destNode parameter is only valid for singlecast frames.

If multiNodeMaskLen is ZERO the next parameter in SerialAPI frame is rxRSSIVal.

4.3.1.10 ApplicationSlaveNodeInformation (only Bridge Controller Library)

```
void ApplicationSlaveNodeInformation(BYTE destNode,
                                   BYTE *listening,
                                   APPL_NODE_TYPE *nodeType,
                                   BYTE **nodeParm,
                                   BYTE *parmLength)
```

Request Application Virtual Slave Node information. The Z-Wave protocol layer calls **ApplicationSlaveNodeInformation** just before transmitting a "Node Information" frame.

The Z-Wave Bridge Controller library requires this function implemented by the application.

Defined in: ZW_controller_bridge_api.h

Parameters:

destNode IN	Which Virtual Node do we want the node information from.	
listening OUT	TRUE if this node is always listening and not moving.	
nodeType OUT	Pointer to structure with the Device Class:	
	(*nodeType).generic	The Generic Device Class [5]. Do not enter zero in this field.
	(*nodeType).specific	The Specific Device Class [5].
nodeParm OUT	Command Class buffer pointer.	Command Classes [12] supported by the device itself and optional Command Classes the device can control in other devices.
parmLength OUT	Number of Command Class bytes.	

Serial API:

The **ApplicationSlaveNodeInformation** is replaced by **SerialAPI_ApplicationSlaveNodeInformation**. Used to set node information for all Virtual Slave Nodes in the embedded module this node information will then be used in all subsequent calls to **ZW_SendSlaveNodeInformation** regardless if using different destNode value as only one Virtual Slave Node node information are kept in RAM at a time. Replaces the functionality provided by the **ApplicationSlaveNodeInformation()** callback function.

```
void SerialAPI_ApplicationSlaveNodeInformation(BYTE destNode,
                                               BYTE listening,
                                               APPL_NODE_TYPE * nodeType,
                                               BYTE *nodeParm,
                                               BYTE parmLength)
```

HOST->ZW: REQ | 0xA0 | destNode | listening | genericType | specificType | parmLength | nodeParm[]

4.3.1.11 ApplicationNetworkLearnModeCompleted (only Controller Libraries)

void ApplicationNetworkLearnModeCompleted(LEARN_INFO *glearnNodeInfo)

Called when node have started inclusion/exclusion through **ZW_NetworkLearnModeStart** and node has been included, excluded or learnmode either failed or timed out.

A controller application MUST implement this function.

*learnNodeInfo.bStatus IN	Status of learn mode:	
	LEARN_MODE_STARTED	The learn process has been started
	LEARN_MODE_DONE	The learn process is complete and the controller is now included into the network
	LEARN_MODE_FAILED	The learn process failed.
*learnNodeInfo.bSource IN	Valid values:	
	0	Node has been Excluded
	1-232	node has been Included and has been assigned this nodeID
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_FAILED	Smart Start secure inclusion failed
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_SMART_START_IN_PROGRESS	A nodeID has been assigned do not go into sleepmode – Inclusion NOT done
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_TIMEOUT	LearnMode process timeout inclusion/exclusion did not start
*learnNodeInfo.pReserved IN	Reserved	
*learnNodeInfo.bReservedLen IN		Length of Reserved

Serial API:

The **ZW_NetworkLearnModeStart** functionality is reached through the Serial API functionality **FUNC_ID_ZW_SET_LEARN_MODE** and the **ApplicationNetworkLearnModeCompleted** results is transmitted to HOST as a **FUNC_ID_ZW_SET_LEARN_MODE** request.

ZW->HOST: REQ | 0x50 | funcID | bStatus | bSource | bReservedLen | bReserved[bReservedLen]

4.3.1.12 ApplicationNetworkLearnModeCompleted (only Slave Libraries)

void ApplicationNetworkLearnModeCompleted(BYTE bNodeID)

Called when node have started inclusion/exclusion through **ZW_NetworkLearnModeStart** and node has been included, excluded or learnmode either failed or timed out.

A slave application MUST implement this function.

bNodeID IN	Valid values:	
	0	Node has been Excluded
	1-232	node has been Included and has been assigned this nodeID
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_FAILED	Smart Start secure inclusion failed
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_SMART_START_IN_PROGRESS	A nodeID has been assigned do not go into sleepmode – Inclusion NOT done
	APPLICATION_NETWORK_LEARN_MODE_COMPLETED_TIMEOUT	LearnMode process timeout inclusion/exclusion did not start

Serial API:

The **ZW_NetworkLearnModeStart** functionality is reached through the Serial API functionality **FUNC_ID_ZW_SET_LEARN_MODE** and the **ApplicationNetworkLearnModeCompleted** results is transmitted to HOST as a **FUNC_ID_ZW_SET_LEARN_MODE** request.

ZW->HOST: REQ | 0x50 | funcID | bNodeID

4.3.1.13 ApplicationRfNotify

void ApplicationRfNotify (BYTE rfState)

This function is used to inform the application about the current state of the radio enabling control of an external power amplifier (PA). The Z-Wave protocol will call the **ApplicationRfNotify** function when the radio changes state as follows:

- From Tx to Rx
- From Rx to Tx
- From power down to Rx
- From power down to Tx
- When internal Tx PA is powered up
- When internal Tx PA is powered down

This enables the application to control an external PA using the appropriate number of I/O pins. For details, refer to [19].

The **ApplicationRfNotify** function MUST be defined in the application even if not being used for controlling an external PA. Remember to include header file `config_lib.h` in application to enable function.

Defined in: `ZW_basis_api.h`

Parameters:

rfState IN	The current mode of the radio.	Refer to <code>ZW_transport_API.h</code> header file
	<code>ZW_RF_TX_MODE</code>	The radio is in Tx mode. Previous mode is either Rx or power down
	<code>ZW_RF_RX_MODE</code>	The radio is in Rx mode. Previous mode is either Tx or power down
	<code>ZW_RF_PA_ON</code>	The radio is in Tx mode and the PA is powered on
	<code>ZW_RF_PA_OFF</code>	The radio is in Tx mode and the PA is powered off

Serial API:

Not implemented

4.3.1.14 ApplicationSecureKeysRequested (only Slave Libraries)

BYTE ApplicationSecureKeysRequested(void);

This function lets the application select which Security network keys are requested during inclusion (add) to a Security 2 capable controller. The including controller may grant all or a subset of the requested keys.

This function is only required in slave_routing and slave_enhanced_232 based applications.

Defined in: ZW_security_api.h

Return value:

BYTE	Bitmask of requested keys. The possible values are	Refer to ZW_security_API.h header file
	SECURITY_KEY_S2_UNAUTHENTICATED_BIT	Request the unauthenticated key.
	SECURITY_KEY_S2_AUTHENTICATED_BIT	Request the authenticated key.
	SECURITY_KEY_S2_ACCESS_BIT	Request the Access Control key.
	SECURITY_KEY_S0_BIT	Request the Security scheme 0 key for backwards compatibility.

Serial API:

Not implemented.

The Requested Security keys can either be set through the Serial API

FUNC_ID_ZW_SECURITY_SETUP function

E_SECURITY_SETUP_CMD_SET_SECURITY_INCLUSION_REQUESTED_KEYS (See 4.3.15.1) or

at compile-time through the config_app.h file for SerialAPIPlus. See the

REQUESTED_SECURITY_KEYS define.

4.3.1.15 **ApplicationSecureAuthenticationRequested (only Slave Libraries)**

BYTE ApplicationSecureAuthenticationRequested(void);

This function lets the application select which Security network authentication are requested during inclusion (add) to a Security 2 capable controller.

This function is only required in slave_routing and slave_enhanced_232 based applications.

Defined in: ZW_security_api.h

Return value:

BYTE	S2 Inclusion Authentication method. The possible values are	Refer to ZW_security_API.h header file
	SECURITY_AUTHENTICATION_SSA	Request Server Side Authentication.
	SECURITY_AUTHENTICATION_CSA	Request Client Side Authentication.

Serial API:

Not implemented.

The Requested Authentication can either be set through the Serial API

FUNC_ID_ZW_SECURITY_SETUP function

E_SECURITY_SETUP_CMD_SET_SECURITY_INCLUSION_REQUESTED_AUTHENTICATION (See

4.3.15.1) or at compile-time through the config_app.h file for SerialAPIPlus. See the

REQUESTED_SECURITY_AUTHENTICATION define.

4.3.1.16 ApplicationSecureCommandsSupported (only Slave Libraries)

```
void
ApplicationSecureCommandsSupported(
    enum SECURITY_KEY eKey,
    BYTE **pCmdClasses,
    BYTE *pLength);
```

The application uses this function to notify the protocol of the command classes it supports using each security key.

This function is only required in slave_routing and slave_enhanced_232 based applications.

Defined in: ZW_security_api.h

Parameters:

eKey IN	The security key to report on.
pCmdClasses OUT	Cmd classes supported using eKey
pLength OUT	Length of pCmdClasses

Serial API:

This SerialAPI call replaces the functionality provided by the ApplicationSecureCommandsSupported() callback function. Must be set prior to inclusion (add). Will be cached in NVM of the SerialAPI embedded node and needs to be set only once.

The define APPL_NODEPARAM_MAX in serialappl.h must be modified accordingly to the number of command classes to be notified.

```
HOST->ZW: REQ | 0x0C
| unincluded_pLength | unincluded_nodeParm[]
| included_unsecure_p | included_unsecure_nodeParm[]
| pLength | pCmdClasses
```

Note: unincluded_nodeParm is sent to ApplicationNodeInformation when the node is not included and when the node is unsecurely included. included_unsecure_nodeParm is being sent to ApplicationNodeInformation when the node is securely included. pLength and pCmdClasses is sent to ApplicationSecureCommandsSupported.

4.3.1.17 ApplicationSecurityEvent (only Slave Libraries)

```
void
ApplicationSecurityEvent(
    s_application_security_event_data_t *securityEvent
);
```

The protocol uses this function to notify the application of security events.

This function is only required in slave_routing and slave_enhanced_232 based applications.

Defined in: ZW_security_api.h

Parameters:

s_application_security_event_data_t IN	securityEvent->event	Security Event descriptor
	securityEvent->eventDataLength	
	securityEvent->eventData	

SecurityEvent can contain following events:

event = E_APPLICATION_SECURITY_EVENT_S2_INCLUSION_REQUEST_DSK_CSA (eventDataLength = 0). This event occurs when node is in LearnMode and the S2 Inclusion (add) requires the CSA DSK (a fragment of the including Controller DSK) to finish. The application should then deliver the CSA DSK by calling ZW_SetSecurityS2InclusionPublicDSK_CSA (See 4.3.15.3) accordingly.

Serial API:

ZW->HOST: 0x9D | event | evenDataLength | eventData[eventDataLength]

4.3.2 Z-Wave Basis API

This section defines functions that are implemented in all Z-Wave nodes.

4.3.2.1 ZW_ExploreRequestInclusion

BYTE ZW_ExploreRequestInclusion()

An application MAY use this function to initiate a Network-Wide Inclusion process. In response to the call, the Z-Wave protocol MUST send out an explorer frame requesting inclusion (add) into a network.

The application MUST enable Learn Mode (refer to 4.4.30 for controllers or 4.8.2 for slaves) with the parameter ZW_SET_LEARN_MODE_NWI before calling this function.

A controller in Network-Wide Inclusion mode MAY accept the inclusion request. In that case, the application requesting inclusion MUST get notified through the callback function specified when calling the ZW_SetLearnMode() function. Once a callback is received from ZW_SetLearnMode() saying that the inclusion process has started, the application MUST NOT make further calls to this function.

NOTE: An application SHOULD NOT call this function more than once every 4 seconds.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Inclusion request queued for transmission
	FALSE	Node is not in learn mode

Serial API

HOST->ZW: REQ | 0x5E

ZW->HOST: RES | 0x5E | retVal

4.3.2.2 ZW_ExploreRequestExclusion

BYTE ZW_ExploreRequestExclusion()

An application MAY use this function to initiate a Network-Wide Exclusion process. In response to the call, the Z-Wave protocol MUST send out an explorer frame requesting exclusion (remove) out of a network.

The application MUST enable Learn Mode (refer to 4.4.30 for controllers or 4.8.2 for slaves) with the parameter ZW_SET_LEARN_MODE_NWE before calling this function and thereby enabling the node to be excluded routed.

A controller in Network-Wide Exclusion mode MAY accept the exclusion request. In that case, the application requesting exclusion MUST get notified through the callback function specified when calling the ZW_SetLearnMode() function. Once a callback is received from ZW_SetLearnMode() saying that the exclusion process has started, the application MUST NOT make further calls to this function.

NOTE: Only an excluding controller on the same HomeID as the excludee can do a routed exclusion.

NOTE: An application SHOULD NOT call this function more than once every 4 seconds.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Exclusion (remove) request queued for transmission
	FALSE	Node is not in learn mode

Serial API

HOST->ZW: REQ | 0x5F

ZW->HOST: RES | 0x5F | retVal

4.3.2.3 ZW_GetBackgroundRSSI

Void ZW_GetBackgroundRSSI(RSSI_LEVELS *rssi_levels)

This function returns the most recent background RSSI levels detected. The RSSI is only measured when the radio is in receive mode.

Defined in: ZW_basis_api.h

Return value:

RSSI_LEVELS* Returns a pointer to a struct containing the rssi levels for each channel in dBms.

The rssi levels struct is defined as

```
typedef struct {
    signed char rssi_dBm[NUM_CHANNELS];
} RSSI_LEVELS;
```

Each value in the rssi_dBm contains an RSSI value encoded according to Table 7. NUM_CHANNELS is 2 or 3 depending on the geographic region of the product.

The rssi level in a single channel is contained in a BYTE encoded as a signed integer:

Table 7, RSSI Encoding

Bit pattern	Value (signed)	Meaning
0x7F	127	RSSI_NOT_AVAILABLE. Returned by ZW_GetBackgroundRSSI if the node has not yet had time to sample the rssi since powerup. Returned by ZW_SendData for unused hops or from pre 6.60 repeaters that does not support appending rssi to the routed frame.
0x7E	126	RSSI_MAX_POWER_SATURATED
0x7D	125	RSSI_BELOW_SENSITIVITY. No signal detected.
...	...	Reserved
0xE0	-32	-32 dBm
0xDF	-33	-33 dBm
...

0xA2	-94	-94 dBm
0xA1	-95	Reserved
...	...	Reserved
0x80	-128	Reserved

Notes: The rssi level is defined as the RSSI measured at the antenna when no Z-Wave traffic is present. The dynamic range of rssi measurements on a 500-series Z-Wave chip is from -94 dBm to -32 dBm. The precision of the measurement is +/- 2 dBm. The returned values assume a path loss of ~7 dBm from chip input to antenna. This corresponds to a typical SAW filter and antenna. For maximum accuracy, these readings should be calibrated with RF measurements performed on a final product including the final antenna design.

Serial API

HOST->ZW: REQ | 0x3B

ZW->HOST: RES | 0x3B | Ch0 | Ch1 for 2-channel systems OR

ZW->HOST: RES | 0x3B | Ch0 | Ch1 | Ch2 for 3-channel systems

4.3.2.4 ZW_GetProtocolStatus

BYTE ZW_GetProtocolStatus(void)

Macro: ZW_GET_PROTOCOL_STATUS()

The application MAY request the status of the protocol by calling this function. In response to this function, the Z-Wave protocol MUST return a bitmask reporting the current status of the protocol.

Defined in: ZW_basis_api.h

Return value:

BYTE	Returns the protocol status as one of the following:
Zero	Protocol is idle.
ZW_PROTOCOL_STATUS_ROUTING	Protocol is analyzing the routing table.
ZW_PROTOCOL_STATUS_SUC	SIS sends pending updates.

Serial API

HOST->ZW: REQ | 0xBF

ZW->HOST: RES | 0xBF | retVal

4.3.2.5 ZW_GetRandomWord

BYTE ZW_GetRandomWord(BYTE *randomWord)

Macro: ZW_GET_RANDOM_WORD(randomWord)

An application SHOULD NOT use this function during normal operation as the radio communication is disabled during function execution. The function MAY however be used for algorithms depending on true randomness, e.g., as a seed generator for Pseudo-Random Number Generator (PRNG) functions used for security encryption. Instead, the function ZW_Random SHOULD be used (refer to 4.3.2.6).

This function returns a random word using the 500 series built-in hardware random number generator based on (internal) RF noise (RFRNG).

Defined in: ZW_basis_api.h

Return value:

BOOL	TRUE	If possible to generate random number.
	FALSE	If not possible – will happen if RF is busy at the time of the function call.

Parameters:

randomWord OUT	Pointer to word variable, which should receive the random word.
----------------	---

Serial API

The Serial API function 0x1C makes use of the ZW_GetRandomWord to generate a specified number of random bytes:

- Call ZW_GetRandomWord until enough random bytes generated or ZW_GetRandomWord returns FALSE.
- Return result to HOST.

HOST -> ZW: REQ | 0x1C | [noRandomBytes]

noRandomBytes

Number of random bytes needed. Optional if not present or equal ZERO then 2 random bytes are returned Range 1...32 random bytes are supported.

ZW -> HOST: RES | 0x1C | randomGenerationSuccess | noRandomBytesGenerated | noRandomGenerated[noRandomBytesGenerated]

randomGenerationSuccess

TRUE if random bytes could be generated

FALSE if no random bytes could be generated

noRandomBytesGenerated

Number of random numbers generated

noRandomBytesGenerated[]

Array of generated random bytes

4.3.2.6 ZW_Random

BYTE ZW_Random(void)

Macro: ZW_RANDOM()

This function implements a simple pseudo-random number generator that generates a sequence of numbers, the elements of which are approximately independent of each other. The same sequence of pseudo-random numbers will be repeated in case the module is power cycled.

An application MAY use this function for implementing random behavior, e.g., when multiple nodes respond to a multicast message. The Z-Wave protocol MAY also use this function for random backoff, etc.

Due to its simple nature, an application MUST NOT use this function for obtaining random values for security key calculation and encryption.

Defined in: ZW_basis_api.h

Return value:

BYTE Random number (0 – 0xFF)

Serial API

HOST->ZW: REQ | 0x1D

ZW->HOST: RES | 0x1D | rndNo

4.3.2.7 ZW_RegisterBackgroundRSSICallback

```
void ZW_RegisterBackgroundRSSICallback(  
    VOID_CALLBACKFUNC(cbFun)(RSSI_LEVELS *))
```

ZW_RegisterBackgroundRSSICallback registers a callback function that is called whenever new background RSSI measurements for all channel are ready.

The callback function is invoked with a pointer argument to a structure containing the RSSI values per channel.

Defined in: ZW_basis_api.h

Parameters:

cbFun IN	Function pointer to the callback function. The callback function must accept a RSSI_LEVELS pointer as its first and only argument.
----------	--

The callback function must accept a pointer argument to a RSSI_LEVELS structure containing the RSSI values per channel. The RSSI_LEVELS structure is defined as:

```
typedef struct {  
    signed char rssi_dBm[NUM_CHANNELS];  
} RSSI_LEVELS;
```

NUM_CHANNELS has a value of 2 or 3 depending on geographical region.

The RSSI values in rssi_dBm are signed byte values with the largest positive values having special meanings. On a 500-series Z-Wave chip, RSSI values between -94 dBm and -32 dBm are returned. RSSI_MAX_POWER_SATURATED is returned if the received background noise exceeds -32 dBm. RSSI_BELOW_SENSITIVITY is returned if the received noise power is below -94 dBm. The precision of the reading is +/- 2 dBms.

The frequency of callbacks is typically around 100 Hz. But it depends on many factors, including how much work is performed in ApplicationPoll and how many interrupts are generated. Customers with specific requirements on the sampling frequency is advised to validate their customized firmware.

A note on loss calibration

(The power levels returned are power levels at the antenna. A path loss of approx. 7 dBms from antenna to chip RF input is assumed to account for SAW filter loss, antenna loss, temperature variations and other factors. For precise readings, it is important to calibrate the measurement to the antenna design of the finished product.

Example use

```
#include <ZW_basis_api.h>

void ZCB_rssi_level_callback( RSSI_LEVELS *noise);
code const void (code * ZCB_rssi_level_callback_p)(RSSI_LEVELS*) =
    &ZCB_rssi_level_callback;
/*===== ZCB_rssi_level_callback =====
** Callback func for rssi level detection
**
**-----
*/
void /* RET Nothing */
ZCB_rssi_level_callback(
    RSSI_LEVELS *rssi) /* IN RSSI levels pointer */
{
    /* Do something with rssi values...*/
    ZW_DEBUG_SEND_NUM(noise->rssi_dBm[0]);
    ZW_DEBUG_SEND_NUM(noise->rssi_dBm[1]);
#ifdef ZW_3CH_SYSTEM
    ZW_DEBUG_SEND_NUM(noise->rssi_dBm[2]);
#endif
}

/*===== ApplicationInitSW =====
=
** Initialization of the Application Software
**
**-----
*/
BYTE /*RET TRUE */
ApplicationInitSW(void) /*IN Nothing */
{
    /* Other initialization code here... */

    ZW_RegisterBackgroundRSSICallback(ZCB_rssi_level_callback);
}

```

Serial API:

Not available via SerialAPI. See the ZW_GetBackgroundRSSI() function instead.

4.3.2.8 ZW_RFPowerLevelSet

BYTE ZW_RFPowerLevelSet(BYTE powerLevel)

Macro: ZW_RF_POWERLEVEL_SET(POWERLEVEL)

An application MAY use this function to set the power level used for RF transmission. The actual RF power is dependent on the settings for transmit power level in App_RFSetup.a51. If this value is changed from the default library value the resulting power levels might differ from the intended values. The returned value is however always the actual one used.

NOTE: This function should only be used in an install/test link situation and the power level should always be set back to normal Power when the testing is done.

Defined in: ZW_basis_api.h

Parameters:

powerLevel IN	Powerlevel to use in RF transmission, valid values:	
	normalPower	Max power possible
	minus1dB	Normal power - 1dB (mapped to minus2dB ¹)
	minus2dB	Normal power - 2dB
	minus3dB	Normal power - 3dB (mapped to minus4dB)
	minus4dB	Normal power - 4dB
	minus5dB	Normal power - 5dB (mapped to minus6dB)
	minus6dB	Normal power - 6dB
	minus7dB	Normal power - 7dB (mapped to minus8dB)
	minus8dB	Normal power - 8dB
	minus9dB	Normal power - 9dB (mapped to minus10dB)

Return value:

BYTE The powerlevel set.

Serial API (Serial API protocol version 4):

HOST->ZW: REQ | 0x17 | powerLevel

ZW->HOST: RES | 0x17 | retVal

¹ 500 Series support only -2dB power level steps

4.3.2.9 ZW_RFPowerLevelGet

BYTE ZW_RFPowerLevelGet(void)

Macro: ZW_RF_POWERLEVEL_GET()

Get the current power level used in RF transmitting.

NOTE: This function should only be used in an install/test link situation.

Defined in: ZW_basis_api.h

Return value:

BYTE The power level currently in effect during
RF transmissions.

Serial API

HOST->ZW: REQ | 0xBA

ZW->HOST: RES | 0xBA | powerlevel

4.3.2.10 ZW_RequestNetWorkUpdate

BYTE ZW_RequestNetWorkUpdate (VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

Macro: ZW_REQUEST_NETWORK_UPDATE (func)

This API call is used to request a network update from a SUC/SIS controller. Any changes are reported to the application by calling the **ApplicationControllerUpdate**.

All controllers MAY use this call if there is a SUC/SIS in the network. Secondary controllers MUST NOT use this call if there is no SUC/SIS in the network.

All types of routing slaves MAY use this call if there is a SUC/SIS in the network. Routing Slaves MUST NOT use this call if there is no SUC/SIS in the network. In case the Routing Slave has called ZW_RequestNewRouteDestinations prior to ZW_RequestNetWorkUpdate, then Return Routes for the destinations specified by the application in ZW_RequestNewRouteDestinations will be updated along with the SUC Return Route.

Checking if a SUC/SIS is known by the node is done using the API call **ZW_GetSUCNodeID**.

NOTE: The SUC/SIS can only handle one network update process at a time. If another request is made during a network update process then the latest requesting node receives a ZW_SUC_UPDATE_WAIT status.

WARNING: This API call will generate a lot of network activity that will use bandwidth and stress the SUC/SIS in the network. Therefore, network updates SHOULD be requested as seldom as possible and never more often than once every hour from a controller.

Defined in: ZW_controller_api.h and ZW_slave_routing_api.h

Return value:

BYTE	TRUE	If the updating process is started.
	FALSE	If the requesting controller is the SUC node or the SUC node is unknown.

Parameters:

completedFunc Transmit complete call back.
IN

Callback function Parameters:

txStatus IN	Status of command:	
	ZW_SUC_UPDATE_DONE	The update process succeeded.
	ZW_SUC_UPDATE_ABORT	The update process aborted because of an error.
	ZW_SUC_UPDATE_WAIT	The SUC node is busy.
	ZW_SUC_UPDATE_DISABLED	The SUC functionality is disabled.
	ZW_SUC_UPDATE_OVERFLOW	The controller requested an update after more than 64 changes have occurred in the network. The update information is then out of date in respect to that controller. In this situation the controller have to make a replication (copy) before trying to request any new network updates.
txStatusReport IN	(see ZW_SendData)	

Serial API:

HOST->ZW: REQ | 0x53 | funcID

Notice: funcID is used to correlate callback with original request. Callback is disabled by setting funcID equal to zero in original request.

ZW->HOST: RES | 0x53 | retVal

ZW->HOST: REQ | 0x53 | funcID | txStatus

4.3.2.11 ZW_RFPowerlevelRediscoverySet

void ZW_RFPowerlevelRediscoverySet(BYTE bNewPower)

Macro: ZW_RF_POWERLEVEL_REDISCOVERY_SET(bNewPower)

This function MAY be used to set the power level locally in the node when finding neighbors.

The default power level used for rediscovery is normal power minus 6dB. The default power level SHOULD be used. The call to ZW_RFPowerlevelRediscoverySet MAY be omitted if the default power level is to be used.

It is NOT RECOMMENDED to use other power levels. Increased power levels may cause weak RF links to be included in the routing table. Weak RF links can increase latency in the network due to retries to get through. Further reduced power levels may cause nodes with good link properties to not be discovered. This may lead to increased latency due to additional hops to the destination.

A call to this function affects the power level used for all future neighbor discovery operations. The function can be called from ApplicationInit or during runtime from ApplicationPoll or ApplicationCommandHandler.

Defined in: ZW_basis_api.h

Parameters:

bNewPower IN Powerlevel to use when doing neighbor discovery, valid values:

normalPower	Max power possible
minus1dB	Normal power - 1dB (mapped to minus2dB ¹)
minus2dB	Normal power - 2dB
minus3dB	Normal power - 3dB (mapped to minus4dB)
minus4dB	Normal power - 4dB
minus5dB	Normal power - 5dB (mapped to minus6dB)
minus6dB	Normal power - 6dB
minus7dB	Normal power - 7dB (mapped to minus8dB)
minus8dB	Normal power - 8dB
minus9dB	Normal power - 9dB (mapped to minus10dB)

Serial API:

¹ 400 Series support only -2dB power level steps

HOST->ZW: REQ | 0x1E | powerLevel

4.3.2.12 ZW_SendNodeInformation

```

BYTE ZW_SendNodeInformation(BYTE destNode,
                           BYTE txOptions,
                           VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

```

Macro: ZW_SEND_NODE_INFO(node,option,func)

Create and transmit a "Node Information" frame. The Z-Wave transport layer builds a frame, request application node information (see **ApplicationNodeInformation**) and queue the "Node Information" frame for transmission. The completed call back function (**completedFunc**) is called when the transmission is complete.

The Node Information Frame is a protocol frame and will therefore not be directly available to the application on the receiver. The API call ZW_SetLearnMode() can be used to instruct the protocol to pass the Node Information Frame to the application.

When ZW_SendNodeInformation() is used in learn mode for adding or removing the node from the network the transmit option TRANSMIT_OPTION_LOW_POWER should NOT be used.

NOTE: ZW_SendNodeInformation uses the transmit queue in the API, so using other transmit functions before the complete callback has been called by the API is not recommended.

WARNING: It is not allowed to call ZW_SendNodeInformation() from a controller when ZW_SetLearnMode() is active.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	If frame was put in the transmit queue
	FALSE	If it was not (callback will not be called)

Parameters:

destNode IN	Destination Node ID (NODE_BROADCAST == all nodes)
txOptions IN	Transmit option flags. (see ZW_SendData)
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	(see ZW_SendData)
txStatusReport IN	(see ZW_SendData)

Serial API:

HOST->ZW: REQ | 0x12 | destNode | txOptions | funcID

ZW->HOST: RES | 0x12 | retVal

ZW->HOST: REQ | 0x12 | funcID | txStatus

4.3.2.13 ZW_SendTestFrame

```
BYTE ZW_SendTestFrame( BYTE nodeID,  
                       BYTE powerlevel,  
                       VOID_CALLBACKFUNC(func)(BYTE txStatus, TX_STATUS_TYPE*  
                       txStatusReport))
```

Macro: ZW_SEND_TEST_FRAME(nodeID, power, func)

Send a test frame directly to nodeID without any routing, RF transmission power is previously set to powerlevel by calling ZW_RF_POWERLEVEL_SET. The test frame is acknowledged at the RF transmission powerlevel indicated by the parameter powerlevel by nodeID (if the test frame got through). This test will be done using 9600 kbit/s transmission rate.

NOTE: This function should only be used in an install/test link situation.

Defined in: ZW_basis_api.h

Parameters:

nodeID IN	Node ID on the node ID (1..232) the test frame should be transmitted to.	
powerLevel IN	Powerlevel to use in RF transmission, valid values:	
	normalPower	Max power possible
	minus1dB	Normal power - 1dB (mapped to minus2dB ¹)
	minus2dB	Normal power - 2dB
	minus3dB	Normal power - 3dB (mapped to minus4dB)
	minus4dB	Normal power - 4dB
	minus5dB	Normal power - 5dB (mapped to minus6dB)
	minus6dB	Normal power - 6dB
	minus7dB	Normal power - 7dB (mapped to minus8dB)
	minus8dB	Normal power - 8dB
	minus9dB	Normal power - 9dB (mapped to minus10dB)
func IN	Call back function called when done.	

¹ 200/300 Series support only -2dB power level steps

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

txStatusReport IN (see **ZW_SendData**)

Return value:

BYTE FALSE If transmit queue overflow.

Serial API

HOST->ZW: REQ | 0xBE | nodeID | powerlevel | funcID

ZW->HOST: RES | 0xBE | retVal

ZW->HOST: REQ | 0xBE | funcID | txStatus

4.3.2.14 ZW_SetExtIntLevel

```
void ZW_SetExtIntLevel( BYTE intSrc,
                       BYTE triggerLevel)
```

Macro: ZW_SET_EXT_INT_LEVEL(SRC, TRIGGER_LEVEL)

This function MAY be used to set the trigger level for external interrupts. Level triggered interrupt MUST be selected as follows:

	Level Triggered
External interrupt 0	IT0 = 0;
External interrupt 1	IT1 = 0;

Defined in: ZW_basis_api.h

Parameters:

intSrc IN The external interrupt valid values:

ZW_INT0

External interrupt 0 (Pin P1.0)

ZW_INT1

External interrupt 1 (Pin P1.1)

triggerLevel IN The external interrupt trigger level:

TRUE

Set the interrupt trigger to high level

FALSE

Set the interrupt trigger to low level

Serial API

HOST->ZW: REQ | 0xB9 | intSrc | triggerLevel

4.3.2.15 ZW_SetPromiscuousMode (only Controller Libraries)

void ZW_SetPromiscuousMode(BOOL state)

Macro: ZW_SET_PROMISCUOUS_MODE(state)

The API call **ZW_SetPromiscuousMode** enable / disable promiscuous mode.

A Controller in promiscuous mode will transfer payload from a promiscuously received application frame destined and originated from nodes residing in same network (HomeID). The promiscuously received application frame (only end destination frame) will be transferred to the application through ApplicationCommandHandler / ApplicationCommandHandler_Bridge with the RECEIVE_STATUS_FOREIGN_FRAME bit set in rxStatus.

A promiscuously application received frame is defined as:

- A frame transmitted using the same HomeID as the promiscuous controller itself.
- A frame neither originated by nor destined the promiscuous controller itself.
- A frame containing the application command class payload

An end destination frame is defined as either:

- Direct frame,
- Outgoing routed frame sent by last repeater,
- Multicast frame or
- Explore frame

With the following exceptions when the controller is a repeater itself:

- Explore frames the controller actively repeats is not transferred to the application.
- Routed frames with the controller as the last repeater - only one promiscuously received application frame is transferred through ApplicationCommandHandler / ApplicationCommandHandler_Bridge and is transferred on the receiving of the frame transmitted by the previous Repeater. This is done even if the controller, as repeater, does retries. Acting as repeater the controller will try transmitting up to 3 times before giving up -> Routed Error.

Promiscuously received frames are delivered to the application via the ApplicationCommandHandler / ApplicationCommandHandler_Bridge callback function (see section 0 / 4.3.1.9).

Defined in: ZW_basis_api.h

Parameters:

state IN TRUE to enable the promiscuous mode,
FALSE to disable it.

Serial API:

HOST->ZW: REQ | 0xD0 | state

See section 0 / 4.3.1.9 for callback syntax when a frame has been promiscuously received.

4.3.2.16 ZW_SetRFReceiveMode

BYTE ZW_SetRFReceiveMode(BYTE mode)

Macro: ZW_SET_RX_MODE(mode)

ZW_SetRFReceiveMode is used to power down the RF when not in use e.g., expects nothing to be received. **ZW_SetRFReceiveMode** can also be used to set the RF into receive mode. This functionality is useful in battery powered Z-Wave nodes e.g., the Z-Wave Remote Controller. The RF is automatic powered up when transmitting data.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	If operation was successful
	FALSE	If operation was none successful

Parameters:

mode IN	TRUE	On: Set the RF in receive mode and starts the receive data sampling
	FALSE	Off: Set the RF in power down mode (for battery power save).

Serial API

HOST->ZW: REQ | 0x10 | mode

ZW->HOST: RES | 0x10 | retVal

4.3.2.17 ZW_Type_Library

BYTE ZW_Type_Library(void)

Macro: ZW_TYPE_LIBRARY()

Get the Z-Wave library type.

Defined in: ZW_basis_api.h

Return value:

BYTE Returns the library type as one of the following:

ZW_LIB_CONTROLLER_STATIC	Static controller library
ZW_LIB_CONTROLLER_BRIDGE	Bridge controller library
ZW_LIB_CONTROLLER	Portable controller library
ZW_LIB_SLAVE_ENHANCED	Enhanced 232 slave library
ZW_LIB_SLAVE_ROUTING	Routing slave library
ZW_LIB_SLAVE	Slave library
ZW_LIB_INSTALLER	Installer library

Serial API

HOST->ZW: REQ | 0xBD

ZW->HOST: RES | 0xBD | retVal

4.3.2.18 ZW_Version

BYTE ZW_Version(BYTE *buffer)

Macro: ZW_VERSION(buffer)

Get the Z-Wave basis API library version.

Defined in: ZW_basis_api.h

Parameters:

buffer OUT Returns the API library version in text using the format:

Z-Wave x.yy

where x.yy is the library version.

Return value:

BYTE Returns the library type as one of the following:

ZW_LIB_CONTROLLER_STATIC	Static controller library
ZW_LIB_CONTROLLER_BRIDGE	Bridge controller library
ZW_LIB_CONTROLLER	Portable controller library
ZW_LIB_SLAVE_ENHANCED	Enhanced 232 slave library
ZW_LIB_SLAVE_ROUTING	Routing slave library
ZW_LIB_SLAVE	Slave library
ZW_LIB_INSTALLER	Installer library

Serial API:

HOST->ZW: REQ | 0x15

ZW->HOST: RES | 0x15 | buffer (12 bytes) | library type

4.3.2.19 ZW_VERSION_MAJOR / ZW_VERSION_MINOR / ZW_VERSION_BETA

Macro: ZW_VERSION_MAJOR/ZW_VERSION_MINOR/ ZW_VERSION_BETA

These #defines can be used to get a decimal value of the used Z-Wave library. ZW_VERSION_MINOR should be 0 padded when displayed to users EG: ZW_VERSION_MAJOR = 1 ZW_VERSION_MINOR =2 should be shown as: 1.02 to the user where as ZW_VERSION_MAJOR = 1 ZW_VERSION_MINOR =20 should be shown as 1.20.

ZW_VERSION_BETA is only defined for beta releases of the Z-Wave Library. In which case it is defined as a single char for instance: 'b'

Defined in: ZW_basis_api.h

Serial API (Not supported)

4.3.2.20 ZW_WatchDogEnable

void ZW_WatchDogEnable(void)

Macro: ZW_WATCHDOG_ENABLE()

This function may be used to enable the 500 Series Z-Wave SoC built-in watchdog.

It is possible to implement a reliable safety system with a hardware watchdog; resetting the entire hardware if a part of the system stops operating correctly. Properly designed, the watchdog handler monitors a critical chain of conditions that must be met before the watchdog is kicked again. See 4.3.2.22.

By default, the watchdog is disabled. The watchdog SHOULD be enabled in released product firmware. It is however RECOMMENDED that the watchdog is not enabled during development and testing prior to final release testing. An enabled watchdog may prevent firmware crashes and stalls from being discovered during development and initial testing. As a side note, debugging a system with an enabled watchdog can be a challenge.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB6

4.3.2.21 ZW_WatchDogDisable

void ZW_WatchDogDisable(void)

Macro: ZW_WATCHDOG_DISABLE ()

This function may be used to disable the 500 Series Z-Wave SoC built in watchdog.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB7

4.3.2.22 ZW_WatchDogKick

void ZW_WatchDogKick(void)

Macro: ZW_WATCHDOG_KICK ()

This function SHOULD be used to keep the watchdog timer from resetting the 500 Series Z-Wave SoC. The watchdog timeout interval is 1 second. If enabled, the watchdog MUST be kicked at least one time per interval. Failing to do so will cause the 500 Series Z-Wave SoC to be reset.

It is possible to implement a reliable safety system with a hardware watchdog; resetting the entire hardware if a part of the system stops operating correctly. Properly designed, the watchdog handler monitors a critical chain of conditions that must be met before the watchdog is kicked again.

It is RECOMMENDED that the designer seeks inspiration in the literature for the design of a reliable watchdog handler.

The resulting executable code does not necessarily require much code space. As a minimum, one SHOULD call **ZW_WatchDogKick** from the function **ApplicationPoll**. An unconditional call of **ZW_WatchDogKick** from **ApplicationPoll** will however only catch Z-Wave protocol exceptions. Without the abovementioned critical chain of conditions, an application may hang infinitely in an unforeseen state without getting reset by the hardware watchdog.

The watchdog SHOULD be kicked one or more times from the function **ApplicationInitSW** to avoid unintentional reset of the application during initialization.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB8

4.3.2.23 ZW_GetTxTimer

```
void ZW_GetTxTimer(    BYTE bChannel,  
                    DWORD *dwTxTime)
```

This function gets the protocols internal tx timer for the specified channel. The returned value is in milli seconds from the last call to ZW_ClearTxTimers(). The tx timers are updated by the protocol every time a frame is send.

Defined in: ZW_basis_api.h

Parameters:

bChannel IN The channel to get the tx timer from.
Valid channels are 0, 1 and 2

dwTxTime OUT The time the transmitter has been
active since the last reset or call to
ZW_ClearTxTimers()

Serial API:

HOST->ZW: REQ | 0x38

ZW->HOST: RES | 0x38 | TxTimeChannel0 | TxTimeChannel1 | TxTimeChannel2

4.3.2.24 ZW_ClearTxTimers

void ZW_ClearTxTimers(void)

This function clears the protocols internal tx timers. The tx timers are updated by the protocol every time a frame is send.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0x37

4.3.2.25 ZW_GetNetworkStats

void ZW_GetNetworkStats(S_NETWORK_STATISTICS *sNetworkStats)

This function retrieves the current Network Statistics as collected by the Z-Wave protocol. The Z-Wave protocol will continuously update any Network Statistics counter until it reaches 65535, which then indicates that the specific counter has reached 65535 or more occurrences. The Network Statistics counters are cleared either on module startup or by calling ZW_ClearNetworkStats().

Defined in: ZW_basis_api.h

Parameters:

<p>*sNetworkStats</p> <p>OUT</p>	<pre>typedef struct _S_NETWORK_STATISTICS_ { WORD wRFTxFrames WORD wRFTxLBTBackOffs; WORD wRFRxFrames; WORD wRFRxLRCErrors; WORD wRFRxCRC16Errors; WORD wRFRxForeignHomeID; } S_NETWORK_STATISTICS;</pre>	<p>Transmitted Frames – including Retries and ACKs</p> <p>Receiving Z-Wave frame or RSSI detected to be too high for starting transmission. 3 channel will if too high RSSI change channel on next try to start same frame transmission. 2 channel will Fail frame after 1 second of continuously LBT Backoffs.</p> <p>Received Frames (No errors)</p> <p>Received Checksum Errors (2 channel only)</p> <p>Received CRC16 Errors</p> <p>Received Foreign Home ID</p>
----------------------------------	---	--

Serial API:

HOST->ZW: REQ | 0x3A

ZW->HOST: RES | 0x3A | wRFTxFrames_MSB | wRFTxFrames_LSB | wRFTxLBTBackOffs_MSB | wRFTxLBTBackOffs_LSB | wRFRxFrames_MSB | wRFRxFrames_LSB | wRFRxLRCErrors_MSB | wRFRxLRCErrors_LSB | wRFRxCRC16Errors_MSB | wRFRxCRC16Errors_LSB | wRFRxForeignHomeID_MSB | wRFRxForeignHomeID_LSB

4.3.2.26 ZW_ClearNetworkStats

void ZW_ClearNetworkStats(void)

This function clears the current Network Statistics collected by the Z-Wave protocol.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0x39

ZW->HOST: RES | 0x01

4.3.2.27 ZW_Power_Management_Init

void ZW_Power_Management_Init(DWORD sleepPeriod, BYTE intEnable)

This function is used to set the WUT sleep period (in seconds) for None listening node which periodically enter WUT sleep mode to preserve power. Also settable is if node should be able to wake up through the EXT1 pin activation.

Defined in: ZW_basis_api.h

Parameters:

sleepPeriod IN Number of seconds the node
 should be in WUT mode before
 application is called again.

intEnable IN Interrupt enable bit mask. Valid
 bit masks are:

ZW_INT_MASK_EXT1

External interrupt 1 (PIN P1_1) is enabled as
interrupt source

0x00

No external Interrupts will wakeup.

Serial API (Not supported)

4.3.2.28 ZW_NetworkLearnModeStart

void ZW_NetworkLearnModeStart(E_NETWORK_LEARN_MODE_ACTION eMode)

This function enables/disables the Network Management module inclusion/exclusion mode sequence according to specified mode.

The Application defined **ApplicationNetworkLearnModeCompleted** (See 4.3.1.11, 4.3.1.12) is called with either status or final result of mode sequence.

Defined in: ZW_basis_api.h

Parameters:

eMode Valid mode values are:

IN	E_NETWORK_LEARN_MODE_DISABLE	Disable learn process
	E_NETWORK_LEARN_MODE_INCLUSION	Enable the learn process to do an inclusion. Will first try Classic inclusion followed by 4 tries of NWI.
	E_NETWORK_LEARN_MODE_EXCLUSION	Enable the learn process to do a Classic exclusion.
	E_NETWORK_LEARN_MODE_EXCLUSION_NWE	Enable the learn process to do a NWE with 4 tries.
	E_NETWORK_LEARN_MODE_INCLUSION_SMARTSTART	Enable the learn process to do an SMART START inclusion.

Serial API

The **ZW_NetworkLearnModeStart** functionality can through Serial API be reached with the **FUNC_ID_ZW_SET_LEARN_MODE** functionality by adding **SERIALPI_SET_LEARN_MODE_LEARN_PLUS_OFFSET** to the needed Network Learn Mode.

SERIALPI_SET_LEARN_MODE_LEARN_PLUS_OFFSET = 0x80

HOST->ZW: REQ | 0x50 | eMode + 0x80 | funcID

ZW->HOST: RES | 0x01

4.3.2.29 ZW_NetworkManagementSetMaxInclusionRequestIntervals

BYTE ZW_NetworkManagementSetMaxInclusionRequestIntervals(BYTE bInclRequestIntervals)

This function can be used to set the maximum interval between SmartStart inclusion requests.

Defined in: ZW_basis_api.h

Return value:

BYTE	FALSE	0: Requested maximum intervals either 0(default) or not valid
	TRUE	5-99: The requested number of intervals set

Parameters:

bInclRequestIntervals IN	The maximum number of 128 sec ticks between SmartStart inclusion requests.	The unit is 128sec and valid range is 5-99. [5...99] => [640 sec ... 12672 sec]
-----------------------------	--	--

Serial API

HOST->ZW: REQ | 0xD6 | bInclRequestIntervals

ZW->HOST: RES | 0xD6 | RetVal

4.3.3 Z-Wave Transport API

The Z-Wave transport layer controls transfer of data between Z-Wave nodes including retransmission, frame check and acknowledgement. The Z-Wave transport interface includes functions for transfer of data to other Z-Wave nodes. Application data received from other nodes is handed over to the application via the **ApplicationCommandHandler** function. The `ZW_MAX_NODES` define defines the maximum of nodes possible in a Z-Wave network.

4.3.3.1 ZW_SendData

```
BYTE ZW_SendData(BYTE nodeID,  
                BYTE *pData,  
                BYTE dataLength,  
                BYTE txOptions,  
                VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus,  
                TX_STATUS_TYPE* txStatusReport ))
```

NOTE: Not supported by the Enhanced 232 Slave library, use ZW_SendDataEx instead.

Macro: ZW_SEND_DATA(node,data,length,options,func)

This function MAY be used to transmit contents of a data buffer to a single node or all nodes (broadcast). The data buffer contents are encapsulated in a Z-Wave transport frame by adding a protocol header and a checksum trailer. The frame is appended to the end of the transmit queue (first in; first out) and transmitted whenever possible.

The protocol layer automatically handles the necessary signaling when the ZW_SendData function is used to initiate a transmission to a FII RS node.

A bridge controller library MUST NOT send to a virtual node belonging to the bridge itself.

The following parameters MUST be specified for the SendData function.

4.3.3.1.1 nodeID parameter

The nodeID parameter MUST specify the destination nodeID.

The nodeID parameter MAY specify the broadcast nodeID (0xFF).

4.3.3.1.2 *pData parameter

The *pData parameter MUST specify a pointer to a data buffer containing a valid Z-Wave command. The data buffer referenced by the *pData parameter MUST contain the number of bytes indicated by the dataLength parameter.

4.3.3.1.3 dataLength parameter

The data buffer referenced by the *pData parameter is used to hold a valid Z-Wave command. The dataLength parameter MUST specify the length of the Z-Wave command.

4.3.3.1.4 txOptions parameter

The calling application MUST compose the txOptions parameter value by combining relevant options chosen from the table below.

One or more callbacks to the completedFunc pointer indicate the status of the operation.

The TRANSMIT_OPTION_ACK option SHOULD be used to request that an acknowledgement is returned by the destination node. If the TRANSMIT_OPTION_ACK transmit option is specified, the protocol layer monitors the arrival of the acknowledgement frame. Up to two retransmissions may be attempted if no acknowledgement frame is received.

The application SHOULD specify the TRANSMIT_OPTION_AUTO_ROUTE option. This will enable mesh routing to destinations which are out of direct range.

The TRANSMIT_OPTION_NO_ROUTE option MAY be specified to limit the transmission to direct range for special application purposes.

Table 8. SendData :: txOptions

TRANSMIT_OPTION_	Description	Priority
ACK	Request acknowledged transmission.	If ACK is disabled (0), all other options are ignored by the SendData function
NO_ROUTE	Request acknowledged transmission and explicitly disable routing.	ACK MUST be enabled (1)
AUTO_ROUTE	Request acknowledged transmission and allow routing. If TRANSMIT_OPTION_AUTO_ROUTE == 0, only the Last Working Route is used for routing if direct range transmission fails. If TRANSMIT_OPTION_AUTO_ROUTE == 1, routed transmission uses the Last Working Route and routing table if direct range transmission fails	ACK MUST be enabled (1) NO_ROUTE MUST be disabled (0)
EXPLORE	Request acknowledged transmission and allow routing. Allow dynamic route resolution if Last Working Route, routing table and direct range transmission fails.	ACK MUST be enabled (1) NO_ROUTE MUST be disabled (0) AUTO_ROUTE SHOULD be enabled (1)

If the broadcast nodeID (0xFF) is specified, the txOptions parameter SHOULD carry the following option values

- TRANSMIT_OPTION_ACK = 0
- TRANSMIT_OPTION_NO_ROUTE = 1
- TRANSMIT_OPTION_AUTO_ROUTE = 0
- TRANSMIT_OPTION_EXPLORE = 0

Table 9. Use of Transmit Options for Controller Libraries

TRANSMIT_OPTION_			Protocol behaviour
NO_ROUTE	ACK	AUTO_ROUTE	
1	0	(ignore)	Transmit frame with no routing, nor retransmission; just as if it was a broadcast frame.
1	1	(ignore)	Frame will be transmitted with direct communication i.e., no routing regardless whether a APR or a LWR exist or not.
0	1	0	In case direct transmission fails, the frame will be transmitted using LWR if one exists to the destination in question.
0	1	1	If direct communication fails, then attempt with LWR. If LWR also fails or simply do not exist to the destination, then routes from the routing table will be used.

4.3.3.1.4.1 TRANSMIT_OPTION_ACK

The transmit option TRANSMIT_OPTION_ACK MAY be used to request the destination node to return a transfer acknowledgement. The Z-Wave protocol layer will retry the transmission if no acknowledgement is received.

The transmit option TRANSMIT_OPTION_ACK SHOULD be specified for all normal application communication.

If the nodeID parameter specifies the broadcast nodeID (0xFF), the Z-Wave protocol layer ignores the transmit option TRANSMIT_OPTION_ACK.

4.3.3.1.4.2 TRANSMIT_OPTION_NO_ROUTE

The transmit option TRANSMIT_OPTION_NO_ROUTE MAY be used to force the protocol to send the frame without routing. All available routing information is ignored.

The transmit option TRANSMIT_OPTION_NO_ROUTE SHOULD NOT be specified for normal application communication.

If the nodeID parameter specifies the broadcast nodeID (0xFF), the Z-Wave protocol layer ignores the transmit option TRANSMIT_OPTION_NO_ROUTE.

4.3.3.1.4.3 TRANSMIT_OPTION_AUTO_ROUTE

The transmit option TRANSMIT_OPTION_AUTO_ROUTE MAY be used to enable routing.

The Z-Wave protocol layer will then try transmitting the frame via repeater nodes in case destination node is out of direct range.

Controller nodes MAY use the TRANSMIT_OPTION_AUTO_ROUTE to enable routing via Last Working Routes, calculated routes and routes discovered via dynamic route resolution.

Routing Slave and Enhanced 232 Slave nodes MAY use the TRANSMIT_OPTION_AUTO_ROUTE to enable routing via return routes for the actual destination nodeID (if any exist).

If the `nodeID` parameter specifies the broadcast `nodeID` (0xFF), the Z-Wave protocol layer ignores the transmit option `TRANSMIT_OPTION_AUTO_ROUTE`.

4.3.3.1.4.4 `TRANSMIT_OPTION_EXPLORE`

The transmit option `TRANSMIT_OPTION_EXPLORE` MAY be used to enable dynamic route resolution. Dynamic route resolution allows a node to discover new routes if all known routes are failing. An explorer frame cannot wake up FLiRS nodes.

An explorer frame uses normal RF power level minus 6dB. This is also the power level used by a node finding its neighbors.

The API function `ZW_SetRoutingMAX` MAY be used to specify the maximum number of routing attempts based on routing table lookups to use before the Z-Wave protocol layer resorts to dynamic route resolution.

A default value of five routing attempts SHOULD be used.

For backwards compatibility reasons, transmissions to nodes which do not support dynamic route resolution will ignore the transmit option flag `TRANSMIT_OPTION_EXPLORE`.

4.3.3.1.4.5 `TRANSMIT_OPTION_LOW_POWER`

The `TRANSMIT_OPTION_LOW_POWER` option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases, this option SHOULD NOT be used.

4.3.3.1.4.6 `completedFunc`

The **`completedFunc`** parameter MUST specify the calling address of a function that can be called when the `SendData` frame transmission completes. Completion includes a range of possible situations:

- Direct range frame was successfully transmitted (as requested) without acknowledgement
- Direct range frame was successfully acknowledged
- Routed frame was successfully acknowledged

The transmit status `txStatus` indicates how the transmission operation was completed.

Table 10. txStatus Values

txStatus	Description
<code>TRANSMIT_COMPLETE_OK</code>	The operation was successful.
<code>TRANSMIT_COMPLETE_NO_ACK</code>	No acknowledgement was received from the destination node.
<code>TRANSMIT_COMPLETE_FAIL</code>	Indicates that the network is busy (jammed).

WARNING: Always use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData or ZW_SendDataMulti in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer there is passed to the transmit queue.

4.3.3.1.5 Payload size

The maximum size of a frame is 64 bytes. The protocol header and checksum takes 10 bytes in a single cast or broadcast frame leaving 54 bytes for the payload. A S0 security enabled single cast takes 20 bytes as overhead. The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used.

Table 11. Maximum Payload Size

Transmit option	Maximum dataLength	
	Non-secure	Secure
Notice: Always use lowest maximum dataLength depending on options used.		
TRANSMIT_OPTION_EXPLORE	46 bytes	26 bytes
TRANSMIT_OPTION_AUTO_ROUTE	48 bytes	28 bytes
TRANSMIT_OPTION_NO_ROUTE	54 bytes	34 bytes

4.3.3.1.6 Embedded API function prototypes

Defined in: ZW_transport_api.h

Return value:

BYTE FALSE If transmits queue overflow

Parameters:

nodeID IN Destination node ID (NODE_BROADCAST == all nodes) The frame will also be transmitted in case the source node ID is equal destination node ID

pData IN Data buffer pointer

dataLength IN Data buffer length The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. For details, see section 3.4. The payload must be minimum one byte.

txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_NO_ROUTE	Only send this frame directly, even if a response route exist
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.
	TRANSMIT_OPTION_AUTO_ROUTE	<p><u>Controllers:</u> Request retransmission via repeater nodes (at normal output power level). Number of max routes can be set using ZW_SetRoutingMax</p> <p><u>Routing and Enhanced 232 Slaves:</u> Send the frame to nodeID using the return routes assigned for nodeID to the routing/enhanced 232 slave, if no routes are valid then transmit directly to nodeID (if nodeID = NODE_BROADCAST then the frame will be a BROADCAST). If return routes exists and the nodeID = NODE_BROADCAST then the frame will be transmitted to all assigned return route destinations. If nodeID != NODE_BROADCAST then the frame will be transmitted via the assigned return routes for nodeID.</p>
	TRANSMIT_OPTION_EXPLORE	Transmit frame as an explore frame if everything else fails.
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus	Transmit completion status:	
	TRANSMIT_COMPLETE_OK	Successfully
	TRANSMIT_COMPLETE_NO_ACK	No acknowledge is received before timeout from the destination node. Acknowledge is discarded in case it is received after the timeout.
	TRANSMIT_COMPLETE_FAIL	Not possible to transmit data because the Z-Wave network is busy (jammed).
txStatusReport	typedef struct _TX_STATUS_TYPE_	
	{ WORD wTransmitTicks;	Passed 10ms ticks
	BYTE bRepeaters;	Repeaters in route
	struct rssi_dBm rssi_values;	Rssi value for each hop (see Table 7).
	BYTE bACKChannelNo;	Channel ack was received on
	BYTE bLastTxChannelNo;	Channel frame was send on
	E_ROUTING_SCHEME bRouteSchemeState;	The last used routing scheme
	BYTE pLastUsedRoute[LAST_USED_ROUTE_SIZE];	Last used route (5 byte array)
	BYTE bRouteTries;	Routing attempts
	S_ROUTE_LINK bLastFailedLink;	Last route that failed
	} TX_STATUS_TYPE;	

Timeout: 65s. This is a worst case scenario that happens very seldom. The ZW_SendData call typically returns a callback.

Exception recovery: If a timeout occurs, it is important to call ZW_SendDataAbort to stop the sending of the frame.

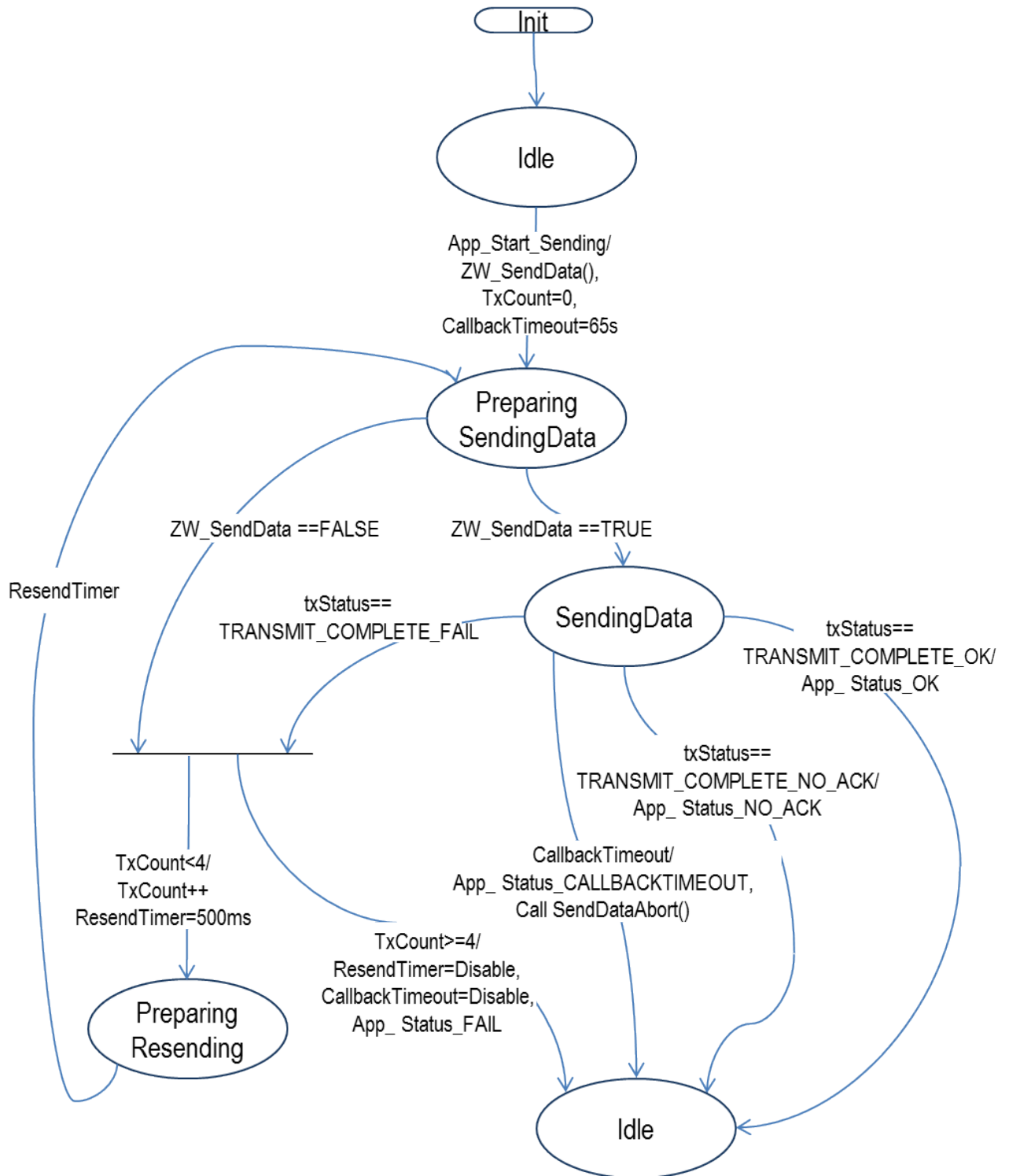


Figure 9. Application State Machine for ZW_SendData

Table 12. ZW_SendData : State/Event Processing

Idle	<p>Waiting for events</p> <p>Event: (Init) => // Initialize timers, etc.</p> <p>Event: App_Start_Sending => // Higher layer application event calls for data to be sent New state: <PreparingSendingData> Actions: Call ZW_SendData() Reset retransmission counter TxCount=0 Set CallbackTimeout=65s</p>
PreparingSendingData	<p>Waiting for events</p> <p>Event: ZW_SendData()==FALSE => // Transmitter queue is full. Transmission is not attempted New state: <PreparingResending> Actions: IF (TxCount<4) THEN Increment TxCount retransmission counter Preset retransmission delay timer ResendTimer to 500ms ELSE Disable retransmission delay timer ResendTimer Disable callback timeout timer CallbackTimeout Generate App_Status_FAIL event for application ENDIF // App_Status_FAIL SHOULD cause application to report to user that // that transmission was not possible, RF media may be jammed</p> <p>Event: ZW_SendData()==TRUE => // Transmitter is starting; await callback events New state: <SendingData> Actions: (none)</p>
SendingData	<p>Waiting for events</p> <p>Event: txStatus==TRANSMIT_COMPLETE_OK => // Callback New state: <Idle> Actions: Generate App_Status_OK event for application</p> <p>Event: txStatus==TRANSMIT_COMPLETE_NO_ACK => // Callback New state: <Idle> Actions: Generate App_Status_NO_ACK event for application // App_Status_NO_ACK SHOULD cause application to report to user that // that transmission failed, Destination may be unreachable.</p> <p>Event: CALLBACKTIMEOUT => // Timer event // This is an exception that should never happen. New state: <Idle> Actions: Generate App_Status_CALLBACKTIMEOUT event for application Call ZW_SendDataAbort() // Recommended application response is hard reset target via watchdog timeout // The state machine may receive one or more SendDataAbort callback events // after entering the <Idle> state. These events must be ignored.</p>
PreparingResending	<p>Waiting for events</p> <p>Event: ResendTimer => // Timer event New state: <PreparingSendingData> Actions: (none)</p>

4.3.3.1.7 Serial API function prototypes

HOST->ZW: REQ | 0x13 | nodeID | dataLength | pData[] | txOptions | funcID

ZW->HOST: RES | 0x13 | RetVal

If either (funcID == 0) OR (RetVal == FALSE) -> no callback

If (funcID != 0) AND (RetVal == TRUE) then callback returns with:

ZW->HOST: REQ | 0x13 | funcID | txStatus

SerialAPI targets supporting IMA

The Devkit 6.60.00 adds a txStatusReport structure to the ZW_SendData callback parameter and this have been introduced into the IMA supporting SerialAPI targets by extending the number of parameters in the ZW_SendData callback parameter list.

HOST->ZW: REQ | 0x13 | nodeID | dataLength | pData[] | txOptions | funcID

ZW->HOST: RES | 0x13 | RetVal

If either (funcID == 0) OR (RetVal == FALSE) -> no callback

If (funcID != 0) AND (RetVal == TRUE) then callback returns with:

ZW->HOST: REQ | 0x13 | funcID | txStatus | wTransmitTicksMSB | wTransmitTicksLSB | bRepeaters | rssi_values.incoming[0] | rssi_values.incoming[1] | rssi_values.incoming[2] | rssi_values.incoming[3] | rssi_values.incoming[4] | bACKChannelNo | bLastTxChannelNo | bRouteSchemeState | repeater0 | repeater1 | repeater2 | repeater3 | routespeed | bRouteTries | bLastFailedLink.from | bLastFailedLink.to

The SerialAPI command FUNC_ID_SERIAL_API_SETUP (0x0B) has been added to enable/disable the transmission of the txStatusReport structure to HOST on ZW_SendData callback.

Notice: For IMA enabled targets the transmission of txStatusReport to HOST is ENABLED at module startup. For NON IMA enabled targets the transmission of txStatusReport to HOST is DISABLED at module startup.

HOST->ZW: REQ | 0x0B | 0x02 | bEnable

ZW->HOST: RES | 0x0B | 0x02 | RetVal

bEnable = 1 -> ENABLE txStatusReport transmission to HOST on ZW_SendData callback.

bEnable = 0 -> DISABLE txStatusReport transmission to HOST on ZW_SendData callback.

RetVal = 1 -> Operation executed successfully.

RetVal = 0 -> Operation executed unsuccessfully.

Notice: Serial API version is unchanged despite changed format in ZW-SendData for this particular application.

4.3.3.2 ZW_SendDataEx (only Slave Libraries)

```
ZW_SENDDATA_EX_RETURN_CODES ZW_SendDataEx(BYTE *pData,
      BYTE dataLength,
      TRANSMIT_OPTIONS_TYPE * pTxOptionsEx,
      VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus,
      TX_STATUS_TYPE* txStatusReport ))
```

NOTE: Only supported by the Enhanced 232 and Routing Slave libraries. All Controller libraries based applications must use ZW_SendData.

NOTE: Broadcast are only allowed unsecure.

This function MAY be used to transmit either unsecure or secure (S0, S2) contents of specified data buffer to a single node or all nodes (broadcast). The data buffer is optionally security encapsulated and then encapsulated in a Z-Wave transport frame by adding a protocol header and a checksum trailer. The frame is appended to the end of the transmit queue (first in; first out) and transmitted whenever possible.

The protocol layer automatically handles the necessary signaling when the ZW_SendDataEx function is used to initiate a transmission to a FIIRS node.

The following parameters MUST be specified for the SendDataEx function.

4.3.3.2.1 *pData parameter

The *pData parameter MUST specify a pointer to a data buffer containing a valid Z-Wave command. The data buffer referenced by the *pData parameter MUST contain the number of bytes indicated by the dataLength parameter.

4.3.3.2.2 dataLength parameter

The data buffer referenced by the *pData parameter is used to hold a valid Z-Wave command. The dataLength parameter MUST specify the length of the Z-Wave command.

4.3.3.2.3 pTxOptionsEx parameter

The calling application MUST fill the application **TRANSMIT_OPTIONS_TYPE** structure the pTxOptionsEx parameter refers to by setting relevant **TRANSMIT_OPTIONS_TYPE** members:

4.3.3.2.3.1 destNode

Destination node for the specified payload data.

4.3.3.2.3.2 bSrcNode

Reserved for future use.

4.3.3.2.3.3 txOptions

See ZW_Senddata txOptions parameter description (4.3.3.1.4)

4.3.3.2.3.4 txSecOptions

Options for enabling specific Security S2 functionality.

4.3.3.2.3.5 securityKey

Security key to use for sending.

4.3.3.2.3.6 txOptions2

Reserved for future use.

4.3.3.2.4 completedFunc

The **completedFunc** parameter MUST specify the calling address of a function that can be called when the SendData frame transmission completes. Completion includes a range of possible situations:

- Direct range frame was successfully transmitted (as requested) without acknowledgement
- Direct range frame was successfully acknowledged
- Routed frame was successfully acknowledged

The transmit status txStatus indicates how the transmission operation was completed.

Table 13. txStatus values

txStatus	Description
TRANSMIT_COMPLETE_OK	The operation was successful.
TRANSMIT_COMPLETE_NO_ACK	No acknowledgement was received from the destination node.
TRANSMIT_COMPLETE_FAIL	Indicates that the network is busy (jammed).

WARNING: Always use the completeFunc callback to determine when the next frame can be send.

4.3.3.2.5 Payload size

The maximum size of a frame is 64 bytes. The protocol header and checksum takes 10 bytes in a single cast or broadcast frame leaving 54 bytes for the payload. A S0 security enabled single cast takes 20 bytes as overhead. The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used.

Table 14. Maximum payload size

Transmit option	Maximum dataLength		
	Non-secure	Security S0	Security2
TRANSMIT_OPTION_EXPLORE	46 bytes	26 bytes	46 bytes
TRANSMIT_OPTION_AUTO_ROUTE	48 bytes	28 bytes	46 bytes
TRANSMIT_OPTION_NO_ROUTE	54 bytes	34 bytes	46 bytes

4.3.3.2.6 Embedded API function prototypes

Defined in: ZW_transport_api.h

Return value:

ZW_SENDDATA_ EX_RETURN_ CODES	ZW_TX_FAILED	If not queued in transmit queue. No callback will be done.
	ZW_TX_IN_PROGRESS	If frame is queued for transmission.

Parameters:

txOptionsEx .destNode IN	Destination node ID (NODE_BROADCAST == all nodes)	The frame will also be transmitted in case the source node ID is equal destination node ID
pData IN	Data buffer pointer	
dataLength IN	Data buffer length	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. For details, see section 3.4. The payload must be minimum one byte.

txOptionsEx .txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_NO_ROUTE	Only send this frame directly, even if a response route exist
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.
	TRANSMIT_OPTION_AUTO_ROUTE	Send the frame to nodeID using the return routes assigned for nodeID to the enhanced 232 slave, if no routes are valid then transmit directly to nodeID (if nodeID = NODE_BROADCAST then the frame will be a BROADCAST). If return routes exists and the nodeID = NODE_BROADCAST then the frame will be transmitted to all assigned return route destinations. If nodeID != NODE_BROADCAST then the frame will be transmitted via the assigned return routes for nodeID.
	TRANSMIT_OPTION_EXPLORE	Transmit frame as an explore frame if everything else fails.
txOptionsEx .bSrcNode IN	Reserved for future use.	
txOptionsEx .txSecOptions IN	Security2-specific options	
	S2_TXOPTION_VERIFY_DELIVERY	This flag will activate frame delivery verification. In this transmission mode ZW_SendDataEx will try to verify that the receiver understood the message sent. This is done by waiting a little to see if the node will respond nonce report to the encrypted message. If the node does respond with a nonce report then the option will automatically cause the system to re-sync the node, and deliver the message. The TRANSMIT_COMPLETE_VERIFIED (0x05) is returned if it could be determined that a successful (Ack received) transmitted S2 encrypted message has been successfully decrypted by destination. The way this can be determined is by the destination returning a decryptable S2 encrypted answer message. A normal

		TRANSMIT_COMPLETE is returned as callback status if message was transmitted successfully (Ack) but no decryptable S2 encrypted message is returned inside timeout (~250ms).
		An example where this can be seen is in the SUPERVISION COMMAND CLASS
	S2_TXOPTION_SINGLECAST_FOLLOWUP	This flag must be present on all single cast followup messages to a multicast.
	S2_TXOPTION_FIRST_SINGLECAST_FOLLOWUP	This flag must be present on the first, and only the first singlecast followup message in a multicast transmission.
txOptionsEx .securityKey IN	Select security key for transmission	
	SECURITY_KEY_NONE	Nonsecure transmission
	SECURITY_KEY_S2_UNAUTHENTICATED	Use S2 Unauthenticated key
	SECURITY_KEY_S2_AUTHENTICATED	Use S2 Authenticated key
	SECURITY_KEY_S2_ACCESS	Use S2 Access key
	SECURITY_KEY_S0	Use Security Scheme 0 key
txOptionsEx .txOptions2 IN	More transmit option flags. Reserved for future use. Must be set to 0x00.	
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus	Transmit completion status:	
	TRANSMIT_COMPLETE_OK	Successfully
	TRANSMIT_COMPLETE_NO_ACK	No acknowledge is received before timeout from the destination node. Acknowledge is discarded in case it is received after the timeout.
	TRANSMIT_COMPLETE_FAIL	Not possible to transmit data because the Z-Wave network is busy (jammed).
	TRANSMIT_COMPLETE_VERIFIED	A S2 encrypted message has been successfully decrypted by destination.
txStatusReport	typedef struct _TX_STATUS_TYPE_	
	{ WORD wTransmitTicks;	Passed 10ms ticks
	BYTE bRepeaters;	Repeaters in route
	struct rssi_dBm rssi_values;	Rssi value for each hop (see Table 7).
	BYTE bACKChannelNo;	Channel ack was received on
	BYTE bLastTxChannelNo;	Channel frame was send on
	E_ROUTING_SCHEME bRouteSchemeState;	The last used routing scheme
	BYTE pLastUsedRoute[LAST_USED_ROUTE_SIZE];	Last used route (5 byte array)
	BYTE bRouteTries;	Routing attempts
	S_ROUTE_LINK bLastFailedLink;	Last route that failed
	} TX_STATUS_TYPE;	

4.3.3.2.7 Serial API function prototypes

HOST->ZW: REQ | 0x0E | nodeID | dataLength | pData[] | txOptions | txSecOptions | securityKey | txOptions2 | funcID

ZW->HOST: RES | 0x0E | RetVal

If either (funcID == 0) OR (RetVal == FALSE) -> no callback

If (funcID != 0) AND (RetVal == TRUE) then callback returns with:

ZW->HOST: REQ | 0x0E | funcID | txStatus | wTransmitTicksMSB | wTransmitTicksLSB | bRepeaters | rssi_values.incoming[0] | rssi_values.incoming[1] | rssi_values.incoming[2] | rssi_values.incoming[3] | rssi_values.incoming[4] | bACKChannelNo | bLastTxChannelNo | bRouteSchemeState | repeater0 | repeater1 | repeater2 | repeater3 | routespeed | bRouteTries | bLastFailedLink.from | bLastFailedLink.to

4.3.3.3 ZW_SendData_Bridge

```

BYTE ZW_SendData_Bridge( BYTE srcNodeID,
                        BYTE destNodeID,
                        BYTE *pData,
                        BYTE dataLength,
                        BYTE txOptions,
                        Void (*completedFunc)(BYTE txStatus,
                                             TX_STATUS_TYPE* txStatusReport))

```

NOTE: Only supported by the Bridge Controller library. For backward compatibility macros for the Bridge Controller library has been made for `ZW_SendData(node,data,length,options,func)` and `ZW_SEND_DATA(node,data,length,options,func)`

Macro: `ZW_SEND_DATA_BRIDGE(srcnodeid, destnodeid, data, length, options, func)`

Transmit the data buffer to a single Z-Wave Node or all Z-Wave Nodes (broadcast). The data buffer is queued to the end of the transmit queue (first in; first out) and when ready for transmission the Z-Wave protocol layer frames the data with a protocol header in front and a checksum at the end.

The transmit option `TRANSMIT_OPTION_ACK` requests the destination node to return a transfer acknowledge to ensure proper transmission. The transmitting node will retry the transmission if no acknowledge received. The Controller nodes can add the `TRANSMIT_OPTION_AUTO_ROUTE` flag to the transmit option parameter. The Controller will then try transmitting the frame via repeater nodes if the direct transmission failed.

The transmit option `TRANSMIT_OPTION_NO_ROUTE` force the protocol to send the frame without routing, even if a response route exist.

To enable dynamic route resolution a new transmit option `TRANSMIT_OPTION_EXPLORE` must be appended to the well known send API calls. This instruct the protocol to transmit the frame as an explore frame to the destination node if source routing fails. An explore frame uses normal RF power level minus 6dB similar to a node finding neighbors. It is also possible to specify the maximum number of source routing attempts before the explorer frame kicks in using the API call `ZW_SetRoutingMAX`. Default value is five with respect to maximum number of source routing attempts. When communicating with nodes, which do not support dynamic route resolution the transmit option flag `TRANSMIT_OPTION_EXPLORE` is ignored. Notice that an explorer frame cannot wake up FLiRS nodes.

The **completedFunc** is called when the frame transmission completes, that is when transmitted if ACK is not requested; when acknowledge received from the destination node, or when routed acknowledge completed if the frame was transmitted via one or more repeater nodes. The transmit status `TRANSMIT_COMPLETE_NO_ACK` indicate that no acknowledge is received from the destination node. The transmit status `TRANSMIT_COMPLETE_FAIL` indicate that the Z-Wave network is busy (jammed).

The `TRANSMIT_OPTION_LOW_POWER` option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases this option should **not** be used.

NOTE: Always use the `completeFunc` callback to determine when the transmit is done. The `completeFunc` should flag the application state machine that the transmit has been done and next state/action can be started. A frame transmit should always be started through the application state machine in order to be sure that the transmit buffer is ready for sending next frame. Calling the `ZW_SendData_Bridge` in a loop without using the `completeFunc` callback will overflow the transmit queue and eventually fail. The payload data buffer in the application must not be changed before `completeFunc` callback is received because it is only the pointer that is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE FALSE If transmit queue overflow

Parameters:

srcNodeID IN	Source node ID. Valid values: NODE_BROADCAST = Bridge Controller NodeID. Bridge Controller NodeID. Virtual Slave NodeID (only existing Virtual Slave NodeIDs).	
destNodeID IN	Destination node ID (NODE_BROADCAST == all nodes)	The frame will also be transmitted in case the source node ID is equal destination node ID
pData IN	Data buffer pointer	
dataLength IN	Data buffer length	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. The payload must be minimum one byte.
txOptions IN	Transmit option flags: TRANSMIT_OPTION_LOW_POWER TRANSMIT_OPTION_NO_ROUTE TRANSMIT_OPTION_EXPLORE TRANSMIT_OPTION_ACK TRANSMIT_OPTION_AUTO_ROUTE	Transmit at low output power level (1/3 of normal RF range). Only send this frame directly, even if a response route exist Transmit frame as an Explore frame if all else fails Request acknowledge from destination node. Request retransmission via repeater nodes (at normal output power level).
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus	Transmit completion status:	
	TRANSMIT_COMPLETE_OK	Successfully
	TRANSMIT_COMPLETE_NO_ACK	No acknowledge is received before timeout from the destination node. Acknowledge is discarded in case it is received after the timeout.
	TRANSMIT_COMPLETE_FAIL	Not possible to transmit data because the Z-Wave network is busy (jammed).
txStatusReport	See ZW_SendData	

Serial API:

HOST->ZW: REQ | 0xA9 | srcNodeID | destNodeID | dataLength | pData[] | txOptions | pRoute[4] | funcID

Devkit 6.x+ -> pRoute[4] not used – use pRoute[4] = {0, 0, 0, 0}

ZW->HOST: RES | 0xA9 | RetVal

ZW->HOST: REQ | 0xA9 | funcID | txStatus
 | wTransmitTicksMSB | wTransmitTicksLSB
 | bRepeaters
 | rssi_values.incoming[0] | rssi_values.incoming[1] | rssi_values.incoming[2]
 | rssi_values.incoming[3] | rssi_values.incoming[4]
 | bAckChannelNo | | bLastTxChannelNo
 | bRouteSchemeState
 | repeater0 | repeater1 | repeater2 | repeater3 | routespeed | bRouteTries
 | bLastFailedLink.from | bLastFailedLink.to

4.3.3.4 ZW_SendDataMulti

```
BYTE ZW_SendDataMulti(BYTE *pNodeIDList,  
                      BYTE *pData,  
                      BYTE dataLength,  
                      BYTE txOptions,  
                      Void (*completedFunc)(BYTE txStatus))
```

Macro: ZW_SEND_DATA_MULTI(nodelist,data,length,options,func)

NOTE: This function is not available in the Bridge Controller library (See ZW_SendDataMulti_Bridge).

Transmit the data buffer to a list of Z-Wave Nodes (multicast frame). If the transmit optionflag TRANSMIT_OPTION_ACK is set the data buffer is also sent as a singlecast frame to each of the Z-Wave Nodes in the node list.

The **completedFunc** is called when the frame transmission completes in the case that ACK is not requested; When TRANSMIT_OPTION_ACK is requested the callback function is called when all single casts have been transmitted and acknowledged.

The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed). The data pointed to by pNodeIDList should not be changed before the callback is called.

NOTE: Always use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData or ZW_SendDataMulti in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer there is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE FALSE If transmit queue overflow

Parameters:

pNodeIDList IN	List of destination node ID's	This is a fixed length bit-mask.
Pdata IN	Data buffer pointer	
DataLength IN	Data buffer length	The maximum size of a packet is 64 bytes. The protocol header, multicast addresses and checksum takes 39 bytes in a multicast frame leaving 25 bytes for the payload. The payload must be minimum one byte.
TxOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_EXPLORE	If TRANSMIT_OPTION_ACK is set the will make the node try sending as an Explore frame if all else fails when doing the single cast transmits
	TRANSMIT_OPTION_ACK	The multicast frame will be followed by a number of single cast frames to each of the destination nodes and request acknowledge from each destination node.
	TRANSMIT_OPTION_AUTO_ROUTE (Controller API only)	Request retransmission on single cast frames via repeater nodes (at normal output power level)
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x14 | numberNodes | pNodeIDList[] | dataLength | pData[] | txOptions | funcID

ZW->HOST: RES | 0x14 | RetVal

ZW->HOST: REQ | 0x14 | funcID | txStatus

4.3.3.5 ZW_SendDataMultiEx (only Slave Libraries)

```
ZW_SENDDATA_EX_RETURN_CODES ZW_SendDataMultiEx(BYTE *pData,
          BYTE dataLength,
          TRANSMIT_MULTI_OPTIONS_TYPE *pTxOptionsMultiEx,
          Void (*completedFunc)(BYTE txStatus))
```

NOTE: Only supported by the Enhanced 232 and Routing Slave libraries.

Transmit the data buffer using S2 multicast to a list of Z-Wave Nodes. Only the multicast frame is transmitted, if singlecast frames are needed then application needs to do this using ZW_SendDataEx for every node in the group.

NOTE: Can only be called successfully if node is S2 included and txOptionsEx.securityKey is set to a supported S2 key.

The **completedFunc** is called when the frame transmission completes.

The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed).

NOTE: Always use the completeFunc callback to determine when the next frame can be send. Trying to transmit in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail.

Defined in: ZW_transport_api.h

Return value:

ZW_SENDDATA_EX_RETURN_CODES	ZW_TX_FAILED	If not queued in transmit queue. No callback will be done.
	ZW_TX_IN_PROGRESS	If frame is queued for transmission.

Parameters:

txOptionsMultiEx .groupID IN	Destination groupID	Group which is to receive the S2 Multicast frame
pData IN	Data buffer pointer	
dataLength IN	Data buffer length	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. For details, see section 3.4. The payload must be minimum one byte.
txOptionsMultiEx .txOptions IN	Reserved to future use.	
txOptionsEx .securityKey IN	Select security key for transmission	
	SECURITY_KEY_S2_UNAUTHENTICATED	Use S2 Unauthenticated key
	SECURITY_KEY_S2_AUTHENTICATED	Use S2 Authenticated key
	SECURITY_KEY_S2_ACCESS	Use S2 Access key
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x0F | dataLength | pData[] | txOptions | securityKey | groupID | funcID

ZW->HOST: RES | 0x0F | RetVal

If either (funcID == 0) OR (RetVal == FALSE) -> no callback

If (funcID != 0) AND (RetVal == TRUE) then callback returns with:

ZW->HOST: REQ | 0x0F | funcID | txStatus

4.3.3.6 ZW_SendDataMulti_Bridge

```
BYTE ZW_SendDataMulti_Bridge(BYTE srcNodeID,  
                              BYTE *pNodeIDList,  
                              BYTE *pData,  
                              BYTE dataLength,  
                              BYTE txOptions,  
                              Void (*completedFunc)(BYTE txStatus))
```

Macro: ZW_SEND_DATA_MULTI_BRIDGE(srcnodid,nodelist,data,length,options,func)

NOTE: This function is only available in the Bridge Controller library.

Transmit the data buffer to a list of Z-Wave Nodes (multicast frame). If the transmit optionflag TRANSMIT_OPTION_ACK is set the data buffer is also sent as a singlecast frame to each of the Z-Wave Nodes in the node list.

The **completedFunc** is called when the frame transmission completes in the case that ACK is not requested; When TRANSMIT_OPTION_ACK is requested the callback function is called when all single casts have been transmitted and acknowledged.

The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed). The data pointed to by pNodeIDList should not be changed before the callback is called.

NOTE: Always use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData_Bridge or ZW_SendDataMulti_Bridge in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it's only the pointer there is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE FALSE If transmit queue overflow

Parameters:

srcNodeID IN	Source node ID. Valid values: NODE_BROADCAST = Bridge Controller NodeID. Bridge Controller NodeID. Virtual Slave NodeID (only existing Virtual Slave NodeIDs).	
pNodeIDList IN	List of destination node ID's	This is a fixed length bit-mask.
Pdata IN	Data buffer pointer	
DataLength IN	Data buffer length	The maximum size of a packet is 64 bytes. The protocol header, multicast addresses and checksum takes 39 bytes in a multicast frame leaving 25 bytes for the payload. In case routed single casts follow multicast the source routing info takes up to 6 bytes depending on the number of hops leaving minimum 19 bytes for the payload. In case it is a singlecast, which piggyback on an explorer frame overhead is 8 bytes leaving minimum 17 bytes for the payload. The payload must be minimum one byte.
TxOptions IN	Transmit option flags: TRANSMIT_OPTION_LOW_POWER TRANSMIT_OPTION_EXPLORE TRANSMIT_OPTION_ACK TRANSMIT_OPTION_AUTO_ROUTE	Transmit at low output power level (1/3 of normal RF range). If TRANSMIT_OPTION_ACK is set the will make the node try sending as an Explore frame if all else fails when doing the single cast transmits The multicast frame will be followed by a number of single cast frames to each of the destination nodes and request acknowledge from each destination node. Request retransmission on single cast frames via repeater nodes (at normal output power level)
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0xAB | srcNodeID | numberNodes | pNodeIDList[] | dataLength | pData[] | txOptions | funcID

ZW->HOST: RES | 0xAB | RetVal

ZW->HOST: REQ | 0xAB | funcID | txStatus

4.3.3.7 ZW_SendDataAbort

void ZW_SendDataAbort(void)

Macro: ZW_SEND_DATA_ABORT

Abort the ongoing transmit started with **ZW_SendData()** or **ZW_SendDataMulti()**. If an ongoing transmission is aborted, the callback function from the send call will return with the status TRANSMIT_COMPLETE_NO_ACK.

Defined in: ZW_transport_api.h

Serial API:

HOST->ZW: REQ | 0x16

4.3.3.8 ZW_LockRoute (only Controllers)

void ZW_LockRoute(bLockRoute)

Macro: ZW_LOCK_ROUTE

This function locks and unlocks all last working routes (LWR) for purging.

Defined in: ZW_transport_api.h

Parameters:

bLockRoute IN	Lock and unlocks all LWR	TRUE lock all LWR – no purging allowed. FALSE unlock purging of LWR
---------------	--------------------------	--

Serial API

HOST->ZW: REQ | 0x90 | bLockRoute

4.3.3.9 ZW_LockRoute (only Slaves)

void ZW_LockRoute(node)

Macro: ZW_LOCK_ROUTE

This function locks and unlocks response route for a given node ID.

Defined in: ZW_transport_api.h

Parameters:

node IN	Lock and unlocks response route for a given node ID	node = 1..232 lock response route for the specified node ID. node = 0 unlock response route.
---------	---	---

Serial API

HOST->ZW: REQ | 0x90 | node

4.3.3.10 ZW_SendConst

void ZW_SendConst(BYTE bStart, BYTE bChNo, BYTE bSignalType)

This function start/stop generating RF test signal.
The test signal can be on of the following:

- Test signal with only the carrier frequency.
- Test signal with a modulated carrier frequency; the signal will switch between sending logical 1 frequency and logical zero frequency

The function also selects which channel to send the test signal on.

This API call can only be called in production test mode from **ApplicationTestPoll**.

The API should only be called when starting\stopping a test.

Defined in: ZW_transport_api.h

Parameters:

bStart IN	Start/Stop generating RF test signal	TRUE start sending RF test signal. FALSE stop sending RF test signal
bChNot IN	The number of channel to send the test signal on.	0..1 for 2 channels targets 0..2 for 3 channels targets
bSignalType IN	type of the RF test signal to generater	ZW_RF_TEST_SIGNAL_CARRIER ZW_RF_TEST_SIGNAL_CARRIER_MODULATED

Serial API (Not supported)

4.3.3.11 ZW_SetListenBeforeTalkThreshold

void ZW_SetListenBeforeTalkThreshold(BYTE bChannel, BYTE bThreshold)

This function sets the “Listen Before Talk” threshold that controls at what RSSI level a Z-Wave node will refuse to transmit because of noise. The default threshold value is set to a value corresponding to the RF regulatory requirements for a Z-Wave module in the specific country. The appropriate value range goes from 34(dec) to 78(dec) and each threshold step corresponds to a 1.5dB input power step.

Region	Default Threshold (dec)	dBm
JP	50	-80
KR	64	-65
EU, US, HK, ANZ, CN, IL, IN, MY & RU	64	-65

For instance, if a SAW filter with an insertion loss of 3dB is inserted between the antenna feed-point and the chip on a JP product, the threshold value should be set to 48(dec) .

NOTICE: In some contries (JP and KR) the value of the LBT threshold is specified in the RF regulatory for the country and must be set to the value corresponding to the regulatory requirements.

Parameters:

bChannel IN Channel number the Threshold should be set for. Valid channel numbers are 0,1 and 2

bThreshold IN The threshold the RSSI should use. Valid threshold range is from 34(dec) to 78(dec).

Defined in: ZW_transport_api.h

Serial API

HOST->ZW: REQ | 0x3C | bChannel | bThreshold
 ZW->HOST: RES | 0x3C | TRUE

4.3.3.12 ZW_Transport_CommandClassVersionGet

BYTE ZW_CommandClassVersionGet(BYTE commandClass)

This function is used to determine the version of the Command Classes handled by the Z-Wave protocol. SHOULD be used as a default case when receiving VERSION GET for Command Class not supported by Application.

Defined in: ZW_transport_api.h

Return value:

BYTE	1..	Command Class Version of the Z-Wave protocol handled commandClass.
	UNKNOWN_VERSION	Specified Command Class not handled by the Z-Wave protocol.

Parameters:

commandClass IN	BYTE	Command Class ID for whom Version is needed.
-----------------	------	--

Serial API (Not supported)

4.3.3.13 ZW_GetDefaultPowerLevels

BYTE ZW_GetDefaultPowerLevels(BYTE *pPowerLevels)

This API call is reserved for serial API binaries delivered by Silicon Labs.

Defined in: ZW_basis_api.h

Serial API (Not supported, see SERIAL_API_SETUP_CMD_TX_POWERLEVEL_GET in [2])

4.3.3.14 ZW_SetDefaultPowerLevels

**BYTE ZW_SetDefaultPowerLevels(BYTE bNormalPower0, BYTE bNormalPower1,
BYTE bNormalPower2, BYTE bLowPower0,
BYTE bLowPower1, BYTE bLowPower2)**

This API call is reserved for serial API binaries delivered by Silicon Labs.

Defined in: ZW_basis_api.h

Serial API (Not supported, see SERIAL_API_SETUP_CMD_TX_POWERLEVEL_SET in [2])

4.3.4 ZWave Firmware Update API

The Firmware Update API provides functionality which together with the SDK supplied ZW_Bootloader module and a big enough external NVM makes it possible to implement firmware update. Currently the external NVM needs to be minimum 1Mbit(128KB) in size to allow for Firmware Updates, but this minimum requirement indicates that the firmware image must have a maximum size for it to be possible to fit in the 1 Mbit NVM together with protocol and application NVM data. The Max firmware using 1Mbit NVM introduces effectively a maximum on the possible usage of BANK3: $0x20000 - 0x7800 - (3 * 0x8000) = 0x2000$, which equals 8KB. If a NVM bigger or equal to 2Mbit a full 128KB firmware image can be updated.

NOTE: The Application MUST call ZW_FirmwareUpdate_NVM_Init prior to calling any other Firmware Update module functionality. If ZW_FirmwareUpdate_NVM_Init returns FALSE it means Firmware Update is NOT possible with attached NVM.

Serial API: The Firmware Update API is also supported by the serial API enabling firmware update via Serial API also called Over The Wire (OTW) firmware update. This is an alternative to program the chip in programming mode [3] via SPI, UART or USB. However, OTW requires a target containing a boot loader and serial API support. The PC Controller supports OTW firmware update via the serial API, refer to [20] for details.

The Firmware Update functionality contains several functions and are all controlled through the FUNC_ID_ZW_FIRMWARE_UPDATE_NVM serialAPI funcID:

HOST->ZW: REQ | 0x78 | FIRMWARE_UPDATE_NVM_functionality | functionalityParameters[]

Defined FIRMWARE_UPDATE_NVM_functionality:

```
FIRMWARE_UPDATE_NVM_INIT = 0
FIRMWARE_UPDATE_NVM_SET_NEW_IMAGE = 1
FIRMWARE_UPDATE_NVM_GET_NEW_IMAGE = 2
FIRMWARE_UPDATE_NVM_UPDATE_CRC16 = 3
FIRMWARE_UPDATE_NVM_IS_VALID_CRC16 = 4
FIRMWARE_UPDATE_NVM_WRITE = 5
```

4.3.4.1 ZW_FirmwareUpdate_NVM_Init

BYTE ZW_FirmwareUpdate_NVM_Init()

Initialize the Firmware Update functionality. The initialization includes determining if attached NVM can be used for Firmware Update. If it is determined the the attached NVM do not support (or if ZW_Firmware_Update_NVM_Init has not been called) following calls to any other FirmwareUpdate_NVM_xyz functionality will do nothing.

defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	NVM_FIRMWARE_UPDATE_SUPPORTED	If NVM is Firmware Update compatible.
	NVM_FIRMWARE_UPDATE_NOT_SUPPORTED	If NVM is NOT Firmware Update compatible

Serial API

HOST->ZW: REQ | 0x78 | 0x00
ZW->HOST: RES | 0x78 | 0x00 | retVal

4.3.4.2 ZW_FirmwareUpdate_NVM_Set_NEWIMAGE

BYTE ZW_FirmwareUpdate_NVM_Set_NEWIMAGE(BYTE bValue)

Set the NEWIMAGE marker in NVM. Used to signal to ZW_Bootloader if a new Firmware Image are present in NVM or not.

NOTE: The Application MUST call ZW_FirmwareUpdate_NVM_Init prior to calling any other Firmware Update module functionality. If ZW_FirmwareUpdate_NVM_Init returns FALSE it means Firmware Update is NOT possible with attached NVM.

Return value:

BYTE	TRUE	If specified bValue has been written to NVM
	FALSE	If the Firmware NEWIMAGE value is already set to bValue

Defined in: ZW_firmware_update_nvm_api.h

Parameters:

bValue IN Value to set "NEWIMAGE" mark to in NVM, which ZW_Bootloader uses to determine if a possible new Firmware exist in external NVM.
 FIRMWARE_UPDATE_NVM_NEWIMAGE_NEW informs the Bootloader that a possible NEW firmware image exist in external NVM.
 FIRMWARE_UPDATE_NVM_NEWIMAGE_NOT_NEW informs the ZW_Bootloader that NO NEW firmware image exists in external NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x01 | value
 ZW->HOST: RES | 0x78 | 0x01 | retVal

4.3.4.3 ZW_FirmwareUpdate_NVM_Get_NEWIMAGE

BYTE ZW_FirmwareUpdate_NVM_Get_NEWIMAGE()

Get New Firmware Image available indicator in NVM. The New Firmware Image indicator is used to signal the ZW_Bootloader if a possible new Firmware Image is present in NVM.

NOTE: The Application MUST call ZW_FirmwareUpdate_NVM_Init prior to calling any other Firmware Update module functionality. If ZW_FirmwareUpdate_NVM_Init returns FALSE it means Firmware Update is NOT possible with attached NVM.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	FIRMWARE_UPDATE_NVM_NEWIMAGE_NOT_NEW	If Indicator indicates NO NEW Firmware Image present
	FIRMWARE_UPDATE_NVM_NEWIMAGE_NEW	If Indicator indicates NEW Firmware Image is present in NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x02
ZW->HOST: RES | 0x78 | 0x02 | retVal

4.3.4.4 ZW_FirmwareUpdate_NVM_UpdateCRC16

**WORD ZW_FirmwareUpdate_NVM_UpdateCRC16(WORD crc,
DWORD nvmOffset,
WORD blockSize)**

Calculate CRC16 for specified NVM block of data.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

WORD	0x0000-0xFFFF	Resulting CRC16 value after CRC16 calculation on specified block of data in external NVM
------	---------------	--

Parameters:

crc IN	Seed CRC16 value to start CRC16 calculation with
nvmOffset IN	Offset into NVM (full address space) where block of data are placed
blockSize IN	Size of block of data in NVM to calculate CRC16 on

Serial API

HOST->ZW: REQ | 0x78 | 0x03 | offset3byte(MSB) | offset3byte | offset2byte(LSB) | length2byte(MSB) | length2byte(LSB) | seedCRC16_high | seedCRC16_low
 ZW->HOST: RES | 0x78 | 0x03 | resCRC16_high | resCRC16_low

4.3.4.5 ZW_FirmwareUpdate_NVM_isValidCRC16

BYTE ZW_FirmwareUpdate_NVM_isValidCRC16(WORD *presCRC16)

Check if Firmware present in NVM is valid using Firmware Descriptor information regarding BANK sizes and the corresponding firmware CRC16 calculated and placed in the Firmware Descriptor structure at compile/link time (fixbootcrc tool). Uses variables initialized by ZW_FirmwareUpdate_NVM_Init to determine where in NVM to find the stored firmware, if present. On return the resulting CRC16 is placed in the WORD which presCRC16 points at.

NOTE: The Application MUST call ZW_FirmwareUpdate_NVM_Init prior to calling any other Firmware Update module functionality. If ZW_FirmwareUpdate_NVM_Init returns FALSE it means Firmware Update is NOT possible with attached NVM.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	TRUE	If NVM contains a valid ZW_Bootloader upgradable Firmware
	FALSE	If NVM do NOT contain a valid ZW_Bootloader upgradable Firmware

Parameters:

*resCRC16	ZERO	if NVM contains a valid ZW_Bootloader Firmware
OUT	0x0001-0xFFFF	if NVM do not contain a valid ZW_Bootloader Firmware

Serial API

HOST->ZW: REQ | 0x78 | 0x04

ZW->HOST: RES | 0x78 | 0x04 | retVal | resCRC16_high | resCRC16_low

4.3.4.6 ZW_FirmwareUpdate_NVM_Write

BYTE ZW_FirmwareUpdate_NVM_Write(**BYTE *sourceBuffer,**
WORD fw_bufsize,
DWORD firmwareOffset)

Write Firmware.Image block to NVM if applicable.

Uses variables initialized by the ZW_FirmwareUpdate_NVM_Init together with the specified firmware offset (where the sourceBuffer belongs) to determine if and where in the external NVM space the sourceBuffer should be written, so that the Bootloader can later do the actual Firmware Update if update was successful.

NOTE: The Application **MUST** call ZW_FirmwareUpdate_NVM_Init prior to calling any other Firmware Update module functionality. If ZW_FirmwareUpdate_NVM_Init returns FALSE it means Firmware Update is **NOT** possible with attached NVM.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	TRUE	If specified sourceBuffer has been written to NVM
	FALSE	If the sourceBuffer contents already are present at specified firmware offset in NVM

Parameters:

sourceBuffer IN	Buffer containing data to write to NVM
fw_bufsize IN	Size of block to write the NVM
firmwareOffset IN	Offset in firmware where sourceBuffer should be written in NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x05 | offset3byte(MSB) | offset3byte | offset2byte(LSB) | length2byte(MSB) | length2byte(LSB) | buffer[]
 ZW->HOST: RES | 0x78 | 0x05 | retVal

4.3.5 Z-Wave Node Mask API

The Node Mask API contains a set of functions to manipulate bit masks. This API is not necessary when writing a Z-Wave application, but is provided as an easy way to work with node ID lists as bit masks.

4.3.5.1 ZW_NodeMaskSetBit

```
void ZW_NodeMaskSetBit(BYTE_P pMask,  
                       BYTE bNodeID)
```

Macro: ZW_NODE_MASK_SET_BIT(pMask, bNodeID)

Set the node bit in a node bit mask.

Defined in: ZW_nodemask_api.h

Parameters:

pMask IN Pointer to node mask

bnodeID IN Node id (1..232) to set in node mask

Serial API (Not supported)

4.3.5.2 ZW_NodeMaskClearBit

```
void ZW_NodeMaskClearBit( BYTE_P pMask,  
                          BYTE bNodeID)
```

Macro: ZW_NODE_MASK_CLEAR_BIT(pMask, bNodeID)

Clear the node bit in a node bit mask.

Defined in: ZW_nodemask_api.h

Parameters:

PMask IN Pointer to node mask

bNodeID IN Node ID (1..232) to clear in node mask

Serial API (Not supported)

4.3.5.3 ZW_NodeMaskClear

```
void ZW_NodeMaskClear( BYTE_P pMask,  
                      BYTE bLength)
```

Macro: ZW_NODE_MASK_CLEAR(pMask, bLength)

Clear all bits in a node mask.

Defined in: ZW_nodemask_api.h

Parameters:

pMask IN Pointer to node mask

bLength IN Length of node mask

Serial API (Not supported)

4.3.5.4 ZW_NodeMaskBitsIn

**BYTE ZW_NodeMaskBitsIn(BYTE_P pMask,
BYTE bLength)**

Macro: ZW_NODE_MASK_BITS_IN (pMask, bLength)

Number of bits set in node mask.

Defined in: ZW_nodemask_api.h

Return value:

BYTE Number of bits set in node mask

Parameters:

pMask IN Pointer to node mask

bLength IN Length of node mask

Serial API (Not supported)

4.3.5.5 ZW_NodeMaskNodeIn

**BYTE ZW_NodeMaskNodeIn (BYTE_P pMask,
BYTE bNode)**

Macro: ZW_NODE_MASK_NODE_IN (pMask, bNode)

Check if a node is in a node mask.

Defined in: ZW_nodemask_api.h

Return value:

BYTE	ZERO	If not in node mask
	NONEZERO	If in node mask

Parameters:

pMask IN	Pointer to node mask
bNode IN	Node to clear in node mask

Serial API (Not supported)

4.3.6 IO API

The 500 Series Z-Wave SoC has four ports: P0, P1, P2, and P3. All IO's can be set as either input or output. The initial state of IO's are input mode with the internal pull-up enabled. The IO cells are push/pull cells. When an IO is set as input, a pull-up can be enabled optionally on the input pin of that IO.

The IO's can be used either as a general purpose IO (GPIO) or for some of the IO's, it can be used by one or more of the built-in HW peripherals. The IO's are default set as GPIO's. This means that they are directly controlled by the MCU. If a built-in HW peripheral is enabled it can take over control of the IO, this means the direction of the IO, the pull-up state or the output state. In the case where several HW peripherals that it takes control over can use a particular IO. The control is prioritized, for example pin P0.4 on a SD3502 support the following functions: GPIO, Key scanner Column 4 output and LED0 output module (Listed with lowest priority first). Refer to the relevant Z-Wave module datasheet for a complete overview of IO functions supported.

The state of the IO's must be fixed before the 500 Series Z-Wave SoC is put into powerdown mode and must be enabled after the 500 Series Z-Wave SoC is powered-up. This is done to avoid unwanted glitches on the IO's when the 500 Series Z-Wave SoC is powered up.

4.3.6.1 ZW_IOS_enable

```
void ZW_IOS_enable( BYTE bStatus)
```

This function is used to unlock or lock the state of the GPIO

Defined in: ZW_basis_api.h

Parameters:

bStatus IN	Lock or Unlock the state of the IO pins	TRUE
------------	---	------

The state of the IO pins can now be changed. If the state of a IO pin was changed before the IO's are enabled then the change will be made when the IO's are enabled

FALSE

The state of the IO pins are now locked and any changes made to the state will not be made until the IO's are enable again

Serial API (Not supported)

4.3.6.2 ZW_IOS_set

```
void ZW_IOS_set( BYTE bPort,
                BYTE bDirection,
                BYTE bValue)
```

This function is used to set the state of the GPIO's In **ApplicationInitHW()**.

Defined in: ZW_basis_api.h

Parameters:

bPort IN	0-3	Port number 0 => P0, 1 => P1, 2 => P2, 3 => P3
bDirection IN	bit pattern	Direction. 0b=output, 1b=input. For example, 0xF0=> upper 4 IO's are inputs and the lower 4 IO's are outputs
bValue IN	bit pattern	Output setting / Pull-up state When an IO is set as output the corresponding bit in bValue will determine the output setting: 1b=high 0b=low When an IO is set as input the corresponding bit in bValue will determine the state of the pull-up resistor in the IO cell: 1b=pull-up disabled 0b=pull-up enabled

Serial API (Not supported)

4.3.6.3 ZW_IOS_get

```
void ZW_IOS_get( BYTE *bPort,
                BYTE *bDirection,
                BYTE *bValue)
```

This function is used to read the state of the GPIO's In **ApplicationInitHW()**.

Defined in: ZW_basis_api.h

Parameters:

bPort IN	0-3	Port number 0 => P0, 1 => P1, 2 => P2, 3 => P3
bDirection OUT	bit pattern	Direction. 0b=output, 1b=input. For example, 0xF0=> upper 4 IO's are inputs and the lower 4 IO's are outputs
bValue OUT	bit pattern	Output setting / Pull-up state When an IO is set as output the corresponding bit in bValue will determine the output setting: 1b=high 0b=low When an IO is set as input the corresponding bit in bValue will determine the state of the pull-up resistor in the IO cell: 1b=pull-up disabled 0b=pull-up enabled

Serial API (Not supported)

4.3.7 GPIO Macros

The GPIOs MAY be controlled individually via a set of helper macros. These macros can set a GPIO as input/output, set the state of the output GPIO or read the value of an input GPIO.

The GPIO name MUST be specified as a parameter in all the macros. The format of the pin name is as follow:

P(port number)(IO number)

Therefore, I/O pin 3 in port 1 name will be P13.

WARNING: Be aware of limitations when using GPIO macros in **ApplicationInitHW()**. Refer to the individual GPIO macros for details.

4.3.7.1 PIN_OUT

PIN_OUT(pin)

This macro sets a GPIO as an output IO.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
--------	-----	--

Example:

```
PIN_OUT (P12) ;
```

4.3.7.2 PIN_IN

PIN_IN(pin, pullup)

This macro sets a GPIO as an input and determines whether the internal pullup is enabled or disabled.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
pullup IN	Boolean	Pull-up state. 0b=disabled, 1b=enabled.

Example:

```
PIN_IN(P30, TRUE);
```

4.3.7.3 PIN_LOW

PIN_LOW(pin)

This macro sets the state of an output GPIO to low.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
--------	-----	--

Example:

```
PIN_LOW(P12);
```

4.3.7.4 PIN_HIGH

PIN_HIGH(pin)

This macro sets the state of an output GPIO to HIGH.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
--------	-----	--

Example:

```
PIN_HIGH(P12);
```

4.3.7.5 PIN_TOGGLE

PIN_TOGGLE(pin)

This macro toggle the state of an output GPIO from high to low or low to high.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
--------	-----	--

Example:

```
PIN_TOGGLE (P12) ;
```

4.3.7.6 PIN_GET

PIN_GET(pin)

This macro gets the state of the pin of a GPIO.

WARNING: The API call **ZW_IOS_enable** MUST be called before calling **PIN_GET** in **ApplicationInitHW()**. It is not necessary to call **ZW_IOS_enable** in case **PIN_GET** is not called in **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
--------	-----	--

Return value

BOOL	TRUE	The pin is high
	FALSE	The pin is low

Example:

```
a=PIN_GET(P12);
```

4.3.8 Z-Wave NVM Memory API

The memory application interface handles accesses to the application data area in NVM.

Routing slave nodes use MTP for storing application data. Enhanced 232 slave and all controller nodes use an external NVM for storing application data. The Z-Wave protocol uses the first part of the external NVM for home ID, node ID, routing table etc. The external NVM is accessed via the SPI1 interface and using P2.5 as chip select. Alternative chip select pins, refer to [18].

NVM variables are declared and defined just like any other variables, apart from the needed use of the "far" keyword: However, when declaring NVM variables use the #pragma ORDER at the top of the file to keep the variables in order. When adding a new variable then append it at the end of the defined far variables. Obsoleting a variable remember to keep a dummy far variable to maintain the variables offset.

```
BYTE far EEOFFSET_SENSOR_LEVEL_far; /* Just an example */
```

NVM variables declared like this will be located in a virtual XDATA class called HDATA ranging from address 0x10000 and upwards. The application NVM variables are located at offset 0x16000 (0x13000 for 16K NVM). The NVM variables can only be accessed through the NVM Memory API, and not directly. The way you should access the NVM variables are like this:

```
ZW_MEM_PUT_BYTE((WORD)&EEOFFSET_SENSOR_LEVEL_far, toggleBasicSet); /* An example */
```

The map file from the linker tells you where your variable are located like this:

```
02016006H HDATA BYTE EEOFFSET_SENSOR_LEVEL_far /* An example */
```

where the first two digits means external data. The last 6 digits are the address of the variable, which is offset by 0x10000 from the physical NVM chip address.

The NVM variables will not be initialized at reset or power on. Only the first time the device is started, the pre-initialized variables will be initialized, because we have a sanity check of the contents. Example of a pre-initialized far variable:

```
BYTE far EEOFFSET_SENSOR_LEVEL_far = 0xff; /* Just an example */
```

You can force an initialization of the pre-initialized NVM contents by calling ZW_SetDefault();

NOTE: The MCU halts while the API is writing to flash memory, so care should be taken not to write to

4.3.8.1 MemoryGetID

void MemoryGetID(BYTE *pHomeID, BYTE *pNodeID)

Macro: ZW_MEMORY_GET_ID(homeID, nodeID)

The **MemoryGetID** function copy the Home-ID and Node-ID from the NVM to the specified RAM addresses.

NOTE: A NULL pointer can be given as the pHomeID parameter if the application is only interested in reading the Node ID.

Defined in: ZW_mem_api.h

Parameters:

pHomeID OUT Home-ID pointer

pNodeID OUT Node-ID pointer

Serial API:

HOST->ZW: REQ | 0x20

ZW->HOST: RES | 0x20 | HomeId(4 bytes) | NodeId

4.3.8.2 MemoryGetByte

BYTE MemoryGetByte(WORD offset)

Macro: ZW_MEM_GET_BYTE(offset)

Read one byte from the NVM allocated for the application.

If a write operation is in progress, the write queue will be checked for the actual data.

Defined in: ZW_mem_api.h

Return value:

BYTE Data from the application area of the external NVM

Parameters:

offset IN Address of declared far variable (see section 4.3.8).

Serial API:

HOST->ZW:

REQ
0x21
offset(MSB) offset into host application NVM memory array
offset(LSB)

ZW->HOST:

RES
0x21
retVal data byte read

4.3.8.3 MemoryPutByte

BYTE MemoryPutByte(WORD offset, BYTE data)

Macro: ZW_MEM_PUT_BYTE(offset,data)

Write one byte to the application area of the NVM.

On controllers and enhanced 232 slaves this function is based on external NVM and a long write time (2-5 msec.) must be taken into consideration when implementing the application.

The data to be written to FLASH are not written immediately to the FLASH. Instead it is saved in a RAM buffer and then written when the RF is not active and it is more than 200ms ago the buffer was accessed.

Defined in: ZW_mem_api.h

Return value:

BYTE FALSE If write buffer full.

Parameters:

offset IN Address of declared far variable
(see section 4.3.8).

data IN Data to store

Serial API:

HOST->ZW:

REQ
0x22
offset(MSB) offset into host application NVM memory array
offset(LSB)
data

ZW->HOST:

RES
0x22
retVal retVal=0 ==> error |
retVal=1 ==> OK (NVM no change) |
retVal>=2 ==> OK (NVM data bytes written + 1)

4.3.8.4 MemoryGetBuffer

```
void MemoryGetBuffer( WORD offset,
                     BYTE *buffer,
                     BYTE length )
```

Macro: ZW_MEM_GET_BUFFER(offset,buffer,length)

Read a number of bytes from the NVM allocated for the application.

If a write operation is in progress, the write queue will be checked for the actual data.

Defined in: ZW_mem_api.h

Parameters:

offset IN	Address of declared far variable (see section 4.3.8).
buffer IN	Buffer pointer
length IN	Number of bytes to read

Serial API:

HOST->ZW:

REQ	
0x23	
offset(MSB)	offset into host application NVM memory array
offset(LSB)	
length	desired length of read operation

ZW->HOST:

RES	
0x23	
buffer[]	buffer

4.3.8.5 MemoryPutBuffer

**BYTE MemoryPutBuffer(WORD offset,
 BYTE *buffer,
 WORD length,
 VOID_CALLBACKFUNC(func)(void))**

Macro: ZW_MEM_PUT_BUFFER(offset,buffer,length, func)

Copy a number of bytes from a RAM buffer to the application area of the NVM.

If an area is to be set to zero there is no need to specify a buffer, just specify a NULL pointer.

Defined in: ZW_mem_api.h

Return value:

BYTE FALSE If the buffer put queue is full.

Parameters:

offset IN Address of declared far variable
 (see section 4.3.8).

buffer IN Buffer pointer If NULL all of the area will be set to 0x00

length IN Number of bytes to read

func IN Buffer write completed function pointer

Serial API:

HOST->ZW:

REQ
 0x24
 offset(MSB) offset into host application NVM memory array
 offset(LSB)
 length(MSB) desired length of write operation
 length(LSB)
 buffer[] buffer
 funcID

ZW->HOST:

RES
 0x24
 retVal=0 ==> error |
 retVal=1 ==> OK (NVM no change) |
 retVal>=2 ==> OK (NVM data bytes written + 1)

ZW->HOST:

REQ
 0x24
 funcID

4.3.8.6 ZW_EepromInit

BOOL ZW_EepromInit(BYTE *homeID)

Macro: ZW_EEPROM_INIT(HOMEID)

Initialize the external NVM by writing zeros to the entire NVM. The API then writes the content of homeID if not zero to the home ID address in the external NVM.

This API call can only be called in production test mode from **ApplicationTestPoll**.

NOTE: This function is not implemented in Routing Slave API Library due to lack of external NVM.

Defined in: ZW_mem_api.h

Return value:

BOOL	TRUE	If the external NVM initialized successfully
	FALSE	Initialization failed

Parameters:

homeID IN The home ID to be written to the external NVM.

Serial API (Not supported)

4.3.8.7 ZW_MemoryFlush

void ZW_MemoryFlush(void)

Macro: ZW_MEM_FLUSH()

This call writes data immediately to the application area of the NVM.

The data to be written to FLASH are not written immediately to the FLASH. Instead it is saved in a SRAM buffer and then written when the RF is not active and it is more than 200ms ago the buffer was accessed. This function can be used to write data immediately to FLASH without waiting for the RF to be idle.

NOTE: This function is only implemented in Routing Slave API libraries because they are the only libraries that use a temporary SRAM buffer. The other libraries use an external NVM. Data is written directly to the external NVM.

Defined in: ZW_mem_api.h

4.3.8.8 ZW_NVRGetValue

void NVRGetValue(BYTE bOffset, BYTE bLength, BYTE *pNVRValue)

Macro: None

Read a value from the NVR Flash memory area. The function will check the checksum of the NVR page and if the checksum is correct the function will read the value in NVR. If the checksum is incorrect the default uninitialized value 0xFF will be read from all fields. The valid offset goes from 0x00 to 0xEF and to hide the lock bits from the application it is offset with 0x10 compared to the addresses that can be seen in the Z-Wave programmer when doing a raw read of the NVR.

The offset of a specific value can be found using the NVR_FLASH_STRUCT. An example of reading the NVM Type could be:

```
ZW_NVRGetValue(offsetof(NVR_FLASH_STRUCT, bNVMTType) , 1, &bMyNVMTType);
```

Defined in: ZW_nvr_api.h

Return value:

pNVRValue NVR Value.
OUT
Valid values are 0x00-0xFF where a
values of 0xFF indicates that the field in
the NVR is not valid

Parameters:

bOffset IN Offset of the NVR value as given by the
NVR_FLASH_STRUCT
bLength IN Length of the NVR value that should be
read

Serial API:

HOST->ZW: REQ | 0x28 | offset | length

ZW->HOST: RES | 0x28 | NVRdata[]

4.3.8.9 ZW_NVRCheck

BOOL ZW_NVRCheck()

Macro: None

Check if the NVR Flash page contains a valid CRC field [22].

Defined in: ZW_nvr_api.h

Return value:

BOOL FALSE, NVR Flash contents is not valid

TRUE, NVR Flash contents is valid

Serial API:

Not supported

4.3.8.10 NVM_get_id

void NVM_get_id(NVM_TYPE_T *pNVMid)

Macro: None

Get NVM ID from external NVM. The NVM ID is collected using a NVM “read ID” command, but not all supported NVMs support this command, so the memoryCapacity is set according to the NVM information in the NVR.

NOTE: This function is only available in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

pNVMid OUT NVM ID structure.

pNVMid->manufacturerID

Valid values for manufacturerID:

0x00-0xFE,

NVM_MANUFACTURER_UNKNOWN

pNVMid->memoryType

Valid values for memoryType:

NVM_TYPE_FLASH,

NVM_TYPE_EEPROM (all NVMs not supporting NVM read ID command)

pNVMid->memoryCapacity

Valid values for memoryCapacity:

NVM_SIZE_16KB, NVM_SIZE_32KB,

NVM_SIZE_128KB, NVM_SIZE_256KB,

NVM_SIZE_512KB,

NVM_SIZE_UNKNOWN

Serial API:

HOST->ZW: REQ | 0x29

ZW->HOST: RES | 0x29 | length | NVMid

4.3.8.11 NVM_ext_read_long_byte

BYTE NVM_ext_read_long_byte(DWORD offset)

Macro: None

Read a byte from external NVM at address offset.

NOTE: This function is used when doing OTA, and it is only available in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

BYTE Data read from the external NVM

Parameters:

offset IN Offset where to data is to be read.
Currently only the 3 least significant bytes are used when addressing the NVM

Serial API:

HOST->ZW: REQ | 0x2C | offset3byte(MSB) | offset3byte | offset3byte(LSB)

ZW->HOST: RES | 0x2C | retval

4.3.8.12 NVM_ext_write_long_byte

BYTE NVM_ext_write_long_byte(DWORD offset, BYTE data)

Macro: None

Write a byte to external NVM at address offset.

NOTE: This function is used when doing OTA, and it is only available in libraries that has an external NVM.

WARNING: This function can write in the full NVM address space and is not offset to start at the application area. So care should be taken when using this function to avoid writing in the protocol NVM area.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

BYTE	FALSE	If no write was needed.
	TRUE	If write was done

Parameters:

offset IN Offset where to data is to be written.
 Currently only the 3 least significant
 bytes are used when addressing the
 NVM.

data IN Data to write to external NVM

Serial API:

HOST->ZW: REQ | 0x2D | offset3byte(MSB) | offset3byte | offset3byte(LSB) | data

ZW->HOST: RES | 0x2D | retval

4.3.8.13 NVM_ext_read_long_buffer

```
void NVM_ext_read_long_buffer( DWORD offset,  
                               BYTE *buffer,  
                               WORD length )
```

Macro: None

Read a number of bytes from external NVM starting from address offset.

NOTE: This function is used when doing OTA, and it is only available in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Parameters:

offset IN	Offset from where data is to be read. Currently only the 3 least significant bytes are used when addressing the NVM
buffer OUT	Buffer pointer
length IN	Number of bytes to read

Serial API:

ZW->HOST: REQ | 0x2A | offset3byte(MSB) | offset3byte | offset3byte(LSB) | length(MSB) | length(LSB)

ZW->HOST: RES | 0x2A | buffer[]

4.3.8.14 NVM_ext_write_long_buffer

```
byte NVM_ext_write_long_buffer(DWORD offset,
                               BYTE *buffer,
                               WORD length )
```

Macro: None

Write a number of bytes to external NVM starting from address offset.

NOTE: This function is used when doing OTA, and it is only available in libraries that has an external NVM.

WARNING: This function can write in the full NVM address space and is not offset to start at the application area. So care should be taken when using this function to avoid writing in the protocol NVM area.

Defined in: ZW_firmware_bootloader_defs.h

Return Value:

BYTE	FALSE	If no write was needed.
	TRUE	If write was done

Parameters:

offset IN	Offset where to data is to be written. Currently only the 3 least significant bytes are used when addressing the NVM.
buffer IN	Buffer pointer
length IN	Number of bytes to write

Serial API:

HOST->ZW: REQ | 0x2B | offset3byte(MSB) | offset3byte | offset3byte(LSB) | length(MSB) | length(LSB) | buffer[]

ZW->HOST: RES | 0x2B | retval

4.3.9 Z-Wave Timer API

The Z-Wave Timer API provides a set of functions which MAY be used by an application to control the timing of events. Applications SHOULD use the Z-Wave Timer API functions. The Z-Wave Timer API supports a high number of concurrent software timer instances.

In addition to the software timers, the application MAY use one or two hardware timers provided by the 8051 architecture. Before using a hardware timer, the application designer MUST make sure that the actual hardware timer is not already allocated for use by the Z-Wave protocol library. Refer to section 3.7.

Software timers are based on a “tick-function” every 10 ms. The “tick-function” triggers a global tick counter and a number of active timers. The global tick counter is incremented on each “tick”. Active software timers are decremented on each “tick”. When an active timer value reaches 0, the registered timer function is called. The timer function is called from the Z-Wave main loop (non-interrupt environment).

Software timers provide limited accuracy. They are stopped while changing RF transmission direction and during sleep mode. The global tick counter and software timers will continue from their current state when resuming operation after sleep mode.

Software timers are targeted for a limited time duration. Longer timers may be implemented by the application designer by multiple software timer periods combined with referring to the global tick counter. The global tick counter is stored in the global variable:

WORD tickTime

4.3.9.1 TimerStart

**BYTE TimerStart(VOID_CALLBACKFUNC(func>(),
 BYTE bTimerTicks,
 BYTE bRepeats)**

Macro: ZW_TIMER_START(func, bTimerTicks, bRepeats)

Register a function that is called when the specified time has elapsed. Remember to check if the timer is allocated by testing the return value. The call back function is called "bRepeats" times before the timer is stopped. It's possible to have up to 5 timers running simultaneously.

Defined in: ZW_timer_api.h

Return value:

BYTE Timer handle (timer table index). 0xFF is returned if the timer start operation failed.

The timer handle is used when calling other timer functions such as TimerRestart, etc.

Parameters:

pFunc IN Timeout function address (not NULL).

bTimerTicks IN Timeout value (value * 10 ms).
 Predefined values:

TIMER_ONE_SECOND

bRepeats IN Number of function calls. Maximum value is 253. Predefined values:

TIMER_ONE_TIME

TIMER_FOREVER

Serial API (Not supported)

4.3.9.2 TimerRestart

BYTE TimerRestart(BYTE bTimerHandle)

Macro: ZW_TIMER_RESTART(BYTE bTimerHandle)

Set the specified timer's tick count to the initial value (extend timeout value).

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired or been canceled.

Defined in: ZW_timer_api.h

Return value:

BYTE TRUE Timer restarted

Parameters:

bTimerHandle IN Timer to restart

Serial API (Not supported)

4.3.9.3 TimerCancel

BYTE TimerCancel(BYTE bTimerHandle)

Macro: ZW_TIMER_CANCEL(bTimerHandle)

Stop and unregister the specified timer.

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired.

Defined in: ZW_timer_api.h

Return value:

BYTE TRUE Timer cancelled

Parameters:

bTimerHandle IN Timer number to stop

Serial API (Not supported)

4.3.9.4 ZW_TimerLongStart

bTimerHandle_t

ZW_TimerLongStart(

VOID_CALLBACKFUNC(func)(,

DWORD dwtimerTicks,

BYTE bRepeats);

Register a function that is called when the specified time has elapsed. Remember to check if the timer is allocated by testing the return value. The callback function is called "bRepeats" times before the timer is stopped.

Defined in: ZW_timer_api.h

Return value:

bTimerHandle_t Timer handle (timer table index). 0xFF is returned if the timer start operation failed.

The timer handle is used when calling other timer functions such as TimerLongRestart, etc.

Parameters:

func IN Callback function (not NULL).

dwtimerTicks IN Timeout value in ms (32 bit).

bRepeats IN Number of function calls. Maximum value is 253. Predefined values:

TIMER_ONE_TIME

TIMER_FOREVER

Serial API (Not supported)

4.3.9.5 ZW_TimerLongRestart

BYTE ZW_TimerLongRestart(bTimerHandle_t bTimerHandle)

Set the specified timer's tick count to the initial value (extend timeout value).

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired or been canceled.

Defined in: ZW_timer_api.h

Return value:

BYTE TRUE Timer restarted

Parameters:

bTimerHandle IN Timer to restart

Serial API (Not supported)

4.3.9.6 ZW_TimerLongCancel

BYTE ZW_TimerLongCancel(bTimerHandle_t bTimerHandle)

Stop and unregister the specified timer.

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired.

Defined in: ZW_timer_api.h

Return value:

BYTE TRUE Timer cancelled

Parameters:

bTimerHandle IN Timer number to stop

Serial API (Not supported)

4.3.9.7 ZW_TimerLongGetTimeLeft

DWORD ZW_TimerLongGetTimeLeft(bTimerHandle_t bTimerHandle)

Returns the time left before the timer calls the registered callback function.

Defined in: ZW_timer_api.h

Return value:

DWORD Time left in ms.

Parameters:

bTimerHandle IN Handle to the timer in question.

Serial API (Not supported)

4.3.10 Power Control API

The 500 Series Z-Wave SoC has two types of power down modes: WUT mode and Stop mode.

Stopped mode is the lowest power mode of the SoC where all circuitry is shut down except for a small basic block that keeps the IO states.

WUT mode is identical to Stopped mode except for enabling of a low power ring oscillator that ticks every second or 1/128 second. The WUT timer can wake up the chip after a programmable period of time.

Wake up of the two modes can also be accomplished by an external source (EXT1 pin).

During power down mode is a small part of the RAM powered called Critical Memory.

4.3.10.1 ZW_SetSleepMode

```
BOOL ZW_SetSleepMode( BYTE mode,  
                      BYTE intEnable,  
                      BYTE beamCount )
```

Macro: ZW_SET_SLEEP_MODE(MODE, MASK_INT)

This function MAY be used to set the SoC in a specified power down mode. Battery-operated devices may use this functionality in order to save power when idle.

If the Z-Wave protocol is currently busy, the node may stay awake for some time after the application issues a call to ZW_SetSleepMode(). When the protocol is idle, (stopped RF transmission etc.) the MCU will power down.

The RF transceiver is turned off so nothing can be received while in WUT or Stop mode. The ADC is also disabled when in WUT or Stop mode. The Z-Wave main loop is stopped until the MCU is awake again. Refer to the mode parameter description regarding how the MCU can be wakened up from sleep mode. In STOP and WUT modes interrupt(s) may be masked out so they cannot wake up the chip.

Any external hardware controlled by the application should be turned off before returning from the application poll function. The Z-Wave main loop is stopped until the MCU is wakened. The chip resumes from sleep mode via a reset event. Therefore, all temporary state must be re-established after the sleep mode.

It is RECOMMENDED that applications implementing FLiRS node functionality stays awake for two seconds after receiving a frame; either singlecast or multicast. This allows a transmitting node to send additional frames to the FLiRS node without prepending a beam to each frame. A two second stay-awake period after each received frame allows a FLiRS to quickly initiate secure communication and to transfer long payloads such as security certificates and firmware images.

When the ASIC is in power-down mode the EXT1 pin can get the SoC out of the power-down state by asserting it. This mode of operation can be activated by setting the intEnable parameter in ZW_SetSleepMode to ZW_INT_MASK_EXT1. If the EXT1 pin is asserted when the SoC is in power-down mode, the ASIC will wake up from reset. If we are in FLiRS mode and the EXT1 pin is asserted and the unasserted during beam search then it will not wakeup the SoC. If we are in FLiRS mode and WUT timeout occur and an event on EXT1 happens simultaneously, the Z-Wave protocol will search for a beam, and if no beam is detected, then it will power down again. So to make sure that an event in EXT1 is detected when in FLiRS mode we should ensure that it is asserted longer than the beam search time (2.5ms for 2 channels and 4ms for 3 channels).

Warning: Using EXT1 pin as both an external interrupt source by setting EX1 = 1 and as wake up

source for a FLiRS node requires that the EXT1 Interrupt Service Routine (ISR) can handle wake up events in an appropriate manner.

NOTE: This function is only implemented in Routing Slave, Enhanced 232 Slave and Portable Controller API libraries.

Defined in: ZW_power_api.h

Return values

BOOL	TRUE	The chip will power down when the protocol is ready
	FALSE	The protocol can not power down because a wakeup beam is being received, try again later.

Parameters:

mode IN	Specify the type of power save mode:	
	ZW_STOP_MODE	The whole chip is turned down. The chip can be wakened up again by Hardware reset or by the external interrupt INT1.
	ZW_WUT_MODE	The chip is powered down, and it can only be waked by the timer timeout or by the external interrupt INT1. The timeout interval of the WUT timer is controlled by the API call ZW_SetWutTimeout .
	ZW_WUT_FAST_MODE	This mode has the same functionality as ZW_WUT_MODE, except that the timer resolution is 1/128 s. The maximum timeout value is 2 s.
	ZW_FREQUENTLY_LISTENING_MODE	This mode make the module enter a Frequently Listening mode where the module will wakeup for a few milliseconds every 1000 ms or 250 ms and check for radio transmissions to the module (See 4.3.1.6 for details about selecting wakeup speed). The application will only wakeup if there is incoming RF traffic or if the intEnable or beamCount parameters are used.

intEnable IN	Interrupt enable bit mask. If a bit mask is 1, the corresponding interrupt is enabled and this interrupt will wakeup the chip from power down. Valid bit masks are:	
	ZW_INT_MASK_EXT1	External interrupt 1 (PIN P1_1) is enabled as interrupt source
	0x00	No external Interrupts will wakeup. Useful in WUT mode
beamCount IN	Frequently listening WUT wakeups	
	0x00	No WUT wakeups in Frequently listening mode. Both macro and serial API call use this value when called.
	0x01-0xFF	Number of frequently listening wakeup interval between the module does a normal WUT wakeup. This parameter is only used if mode is set to ZW_FREQUENTLY_LISTENING_MODE.

Serial API

HOST->ZW: REQ | 0x11 | mode | intEnable

4.3.10.2 ZW_SetWutTimeout

void ZW_SetWutTimeout (BYTE wutTimeout)

Macro: ZW_SET_WUT_TIMEOUT(TIME)

ZW_SetWutTimeout is specifically intended to set the WUT timer interval.

The chip resumes from sleep mode via a reset event. Therefore, **ZW_SetWutTimeout** SHOULD be called before every call to **ZW_SetSleepMode** when enabling ZW_WUT_MODE. If not calling **ZW_SetWutTimeout**, a default value of 0 (zero) will be used (corresponding to 1 second).

The timer resolution of the WUT timer is one second. The maximum timeout value is 256 secs.

NOTE: This function is only implemented in Routing Slave, Enhanced 232 Slave and Portable Controller API libraries.

Defined in: ZW_power_api.h

Parameters:

wutTimeout IN	The Wakeup Timer timeout value.	The unit is the second. The resolution is 8 bit. [0..255] => [1 sec .. 256 sec]
---------------	---------------------------------	---

Serial API

HOST->ZW: REQ | 0xB4 | wutTimeout

4.3.11 SPI Interface API

The 500 Series Z-Wave SoC offers up to two SPI interfaces:

SPI0: operate as a SPI master or as a SPI slave

SPI1: operates as a SPI master

The SPI master, SPI1, is reserved by the Z-Wave protocol, if the 500 Series Z-Wave SoC is programmed as one of the following Z-Wave nodes types: Portable Controller, Static Controller, Bridge Controller, or Enhanced 232 Slave.

The state of the IO's used for SCK, MOSI, MISO and SS_N automatically setup by the SPI once it is enabled.

The SS_N input is used as SPI Slave Select for an SPI setup as a slave. If the SPI controller is master and it needs to select the slave(s), this has to be controlled by the application SW and an extra IO pin(s) has to be used for that purpose.

4.3.11.1 Operation

Data to be transmitted is written to a SPI data register, one byte at the time and data received is read from a SPI data register one byte at the time.

A SPI interrupt is set when the SPI interface has transferred a byte on the SPI interface. T

4.3.11.2 ZW_SPI0_init

void ZW_SPI0_init(BYTE bSpilnit)

Initializes the 500 Series Z-Wave SoC built-in SPI0 master/slave controller. Notice that not all 500 Series Z-Wave SoC/modules has this SPI available on the pin-out and for some Z-Wave device types this SPI is reserved for the Z-Wave protocol.

This function sets the SPI clock speed, the signaling mode and the data order. For example,

```
ZW_SPI0_init(SPI_SPEED_8_MHZ|SPI_MODE_0|SPI_MSB_FIRST)
```

Sets clock speed to 8MHz, SPI clock idle to low, data sampled at rising edge and clocked at falling edge, and sends most significant bit first.

Defined in: ZW_spi_api.h

Parameters:

bSpilnit IN	bit mask:	
	Speed of the SPI clock (master mode only)	
	SPI_SPEED_8_MHZ	SPI clock runs at @8MHz
	SPI_SPEED_4_MHZ	SPI clock runs at @4MHz
	SPI_SPEED_2_MHZ	SPI clock runs at @2MHz
	SPI_SPEED_1_MHZ	SPI clock runs at @1MHz
	SPI signaling modes ¹	
	SPI_MODE_0	SPI clock idle low, data sampled at rising edge and clocked at falling edge
	SPI_MODE_1	SPI clock idle low, data sampled at falling edge and clocked at rising edge
	SPI_MODE_2	SPI clock idle high, data sampled at falling edge and clocked at rising edge
	SPI_MODE_3	SPI clock idle high, data sampled at rising edge and clocked at falling edge
	Data order	
	SPI_MSB_FIRST	send MSB bit first
	SPI_LSB_FIRST	send LSB bit first
	Master/Slave	
	SPI_MASTER	enable SPI master mode
	SPI_SLAVE	enable SPI slave mode

¹ In the 400 series API SPI_MODE_0 was called SPI_SIG_MODE_1, SPI_MODE_1 was called SPI_SIG_MODE_2, etc. The 400 names can still be used in a 500 Series application, but beware of the numbering.

Slave Select (Slave mode only)

SPI_SS_N_SS

SPI_SS_N_GPIO

use io SS_N IO as the slave select signal input when the 500 Series Z-Wave SoC is in SPI slave mode slave controller is always enabled when the 500 Series Z-Wave SoC is in SPI slave mode. The IO, SS_N, can freely be used as a GPIO or for another HW function.

Serial API (Not supported)

4.3.11.3 ZW_SPI0_enable

void ZW_SPI0_enable(BYTE bState)

Function enables the SPI0 master and allocates the pins MISO0, MOSI0, and SCK0. If SPI_SS_N_SS is set in **ZW_SPI0_init()** then also SS_N0 is allocated.

Defined in: ZW_spi_api.h

Parameters:

bState IN	TRUE	enable the SPI0 controller
	FALSE	disable the SPI0 controller

Serial API (Not supported)

4.3.11.4 ZW_SPI0_rx_get

BYTE ZW_SPI0_rx_get(void)

Function returns a previously received byte from SPI0.

This function does not wait until data has been received.

Defined in: ZW_spi_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.11.5 ZW_SPI0_tx_set

void ZW_SPI0_tx_set(BYTE data)

For SPI master:

Function starts transmission over the SPI0. Waits until SPI0 transmitter is idle before it sends the new data and will then immediately return before the serial transmission has taken place.

For SPI slave:

Function transfers a data byte to the SPI0 register. Waits until SPI0 transmitter is idle before it transfers the new data, but it will not ensure that the transfer of data to the SPI0 register didn't happen without colliding with the next byte transfer. Use the function **ZW_SPI0_rx_coll_get()** to check whether a collision has occurred. The function will then immediately return possibly before the serial transmission is started (initiated by the SPI master).

Defined in: ZW_spi_api.h

Parameters:

data IN Data to be send.

Serial API (Not supported)

4.3.11.6 ZW_SPI0_active_get

BYTE ZW_SPI0_active_get(void)

Read the SPI0 send data status.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 Transmitter is busy
	zero (0x00)	SPI0 Transmitter is idle

Serial API (Not supported)

4.3.11.7 ZW_SPI0_coll_get

BYTE ZW_SPI0_coll_get(void)

This function returns the state of the SPI0 collision flag and then clears the collision flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 data collided
	zero (0x00)	SPI0 no collisions

Serial API (Not supported)

4.3.11.8 ZW_SPI0_int_enable

void ZW_SPI0_int_enable(BYTE boEnable)

Call will enable or disable the SPI0 interrupt. If enabled an interrupt routine must be defined. Default is the SPI0 interrupt is disabled.

NOTE: If the SPI0 interrupt is used, then the SPI0 interrupt flag should be reset before returning from the interrupt routine by calling **ZW_SPI0_int_clear**.

Defined in: ZW_spi_api.h

Parameters:

boEnable IN	TRUE	Enables the SPI0 interrupt.
	FALSE	Disables the SPI0 interrupt.

Serial API (Not supported)

4.3.11.9 ZW_SPI0_int_get

BYTE ZW_SPI0_int_get(void)

This function returns the state of the SPI0 interrupt/transmission done flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 interrupt/transmission flag is set
	zero (0x00)	SPI0 interrupt/transmission flag is cleared

Serial API (Not supported)

4.3.11.10 ZW_SPI0_int_clear

void ZW_SPI0_int_clear(void)

Function clears the SPI0 interrupt/transmission done flag

Defined in: ZW_spi_api.h

Serial API (Not supported)

4.3.11.11 ZW_SPI1_init

void ZW_SPI1_init(BYTE bSpilnit)

Initializes the 500 Series Z-Wave SoC built-in SPI master controller, SPI1. Notice that not all 500 Series Z-Wave SoC/modules has this SPI available on the pin-out and for some Z-Wave device types this SPI is reserved for the Z-Wave protocol.

The function sets the SPI clock speed, the signaling mode and the data order. E.g.:

```
ZW_SPI1_init(SPI_SPEED_8_MHZ|SPI_MODE_0|SPI_MSB_FIRST)
```

Sets clock speed to 8MHz, SPI clock idle to low, data sampled at rising edge and clocked at falling edge, and sends most significant bit first.

Defined in: ZW_spi_api.h

Parameters:

bSpilnit IN	bit mask:	
	Speed of the SPI clock	
	SPI_SPEED_8_MHZ	SPI clock runs at @8MHz
	SPI_SPEED_4_MHZ	SPI clock runs at @4MHz
	SPI_SPEED_2_MHZ	SPI clock runs at @2MHz
	SPI_SPEED_1_MHZ	SPI clock runs at @1MHz
	SPI signaling modes ¹	
	SPI_MODE_0	SPI clock idle low, data sampled at rising edge and clocked at falling edge
	SPI_MODE_1	SPI clock idle low, data sampled at falling edge and clocked at rising edge
	SPI_MODE_2	SPI clock idle high, data sampled at falling edge and clocked at rising edge
	SPI_MODE_3	SPI clock idle high, data sampled at rising edge and clocked at falling edge
	Data order	
	SPI_MSB_FIRST	send MSB bit first
	SPI_LSB_FIRST	send LSB bit first

Serial API (Not supported)

¹ In the 400 series API SPI_MODE_0 was called SPI_SIG_MODE_1, SPI_MODE_1 was called SPI_SIG_MODE_2, etc. The 400 names can still be used in a 500 Series application, but beware of the numbering.

4.3.11.12 ZW_SPI1_enable

void ZW_SPI1_enable(BYTE bState)

Function enables the SPI1 master and allocates the pins MISO1, MOSI1, and SCK1.

Defined in: ZW_spi_api.h

Parameters:

bState IN	TRUE	enable the SPI1 controller
	FALSE	disable the SPI1 controller

Serial API (Not supported)

4.3.11.13 ZW_SPI1_rx_get

BYTE ZW_SPI1_rx_get(void)

This function returns a previously received byte from SPI1.

This function does not wait until data has been received.

Defined in: ZW_spi_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.11.14 ZW_SPI1_tx_set

void ZW_SPI1_tx_set(BYTE data)

Function starts transmission over the SPI1. Waits until SPI1 transmitter is idle before it sends the new data and will then immediately return before the serial transmission has taken place.

Defined in: ZW_spi_api.h

Parameters:

data IN Data to be send.

Serial API (Not supported)

4.3.11.15 ZW_SPI1_active_get

BYTE ZW_SPI1_active_get(void)

Read the SPI1 send data status.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 Transmitter is busy
	zero (0x00)	SPI1 Transmitter is idle

Serial API (Not supported)

4.3.11.16 ZW_SPI1_coll_get

BYTE ZW_SPI1_coll_get(void)

This function returns the state of the SPI1 collision flag and then clears the collision flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 data collided
	zero (0x00)	SPI1 no collisions

Serial API (Not supported)

4.3.11.17 ZW_SPI1_int_enable

void ZW_SPI1_int_enable(BYTE boEnable)

Call will enable or disable the SPI1 interrupt. If enabled an interrupt routine must be defined. Default is the SPI1 interrupt is disabled.

NOTE: If the SPI1 interrupt is used, then the SPI1 interrupt flag should be reset before returning from the interrupt routine by calling **ZW_SPI1_int_clear**.

Defined in: ZW_spi_api.h

Parameters:

boEnable IN	TRUE	Enables the SPI1 interrupt.
	FALSE	Disables the SPI1 interrupt.

Serial API (Not supported)

4.3.11.18 ZW_SPI1_int_get

BYTE ZW_SPI1_int_get(void)

This function returns the state of the SPI1 interrupt/transmission done flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 interrupt/transmission flag is set
	zero (0x00)	SPI1 interrupt/transmission flag is cleared

Serial API (Not supported)

4.3.11.19 ZW_SPI1_int_clear

void ZW_SPI1_int_clear(void)

Function clears the SPI1 interrupt/transmission done flag

Defined in: ZW_spi_api.h

Serial API (Not supported)

4.3.12 ADC Interface API

The ADC interface API provides access to an 8/12-bit ADC with input multiplexer.

Refer to [16] for a detailed description of the ADC hardware.

The ADC MAY be used for monitoring battery levels [15], voltages across various sensors etc. The ADC MAY be configured to generate an interrupt request if the measured voltage is above, below or equal to a threshold depending on the configuration settings. The ADC MAY use up to 4 GPIO as inputs depending on its configuration. Input pins that are not enabled MAY be used as GPIO's for by other peripherals.

Three sources can work as voltage-references for the ADC, namely either the power-supply for the chip, an internal 1.2V voltage-reference or the P3.7 pin (ADC_PIN3). The maximum sample rate when in continuous conversion mode is 23.6k sample/s for 8 bit conversions and 10.9k sample/s for 12 bit conversions.

The figures below show when the ADC interrupt is released dependent on, how the ADC threshold gradient is set:

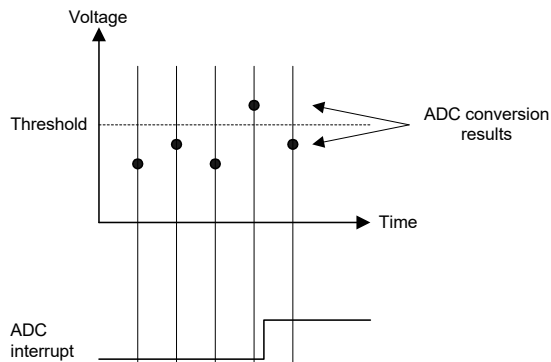


Figure 10. Threshold Functionality when Threshold Gradient Set to High

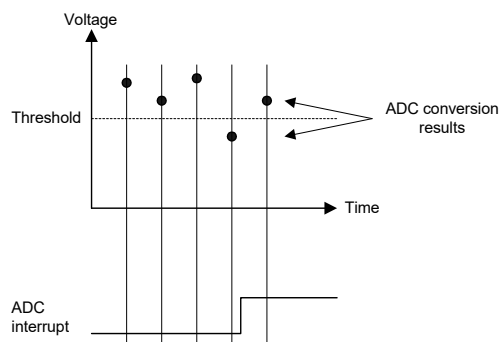


Figure 11. Threshold Functionality when Threshold Gradient Set to Low

The figure below shows how the connections to the ADC can be configured:

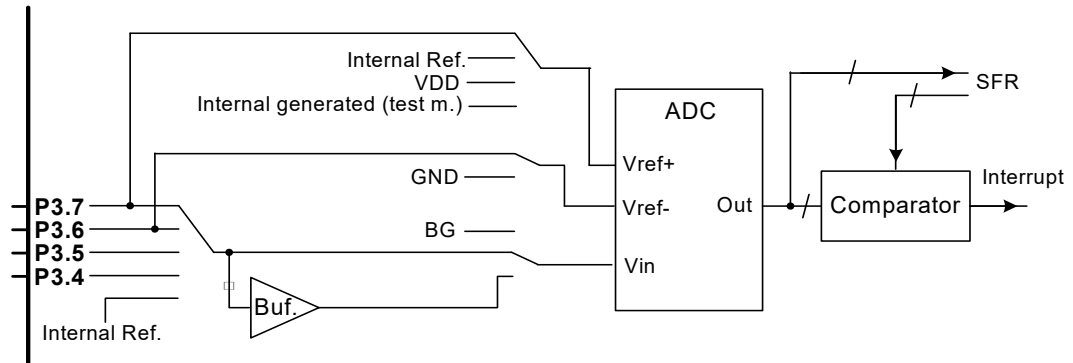


Figure 12. Configuration of Input Pins

```

/*****
* To be placed in interrupt routine module
*****/

void
adc_int (void) interrupt INUM_ADC
{
    _push_ (SFRPAGE);
    ZW_ADC_int_clear();
    adc_triggered=TRUE;
    adc_value=ZW_ADC_result_get();
    _pop_ (SFRPAGE);
}

:

/*****
* To be placed in applicationInithw()
*****/

// Power up ADC and set ADC conversion mode, references, pins
ZW_ADC_init(ADC_IO_MULTI_MODE,ADC_REF_U_VDD,ADC_REF_L_VSS,\
    ADC_PIN1|ADC_PIN2);
// Set auto zero period
ZW_ADC_auto_zero_set(ADC_AZPL_128);
// Set ADC resolution
ZW_ADC_resolution_set(ADC_8_BIT);
// Clear ADC interrupt flag
ZW_ADC_int_clear();
// Enable ADC interrupt
ZW_ADC_int_enable(TRUE);

:

```

```
/*
 * To be placed in applicationPoll()
 */

if (state==powerUp)
{
    // select ADC input pin
    if (measure==sensor1)
    {
        // sensor 1 is on ADC pin 1
        ZW_ADC_pin_select(ADC_PIN1);
        // enable lower threshold
        ZW_ADC_threshold_mode_set(ADC_THRES_LOWER);
        // set threshold level to ~25% of VDD
        ZW_ADC_threshold_set(0x0040);
    }
    else
    {
        // sensor 2 is on ADC pin 2
        ZW_ADC_pin_select(ADC_PIN2);
        // enable upper threshold
        ZW_ADC_threshold_mode_set(ADC_THRES_UPPER);
        // set threshold level to ~50% of VDD
        ZW_ADC_threshold_set(0x0080);
    }
    // Start ADC
    ZW_ADC_enable(TRUE);
    state=xxx;
}

:
if (state==running)
{
    // React on sampled ADC value
    if (adc_triggered)
    {
        if (measure==sensor1)
            do_something1(adc_value);
        else
            do_something2(adc_value);
        adc_triggered=FALSE;
    }
}

:
```

Figure 13, ADC Code Sample Snippets Using an I/O as Input


```

/*****
* To be placed in applicationInitHW()
*****/

// Set ADC to battery monitoring mode, other parameters are ignored
ZW_ADC_init(ADC_BATT_SINGLE_MODE, 0, 0, 0);
// Set auto zero period
ZW_ADC_auto_zero_set(ADC_AZPL_128);
// Set ADC resolution
ZW_ADC_resolution_set(ADC_12_BIT);

/*****
* To be placed in applicationPoll()
*****/

if (state==startBatteryVoltageMeasurement)
{
    // Power up ADC
    ZW_ADC_power_enable(TRUE);
    // Start ADC
    ZW_ADC_enable(TRUE);
    state=awaitingBatteryVoltageMeasurement;
}

:

if ((state==awaitingBatteryVoltageMeasurement)
{
    battLevel=ZW_ADC_result_get();
    if (battLevel!= ADC_NOT_FINISHED))
    {
        // Calc battery level in mV (Vbg is the band gab voltage)
        battVol=(DWORD)Vbg*4096/(DWORD)battLevel
        // Return battery voltage in mV
        send(battVol);
        state=xxx;
        // Power down ADC
        ZW_ADC_power_enable(FALSE);
    }
}
}

```

Figure 14, ADC Code Sample Snippets Using Battery Monitoring Mode

4.3.12.1 ZW_ADC_init

```
void ZW_ADC_init ( BYTE bMode,  
                  BYTE bUpper_ref,  
                  BYTE bLower_ref,  
                  BYTE bPin_en)
```

This function MAY be used to power up and initialize the ADC unit. The ADC unit may be operated in two different modes, battery monitoring mode and I/O mode.

In battery monitoring mode the ADC will automatically be configured to have the VDD as upper reference voltage, VSS as lower reference voltage and the band gap as the ADC input. In battery monitoring mode the parameters bUpper_ref, bLower_ref and bPin_en are ignored.

Refer to [15] for a detailed description of battery monitoring mode and of battery powered Z-Wave applications in general..

In I/O mode the ADC unit can sample four hardware inputs with user selectable upper and lower voltage references.

The upper reference voltage can be set to be VDD, internal bandgap or external voltage on ADC_PIN3. Lower reference voltage can be set to be either VSS (GND) or external voltage on pin ADC_PIN2.

If called in I/O mode, the parameter bPin_en MUST be used to enable one or more of the I/O pins P3.4 .. P3.7 (ADC_PIN0 .. ADC_PIN3) as ADC inputs pins. If a pin is enabled as ADC input this pin can not be used as a GPIO at the same time. Be aware that enabling other peripherals (like Keypad scanner, IR and Triac Controller) can overrule this setting.

Even though the bPin_en is set, no I/O pin will be selected as the active ADC input by this function. To select the active ADC input, **ZW_ADC_pin_select** MUST be called before **ZW_ADC_enable(TRUE)** is called.

The ADC can either run in single conversion mode or multi (continuous) conversion mode

Refer to [16] for a detailed description of the ADC hardware and of PCB layout.

Defined in: ZW_adcdriv_api.h

Parameters

bMode IN	ADC_IO_MULTI_MODE	Set the ADC in multi conversion mode ADC input will be from the I/O's. The ADC will continue converting until it is stopped.
	ADC_IO_SINGLE_MODE	Set the ADC in single conversion mode ADC input will be from the I/O's. The ADC will convert one time then stop.
	ADC_BATT_MULTI_MODE	Set the ADC in battery monitoring mode. The chip supply voltage (VDD) is selected as upper reference. GND will be selected as lower reference voltage. The ADC input will be the band gap circuit. The ADC will continue converting until it is stopped.
	ADC_BATT_SINGLE_MODE	Set the ADC in battery monitoring mode. The chip supply voltage (VDD) is selected as upper reference. GND will be selected as lower reference voltage. The ADC input will be the band gap circuit. The ADC will convert one time then stop.
bUpper_ref		Ignored when battery monitoring mode is enabled
	ADC_REF_U_VDD	Select the chip power supply (VDD) as the upper reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_U_EXT	Select IO P3.7 as the upper reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_U_BGAB	Select the band gap circuit as the upper reference voltage. Ignored when ADC in battery monitor mode.
bLower_ref		Ignored when battery monitoring mode is enabled
	ADC_REF_L_VSS	Select the ground (VSS) as the lower reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_L_EXT	Select IO P3.6 as lower reference voltage. Ignored when ADC in battery monitor mode.

bPin_en	Ignored when battery monitoring mode is enabled
Bitmask	Select which IO to enable as ADC inputs. Selected pins MUST NOT be used as GPIOs
ADC_PIN0	Select I/O P3.4 as an ADC input
ADC_PIN1	Select I/O P3.5 as an ADC input
ADC_PIN2	Select I/O P3.6 as an ADC input
ADC_PIN3	Select I/O P3.7 as an ADC input

Serial API (Not supported)

4.3.12.2 ZW_ADC_power_enable

void ZW_ADC_power_enable(BYTE boEnable)

This function SHOULD be used to control when the ADC unit is powered. ADC is powered down, when the module enters sleep mode.

Calling **ZW_ADC_init()** will power up the ADC.

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable IN	TRUE	Turn the ADC power on
	FALSE	Turn the ADC power off. The ADC will cancel any activity immediately.

Serial API (Not supported)

4.3.12.3 ZW_ADC_enable

void ZW_ADC_enable(BYTE boStart)

This function MAY be used to start / stop the ADC unit.

If **ZW_ADC_enable(FALSE)** is called when the ADC unit is currently performing multi conversions, any current running conversion process will continue running is has finished whereafter this function call will return.

If the ADC is powered off **ZW_ADC_power_enable(TRUE)** MUST be called before **ZW_ADC_enable(TRUE)** is called.

Defined in: ZW_adcdriv_api.h

Parameters:

boStart IN	TRUE	Start the ADC and begin conversion
	FALSE	Single mode: stop the ADC. Multi mode: wait for conversion to finish then stop ADC

Serial API (Not supported)

4.3.12.4 ZW_ADC_pin_select

void ZW_ADC_pin_select(BYTE bAdcPin)

This function MAY be used to select the IO pin to use as the active ADC input.

Not applicable in battery monitoring mode.

The IO pin MUST be enabled as an ADC input before calling **ZW_ADC_enable(TRUE)**.

Defined in: ZW_adcdriv_api.h

Parameters:

bAdcPin IN	ADC_PIN0	Select I/O P3.4 as an ADC input
	ADC_PIN1	Select I/O P3.5 as an ADC input
	ADC_PIN2	Select I/O P3.6 as an ADC input
	ADC_PIN3	Select I/O P3.7 as an ADC input

Serial API (Not supported)

4.3.12.5 ZW_ADC_threshold_mode_set

void ZW_ADC_threshold_mode_set(BYTE bThresMode)

This function MAY be used to set the threshold mode of the ADC unit. The threshold mode controls when the ADC generates an interrupt request.

Use **ZW_ADC_threshold_set()** to set the actual threshold level.

Defined in: ZW_adcdriv_api.h

Parameters:

bThresMode	ADC_THRES_UPPER	Generate an interrupt request when input is above/equal to the threshold value
	ADC_THRES_LOWER	Generate an interrupt request when input is below/equal to the threshold value

Serial API (Not supported)

4.3.12.6 ZW_ADC_threshold_set

void ZW_ADC_threshold_set(WORD wThreshold)

This function MAY be used to set the ADC threshold value.

Depending on the threshold mode (set by **ZW_ADC_threshold_mode_set**), the threshold value is used to trigger an interrupt when the sampled value is above/equal or below/equal the threshold value.

The API **ZW_ADC_threshold_mode_set** MUST be called before calling this function.

Defined in: ZW_adcdriv_api.h

Parameters:

wThreshold IN	8-bit resolution	Threshold value range is 0 .. 255
	12-bit resolution	Threshold value range is 0 .. 4095

Serial API (Not supported)

4.3.12.7 ZW_ADC_int_enable

void ZW_ADC_int_enable(BYTE boEnable)

Therefore, function MAY be used to enable or disable ADC interrupt requests. If enabled, an interrupt routine MUST be defined. The ADC interrupt is disabled by default.

If ADC interrupts are enabled, the ADC interrupt flag MUST be reset by calling **ZW_ADC_int_clear** before returning from the interrupt routine.

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable IN	TRUE	Enable the ADC interrupt
	FALSE	Disable the ADC interrupt

Serial API (Not supported)

4.3.12.8 ZW_ADC_int_clear

void ZW_ADC_int_clear(void)

If ADC interrupts are enabled, this function **MUST** be called before returning from the interrupt routine.

Defined in: ZW_adcdriv_api.h

Serial API (Not supported)

4.3.12.9 ZW_ADC_is_fired

BOOL ZW_ADC_is_fired(void)

This function MAY be used to check if the most recent ADC conversion result meets the threshold criterion.

Defined in: ZW_adcdriv_api.h

Retrun value:

BOOL	TRUE	The most recent conversion result meets the threshold criterion
	FALSE	ADC conversion is not finished or the most recent conversion result does not meet the threshold criterion

Serial API (Not supported)

4.3.12.10 ZW_ADC_result_get

WORD ZW_ADC_result_get(void)

This function MAY be used to read back the result of the most recent ADC conversion. The return value is an 8-bit or 12-bit integer depending on the ADC resolution mode. The value ADC_NOT_FINISHED may be returned in case the ADC conversion process is still running.

Defined in: ZW_adcdriv_api.h

Return value:

WORD	8-bit resolution	Return value range is 0 .. 255 in bits 0..7 The 8 MS bits of the return value MUST be ignored
	12-bit resolution	Return value range is 0 .. 4095 in bits 0..11 The 4 MS bits of the return value MUST be ignored.

Serial API (Not supported)

4.3.12.11 ZW_ADC_buffer_enable

void ZW_ADC_buffer_enable(BYTE boEnable)

This function MAY be used to enable or disable an input buffer between the analog input and the ADC converter. The input buffer is disabled by default.

The input buffer SHOULD be enabled when interfacing to a high impedance analog input. A high impedance analog input connected directly to the ADC converter may cause increased ADC settling time.

Not applicable in battery monitoring mode.

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable	TRUE	Enable the input buffer
	FALSE	Disable the input buffer

Serial API (Not supported)

4.3.12.12 ZW_ADC_auto_zero_set

void ZW_ADC_auto_zero_set(BYTE bAzpl)

This function MAY be used to define the ADC sampling period. Default value is ADC_AZPL_128. It is RECOMMENDED to use longer sampling periods for high impedance analog inputs.

Defined in: ZW_adcdriv_api.h

Parameters:

bAzpl	ADC_AZPL_1024	Set the autozero period to 128us RECOMMENDED for high impedance analog inputs
	ADC_AZPL_512	Set the autozero period to 64us RECOMMENDED for medium to high impedance analog inputs.
	ADC_ZPL_256	Set the autozero period to 32us RECOMMENDED for medium to low impedance analog inputs.
	ADC_ZPL_128	Set the autozero period to 16us RECOMMENDED for low impedance analog inputs.

Serial API (Not supported)

4.3.12.13 ZW_ADC_resolution_set

void ZW_ADC_resolution_set(BYTE bReso)

Therefore, function SHOULD be used to set the resolution of the ADC.
The threshold value SHOULD also be updated when changing the ADC resolution.

Apart from setting the resolution this function will, together with the auto zero period, also set the sampling rate.

When resolution is ADC_8_BIT the sampling rate is

23.6k samples/s	@autozero=128
17.1k samples/s	@autozero=256
11.1k samples/s	@autozero=512
6.5k samples/s	@autozero=1024

When resolution is ADC_12_BIT the sampling rate is

10.9k samples/s	@autozero=128
9.3k samples/s	@autozero=256
7.2k samples/s	@autozero=512
4.9k samples/s	@autozero=1024

Defined in: ZW_adcdriv_api.h

Parameters:

bReso	ADC_12_BIT	Set the ADC resolution to 12 bits
	ADC_8_BIT	Set the ADC resolution to 8 bits

Serial API (Not supported)

4.3.13 UART Interface API

The UART (Universal Asynchronous Receiver Transmitter) interface is for serial communication with external devices such as PC's, host controllers etc. The two UART interfaces transmits data in an asynchronous way, and is a two-way communication protocol, using 2 pins each as a communications means: TxD and RxD. The two pins can be enabled and disabled individually. If only using RX mode the TxD pin can be used as general IO pins and vice versa. The UART's use dedicated timers and do not take up any 8051 timer resources.

Since the two UART's are identical the description of each function is collapsed using the notation UARTx, where x is either 0 or 1.

The UARTx supports full duplex and can operate with the baud rates between 9.6kbaud and 230.4 kbaud. (See under **ZW_UARTx_init**)

The interface operates with 8 bit words, one start bit (low), one stop bit (high) and no parity. This setup is hardwired and can not be changed.

The UARTx shifts data in/out in the following order: start bit, data bits (LSB first) and stop bit. The figure below gives the waveform of a serial byte.

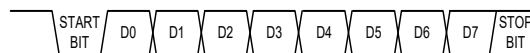


Figure 15. Serial Waveform

4.3.13.1 Transmission

An interrupt is released when D7 has been sent on the TxD pin. A new byte can be written to the buffer when the interrupt has been released.

4.3.13.2 Reception

The reception is activated by a falling edge on RxD. If the falling edge is not verified by the majority voting on the start bit, then the serial port stops reception and waits for another falling edge on RxD. When the MSB of the byte has been received a stop bit is expected. The first 2/3 of the stop bit is sampled and a majority decision is made on these samples. The interrupt will be released if the stop bit is recognized as high.

When 2/3 of the stop bit has been received the serial port waits for another high-to-low transition (start bit) on the RxD pin.

4.3.13.3 RS232

Connecting a RS232 level converter to the 2 pins of a UART interface makes the 500 Series Z-Wave SoC able to communicate according to the RS232 standard.

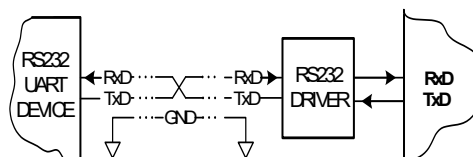


Figure 16. RS232 Setup

4.3.13.4 Integration

Before using the UARTx the UART should be initialized and mapped to the IO pins. This initialization should be performed in the initialization function **ApplicationInitHW**. The initialization and IO mapping is performed using the **ZW_UARTx_init** function.

The use of the UART is typically performed in the **ApplicationPoll**. The UART is then polled and characters are received / transmitted. Alternatively, the UART can be serviced in an ISR, but this approach is often too slow for higher baudrates.

A UART application typically writes a character or string to a terminal. This can be performed by initializing the modem as described above in **ApplicationInitHW** and then calling **ZW_UARTx_tx_send_str(BYTE *str)** for an entire string. The function waits until the UART is ready before sending each character. However in some cases it is not desirable to wait until the UART is ready before continuing code execution. In this case it is better to poll to see if the UART is ready and then transmit characters when the UART is ready. In this case a different set of functions are needed as given below.

```
if (!ZW_UART0_tx_active_get())
{
    ZW_UART0_tx_send_str();
}
```

Another possibility is to use the interrupt flags:

```
if (ZW_UART0_tx_int_get())
{
    ZW_UART0_tx_int_clear();
    ZW_UART0_tx_send_str();
}
```

However the latter method has the disadvantage that it requires an initial write to the UART or else the first interrupt flag will not go high and the writing will never start.

Another typical UART application is to receive a character to the 500-series Z-Wave SoC. Similarly as for the TX setup, it is possible to poll for a new character before reading it.

An example of the preferred solution to receive characters is given below:

```
if (ZW_UART0_rx_int_get())
{
    ZW_UART0_rx_int_clear(); // Clear flag right after detection
    ch = ZW_UART0_rx_data_get(); // Where ch is of the type BYTE
    ...
}
```

Note: It is important to clear the interrupt flag as fast as possible after detecting the interrupt flag (even before reading data). Omitting to do this may lead to loss of data as the interrupt flag may trigger again before the flag is cleared. This is especially a concern at high baudrates.

The serial interface API handles transfer of data via the serial interfaces using the 500 Series Z-Wave SoC built-in UART0 and UART1.

4.3.13.5 Operation

Data to be transmitted is written to a UART data register, one byte at the time and data received is read from a SPI data register one byte at the time. A UART interrupt can be issued when the UART controller has transferred a byte on the UART interface. This API supports transmissions of either a single byte, or a data string. The received characters are read by the application one-by-one.

4.3.13.6 ZW_UART0_init / ZW_UART1_init

```
void ZW_UART0_init(WORD bBaudRate, BYTE bEnableTx, BYTE bEnableRx) /
void ZW_UART1_init(WORD bBaudRate, BYTE bEnableTx, BYTE bEnableRx)
```

Initializes the 500 Series Z-Wave SoC built-in UARTx to support ZM5101 and SD3502. Using ZM5202 requires that the NVR uart pin swap bit is set in the NVR to map to correct pin configuration. The function should be called in the **ApplicationInitHW()** so the ports are mapped correctly when the chip starts up.

The init functions optionally enable/disable UARTx transmit and/or receive, clears the rx and tx interrupt flags and sets the specified baud rate.

Defined in: ZW_uart_api.h

Parameters:

bBaudRate IN	Baud Rate / 100	Valid values: 96 ⇒ 9.6kbaud, 144 ⇒ 14.4kbaud, 192 ⇒ 19.2kbaud, 384 ⇒ 38.4kbaud, 576 ⇒ 57.6kbaud, 1152 ⇒ 115.2kbaud, 2304 ⇒ 230.4kbaud
bEnableTx IN	TRUE	Enable UARTx transmitter and allocate TxD pin as follows: UART0 TxD is allocated on P2.1 UART1 TxD is allocated on P3.1
	FALSE	Disable UARTx Transmitter and de-allocate TxD pin
bEnableRx IN	TRUE	Enable UARTx receiver and allocate RxD pin as follows: UART0 RxD is allocated on P2.0 UART1 RxD is allocated on P3.0
	FALSE	Disable UARTx receiver and de-allocate RxD pin

Serial API (Not supported)

4.3.13.7 **ZW_UART0_rx_data_get / ZW_UART1_rx_data_get**

BYTE ZW_UART0_rx_data_get(void) / BYTE ZW_UART1_rx_data_get(void)

This function returns the last received byte from UARTx. The UART should be polled using the **ZW_UART0_rx_int_get / ZW_UART1_rx_int_get** to see whether a new byte is ready before calling this function.

The function does not wait for a byte to be received but returns immediately. The alternative functions **ZW_UART0_rx_data_wait_get / ZW_UART1_rx_data_wait_get** waits until a byte is received before returning.

Defined in: ZW_uart_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.13.8 ZW_UART0_rx_data_wait_get / ZW_UART1_rx_data_wait_get

BYTE ZW_UART0_rx_data_wait_get(void) / BYTE ZW_UART1_rx_data_wait_get(void)

Returns a byte from the UARTx receiver. If no byte is available the function waits until data has been received. This function should be used with *extreme caution* as it may freeze the system if no character is received. In normal cases it is better to use polling, `ZW_UART0_rx_int_get / ZW_UART1_rx_int_get`, to check if a new byte is received and then `ZW_UART0_rx_data_get / ZW_UART1_rx_data_get` to get the byte.

Defined in: ZW_uart_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.13.9 ZW_UART0_tx_active_get / ZW_UART1_tx_active_get

BYTE ZW_UART0_tx_active_get(void) / BYTE ZW_UART1_tx_active_get(void)

Read the UARTx send data status. The function returns TRUE if the UART is currently busy transmitting data. The function is typically used in a polled TX setup to check whether the UART is ready before sending the next character using **ZW_UART0_tx_data_set / ZW_UART1_tx_data_set**.

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Transmitter is busy
	zero (0x00)	UARTx Transmitter is idle

Serial API (Not supported)

4.3.13.10 **ZW_UART0_tx_data_set / ZW_UART1_tx_data_set**

void ZW_UART0_tx_data_set(BYTE data) / void ZW_UART1_tx_data_set(BYTE data)

Function sets the transmit data register

This function does not wait until UARTx transmitter is idle before it sends the new data. The function should not be called unless the UART is ready. To check if the UART is ready is done using the **ZW_UART0_tx_active_get / ZW_UART1_tx_active_get**. Data send to the UART when it is not ready will be ignored.

Defined in: ZW_uart_api.h

Parameters:

data IN Data to send.

Serial API (Not supported)

4.3.13.11 **ZW_UART0_tx_send_num / ZW_UART1_tx_send_num**

void ZW_UART0_tx_send_num(BYTE data) / void ZW_UART1_tx_send_num(BYTE data)

Converts a byte to a two-byte hexadecimal ASCII representation, and transmits it over the UART. This function waits until UARTx transmitter is idle before it sends the new data. The function does not wait until the last data byte has been sent.

See also: **ZW_UART0_tx_send_str / ZW_UART1_tx_send_str**

Defined in: ZW_uart_api.h

Parameters:

data IN Byte value to be converted into two-byte hexadecimal ASCII representation and transmitted via the UART.

Serial API (Not supported)

4.3.13.12 ZW_UART0_tx_send_str / ZW_UART1_tx_send_str

void ZW_UART0_tx_send_str(BYTE* pStr) / void ZW_UART1_tx_send_str(BYTE* pStr)

Transmit a null terminated string over UARTx. The null data is not transmitted. This function waits until UARTx transmitter is idle before it sends the first data byte data. The function does not wait until the last data byte has been sent.

See also: **ZW_UART0_tx_send_num / ZW_UART1_tx_send_num**

Defined in: ZW_uart_api.h

Parameters:

pStr IN Pointer to zero terminated string to be transmitted via the UART.

Serial API (Not supported)

4.3.13.13 ZW_UART0_INT_ENABLE / ZW_UART1_INT_ENABLE

ZW_UART0_INT_ENABLE / ZW_UART1_INT_ENABLE

This macros enables UARTx interrupts

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.14 ZW_UART0_INT_DISABLE / ZW_UART1_INT_DISABLE

ZW_UART0_INT_DISABLE / ZW_UART1_INT_DISABLE

This macros disables UARTx interrupts

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.15 ZW_UART0_tx_send_ni / ZW_UART1_tx_send_ni

void ZW_UART0_tx_send_ni(void) / void ZW_UART1_tx_send_ni(void)

Transmit “new line” sequence (CR + LF) over UARTx .

See also: **ZW_UART0_tx_send_num / ZW_UART1_tx_send_num** and **ZW_UART0_tx_send_str / ZW_UART1_tx_send_str**

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.16 ZW_UART0_tx_int_clear / ZW_UART1_tx_int_clear

void ZW_UART0_tx_int_clear(void) / void ZW_UART1_tx_int_clear(void)

Clear the UARTx transmit interrupt/done flag.

See also: **ZW_UART0_tx_int_get / ZW_UART1_tx_int_get**

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.17 ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear

void ZW_UART0_rx_int_clear(void) / void ZW_UART1_rx_int_clear(void)

Clear the UARTx receiver interrupt/ready flag.

See also: **ZW_UART0_rx_int_get / ZW_UART1_rx_int_get**

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.18 ZW_UART0_tx_int_get / ZW_UART1_tx_int_get

BYTE ZW_UART0_tx_int_get(void) / BYTE ZW_UART1_tx_int_get(void)

Returns the state of the Transmitter done/interrupt flag. This function has limited used and in practice it is preferred to check if the UART is ready using the **ZW_UART0_tx_active_get / ZW_UART1_tx_active_get** function in a polled configuration. The **ZW_UART0_tx_active_get / ZW_UART1_tx_active_get** does not require the interrupt flag to be cleared.

See also : **ZW_UART0_tx_int_clear / ZW_UART1_tx_int_clear**

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Transmitter done/interrupt flag is set
	zero (0x00)	UARTx Transmitter done/interrupt flag is cleared

Serial API (Not supported)

4.3.13.19 ZW_UART0_rx_int_get / ZW_UART1_rx_int_get

BYTE ZW_UART0_rx_int_get(void) / BYTE ZW_UART1_rx_int_get(void)

Returns the state of the receiver data ready/interrupt flag. The flag goes high when a new byte has been received. The flag should be cleared as soon as possible after detection in order to minimize risk of data loss (especially at high baud rates). Clearing the interrupt flag is done using the function **ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear**. When a new byte is detected the byte can be read using the **ZW_UART0_rx_data_get / ZW_UART1_rx_data_get** function.

See also: **ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear** and **ZW_UART0_rx_data_get / ZW_UART1_rx_data_get**

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Receiver data ready/interrupt flag is set
	zero (0x00)	UARTx receiver data ready/interrupt flag is cleared

Serial API (Not supported)

4.3.13.20 ZW_UART0_rx_enable / ZW_UART1_rx_enable

void ZW_UART0_rx_enable(BYTE bState) / void ZW_UART1_rx_enable(BYTE bState)

This function is used to enable or disable the UARTx Rx function in runtime. Use the function **ZW_UARTx_init** to set the initial state of the Rx function. When enabling the UARTx Rx function the UARTx Rx pin will become an input.

Defined in: ZW_uart_api.h

Parameters:

bState IN	TRUE	UARTx Rx enabled
	FALSE	UARTx Rx disabled

Serial API (Not supported)

4.3.13.21 ZW_UART0_tx_enable / ZW_UART1_tx_enable

void ZW_UART0_tx_enable(BYTE bState) / void ZW_UART1_tx_enable(BYTE bState)

This function is used to enable or disable the UARTx TX function in runtime. Use the function **ZW_UARTx_init** to set the initial state of the Rx function. When enabling the UARTx Tx function the UARTx Tx pin will become an output.

Defined in: ZW_uart_api.h

Parameters:

bState IN	TRUE	UARTx Tx enabled
	FALSE	UARTx Tx disabled

Serial API (Not supported)

4.3.14 Application HW Timers/PWM Interface API

The 500 Series Z-Wave SoC has three built-in HW timers available for the application:

1. Timer0
2. Timer1
3. GPTimer or PWM generator.

Timer	bits	Clocked by	Count up/down
Timer0	8/13/16	32MHz / 2 or P3.4	Counts up
Timer1	8/13/16	32MHz / 2 or P3.5	Counts up
GPTimer	16	32MHz / 8 or 32MHz / 1024	Counts down

Timer0 and Timer1 are standard 8051 timers that can be configured to:

- be enabled/disabled
- use the system clock divided by 2 (16MHz) or use a pin as clock source
- generate an interrupt at overflow

Refer to figure below for principle diagrams of how the clock control works for Timer0.

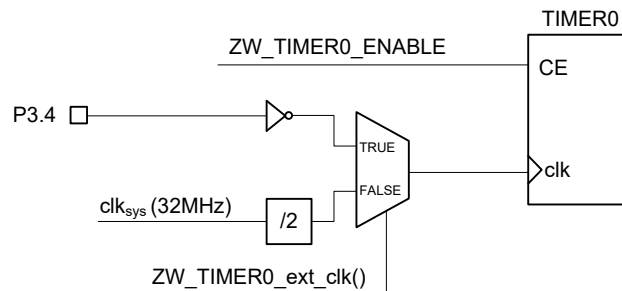


Figure 17. Principle of Clock Control for Timer0

Refer to figure below for principle diagrams of how the clock control works for Timer0.

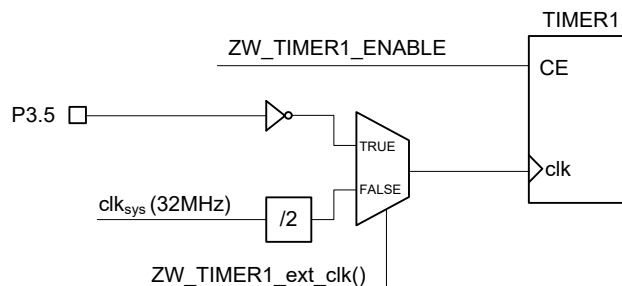


Figure 18. Principle of Clock Control (mode 0-2) for Timer1

Timer0 and Timer1 can operate in four different modes. Refer to the description of **ZW_TIMER1_init**

4.3.14.1 ZW_TIMER0_init

void ZW_TIMER0_init(BYTE bValue)

This function SHOULD be used to initialize Timer0.

Defined in: ZW_apptimer_api.h

Parameters:

bValue	Timer0 Mode:	
	TIMER_MODE_0	13 bit mode. The 5 lower bits of the low register acts as a 5 bit prescaler for the high byte
	TIMER_MODE_1	16 bit mode
	TIMER_MODE_2	8bit - auto reload mode. The 8bit timer runs in the high byte register. After an overflow the low byte register value is loaded into the high byte register
	TIMER_MODE_3	Timer 0 division mode. Timer 0 is divided into two 8 bit timers, one controlled by the Timer 0 control bits and the other controlled by the Timer 1 control bits. Warning: Enabling this will stop Timer 1

Serial API (Not supported)

4.3.14.2 ZW_TIMER1_init

void ZW_TIMER1_init(BYTE bValue)

This function SHOULD be used to initialize Timer1.

Defined in: ZW_apptimer_api.h

Parameters:

bValue	Timer1 Mode:	
	TIMER_MODE_0	13 bit mode. The 5 lower bits of the low register acts as a 5 bit prescaler for the high byte
	TIMER_MODE_1	16 bit mode (no reload)
	TIMER_MODE_2	8bit - auto reload mode. The 8bit timer runs in the high byte register. After an overflow the low byte register value is loaded into the high byte register
	TIMER_MODE_3	Disabled. Warning: If Timer0 uses mode 3 then Timer1 is stopped.

Serial API (Not supported)

4.3.14.3 ZW_TIMER0_INT_CLEAR / ZW_TIMER1_INT_CLEAR

ZW_TIMERx_INT_CLEAR

This macro SHOULD be used to clear timer interrupt/overflow flags.

Mode0-2: This macro clears the TIMER0/TIMER1 interrupt/overflow flag.

Mode3: This macro clears the TIMER0/TIMER1 high counter interrupt/overflow flag.

Defined in: ZW_apptimer_api.h

Serial API (Not supported)

4.3.14.4 ZW_TIMER0_INT_ENABLE / ZW_TIMER1_INT_ENABLE

ZW_TIMERx_INT_ENABLE(BYTE bState)

This macro SHOULD be used to enable or disable the Timer0/Timer1 interrupt.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	Mode 0-2: TIMER0/TIMER1 interrupt is enabled Mode 3: TIMER0/TIMER1 high counter interrupt is enabled
	FALSE	Mode 0-2: TIMER0/TIMER1 interrupt is disabled Mode 3: TIMER0/TIMER1 high counter interrupt is disabled

Serial API (Not supported)

4.3.14.5 ZW_TIMER0_ENABLE / ZW_TIMER1_ENABLE

ZW_TIMERx_ENABLE(BYTE bState)

This macro SHOULD be used to enable or halt Timer0/Timer1.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	Mode 0-2: TIMER0/TIMER1 runs Mode 3: Timer0/Timer1 high counter runs
	FALSE	Mode 0-2: TIMER0/TIMER1 is halted Mode 3: Timer0/timer1 high counter is halted

Serial API (Not supported)

4.3.14.6 ZW_TIMER0_ext_clk / ZW_TIMER1_ext_clk

ZW_TIMERx_ext_clk(BYTE bState)

This function SHOULD be used to set the clock source for timer0/timer1

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	Timer0 runs on external clock (falling edge) of P3.4. Timer1 runs on external clock (falling edge) of P3.5. (synchronized to the system clock)
	FALSE	Timer0/Timer1 runs on system clock (divided by 2) - default value after reset

Serial API (Not supported)

4.3.14.7 ZW_TIMER0_LOWBYTE_SET / ZW_TIMER1_LOWBYTE_SET

ZW_TIMERx_LOWBYTE_SET (BYTE bValue)

This macro SHOULD be used to set the timer0/timer1 low byte value, see below.

Defined in: ZW_apptimer_api.h

Parameters:

bValue IN The input value depends on the chosen mode:

- Mode0: Lower 5 bits sets the prescaler value for the 13 bit timer
- Mode1: Sets the lower 8 bits of the 16 bit timer
- Mode2: N.A.
- Mode3: N.A.

Serial API (Not supported)

4.3.14.8 ZW_TIMER0_HIGHBYTE_SET / ZW_TIMER1_HIGHBYTE_SET

ZW_TIMERx_HIGHBYTE_SET (BYTE bValue)

This macro SHOULD be used to set the timer0/timer1 high byte value, see below.

Defined in: ZW_apptimer_api.h

Parameters:

bValue IN The input value depends on the chosen mode:

- Mode0: Sets the 8 bit timer value
- Mode1: Sets the upper 8 bits of the 16 bit timer
- Mode2: Sets the 8 bit reload value of the 8 bit timer0
- Mode3: N.A.

Serial API (Not supported)

4.3.14.9 ZW_TIMER0_HIGHBYTE_GET / ZW_TIMER1_HIGHBYTE_GET

BYTE ZW_TIMERx_HIGHBYTE_GET

This macro MAY be used to query the timer0/timer1 high register value

Defined in: ZW_apptimer_api.h

Return value:

BYTE The return value depends on the chosen mode:

Mode0: 8 bit timer value
Mode1: upper 8 bits of the 16 bit timer
Mode2: 8 bit timer value
Mode3: N.A.

Serial API (Not supported)

4.3.14.10 ZW_TIMER0_LOWBYTE_GET / ZW_TIMER1_LOWBYTE_GET

BYTE ZW_TIMERx_LOWBYTE_GET

This macro MAY be used to query the timer0/timer1 timer low register value

Defined in: ZW_apptimer_api.h

Return value:

BYTE The return value depends on the chosen mode:

Mode0: 5 bit prescaler value for the 13 bit timer. (lower 5 bits)

Mode1: lower 8 bits of the 16 bit timer

Mode2: 8 bit timer value

Mode3: N.A.

Serial API (Not supported)

4.3.14.11 ZW_TIMER0_word_get / ZW_TIMER1_word_get

WORD ZW ZW_TIMERx_word_get (void)

This function MAY be used to query the two 8 bit timer0/timer1 register values as one 16 bit value. Used when timer0/timer1 is set in mode 1.

Defined in: ZW_apptimer_api.h

Return value:

WORD 16bit timer value

Serial API (Not supported)

4.3.14.12 ZW_GPTIMER_init

void ZW_GPTIMER_init(BYTE bValue)

This function SHOULD be used to initialize the GPTimer. Calling **ZW_GPTIMER_init()** will disable the PWM, since the GP Timer and the PWM share the same hardware resources. The GPTimer is hardcoded to count down.

Defined in: ZW_apptimer_api.h

Parameters:

bValue IN	Bit mask:	
	Prescaler setting	
	PRESCALER_BIT	When set: Timer counter runs @ 32MHz / 1024 = 31.25kHz
		When not set: Timer counter runs @ 32MHz / 8 = 4MHz
	Reload Timer	
	RELOAD_BIT	When set: The GPTimer counter registers are reloaded with the reload register value upon underrun.
		When not set: The GPTimer stops upon underrun.
	Immediate write	
	IMWR_BIT	When set: The GP Timer counters will be loaded with the value of the reload register when it is disabled or immediately when the reload values are set.
		When not set: The GP Timer counters will be loaded with the value of the reload register when it is disabled or when it times out (underrun).

Serial API (Not supported)

4.3.14.13 ZW_GPTIMER_int_clear

void ZW_GPTIMER_int_clear (void)

This function SHOULD be used to clear the GP Timer interrupt flag.

Defined in: ZW_apptimer_api.h

Serial API (Not supported)

4.3.14.14 ZW_GPTIMER_int_get

BYTE ZW_GPTIMER_int_get (void)

This function MAY be used to query the state of the GP Timer interrupt flag.

Defined in: ZW_apptimer_api.h

Return value:

BYTE 0x00: interrupt flag is not set
 mom-0x00: Interrupt is set

Serial API (Not supported)

4.3.14.15 ZW_GPTIMER_int_enable

void ZW_GPTIMER_int_enable(BYTE bState)

This function SHOULD be used to enable or disable the GPTimer interrupt.

The application designer MUST declare an Interrupt Service Routine (ISR) to handle the GP Timer interrupt. The ISR MUST use the ISR number INUM_GP_TIMER as declared in section 3.9.

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	enable GPTimer interrupt
	FALSE	disable GPTimer interrupt

Serial API (Not supported)

4.3.14.16 ZW_GPTIMER_enable

void ZW_GPTIMER_enable(BYTE bState)

This function SHOULD be used to enable or disable the GPTimer.
Disabling the GPTimer also clears the interrupt flag and resets the GPTimer counters.

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	enable GPTimer.
	FALSE	disable GPTimer.

Serial API (Not supported)

4.3.14.17 ZW_GPTIMER_pause

void ZW_GPTIMER_pause(BYTE bState)

This function MAY be used to control the GPTimer pause state.

When entering the pause state, the GPTimer counters stops counting.

When leaving the pause state, the counters will start counting from the state they were in when the pause state was entered.

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	Enter GPTimer pause state.
	FALSE	Leave GPTimer pause state.

Serial API (Not supported)

4.3.14.18 ZW_GPTIMER_reload_set

void ZW_GPTIMER_reload_set(WORD wReloadValue)

This function SHOULD be used to set the 16 bit GPTimer reload register. This value sets the time from where the GPTimer is enabled or is reloaded until it reaches zero (issues an interrupt).

As an example, if the GPTimer reload value is set to 0x0137 and the prescaler is set to 1024, the timer will reach zero after $0x137 * 1024 * (32\text{MHz})^{-1} = 9.95\text{ms}$.

The value 0x0000 equals a timer reload value of 0x10000. E.g. if the GPtimers reload value is set to 0x0000 and the prescaler is set to 8, the timer will reach zero after $0x10000 * 8 * (32\text{MHz})^{-1} = 16.38\text{ms}$.

Defined in: ZW_apptimer_api.h

Parameters:

wReloadValue IN 16 bit reload value

Serial API (Not supported)

4.3.14.19 ZW_GPTIMER_reload_get

WORD ZW_GPTIMER_reload_get(void)

This function MAY be used to query the 16 bit GPTimer reload register value.

Defined in: ZW_apptimer_api.h

Return value:

WORD 16 bit reload value

Serial API (Not supported)

4.3.14.20 ZW_GPTIMER_get

WORD ZW_GPTIMER_get(void)

This function MAY be used to query the 16 bit GPTimer counter register value. The returned value is in the range [reload_value-1;0]. As an example, if the reload value is set to 0x2A40, **ZW_GPTIMER_get()** will return a value in the range [0x2A3F;0].

An application SHOULD be designed to be robust if a higher value is returned, e.g. because the reload value was not correctly stored in the chip.

Defined in: ZW_apptimer_api.h

Return value:

WORD 16 bit counter value

Serial API (Not supported)

4.3.14.21 ZW_PWM_init

void ZW_PWM_init(BYTE bValue)

This function SHOULD be used to initialize the pulse width modulator. Calling **ZW_PWM_init()** will disable the GPTimer function, since the PWM and the GP Timer share the same hardware.

It is NOT RECOMMENDED that Immediate write mode is enabled as it introduces a risk of unintended waveforms.

Defined in: ZW_apptimer_api.h

Parameters:

bValue IN	Bit mask:	
	Prescaler setting	
	PRESCALER_BIT	When set: PWM counter runs @ 32MHz / 1024 = 31.25kHz When not set: PWM counter runs @ 32MHz / 8 = 4MHz
	Invert signal	
	PWMINV_BIT	When set: PWM signal is inverted. When not set: The signal is not inverted
	Immediate write	
	IMWR_BIT	When set: The PWM counters will be loaded with the value of the waveform registers when it is disabled or immediately when the waveform values are set. When not set: The PWM counters will be loaded with the value of the waveform registers when it is disabled or at the end of a PWM signal period.

Serial API (Not supported)

4.3.14.22 ZW_PWM_enable

void ZW_PWM_enable(BYTE bState)

This function SHOULD be used to enable or disable the PWM.
Disabling the PWM also clears the interrupt flag and resets the PWM counter.

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	enable PWM.
	FALSE	disable PWM.

Serial API (Not supported)

4.3.14.23 ZW_PWM_int_clear

void ZW_PWM_int_clear (void)

This function SHOULD be used to clear the PWM interrupt flag.

Defined in: ZW_apptimer_api.h

Serial API (Not supported)

4.3.14.24 ZW_PWM_int_get

BYTE ZW_PWM_int_get (void)

This function MAY be used to query the state of the PWM interrupt flag.

Defined in: ZW_apptimer_api.h

Return value:

BYTE 0x00: interrupt flag is not set
 non-0x00: Interrupt is set

Serial API (Not supported)

4.3.14.25 ZW_PWM_int_enable

void ZW_PWM_int_enable(BYTE bState)

This function SHOULD be used to enable or disable the PWM interrupt.

The PWM interrupt is triggered on the rising edge of the PWM signals (or at the falling edge of the PWM signal if PWMINV_BIT is set in ZW_PWM_init()).

The application designer MUST declare an Interrupt Service Routine (ISR) to handle the PWM controller interrupt. The ISR MUST use the ISR number INUM_GP_TIMER as declared in section 3.9.

Section 4.3.14.25 recommends that Immediate write is not enabled. With Immediate write disabled, the application may unintentionally inhibit the flow of IRQs from the PWM controller. This may happen if the application calls ZW_PWM_waveform_set with the parameter value (0,0). Refer to 4.3.14.26 on how to recover from this situation.

Defined in: ZW_apptimer_api.h

Parameters:

bState IN	TRUE	enable PWM interrupt
	FALSE	disable PWM interrupt

Serial API (Not supported)

4.3.14.26 ZW_PWM_waveform_set

**void ZW_PWM_waveform_set (BYTE bHigh,
BYTE bLow)**

This function SHOULD be used to set the high and low time of the PWM signal. Refer to figure below.

High time of PWM signal: $t_{hPWM} = (bHigh * PRESCALER) / f_{sys}$
 Low time of PWM signal: $t_{lPWM} = (bLow * PRESCALER) / f_{sys}$
 Total period of PWM signal: $T_{PWM} = t_{hPWM} + t_{lPWM}$

where f_{sys} is 32MHz and
 PRESCALER is 1024 when PRESCALER_BIT is set by ZW_PWM_init() and
 PRESCALER is 8 when PRESCALER_BIT is not set.

NOTE: If PWMINV_BIT was set by ZW_PWM_init(), bHigh defines the duration of the low period and bLow defines the duration of the high period..

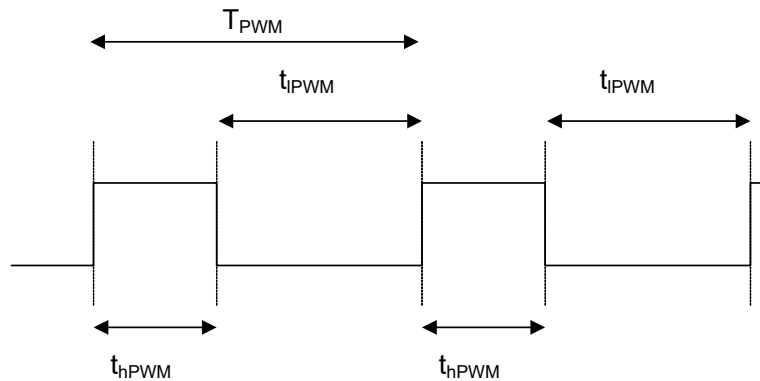


Figure 19. PWM Waveform

Section 4.3.14.25 recommends that Immediate write is not enabled. With Immediate write disabled, the application SHOULD NOT call ZW_PWM_waveform_set with the parameter value (0,0). In case the parameter value (0,0) has been used, the application MUST call ZW_PWM_waveform_set with one or two non-zero values and subsequently disable and re-enable the PWM controller by calling ZW_PWM_enable.

While NOT RECOMMENDED, Immediate write MAY be enabled. In that case, the application MAY call ZW_PWM_waveform_set with any parameter value.

Defined in: ZW_apptimer_api.h

Parameters:

bHigh IN high time

bLow IN low time

Serial API (Not supported)

4.3.14.27 ZW_PWM_waveform_get

```
void ZW_waveform_get(BYTE *bHigh,  
                    BYTE *bLow)
```

This function MAY be used to query the values of the waveform registers.

Defined in: ZW_apptimer_api.h

Parameters:

bHigh OUT high time

bLow OUT low time

Serial API (Not supported)

4.3.15 Security API

This API handles security keys on application level.

4.3.15.1 ZW_GetSecurityKeys (Only slave libraries)

BYTE ZW_GetSecurityKeys()

This function returns a bitmask of security keys the node posses. The application can request **ZW_SendDataEx()** to use these keys for outgoing messages. Incoming messages sent with any of these keys will be decrypted and delivered to the application. An excluded node returns no security keys.

Defined in: ZW_security_api.h

Parameters:

BYTE OUT Bit mask:

0x00 = SECURITY_KEY_NONE_MASK No security keys

0x01 = SECURITY_KEY_S2_UNAUTHENTICATED_BIT

0x02 = SECURITY_KEY_S2_AUTHENTICATED_BIT

0x04 = SECURITY_KEY_S2_ACCESS_BIT

0x80 = SECURITY_KEY_S0_BIT

Serial API

HOST->ZW: REQ | 0x9C | 0

ZW->HOST: RES | 0x9C | 0 | securityKeys_bitmaskLen(1) | securityKeys_bitmask

In the Serial API the Security API functions are reached through the FUNC_ID_ZW_SECURITY_SETUP (0x9C) and this Serial API FUNC_ID makes it possible to set the Requested Security Keys and Requested Authentication method in a Slave Routing/Enhanced 232 based Serial API Node prior to inclusion (add). The Requested Security Keys and Authentication is requested by the protocol during S2 inclusion.

Set Requested Security Inclusion Keys

(E_SECURITY_SETUP_CMD_SET_SECURITY_INCLUSION_REQUESTED_KEYS):

HOST->ZW: REQ | 0x9C | 5 | registeredSecurityKeysLen(1) | registeredSecurityKeys

ZW->HOST: RES | 0x9C | 5 | retValLen(1) | retVal - retVal == TRUE => success

Set Requested Security Inclusion Authentication

(E_SECURITY_SETUP_CMD_SET_SECURITY_INCLUSION_REQUESTED_AUTHENTICATION):

HOST->ZW: REQ | 0x9C | 6 | registeredSecurityAuthenticationLen(1) | registeredSecurityAuthentication

ZW->HOST: RES | 0x9C | 6 | retValLen(1) | retVal - retVal == TRUE => success

4.3.15.2 ZW_s2_inclusion_init(Only slave libraries)

void ZW_s2_inclusion_init(void)

Initialises the S2 inclusion machine. Must only be called if Requested Security Keys or Requested Authentication method is changed.

Defined in: ZW_security_api.h

Serial API

Not implemented. SerialAPI Application calls ZW_s2_inclusion_init() when changing either the Requested Security Keys or the Requested Authentication Method (See 4.3.15.1).

4.3.15.3 ZW_SetSecurityS2InclusionPublicDSK_CSA(Only slave libraries)

```
void ZW_SetSecurityS2InclusionPublicDSK_CSA(s_SecurityS2InclusionCSAPublicDSK_t  
*response)
```

Set the Controller DSK requested by protocol through ApplicationSecurityEvent with the Security Event E_APPLICATION_SECURITY_EVENT_S2_INCLUSION_REQUEST_DSK_CSA.

Defined in: ZW_security_api.h

Parameters:

s_SecurityS2InclusionCSAPublicDSK_t* IN response->aCSA_DSK[4] Pointer to 4 BYTE
Public CSA DSK

Serial API

HOST->ZW: REQ | 0x9C | 4 | bCSA_DSKLen(4) | aCSA_DSK[4]

ZW->HOST: RES | 0x9C | 4 | retValLen(1) | retVal - retVal == TRUE => success

4.3.15.4 ZW_GetSecurityS2PublicDSK(Only slave libraries)

void ZW_GetSecurityS2PublicDSK(BYTE *buf)

This function returns the 16 byte Public DSK for the node in the 16 byte long array buf points to – buf most point to an array at least 16 byte in size. Can be used to do S2 SSA Authenticated inclusion (add) by using the returned DSK to present to user which then must enter the needed part of the DSK on the Controller when doing Authenticated S2 inclusion.

Defined in: ZW_security_api.h

Parameters:

BYTE OUT	*buf	Pointer to 16 byte array the DSK should be written to.
----------	------	--

Serial API

HOST->ZW: REQ | 0x9C | 2

ZW->HOST: RES | 0x9C | 2 | publicDSKLen(16) | publicDSK[16]

4.3.15.5 ZW_SetSecurityS2CriticalNodeID (Only routing slave library)

void ZW_SetSecurityS2CriticalNodeID(BYTE bNodeID)

This function set the S2 Critical NodeID used when a S2 included slave_routing based node enter sleepmode. When Sleepmode is entered the SPAN used in connection with S2 communicating with the Critical NodeID is saved in Retention RAM and restored when wakeup. This makes SPAN resync not necessary when communicating with the Critical NodeID after wakeup.

Defined in: ZW_security_api.h

Parameters:

BYTE IN	bNodeID:	
	0	Save MRU SPAN in retention RAM when going into Sleep Mode.
	1 – 232	Save SPAN concerning bNodeID (if present) in retention when going into Sleep Mode.
	233 – 255	Reserved.

Serial API

HOST->ZW: REQ | 0x9C | 3 | bNodeIDLen(1) | nodeID

ZW->HOST: RES | 0x9C | 3 | retValLen(1) | retVal - retVal == TRUE => success

4.3.15.6 ZW_SetSecurityS0NetworkKey (Only enhanced 232 slave library)

void ZW_SetSecurityS0NetworkKey(BYTE *network_key)

This function is only used after a firmware update of an application that is securely included in a S0 based network. The call transfer the S0 network key from the application area in external NVM to the Z-Wave Protocol area in external NVM.

Defined in: ZW_security_api.h

Parameters:

network_key IN	Array of 16 bytes	Pointer to byte array containing the S0 network key
----------------	-------------------	---

Serial API

HOST->ZW: REQ | 0x9C | 1 | networkkeyLen(16) | network_key[16]

ZW->HOST: RES | 0x9C | 1 | retValLen(1) | retVal - retVal == TRUE => success

retVal = FALSE if ZW_SetSecurityS0NetworkKey was NOT called (network_key must be 16 bytes)

retVal = TRUE if ZW_SetSecurityS0NetworkKey was called with specified network_key

4.3.16 AES API

The built-in AES-128 hardware engine is a NIST standardized AES 128 block cipher. The cipher engine is used by the Z-Wave Protocol to encrypt/decrypt Z Wave frame payload and to authenticate Z Wave frames. In addition this AES-128 encryption engine can also be used to encrypt a 128bit data block (Using ECB - Electronic CookBook mode) by the application.

The input and output data and key for the AES API's are 16 bytes long char arrays. **ZW_AES_ecb_set** is used to set the input data (plaintext and key) and the function **ZW_AES_ecb_get** is used to return the cipher data from the AES engine. The ECB process is started using the function **ZW_AES_ecb_enable(TRUE)** and it lasts about 24µs. The process can be canceled by calling **ZW_AES_ecb_enable(FALSE)**. The AES engine must be polled, using the function **ZW_AES_ecb_active** to check when a ECB process is done. Figure below gives an example of how the AES engine functions are called.

```
/* Example of ECB ciphering. Vectors are from FIPS-197 */

void ApplicationPoll()
{
    :
    switch (mainState)
    {
        :
        case START_AES_TEST:
            keybuffer[15] = 0x00;
            keybuffer[14] = 0x01;
            keybuffer[13] = 0x02;
            keybuffer[12] = 0x03;
            keybuffer[11] = 0x04;
            keybuffer[10] = 0x05;
            keybuffer[9] = 0x06;
            keybuffer[8] = 0x07;
            keybuffer[7] = 0x08;
            keybuffer[6] = 0x09;
            keybuffer[5] = 0x0A;
            keybuffer[4] = 0x0B;
            keybuffer[3] = 0x0C;
            keybuffer[2] = 0x0D;
            keybuffer[1] = 0x0E;
            keybuffer[0] = 0x0F;

            plainbuffer[15] = 0x00;
            plainbuffer[14] = 0x11;
            plainbuffer[13] = 0x22;
            plainbuffer[12] = 0x33;
            plainbuffer[11] = 0x44;
            plainbuffer[10] = 0x55;
            plainbuffer[9] = 0x66;
            plainbuffer[8] = 0x77;
            plainbuffer[7] = 0x88;
            plainbuffer[6] = 0x99;
            plainbuffer[5] = 0xAA;
            plainbuffer[4] = 0xBB;
            plainbuffer[3] = 0xCC;
            plainbuffer[2] = 0xDD;
            plainbuffer[1] = 0xEE;
            plainbuffer[0] = 0xFF;

            cipherbuffer[15] = 0x69;
            cipherbuffer[14] = 0xC4;
            cipherbuffer[13] = 0xE0;
            cipherbuffer[12] = 0xD8;
```

```
    cipherbuffer[11] = 0x6A;
    cipherbuffer[10] = 0x7B;
    cipherbuffer[9] = 0x04;
    cipherbuffer[8] = 0x30;
    cipherbuffer[7] = 0xD8;
    cipherbuffer[6] = 0xCD;
    cipherbuffer[5] = 0xB7;
    cipherbuffer[4] = 0x80;
    cipherbuffer[3] = 0x70;
    cipherbuffer[2] = 0xB4;
    cipherbuffer[1] = 0xC5;
    cipherbuffer[0] = 0x5A;
    /* Set AES ECB input data pointers */
    ZW_AES_ecb_set(plainbuffer, keybuffer);
    /* Start AES ECB function */
    ZW_AES_enable(TRUE);
    mainState= WAIT_AES_ECB;
    break;
case WAIT_AES_ECB:
    /* Check to see if AES ECB procedure is done */
    if (ZW_AES_active_get() == FALSE)
    {
        ZW_AES_ecb_get(plainbuffer);
        /* check against proven data */
        fail=FALSE;
        for (i=0; i<16; i++)
        {
            if (plainbuffer[i] != cipherbuffer[i])
            {
                fail=TRUE;
                break;
            }
        }
        if (fail) report();

        mainState= IDLE;
    }
    :
    break;
}
```

Figure 20. Example of ECB Cipherng. Vectors are from FIPS-197.

4.3.16.1 ZW_AES_ecb_set

```
void ZW_AES_ecb_set( BYTE *bData,  
                   BYTE *bKey)
```

Call this function to setup the input data for the AES in ECB mode (Electronic Cookbook mode). Use the function `ZW_AES_swap_byte` to swap the order of which the data from the array is read into the AES engine.

Defined in: `ZW_aes_api.h`

Parameters:

<code>bData</code>	Array of 16 bytes	Pointer to byte array containing the data to be encrypted.
<code>bKey</code>	Array of 16 bytes	Pointer to byte array containing the encryption key

Serial API (Not supported)

4.3.16.2 ZW_AES_ecb_get

void ZW_AES_ecb_get(BYTE *bData)

After calling **ZW_AES_ecb_set** , use **ZW_AES_active_get** to see if the AES process is done. When this is the case, call **ZW_AES_ecb_get** to transfer the result of a AES ECB process to the array bData. Use the function **ZW_AES_swap_byte** to swap the order of which the data from the array is read from the AES engine.

Defined in: ZW_aes_api.h

Parameters:

bData	Array of 16 bytes	Pointer to byte array buffer containing encrypted data
-------	-------------------	--

Serial API (Not supported)

4.3.16.3 ZW_AES_enable

void ZW_AES_enable(BOOL bState)

Call **ZW_AES_enable(TRUE)** to enable the AES engine and start the ECB process. The AES engine will automatically be disabled when a ECB process is done. Call **ZW_AES_enable(FALSE)** if a ECB process is to be canceled.

Defined in: ZW_aes_api.h

Parameters:

bState	TRUE	Enable the AES and start the ECB mode.
	FALSE	Disable the AES.

Serial API (Not supported)

4.3.16.4 ZW_AES_swap_data

void ZW_AES_swap_data(BOOL bState)

The function is used to enable the option to swap the byte order of the data read into and read from the the AES engine.

Defined in: ZW_aes_api.h

Parameters:

bState	TRUE	Swap data bytes.
	FALSE	Do not swap data bytes

Serial API (Not supported)

4.3.16.5 ZW_AES_active_get

BYTE ZW_AES_active_get (void)

Returns the active/idle state of the AES engine. Use this function to see when a ECB process is done.

Defined in: ZW_aes_api.h

Return value:

BOOL	TRUE	The AES is busy.
	FALSE	The AES is idle.

Serial API (Not supported)

4.3.16.6 ZW_AES_int_enable_get

void ZW_AES_int_enable (BYTE bState)

Call this function to enable or disable AES interrupts.

Defined in: ZW_aes_api.h

Parameters:

bState IN	TRUE	The AES interrupt is enabled.
	FALSE	The AES interrupt is disabled

Serial API (Not supported)

4.3.16.7 ZW_AES_int_get

BYTE ZW_AES_int_get (void)

The function return the state of the AES interrupt flag.

Defined in: ZW_aes_api.h

Return value:

BYTE	0x00	The AES interrupt flag is set
	non-0x00	The AES interrupt flag is cleared

Serial API (Not supported)

4.3.16.8 ZW_AES_int_clear

void ZW_AES_int_clear (void)

Call this function to clear the AES interrupt flag.

Defined in: ZW_aes_api.h

Serial API (Not supported)

4.3.16.9 ZW_AES_ecb/ZW_AES_ecb_dma

```

BYTE ZW_AES_ecb ( BYTE *bKey
                  BYTE *bInput
                  BYTE *bOutput)
BYTE ZW_AES_ecb_dma (BYTE *bKey
                    BYTE *bInput
                    BYTE *bOutput)

```

These functions execute a AES-128 ECB task and return the encrypted data. Once started the functions will be blocking until the task is done. The function **ZW_AES_ecb_dma** will use the built-in DMA function to transfer data between the AES engine and the XRAM, whereas the data handling will be done purely by the 8051 using the function **ZW_AES_ecb** . Use the function **ZW_AES_swap_byte** to swap the order of which the data bytes from the array are written to and read from the AES engine.

Defined in: ZW_aes_api.h

Parameters:

*bKey IN	pointer to byte array in lower 4kB XRAM containing the input data (16 bytes)	
*bInput IN	pointer to byte array in lower 4kB XRAM containing the key (16 bytes)	The AES is idle.
*bOutput OUT	pointer to byte array in lower 4kB XRAM containing the output data (16 bytes)	The AES is idle.

Serial API (Not supported)

4.3.17 TRIAC Controller API

The built-in TRIAC Controller is targeted at controlled light / power dimming applications. The Triac Controller is able to drive both TRIAC's and FET's/IGBT's. The Triac Controller can dim the load with a precision of 1000 steps in each half-period.

When controlling TRIAC's the Triac Controller will generate one or more fire pulses in each half period of the mains to turn on the Triac. The fire angle is set by the specified dim level. The Triac Controller will generate multiple pulses if the fire angle is less than 90°. The multiple pulses ensure that at least one pulse is located after the middle of a half-period, thereby ensuring that the Triac will be fired even with fully inductive loads, while still limiting the current consumption.

When controlling a FET/IGBT the Triac Controller will generate a fire pulse with a width that is proportional to the dim level. The pulse can be either leading or falling edge controlled.

The Triac Controller can operate in both 50Hz and 60Hz environments.

The application software can use the following TRIAC API calls to control the 500 Series Z-Wave SoC TRIAC Controller.

4.3.17.1 ZW_TRIAC_init

```

BYTE ZW_TRIAC_init(BYTE bMode,
                   WORD wPulseLength,
                   BYTE bPulseRepLength,
                   BYTE bZeroXMode,
                   BYTE blnitMask,
                   BYTE blnvZerox,
                   BYTE bMainsFreq,
                   WORD wCorrection,
                   BYTE bCorPrescale,
                   BYTE bKeepOff)

```

ZW_TRIAC_init initializes the 500 Series Z-Wave SoC's integrated TRIAC controller. Refer to the section after the function parameter list for a description of the setup of the different zero-cross modes (page 283). Place this function call in **ApplicationInitHW**.

Defined in: ZW_triac_api.h

Parameters:

bMode IN	Mode of operation:	
	TRIAC_MODE	Triac mode. Multiple short pulses before 90 degrees and single short pulse after 90 degrees
	FET_TRAILING_EDGE_MODE	FET/IGBT trailing edge mode. Single pulse control signal (TRIAC) which goes high at 0° and low in 0-180° depending of dim level
	FET_LEADING_EDGE_MODE	FET/IGBT leading edge mode. Single pulse control signal (TRIAC) which goes high at 0-180° depending of dim level and goes low at the next zero-cross
wPulseLength IN	Triac Fire pulse length	<i>Not applicable in FET Modes, where this value must be set to 0</i>
	Legal values: 1-250 (Triac mode)	
	Each step equals $\frac{n}{32MHz}$, where n is	Set this parameter so that is equals the minimum Triac gate high time according to the datasheet of the specific Triac in use.
	265 in 60Hz systems	
	318 in 50Hz systems	The pulse length can not exceed a quarter of the halfperiod length. E.g. for a 50Hz system the pulse length can not exceed 10ms/4=2.5ms.
	E.g. setting this parameter to 40 in a 50Hz system gives a Triac pulse	
	length of $40 \cdot \frac{318}{32MHz} = 397.5us$	These relations must be fulfilled: bPulseRepLength*4+wPulseLength<500 bPulseRepLength*4 > wPulseLength

bPulseRepLength IN	<p>Triac fire pulse repetition period</p> <p>Legal values: 18-125</p> <p>Each step equals $\frac{4 \cdot n}{32MHz}$, where n is</p> <p>265 in 60Hz systems 318 in 50Hz systems</p> <p>i.e., setting this parameter to 20 in a 50 Hz system gives a Triac pulse length of $20 \cdot \frac{4 \cdot 318}{32MHz} = 795us$</p>	<p>Not applicable in FET Mode (Where it must be set to 0)</p> <p>This parameter sets the period from the rising edge of one fire pulse to the rising edge of the next fire pulse.</p> <p>The Triac Controller will generate multiple fire pulses when the fire angle is less than 90°</p> <p>These relations must be fulfilled: bPulseRepLength*4+wPulseLength>500 bPulseRepLength > wPulseLength/4</p>
bZeroXMode IN	<p>Bridge types:</p> <p>TRIAC_FULLBRIDGE</p> <p>TRIAC_HALFBRIDGE_A</p> <p>TRIAC_HALFBRIDGE_B</p>	<p>The TRIAC signal is sync'ed to</p> <ul style="list-style-type: none"> - the rising edges of the ZEROX signal if blnvZerex is FALSE. <p>or</p> <ul style="list-style-type: none"> -the falling edges of the ZEROX signal if blnvZerex is TRUE. <p>The TRIAC signal is sync'ed to the rising and the falling edges of the ZEROX signal.</p> <p>The TRIAC signal is sync'ed to</p> <ul style="list-style-type: none"> - the rising edge of the ZEROX signal in every second halfperiod if blnvZerex is FALSE <p>or</p> <ul style="list-style-type: none"> - the falling edge of the ZEROX signal in every second halfperiod if blnvZerex is TRUE
blnitMask IN	<p>Initial zero-cross mask:</p> <p>TRUE</p> <p>FALSE</p>	<p>Mask out noise impulses on the mains from the point of a detected zero-cross to the start of the Triac fire pulse</p> <p>Do not Mask out impulse noise on the mains from the point of a detected zero-cross to the start of the Triac fire pulse</p>

bInvZeroX IN	Inverse zero-cross signal:	
	TRUE	Inverse zero-cross signal
	FALSE	Do not inverse zero-cross signal
bMainsFreq IN	AC mains frequency:	
	FREQUENCY_50HZ	Using 50Hz AC mains supply
	FREQUENCY_60HZ	Using 60Hz AC mains supply
wCorrection IN	ZeroX Duty-Cycle correction	Half Bridge Mode A:
	<p>Legal values: 0-1023.</p> <p>The Triac controller has a timer, that can compensate for a non-50/50 duty cycle of the ZeroX signal when using Half Bridge Mode A or to adjust the starting point of the second half period when using Half Bridge Mode B.</p> <p>The timer can run on a prescaled clock (see bCorPrescale below)</p> <p>In other words, setting this parameter to 300 and bCorPrescale to '1' gives a correction of</p> $300 \cdot \frac{3}{32MHz} = 28.1\mu s .$	<p>The parameter is used to compensate from a ZeroX signal duty-cycle that is not exactly 50/50, in half bridge mode A.</p> <p>Typically, the high time of a ZeroX signal in half bridge mode is shorter than the low time. In this case, setting this parameter to value greater than 0, can correct this mismatch. If the high time is n ns longer than the low time, this parameter should be set so that it equals n/2 ns.</p> <p>Half Bridge Mode B:</p> <p>60Hz systems: This value should be set to $\left[26 + 88 \frac{1}{3} \cdot bKeepOff \right]$</p> <p>50Hz systems: This value should be set to $31 + 106 \cdot bKeepOff$</p> <p>Full Bridge Mode:</p> <p>N.A. (Set this value to 0)</p>

bCorPrescale	<p>Correction prescaler</p> <p>Legal values: 0: Prescaler disabled 1: Prescaler enabled</p>	<p>When this parameter is set to 1, the clock signal that is used for the correction timer (see under <code>wCorrection</code> above) is prescaled by a factor of 3. That is, the timer clock will run at 32MHz/3~10.67MHz</p> <p>When this parameter is set to 0, the correction timer will run using the system clock (32.00MHz).</p> <p>Half Bridge Mode A:</p> <p style="padding-left: 40px;">Set this parameter to 1 if the needed correction has to be longer than $1023 \cdot (32\text{MHz})^{-1} = 31.97 \mu\text{s}$</p> <p>Half Bridge Mode B:</p> <p style="padding-left: 40px;">N.A. (Set this value to 0)</p> <p>Full Bridge Mode:</p> <p style="padding-left: 40px;">N.A. (Set this value to 0)</p>
bKeepOff	<p>KeepOff distance</p> <p>Legal values: 0-9</p> <p>Use this parameter to specify the minimum distance from the falling edge of the Triac pulse to the zero cross of the mains signal (ZeroX).</p> <p>This parameter will also specify the distance from where the Triac controller starts looking for a new ZeroX to the nominal ZeroX point. That is, use this parameter in regions where the mains frequency has large deviations.</p>	<p>The distance for a nominal 50Hz mains will be:</p> $2.9 \mu\text{s} + \left\lfloor \frac{bKeepOff}{4} \right\rfloor \cdot \frac{318 \cdot 4}{32 \text{MHz}}$ <p>The distance for a nominal 60Hz mains can be calculated as:</p> $2.4 \mu\text{s} + \left\lfloor \frac{bKeepOff}{4} \right\rfloor \cdot \frac{265 \cdot 4}{32 \text{MHz}}$

Return values:

BYTE	0x00	OK
	0x01	Error: <code>bPulseRepLength < wPulseLength/4</code> :
	0x02	Error: <code>bPulseRepLength < 18</code>
	0x03	Error: <code>bPulseRepLength*4+wPulseLength>500</code>

Serial API (Not supported)

4.3.17.1.1 Zero-x configuration

Half bridge A:

In this mode, the Triac Controller uses both edges on the zero-cross signal for each period of the mains signal. That is, the zero-cross signal is expected to go high at the beginning of the mains period and the go low at the next zero-cross, as depicted in figure below. Since this is not usually the case, because of input threshold level the duty cycle, the rising edge is delayed, and the falling edge is too early. This results in a non-50/50 duty cycle, which again will result in a DC voltage over the Triac load. Use the parameters `wCorrection` and `bCorPrescale` to correct the duty-cycle, and thereby to get rid of the DC voltage. Setting these parameters will “delay” the falling edge in the Triac controller, as depicted in figure below.

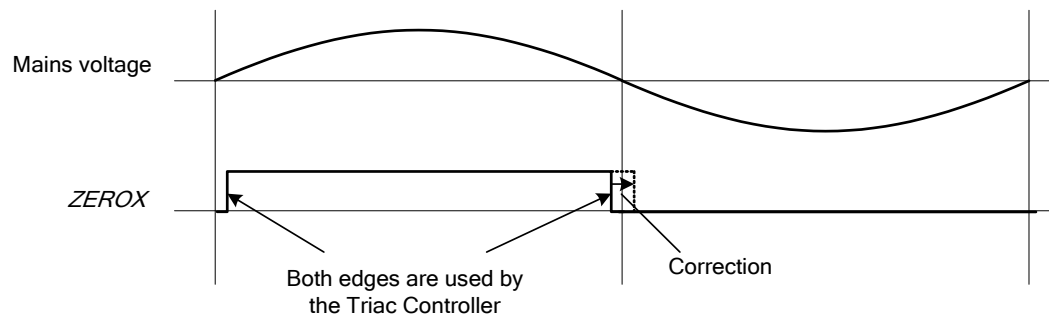


Figure 21. Half-Bridge A Zero-x Signal

Half bridge B:

In this mode, the Triac Controller only uses one edge on the zero-x signal for each period of the mains signal. That is, the zero-x signal is expected to go high at the beginning of the mains period and the go low before the beginning of the next period, as depicted in figure below.

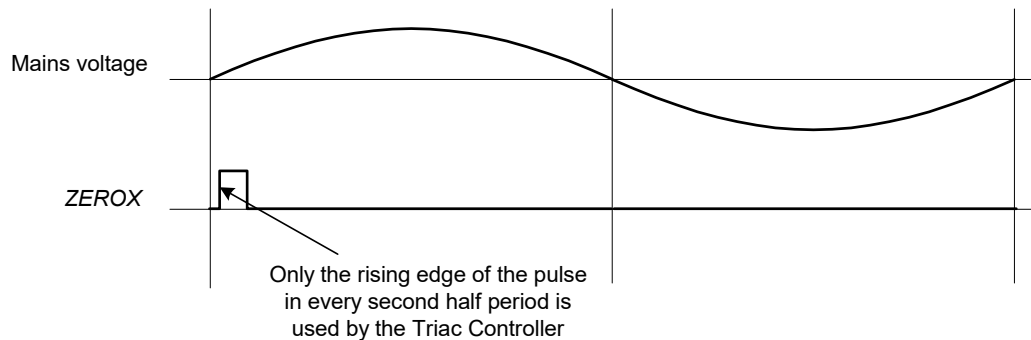


Figure 22. Example of Half-Bridge B Zero-x Signal

Full Bridge:

In this zero-x mode, the Triac Controller uses two rising edges on the zero-cross signal for each period of the mains signal. That is, the zero-cross signal is expected to go high at the beginning of the mains period and the go low before the beginning of the next half-period, then high again after the following zero-cross, and finally low again before the end of the period, as depicted in the two figures below.

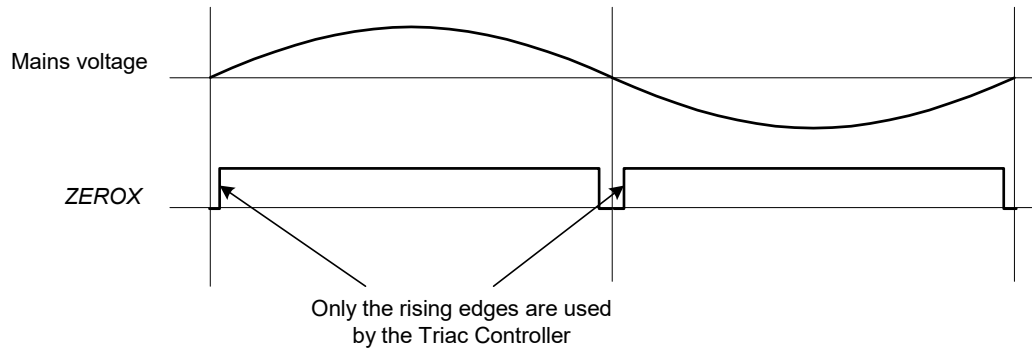


Figure 23. Example 1 of a Full Bridge Zero-x Signal

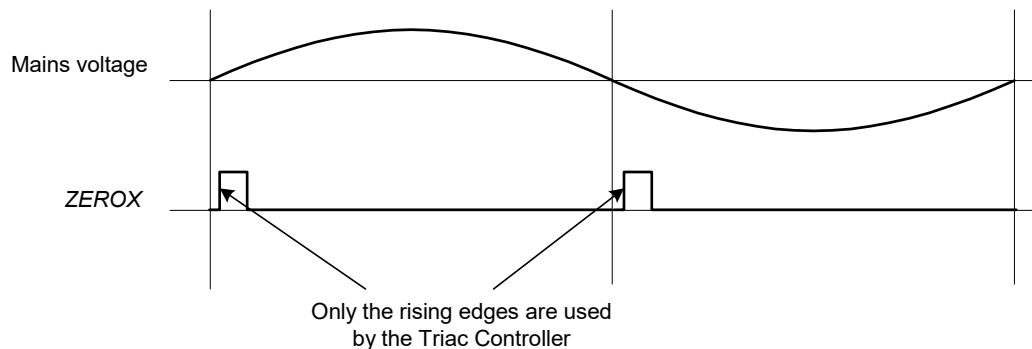


Figure 24. Example 2 of a Full Bridge Zero-x Signal

Zero-x mask

Once the Triac Controller is started, the ZEROX signal is masked off the whole half period, except for a short period just before the next zero-cross. This period can be adjusted using the parameter `bKeepOff`. See figure below

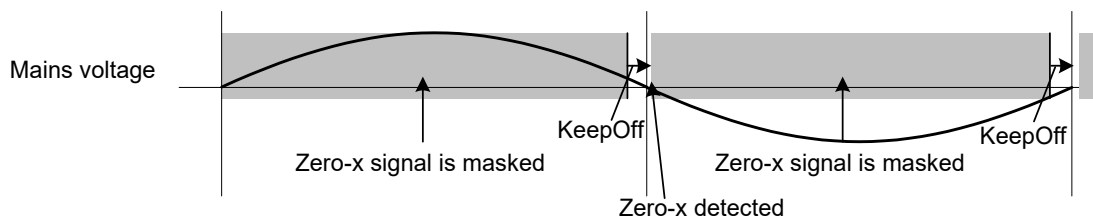


Figure 25. Masked Zero-X Signal

4.3.17.1.2 Modes of Operation

The Triac controller can operate in three modes:

- Triac mode
- FET trailing edge mode (for FET's and IGBT's)
- FET leading edge mode (for FET's and IGBT's)

Triac Mode

In Triac Mode the Triac Controller will generate multiple pulses if the fire angle is less than 90° . The length of each of the pulses is set by the parameter `wPulseLength` and the repetition length is set by the parameter `wPulseReplength`. Depending on the dimming level the number of pulses will automatically be calculated so that at least one full pulse is generated in the period from 90° to 180° of a halfperiod. One pulse will be generated if the dimming level is set so that the first pulse is in the period from 90° to 180° of a halfperiod. The dimming level, i.e., position of the first pulse, is set by the function `ZW_TRIAC_dimlevel_set`. See figure below.

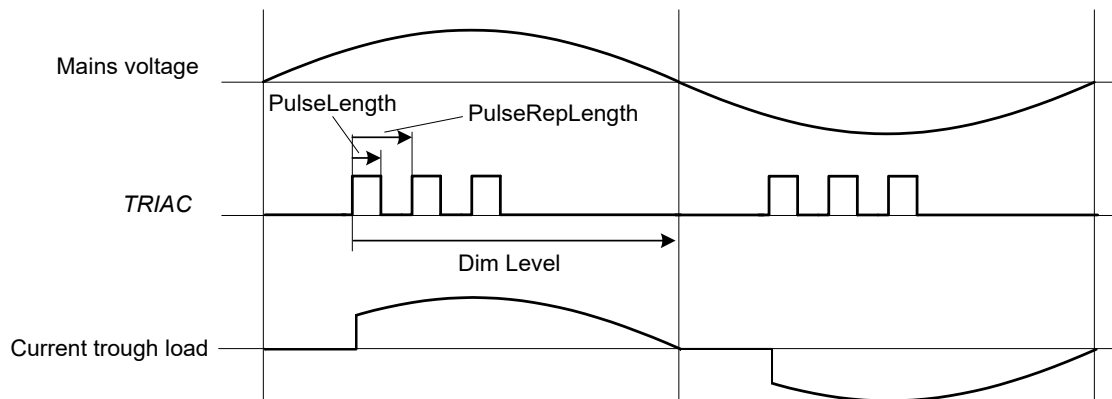


Figure 26. PulseLength and PulseReplength used in Triac Mode (Resistive Load)

FET/IGBT Modes

In the FET/IGBT Modes the Triac Controller will generate one pulse per half period. The length of the pulse is set by the function `ZW_TRIAC_dimlevel_set()`. In FET trailing edge mode the FET/IGBT control signal (TRIAC) is set high at the zero-cross at 0° and set low in the halfperiod from 0° to 180° depending of the dim level. See Figure 27. In FET leading edge mode the FET/IGBT control signal (TRIAC) is set high in the halfperiod from 0° to 180° depending of the dim level and set low before the next zero-cross at 180° . See Figure 28

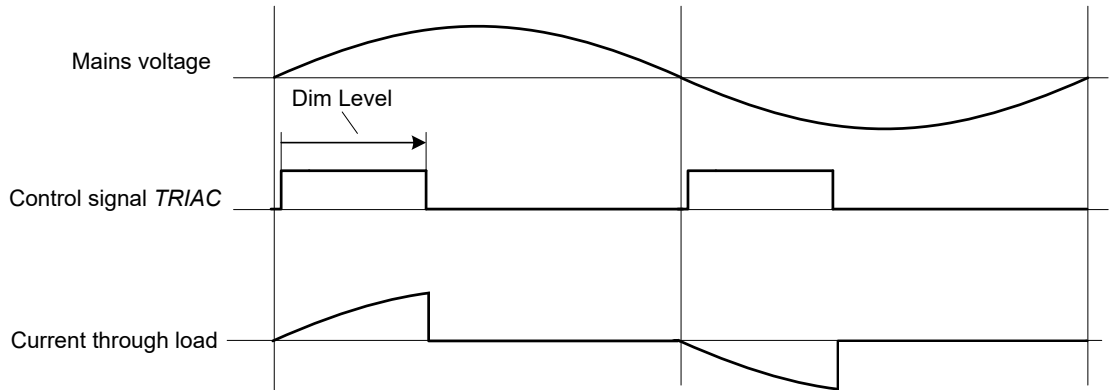


Figure 27 TRIAC Output in FET Trailing Edge Mode (Example with Resistive Load)

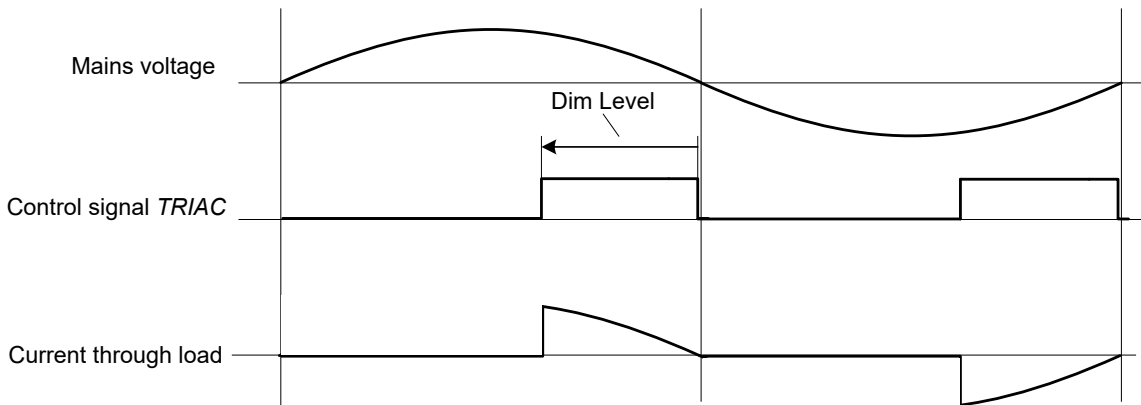


Figure 28 TRIAC Output in FET Leading Edge Mode (Example with Resistive Load)

4.3.17.2 ZW_TRIAC_enable

void ZW_TRIAC_enable(BOOL boEnable)

ZW_TRIAC_enable enables/disables the Triac Controller. When enabled the Triac controller takes control over the TRIAC (P3.6) and the ZEROX¹ (P3.7) pins. **ZW_TRIAC_init** must have been called before the Triac Controller is enabled.

Note: Calling **ZW_TRIAC_enable(TRUE)** will (besides from enabling the Triac Controller Fire signal output) disable the Triac Controller ZEROX interrupt. So to use both the Triac Controller for generating the Fire signal output and the zero-x interrupt first call **ZW_TRIAC_enable(TRUE)** then call **ZW_TRIAC_int_enable(TRUE)**.

Defined in: ZW_triac_api.h

Parameters:

boEnable IN TRUE or FALSE

TRUE: enables the Triac Controller

Serial API (Not supported)

¹ If the PWM is enabled, see `ZW_PWM_enable()`, then the PWM will control the P3.7 pin

4.3.17.3 ZW_TRIAC_dimlevel_set

BOOL ZW_TRIAC_dimlevel_set(WORD wLevel)

ZW_TRIAC_dimlevel_set turns the Triac controller on and sets the dimming level. **ZW_TRIAC_init** must have been called before the Triac Controller is started.

Defined in: ZW_triac_api.h

Parameters:

wLevel IN Dimming level (0-1000),
where 0 is shut off and 1000 is full on

Return values:

BOOL	TRUE	The new dim level has been accepted by the Triac Controller
	FALSE	The Triac Controller has not yet read in the previous dim level. Wait up to one half period of the mains signal (50Hz: 10ms, 60 Hz 8.33ms) and try again

Serial API (Not supported)

4.3.17.4 ZW_TRIAC_int_enable

void ZW_TRIAC_int_enable(BYTE boEnable)

ZW_TRIAC_int_enable enables/disables the zero cross (ZeroX) interrupt. The ZeroX interrupt is issued when the TRIAC controller detects a zero cross on the ZEROX signal. Hence, the Triac Controller will take control of the ZEROX pin (P3.7) when **ZW_TRIAC_int_enable(TRUE)** has been called.

The ZeroX interrupt can be used to implement a SW based TRIAC controller where the TRIAC signal is controlled by the SW. The Triac Controller will generate the ZeroX interrupt when it detects a zero cross on the ZEROX signal, even if the Triac Controller has been disabled (by calling **ZW_TRIAC_int_enable(FALSE)**) as long as **ZW_TRIAC_int_enable(TRUE)** has been called.

Defined in: ZW_triac_api.h

Parameters:

boEnable IN	TRUE	Enable the interrupt. The Triac controller will issue an interrupt when a zero cross is detected on the ZEROX signal.
	FALSE	Disable the Triac interrupt.

Serial API (Not supported)

The interrupt number is set by the define, INUM_TRIAC, as described in ZW050x.h

4.3.17.5 ZW_TRIAC_int_get

BOOL ZW_TRIAC_int_get(void)

ZW_TRIAC_int_get returns the state of the Triac Controller interrupt flag. Call **ZW_TRIAC_int_enable(TRUE)** to enable the interrupt.

Defined in: ZW_triac_api.h

Return values:

BOOL	TRUE	The Triac Controller interrupt flag is set.
	FALSE	The Triac Controller interrupt flag is cleared.

Serial API (Not supported)

4.3.17.6 ZW_TRIAC_int_clear

void ZW_TRIAC_int_clear(void)

ZW_TRIAC_int_get clears the Triac Controller interrupt flag. Call **ZW_TRIAC_int_enable(TRUE)** to enable the interrupt and use **ZW_TRIAC_int_get** to see whether the interrupt has been set.

Defined in: ZW_triac_api.h

Serial API (Not supported)

4.3.18 LED Controller API

The built-in LED Controller is targeted at LED light dimming applications. The controller can control up to four individual channels in 3 different modes of operation. The application can use the following LED API calls to control the 500 Series Z-Wave SoC LED Controller.

4.3.18.1 ZW_LED_init

```
void ZW_LED_init(BYTE bMode,
                BYTE bChannelEn)
```

ZW_LED_init SHOULD be used to initialize the 500 Series Z-Wave SoC's integrated LED controller. The function configures the desired mode of operation and the desired number of active channels. This function SHOULD be called in **ApplicationHWInit**.

Defined in: ZW_led_api.h

Parameters:

bMode IN Mode of operation type:

LED_MODE_NORMAL

In this mode, the LED controller generates a pulse width modulated signal for each active channel. The PWM signals has no phase skew. The frequency of all of the PWM signals is $32\text{MHz}/2^{16} = 488.28\text{Hz}$. The duty-cycle of the PWM signals is set by the **ZW_LED_waveforms_set** function.

LED_MODE_SKEW

The SKEW mode is same as the NORMAL mode except that phase of the channels are skewed. That is, the signal of channel 1 is skewed $\frac{1}{4}$ of a period compared to the signal of channel 0, the signal of channel 2 is skewed $\frac{1}{4}$ of a period compared to the signal of channel 1, etc.

LED_MODE_PRBS

In this mode, the LED controller uses a PRBS signal generator to generate to LED signals. The total high time in this mode equals the total high time in the other modes.

bChannelEn IN Bit mask of one of the channels to be enabled

LED_CHANNEL0

Enable channel 0. The LED Controller takes control of the P0.4 pin.

LED_CHANNEL1

Enable channel 1. The LED Controller takes control of the P0.5 pin.

LED_CHANNEL2

Enable channel 2. The LED Controller takes control of the P0.6 pin.

LED_CHANNEL3

Enable channel 3 The LED Controller takes control of the P0.7 pin.

Serial API (Not supported)

4.3.18.2 ZW_LED_waveforms_set

void ZW_LED_waveforms_set(WORD *pwLevel)

ZW_LED_waveforms_set SHOULD be used to set the duty cycle for all LED Controller channels in one operation. The function configures the waveform for all channels even if some channels are not enabled.

The function MUST NOT be called repeatedly, as it may run for up to 2.048ms to prevent race conditions in the LED controller latch registers. This may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Parameters:

pwLevel IN A pointer to an array with 4 16-bits values.

0x0000-0xFFFF

Duty cycle times of the LED controller channels. The first 16 bit element in the array determines the value for channel 0. The next 16 bit element determines the value for channel 1, etc.

Serial API (Not supported)

4.3.18.3 ZW_LED_waveform_set

```
void ZW_LED_waveform_set( BYTE bChannel  
                          WORD wLevel)
```

ZW_LED_waveform_set MAY be used to set the duty cycle time of one LED controller channel.

The function SHOULD NOT be called repeatedly. This may cause race conditions in the LED controller latch registers. The companion function **ZW_LED_data_busy** MAY be used to check if the LED controller is ready for a new value.

The application MUST NOT repeatedly call **ZW_LED_data_busy** from a busy waiting loop as this may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Parameters:

bChannel IN	The channel ID
	LED_CHANNEL0
	LED_CHANNEL1
	LED_CHANNEL2
	LED_CHANNEL3
wLevel	The duty cycle of the channel
	0x0000-0xFFFF

Serial API (Not supported)

4.3.18.4 ZW_LED_data_busy

BOOL ZW_LED_data_busy(void)

ZW_LED_data_busy is used to check to see if the LED controller is ready for a new value.

The application **MUST NOT** repeatedly call **ZW_LED_data_busy** from a busy waiting loop as this may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Return values:

BOOL	TRUE	The LED controller cannot accept new waveform values, since it has not yet read in the previous data set. Wait up to $2^{16}/32\text{MHz} = 2.048\text{ms}$ and check again.
	FALSE	The LED controller can accept new waveform values

Serial API (Not supported)

4.3.19 Infrared Controller API

The built-in Infrared (IR) Controller is targeted at IR remote control applications. The IR controller can operate either as an IR transmitter or as an IR receiver. When operating as a transmitter one or more of the three outputs (P3.4, P3.5, and P3.6) can be enabled as IR outputs that drive an IR LED, as depicted in figure below. Each output can drive 12mA. Hence, using three outputs give a drive strength of 36mA. If 36mA is insufficient you will have to implement an external driver.

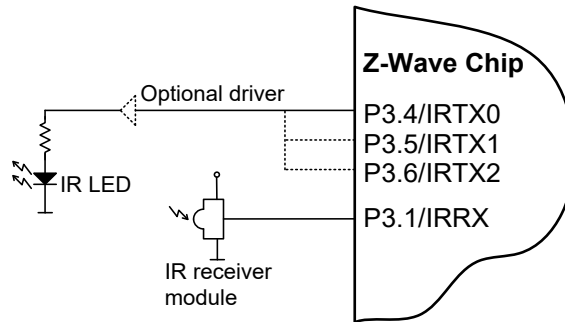


Figure 29. External IR Hardware

An external IR receiver module or an IR transistor must be connected to Pin P3.1 when operating in Receive mode. An IR receiver module has a built-in photo transistor and preamplifier with automatic gain control and gives a digital TTL/CMOS output signal. The IR receivers can be found in two versions, with and without demodulator. The versions without demodulator (like Vishay TSOP 98200) generates an output signal with carrier (as depicted in the upper part of figure below), whereas the versions with demodulator (like Vishay TSOP322xx) generates an output signal without the carrier (as depicted in the lower part of figure below). Therefore, the one without demodulator is best for code learning applications, where you want to be able to detect the carrier frequency. The one with modulator has improved immunity against ambient light such as fluorescent lamps.

Using an photo transistor, where the transistor is connected directly to the 500 Series Z-Wave Chip requires that the transmitting IR LED is placed within a short range (2"-4") of the IR transistor, since the IR transistor signal is analog and isn't amplified. This circuit is also sensitive also to ambient light.

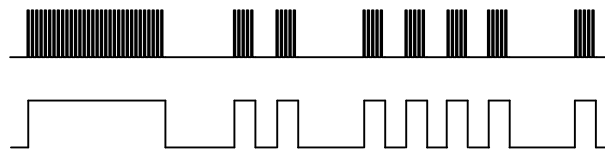


Figure 30. IR Signal with and without Carrier

In both cases, the IR Receiver detects widths of the marks (high/carrier on) and spaces (low) of a coded IR message, as seen in figure below. The mark/space width data is stored in SRAM using DMA. While running, the IR Controller requires very little MCU processing. The IR receiver is able to detect the waveform of the carrier¹.

The IR Transmitter generates a carrier and the marks and spaces for an IR message. The widths of the marks and the spaces are read from SRAM using DMA.

¹ Note that the IR receiver module can distort the duty cycle of the carrier.



Figure 31. IR Coded Message with Carrier

Both the IR Receiver and the IR Transmitter can be configured to detect/generate a wide range of IR coding formats.

4.3.19.1 Carrier Detector/Generator

The carrier detector can detect the carrier waveform (high and low periods) of a carrier modulated IR signal.

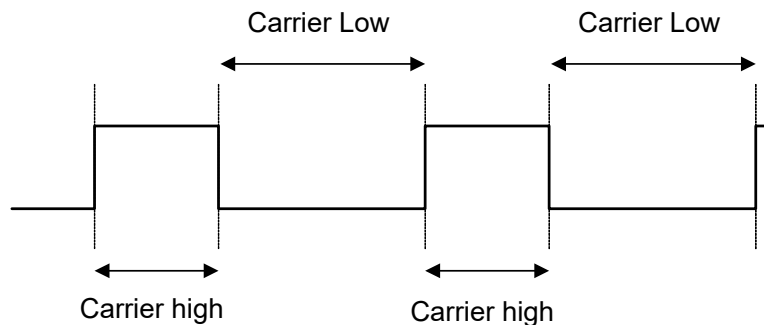


Figure 32. Carrier Waveform

The following bullets provide a short feature list of the Carrier Detector/generator.

1. IR Carrier Generator frequency range: 7.8 kHz – 16 MHz (50/50 duty cycle) or 10.4 kHz -10.7 MHz (33/66 duty cycle)
2. A built-in Glitch Remover is able to remove glitches on the incoming IR signal.
3. For each detection process the IR Carrier Detector can calculate an average of the “high” duration and an average of the “low” duration over 1 (no averaging), 2, 4, or 8 periods.

4.3.19.2 Organization of Mark/Space Data in Memory

Both the IR Receiver engine and the IR Transmitter engine use SRAM to store mark/space data information. The data is stored in the same format for both engines, as depicted in figure below. The width of a mark is stored in 1 to 3 bytes – likewise the width of a space is stored in 1-3 bytes.

Bit 7 in each byte is used to differentiate the mark and space bytes. That is, bit 7 of all “mark”-bytes are set to 1 and bit 7 of all “space”-bytes are set to 0.

The maximum number of bits used to describe a mark or space width is 16. This means that 3 bytes are needed to store a 16 bit value (the upper 6 bits of the 3rd byte are unused); whereas 2 bytes are needed to store a 14 bit value, and only one byte is needed to store a 7 bits value.

Refer to the example as depicted in figure below, where:

- 3 bytes are used for the start mark (PS0)
- 3 bytes are used for the start space (PS1)
- 2 bytes are used for each of the rest of the mark/spaces

The maximum size of the mark/space data information is 511 bytes. The data can be stored anywhere in the lower 4K XRAM in the 500 series Z-Wave SoC.

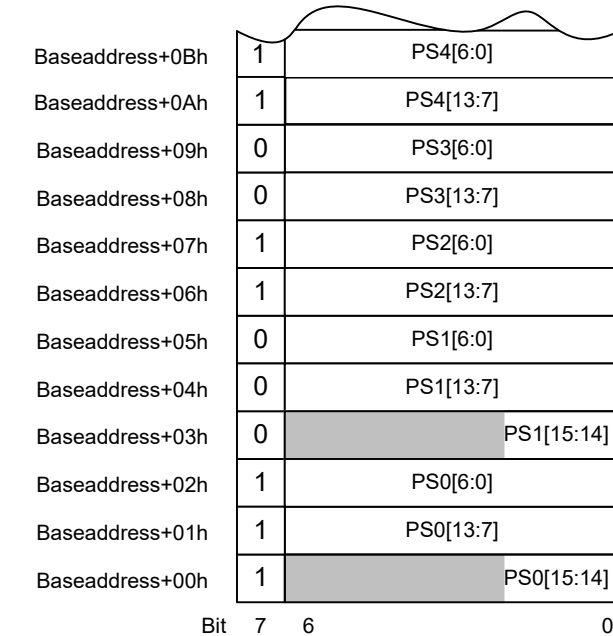


Figure 33. Mark/Space Data Memory Organization

The width is described as a certain count of prescaled clock periods. E.g if the prescaler is set to 1/16 and the width of a mark is 889us, the width will be stored as

$$\frac{\text{period}}{\text{prescaler} \cdot f_{\text{sys}}} = \frac{889\mu\text{s}}{16 \cdot 32\text{MHz}} = 1798\text{LSB}$$

That is,

$$\frac{\ln(1798)}{\ln(2)} = 10.81$$

11 bits are needed \Rightarrow 2 bytes.

Since the maximum number of bits used to store each mark or space width is 16. It results in a maximum mark or space width of:

- 262ms using clock divider of 128 or
- 1.7s using the Carrier Generator @ 36kHz

4.3.19.3 IR Transmitter

Before the IR transmitter can start generating the IR stream the IR Transmitter must have been initialized, the Mark/Space data must have been built in a buffer in the lower 4kB XRAM, and the IR interrupt is optionally enabled. The organization of the Mark/Space data is described in section 4.3.19.2. Additionally, the Carrier Generator must be initialized.

The function **ZW_IR_tx_init** must be called to initialize all the needed parameters as described below and in section 4.3.19.5:

1. The prescaler value for generating the carrier signal can be either: 1, 2, 3, 4, 5, 6, 7, or 8 resulting in a clock speed of either 32MHz, 16MHz, 32/3MHz, 8MHz, 32/5MHz, 16/3MHz, 32/7MHz, or 4MHz
2. The IR transmitter can use a prescaler that use the 32MHz clock divided by 1, 2, 4, 8, 16, 32, 64, or 128. It can also use the rising edge of the carrier generated by the Carrier Generator.
3. The output(s) can be inverted as an option
4. The Idle state of the IR signal can be either high or low
5. One, two, or three IO's can be used in parallel for driving an IR LED. Each output buffer can drive 12mA.
6. The carrier wave form is set by the carrier prescaler and two parameters that sets the low and high period of the carrier signal.

If only one IR coding style is used in a application the **ZW_IR_tx_init** function can be placed in **ApplicationInitHW**, otherwise it can be placed in other parts of the code, typically in **ApplicationPoll**

The function **ZW_IR_tx_data** must be called when a certain IR stream is to be transmitted. The parameters for this function sets is described below and in section 4.3.19.6

1. The address of the buffer in lower 4kB XRAM.
2. Size of IR data buffer in XRAM. The maximum size of the XRAM buffer is 511 bytes.

The IR Transmitter takes over control of the enabled IO's (P3.4, P3.5, and/or P3.6) when the function **ZW_IR_tx_data** is called and releases the control of the enabled IO's when the IR signal has been transmitted. Therefore, to make sure that IO's used by the IR transmitter (P3.4, P3.5, and/or P3.6) are output(s) and at the correct idle state, the GPIO must be set as outputs and the state must be set accordingly.

An IR interrupt routine is supplied with the `ZW_phy_infrared_040x` library. A variable `ir_tx_flag` (BOOL) is set TRUE when an IR message has been transmitted after **ZW_IR_tx_data** has been called. The `ir_tx_flag` variable is cleared when calling **ZW_IR_tx_data**.

Once the IR Transmitter is started, use the function **ZW_IR_disable** to cancel the operation.

An example of how to initialize and run the IR Transmitter is shown in Figure 34.

```
void ApplicationInitHW()
{
    EA=1;
    EIR=1;
    :
    /* Carrier freq = 8MHz/(74+148)=36kHz, Carrier duty cycle 33/66 */
    ZW_IR_tx_init(FALSE, // Use Mark/Space prescaler
        3, // Prescaler: 32MHz/(2^3)=4MHz
        FALSE, // Output is not inverted
        FALSE, // Output state is low
        0x03, // Enable P3.4 and P3.5
        3, // Carrier prescaler set to 4 (32MHz/4=8MHz)
        74, // Carrier low 74/8MHz = 9.25us
        148); // Carrier high 148/8MHz = 18.5us
    :
}

void ApplicationPoll()
{
    BYTE bIrBuffer[16];

    switch (mainState)
    {
        :
        case SEND_PLAY:
            // This IR message send a "PLAY" command
            bIrBuffer[0]=0xA0;
            bIrBuffer[1]=0x20;
            bIrBuffer[2]=0xBF;
            bIrBuffer[3]=0x20;
            bIrBuffer[4]=0xA0;
            bIrBuffer[5]=0x20;
            bIrBuffer[6]=0xA0;
            bIrBuffer[7]=0x20;
            bIrBuffer[8]=0xA0;
            bIrBuffer[9]=0x20;
            bIrBuffer[10]=0xA0;
            bIrBuffer[11]=0x20;
            bIrBuffer[12]=0xBF;
            bIrBuffer[13]=0x20;
            bIrBuffer[14]=0xDF;
            bIrBuffer[15]=0x80;
            ZW_IR_status_clear(); // Clear all IR status flags
    }
}
```



```

    /* Use IrBuffer as buffer, size 16 bytes */
    ZW_IR_tx_data((WORD)bIrBuffer, // Address of buffer
                16);              // Size of buffer
    mainState=WAIT_IR_DONE;
    break;
case WAIT_IR_DONE:
    if (ir_tx_flag==TRUE)        // Wait until IR TX flag is set
    {
        mainState=IDLE;
    }

    break;
}
}

```

Figure 34. Code Example on Use of IR Transmitter

4.3.19.4 IR Receiver

Before the IR Receiver can be used to learn an incoming IR stream the IR receiver must have been initialized, the Mark/Space data buffer must have been allocated in the lower 4kB XRAM, and the IR interrupt *must* be enabled.

The organization of the Mark/Space data is described in section 4.3.19.2.

The function **ZW_IR_learn_init** must be called to initialize all the needed parameters as described below and in section 4.3.19.5:

1. The Rx SRAM buffer size is configurable. (1-511 bytes)
2. The Mark/Space detector in the IR Receiver can use either a prescaler that use the 32MHz clock divided by 1, 2, 4, 8, 16, 32, 64, or 128.
3. If the IR Receiver requires more SRAM space for the incoming IR stream, the MCU is interrupted and an error flag is set
4. The IR Receiver can be configured to remove glitches on the incoming IR signal
5. The IR Receiver can be configured to average the detected duration of the low/high periods of the Carrier
6. The IR input signal can be inverted as an option.
7. The IR Receiver can detect that the trailing space after the last mark of a received IR message is longer than a specific size. This size must be set and this works at the same time as a timeout if the message for some reason is shorter than expected.

Call the function **ZW_IR_learn_data** to start the learn process. The function is described below and in section 4.3.19.9:

1. When the learn process starts the IR receiver will start out using the highest possible prescaler value for the Carrier detector. When it then detects a carrier, it will measure the duration of the low and high periods of the carrier and, if possible, rescale the prescaler to a lower value and rerun the carrier measurement. This is done to achieve the highest precision of the carrier measurement while preventing timer overflow.
2. The learn process will terminate when the IR Receiver has detected at least one Mark and then a Space larger than a configurable amount of time, as described above.

An IR interrupt routine is supplied with the **ZW_phy_infrared_040x** library. A variable **ir_rx_flag** (BOOL) is set TRUE when an IR message has been received. The **ir_rx_flag** variable is cleared when calling **ZW_IR_learn_data**.

Call the function **ZW_IR_learn_status_get** to get the size of the received mark/space data, the detected carrier characteristics and error state (status flags). The function **ZW_IR_status_clear** clears the status flag.

Once the IR Receiver is started, use the function **ZW_IR_disable** to cancel the operation.

An example of how to initialize and run the IR Receiver is shown below.

```
BYTE bIrBuffer[256];

void ApplicationInitHW()
{
    EA=1;
    EIR=1;

    ZW_IR_learn_init((WORD)bIrBuffer // Buffer address
                    256,           // Buffer Size
                    4,             // Prescaler: 32MHz/(2^4)=2MHz
                    7,             // Trailing space min 2^16/2MHz=32.8ms
                    2,             // Run average over 4 periods
                    1,             // Remove glitches below 125ns
                    FALSE);       // Do not invert input
}

void ApplicationPoll()
{
    WORD wRxDataLen;
    BYTE bRxCarrierLow;
    BYTE bRxCarrierHigh;
    BYTE bRxStatus;
    :
    switch(mainState)
    {
        case START_IR_LEARN:
            ZW_IR_status_clear(); // Clear all IR status flags
            ZW_IR_learn_data();   // Start IR Receiver
            mainState=WAIT_IR_DONE;
            break;
        case WAIT_IR_DONE:
            if (ir_rx_flag==TRUE) // Wait until IR RX flag is set
            {
                ZW_IR_learn_status_get( &wRxDataLen,
                                        &bCarrierPrescaler,
                                        &bRxCarrierLow,
                                        &bRxCarrierHigh,
                                        &bRxStatus);
            }
    }
}
```

```
    if (bRxStatus == 0x00 || bRxStatus == IRSTAT_CDONE)
    {
        if (bRxStatus != IRSTAT_CDONE)
        {
            /* report that carrier could not be detected */
            :
        }
        /* decode received data */
        :
    }
    else
    {
        /* error handling */
        :
    }
    mainState=IDLE;
}
else
{
    /* Cancel the operation when boCancelIR is set
    TRUE by other part of the code */
    if (boCancelIR == TRUE)
        ZW_IR_disable();
    mainState=IDLE;
}
break;
}
}
```

Figure 35. Code Example on Use of IR Receiver

The application software can use the following IR API calls to control the 500 Series Z-Wave SoC IR Controller.

4.3.19.5 ZW_IR_tx_init

```
void ZW_IR_tx_init( BYTE boMSTimer,
                  BYTE bMSPrescaler,
                  BYTE boInvertOutput,
                  BYTE boHighDrive,
                  BYTE boldleState,
                  BYTE bOutputEnable,
                  BYTE bCarrierPrescaler,
                  BYTE bCarrierLow,
                  BYTE bCarrierHigh)
```

ZW_IR_tx_init initializes the 500 Series Z-Wave SoC's integrated IR controller to Transmitter mode and sets the required TX options.

Defined in: ZW_infrared_api.h

Parameters:

boMSTimer IN	TX Mark/Space prescaler mode: TRUE FALSE	 Mark/space generator runs on carrier period timer. That is, the length of the Marks/Spaces is calculated as the carrier period multiplied by the value read in XRAM Mark/space generator runs on a prescaled timer. That is, the length of the Marks/Spaces is calculated as the prescaled timer period multiplied by the value read in XRAM. Prescaler value is set by bMSPrescaler.
bMSPrescaler IN	Mark/Space timer prescaler Valid values: 0-7 Resulting timer clock frequency: 0: 32 MHz 1: 16 MHz 2: 8 MHz 3: 4 MHz 4: 2 MHz 5: 1 MHz 6: 500 kHz 7: 250 kHz	Not applicable when boMSTimer is true
boInvertOutput IN	Invert IR output TRUE FALSE	output is inverted output is not inverted
boHighDrive	Invert IR output TRUE FALSE	use 12mA drive strength of IR Tx IO output buffers use 8mA drive strength of IR Tx IO out buffers

bIdleState IN	Idle State of IR output TRUE FALSE	Idle state is high Idle state is low
bOutputEnable IN	Outputs enabled Valid values: 0-7 000: All outputs disabled xx1: P3.4 enabled x1x: P3.5 enabled 1xx: P3.6 enabled	Idle state is high
bCarrierPrescaler IN	Carrier generator prescaler Valid values: 0-7 Resulting timer clock frequency: 0: 32MHz 1: 32MHz/2 2: 32MHz/3 3: 32MHz/4 4: 32MHz/5 5: 32MHz/6 6: 32MHz/7 7: 32MHz/8	
bCarrierLow IN	Carrier low time 0: 1 prescaled clock period 1: 2 prescaled clock periods : : 255: 256 prescaled clock periods	
bCarrierHigh IN	Carrier High time 0: 1 prescaled clock period 1: 2 prescaled clock periods : : 255: 256 prescaled clock periods	

Serial API (Not supported)

4.3.19.6 ZW_IR_tx_data

```
void ZW_IR_tx_data(WORD pBufferAddress,  
                  WORD wBufferLength)
```

ZW_IR_tx_data sets the address and the length of the buffer containing the Mark/space data to be sent. The IR Controller will start to transmit immediately after these values have been set.

Defined in: ZW_infrared_api.h

Parameters:

pBufferAddress IN Address of Tx buffer in lower XRAM memory

wBufferLength IN Number of bytes in TX buffer. Valid values (1-511)

Serial API (Not supported)

4.3.19.7 ZW_IR_tx_status_get

BYTE ZW_IR_tx_status_get(void)

ZW_IR_tx_status_get is used to check to the status of the IR controller after an IR message has been transmitted.

Defined in: ZW_infrared_api.h

Return values:

IRSTAT_MSOVERFLOW

The format of the data in the IR buffer is invalid. The perceived Mark/Space value is greater than 2^{16} .

IRSTAT_PSSTARV

The IR controller's DMA engine was not able to read data from XRAM in time because the access to the XRAM was used by (an) other DMA engine(s) with higher priority. To get rid of this error, try to disable other DMA engines (USB, RF, etc.) and run the IR transmitter again.

IRSTAT_ACTIVE

The IR Controller is active

Serial API (Not supported)

4.3.19.8 ZW_IR_learn_init

```
void ZW_IR_learn_init( WORD pBufferAddress,  
                      WORD wBufferLen,  
                      BYTE bMSPrescaler,  
                      BYTE bTrailSpace,  
                      BYTE bCAverager,  
                      BYTE bCGlitchRemover,  
                      BYTE bolInvertInput)
```

ZW_IR_learn_init initializes the 500 Series Z-Wave SoC's integrated IR controller to receive/learn mode and sets the required RX options.

Defined in: ZW_infrared_api.h

Parameters:

pBufferAddress IN Address of Rx buffer in lower XRAM memory

wBufferLength IN Size of RX buffer.

Valid values (1-511)

bMSPrescaler IN Mark/Space timer prescaler

Valid values: 0-7

Resulting timer clock frequency:

0:	32MHz
1:	16MHz
2:	8MHz
3:	4MHz
4:	2MHz
5:	1MHz
6:	500kHz
7:	250kHz

bTrailSpace IN Trailing space after last Mark. After the incoming IR signal has been low for this period of time the IR receiver stops.

Valid values: 0-7

0:	512 prescaled clock periods
1:	1024 prescaled clock periods
2:	2048 prescaled clock periods
3:	4096 prescaled clock periods
4:	8192 prescaled clock periods
5:	16384 prescaled clock periods
6:	32768 prescaled clock periods
7:	65536 prescaled clock periods

bCAverager IN Average Carrier high/low length measurement over multiple carrier periods.

Valid values: 0-3

0:	1 carrier period
1:	2 carrier periods
2:	4 carrier periods
3:	8 carrier periods (Recommended value)

bCGlitchRemover IN Remove glitches from incoming IR signal.

Valid values: 0-3

0:	disabled
1:	< 125ns
2:	< 250ns
3:	< 500ns

bolInvertInput IN TRUE
FALSE

IR input is inverted
IR input is not inverted

Serial API (Not supported)

4.3.19.9 ZW_IR_learn_data

void ZW_IR_learn_data(void)

ZW_IR_learn_data clears the `ir_rx_flag` variable and starts the IR Controller in Rx/learn mode. Use **ZW_IR_disable** to cancel on ongoing learn process.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

Refer to section 0 for a detailed description of the learn function.

4.3.19.10 ZW_IR_learn_status_get

```
void ZW_IR_learn_status_get( WORD *wDataLength,  
                             BYTE *bCarrierPrescaler,  
                             BYTE *bCarrierLow,  
                             BYTE *bCarrierHigh,  
                             BYTE *bStatus)
```

ZW_IR_learn_status_get is used to check to the status of the IR controller, to get the length of the received data, the detected carrier characteristics, and the error state. Call this function after a learn operation is done, i.e., after the `ir_rx_flag` variable has been set.

Defined in: ZW_infrared_api.h

Parameters:

wDataLength OUT	Length of the received data	
bCarrierPrescaler OUT	Optimal Carrier prescaler value	
	Valid values: 0-7	
	0: 32MHz	
	1: 32MHz/2	
	2: 32MHz/3	
	3: 32MHz/4	
	4: 32MHz/5	
	5: 32MHz/6	
	6: 32MHz/7	
	7: 32MHz/8	
bCarrierLow OUT	Length of the Low period of the Carrier (in prescaled system clocks)	
bCarrierHigh OUT	Length of the High period of the Carrier (in prescaled system clocks)	
bStatus OUT	IRSTAT_PSSTARV	The IR controller's DMA engine was not able to write data from XRAM in time because the access to the XRAM was used by (an) other DMA engine(s) with higher priority. To get rid of this error, try to disable other DMA engines (USB, RF, etc.) and run the IR transmitter again.
	IRSTAT_MSOVERFLOW	The duration of a mark/space exceeded 2 ¹⁶ prescaled clock periods.
	IRSTAT_COF	The Carrier detector failed because the perceived carrier low/high period was too long.
	IRSTAT_CDONE	The Carrier detector completed measuring the carrier without errors
	IRSTAT_RXBUFOVERFLOW	The RX buffer was too small to store the received IR data
	IRSTAT_ACTIVE	The IR Controller is active

Serial API (Not supported)

4.3.19.11 ZW_IR_status_clear

void ZW_IR_status_clear(void)

ZW_IR_status_clear clears the Tx and Rx IR Status flags. Call this function before rerunning the IR Controller.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

4.3.19.12 ZW_IR_disable

void ZW_IR_disable(void)

This function disables any ongoing IR operation and sets the IR Controller to its idle state. Use **ZW_IR_status_clear** to clear any status bit before starting the IR Transmitter or IR Receiver.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

4.3.20 Keypad Scanner Controller API

The built-in hardware keypad scanner is able to scan a key matrix of up to 8 rows x 16 columns. When the Keypad Scanner is activated, the 8 row inputs (P1.0-P1.7) must either be connected to the hardware key matrix or kept open. The number of columns can be configured to the range 1-16. The actual IO's being used as column outputs are "KSCOL0" (P0.0) when the column count is set to one, "KSCOL0, KSCOL1" (P0.0, P0.1) when the column count is set to two, "KSCOL0, KSCOL1, KSCOL2" (P0.0, P0.1, P0.2) when the column count is set to three, etc. A column output can be left open, though.

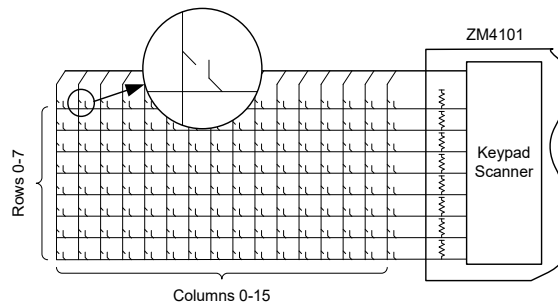


Figure 36. Keypad Matrix

Once the Keypad Scanner is enabled, it will scan each column for an amount of time (Scan Delay). If it, at a certain column detects a key press, it will wait for a period (Debounce delay) to get any eventual debounce noise to disappear. Then it will detect whether the input stays stable for another amount of time (Stable delay). The Keypad Scanner will issue an interrupt request to the MCU, if the row input is stable for the defined amount of "Stable delay" time. See figure below.

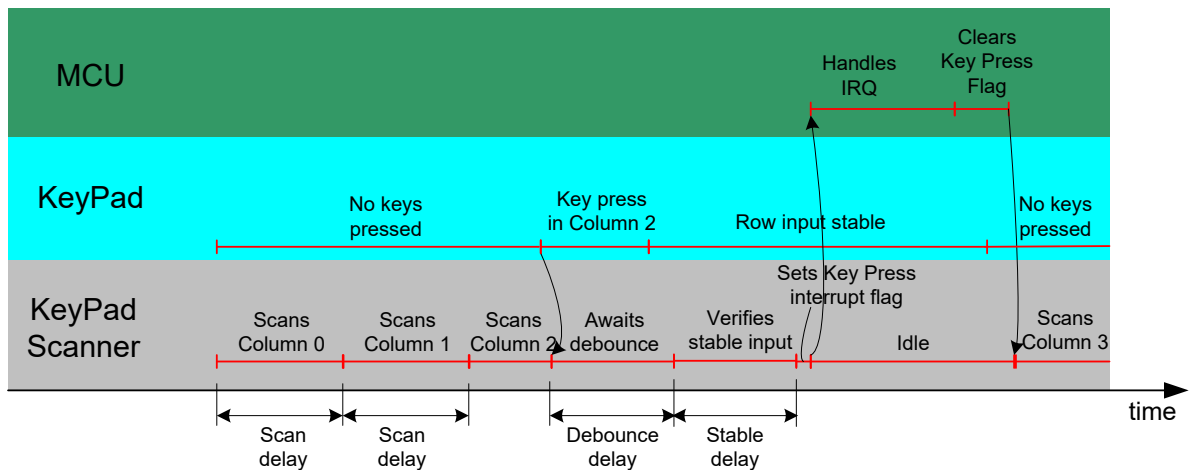


Figure 37. Scan Flow

Each of these delays can be configured by using the function **ZW_KS_init**, which must be called in **ApplicationInitHW** as shown in figure below.

```

void KeyPadChanges (BYTE_P pbKeypadMatrix, BYTE bStatus)
{
    /* Call the user defined application function
       InterpretKeys with the keypad matrix as parameter */
    switch (bStatus)
    {
        case ZW_KS_KEYPRESS_VALID:
            InterpretKeys (keyPadMatrix);
            break;
        case ZW_KS_KEYPRESS_INVALID:
            beep ();
            break;
        case ZW_KS_KEYPRESS_RELEASED:
            cleanup ();
            break
        default:
    }
}

void ApplicationInitHW (BYTE bWakeupReason)
{
    :
    ZW_KS_init (7,      /* 8 Columns */
               4,      /* Column scan delay 10ms */
               15,     /* Debounce delay 32ms */
               5,      /* Row Stable delay 12ms */
               10,     /* Polling period of 100 ms*/
               KeyPadChanges /* The callback function used to notify */
                               /* the application when changes occurs */
                               /* to the keypad matrix */
            )
    ZW_KS_enable (TRUE);
    :
}

void ApplicationPoll ()
{
    :
    /* Go into power down mode */
    ZW_KS_pd_enable (TRUE);
    ZW_SetSleepMode (WUT_MODE, ZW_INT_MASK_EXT1, 0);
    :
}

```

Figure 38. Example of the API Calls for the KeyPad Scanner

The Keypad ISR will detect any changes occurred to the keypad matrix. The changes to the keypad matrix array will be polled periodically. The polling period is defined by the application through **ZW_KS_init**.

Apart from setting the size of the key matrix and the delays, a callback function must be defined in **ZW_KS_init**. If any changes to the keypad matrix are detected the application will be notified by calling this user defined callback function. Figure above shows an example of how **ZW_KS_init** is used.

The parameter to the callback function is an array of the type BYTE. The array has 16 elements one for each column. It has 16 elements regardless of the number of actual configured columns in use. The element with index *n* holds the row-status for column number *n*. That is, bit 0 of an element hold the

status of row 0, bit 1 of an element hold the status of row 1, etc. The array is defined in the Keypad API library.

Note: the Keypad Scanner IRQ signal is shared with “EXT1”, external interrupt 1. Therefore, that interrupt routine must not be included in the application code, when using the Keypad Scanner.

When a key press must wake up the 500 Series Z-Wave SoC from powerdown mode, **ZW_KS_pd_enable(TRUE)** must be called just before the chip is put into powerdown mode. Doing so, will activate the external interrupt, if any key is pressed. When the 500 Series Z-Wave SoC is awake first the function **ZW_KS_init** and then **ZW_KS_enabled** must be called to initialize and enable the Key Scanner and thereby grab the actual key combination.

4.3.20.1 ZW_KS_init

```
void ZW_KS_init( BYTE bCols
                BYTE bScanDelay
                BYTE bDebounceDelay,
                BYTE bStableDelay
                BYTE bReportWaitTimeout,
                VOID_CALLBACKFUNC(KeyPadCallBack)(BYTE_P keyMatrix, BYTE bStatus) )
```

ZW_KS_init initializes the 500 Series Z-Wave SoC's integrated Keypad Scanner.

Defined in: ZW_keypad_scanner_api.h

Parameters:

bCols IN	Sets the number of enabled columns. Valid values 0-15. 0: 1 Column 1: 2 Columns : 15: 16 Columns E.g. setting this to 7 will enable KSCOL0-KSCOL7 (P0.0-P0.7)
bScanDelay IN	Sets column "Scan delay" 0: 2ms 1: 4ms : 15: 32ms
bDebounceDelay IN	Sets "debounce delay" 0: 2ms 1: 4ms : 15: 32ms
bStableDelay IN	Sets "stable delay" 0: 2ms 1: 4ms : 15: 32ms
bReportWaitTimeout IN	Set the timeout delay before the main loop call the KeyPadCallBack function. 0: not valid 1: 10 ms 2: 20 ms : 255: 2550 ms

KeyPadCallBack IN

The call back function that the main loop will use to notify the application about the changes in the keypad matrix.

The function will only be called when changes to the keypad matrix occurs.

Parameters:

pbKeyMatrix OUT:

Pointer to the keypad matrix BYTE array.

bStatus OUT:

Returns the status of the contents of the key matrix as one of the following:

ZW_KS_KEYPRESS_VALID	The contents of the key matrix array is valid
ZW_KS_KEYPRESS_INVALID	The contents of the key matrix array is invalid, i.e., more than 3 keys are pressed in an invalid manner
ZW_KS_KEYPRESS_RELEASED	All keys have been released

Serial API (Not supported)

4.3.20.2 ZW_KS_enable

void ZW_KS_enable(BOOL boEnable)

ZW_KS_enable enables or disables the Keypad Scanner. Must be called in **ApplicationInitHW**.

Defined in: ZW_keypad_scanner_api.h

Parameters:

boEnable IN	TRUE	Enables Keypad Scanner
	FALSE	Disables Keypad Scanner

Serial API (Not supported)

4.3.20.3 ZW_KS_pd_enable

void ZW_KS_pd_enable(BYTE boEnable)

ZW_KS_pd_enable(TRUE) must be called before putting the 500 Series Z-Wave SoC into powerdown mode, if the chip is to be woken by a key press.

Defined in: ZW_keypad_scanner_api.h

Parameters:

boEnable IN	TRUE	Enables Keypad Scanner Powerdown mode
	FALSE	Disables Keypad Scanner Powerdown mode

Serial API (Not supported)

4.3.21 USB/UART Common API

This is a simple unified API for using the UART0 or USB interfaces.

If the C-define "USBVCP" is defined, then all functions in this chapter will access the USB interface, otherwise UART0 will be used

First the API calls **ZW_InitSerialf** and **ZW_FinishSerialf** must be called to initialize the interface, after that data can be transferred using the put and get functions described in the following sections.

For USB: On windows you need a driver included in the DevKit. On linux and Mac no driver is needed. On all platforms you will get a virtual serial port on the PC side. The certified USB interface complies to USB 2.0 full speed. However, USB driver supports only Bus-Powered USB devices and not Self-Powered.

4.3.21.1 ZW_InitSerialIf

void ZW_InitSerialIf(WORD wBaudRate)

This function initializes the controller using the baud rate indicated by the parameter wBaudRate. It is important to call the function **ZW_FinishSerialIf** immediately after to indicate that initialization is finished.

Notice: When using the USB-interface, this parameter does not impact the actual transmission-speed as it is dictated by the USB standard.

Defined in: ZW_conbufio.h

Parameters:

bBaudRate IN 96=>9600baud/s, 1152=>115200baud/s

Serial API (Not supported)

4.3.21.2 ZW_FinishSerialf

BOOL ZW_FinishSerialf(void)

This function must be called immediately after **ZW_InitSerialf** to indicate that initialization is finished.

Defined in: ZW_conbufio.h

Return value

Always TRUE

Serial API (Not supported)

4.3.21.3 ZW_SerialCheck

BYTE ZW_SerialCheck(void)

This function checks if data has been received and is ready to be read

Defined in: ZW_conbufio.h

Return value

Nonzero if there is data in the input queue

Serial API (Not supported)

4.3.21.4 ZW_SerialGetByte

BYTE ZW_SerialGetByte(void)

This function reads one byte from the input buffer. First use ZW_SerialCheck to make sure that there is data available.

Defined in: ZW_conbufio.h

Return value

The byte received from the USB/UART interface

Serial API (Not supported)

4.3.21.5 ZW_SerialPutByte

BYTE ZW_SerialPutByte(BYTE b)

This function puts one byte into the USB/UART output buffer

Defined in: ZW_conbufio.h

Return value

Non-zero for success

Parameters:

Byte b

Data to be written to the USB/UART output buffer

Serial API (Not supported)

4.3.22 Flash API

The Flash API provides functions for reading the NVR area of the Flash as well as functions for erasing and programming Flash code sectors. Each sector is 2KB and there is 64 sectors in total. The code address range for sector 0 is 0x00000-0x07FF, sector 1 is 0x00800-0x00FFF, etc.

The Flash is erased sector by sector and each sector is programmed one page (256bytes) at a time. The data to be programmed into the flash sector is read from the lower 4kB XRAM.

To minimize the possibility to erase or program the flash code area by a mistake a function, **ZW_FLASH_code_prog_unlock()** that takes a "unlock string" as parameter, has to be called before an erase or program operation can be excised.

Only those sectors that not have been protected by lock bits can be erased/programming by the MCU API calls. Refer to [3] for a description of how to set the protection lock bits.

```
// Program sectors 10 to 13
for (sector=10;sector<14;sector++)
{
    // Unlock the flash erase and program funtions
    // the unlock string contains the four byte unlock string
    ZW_FLASH_code_prog_unlock(&unlock[0]);
    // Erase sector
    if(ZW_FLASH_code_sector_erase(sector))
    {
        Handle error
    }
    // Check state
    if (ZW_FLASH_prog_state())
    {
        Handle error
    }
    // lock the erase and program function
    ZW_FLASH_code_prog_lock();
    // program flash sector page by page
    for (i=0; i<8; i++)
    {
        Make data ready in buffer in memory
        // unlock programming
        if(ZW_FLASH_code_prog_unlock(&unlock[0]))
        {
            Handle error
        }
        // program page 'i' in sector 'sector' with contents from
        // XRAM starting from the address set by '&buffer'
        if(ZW_FLASH_code_page_prog(&buffer,
                                   sector,
                                   i)) // page
        {
            Handle error
        }
        // lock the erase and program function
        ZW_FLASH_code_prog_lock();
        Handle error
    }
}
// clear unlock to prevent undecired earse or prog operations
unlock={0x00,0x00,0x00,0x00};
```

4.3.22.1 ZW_FLASH_code_prog_unlock

BYTE ZW_Flash_code_prog_unlock(BYTE pbUnlockString)

This function enables erase and program operations on non-protected Flash code sectors.

Defined in: ZW_flash_api.h

Parameters:

pbUnlockString IN	Pointer to a 4 byte string.	The string: 0xDE, 0xAD, 0xBE, 0xEF
--------------------------	-----------------------------	------------------------------------

Return value:

BYTE	Bit mask:	
	FLASH_STATE_LOCK:	Flash erase and programming is locked
	Zero:	Flash erase and programming is unlocked

Serial API (Not supported)

4.3.22.2 ZW_FLASH_code_prog_lock

BYTE ZW_Flash_code_prog_lock(void)

This function disables erase and program operations on Flash code sectors.

Defined in: ZW_flash_api.h

Return value:

BYTE

Bit mask

FLASH_STATE_LOCK: Flash erase and programming is locked
Zero: Flash erase and programming is unlocked

Serial API (Not supported)

4.3.22.3 ZW_FLASH_code_sector_erase

BYTE ZW_Flash_code_sector_erase(BYTE bSector)

This function erases a non-protected Flash code sector. The erase operation has to be unlocked before this function will work, refer to **ZW_FLASH_code_prog_unlock()**. To check which sectors that have been protected use the function **ZW_FLASH_nvr0_get()** to read the protection bits in the bytes located at the NVR0 addresses 0-7.

The MCU code execution will be halted for 5ms while the program operation is running.

Defined in: ZW_flash_api.h

Parameters:

bSector IN Sector number (0-63).

Return value:

BYTE Bit mask

FLASH_STATE_ERR: The Flash erase process failed
FLASH_STATE_DONE: The Flash erase process passed

Serial API (Not supported)

4.3.22.4 ZW_FLASH_code_page_prog

**BYTE ZW_Flash_code_page_prog(BYTE pbRamAddress,
 BYTE bSector,
 BYTE bPage**

This function programs a non-protected Flash code sector page with data from XRAM. The program operation has to be unlocked before this function will work, refer to **ZW_FLASH_code_prog_unlock()**. To check which sectors that have been prptected use the function **ZW_FLASH_nvr0_get()** to read the protection bits in the bytes located in NVR0 at the addresses 0-7.

The MCU code execution will be halted for up to 1.6ms while the program operation is running.

Defined in: ZW_flash_api.h

Parameters:

pbRamAddress IN Pointer to data buffer in lower
 4KB XRAM

bSector IN Sector number (0-63).

bPage IN Page number (0-7).

Return value:

BYTE Bit mask

FLASH_STATE_LOCK:	Flash erase and programming is locked
FLASH_STATE_ERR:	The Flash programming process failed
FLASH_STATE_DONE:	The Flash programming process passed

Serial API (Not supported)

4.3.22.5 ZW_FLASH_auto_prog_set

void ZW_FLASH_auto_prog_set(void)

This function enables the Auto Program Mode and resets the 500 Series Z-Wave SOC after 7.8ms..

Defined in: ZW_flash_api.h

Parameters:

none

Serial API:

HOST->ZW: REQ | 0x27

4.3.23 CRC API

The CRC API provides functions for calculating and checking CRC-16 value of a data area. The checksum is based on CRC-CCITT (0x1D0F).

4.3.23.1 ZW_CheckCrc16

**WORD ZW_CheckCrc16(WORD crc,
 BYTE pDataAddr,
 WORD bDataLen)**

This function calculates or check CRC-16 value of a data area having a starting address and length.

Defined in: ZW_crc.h

Parameters:

crc IN	Initialization or CRC-16 value.	To calculate CRC-16 for a given data area set the initialization value equal to 0x1D0F. It can also be used to carry over CRC-16 value between separate calculations of multiple data areas.
pDataAddr IN	Address of data area.	
bDataLen IN	Size of data area.	

Return value:

WORD	CRC-16 value: Zero:	Calculated CRC-16 value CRC-16 value matches CRC-16 input value.
------	------------------------	---

Serial API (Not supported)

4.3.23.2 ZW_CreateCrc16

WORD ZW_CreateCrc16(**BYTE pHeaderAddr,**
 BYTE bHeaderLen,
 BYTE pPayloadAddr,
 BYTE bPayloadLen)

This function calculates a combined CRC-16 value of two data areas both having a starting address and length. This function calls **ZW_CheckCrc16** twice.

Defined in: ZW_crc.h

Parameters:

pHeaderAddr IN	Pointer to address of data area1.
bHeaderLen IN	Size of data area1.
pPayloadAddr IN	Pointer to address of data area2.
bPayloadLen IN	Size of data area2.

Return value:

WORD	CRC-16 value:	Calculated CRC-16 value.
------	---------------	--------------------------

Serial API (Not supported)

4.4 Z-Wave Controller API

The Z-Wave Controller API makes it possible for different controllers to control the Z-Wave nodes and get information about each node's capabilities and current state. The node control commands can be sent to a single node, all nodes or to a list of nodes (group, scene...).

4.4.1 ZW_AddNodeToNetwork

```
void ZW_AddNodeToNetwork(BYTE bMode,
    VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_ADD_NODE_TO_NETWORK(bMode, func)
Defined in: ZW_controller_api.h

Serial API: Func_ID = 0x4A

HOST->ZW: REQ | 0x4A | mode | funcID

ZW->HOST: REQ | 0x4A | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

ZW_AddNodeToNetwork is used to add a node to a Z-Wave network.

The AddNodeToNetwork function MAY be called by a primary controller application to invoke the inclusion (add) of new nodes in a Z-Wave network. Slave and secondary controller applications MUST NOT call this function.

A controller application MUST implement support for the AddNodeToNetwork function. The controller application MUST provide a user interface for activation of the AddNodeToNetwork function.

The bMode and completedFunc parameters MUST be specified for the AddNodeToNetwork function.

Refer to Figure 39 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.1.1 bMode parameter

The bMode parameter MUST be composed of commands and flags found in Table 15. The bMode parameter MUST NOT be assigned more than one command. The bMode parameter MAY be assigned one or more option flags. One command and multiple options are combined by logically OR'ing the bMode flags of Table 15.

Table 15. AddNode :: bMode

bMode flag	Description	Usage
ADD_NODE_ANY	Command to initiate inclusion (add) of new node of any type.	MUST be included when initiating inclusion (add).
ADD_NODE_SLAVE	-	<u>DEPRECATED</u> . Use ADD_NODE_ANY
ADD_NODE_CONTROLLER	-	<u>DEPRECATED</u> . Use ADD_NODE_ANY
ADD_NODE_EXISTING	-	<u>DEPRECATED</u> . Use ADD_NODE_ANY
ADD_NODE_SMART_START	Command for entering SMART START Listen mode.	MUST be used for initiating SMART START listen mode.

ADD_NODE_STOP	Command to abort the inclusion (add) process. May only be used in certain states.	MAY be used to abort an active inclusion process. MUST be used to terminate the inclusion process when completed.
ADD_NODE_STOP_FAILED	Command to notify the remote end when a controller replication (copy) is aborted.	SHOULD be used if aborting a controller replication (copy).
ADD_NODE_OPTION_NORMAL_POWER	Option flag to enable normal inclusion range.	SHOULD be included with ADD_NODE_ANY to achieve normal inclusion range. MAY be omitted for ADD_NODE_ANY to achieve reduced inclusion range.
ADD_NODE_OPTION_NETWORK_WIDE	Option flag to enable Network-Wide Inclusion (NWI).	MUST be used.

Using an illegal value as bMode parameter then ADD_NODE_ANY are used instead.

4.4.1.1.1 ADD_NODE_ANY command

To invoke inclusion (add) of a new node, a primary controller MUST call the AddNodeToNetwork function with a bMode value including the ADD_NODE_ANY command. Slave and secondary controller nodes MUST NOT call the AddNodeToNetwork function.

The RECOMMENDED call of the AddNodeToNetwork function () when adding nodes is as follows:

```
ZW_ADD_NODE_TO_NETWORK ( (ADD_NODE_ANY |
                          ADD_NODE_OPTION_NORMAL_POWER |
                          ADD_NODE_OPTION_NETWORK_WIDE) ,
                          completedFunc) ;
```

While defined in Z-Wave protocol libraries, it is NOT RECOMMENDED to use the ADD_NODE_SLAVE, ADD_NODE_CONTROLLER or ADD_NODE_EXISTING command codes.

4.4.1.1.2 ADD_NODE_SMART_START command

To invoke SMART START Listen mode a primary/inclusion controller MUST call the AddNodeToNetwork function with a bMode value including the ADD_NODE_SMART_START command. When a controller in SMART START Listen mode receives either an INIF (only from foreign HomeID) or a SMART START inclusion request, it will inform the application through **ApplicationControllerUpdate** (See 4.3.1.8) about the SMART START event.

4.4.1.1.3 ADD_NODE_STOP command

A controller MAY use the ADD_NODE_STOP command to abort an ongoing inclusion process.

After receiving an ADD_NODE_STATUS_DONE status callback, the application MUST terminate the inclusion process by calling the AddNodeToNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

Due to the inherent risk of creating ghost nodes with duplicate NodeIDs, a controller SHOULD NOT call the AddNodeToNetwork function in the time window starting with the reception of an ADD_NODE_STATUS_NODE_FOUND status callback and ending with the reception of an ADD_NODE_STATUS_PROTOCOL_DONE status callback. An application may time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status callback or the application may receive an ADD_NODE_STATUS_FAILED status callback. In all three cases, the application MUST terminate the inclusion process by calling AddNodeToNetwork(ADD_NODE_STOP) with a valid completedFunc callback pointer. The API MUST return an ADD_NODE_STATUS_DONE status callback in response.

After receiving an ADD_NODE_STATUS_DONE status callback, the application MUST terminate the inclusion process by calling the AddNodeToNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

4.4.1.1.4 ADD_NODE_STOP_FAILED command

When a new controller node is included in a Z-Wave network, the primary controller replicates protocol-specific databases to the new controller. An optional application-specific phase may follow after protocol-specific replication (copy).

A primary controller SHOULD use the ADD_NODE_STOP_FAILED command during the application-specific phase to notify the receiving end of the application replication (copy) that the process is being aborted.

4.4.1.1.5 ADD_NODE_OPTION_NORMAL_POWER option

The default power level for Z-Wave communication is the high power level. Therefore, the high power level is frequently referred to as the normal power level.

When including a new node, the ADD_NODE_OPTION_NORMAL_POWER option SHOULD be added to the bMode parameter.

If special application requirements dictate the need for low power transmission during inclusion (add) of a new node, a primary controller MAY omit the ADD_NODE_OPTION_NORMAL_POWER option from the bMode parameter. However, this is NOT RECOMMENDED.

4.4.1.1.6 ADD_NODE_OPTION_NETWORK_WIDE option

Network-Wide Inclusion (NWI) allows a new node to be included across an existing Z-Wave network without direct range connectivity between the primary controller and the new node. The ADD_NODE_OPTION_NETWORK_WIDE option enables NWI. NWI inclusion is backwards compatible with old nodes that do not implement NWI support.

When including a new node, the ADD_NODE_OPTION_NETWORK_WIDE option MUST be added to the bMode parameter.

4.4.1.2 completedFunc parameter

Being the exception to the rule, an application calling AddNodeToNetwork(ADD_NODE_STOP) to confirm the reception of a ADD_NODE_STATUS_DONE return code MUST specify the NULL pointer for the completedFunc parameter.

In all other cases, an application calling the AddNodeToNetwork function with any command and option combination MUST specify a valid pointer to a callback function provided by the application. The callback function MUST accept a pointer parameter to a LEARN_INFO struct. The parameter provides access to actual status as well as companion data presenting a new node. The LEARN_INFO struct only contains a valid pointer to the Node Information Frame of the new node when the status of the callback is ADD_NODE_STATUS_ADDING_SLAVE or ADD_NODE_STATUS_ADDING_CONTROLLER.

Table 16. AddNode :: completedFunc :: learnNodeInfo

LEARN_NODE struct member	Description
*learnNodeInfo.bStatus	Callback status code
*learnNodeInfo.bSource	NodeID of the new node
*learnNodeInfo.bLen	Length of pCmd element following the bLen element. If bLen is zero, there is no valid pCmd element.
*learnNodeInfo.pCmd	Pointer to Application Node Information (see ApplicationNodeInformation - nodeParm). NULL if no information present.

Individual status codes are presented in the following sections.

Table 17. AddNode :: completedFunc :: learnNodeInfo.bStatus

LEARN_NODE.bStatus	Description
ADD_NODE_STATUS_LEARN_READY	Z-Wave protocol is ready to include new node.
ADD_NODE_STATUS_NODE_FOUND	Z-Wave protocol detected node.
ADD_NODE_STATUS_ADDING_SLAVE	Z-Wave protocol included a slave type node
ADD_NODE_STATUS_ADDING_CONTROLLER	Z-Wave protocol included a controller type node
ADD_NODE_STATUS_PROTOCOL_DONE	Z-Wave protocol completed operations related to inclusion (add). If new node type is controller, the controller application MAY invoke application replication (copy).
ADD_NODE_STATUS_DONE	All operations completed. Protocol is ready to return to idle state.
ADD_NODE_STATUS_FAILED	Z-Wave protocol reports that inclusion (add) was not successful. New node is not ready for operation
ADD_NODE_STATUS_NOT_PRIMARY	Z-Wave protocol reports that the requested operation cannot be performed since it requires that the node is in primary controller state.

Refer to Figure 39 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.1.2.1 ADD_NODE_STATUS_LEARN_READY status

Z-Wave protocol is ready to include new node. An application MAY time out waiting for the ADD_NODE_STATUS_LEARN_READY status if it does not receive the indication within 10 sec after calling AddNodeToNetwork(ADD_NODE_ANY)

If the application times out waiting for the ADD_NODE_STATUS_LEARN_READY status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL).

4.4.1.2.2 ADD_NODE_STATUS_NODE_FOUND status

Z-Wave protocol detected node. An application MUST time out waiting for the ADD_NODE_STATUS_NODE_FOUND status if it does not receive the indication after calling AddNodeToNetwork(ADD_NODE_ANY). The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_NODE_FOUND status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL).

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.3 ADD_NODE_STATUS_ADDING_SLAVE status

Z-Wave protocol included a slave type node.

An application MUST time out waiting for the ADD_NODE_STATUS_ADDING_SLAVE status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_ADDING_SLAVE status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.4 ADD_NODE_STATUS_ADDING_CONTROLLER status

Z-Wave protocol included a controller type node.

An application MUST time out waiting for the ADD_NODE_STATUS_ADDING_CONTROLLER status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_ADDING_CONTROLLER status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive an ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.5 ADD_NODE_STATUS_PROTOCOL_DONE status

Z Wave protocol completed operations related to inclusion (add). If new node type is controller, the controller application MAY invoke application replication (copy).

In response to the ADD_NODE_STATUS_PROTOCOL_DONE , the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive an ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

An application MUST time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The time period depends on the network size and the node types in the network. Refer to 4.4.1.3.3.

If the application times out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.6 ADD_NODE_STATUS_DONE status

All operations completed. Protocol is ready to return to idle state.

In response to the ADD_NODE_STATUS_DONE status callback, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL). The application MUST specify the NULL pointer for the callback function.

4.4.1.2.7 ADD_NODE_STATUS_FAILED status

An application may time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status callback or the application may receive an ADD_NODE_STATUS_PROTOCOL_FAILED status callback. In either case, the application MUST terminate the inclusion process by calling AddNodeToNetwork(ADD_NODE_STOP). Refer to 4.4.1.1.3.

4.4.1.2.8 ADD_NODE_STATUS_NOT_PRIMARY status

An application MUST NOT call the AddNodeToNetwork function if the application is not running in a primary controller. If the function is called by an application running in slave or a secondary controller, the API MUST return the ADD_NODE_STATUS_NOT_PRIMARY status callback.

4.4.1.3 completedFunc callback timeouts

4.4.1.3.1 ProtocolReadyTimeout

The API MUST return an ADD_NODE_STATUS_LEARN_READY status callback within less than 10 sec after receiving a call to AddNodeToNetwork(ADD_NODE_ANY).

If an application has not received an ADD_NODE_STATUS_LEARN_READY status callback 200 msec after calling AddNodeToNetwork(ADD_NODE_ANY), the application MAY time out and return to its idle state.

4.4.1.3.2 NodeTimeout

An application **MUST** implement a timeout for waiting for an `ADD_NODE_STATUS_NODE_FOUND` status callback.

The application **SHOULD NOT** wait for an `ADD_NODE_STATUS_NODE_FOUND` status callback for more than 60 sec after calling `AddNodeToNetwork(ADD_NODE_ANY)`. If timing out, the application **SHOULD** abort inclusion (add).

4.4.1.3.3 AddNodeTimeout

An application **MUST** implement a timeout for waiting for the protocol library to complete inclusion (add). The timeout **MUST** be calculated according to the formulas presented in sections 4.4.1.3.3.1 and 4.4.1.3.3.2.

4.4.1.3.3.1 New slave

$$\text{AddNodeTimeout.NewSlave} = 76000\text{ms} + \\ \text{LISTENINGNODES} * 217\text{ms} + \\ \text{FLIRSNODES} * 3517\text{ms}$$

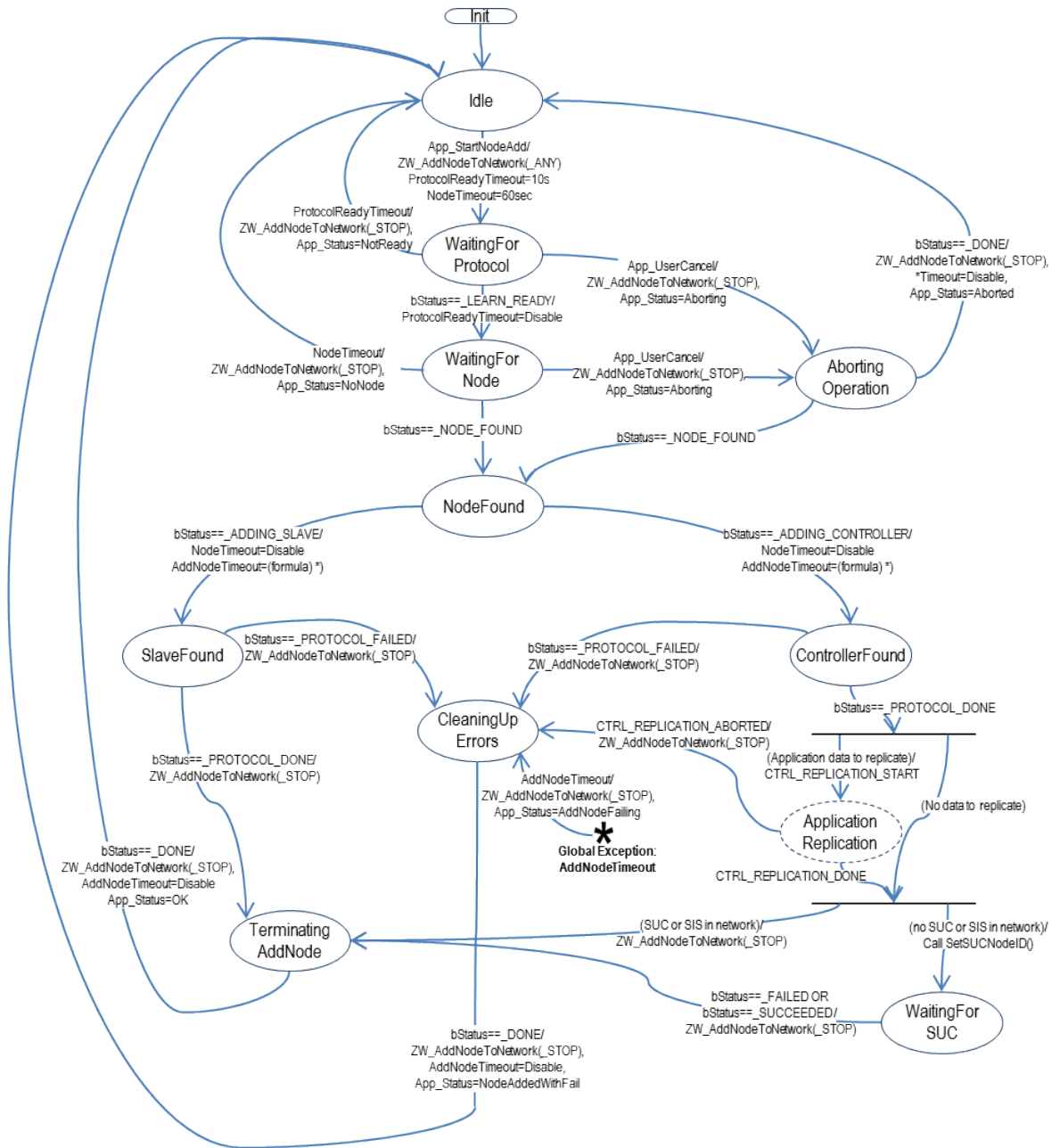
where *LISTENINGNODES* is the number of listening nodes in the network,
and *FLIRSNODES* is the number of nodes in the network that are reached via beaming.

4.4.1.3.3.2 New controller

$$\text{AddNodeTimeout.NewController} = 76000\text{ms} + \\ \text{LISTENINGNODES} * 217\text{ms} + \\ \text{FLIRSNODES} * 3517\text{ms} + \\ \text{NETWORKNODES} * 732\text{ms},$$

where *LISTENINGNODES* is the number of listening nodes in the network,
and *FLIRSNODES* is the number of nodes in the network that are reached via beaming.

NETWORKNODES is the total number of nodes in the network, i.e.,
NONLISTENINGNODES + *LISTENINGNODES* + *FLIRSNODES*.



Formula for calculating AddNodeTimeout: New slave: $AddNodeTimeout = 76000ms + LISTENINGNODES * 217ms + FLIRSNODES * 3517ms$
 New controller: $AddNodeTimeout = 76000ms + LISTENINGNODES * 217ms + FLIRSNODES * 3517ms + NETWORKNODES * 732ms$
 NETWORKNODES is the total number of nodes of any type

Figure 39. Adding a Node to the Network

Table 18. AddNode : State/Event processing – 1

States	
(Any State)	Event: AddNodeTimeout=> // GLOBAL Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
Idle	Event: (Init) => // Initialize timers, etc. Event: App_StartNodeAdd => // Higher layer application event calls for node to be added New state: <WaitingForProtocol> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_ANY) ProtocolReadyTimeout=10s AddNodeTimeout=60sec
WaitingForProtocol	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==ADD_NODE_STATUS_LEARN_READY => //Callback New state: <WaitingForNode> Actions: Disable ProtocolReadyTimeout timer Event: ProtocolReadyTimeout => // Timer event New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP, func=NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NotReady event for application
WaitingForNode	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: < AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==ADD_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Event: NodeTimeout=> // Timer event New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP, func=NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NoNode event for application

Table 19. AddNode : State/Event processing – 2

States	
NodeFound	<p>Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application</p> <p>Event: bStatus==ADD_NODE_STATUS_ADDING_SLAVE => //Callback New state: <SlaveFound> Actions: AddNodeTimeout= (calculated as follows): Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type</p> <p>Event: bStatus==ADD_NODE_STATUS_ADDING_CONTROLLER => //Callback New state: <ControllerFound> Actions: AddNodeTimeout= (calculated as follows): Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type</p> <p>Event: NodeFoundTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p>
SlaveFound	<p>Event: bStatus==ADD_NODE_STATUS_PROTOCOL_DONE => //Callback New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p> <p>Event: bStatus==ADD_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p> <p>Event: AddNodeTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p>
ControllerFound	<p>Event: bStatus==ADD_NODE_STATUS_PROTOCOL_DONE => //Callback IF (Application data to replicate) THEN New state: <ApplicationReplication> Actions: Generate CTRL_REPLICATION_START for <ApplicationReplication> sub-state machine ELSE // No data to replicate IF (No SUC or SIS in the network) THEN New state: <WaitingForSUC> Actions: Call ZW_SetSUCNodeID(NodeID) ELSE New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) ENDIF ENDIF</p> <p>Event: bStatus==ADD_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p>

Table 20. AddNode : State/Event processing – 3

<ApplicationReplication>	<p><Application Replication> is a self-contained state diagram. Stay here until finished.</p> <p>Event: CTRL_REPLICATION_ABORTED New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p> <p>Event: CTRL_REPLICATION_DONE IF (No SUC or SIS in the network) THEN New state: <WaitingForSUC> Actions: Call ZW_SetSUCNodeID(NodeID) ELSE New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) ENDIF</p>
WaitingForSUC	<p>Event: bStatus==ZW_SUC_SET_SUCCEEDED => //Callback New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p> <p>Event: bStatus==ZW_SUC_SET_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p> <p>Event: AddNodeTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)</p>
TerminatingAddNode	<p>Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Actions: AddNodeTimeout=Disable Actions: Generate App_Status=OK event for application</p>
CleaningUpErrors	<p>Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_AddNodeToNetwork(ADD_NODE_STOP, NULL) Generate App_Status=NodeAddedWithFail event for application</p>
AbortingOperation	<p>Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_AddNodeToNetwork(ADD_NODE_STOP, NULL) Generate App_Status=Aborted event for application</p> <p>Event: bStatus==ADD_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: AddNodeTimeout= (calculated as follows): Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type</p>

4.4.2 ZW_AddNodeDskToNetwork

```
void ZW_AddNodeDskToNetwork(BYTE bMode, BYTE *pDSK,
    VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_ADD_NODE_DSK_TO_NETWORK(bMode, pDsk, func)

Defined in: ZW_controller_api.h

ZW_AddNodeDskToNetwork MAY be used to add a specific SMART START node to a Z-Wave network.

The AddNodeDskToNetwork function MAY be called by a primary controller application to invoke the inclusion (add) of new nodes in a Z-Wave network. Slave and secondary controller applications MUST NOT call this function.

A controller application MUST implement support for the ZW_AddNodeDskToNetwork function. The controller application MUST provide a user interface for activation of the ZW_AddNodeDskToNetwork function.

The bMode and completedFunc parameters MUST be specified for the ZW_AddNodeDskToNetwork function.

Refer to Figure 39 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.2.1 bMode parameter

The bMode parameter MUST be composed of commands and flags found in Table 15 and Table 21. The bMode parameter MUST NOT be assigned more than one command. The bMode parameter MAY be assigned one or more option flags. One command and multiple options are combined by logically OR'ing the bMode flags of Table 15 (See also 4.4.1.1).

Table 21. AddNodeDsk :: bMode

bMode flag	Description	Usage
ADD_NODE_HOME_ID	Command for initiating the SMART START inclusion of a specific SMART START node.	MUST be used for initiating inclusion of specific SMART START.

4.4.2.1.1 ADD_NODE_HOME_ID command

To invoke the inclusion of a specific SMART START node a primary/inclusion controller MUST call the **ZW_AddNodeDskToNetwork** function with a bMode value including the ADD_NODE_HOME_ID command and specify the SMART START DSK identifying the specific SMART START node to include.

4.4.2.2 pDSK parameter

If `bMode == ADD_NODE_HOME_ID` then the pDSK parameter MUST point to the matching DSK part of the SMART START node which should be included. Only the `bMode == ADD_NODE_HOME_ID` mode uses the pDSK parameter.

4.4.2.3 completedFunc parameter

See description of `ZW_AddNodeToNetwork` (4.4.1) specifically 4.4.1.2 and 4.4.1.3.

4.4.2.4 Smart Start Network Wide Inclusion

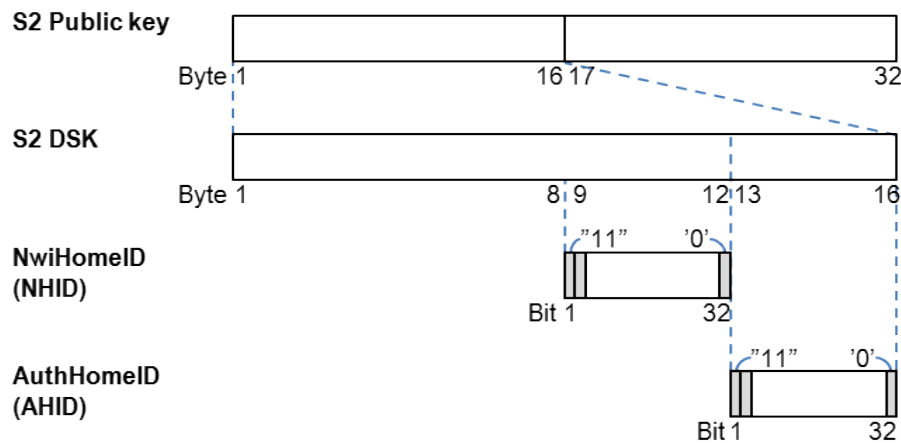


Figure 40. Smart Start S2 Public Key Derived Inclusion homeIDs

Serial API:

No `Func_ID` defined for `ZW_AddNodeDskToNetwork` but the Serial API uses the `ZW_AddNodeToNetwork` `Func_ID = 0x4A` to access the `ZW_AddNodeDskToNetwork` specific `bMode == ADD_NODE_HOME_ID (0x08)` command.

HOST->ZW: REQ | 0x4A | 0x08 | funcID | pDsk[0] | pDsk[1] | pDsk[2] | pDsk[3] | pDsk[4] | pDsk[5] | pDsk[6] | pDsk[7]

ZW->HOST: REQ | 0x4A | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

4.4.3 ZW_AreNodesNeighbours

**BYTE ZW_AreNodesNeighbours(BYTE bNodeA,
BYTE bNodeB)**

Macro: ZW_ARE_NODES_NEIGHBOURS (nodeA, nodeB)

Used to check if two nodes are marked as being within direct range of each other

Defined in: ZW_controller_api.h

Return value:

BYTE	FALSE	Nodes are not neighbours.
	TRUE	Nodes are neighbours.

Parameters:

bNodeA IN Node ID A (1...232)

bNodeB IN Node ID B (1...232)

Serial API

HOST->ZW: REQ | 0xBC | nodeID | nodeID

ZW->HOST: RES | 0xBC | retVal

4.4.4 ZW_AssignReturnRoute

```

BOOL ZW_AssignReturnRoute(
    BYTE bSrcNodeID,
    BYTE bDstNodeID,
    VOID_CALLBACKFUNC(completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

```

Macro: `ZW_ASSIGN_RETURN_ROUTE(routingNodeID, destNodeID, func)`

Use to assign static return routes (up to 4) to a Routing Slave or Enhanced 232 Slave node. This allows the Routing Slave node to communicate directly with either controllers or other slave nodes. The API call calculates the shortest routes from the Routing Slave node (bSrcNodeID) to the destination node (bDestNodeID) and transmits the return routes to the Routing Slave node (bSrcNodeID). The destination node is part of the return routes assigned to the slave. Up to 5 different destinations can be allocated return routes in a Routing Slave. Attempts to assign new return routes when all 5 destinations already are allocated will be ignored. It is possible to allocate up to 232 different destinations in an Enhanced 232 Slave. Call **ZW_AssignReturnRoute** repeatedly to allocate more than 5 destinations in an Enhanced 232 Slave. Use the API call **ZW_DeleteReturnRoute** to clear assigned return routes.

Defined in: `ZW_controller_api.h`

Return value:

BOOL	TRUE	If Assign return route operation started
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

bSrcNodeID IN	Node ID (1...232) of the routing slave that should get the return routes.
bDstNodeID IN	Destination node ID (1...232)
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	Status of return route assignment	
	(all status codes from <code>ZW_SendData</code>)	See ZW_SendData , section 4.3.3.1
	<code>TRANSMIT_COMPLETE_NOROUTE</code>	No routes assigned because a route between source and destination node could not be found.
txStatusReport IN	(see ZW_SendData)	

Serial API:

HOST->ZW: REQ | 0x46 | bSrcNodeID | bDstNodeID | funcID

ZW->HOST: RES | 0x46 | retVal

ZW->HOST: REQ | 0x46 | funcID | bStatus

4.4.5 ZW_AssignSUCReturnRoute

```
BOOL ZW_AssignSUCReturnRoute(
    BYTE bSrcNodeID,
    VOID_CALLBACKFUNC(completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))
```

Macro: ZW_ASSIGN_SUC_RETURN_ROUTE(srcnode,func)

Notify presence of a SUC/SIS to a Routing Slave or Enhanced 232 Slave. Furthermore is static return routes (up to 4) assigned to the Routing Slave or Enhanced 232 Slave to enable communication with the SUC/SIS node. The return routes can be used to get updated return routes from the SUC/SIS node by calling ZW_RequestNetWorkUpdated in the Routing Slave or Enhanced 232 Slave.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the assign SUC return route operation is started.
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

bSrcNodeID IN The node ID (1...232) of the routing slave that should get the return route to the SUC/SIS node.

completedFunc IN Transmit complete call back.

Callback function Parameters:

bStatus IN (see ZW_SendData)

txStatusReport IN (see ZW_SendData)

Serial API:

HOST->ZW: REQ | 0x51 | bSrcNodeID | funcID | funcID

The extra funcID is added to ensures backward compatible. This parameter has been removed starting from dev. kit 4.1x. and onwards and has therefore no meaning anymore.

ZW->HOST: RES | 0x51 | retVal

ZW->HOST: REQ | 0x51 | funcID | bStatus

4.4.6 ZW_AssignPriorityReturnRoute

```

BOOL ZW_AssignPriorityReturnRoute(
    BYTE bSrcNodeID,
    BYTE bDstNodeID,
    XBYTE *pPriorityRoute,
    VOID_CALLBACKFUNC(completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

```

Assign a application defined Priority Return Route to a routing or an enhanced slave that always will be tried as the first return route attempt. The function will assign the specified Priority Return Route and if possible it will also assign up to three return routes calculated from the routing table in the same manner as **ZW_AssignReturnRoute**.

Use the API call **ZW_DeleteReturnRoute** to clear the assigned Priority Return Route together with the other Return Routes.

NOTE: If the routing/enhanced slave is based on a SDK prior to 6.60 it can not be guaranteed that the first Return Route is the specified Priority Return Route. The Priority Return Route will be used but its placement in the Return Route sequence is based on internal prioritization in the slave.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If Assign return route operation started
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

bSrcNodeID	IN	Node ID (1...232) of the routing slave that should get the return routes.
bDstNodeID	IN	Destination node ID (1...232)
pPriorityRoute		Pointer for a 5-byte array containing the new Priority Return Route to be set. The 5-byte array contains 4 repeater node bytes (index 0 - 3) and 1 routespeed byte (index 4). The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the Priority Return Route is direct. The routespeed byte (index 4) can be either ZW_PRIORITY_ROUTE_SPEED_9600 , ZW_PRIORITY_ROUTE_SPEED_40K or ZW_PRIORITY_ROUTE_SPEED_100K
completedFunc		Transmit completed call back function

IN

Callback function Parameters:

txStatus IN	Status of return route assignment	
	(all status codes from ZW_SendData)	See ZW_SendData , section 4.3.3.1
	TRANSMIT_COMPLETE_NOROUTE	No routes assigned because a route between source and destination node could not be found.

txStatusReport IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x4F | bSrcNodeID | bDstNodeID | PriorityRoute | funcID

ZW->HOST: RES | 0x4F | retVal

ZW->HOST: REQ | 0x4F | funcID | bStatus

4.4.7 ZW_AssignPrioritySUCReturnRoute

```

BOOL ZW_AssignPriorityReturnRoute(
    BYTE bSrcNodeID,
    XBYTE *pPriorityRoute,
    VOID_CALLBACKFUNC(completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

```

Assign a application defined Priority SUC Return Route to a routing or an enhanced slave that always will be tried as the first return route attempt. The function will assign the specified Priority SUC Return Route and if possible it will also assign up to three return routes calculated from the routing table in the same manner as **ZW_AssignSUCReturnRoute**.

Use the API call **ZW_DeleteSUCReturnRoute** to clear the assigned Priority SUC Return Route together with the other Return Routes.

NOTE: If the routing/enhanced slave is based on a SDK prior to 6.60 it can not be guaranteed that the first return route is the specified priority route. The priority route will be used but its placement in the return route sequence is based on internal prioritization in the slave.

Defined in: **ZW_controller_api.h**

Return value:

BOOL	TRUE	If the assign Priority SUC return route operation is started.
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

bSrcNodeID	IN	The node ID (1...232) of the routing slave that should get the Priority Return Route to the SUC/SIS node.
pPriorityRoute		Pointer for a 5-byte array containing the new Priority Return Route to be set. The 5-byte array contains 4 repeater node bytes (index 0 - 3) and 1 routespeed byte (index 4). The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the Priority Return Route is direct. The routespeed byte (index 4) can be either ZW_PRIORITY_ROUTE_SPEED_9600 , ZW_PRIORITY_ROUTE_SPEED_40K or ZW_PRIORITY_ROUTE_SPEED_100K
completedFunc	IN	Transmit complete call back.

Callback function Parameters:

bStatus IN (see **ZW_SendData**)

txStatusReport IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x58 | bSrcNodeID | PriorityRoute | funcID

ZW->HOST: RES | 0x58 | retVal

ZW->HOST: REQ | 0x58 | funcID | bStatus

4.4.8 ZW_ControllerChange

```
void ZW_ControllerChange (BYTE mode,
    VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_CONTROLLER_CHANGE(mode, func)

ZW_ControllerChange is used to add a controller to the Z-Wave network and transfer the role as primary controller to it.

This function has the same functionality as `ZW_AddNodeToNetwork(ADD_NODE_ANY,...)` except that the new controller will be a primary controller and the controller invoking the function will become secondary.

Defined in: ZW_controller_api.h

Parameters:

mode IN	The learn node states are:	
	CONTROLLER_CHANGE_START	Start the process of adding a controller to the network.
	CONTROLLER_CHANGE_STOP	Stop the controller change
	CONTROLLER_CHANGE_STOP_FAILED	Stop the controller change and report a failure
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters (completedFunc):

*learnNodeInfo.bStatus IN	Status of learn mode: ADD_NODE_STATUS_LEARN_READY ADD_NODE_STATUS_NODE_FOUND ADD_NODE_STATUS_ADDING_CONTROLLER ADD_NODE_STATUS_PROTOCOL_DONE ADD_NODE_STATUS_DONE ADD_NODE_STATUS_FAILED	The controller is now ready to include a node into the network. A node that wants to be included into the network has been found A new controller has been added to the network The protocol part of adding a controller is complete, the application can now send data to the new controller using ZW_ReplicationSend() The new node has now been included and the controller is ready to continue normal operation again. The learn process failed
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see ApplicationNodeInformation - nodeParm). NULL if no information present. The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x4D | mode | funcID

ZW->HOST: REQ | 0x4D | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

4.4.9 ZW_DeleteReturnRoute

```

BOOL ZW_DeleteReturnRoute(
    BYTE nodeID,
    VOID_CALLBACKFUNC(completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

```

Macro: ZW_DELETE_RETURN_ROUTE(nodeID, func)

Delete all static return routes from a Routing Slave or Enhanced 232 Slave node.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If Delete return route operation started
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

nodeID IN	Node ID (1...232) of the routing slave node.
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	(see ZW_SendData)
txStatusReport IN	(see ZW_SendData)

Serial API:

HOST->ZW: REQ | 0x47 | nodeID | funcID

ZW->HOST: RES | 0x47 | retVal

ZW->HOST: REQ | 0x47 | funcID | bStatus

4.4.10 ZW_DeleteSUCReturnRoute

```

BOOL ZW_DeleteSUCReturnRoute(
    BYTE bNodeID,
    VOID_CALLBACKFUNC (completedFunc)
    (BYTE txStatus, TX_STATUS_TYPE* txStatusReport))

```

Macro: ZW_DELETE_SUC_RETURN_ROUTE (nodeID, func)

Delete the return routes of the SUC/SIS node from a Routing Slave node or Enhanced 232 Slave node.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the delete SUC return route operation is started.
	FALSE	If an "assign/delete return route" operation already is active.

Parameters:

bNodeID IN Node ID (1..232) of the routing slave node.

completedFunc IN Transmit complete call back.

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

txStatusReport IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x55 | nodeID | funcID

ZW->HOST: RES | 0x55 | retVal

ZW->HOST: REQ | 0x55 | funcID | bStatus

4.4.11 ZW_GetControllerCapabilities

BYTE ZW_GetControllerCapabilities(void)

Macro: ZW_GET_CONTROLLER_CAPABILITIES()

ZW_GetControllerCapabilities returns a bitmask containing the capabilities of the controller. It's an old type of primary controller (node ID = 0xEF) in case zero is returned.

NOTE: Not all status bits are available on all controllers' types

Defined in: ZW_controller_api.h

Return value:

BYTE	CONTROLLER_IS_SECONDARY	If bit is set then the controller is a secondary controller
	CONTROLLER_ON_OTHER_NETWORK	If this bit is set then this controller is not using its built-in home ID
	CONTROLLER_IS_SUC	If this bit is set then this controller is a SUC
	CONTROLLER_NODEID_SERVER_PRESENT	If this bit is set then there is a SUC ID server (SIS) in the network and this controller can therefore include/exclude nodes in the network. This is called an inclusion controller.
	CONTROLLER_IS_REAL_PRIMARY	If this bit is set then this controller was the original primary controller in the network before the SIS was added to the network

Serial API:

HOST->ZW: REQ | 0x05

ZW->HOST: RES | 0x05 | RetVal

4.4.12 ZW_GetNeighborCount

BYTE ZW_GetNeighborCount(BYTE nodeID)

Macro: ZW_GET_NEIGHBOR_COUNT (nodeID)

Used to get the number of neighbors the specified node has registered.

Defined in: ZW_controller_api.h

Return value:

BYTE	0x00-0xE7	Number of neighbors registered.
	NEIGHBORS_ID_INVALID	Specified node ID is invalid.
	NEIGHBORS_COUNT_FAILED	Could not access routing information - try again later.

Parameters:

nodeID IN Node ID (1...232) on the node to count neighbors on.

Serial API

HOST->ZW: REQ | 0xBB | nodeID

ZW->HOST: RES | 0xBB | retVal

4.4.13 ZW_GetPriorityRoute

BYTE ZW_GetPriorityRoute (BYTE bNodeID, XBYTE *pPriorityRoute)

Macro: ZW_GET_PRIORITY_ROUTE(bNodeID, pPriorityRoute)

Use this API call to get the route with the highest priority. If a route has been set with the ZW_SetPriorityRoute then that route will be returned. If no priority route has been set the call will return either the Last Working Route (LWR) or the Next to Last Working Route (NLWR). The LWR is the last successful route used between sender and destination node and the NLWR is the previous LWR. The PriorityRoute, LWR and NLWR are all stored in NVM.

Note: ZW_GetPriorityRoute superceeds the ZW_GetLastWorkingRoute functionality, which is obsolete.

Defined in: ZW_controller_api.h

Return value:

BYTE	ZW_PRIORITY_ROUTE_APP_PR	App defined Priority Route.
	ZW_PRIORITY_ROUTE_ZW_LWR	Last Working Route
	ZW_PRIORITY_ROUTE_ZW_NLWR	Next to Last Working Route
	FALSE	No Priority Route found for bNodeID.

Parameters:

bNodeID IN	The Node ID (1...232) specifies the destination node whom the Priority Route is wanted from.
pPriorityRoute IN	Pointer to a 5-byte array where the wanted Priority Route will be copied. The 5-byte array contains in the first 4 byte the max 4 repeaters (index 0 - 3) and 1 routespeed byte (index 4) used in the Route. The Route which pPriorityRoute points to is valid if function return value is NON ZERO. The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the Route is direct. The routespeed byte (index 4) can be either ZW_PRIORITY_ROUTE_SPEED_9600, ZW_PRIORITY_ROUTE_SPEED_40K or ZW_PRIORITY_ROUTE_SPEED_100K

Serial API

HOST->ZW: REQ | 0x92 | bNodeID

ZW->HOST: RES | 0x92 | bNodeID | retVal | repeater0 | repeater1 | repeater2 | repeater3 | routespeed

4.4.14 ZW_SetPriorityRoute

BOOL ZW_SetPriorityRoute(BYTE bNodeID, XBYTE *pPriorityRoute)

Macro: ZW_SET_PRIORITY_ROUTE(bNodeID, pPriorityRoute)

Use this API call to set the Priority Route for a destination node. The Priority Route is the route that will be used as the first routing attempt by the protocol when transmitting to a node. The Priority Route is stored in NVM.

Note: ZW_SetPriorityRoute superceeds the ZW_SetLastWorkingRoute functionality, which is obsolete.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	The Priority Route for bNodeID was successfully set to the specified 5-byte Priority Route pointed out by pPriorityRoute.
	FALSE	The specified bNodeID was not valid and no Priority Route was set.

Parameters:

bNodeID IN	The Node ID (1...232) - specifies the destination node for whom the Priority Route is to be set.
pPriorityRoute IN	Pointer for a 5-byte array containing the new Priority Route to be set. If NULL then current APR is released (protocol now has 2 entries for LWRs). The 5-byte array contains 4 repeater node bytes (index 0 - 3) and 1 routespeed byte (index 4). The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the Priority Route is direct. The routespeed byte (index 4) can be either ZW_PRIORITY_ROUTE_SPEED_9600, ZW_PRIORITY_ROUTE_SPEED_40K or ZW_PRIORITY_ROUTE_SPEED_100K

Serial API

HOST->ZW: REQ | 0x93 | bNodeID | repeater0 | repeater1 | repeater2 | repeater3 | routespeed

ZW->HOST: RES | 0x93 | bNodeID | retVal

4.4.15 ZW_GetNodeProtocolInfo

```
void ZW_GetNodeProtocolInfo(BYTE bNodeID,
                           NODEINFO *nodeInfo)
```

Macro: ZW_GET_NODE_STATE(nodeID, nodeInfo)

Return the Node Information Frame without command classes from the NVM for a given node ID:

Byte descriptor \ Bit number	7	6	5	4	3	2	1	0
Capability	Listening	Z-Wave Protocol-Specific Part						
Security	Opt. Func.	Sensor 1000ms	Sensor 250ms	Z-Wave Protocol-Specific Part				
Reserved	Z-Wave Protocol-Specific Part							
Basic	Basic Device Class (Z-Wave Protocol-Specific Part)							
Generic	Generic Device Class (Z-Wave Appl.-Specific Part)							
Specific	Specific Device Class (Z-Wave Appl.-Specific Part)							

Figure 41. Node Information Frame Structure without Command Classes

All the Z-Wave protocol-specific fields are initialized by the protocol. The Listening flag, Generic, and Specific Device Class fields are initialized by the application. Regarding initialization, refer to the function **ApplicationNodeInformation**.

Defined in: ZW_controller_api.h

Parameters:

bNodeID IN	Node ID	1..232
nodeInfo OUT	Node info buffer (see figure above)	If (*nodeInfo).nodeType.generic is 0 then the node doesn't exist.

Serial API:

HOST->ZW: REQ | 0x41 | bNodeID

ZW->HOST: RES | 0x41 | nodeInfo (see figure above)

4.4.16 ZW_GetRoutingInfo

```
void ZW_GetRoutingInfo(BYTE bNodeID,
                      BYTE_P pMask,
                      BYTE bOptions)
```

Macro: ZW_GET_ROUTING_INFO(bNodeID, pMask, bOptions)

ZW_GetRoutingInfo is a function that can be used to read out neighbor information from the protocol.

This information can be used to ensure that all nodes have a sufficient number of neighbors and to ensure that the network is in fact one network.

The format of the data returned in the buffer pointed to by pMask is as follows:

pMask[i] ($0 \leq i < (ZW_MAX_NODES/8)$)								
Bit	0	1	2	3	4	5	6	7
NodeID	$i*8+1$	$i*8+2$	$i*8+3$	$i*8+4$	$i*8+5$	$i*8+6$	$i*8+7$	$i*8+8$

If a bit n in $pMask[i]$ is 1 it indicates that the node $bNodeID$ has node $(i*8)+n+1$ as a neighbour. If n in $pMask[i]$ is 0, $bNodeID$ cannot reach node $(i*8)+n+1$ directly.

Defined in: ZW_controller_api.h

Parameters:

bNodeID IN	Node ID (1...232) specifies the node whom routing info is needed from.	
pMask OUT	Pointer to buffer where routing info should be put. The buffer should be at least ZW_MAX_NODES/8 bytes	
bOptions IN	Upper nibble (upper 4-bit in byte) is bit flag options, lower nibble is speed. Combine exactly one speed with any number of options. Bit flags options for upper nibble: GET_ROUTING_INFO_REMOVE_NON_REPS (bRemoveNonReps) GET_ROUTING_INFO_REMOVE_BAD (bRemoveBad)	Remove non-repeaters from the routing info. Remove bad link from routing info Bad links are a short list of nodes which recently has failed to answer a transmission
	Speed values for lower nibble: ZW_GET_ROUTING_INFO_9600 or ZW_GET_ROUTING_INFO_40K or ZW_GET_ROUTING_INFO_100K or ZW_GET_ROUTING_INFO_ANY	Return only nodes supporting this speed. Only one speed value may be used at a time.

Serial API:

HOST->ZW: REQ | 0x80 | bNodeID | bRemoveBad | bRemoveNonReps | funcID

ZW->HOST: RES | 0x80 | NodeMask[29]

NOTE: funcID must be set to 0.

NOTE: Serial API func FUNC_ID_GET_ROUTING_TABLE_LINE (0x80) is the Serial API command ID for ZW_GetRoutingInfo and the current implementation do not support for specifying Speed value.

4.4.17 ZW_GetSUCNodeID

BYTE ZW_GetSUCNodeID(void)

Macro: ZW_GET_SUC_NODEID()

API call used to get the currently registered SUC/SIS node ID.

Defined in: ZW_controller_api.h

Return value:

BYTE The node ID (1..232) on the currently registered SUC/SIS, if ZERO then no SUC/SIS available.

Serial API:

HOST->ZW: REQ | 0x56

ZW->HOST: RES | 0x56 | SUCNodeID

4.4.18 ZW_IsFailedNode

BYTE ZW_IsFailedNode(BYTE nodeID)

Macro: ZW_IS_FAILED_NODE_ID(nodeID)

Used to test if a node ID is stored in the failed node ID list.

The failed node list is limited to 5 entries. If a node is added to a full list the node with the lowest failed count will be replaced with the new node ID.

Defined in: ZW_controller_api.h

Return value:

BYTE	TRUE	If node ID (1..232) is in the list of failing nodes.
------	------	--

Parameters:

nodeID IN The node ID (1...232) to check.

Serial API:

HOST->ZW: REQ | 0x62 | nodeID

ZW->HOST: RES | 0x62 | retVal

4.4.19 ZW_IsPrimaryCtrl

BOOL ZW_IsPrimaryCtrl (void)

Macro: ZW_PRIMARYCTRL()

This function is used to request whether the controller is a primary controller or a secondary controller in the network.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	Returns TRUE when the controller is a primary controller in the network.
	FALSE	Return FALSE when the controller is a secondary controller in the network.

Serial API (Not supported)

4.4.20 ZW_RemoveFailedNode

**BYTE ZW_RemoveFailedNode(BYTE NodeID,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))**

Macro: ZW_REMOVE_FAILED_NODE_ID(node,func)

Used to remove a non-responding node from the routing table in the requesting controller. A non-responding node is put onto the failed node ID list in the requesting controller. In case the node responds again at a later stage then it is removed from the failed node ID list. A node must be on the failed node ID list and as an extra precaution also fail to respond before it is removed. Responding nodes can't be removed. The call works on a primary controller and an inclusion controller.

A call back function should be provided otherwise the function will return without removing the node.

Defined in: ZW_controller_api.h

Return value (If the replacing process started successfully then the function will return):

BYTE ZW_FAILED_NODE_REMOVE_STARTED The removing process started

Return values (If the replacing process cannot be started then the API function will return one or more of the following flags):

BYTE	ZW_NOT_PRIMARY_CONTROLLER	The removing process was aborted because the controller is not the primary one.
	ZW_NO_CALLBACK_FUNCTION	The removing process was aborted because no call back function is used.
	ZW_FAILED_NODE_NOT_FOUND	The requested process failed. The nodeID was not found in the controller list of failing nodes.
	ZW_FAILED_NODE_REMOVE_PROCESS_BUSY	The removing process is busy.
	ZW_FAILED_NODE_REMOVE_FAIL	The requested process failed. Reasons include: <ul style="list-style-type: none"> • Controller is busy • The node responded to a NOP; therefore, the node is no longer failing.

Parameters:

nodeID IN The node ID (1..232) of the failed node to be deleted.

completedFunc IN Remove process completed call back function

Callback function Parameters:

txStatus IN Status of removal of failed node:

ZW_NODE_OK	The node is working properly (removed from the failed nodes list).
ZW_FAILED_NODE_REMOVED	The failed node was removed from the failed nodes list.
ZW_FAILED_NODE_NOT_REMOVED	The failed node was not removed because the removing process cannot be completed.

Serial API:

HOST->ZW: REQ | 0x61 | nodeID | funcID

ZW->HOST: RES | 0x61 | retVal

ZW->HOST: REQ | 0x61 | funcID | txStatus

4.4.21 ZW_ReplaceFailedNode

```
BYTE ZW_ReplaceFailedNode( BYTE NodeID,  
                           BOOL bNormalPower,  
                           VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))
```

Macro: ZW_REPLACE_FAILED_NODE(node,func)

This function replaces a non-responding node with a new one in the requesting controller. A non-responding node is put onto the failed node ID list in the requesting controller. In case the node responds again at a later stage then it is removed from the failed node ID list. A node must be on the failed node ID list and as an extra precaution also fail to respond before it is removed. Responding nodes can't be replace. The call works on a primary controller and an inclusion controller.

A call back function should be provided otherwise the function would return without replacing the node.

Defined in: ZW_controller_api.h

Return value (If the replacing process started successfully then the function will return):

BYTE ZW_FAILED_NODE_REMOVE_STARTED The replacing process has started.

Return values (If the replacing process cannot be started then the API function will return one or more of the following flags:):

BYTE ZW_NOT_PRIMARY_CONTROLLER	The replacing process was aborted because the controller is not a primary/inclusion/SIS controller.
ZW_NO_CALLBACK_FUNCTION	The replacing process was aborted because no call back function is used.
ZW_FAILED_NODE_NOT_FOUND	The requested process failed. The nodeID was not found in the controller list of failing nodes.
ZW_FAILED_NODE_REMOVE_PROCESS_BUSY	The removing process is busy.
ZW_FAILED_NODE_REMOVE_FAIL	The requested process failed. Reasons include: <ul style="list-style-type: none"> • Controller is busy • The node responded to a NOP; therefore, the node is no longer failing.

Parameters:

nodeID IN	The node ID (1...232) of the failed node to be deleted.
bNormalPower IN	If TRUE then using Normal RF Power.
completedFunc IN	Replace process completed call back function

Callback function Parameters:

txStatus IN	Status of replace of failed node:	
	ZW_NODE_OK	The node is working properly (removed from the failed nodes list). Replace process is stopped.
	ZW_FAILED_NODE_REPLACE	The failed node is ready to be replaced and controller is ready to add new node with the nodeID of the failed node. Meaning that the new node must now emit a nodeinformation frame to be included.
	ZW_FAILED_NODE_REPLACE_DONE	The failed node has been replaced.
	ZW_FAILED_NODE_REPLACE_FAILED	The failed node has not been replaced.

Serial API:

HOST->ZW: REQ | 0x63 | nodeID | funcID

ZW->HOST: RES | 0x63 | retVal

ZW->HOST: REQ | 0x63 | funcID | txStatus

4.4.22 ZW_RemoveNodeFromNetwork

```
void ZW_RemoveNodeFromNetwork(BYTE bMode,  
                               VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_REMOVE_NODE_FROM_NETWORK(bMode, func)

Defined in: ZW_controller_api.h

Serial API: Func_ID = 0x4B

HOST->ZW: REQ | 0x4B | bMode | funcID

ZW->HOST: REQ | 0x4B | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

ZW_RemoveNodeFromNetwork is used to remove a node from a Z-Wave network. It is also possible to perform out-of-range removal of nodes from the network when repeater nodes are capable of forwarding the new network wide exclusion (NWE) frame. It is not possible to perform out-of-range removal of nodes based on a SDK older than SDK 6.61.xx.

The RemoveNodeFromNetwork function MAY be called by a primary controller application to invoke the removal of nodes from a Z-Wave network. Slave and secondary controller applications MUST NOT call this function.

A controller application MUST implement support for the RemoveNodeFromNetwork function. The controller application MUST provide a user interface for activation of the RemoveNodeFromNetwork function.

The bMode and completedFunc parameters MUST be specified for the RemoveNodeFromNetwork to function.

Refer to Figure 42 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.22.1 bMode parameter

The bMode parameter MUST carry one of the commands found in Table 22. The bMode parameter MUST NOT be assigned more than one command. The bMode parameter MAY be assigned one or more option flags. One command and multiple options are combined by logically OR'ing the bMode flags of Table 15.

Table 22. RemoveNode :: bMode

bMode flag	Description	Usage
REMOVE_NODE_ANY	Command to initiate removal of node of any type.	MUST be included when initiating removal.
REMOVE_NODE_SLAVE	-	<u>DEPRECATED</u> . Use REMOVE_NODE_ANY
REMOVE_NODE_CONTROLLER	-	<u>DEPRECATED</u> . Use REMOVE_NODE_ANY
REMOVE_NODE_STOP	Command to abort the removal process. May only be used in certain states.	MAY be used to abort an active removal process. MUST be used to terminate the removal process when completed.
REMOVE_NODE_OPTION_NETWORK_WIDE	Option flag to enable Network-Wide Exclusion (NWE).	MUST be used together with REMOVE_NODE_ANY.

4.4.22.1.1 REMOVE_NODE_ANY command

To invoke removal of a node, a primary controller MUST call the RemoveNodeFromNetwork function with a bMode value including the REMOVE_NODE_ANY command. Slave and secondary controller nodes MUST NOT call the RemoveNodeFromNetwork function.

The option REMOVE_NODE_OPTION_NETWORK_WIDE MUST also be used when calling RemoveNodeFromNetwork to enable the NWE feature. The NWE feature makes a Controller exclude a node transmitting the ZWAVE_CMD_EXCLUDE_REQUEST protocol command frame. The ZWAVE_CMD_EXCLUDE_REQUEST protocol command frame is essentially a Node information protocol command frame but with ZWAVE_CMD_EXCLUDE_REQUEST as command and are only transmitted as an explore frame.

While defined in Z-Wave protocol libraries, it is NOT RECOMMENDED to use the REMOVE_NODE_SLAVE or REMOVE_NODE_CONTROLLER command codes.

4.4.22.1.2 REMOVE_NODE_STOP command

A controller MAY use the REMOVE_NODE_STOP command to abort an ongoing removal process.

After receiving a REMOVE_NODE_STATUS_DONE status callback, the application MUST terminate the removal process by calling the RemoveNodeFromNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

4.4.22.2 completedFunc parameter

Being the exception to the rule, an application calling `RemoveNodeFromNetwork(REMOVE_NODE_STOP)` to confirm the reception of a `REMOVE_NODE_STATUS_DONE` return code MUST specify the NULL pointer for the `completedFunc` parameter.

In all other cases, an application calling the `RemoveNodeFromNetwork` function MUST specify a valid pointer to a callback function provided by the application. The callback function MUST accept a pointer parameter to a `LEARN_INFO` struct. The parameter provides access to actual status as well as companion data presenting the node being removed. The `LEARN_INFO` struct only contains a valid pointer to the Node Information Frame of a node when the status of the callback is `REMOVE_NODE_STATUS_REMOVING_SLAVE` or `REMOVE_NODE_STATUS_REMOVING_CONTROLLER`.

Table 23. RemoveNode :: completedFunc :: learnNodeInfo

LEARN_NODE struct member	Description
<code>*learnNodeInfo.bStatus</code>	Callback status code
<code>*learnNodeInfo.bSource</code>	NodeID of the node that was removed
<code>*learnNodeInfo.bLen</code>	Length of pCmd element following the bLen element. If bLen is zero, there is no valid pCmd element.
<code>*learnNodeInfo.pCmd</code>	Pointer to Application Node Information (see ApplicationNodeInformation - nodeParm). NULL if no information present.

Individual status codes are presented in the following sections.

Table 24. RemoveNode :: completedFunc :: learnNodeInfo.bStatus

LEARN_NODE.bStatus	Description
REMOVE_NODE_STATUS_LEARN_READY	Z-Wave protocol is ready to remove a node.
REMOVE_NODE_STATUS_NODE_FOUND	Z-Wave protocol detected node.
REMOVE_NODE_STATUS_REMOVING_SLAVE	Z-Wave protocol removed a slave type node
REMOVE_NODE_STATUS_REMOVING_CONTROLLER	Z-Wave protocol removed a controller type node
REMOVE_NODE_STATUS_DONE	All operations completed. Protocol is ready to return to idle state.
REMOVE_NODE_STATUS_FAILED	Z-Wave protocol reports that removal was not successful. Node may not have been removed.
ADD_NODE_STATUS_NOT_PRIMARY	Z Wave protocol reports that the requested operation cannot be performed since it requires that the node is in primary controller state.

Refer to Figure 42 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.22.2.1 REMOVE_NODE_STATUS_LEARN_READY status

Z-Wave protocol is ready to remove a node. An application MAY time out waiting for the REMOVE_NODE_STATUS_LEARN_READY status if it does not receive the indication within 200 msec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY).

If the application times out waiting for the REMOVE_NODE_STATUS_LEARN_READY status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL).

4.4.22.2.2 REMOVE_NODE_STATUS_NODE_FOUND status

Z-Wave protocol detected node. An application MUST time out waiting for the REMOVE_NODE_STATUS_NODE_FOUND status if it does not receive the indication after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY). The RECOMMENDED interval is 60 sec.

If the application times out waiting for the REMOVE_NODE_STATUS_NODE_FOUND status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL).

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.22.2.3 REMOVE_NODE_STATUS_REMOVING_SLAVE status

Z-Wave protocol is removing a slave type node. The NodeID of the node is included in the callback.

An application MUST time out waiting for the REMOVE_NODE_STATUS_REMOVING_SLAVE status if it does not receive the indication within a 14 sec after receiving the REMOVE_NODE_STATUS_NODE_FOUND status.

If the application times out waiting for the REMOVE_NODE_STATUS_REMOVING_SLAVE status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a REMOVE_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.22.2.4 REMOVE_NODE_STATUS_REMOVING_CONTROLLER status

Z-Wave protocol is removing a controller type node. The NodeID of the node is included in the callback.

An application MUST time out waiting for the REMOVE_NODE_STATUS_REMOVING_CONTROLLER status if it does not receive the indication within a 14 sec after receiving the REMOVE_NODE_STATUS_NODE_FOUND status.

If the application times out waiting for the REMOVE_NODE_STATUS_REMOVING_CONTROLLER status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a REMOVE_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.22.2.5 REMOVE_NODE_STATUS_DONE status

All operations completed. Protocol is ready to return to idle state.

In response to the REMOVE_NODE_STATUS_DONE status callback, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL). The application MUST specify the NULL pointer for the callback function.

4.4.22.2.6 REMOVE_NODE_STATUS_FAILED status

If an application receives a REMOVE_NODE_STATUS_PROTOCOL_FAILED status callback, the application MUST terminate the removal process by calling RemoveNodeFromNetwork(REMOVE_NODE_STOP). Refer to 4.4.22.1.2.

4.4.22.2.7 ADD_NODE_STATUS_NOT_PRIMARY status

An application MUST NOT call the RemoveNodeFromNetwork function if the application is not running in a primary controller. If the function is called by an application running in slave or a secondary controller, the API MUST return the ADD_NODE_STATUS_NOT_PRIMARY status callback.

4.4.22.3 completedFunc callback timeouts

4.4.22.3.1 ProtocolReadyTimeout

The API MUST return a REMOVE_NODE_STATUS_LEARN_READY status callback within less than 200 msec after receiving a call to RemoveNodeFromNetwork(REMOVE_NODE_ANY).

If an application has not received a REMOVE_NODE_STATUS_LEARN_READY status callback 200 msec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY), the application MAY time out and return to its idle state.

4.4.22.3.2 NodeTimeout

An application **MUST** implement a timeout for waiting for an REMOVE_NODE_STATUS_NODE_FOUND status callback.

The application **SHOULD NOT** wait for a REMOVE_NODE_STATUS_NODE_FOUND status callback for more than 60 sec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY). If timing out, the application **SHOULD** abort removal.

4.4.22.3.3 RemoveNodeTimeout

An application **MUST** time out if removal has not been completed within 14 sec after the reception of the REMOVE_NODE_STATUS_NODE_FOUND status callback.

If timing out, the application **MUST** evaluate the controller node list to verify that the NodeID was removed. The removal process **SHOULD** be repeated if the NodeID is still found in the node list.

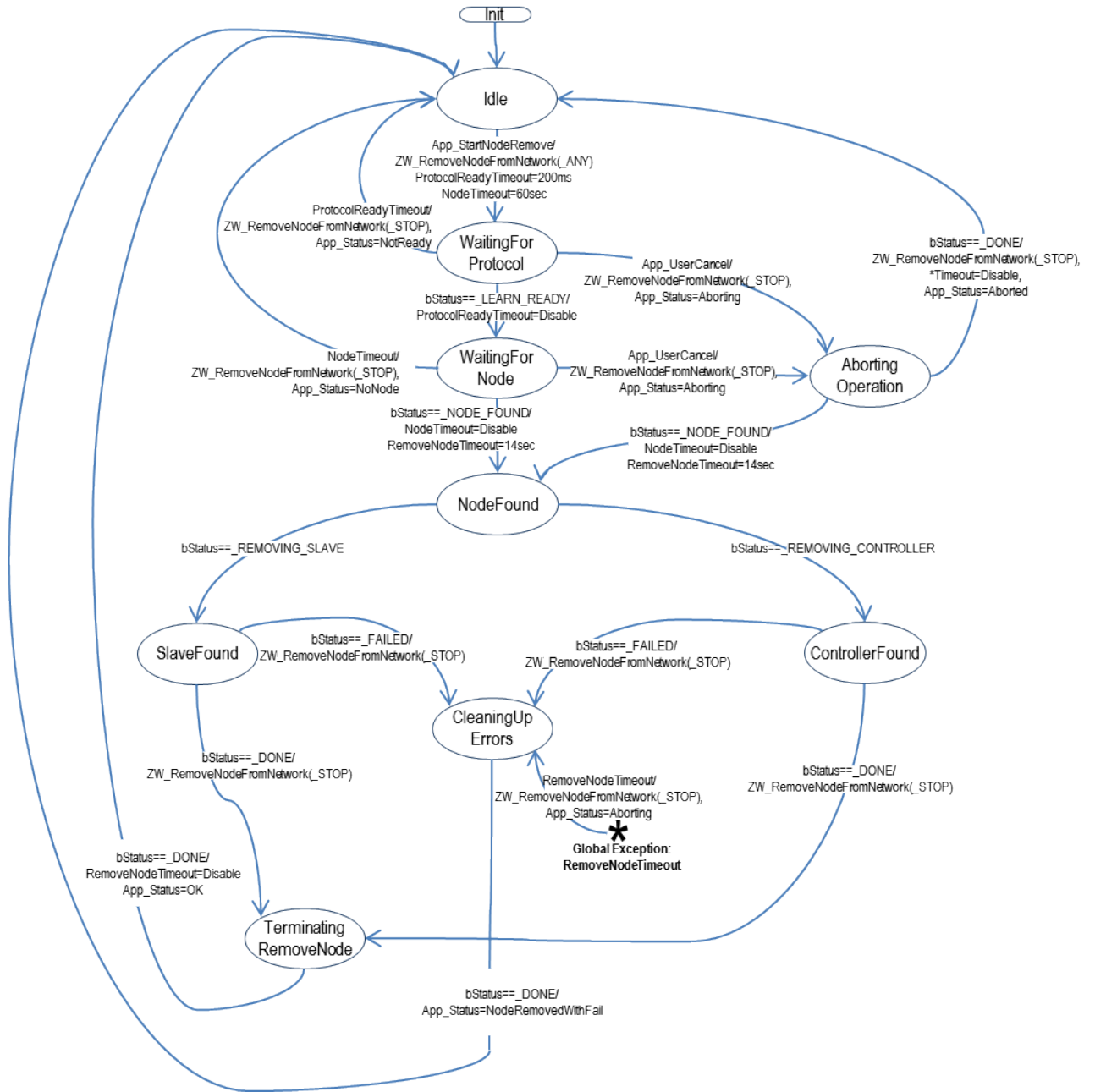


Figure 42. Removing a Node from the Network

Table 25. RemoveNode : State/Event processing - 1

(Any State)	<p>Event: RemoveNodeTimeout=> // GLOBAL Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p>
Idle	<p>Event: (Init) => // Initialize timers, etc.</p> <p>Event: App_StartNodeRemove => // Higher layer application event calls for node to be removed New state: <WaitingForProtocol> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_ANY) ProtocolReadyTimeout=200ms NodeTimeout=60sec</p>
WaitingForProtocol	<p>Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_AddNodeToNetwork(REMOVE_NODE_STOP) Generate App_Status=Aborting event for application</p> <p>Event: bStatus==REMOVE_NODE_STATUS_LEARN_READY => //Callback New state: <WaitingForNode> Actions: Disable ProtocolReadyTimeout timer</p> <p>Event: ProtocolReadyTimeout => // Timer event New state: <Idle> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NotReady event for application</p>
WaitingForNode	<p>Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Generate App_Status=Aborting event for application</p> <p>Event: bStatus==REMOVE_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: NodeTimeout=Disable Actions: RemoveNodeTimeout=14 sec</p> <p>Event: NewNodeTimeout=> // Timer event New state: <Idle> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NoNode event for application</p>
NodeFound	<p>Event: bStatus==REMOVE_NODE_STATUS_REMOVING_SLAVE => //Callback New state: <SlaveFound></p> <p>Event: bStatus==REMOVE_NODE_STATUS_REMOVING_CONTROLLER => //Callback New state: <ControllerFound></p> <p>Event: NodeFoundTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p>

Table 26. RemoveNode : State/Event processing - 2

States	
SlaveFound	<p>Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <TerminatingRemoveNode> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p> <p>Event: bStatus==REMOVE_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p> <p>Event: RemoveNodeTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p>
ControllerFound	<p>Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <TerminatingRemoveNode> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p> <p>Event: bStatus==REMOVE_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p> <p>Event: RemoveNodeTimeout=> // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)</p>
TerminatingRemoveNode	<p>Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: RemoveNodeTimeout=Disable Actions: Generate App_Status=OK event for application</p>
CleaningUpErrors	<p>Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Generate App_Status=NodeRemoveWithFail event for application</p>
AbortingOperation	<p>Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) Generate App_Status=Aborted event for application</p> <p>Event: bStatus==REMOVE_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: NodeTimeout=Disable Actions: RemoveNodeTimeout=14 sec</p>

4.4.23 ZW_RemoveNodeIDFromNetwork

```
void ZW_RemoveNodeIDFromNetwork(BYTE bMode,  
                                BYTE bNodeID,  
                                VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_REMOVE_NODE_ID_FROM_NETWORK(mode, nodeid, func)
Defined in: ZW_controller_api.h

Serial API: Func_ID = 0x3F

HOST->ZW: REQ | 0x3F | bMode | bNodeID | funcID

ZW->HOST: REQ | 0x3F | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

ZW_RemoveNodeIDFromNetwork can be used to remove a specific node from a Z-Wave network.

The RemoveNodeIDFromNetwork function MAY be called by a primary controller application to invoke the removal of a specific node from the Z-Wave network in question. Slave and secondary controller applications MUST NOT call this function.

The bMode, bNodeID and completedFunc parameters MUST be specified for the RemoveNodeIDFromNetwork function to function.

Refer to Figure 42 and substitute ZW_RemoveNodeFromNetwork with ZW_RemoveNodeIDFromNetwork for a state diagram outlining the processing of status callbacks and timeouts.

4.4.23.1 bMode parameter

See ZW_RemoveNodeFromNetwork 4.4.22.1 and substitute ZW_RemoveNodeFromNetwork with ZW_RemoveNodeIDFromNetwork for a description of the bMode parameter.

4.4.23.2 bNodeID parameter

The bNodeID parameter can be used to specify that only the node with the exact nodeID as specified can be excluded through the started exclusion process.

If a valid bNodeID value (1-232) is specified then only the specified bNodeID with the same HomeID as the excluding controller and matching the mode settings can be removed.

If REMOVE_NODE_ID_ANY or any NONE valid nodeID (0, 233-255) is specified then ZW_RemoveNodeIDFromNetwork functions exactly as ZW_RemoveNodeFromNetwork (See 4.4.22).

4.4.23.3 completedFunc parameter

See ZW_RemoveNodeFromNetwork 4.4.22.2 and substitute ZW_RemoveNodeFromNetwork with ZW_RemoveNodeIDFromNetwork for a description of the completedFunc parameter.

4.4.24 ZW_ReplicationReceiveComplete

void ZW_ReplicationReceiveComplete(void)

Macro: ZW_REPLICATION_COMMAND_COMPLETE

Sends command completed to sending controller. Called in replication mode when a command from the sender has been processed and indicates that the controller is ready for next packet.

Defined in: ZW_controller_api.h

Serial API:

HOST->ZW: REQ | 0x44

4.4.25 ZW_ReplicationSend

```

BYTE ZW_ReplicationSend( BYTE destNodeID,
                        BYTE *pData,
                        BYTE dataLength,
                        BYTE txOptions,
                        VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

```

Macro: ZW_REPLICATION_SEND_DATA(node,data,length,options,func)

Used when the controller is in replication mode. It sends the payload and expects the receiver to respond with a command complete message (ZW_REPLICATION_COMMAND_COMPLETE).

Messages sent using this command should always be part of the Z-Wave controller replication command class.

Defined in: ZW_controller_api.h

Return value:

BYTE FALSE If transmit queue overflow.

Parameters:

destNode IN Destination Node ID
(not equal NODE_BROADCAST).

pData IN Data buffer pointer

dataLength IN Data buffer length

txOptions IN Transmit option flags. (see **ZW_SendData**, but avoid using routing!)

completedFunc IN Transmit completed call back function

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x45 | destNodeID | dataLength | pData[] | txOptions | funcID

ZW->HOST: RES | 0x45 | RetVal

ZW->HOST: REQ | 0x45 | funcID | txStatus

4.4.26 ZW_RequestNodeInfo

**BOOL ZW_RequestNodeInfo (BYTE nodeID,
VOID (*completedFunc)(BYTE txStatus))**

Macro: ZW_REQUEST_NODE_INFO(NODEID)

This function is used to request the Node Information Frame from a controller based node in the network. The Node info is retrieved using the **ApplicationControllerUpdate** callback function with the status UPDATE_STATE_NODE_INFO_RECEIVED. The **ZW_RequestNodeInfo** API call is also available for routing slaves.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the request could be put in the transmit queue successfully.
	FALSE	If the request could not be put in the transmit queue. Request failed.

Parameters:

nodeID IN The node ID (1...232) of the node to request the Node Information Frame from.

completedFunc IN Transmit complete call back.

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x60 | NodeID

ZW->HOST: RES | 0x60 | retVal

4.4.27 ZW_RequestNodeNeighborUpdate

```
BYTE ZW_RequestNodeNeighborUpdate(
    NODEID,
    VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))
```

Macro: ZW_REQUEST_NODE_NEIGHBOR_UPDATE(nodeid, func)

Get the neighbors from the specified node. To ensure strong RF links the node uses normal RF power level minus 6dB to find its neighbors. This call can only be called by a primary/inclusion controller. An inclusion controller should call **ZW_RequestNetWorkUpdate** in advance because the inclusion controller may not have the latest network topology.

Defined in: ZW_controller_api.h

Return value:

BYTE	TRUE	The discovery process is started and the function will be completed by the callback
	FALSE	The discovery was not started and the callback will not be called. The reason for the failure can be one of the following: <ul style="list-style-type: none"> • This is not a primary/inclusion controller • There is only one node in the network, nothing to update. • The controller is busy doing another update.

Parameters:

nodeID IN Node ID (1...232) of the node that the controller wants to get new neighbors from. Not allowed to use controllers own node ID.

completedFunc IN Transmit complete call back.

Callback function Parameters:

bStatus IN	Status of command:	
	REQUEST_NEIGHBOR_UPDATE_STARTED	Requesting neighbor list from the node is in progress.
	REQUEST_NEIGHBOR_UPDATE_DONE	New neighbor list received
	REQUEST_NEIGHBOR_UPDATE_FAIL	Getting new neighbor list failed

Serial API:

HOST->ZW: REQ | 0x48 | nodeID | funcID

ZW->HOST: REQ | 0x48 | funcID | bStatus

4.4.28 ZW_SendSUCID

**BYTE ZW_SendSUCID (BYTE node,
 BYTE txOption,
 VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus,
 TX_STATUS_TYPE* txStatusReport))**

Macro: ZW_SEND_SUC_ID(nodeID, txOption, func)

Transmit SUC/SIS node ID from a primary controller or static controller to the controller node ID specified. Routing slaves ignore this command, use instead ZW_AssignSUCReturnRoute.

Defined in: ZW_controller_api.h

Return value:

TRUE	In progress.
FALSE	Not a primary controller or static controller.

Parameters:

node IN	The node ID (1...232) of the node to receive the current SUC/SIS node ID.
txOption IN	Transmit option flags. (see ZW_SendData)
completedFunc IN	Transmit complete call back.

Callback function parameters:

txStatus IN	(see ZW_SendData)
txStatusReport IN	(see ZW_SendData)

Serial API:

HOST->ZW: REQ | 0x57 | node | txOption | funcID

ZW->HOST: RES | 0x57 | RetVal

ZW->HOST: REQ | 0x57 | funcID | txStatus

4.4.29 ZW_SetDefault

void ZW_SetDefault(VOID_CALLBACKFUNC(completedFunc)(void))

Macro: ZW_SET_DEFAULT(func)

This function set the Controller back to the factory default state. Erase all Nodes, routing information and assigned homeID/nodeID from the NVM. In case the previous home ID was randomly generated then a new random home ID written to the NVM (random range: 0xC0000000-0xFFFFFFFF). A home ID outside random range reuses the initially configured home ID (configured during production).

Warning: Use this function with care as it could render a Z-Wave network unusable if the primary controller in an existing network is set back to default.

Defined in: ZW_controller_api.h

Parameters:

completedFunc IN Command completed call back function

Serial API:

HOST->ZW: REQ | 0x42 | funcID

ZW->HOST: REQ | 0x42 | funcID

Timeout: 1000ms

Exception Recovery: Resume normal operation, check nodelist to see if the controller has been reset. A controller MUST have nodeID ==1 after a set default.

4.4.30 ZW_SetLearnMode

**void ZW_SetLearnMode (BYTE mode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))**

Macro: ZW_SET_LEARN_MODE(mode, func)

ZW_SetLearnMode is used to add or remove the controller to/from a Z-Wave network.

This function is used to instruct the controller to allow it to be added or removed from the network.

When a controller is added to the network the following things will happen:

1. If the current stored ID's are zero and the assigned ID's are nonzero, the received ID's will be stored (node was added to the network).
2. If the received ID's are zero the stored ID's will be set to zero (node was removed from the network).
3. The controller receives updates to the node list and the routing table but the ID's remain unchanged.

This function will probably change the capabilities of the controller so it is recommended that the application calls `ZW_GetControllerCapabilities()` after completion to check the controller status.

The **learnFunc** is called as the "Assign" process progresses. The returned `nodeID` is the nodes new Node ID. If no "Assign" is received from the including controller the callback function will not be called. It is then up to the application code to switch of Learn mode. Once the assignment process has been started the Callback function may be called more than once. The learn process is not complete before the callback function is called with `LEARN_MODE_DONE`.

Network wide inclusion (add) should always be used as the default mode in inclusion to ensure compatibility with all implementations of Z-Wave controllers.

For information about how to use the different learn modes to make a inclusion that is compatible with all generations of Z-Wave nodes see [4]

NOTE: Learn mode should only be enabled when necessary and disabled again as quickly as possible. It is recommended that learn mode is not enabling for more than 2 second in `ZW_SET_LEARN_MODE_CLASSIC` mode and 5 seconds in either `ZW_SET_LEARN_MODE_NWI` or `ZW_SET_LEARN_MODE_NWE` mode.

NOTE: When the controller is already included into a network (secondary or inclusion controller) the callback status `LEARN_MODE_STARTED` will not be made but the `LEARN_MODE_DONE/FAILED` callback will be made as normal.

WARNING: The learn process should not be stopped with `ZW_SetLearnMode(FALSE,..)` between the `LEARN_MODE_STARTED` and the `LEARN_MODE_DONE` status callback.

Defined in: ZW_controller_api.h

Parameters:

mode IN	The learn mode states are:	
	ZW_SET_LEARN_MODE_CLASSIC	Start the learn mode on the controller and only accept being included and excluded in direct range.
	ZW_SET_LEARN_MODE_NWI	Start the learn mode on the controller and accept routed inclusion (add). NWI mode must not be used for exclusion (remove).
	ZW_SET_LEARN_MODE_NWE	Start the learn mode on the controller and accept routed exclusion (remove) as well as direct. NWE mode must not be used for inclusion (add).
	ZW_SET_LEARN_MODE_DISABLE	Stop learn mode on the controller
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters (completedFunc):

*learnNodeInfo.bStatus IN	Status of learn mode:	
	LEARN_MODE_STARTED	The learn process has been started
	LEARN_MODE_DONE	The learn process is complete and the controller is now included into the network
	LEARN_MODE_FAILED	The learn process failed.
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see ApplicationNodeInformation - nodeParm). NULL if no information present.	
	The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x50 | mode | funcID

ZW->HOST: RES | TRUE

ZW->HOST: REQ | 0x50 | funcID | bStatus | bSource | bLen | pCmd[]

4.4.31 ZW_SetRoutingInfo

```
void ZW_SetRoutingInfo(BYTE bNodeID,
                      BYTE bLength,
                      BYTE_P pMask )
```

Macro: ZW_SET_ROUTING_INFO(bNodeID, bLength, pMask)

ZW_SetRoutingInfo is a function that can be used to overwrite the current neighbor information for a given node ID in the protocol locally.

The format of the routing info must be organised as follows:

pMask[i] (0 ≤ i < (ZW_MAX_NODES/8))								
Bit	0	1	2	3	4	5	6	7
NodeID	i*8+1	i*8+2	i*8+3	i*8+4	i*8+5	i*8+6	i*8+7	i*8+8

If a bit n in pMask[i] is 1 it indicates that the node bNodeID has node (i*8)+n+1 as a neighbour. If n in pMask[i] is 0, bNodeID cannot reach node (i*8)+n+1 directly.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	Neighbor information updated successfully.
	FALSE	Failed to update neighbor information.

Parameters:

bNodeID IN	Node ID (1...232) to be updated with respect to neighbor information.
bLength IN	Routing info buffer length in bytes.
pMask IN	Pointer to buffer where routing info should be taken from. The buffer should be at least ZW_MAX_NODES/8 bytes

Serial API (Only Developer's Kit v4.5x):

HOST->ZW: REQ | 0x1B | bNodeID | NodeMask[29]

ZW->HOST: RES | 0x1B | retVal

4.4.32 ZW_SetRoutingMAX

void ZW_SetRoutingMAX(BYTE maxRouteTries)

Use this function to set the maximum number of source routing attempts before the next mechanism kicks-in. Default value with respect to maximum number of source routing attempts is five. See section 3.10 wrt. the routing attempts for a given Z-Wave node. Remember to enable the transmit option flag TRANSMIT_OPTION_AUTO_ROUTE or TRANSMIT_OPTION_AUTO_ROUTE | TRANSMIT_OPTION_EXPLORE in the send data calls.

Defined in: ZW_controller_api.h

Parameters:

maxRouteTries IN 1...20 Maximum number of source routing attempts

Serial API:

HOST->ZW: REQ | 0xD4 | maxRoutesTries

ZW->HOST: RES | 0xD4 | TRUE

4.4.33 ZW_SetSUCNodeID

```

BYTE ZW_SetSUCNodeID (BYTE nodeID,
                      BYTE SUCState,
                      BYTE bTxOption,
                      BYTE capabilities,
                      VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus,
                      TX_STATUS_TYPE* txStatusReport))

```

Macro: ZW_SET_SUC_NODE_ID(nodeID, SUCState, bTxOption, capabilities, func)

Used to configure a static/bridge controller to be a SUC/SIS node or not. The primary controller should use this function to set a static/bridge controller to be the SUC/SIS node, or it could be used to stop previously chosen static/bridge controller being a SUC/SIS node (not recommended).

A controller can set itself to a SUC/SIS by **ZW_SetSUCNodeID** with its own node ID. It's recommended to do this when the Z-Wave network only comprise of the primary controller to get the SUC/SIS role distributed when new nodes are included. It is possible to include a virgin primary controller with SUC/SIS capabilities configured into another Z-Wave network.

NOTICE: It is not allowed to call **ZW_SetSUCNodeID** with its own node ID and SUCState = FALSE during upstart because this prevent other nodes to set it to a SUC/SIS node.

Defined in: ZW_controller_api.h

Return value:

TRUE	If the process of configuring the static/bridge controller is started.
FALSE	The process not started because the calling controller is not the master or the destination node is not a static/bridge controller.

Parameters:

nodeID IN	The node ID (1...232) of the static controller to configure.	
SUCState IN	TRUE	Want the static controller to be a SUC/SIS node.
	FALSE	If the static/bridge controller should not be a SUC/SIS node.
bTxOption IN	TRUE	Want to send the frame with low transmission power
	FALSE	Want to send the frame at normal transmission power
capabilities IN	SUC capabilities that is enabled:	
	ZW_SUC_FUNC_NODEID_SERVER	Enable the node ID server functionality to become a SIS.
completedFunc IN	Transmit complete call back.	

Callback function Parameters:

txStatus IN	Status of command:	
	ZW_SUC_SET_SUCCEEDED	The process ended successfully.
	ZW_SUC_SET_FAILED	The process failed.
txStatusReport IN	(see ZW_SendData)	

Serial API:

HOST->ZW: REQ | 0x54 | nodeID | SUCState | bTxOption | capabilities | funcID

ZW->HOST: RES | 0x54 | RetVal

ZW->HOST: REQ | 0x54 | funcID | txStatus

In case **ZW_SetSUCNodeID** is called locally with the controllers own node ID then only the response is returned. In case true is returned in the response then it can be interpreted as the command is now executed successfully.

4.5 Z-Wave Static Controller API

The Static Controller application interface is an extended Controller application interface with added functionality specific for the Static Controller.

4.5.1 ZW_CreateNewPrimaryCtrl

```
Void ZW_CreateNewPrimaryCtrl(BYTE mode,
    VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))
```

Macro: ZW_CREATE_NEW_PRIMARY_CTRL

NOTE: Legacy function. This function is no longer relevant for a controller because it is no longer possible to have a SUC without a SIS. This function should not be used.

ZW_CreateNewPrimaryCtrl is used to add a controller to the Z-Wave network as a replacement for the old primary controller.

This function has the same functionality as `ZW_AddNodeToNetwork(ADD_NODE_CONTROLLER,...)` except that the new controller will be a primary controller and it can only be called by a SUC. The function is not available if the SUC is a node ID server (SIS).

WARNING: This function should only be used when it is 100% certain that the original primary controller is lost or broken and will not return to the network.

Defined in: ZW_controller_static_api.h

Parameters:

mode IN	The learn node states are:	
	CREATE_PRIMARY_START	Start the process of adding a new primary controller to the network.
	CREATE_PRIMARY_STOP	Stop the process.
	CREATE_PRIMARY_STOP_FAILED	Stop the inclusion (add) and report a failure to the other controller.
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters:

*learnNodeInfo.bStatus IN Status of learn mode:

	ADD_NODE_STATUS_LEARN_READY	The controller is now ready to include a controller into the network.
	ADD_NODE_STATUS_NODE_FOUND	A controller that wants to be included into the network has been found
	ADD_NODE_STATUS_ADDING_CONTROLLER	A new controller has been added to the network
	ADD_NODE_STATUS_PROTOCOL_DONE	The protocol part of adding a controller is complete, the application can now send data to the new controller using ZW_ReplicationSend()
	ADD_NODE_STATUS_DONE	The new controller has now been included and the controller is ready to continue normal operation again.
	ADD_NODE_STATUS_FAILED	The learn process failed
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see ApplicationNodeInformation - nodeParm). NULL if no information present.	
	The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x4C | mode | funcID

ZW->HOST: REQ | 0x4C | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[]

4.6 Z-Wave Bridge Controller API

The Bridge Controller application interface is an extended Controller application interface with added functionality specific for the Bridge Controller.

4.6.1 ZW_SendSlaveNodeInformation

```

BYTE ZW_SendSlaveNodeInformation(BYTE srcNode,
                                BYTE destNode,
                                BYTE txOptions,
                                VOID_CALLBACKFUNC(completedFunc)(
                                    BYTE txStatus,
                                    TX_STATUS_TYPE* txStatusReport))

```

Macro: ZW_SEND_SLAVE_NODE_INFO(srcnode, destnode, option, func)

Create and transmit a Virtual Slave node "Node Information" frame from Virtual Slave node srcNode. The Z-Wave transport layer builds a frame, request the application slave node information (see **ApplicationSlaveNodeInformation**) and queue the "Node Information" frame for transmission. The completed call back function (**completedFunc**) is called when the transmission is complete.

NOTE: ZW_SendSlaveNodeInformation uses the transmit queue in the API, so using other transmit functions before the complete callback has been called by the API might fail.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If frame was put in the transmit queue.
	FALSE	If transmitter queue overflow or if bridge controller is primary or srcNode is invalid then completedFunc will NOT be called.

Parameters:

srcNode IN	Source Virtual Slave Node ID	
destNode IN	Destination Node ID (NODE_BROADCAST == all nodes)	
txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range). NOTE: The TRANSMIT_OPTION_LOW_POWER option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases this option should not be used.
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.

completedFunc IN Transmit completed call back function

Callback function Parameters:

txStatus (see **ZW_SendData**)

txStatusReport IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0xA2 | srcNode | destNode | txOptions | funcID

ZW->HOST: RES | 0xA2 | retVal

ZW->HOST; REQ | 0xA2 | funcID | txStatus

4.6.2 ZW_SetSlaveLearnMode

```
BYTE ZW_SetSlaveLearnMode(BYTE node,
                           BYTE mode,
                           VOID_CALLBACKFUNC(learnSlaveFunc)(BYTE state, BYTE orgID,
                                                                    BYTE newID))
```

Macro: ZW_SET_SLAVE_LEARN_MODE (node, mode, func)

ZW_SetSlaveLearnMode enables the possibility for enabling or disabling “Slave Learn Mode”, which when enabled makes it possible for other controllers (primary or inclusion controllers) to add or remove a Virtual Slave Node to the Z-Wave network. Also is it possible for the bridge controller (only when primary or inclusion controller) to add or remove a Virtual Slave Node without involving other controllers. Available Slave Learn Modes are:

VIRTUAL_SLAVE_LEARN_MODE_DISABLE – Disables the Slave Learn Mode so that no Virtual Slave Node can be added or removed.

VIRTUAL_SLAVE_LEARN_MODE_ENABLE – Enables the possibility for other Primary/Inclusion controllers to add or remove a Virtual Slave Node. To add a new Virtual Slave node to the Z-Wave Network the provided “node” ID must be ZERO and to make it possible to remove a specific Virtual Slave Node the provided “node” ID must be the nodeID for this specific (locally present) Virtual Slave Node. When the Slave Learn Mode has been enabled the Virtual Slave node must identify itself to the external Primary/Inclusion Controller node by sending a “Node Information” frame (see **ZW_SendSlaveNodeInformation**) to make the add/remove operation commence.

VIRTUAL_SLAVE_LEARN_MODE_ADD – Add Virtual Slave Node to the Z-Wave network without involving any external controller. This Slave Learn Mode is only possible when bridge controller is either a Primary controller or an Inclusion controller.

VIRTUAL_SLAVE_LEARN_MODE_REMOVE - Remove a locally present Virtual Slave Node from the Z-Wave network without involving any external controller. This Slave Learn Mode is only possible when bridge controller is either a Primary controller or an Inclusion controller.

The **learnSlaveFunc** is called as the "Assign" process progresses. The returned “orgID” is the Virtual Slave node put into Slave Learn Mode, the “newID” is the new Node ID. If the Slave Learn Mode is VIRTUAL_SLAVE_LEARN_MODE_ENABLE and nothing is received from the assigning controller the callback function will not be called. It is then up to the main application code to switch of Slave Learn mode by setting the VIRTUAL_SLAVE_LEARN_MODE_DISABLE Slave Learn Mode. Once the assignment process has been started the Callback function may be called more than once.

NOTE: Slave Learn Mode should only be set to VIRTUAL_SLAVE_LEARN_MODE_ENABLE when necessary, and it should always be set to VIRTUAL_SLAVE_LEARN_MODE_DISABLE again as quickly as possible. It is recommended that Slave Learn Mode is never set to VIRTUAL_SLAVE_LEARN_MODE_ENABLE for more than 1 second.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If learnSlaveMode change was successful.
	FALSE	If learnSlaveMode change could not be done.

Parameters:

node IN	Node ID (1...232) on node to set in Slave Learn Mode, ZERO if new node is to be learned.	
mode IN	Valid modes:	
	VIRTUAL_SLAVE_LEARN_MODE_DISABLE	Disable Slave Learn Mode
	VIRTUAL_SLAVE_LEARN_MODE_ENABLE	Enable Slave Learn Mode
	VIRTUAL_SLAVE_LEARN_MODE_ADD	ADD: Create locally a Virtual Slave Node and add it to the Z-Wave network (only possible if Primary/Inclusion Controller).
	VIRTUAL_SLAVE_LEARN_MODE_REMOVE	Remove locally present Virtual Slave Node from the Z-Wave network (only possible if Primary/Inclusion Controller).
learnFunc IN	Slave Learn mode complete call back function	

Callback function Parameters:

bStatus	Status of the assign process.	
	ASSIGN_COMPLETE	Is returned by the callback function when in the VIRTUAL_SLAVE_LEARN_MODE_ENABLE Slave Learn Mode and assignment is done. Now the Application can continue normal operation.
	ASSIGN_NODEID_DONE	Node ID have been assigned. The "orgID" contains the node ID on the Virtual Slave Node who was put into Slave Learn Mode. The "newID" contains the new node ID for "orgID". If "newID" is ZERO then the "orgID" Virtual Slave node has been deleted and the assign operation is completed. When this status is received the Slave Learn Mode is complete for all Slave Learn Modes except the VIRTUAL_SLAVE_LEARN_MODE_ENABLE mode.
	ASSIGN_RANGE_INFO_UPDATE	Node is doing Neighbour discovery Application should not attempt to send any frames during this time, this is only applicable when in VIRTUAL_SLAVE_LEARN_MODE_ENABLE.
orgID	The original node ID that was put into Slave Learn Mode.	
newID	The new Node ID. Zero if "OrgID" was deleted from the Z-Wave network.	

Serial API:

HOST->ZW: REQ | 0xA4 | node | mode | funcID

ZW->HOST: RES | 0xA4 | retVal

ZW->HOST: REQ | 0xA4 | funcID | bStatus | OrgID | newID

4.6.3 ZW_IsVirtualNode

BYTE ZW_IsVirtualNode(BYTE nodeID)

Macro: ZW_IS_VIRTUAL_NODE (nodeid)

Checks if “nodeID” is a Virtual Slave node.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If “nodeID” is a Virtual Slave node.
	FALSE	If “nodeID” is not a Virtual Slave node.

Parameters:

nodeID IN Node ID (1...232) on node to check if it is a Virtual Slave node.

Serial API:

HOST->ZW: REQ | 0xA6 | nodeID

ZW->HOST: RES | 0xA6 | retVal

4.6.4 ZW_GetVirtualNodes

VOID ZW_GetVirtualNodes(BYTE *pnodeMask)

Macro: ZW_GET_VIRTUAL_NODES (pnodemask)

Request a buffer containing available Virtual Slave nodes in the Z-Wave network.

The format of the data returned in the buffer pointed to by pnodeMask is as follows:

pnodeMask[i] ($0 \leq i < (ZW_MAX_NODES/8)$)								
Bit	0	1	2	3	4	5	6	7
NodeID	$i*8+1$	$i*8+2$	$i*8+3$	$i*8+4$	$i*8+5$	$i*8+6$	$i*8+7$	$i*8+8$

If bit n in pnodeMask[i] is 1, it indicates that node $(i*8)+n+1$ is a Virtual Slave node. If bit n in pnodeMask[i] is 0, it indicates that node $(i*8)+n+1$ is not a Virtual Slave node.

Defined in: ZW_controller_bridge_api.h

Parameters:

pNodeMask IN Pointer to nodemask (29 byte size)
buffer where the Virtual Slave
nodeMask should be copied.

Serial API:

HOST->ZW: REQ | 0xA5

ZW->HOST: RES | 0xA5 | pnodeMask[29]

4.7 Z-Wave Portable Controller API

The Portable application interface is basically an extended Controller interface that gives the application access to functions that can be used to create more advanced installation tools, which provide better diagnostics and error locating capabilities.

4.7.1 zwTransmitCount

BYTE zwTransmitCount

Macro: ZW_TX_COUNTER

ZW_TX_COUNTER is a variable that returns the number of transmits that the protocol has done since last reset of the variable. If the number returned is 255 then the number of transmits \geq 255. The variable should be reset by the application, when it is to be restarted.

Defined in: ZW_controller_portable_api.h

Serial API:

To read the transmit counter:

HOST->ZW: REQ | 0x81 | (FUNC_ID_GET_TX_COUNTER)

ZW->HOST: RES | 0x81 | ZW_TX_COUNTER (1 byte)

To reset the transmit counter:

HOST->ZW: REQ | 0x82 | (FUNC_ID_RESET_TX_COUNTER)

4.7.2 ZW_StoreNodeInfo

```
BOOL ZW_StoreNodeInfo( BYTE bNodeID,  
                      BYTE_P pNodeInfo,  
                      VOID_CALLBACKFUNC(func))
```

Macro: ZW_STORE_NODE_INFO(NodeID,NodeInfo,function)

ZW_StoreNodeInfo is a function that can be used to restore protocol node information from a backup or the like. The format of the node info frame should be identical with the format used by ZW_GET_NODE_STATE.

NOTE: The restored values will not take effect before the Z-Wave module has been reset.

Defined in: ZW_controller_portable_api.h

Return value:

BOOL	TRUE	If NodeInfo was Stored.
	FALSE	If NodeInfo was not Stored. (Illegal NodeId or MemoryWrite failed)

Parameters:

bNodeID IN	Node ID (1...232) to store information at.
pNodeInfo IN	Pointer to Node Information Frame.
func IN	Callback function. Called when data has been stored.

Serial API:

HOST->ZW: REQ | 0x83 | bNodeID | nodeInfo (nodeInfo is a NODEINFO field) | funcID

ZW->HOST: RES | 0x83 | retVal

ZW->HOST: REQ| 0x83 | funcID

4.7.3 ZW_StoreHomeID

**void ZW_StoreHomeID(BYTE_P pHomeID,
 BYTE bNodeID)**

Macro: ZW_STORE_HOME_ID(pHomeID, NodeID)

ZW_StoreHomeID is a function that can be used to restore HomeID and NodeID information from a backup.

NOTE: The restored values will not take effect before the Z-Wave module has been reset.

Defined in: ZW_controller_portable_api.h

Parameters:

pHomeID IN Pointer to HomeID structure to store

bNodeID IN NodeID to store.

Serial API:

HOST->ZW: REQ | 0x84 | pHomeID[0] | pHomeID[1] | pHomeID[2] | pHomeID[3] | bNodeID

4.8 Z-Wave Slave API

The Slave application interface is an extension to the Basis application interface enabling inclusion/exclusion (add/remove) of Routing Slave, and Enhanced 232 Slave nodes.

4.8.1 ZW_SetDefault

void ZW_SetDefault(void)

Macros: ZW_SET_DEFAULT

This function set the slave back to the factory default state. Erase routing information and assigned homeID/nodeID from the external NVM. Finally write a new random home ID to the external NVM.

Defined in: ZW_slave_api.h

Serial API:

HOST->ZW: REQ | 0x42 | funcID

ZW->HOST: REQ | 0x42 | funcID

4.8.2 ZW_SetLearnMode

void ZW_SetLearnMode(BYTE mode, VOID_CALLBACKFUNC(learnFunc)(BYTE bStatus, BYTE nodeID))

Macro: ZW_SET_LEARN_MODE(mode, func)

ZW_SetLearnMode enable or disable home and node ID's learn mode. Use this function to add a new Slave node to a Z-Wave network or to remove an already added node from the network again.

The Slave node must identify itself to the including controller node by sending a Node Information Frame (see **ZW_SendNodeInformation**).

When learn mode is enabled, the following two actions can be performed by the protocol:

1. If the current stored ID's are zero and the assigned ID's are nonzero, the received ID's will be stored (node was added to the network).
2. If the received ID's are zero the stored ID's will be set to zero (node was removed from the network).

The **learnFunc** is called as the "Assign" process progresses. The returned nodeID is the nodes new Node ID. If no "Assign" is received from the including controller the callback function will not be called. It is then up to the application code to switch of Learn mode. Once the assignment process has been started the Callback function may be called more than once. The learn process is not complete before the callback function is called with ASSIGN_COMPLETE.

NOTE: Learn mode should only be enabled when necessary and disabled again as quickly as possible. It is recommended that learn mode is not enabled for more than 2 seconds in

ZW_SET_LEARN_MODE_CLASSIC mode and 5 seconds when in either ZW_SET_LEARN_MODE_NWI or ZW_SET_LEARN_MODE_NWE mode.

Defined in: ZW_slave_api.h

Parameters:

mode IN	ZW_SET_LEARN_MODE_CLASSIC	Start the learn mode on the slave and only accept being included and excluded in direct range.
	ZW_SET_LEARN_MODE_NWI	Start the learn mode on the slave and accept routed inclusion (add). NWI mode must not be used for exclusion (remove).
	ZW_SET_LEARN_MODE_NWE	Start the learn mode on the slave and accept routed exclusion (remove). NWE mode must not be used for inclusion (add).
	ZW_SET_LEARN_MODE_DISABLE	Stop learn mode on the slave
learnFunc IN	Node ID learn mode completed call back function	

Callback function Parameters:

bStatus	Status of the assign process	
	ASSIGN_COMPLETE	Assignment is done and Application can continue normal operation.
	ASSIGN_NODEID_DONE	Node ID has been assigned. More information may follow.
	ASSIGN_RANGE_INFO_UPDATE	Node is doing Neighbor discovery Application should not attempt to send any frames during this time.
nodeID	The new (learned) Node ID (1...232)	

NOTE: The ASSIGN_COMPLETE callback is not synchronized with the ADD_NODE_STATUS_DONE callback on the including controller. The including controller MAY start sending frames to the included node before the ASSIGN_COMPLETE callback. In that case the included node MAY respond before the ASSIGN_COMPLETE callback arrives. Broadcast frames received before the ASSIGN_COMPLETE callback MUST NOT trigger a response transmission.

Serial API:

HOST->ZW: REQ | 0x50 | mode | funcID

ZW->HOST: RES | TRUE

ZW->HOST: REQ | 0x50 | funcID | bstatus | nodeID

4.9 Z-Wave Routing and Enhanced 232 Slave API

The Routing and Enhanced 232 Slave application interface is an extension of the Basis and Slave application interface enabling control of other nodes in the Z-Wave network.

4.9.1 ZW_GetSUCNodeID

BYTE ZW_GetSUCNodeID(void)

Macro: ZW_GET_SUC_NODEID()

API call used to get the currently registered SUC/SIS node ID. A controller must have called **ZW_AssignSUCReturnRoute** before a SUC/SIS node ID is registered in the routing or enhanced 232 slave.

Defined in: ZW_slave_routing_api.h

Return value:

BYTE The node ID (1..232) on the currently registered SUC/SIS, if ZERO then no SUC/SIS available.

Serial API:

HOST->ZW: REQ | 0x56

ZW->HOST: RES | 0x56 | SUCNodeID

4.9.2 ZW_IsNodeWithinDirectRange

BYTE ZW_IsNodeWithinDirectRange(BYTE bNodeID)

Macro: ZW_IS_NODE_WITHIN_DIRECT_RANGE (bNodeID)

Check if the supplied nodeID is marked as being within direct range in any of the existing return routes.

Defined in: ZW_slave_routing_api.h

Return value:

TRUE	If node is within direct range
FALSE	If the node is beyond direct range or if status is unknown to the protocol

Parameters:

bNodeID IN Node id to examine

Serial API:

HOST->ZW: REQ | 0x5D | bNodeID

ZW->HOST: RES | 0x5D | retVal

4.9.3 ZW_RediscoveryNeeded

**BYTE ZW_RediscoveryNeeded (BYTE bNodeID,
VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))**

Macro: ZW_REDISCOVERY_NEEDED(nodeid, func)

This function can request a SUC/SIS controller to update the requesting nodes neighbors. The function will try to request a neighbor rediscovery from a SUC/SIS controller in the network. In order to reach a SUC/SIS controller it uses other nodes (bNodeID) in the network. The application must implement the algorithm for scanning the bNodeID's to find a node which can help.

If bNodeID supports this functionality (routing slave and enhanced 232 slave libraries), bNodeID will try to contact a SUC/SIS controller on behalf of the node that requests the rediscovery. If the functionality is unsupported by bNodeID ZW_ROUTE_LOST_FAILED will be returned in the callback function and the next node can be tried.

NOTICE: It is highly recommended to use the transmit option TRANSMIT_OPTION_EXPLORE to enable dynamic route resolution in API calls such as ZW_SendData as an alternative to ZW_RediscoveryNeeded.

The callback function is called when the request have been processed by the protocol.

Defined in: ZW_slave_routing_api.h

Return value:

FALSE	The node is busy doing another update.
TRUE	The help process is started; status will come in the callback.

Parameters:

bNodeID IN	Node ID (1..232) to request help from
completedFunc IN	Transmit completed call back function

Callback function parameters:

ZW_ROUTE_LOST_ACCEPT	The node bNodeID accepts to forward the help request. Wait for the next callback to determine the outcome of the rediscovery.
ZW_ROUTE_LOST_FAILED	The node bNodeID has responded it is unable to help and the application can try next node if it decides so.
ZW_ROUTE_UPDATE_ABORT	No reply was received before the protocol has timed out. The application can try the next node if it decides so.
ZW_ROUTE_UPDATE_DONE	The node bNodeID was able to contact a controller and the routing information has been updated.

Serial API:

HOST->ZW: REQ | 0x59 | bNodeID | funcID

ZW->HOST: RES | 0x59 | retVal

ZW->HOST: REQ | 0x59 | funcID | bStatus

4.9.4 ZW_RequestNewRouteDestinations

**BYTE ZW_RequestNewRouteDestinations(BYTE *pDestList,
 BYTE bDestListLen ,
 VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))**

Macro: ZW_REQUEST_NEW_ROUTE_DESTINATIONS (pdestList, destListLen, func)

Used to request new return route destinations from the SUC/SIS node.

NOTE: No more than the first ZW_MAX_RETURN_ROUTE_DESTINATIONS will be requested regardless of bDestListLen.

Defined in: ZW_slave_routing_api.h

Return value:

TRUE	If the updating process is started.
FALSE	If the requesting routing slave is busy or no SUC/SIS node known to the slave.

Parameters:

pDestList IN	Pointer to a list of new destinations for which return routes is needed.
bDestListLen IN	Number of destinations contained in pDestList.
completedFunc IN	Transmit completed call back function

Callback function parameters:

ZW_ROUTE_UPDATE_DONE	The update process is ended successfully
ZW_ROUTE_UPDATE_ABORT	The update process aborted because of error
ZW_ROUTE_UPDATE_WAIT	The SUC/SIS node is busy
ZW_ROUTE_UPDATE_DISABLED	The SUC/SIS functionality is disabled

Serial API:

HOST->ZW: REQ | 0x5C | destList[5] | funcID

ZW->HOST: RES | 0x5C | retVal

ZW->HOST: REQ | 0x5C | funcID | bStatus

4.9.5 ZW_RequestNodeInfo

**BOOL ZW_RequestNodeInfo (BYTE nodeID,
VOID (*completedFunc)(BYTE txStatus,
TX_STATUS_TYPE* txStatusReport))**

Macro: ZW_REQUEST_NODE_INFO(NODEID)

This function is used to request the Node Information Frame from a node in the network. The Node info is retrieved using the **ApplicationSlaveUpdate** callback function with the status UPDATE_STATE_NODE_INFO_RECEIVED. The **ZW_RequestNodeInfo** API call is also available for controllers.

Defined in: ZW_slave_routing_api.h

Return value:

BOOL	TRUE	If the request could be put in the transmit queue successfully.
	FALSE	If the request could not be put in the transmit queue. Request failed.

Parameters:

nodeID IN The node ID (1...232) of the node to request the Node Information Frame from.

completedFunc IN Transmit complete call back.

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

txStatusReport IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x60 | NodeID

ZW->HOST: RES | 0x60 | retVal

The Serial API implementation do not return the callback function (no parameter in the Serial API frame refers to the callback), this is done via the **ApplicationSlaveUpdate** callback function:

- If request nodeinfo transmission was unsuccessful, (no ACK received) then the **ApplicationSlaveUpdate** is called with UPDATE_STATE_NODE_INFO_REQ_FAILED (status only available in the Serial API implementation).

- If request nodeinfo transmission was successful, there is no indication that it went well apart from the returned Nodeinfo frame which should be received via the **ApplicationSlaveUpdate** with status UPDATE_STATE_NODE_INFO_RECEIVED.

4.10 Serial Command Line Debugger

The debug driver is a simple single line command interpreter, operated via the serial interface (UART – RS232). The command line debugger is used to dump and edit memory, including the memory mapped registers.

For a controller/slave_enhanced node the debugger startup by displaying the following help text on the debug terminal:

```
Z-Wave Commandline debugger Vx.nn
  Keyes(VT100): BS; ^,<,> arrows; F1.
H                               Help
D[X|E|F] <addr> [<length>]     Dump memory
E[X|E]   <addr>                 Edit memory (Key: SP)
W[X|E|F] <addr>                 Watch memory location
      is idata (80-FF is SFR)
  X      is xdata
    E    is External EEPROM
      F  is flash
>
```

For a slave node the debugger startup by displaying the following help text on the debug terminal:

```
Z-Wave Commandline debugger Vx.nn
  Keyes(VT100): BS; ^,<,> arrows; F1.
H                               Help
D[X|I|F] <addr> [<length>]     Dump memory
E[X|I]   <addr>                 Edit memory (Key: SP)
W[X|I|F] <addr>                 Watch memory location
      is idata (80-FF is SFR)
  X      is xdata
    I    is "Internal EEPROM" flash
      F  is flash
>
```

The command debugger is then ready to receive commands via the serial interface.

Special input keys:

- F1 (function key 1) same as the help command line.
- BS (backspace) delete the character left to the cursor.
- < (left arrow) move the cursor one character left.
- > (right arrow) move the cursor one character right.
- ^ (up arrow) retrieve last command line.

Commands:

H[elp]		Display the help text.
D[ump]	<addr> [<length>]	Dump idata (0-7F) or SFR memory (80-FF).
DX	<addr> [<length>]	Dump xdata (SRAM) memory.
DI	<addr> [<length>]	Dump "internal EEPROM" flash (slave only).
DE	<addr> [<length>]	Dump external EEPROM (controllers/slave_enhanced only).
DF	<addr> [<length>]	Dump FLASH memory.
E[dit]	<addr>	Edit idata (0-7F) or SFR memory (80-FF).
EX	<addr>	Edit xdata memory.
EI	<addr>	Edit "internal EEPROM" flash (slave only).
EE	<addr>	Edit external EEPROM (controllers/slave_enhanced only).
W[atch]	<addr>	Watch idata (0-7F) or SFR memory (80-FF).
WX	<addr>	Watch xdata memory.
WI	<addr>	Watch "internal EEPROM" flash (slave only).
WE	<addr>	Watch external EEPROM memory (controllers/slave_enhanced only).
WF	<addr>	Watch FLASH memory.

The Watch pointer gives the following log (when memory change):

```
idata SRAM memory      Rnn
xdata SRAM memory Xnn
Internal EEPROM  flash Inn      (slave only)
External EEPROM  Enn      (controllers/slave_enhanced only)
```

Examples:

```
>dx 0 ; Edit offset 0x0000 and 0x0001 of xdata SRAM
0000 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
>ex 0 ; Edit offset 0x0000 and 0x0001 of xdata SRAM
0000 00-1 00-2
>dx 0 ; Dump offset 0x0000 to 0x000f of xdata SRAM
0000 01 02 00 00 00 00 00 00 00 00 00 00 00 00 00
>wx 1X02 ; Watch offset 0x0001 of xdata SRAM
>ex 1
0001 02-1X01
>
```

4.10.1 ZW_DebugInit

void ZW_DebugInit(WORD baudRate)

Macro: ZW_DEBUG_CMD_INIT(baud)

Command line debugger initialization. The macro can be placed within the application initialization function (see function **ApplicationInitSW**).

Example:

```
ZW_DEBUG_CMD_INIT(96); /* setup command line speed to 9600 bps. */
```

Defined in: ZW_debug_api.h

Parameters:

baudRate IN Baud Rate / 100 (e.g. 96 = 9600 bps,
384 = 38400 bps, 1152 = 115200 bps)

Serial API (Not supported)

4.10.2 ZW_DebugPoll

void ZW_DebugPoll(void)

Macro: ZW_DEBUG_CMD_POLL

Command line debugger poll function. Collect characters from the debug terminal and execute the commands.

Should be called via the main poll loop (see function **ApplicationPoll**).

By using the debug macros (ZW_DEBUG_CMD_INIT, ZW_DEBUG_CMD_POLL) the command line debugger can be enabled by defining the compile flag "ZW_DEBUG_CMD" under CDEFINES in the makefile as follows:

```
CDEFINES+= EU,\
    ZW_DEBUG_CMD,\
    SUC_SUPPORT,\
    ASSOCIATION,\
    LOW_FOR_ON,\
    SIMPLELED
```

Both the debug output (ZW_DEBUG) and the command line debugger (ZW_DEBUG_CMD) can be enabled at the same time.

Defined in: ZW_debug_api.h

Serial API (Not supported)

4.11 RF Settings in App_RFSetup.c file

The RF normal and low power transmit levels are set by the module APP_RFSETUP in the Z-Wave library.

Table 27. App_RFSetup.c Module Definitions for 500 Series Z-Wave SoC

Offset to table start	Define name	Default value	Description
2	FLASH_APPL_NORM_POWER_OFFS_0 FLASH_APPL_NORM_POWER_OFFS_1 FLASH_APPL_NORM_POWER_OFFS_2	0xFF	If 0xFF the default lib value is used: 0x3F
5	FLASH_APPL_LOW_POWER_OFFS_0 FLASH_APPL_LOW_POWER_OFFS_1 FLASH_APPL_LOW_POWER_OFFS_2	0xFF	If 0xFF the default lib value is used: 0x04

TXnormal Power need maybe adjustment to fulfil FCC compliance tests. According to the FCC part 15, the output-radiated power will not exceed 94dBuV/m. This radiated power is the result of the module output power and your product antenna gain. As the antenna gain is different from product to product, the module output power needs to be adjusted to comply with the FCC regulations.

Use the Z-Wave Programmer [13] to find the RF power transmit levels to fulfil FCC compliance tests. The entered RF power transmit levels overrule the ones defined in the App_RFSetup.c file. Update the App_RFSetup.c file with the determined RF power transmit levels and build a new hex file containing the final RF power transmit levels.

Make a copy of the template file ...\\Z-Wave\\IO_defines\\App_RFSetup.c, and place it in your application's directory, and fill in your final RF power transmit levels and build a new hex file containing the final RF power transmit levels. The App_RFSetup.c file in your application directory will override the one from the library.

An alternative way is to use the file ...\\Z-Wave\\IO_defines\\App_RFSetup.c directly to override the RF normal and low power transmit levels from the Z-Wave library. Then you must set:
APP_RFSETUP_FILE:=App_RFSetup.obj
in your application's Makefile somewhere before the inclusion of
include \$(ZWUTILDIR)\\Makefile.common
(during the setup of the build environment).

Notice that the RF power transmit levels set by the Z-Wave Programmer are erased after a OTA or OTW firmware update. The Z-Wave Programmer must therefore not be used to set the RF power transmit levels on the production line.

5 APPLICATION NOTE: SUC/SIS IMPLEMENTATION

5.1 Implementing SUC/SIS Support in all Nodes

Having Static ID Server (SIS) support in Z-Wave products requires that several API calls must be used in the right order. This chapter provides details about how SUC/SIS support can be implemented in the different node types in the Z-Wave network.

5.2 Static Controllers

All static controllers has the functionality needed for acting as a SUC/SIS in the network, By default all static controllers has the SUC/SIS functionality enabled. A Static Controller will not act as a SUC/SIS until the primary controller in the network has requested it to do so. Or the application on the static controller has forced the controller to become SUC/SIS.

5.2.1 Request for Becoming an SUC Node ID Server (SIS)

The static controller will accept to become SUC/SIS if/when the primary controller request it by calling **ZW_SetSUCNodeID()** with the Static controllers node ID, or the application on the static controller has forced the controller to become SUC/SIS by calling **ZW_SetSUCNodeID()** with its own node ID.

There can only be one SUC/SIS in a network.

NOTE: There can only be one SUC/SIS in a network, but there can be many static controllers that are enabled for an assignment of the SIS capabilities in a network.

5.2.2 Updates from the Primary Controller

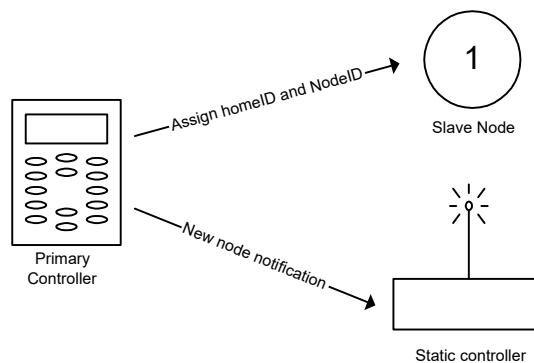


Figure 43. Inclusion (Add) of a Node Having an SUC in the Network

When a new node is added to the network or an existing node is removed from the network the inclusion controller will send a network update to the SUC/SIS to notify about the changes in the network. The application in the SUC/SIS will be notified about such a change through the callback function **ApplicationControllerUpdate**). All update of node lists and routing tables is handled by the protocol so the call is just to notify the application in the static controller that a node has been added or removed.

5.2.3 Assigning SUC Routes to Routing Slaves

When the SUC/SIS is present in a Z-Wave network routing slaves can ask it for updates, but the routing slave must first be told that there is a SUC/SIS in the network and it must be told how to reach it. That is done from the SUC/SIS by assigning a set of return routes to the routing slave so it knows how to reach the SUC/SIS. Assigning the routes to routing slaves is done by calling **ZW_AssignSUCReturnRoute** with the nodeID of the routing slave that should be configured.

NOTE: Routing slaves are notified by the presence of a SUC/SIS as a part of the inclusion (add), but it is good practice to have the application on the SUC/SIS assign SUC/SIS return routes to new nodes so they have a full set of updated return routes.

5.2.4 Receiving Requests for Network Updates

When a SUC/SIS receives a request for sending network updates to a secondary controller or a routing slave, the protocol will handle all the communication needed for sending the update, so the application doesn't need to do anything and it will not get any notifications about the request.

The SUC/SIS will also receive requests for reserving node IDs for use when other controllers add nodes to the network. The protocol will handle all that communication without any involvement from the application.

5.3 The Primary Controller

The primary controller is responsible for choosing what static controller in the network that should act as a SUC/SIS. The application in a primary controller is responsible for choosing the static controller that should be the SUC/SIS. There is no fixed strategy for how to choose the static controller, so it is entirely up to the application to choose the controller that should become SUC/SIS. Once a static controller has been selected the application must use the **ZW_SetSUCNodeID** to request that the static controller becomes SUC/SIS.

Once a SUC/SIS has been selected, the protocol in the primary controller will automatically send notifications to the SUC/SIS about all changes in the network topology.

NOTE: A controller can decline the role as SUC/SIS and in that case, the callback function from **ZW_SetSUCNodeID** will return with a FAILED status. The static controller (legacy controller) can also refuse to become SIS if that was what the primary controller requested, but accept to become a SUC.

5.4 Secondary Controllers

All controllers in a network containing a SUC/SIS can ask it for network topology changes and receive the updates from the SUC/SIS. It is entirely up to the application if and when an update is needed.

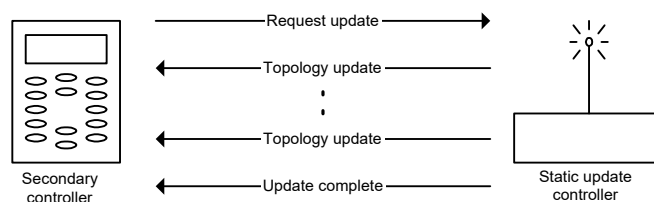


Figure 44. Requesting Network Updates from a SUC/SIS in the Network

5.4.1 Knowing the SUC/SIS

The first thing the secondary controller should check is if it knows a SUC at all. Checking if a SUC is known by the controller is done with the **ZW_GetSUCNodeID** call and until this call returns a valid node ID the secondary controller can't use the SUC. The only time a secondary controller gets information about the presence of a SUC is during controller replication, so it is only necessary to check after a successful controller replication.

5.4.2 Asking for and Receiving Updates

If a controller knows the SUC/SIS, it can ask for updates from the SUC/SIS. Asking for updates is done using the **ZW_RequestNetWorkUpdate** function. If the call was successful the update process will start and the controller application will be notified about any changes in the network through calls to **ApplicationControllerUpdate**). Once the update process is completed, the callback function provided in **ZW_RequestNetWorkUpdate** will be called.

If the callback functions returns with the status **ZW_SUC_UPDATE_OVERFLOW** then it means that there has been more than 64 changes made to the network since the last update of this secondary controller and it is therefore necessary to do a controller replication (copy) to get this controller updated.

NOTE: The SUC/SIS can refuse to update the controller for several reasons, and if that happens the callback function will return with a value explaining why the update request was refused.

WARNING: Consider carefully how often the topology of the network changes and how important it is for the application that the secondary controller is updated with the latest.

5.5 Inclusion Controllers

When a SIS is present in a Z-Wave network then all the controllers that knows the SIS will change state to Inclusion Controllers, and the concept of primary and secondary controllers will no longer apply for the controllers. The Inclusion controllers has the functionality of a Secondary Controller so the functionality described in section 5.4 also applies for secondary controllers, but Inclusion Controllers are also able to include/exclude nodes to the network on behalf of the SIS. The application in a controller can check if a SIS is present in the network by using the **ZW_GetControllerCapabilities** function call. This allows the application to adjust the user interface according to the capabilities. If a SIS is present in the network then the **CONTROLLER_NODEID_SERVER_PRESENT** bit will be set and the **CONTROLLER_IS_SECONDARY** bit will not be set.

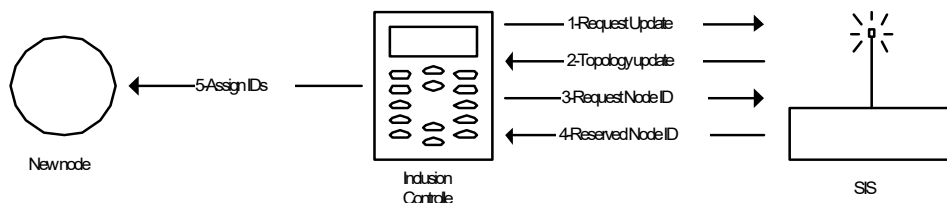


Figure 45. Inclusion (Add) of a Node Having a SIS in the Network

5.6 Routing Slaves

The routing slave can request a update of its stored return routes from a SUC/SIS by using the **ZW_RequestNetWorkUpdate** API call. There is no API call in the routing slave to check if the SUC/SIS is known by the slave so the application must just try **ZW_RequestNetWorkUpdate** and then determine from the return value if the SUC/SIS is known or not. If the SUC/SIS was known and the update was a success then the routing slave would get a callback with the status SUC_UPDATE_DONE, the slave will not get any notifications about what was changed in the network.

A SUC/SIS can help a battery-operated routing slave to be re-discovered in case it is moved to a new location. The lost slave initiates the dynamic route resolution process because it will be the first to recognize that it is unable to reach the configured destinations.

The lost battery operated routing slave start to send "I'm lost" frames to each node beginning with node ID = 1. It continues until it find a routing slave which can help it, i.e., the helping routing slave can obtain contact with a SUC/SIS. Scanning through the node ID's is done on application level. Other strategies to send the "I'm lost" frame can be implemented on the application level.

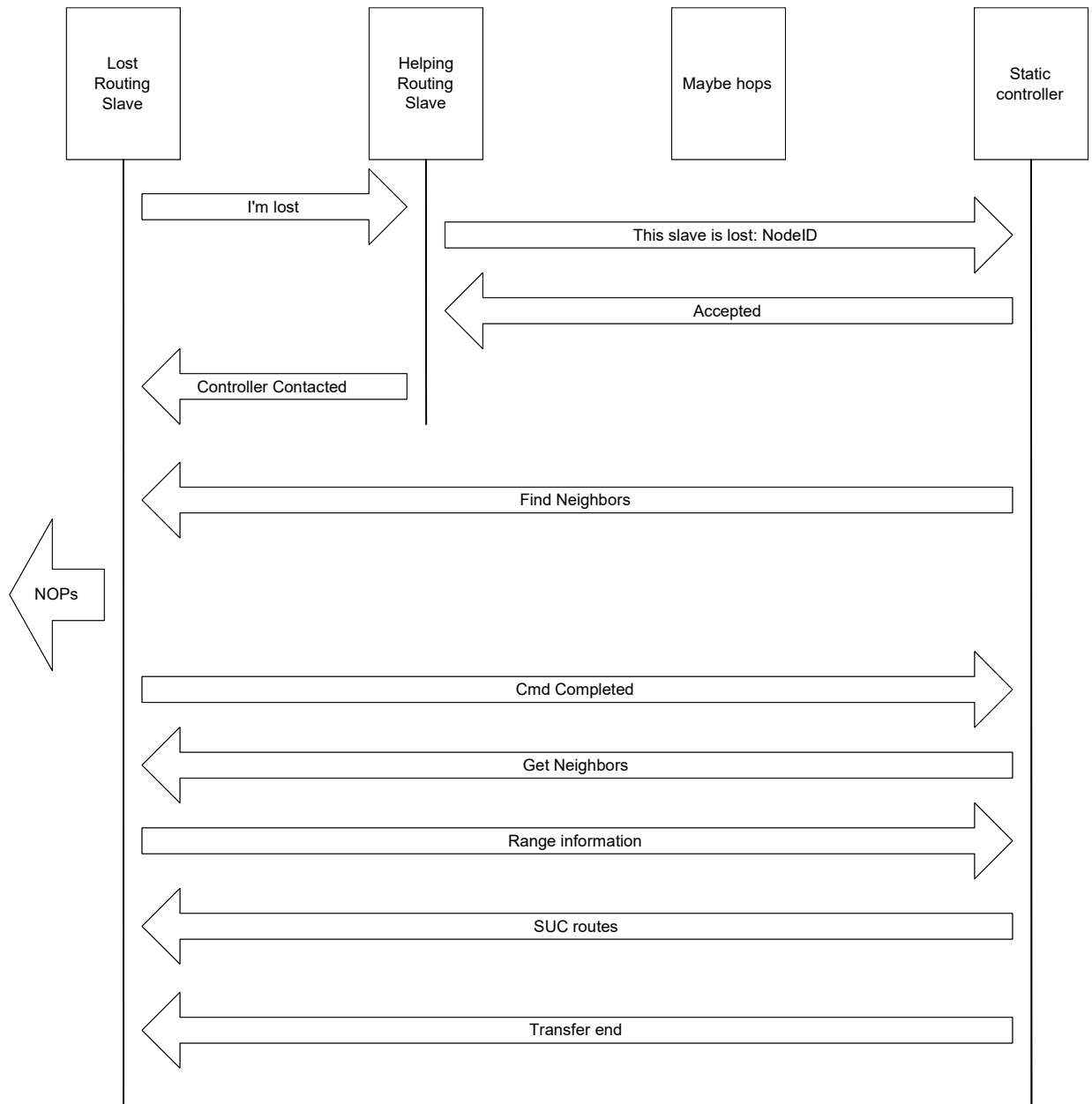


Figure 46. Lost Routing Slave Frame Flow

The helping routing slave must maximum use three hops to get to the controller, because it is the fourth hop when the controller issues the re-discovery to the lost routing slave. All handling in the helping slave is implemented on protocol level. In case a primary controller is found then it will check if a SUC/SIS exists in the network. In case a SUC/SIS is available, it will be asked to execute the re-discovery procedure. When the controller receive the request “Re-discovery node ID x” it update the routing table with the new neighbor information. This allows the controller to execute a normal re-discovery procedure.

6 APPLICATION NOTE: CONTROLLER SHIFT IMPLEMENTATION

This note describes how a controller is able to include a new controller that after the inclusion (add) will become the primary controller in the network. The controller that is taking over the primary functionality should just enter learn mode like when it is to be included in a network. The existing primary controller makes the controller change by calling `ZW_ControllerChange(CONTROLLER_CHANGE_START, ...)`.)

After a successful change, the controller that called `ZW_ControllerChange` will be secondary and no longer able to include devices.

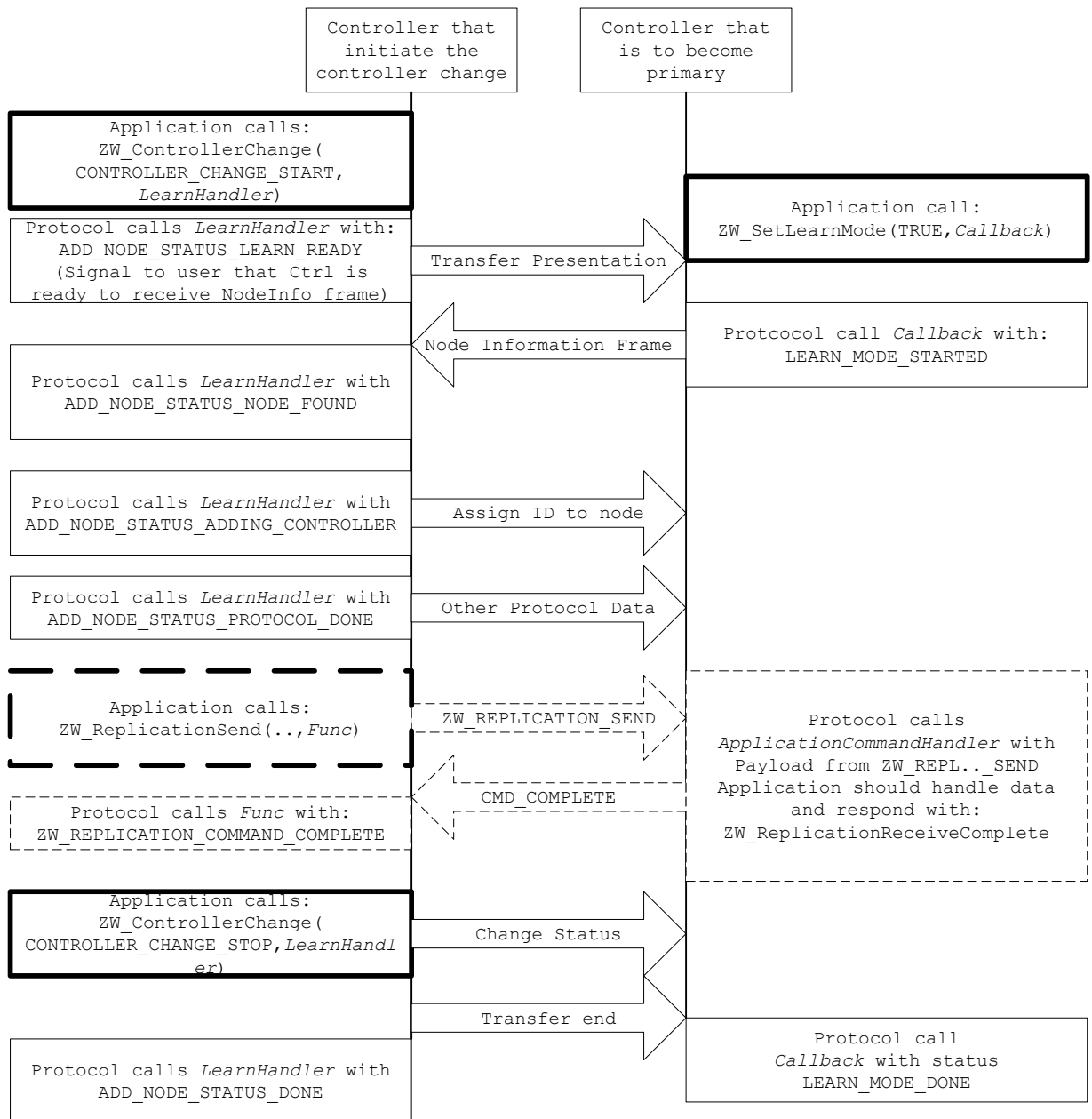


Figure 47. Controller Shift Frame Flow

7 APPLICATION NOTE: Z-WAVE PROTOCOL VERSIONS ETC

The below table lists existing Z-Wave Protocol versions etc. for a given Software Developer's Kit version. The Version Command Class [6] returns the version of Z-Wave Protocol and Z-Wave Plus Framework & Embedded Apps. Refer to [2] regarding retrieving version of Serial API interface.

Software Developer's Kit Version	Z-Wave Protocol & serial API Apps Version	Z-Wave Plus Framework & Certified Apps Version	Serial API Interface Version
6.82.01	6.09.00 & 6.09	4.04.01 & 4.04	8
6.82.00	6.08.00 & 6.08	4.04.00 & 4.04	8
6.81.06	6.07.00 & 6.07	4.03.00 & 4.03	8
6.81.05	6.06.00 & 6.06	4.02.00 & 4.02	8
6.81.04	6.05.00 & 6.05	4.01.03 & 4.01	8
6.81.03	6.04.00 & 6.04	4.01.02 & 4.01	8
6.81.02	6.03.00 & 6.01	4.01.02 & 4.01	8
6.81.01	6.02.00 & 6.01	4.01.01 & 4.01	8
6.81.00	6.01.00 & 5.14	4.01.00 & 4.01	8
6.80.00 Beta	6.01.00 & 5.14	4.01.00 & 4.01	8
6.71.03	5.03.00 & 5.50	3.01.01 & 3.01	7
6.71.02	5.02.00 & 3.01	3.01.00 & 3.01	7
6.71.01	4.61 & 5.34	-	7
6.71.00	4.60 & 5.29	-	7
6.70.01 Beta	4.45 & 5.19	-	6
6.70.00 Beta	4.28 & 5.05	-	6
6.61.01	4.62 & 5.36	-	6
6.61.00	4.33 & 5.10	-	6
6.60.00 Beta	4.12 & 1.12	-	6
6.51.10	4.54	-	5
6.51.09	4.38	-	5
6.51.08	4.34	-	5
6.51.07	4.24	-	5
6.51.06	4.05	-	5
6.51.04	4.01	-	5
6.51.03	3.99	-	5
6.51.02	3.95	-	5
6.51.01	3.92	-	5
6.51.00	3.83	-	5
6.50.01	3.79	-	5
6.50.00	3.71	-	5
6.11.01 (JP)	3.53	-	5
6.11.00 (JP)	3.45	-	5
6.10.01 (JP)	3.38	-	5
6.10.00	3.35	-	5
6.02.00	3.41	-	5
6.01.03	3.37	-	5
6.01.02	3.33	-	5
6.01.01 (2-ch)	3.26	-	5
6.01.00	3.10	-	5
6.00.05 Beta 1	3.07	-	5
6.00.04 Beta 1	3.06	-	5
6.00 Beta 1 Patch 3	3.04	-	5
6.00 Beta 1 Patch 2	3.03	-	5

6.00 Beta 1 Patch 1	2.99	-	5
6.00 Beta 1	2.96	-	5
5.03.00	3.28	-	5
5.02 Patch 3	2.78	-	5
5.02 Patch 2	2.64	-	5
5.02 Patch 1	2.51	-	5
5.02	2.48	-	5
5.01	2.36	-	5
5.00 Beta 1 Patch 1	2.22	-	5
5.00 Beta 1	2.16	-	5
4.55.00	3.67	-	5
4.54.02	3.52	-	5
4.54.01	3.42	-	5
4.54.00	3.40	-	5
4.53.01	3.36	-	5
4.53.00	3.34	-	5
4.52.01	3.22	-	5
4.52.00	3.20	-	5
4.51	2.97	-	5
4.50 Beta 1 Patch 1	2.79	-	
4.50 Beta 1	2.74	-	
4.30 Beta 1	2.30	-	
4.28	2.67	-	
4.27	2.40	-	
4.26	2.32	-	
4.25	2.31	-	
4.24 Patch 1	2.28	-	
4.24	2.24	-	
4.23	2.17	-	
4.22	2.09	-	
4.21	2.06	-	
4.20	1.97	-	
4.11	1.91	-	
4.10	1.78	-	
4.07	2.27	-	
4.06	2.23	-	
4.05	2.07	-	
4.04	1.99	-	
4.03	1.81	-	
4.02	1.69	-	
4.01	1.68	-	
4.00	1.59	-	
3.40	1.53	-	
3.31	1.44	-	
3.30	1.37	-	
3.22	1.39	-	
3.21	1.25	-	
3.20	1.21	-	

Table 28, Z-Wave Protocol Version for a Given Software Developer's Kit Version

Warning: Products can only be Z-Wave certified based on matured versions of the Z-Wave Protocol, i.e., SDKs having versions different from x.y0 or x.y0.zz.

8 REFERENCES

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- [6] SD, SDS10242, Software Design Specification, Z-Wave Device Class Specification.
- [7] SD, SDS10865, Software Design Specification, Z-Wave Security Application Layer.
- [8] SD, SDS13781, Software Design Specification, Z-Wave Application Command Class Specification.
- [9] SD, SDS13782, Software Design Specification, Z-Wave Management Command Class Specification.
- [10] SD, SDS13783, Software Design Specification, Z-Wave Transport-Encapsulation Command Class Specification.
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