WD-H

User Manual

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Terms and Abbreviations

API	application programming interface
ATEX	ATmosphère EXplosive
dB	decibel
DC	Direct current
e.g.	exempli gratia, meaning "for example"
EC	European Commission
EN	European standards
HART	Highway Addressable Remote Transducer
HCF	HART Communication Foundation
i.e.	id est, meaning "that is; in other words"
IC	Integrated Circuit
ID	Identification
LCD	liquid crystal display
LDO	low-dropout
mA	Milliampere
MCU	microcontroller unit
mm	millimeter
mW	Milliwatt
OEM	original equipment manufacturer
PNP	pointing in (proudly), a type of Bipolar junction transistor
RF	Radio Frequency
RX	receive
TDMA	Time division multiple access
TTL	Transistor–transistor logic
TX	transmit
UART	universal asynchronous receiver/transmitter
V	Volt
WD-H	Wireless Device HART

1. Introduction and Overview

*Wireless*HART is a wireless mesh network communications protocol that primarily addresses the requirements of industrial automation. It adds wireless capabilities to the HART Protocol while maintaining compatibility with existing HART devices, commands, and tools.

The WD-H is an OEM radio module which is compliant to the *Wireless*HART standard. It has been designed for a fast and simple integration into field devices, transmitters and instruments. This module features an internationally certified hardware with a very small footprint, including all radio components and antenna connector, which helps to reduce the complex RF design and is designed for operation in ATEX Zone 2. Furthermore, it is designed for ultra-low power consumption which enables years of battery life on two AA batteries. In few words, the certifications, the RF solution, complete APIs, and comprehensive documentation for the WD-H module offer rapid field device integration, reduced development time, and reduced cost for *Wireless*HART solutions.

This manual describes how to integrate the WD-H in a field device with as little effort as possible.

1.1. Manual purpose and target groups

This manual is aimed at developers and manufacturers of *Wireless*HART devices who want to adapt these devices to an HART environment.

The manual is divided into the following chapters:

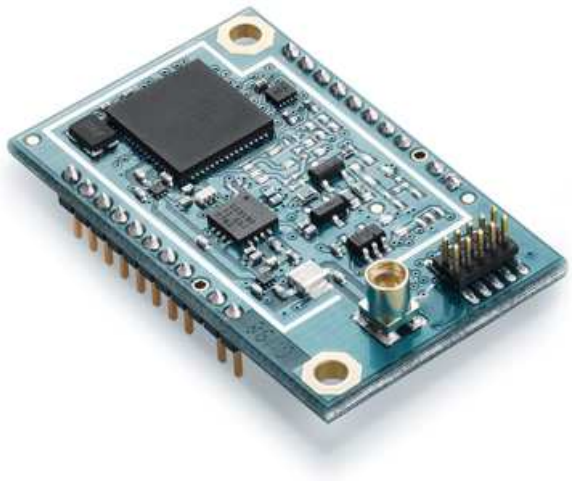
- Chapter 1 **– Introduction and Overview –** summarizes the information given in this manual and lists reference literature that provides additional information.
- Chapter 2 **– WD-H – The *Wireless*HART module –** lists the components of the WD-H delivery pack and illustrates a typical system architecture of a *Wireless*HART device.
- Chapter 3 **– Mechanical and electrical specifications –** provides an overview of mechanical and electrical specifications.
- Chapter 4 **– Communication –** outlines the WD-H software and its components.
- Chapter 5 **– Burst mode support –** describes in detail the burst mode support.
- Chapter 6 **– Integration for use in hazardous areas (ATEX) –** explains how to integrate the WD-H in a device for operation in hazardous areas.
- Chapter 7 **– Energy limiting circuit for the usage of the WD-H module in explosive atmospheres –** describes the settings to be considered when integrating the *Wireless*HART device into an existing HART environment.
- Chapter 8 **– Low power operation –** explains how low power operation works.
- Chapter 9 **– Regulatory and standards compliance –** describes what regulations and standards have to be considered.
- **The Appendices A and B** contain tables providing overviews of particular HART commands.
- **At the end of the manual:**
  - Terms and abbreviations
  - Table of figures

1.2. Literature

/1/ Wireless Command Specification – HCF_SPEC-155 v1.1

/2/ HART Field Communication Protocol Specification – HCF_SPEC-13 v7.3

2. WD-H – The *Wireless*HART module



The WD-H module is used to enable *Wireless*HART communication for field devices or similar equipment. It can be embedded in a device and will provide efficient and compliant *Wireless*HART communication to other field devices or infrastructure devices. The *Wireless*HART module WD-H covers

- compliant *Wireless*HART protocol communication
- low power operation
- burst mode

For the integration, the WD-H offers a powerful interface to control and configure the wireless communication as well as transport control and maintenance data.

The WD-H module is connected to the field device via a bidirectional asynchronous digital interface. The interface is based on a standard HART interface and is used to exchange process data and additional information between the WD-H module and the field device. For a detailed description of the HART protocol see the HART 7 specification.

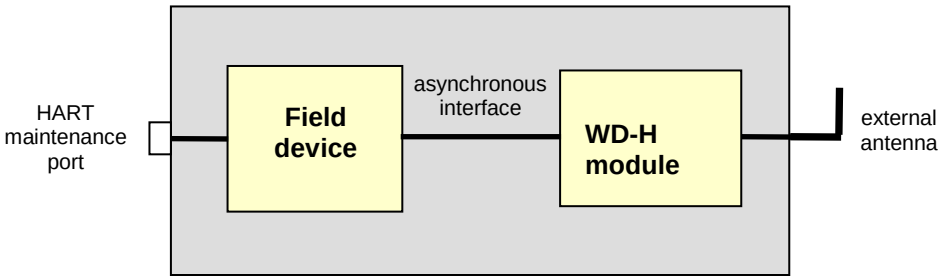


Figure 1: Typical system architecture of a *Wireless*HART device

3. Mechanical and electrical specifications

3.1. Mechanical specifications

The mechanical dimensions of the WD-H module are depicted below. The unit comprises an area of 39 mm x 24.9 mm and is 8.92 mm high. ICs are mounted on top and bottom.

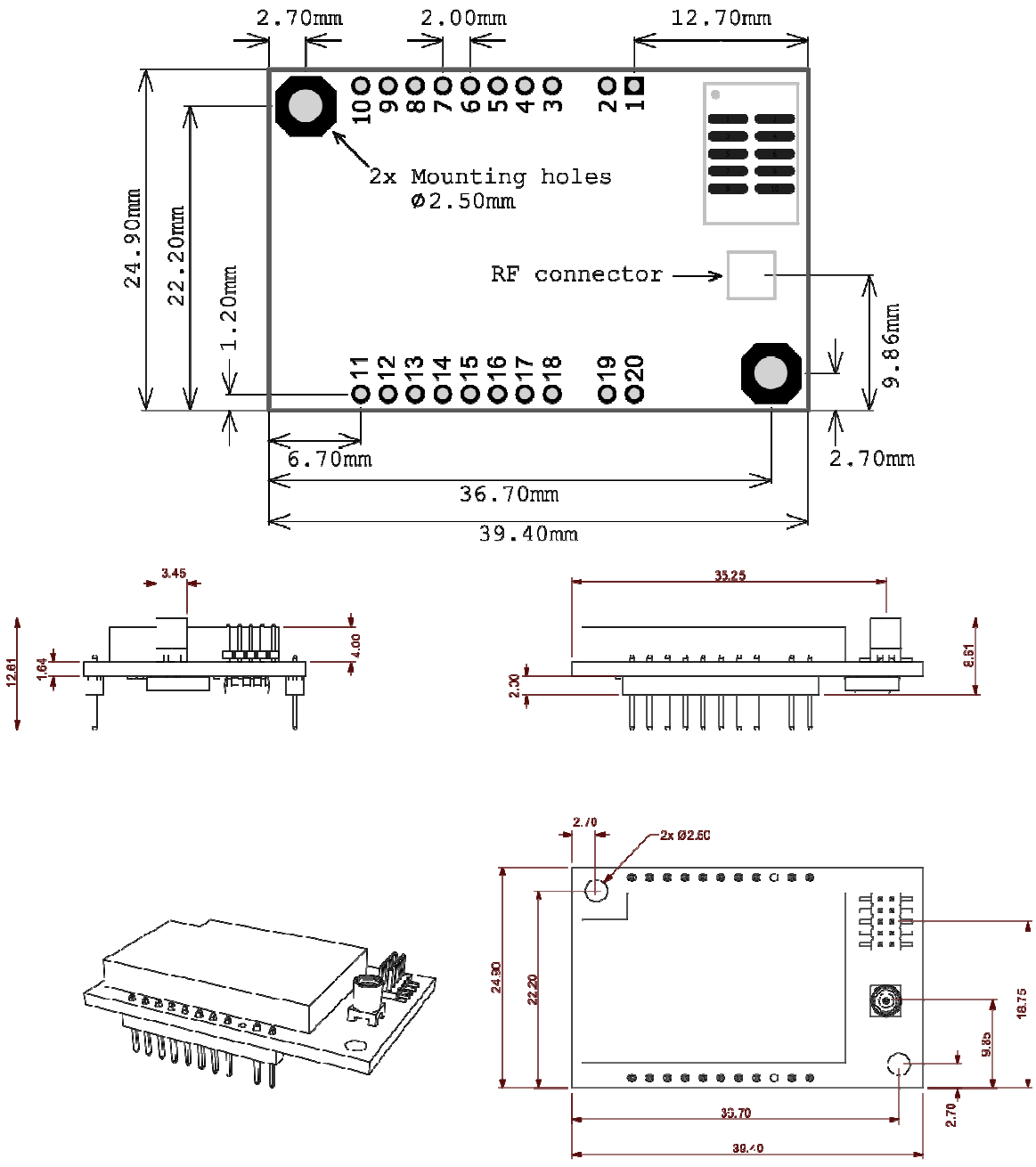


Figure 2: Mechanical dimensions of the WD-H module

3.2. Pin Assignment

There are two rows of pins with 10 pins each to connect the field device. The meaning and the direction of each pin is described in the following table. The direction is seen from the WD-H module, i.e. an output pin shall be an input of the field device controller.

Terminal		Direction	Description
#	Name		
1	GND	-	Ground
2	VIN	-	Power supply must be regulated and the voltage shall be 2.7 V to 3.3 V.
3	ITXD	in	Field device interface: UART TX
4	ORXD	out	Field device interface: UART RX
5	*RESERVED*	-	Do not connect
6	*RESERVED*	-	Do not connect
7	*RESERVED*	-	Do not connect
8	CD	out	Field device interface: Carrier detect
9	*RESERVED*	-	Do not connect
10	*RESERVED*	-	Do not connect
11	RTS	in	Field device interface: Request to send
12	*RESERVED*	-	Do not connect
13	*RESERVED*	-	Do not connect
14	*RESERVED*	-	Do not connect
15	*RESERVED*	-	Do not connect
16	*RESERVED*	-	Do not connect
17	*RESERVED*	-	Do not connect
18	*RESERVED*	-	Do not connect
19	*RESERVED*	-	Do not connect
20	RESET	in	Reset when pulled low.

Table 1: Signals of the WD-H

3.3. Electrical specifications

Operating Conditions	
Supply Voltage	2.7V…3.3V
Operating Temperature	-40°C…+85°C (-40°C…+75°C for ATEX Usage)
Relative Humidity	<90%
Current Consumption	
Current	58mA (Transmit, +10dBm), 37mA (Transmit, +0dBm), 27mA (Receive), 25µA (Sleep)
Electrical Specifications	
Output	0*Vcc…0.2*Vcc (Low), 0.8*Vcc (High)
Input	0*Vcc…0.3*Vcc (Low), 0.7*Vcc (High)
Radio Characteristics	
Frequency Band	2.4GHz…2.48GHz
Number Of Channels	15
Channel Separation	5MHz
Occupied Bandwidth	2.7MHz
Raw Data Rate	250kbps
Receiver Sensitivity	-90dBm
Output Power	-30dBm…10dBm
Output Impedance	50Ω
Frequency Accuracy	-40ppm…40ppm
Conformity / Certification	
Radio Frequency (RF)	EN 300328, EN 301489-1/-3, EN 60950 R&TTE FCC Part 15B, FCC Part 15C Compliant to Japanese Standards
ATEX	EEx II 2 (1) G Ex ia IIC T4, EEx II (1) D [Ex iaD]

3.3.1. Logical connection

The field device and the WD-H are connected via a standard universal asynchronous serial interface (UART) and two additional control lines. All digital signals use 3V TTL levels. The data rate used is 19,200 characters per second (t_{char} = *0.57 ms*). The character format is the standard UART 8E1 character format, i.e. one start bit with 8 data bits, even parity and one stop bit make up one character. The least significant bit is transmitted first. According to the table in the previous chapter the terminals used for communication are:

ITXD Transmit line of the UART interface. The field device controller uses this line to transmit information to the WD-H. Whenever no transmission is in progress it shall be pulled high.

ORXD Receive line of the UART interface. The WD-H uses this line to transmit information to the field device controller. Whenever the WD-H does not transmit it pulls this line high (weak pull-up).

RTS The request to send signal is used by the field device controller to indicate that it wants to send data to the WD-H. The signal is active low, i.e. when the signal is high the field device controller must not send any data. Before data is sent the signal must be pulled low and stay low at least as long as any data is transmitted to the WD-H. Since the WD-H may be in a deep sleep mode the RTS signal must be pulled low t_{pre} before the transmission (see below).

CD The carrier detect signal is used by the WD-H to indicate that it will send data. If no data is transmitted the CD signal is high. Before the WD-H starts to transmit it pulls the signal low and keeps it low until all data is transmitted. The WD-H starts to transmit preambles immediately after pulling CD low. If the field device controller needs a certain time before it can receive information the number of preambles shall be set accordingly (see initialization phase).

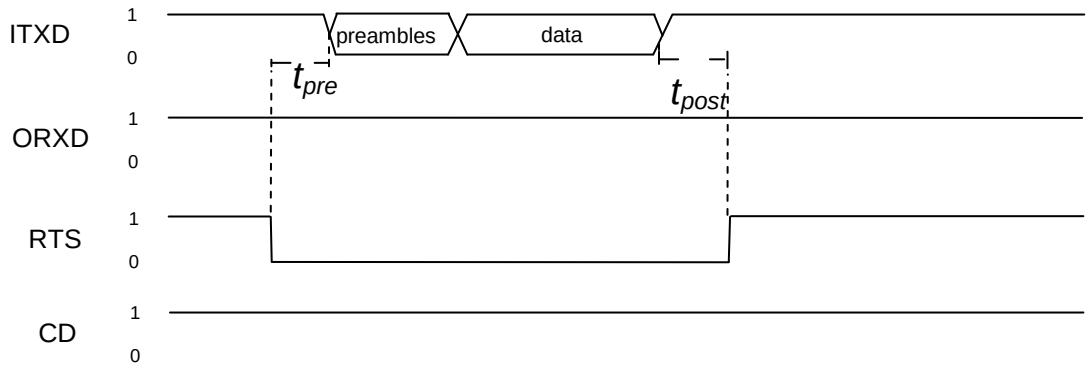


Figure 3: Transmission of data from the field device controller to the WD-H

In figure 3 a transmission of data to the WD-H is seen. Before the real data is sent preambles are sent. The character `0xFF` is used as preamble. The field device controller may start to send preambles immediately after pulling down RTS but after t_{pre} there must follow at least two preambles. After the byte of the frame transmitted the RTS line may be pulled back inactive. It must be held down during the whole frame including full bit-time of the last bit of the frame.

The time values for interfacing the WD-H are:

t_{pre} *= 2 ms*
t_{char} *= 0.57 ms*
t_{post} *>=0µs (RTS inactive after last bit)*

This means at least 6 preambles shall be sent if starting immediately after pulling down RTS.

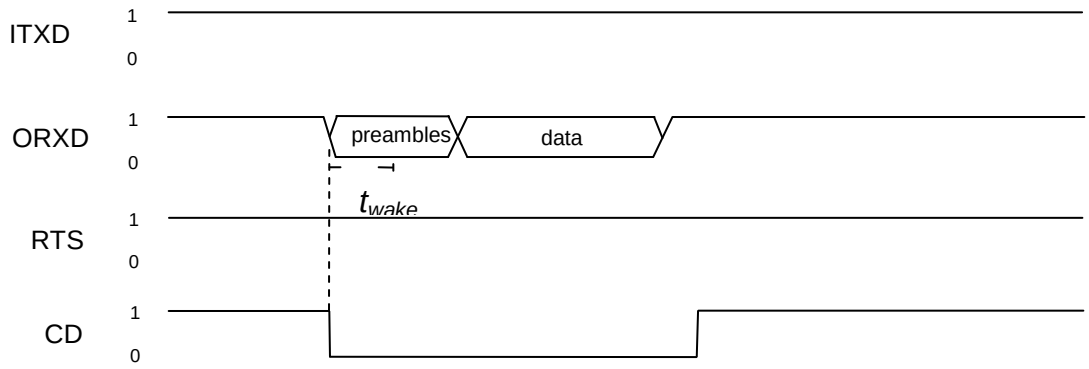


Figure 4: Transmission of data from the WD-H to the field device controller

In figure 4, communication in the opposite direction - from the WD-H to the field device controller - is depicted. The WD-H starts to transmit preambles immediately after it pulls down the CD signal. The default number of preambles sent is 6. This can be changed during initialization phase.

Assumed the field device controller requires at least two correct preambles it has t_{wake} time to be ready for reception after CD was pulled low. With 6 preambles

$t_{wake} < 2.2\ ms$

4. Communication

A valid communication sequence includes a request from a *master* and a response from a *slave*. Both WD-H and field device can act as *master* and shall be able to act as *slave*. To every request there always must be a response even if there is no data to be transmitted. Exceptions are certain cases where the request data frame is corrupted (see HART specification for details).

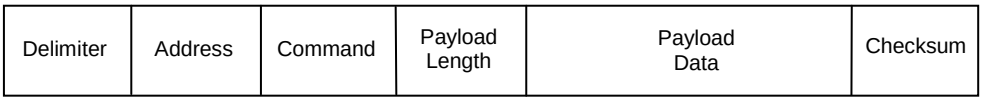
Transmission of the response must be started earlier than *16 ms* (28 character times) after the end of the request data frame was received. If this does not happen the *master* may send the request again. The WD-H does retry up to 3 times if it does not receive the response in-time.

A full bus arbitration as described in the HART specification is not required since only a peer-to-peer communication between the WD-H and the field device controller is allowed. Both peers are known and there must not be any other devices communicating on the same lines. So WD-H and field device may send immediately as long as the other one is not transmitting at the moment. However, to ensure that each peer can send its request and one is not blocking the other, both *masters* are not allowed to send a request in a period of *4.5 ms* (8 character times) after the reception of a response (ACK data frame). This allows the other *master* to send its request.

4.1. Data frame format

As communication protocol a subset of the HART token passing link layer and application protocol as described in the HART 7.1 specification is used. For a full description see the "Token-Passing Link Layer"[1] and the "Network Management"[2] specification.

All data frames exchanged between the field device and the WD-H share the following format. Big - endian byte order is used for multi-byte data.



The delimiter is 8-bit wide and is the first byte following the preambles. Its value describes the type of the data frame and which addressing is used. In table 2 all delimiters relevant for the WD-H interface are listed with its meaning. Frames with delimiters not listed shall be ignored.

Delimiter	Description
0x02	STX using poll (short) address: HART request during initialization phase.
0x82	STX using long address: HART request.
0x06	ACK using poll (short) address: HART response during initialization phase.
0x86	ACK using long address: HART response.

Table 2: List of valid frame delimiters

[1] HCF_SPEC-081 Revision 8.2
[2] HCF_SPEC-085 Revision 1.2

Depending on the delimiter the address field is either 1-byte wide for poll (short) addresses or 5-byte wide if long addresses are used. In figure 5 the formats of the poll and the long address are depicted. The most significant bit of the polling and long address always identifies the peer which sent the HART request. This is called the *master address*. The *slave address* identifies the peer which receives the request and sends the response. When poll addresses are used the *slave address* is 6-bit long and can take values between *0-63*. For long addresses the *slave address* consists of a unique device ID and the expanded device type (see the HART 7 specification[2] for details).

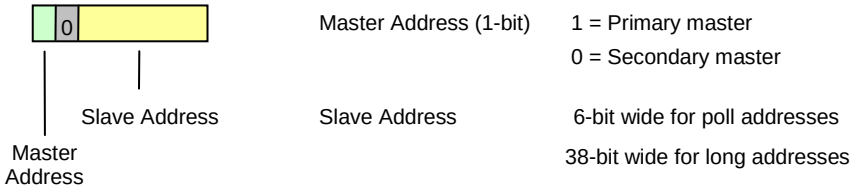


Figure 5: Address format

The WD-H always acts as *primary master*, i.e. the field device shall be *secondary master* when sending requests. When poll addresses are used the field device shall use 0 as poll *slave address* and the WD-H uses *15*. The long address of the WD-H consists of the *38* least significant bits of *0x0000000000*.

A response must use the same address type as was used by the request and since master and slave roles are unchanged the response uses the same address field as the request.

Example: The WD-H sends a request to the field device and uses poll addresses (since it does not know the long address of the field device yet). The address field of the request's data frame is 0x80 (primary master and slave address 0). When the field device responds the address field does not change and is 0x80 too.

The command field is 8-bit wide and contains the HART command number. If the HART command is higher than *255* it contains *0x1F*; then the 16-bit command number is part of the payload. Like the address field the command field of a response is the same as in the request.

Payload length is 8-bit wide and is equal to the number of bytes contained in the payload, i.e. the number of bytes between the payload length field and the checksum. Payload length field and checksum are not included.

The checksum field at the end of the data frame is 8-bit wide. It is calculated by XOR'ing all bytes of the data frame starting with the delimiter.

Depending on the type of data frame, i.e. whether it is a request or a response and if there were errors during command processing or not, the payload data can have different formats as well.

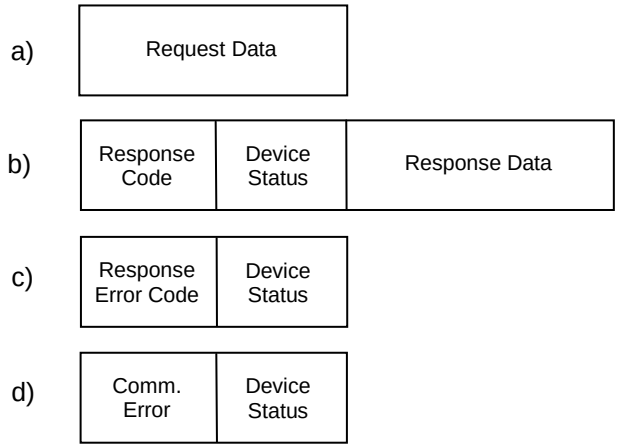


Figure 6: a) Request payload; b) Normal response payload;
c) Command error response payload; d) Communication error response payload

In figure 6 the payload data format for HART commands lower or equal *255* is depicted. Request and response data can be up to *90* bytes long and contain the data items found in the respective HART command description. The response payload additionally contains the one byte response code and the one byte device status.

If there is an error during command processing only the error response code and the device status, both one byte long, are returned in the response.

For HART commands higher than *255* the command field of the data frame contains *0x1F* and the real 16-bit command is stored in the payload. In figure 7 the format of the request and response payload is shown.

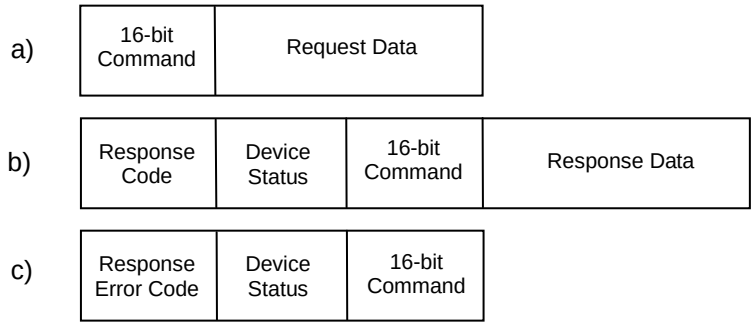


Figure 7: a) Request payload; b) Normal response payload;
c) Command error response payload

The communication error response is the same as for 8-bit commands (see figure 6).

4.2. Initialization phase

After start-up the WD-H is in its initialization phase. When the internal initialization is done the WD-H starts to periodically send HART command #0 requests to the field device until it receives a response. The request is sent to poll address *0*. As soon as the field device is ready for operation it shall answer the request with a valid response. The response contains all information required to form the long address of the field device. As soon as the WD-H receives the response initialization phase is done and normal operation mode is entered.

To be compliant to the HART specification the WD-H uses the long address for all requests after the initialization phase.

4.3. Operational phase

After the initialization phase the system is in the operational phase. During the normal operational phase there are three reasons for communication between the WD-H and the field device controller:

- HART command request from the *Wireless*HART gateway or network manager
- Maintenance port usage
- Intra-system communication to synchronize information base and device status

4.4. *Wireless*HART network request

In normal operation a *Wireless*HART field device receives HART command requests from the *Wireless*HART gateway or network manager. This is besides autonomous publishing of process values the most common type of wireless network communication. Whenever a request is received by the WD-H it has to be decided whether the command is processed by the WD-H itself or if it has to be processed by the field device cont

HART command	Description
103	Write burst period
104	Write burst trigger
105	Read burst mode configuration
107	Write burst device variables
108	Write burst mode command number
109	Burst mode control
115	Read event notification summary
116	Write event notification bit mask
117	Write event notification timing
118	Event notification control
119	Event acknowledge
768 - 976	*All mandatory wireless commands.*

Table 3: Standard HART commands supported by the WD-H

Table 3 lists all commands which are processed by the WD-H directly. In general all *Wireless*HART commands[1] and all burst mode commands are supported. The field device controller does not get any notice of those HART commands since they are consumed and answered in the WD-H. All other commands are forwarded to the field device controller, i.e. a HART command request is sent to the field device. The response is sent back into the *Wireless*HART network.

*Wireless*HART devices must support a list of mandatory commands. All mandatory commands not already supported by the WD-H must be implemented by the field device. The implementation has to be conforming to the HART 7.1 specification. The required commands are listed in table 4 below.

HART command	Description
0	Read Unique Identifier
1	Read Primary Variable
2	Read Loop Current and Percent of Range
3	Read Dynamic Variables and Loop Current
6	Write Polling Address
7	Read Loop Configuration
8	Read Dynamic Variable Classification
9	Read Device Variables with Status
11	Read Unique Identifier Associated with Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read Primary Variable Transducer Information
15	Read Device Information
16	Read Final Assembly Number
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
20	Read Long Tag
21	Read Unique Identifier Associated with Long Tag
22	Write Long Tag
38	Reset Configuration Changed Flag
41	Perform Self Test
42	Perform Device Reset
48	Reset Additional Device Status
54	Read Device Variable Information
59	Write Number of Response Preambles
78	Read Aggregated Commands
79	Write Device Variable
90	Read Real-Time Clock
106	Flush Delayed Response Buffers

Table 4: Mandatory HART commands

[1] HCF_SPEC-155 Revision 1.1

4.5. Maintenance port

All *Wireless*HART field devices must provide a maintenance port that complies with the token-passing data link layer specification[1] and supports at least one of the specified physical layers. The maintenance port can either be a standard HART process interface or a dedicated maintenance port (see HART specification for details). The WD-H does not provide a maintenance port thus it is the responsibility of the field device to provide one.

The maintenance port is used for configuration purposes and therefore is also used to configure burst mode and especially to setup *Wireless*HART network configuration which is required to connect to the *Wireless*HART network. It is necessary that the field device controller forwards all commands to the WD-H which are received via the maintenance port and not processed by the field device itself.

4.6. Intra-system communication

Intra-system communication, i.e. communication between the WD-H and the field device controller which is not triggered by the *Wireless*HART network or the maintenance port, can be used to exchange device status and configuration data. This can be for example the unique device information contained in the HART command #0 which is requested by the WD-H during start-up and network join processed.

Example: The WirelessHART device is showing the WirelessHART network tag in a LCD. The display is controlled by the field device controller. To get the current network tag the field device controller sends a command #776 request to the WD-H and receives the current tag with the response.

Additionally to all standard HART commands in listed in table 3 the WD-H implements a number of device specific commands which provides additional information and functionality. Some commands should only be used for intra-system communication and are not allowed for requests from the maintenance port. It is the field device controller responsibility to filter those requests and not forward them to the WD-H[2]. A list of the device specific commands and their restriction is found in the table 5 below. The complete description of the device specific commands can be found in annex A.

HART command	Description
64525	Write *Wireless*HART power settings [restricted]
64530	Set/clear Write Protect [restricted]
64531	Read Write Protect [restricted]
64535	Read Burst Mode Module Configuration [restricted]
64536	Write Burst Mode Module Configuration [restricted]
64537	External Request Service [restricted]
64538	External Delete Service [restricted]
64539	Publish on *Wireless*HART [restricted]
64600	Read diagnostic information
64601	Reset diagnostic information

Table 5: WD-H device specific HART commands

[1] HCF_SPEC-81 Revision 8.2
[2] The WD-H does not allow access to those commands via the WirelessHART networks.

Another very important use for intra-system communication is status synchronization between the field device controller and the WD-H. The various aspects of status synchronization are discussed in the chapter "Synchronization". Table 6 lists the HART commands which may be sent to the field device controller by the WD-H. It is recommended that the field device can process these. A complete description of the commands can be found in annex B.

HART command	Description
64518	Status change indication
64519	*Wireless*HART connection indication

Table 6: Recommended HART commands to be supported by the field device

5. Synchronization

5.1. Device status

Status synchronization between the WD-H and the field device controller is completely realized by HART indication requests (HART commands 64518/64520 via Softing API). Indication requests are sent over the Softing API in both directions, from the WD-H to the field device controller and vice-versa. The WD-H uses command 64518 to issue a status change indication and the field device controller uses command 64520 to signal status updates. Even though the command numbers are not the same, both commands are constructed in the same way. The request data contains the current status of the source and the response back to the originator contains the status of the destination.
Every time an internal status change occurs, the module issues a configuration changed command to the other side. WD-H keeps an internal mirror of the other field device controller module's status variables and crafts together the status on-the-fly whenever it is required (e.g. during packet/message construction). The field device controller should also mirror all status variables of the WD-H and create the current state out of these values and the internal status variables (status variables should be OR'ed together. Configuration changed counters should be added).

Status which must be synchronized:
- device status (see also HCF_SPEC-099 Revision 9.0, Field Device Status)
- extended device status (see also HCF_SPEC-183 Revision 20.0, Common Table 17)
- standardized status 3 (also known as wireless status, see also Common Table 32)
- configuration changed counter value (16bit)

The following chapters will describe the indication mechanism in detail for both the direction from WD-H to field device controller and from field device controller to WD-H and the implementation requirements of the field device controller.

5.1.1. General structure

The field device controller should keep a copy of both, its internal state and the „remote" state of the WD-H. An example structure of all local and remote variables is shown below:

```
typedef struct
{
      uint8_t localDeviceStatusCommon;
      uint8_t localDeviceStatus[ MAX_NUMBER_OF_MASTERS ];
      uint8_t localExtendedStatus;
      uint8_t localStandardizedStatus3;
      uint16_t localConfigChangedCounter;

      uint8_t remoteDeviceStatusCommon;
      uint8_t remoteExtendedStatus;
      uint8_t remoteStandardizedStatus3;
      uint16_t remoteConfigChangedCounter;
```

```
} T_STATUS_DATA;
```

The localDeviceStatusCommon/remoteDeviceStatusCommon variables contain all status bits except the cold start and configuration changed bit:

0x80 Device malfunction
0x40 **NOT SET** (Configuration changed)
0x20 **NOT SET** (Cold start)
0x10 More status available
0x08 Loop current fixed
0x04 Loop current saturated
0x02 Non-primary variable out of limits
0x01 Primary variable out of limits

The localDeviceStatus fields which are present for every connected master only contain the two flags which are not contained in the localDeviceStatusCommon variable. These are the cold start and the configuration changed flag which can be set in two ways:

- local event (cold start or configuration changed event)
- incoming trigger via indication command

They can only be reset by a particular master via incoming commands from that master and also for this master only. The first incoming command from a particular master resets the cold start flag. Command 38 (reset configuration changed flag) is used to reset the config changed flag.

5.1.2. Issuing an indication – command #64520

Whenever any of the internal status variables changes a status changed indication (command 64520 request) must be sent to the WD-H with the current values (for detailed command description see B.3). This for example applies to configuration changes (e.g. command 17 – write message) or if the field device controller sets a status bit (e.g. Device Malfunction, More status available).
Changes which concern every master attached to either the wired or wireless part are handled in a special way, these are:

- configuration changes
- cold starts

These flags are ignored in the device status byte of command 64520, but they are transmitted in an extra field (byte 5 of cmd 64520), see also command description of cmd 64520). During a cold start or configuration changed event, the field device controller sets the corresponding bit(s) of the flag byte and issues the indication once. The state of the flag byte is not repeated, it's just a trigger and only issued once. If anyhow the packet gets lost, the WD-H will miss the trigger and not set its master flags accordingly. This is not completely correct but it's also not that important and the configuration changed counter is consistent anyway.

Each status variable or status flag which is not used or known by the field device controller itself must be set to 0. The WD-H will also OR remote and local values together and if remote flags are not set, its internal state will be used.

5.1.3. Reception of an indication – command #64518

Each time the field device controller receives a command 64518 indication request from the WD-H module, it must update its remote values and answer the command using its local status values in the response (for detailed command description see B.1).

The received remote values shall update the local mirrors (by overwriting old values). This applies to:

- device status
- extended device status
- standardized status 3
- configuration changed counter

According to the flags set in byte 5 of the request, the field device controller must set the corresponding flags of all of its master in the localDeviceStatus array (e.g. if cold start flag is triggered, the field device controller must set the cold start bit in localDeviceStatus for each master).
The field device controller shall use its internal status values to craft together the cmd 64518 response. But it must not repeat the cold start/configuration changed triggers of the WD-H when there was no local event in the meantime, too.

5.1.4. Creating current status information and changed counter value

The current status variables are a combination (OR'ed together) of both the local and the remote variables plus local master-specific flags:

```
deviceStatus = localDeviceStatusCommon | localDeviceStatus[ masterId ] |
               remoteDeviceStatusCommon
```

The same applies to all other status variables with one exception that there is no master-specific status for these variables (extended device status, standardized status 3):

```
statusVariable = localStatus | remoteStatus
```

The actual configuration changed counter is just the sum of both the local and the remote value:

```
configChangedCounter = localConfigChangedCounter +
                       remoteConfigChangedCounter
```

5.2. Device lock

In HART and *Wireless*HART system every master can lock a device for configuration purposes if the device supports the HART commands #71 and #76. When the device is locked it shall accept write commands only from the master who requested the lock.

All lock commands from the *Wireless*HART network are forwarded to the field device controller. The field device should not allow any more write commands from the maintenance port until the lock is released. The field device itself can forward lock commands to the WD-H. In this case the WD-H will not allow any more write commands from either the network manager or the *Wireless*HART gateway until the lock is released.

5.3. *Wireless*HART join status

Every time the actual join status of the *Wireless*HART stack changes, e.g. from *operational* to *disconnected* a *Wireless*HART connection indication is sent to the field device controller. A connection indication is a HART command #64519 request containing the current wireless operation mode (see annex B.

6. Burst mode support

Event notifications and burst messages are natively supported by the WD-H burst mode functionality. They are only supported on the *Wireless*HART network (TDMA data link layer) since the WD-H itself does not have a wired HART interface (token passing link layer). All commands related to burst mode and event notifications are processed by the WD-H.

Burst messages are HART command responses to the commands #1, #2, #3, #9, #33, #48 or device specific commands published to the *Wireless*HART gateway periodically. For the universal commands there are enhanced burst modes which alter the publishing period according to events (see HART specification for more information on enhanced burst modes). Device specific command responses can only be published at a continuous rate. The HART command responses to be published are updated by the WD-H automatically, i.e. the WD-H requests the responses to all HART commands used in burst messages periodically from the field device. The update rate is equal to the minimum update period configured for the burst message.

The requests for updating the universal commands issued by the WD-H are determined by the burst message configuration. Device specific command update requests do not have any payload.

Event notifications require monitoring of the complete device status. The WD-H periodically requests updates of HART command #48 from the field device. The update rate is half the de-bounce period configured for the event notification.

The complete timing and publishing of the burst messages and event notifications is done by the burst mode implementation of the WD-H.

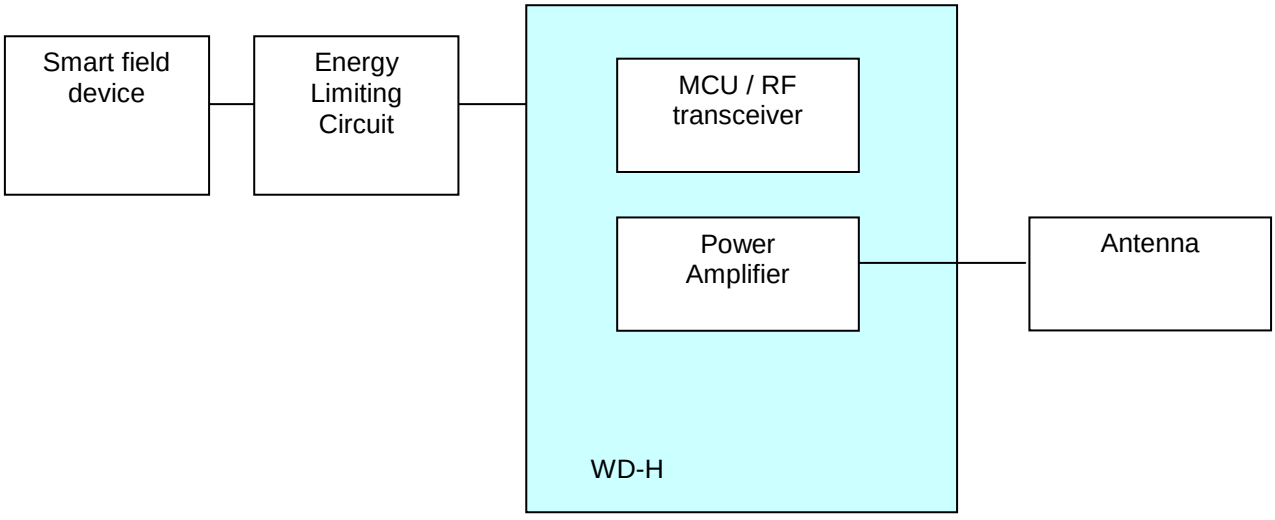
7. Integration for use in hazardous areas (ATEX)

7.1. Functional description

The communication interface type WD-H is an OEM radio module which is compliant to the *Wireless*HART standard. It has been designed for a fast and simple integration into field devices, transmitters and instruments of category 2G or 2D. These devices provide power and a communication path to the communication interface type WD-H. Only the antenna output is suitable for 1G or 1D. The communication interface type WD-H comes without enclosure which means that additional requirements have to be met when integrating this module. No galvanic isolation is provided by the communication interface type WD-H. So the communication interface type WD-H must be supplied by an ia circuit.

7.2. Block diagram

The block diagram shows the essential hardware units. A detailed description of these units is found in the following chapters.



The WD-H is supplied with regulated and stabilized power from the Smart Field Device via an Energy Limiting Circuit. This Energy Limiting Circuit may be included in the Smart Field Device. The main control unit of the WD-H is a microcontroller which communicates with the Smart Field Device and executes the protocol software for the wireless interface, e.g. *Wireless*HART. The Power Amplifier is used to adjust the RF output power. The WD-H provides no galvanic isolation to the Smart Field Device. The WD-H provides an antenna connector for the use of an external antenna.

7.3. Definition of the electric values

See ATEX Certificate of WD-H

7.4. Definition of contacts to external circuits

The connector is described in chapter 3, all signals are galvanically connected.

7.5. Marking

The WD-H is marked on top of the metallic shield with a direct print or a label similar to the following sample.

7.6. Special conditions for safe use

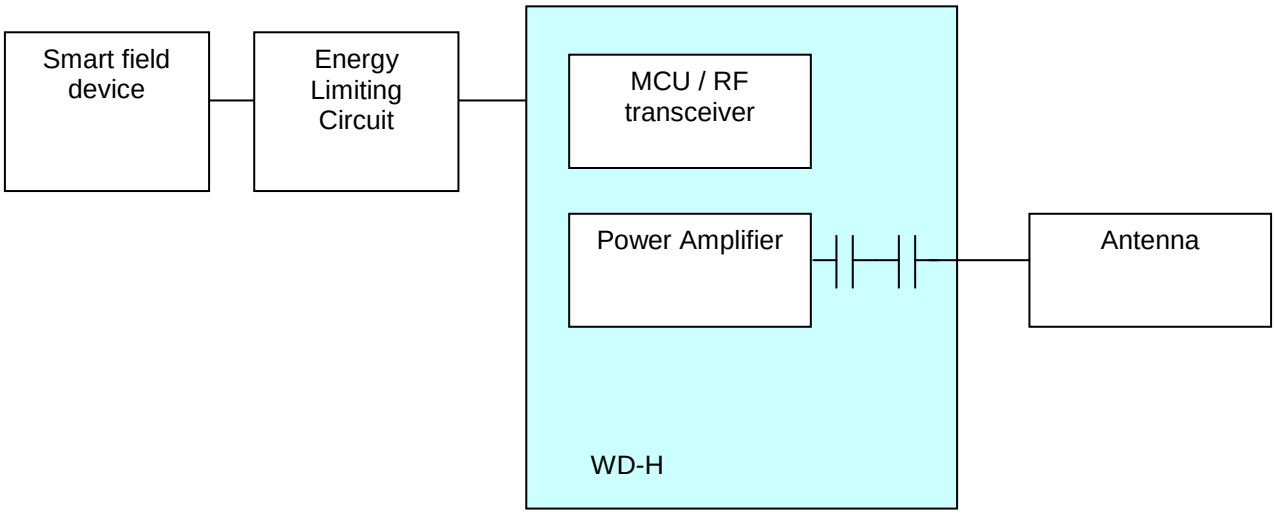
For the use of the WD-H inside an Ex area additional measures have to be taken. These measures are to be found in the certificate.

- Installation must be done with regard to legal requirements and safety regulations.
- This device has no housing and must be protected in a cabinet against splash water, dirt, moisture mechanical force exceeding pollution degree 1.
- This device must be protected against electrostatic discharge.
- The communication interface must provide the in ATEX certificate specified electrical input data from an ia IIC circuit.
- This protection may be realized similar to the circuit described in the application note " WD-H_addon_ex v102"
- The communication interface can only be used in certified electrical equipment category 2D or 2G. Only the antenna output is protected for 1D or 1G.
- Only antennas with 50 ohm impedance and maximum gain of 3dB can be used.
- Connector X4 must only be used outside the potentially hazardous atmospheres.
- For the use in combustible dust atmosphere additional requirements apply e.g. only housing with IP6x and a certification of the final assembly is required.

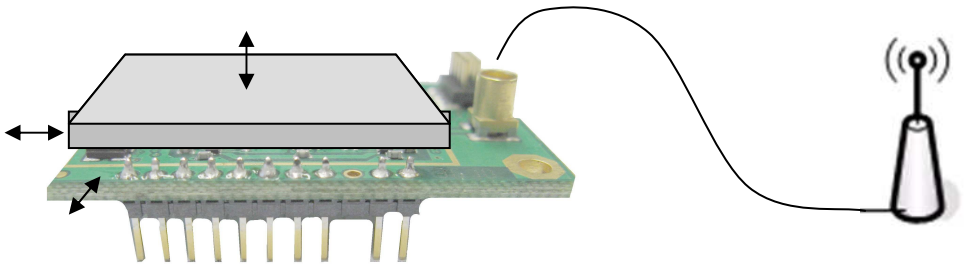
- For the use in gas atmosphere additional requirements apply e.g. housing with min. IP20 and a certification of the final assembly is required.

7.7. Integration of the WD-H module in a custom device

A typical scenario for integration of the WD-H in a customer system is as follows.



Air and Creepage distances:



Isolation distances to other intrinsic safe circuits or non intrinsic safe circuits must be observed according to EN 60079-11.

7.8. Antenna

Antennas should be used with a maximum gain < 3dB.
Antenna impedance 50 Ohm.

7.9. Enclosure

The WD-H is conformal coated and partially potted but without a housing. Therefore depending on the usage and environment an appropriate housing is required according to EN60079-11, EN60079-0. Additional requirements apply for the use in environment with combusted dust like IEC61241-11. An appropriate ingress protection for the enclosure may be needed.

7.10. Usage

This device is certified for appropriate and normal use. Warranty void if these rules are violated.

7.11. Assembling and disassembling

Assembly and disassembly has to comply with state of the art techniques.
Especially when working on electrical installations special safety regulations have to be observed.
Following items have to be observed:

- installation done according to instructions,
- guidelines for explosion group IIG are followed
- device is not damaged
- clean installation space
- all screws are fixed

7.12. Maintenance

The function of the device needs no regular adjustment. No maintenance is required.

- if failures of the device are observed, disassemble the device or the affected apparatus. Electronic components are not to be maintained on customer site. If necessary please send this device for repair back to the manufacturer.
- No repair allowed.

7.13. Fault clearance

There are no modifications on the device allowed.

7.14. Disposal

Disposal of packaging and used parts must be done according to legal regulations of the country of installation.

8. Energy limiting circuit for the usage of the WD-H module in explosive atmospheres

In order to use the WD-H module in an explosive environment according to ATEX (EN60079-11, EEx II 2 (1) G Ex ia IIC T4) the maximum energy applied to the system must be limited. An exemplary limiting circuit is introduced in this document.

8.1. General definitions

This chapter defines variables used in all calculations.
Detailed parameters and ordering number of all parts are described in the part list.

max. intrinsic safe input voltage:	$U_i = \underline{24V}$
Fuse F1:	$I_{F1} = \underline{0.125A}$
max. voltage VIN2 (3.6V):	$U_{MAX\_VIN2} = \underline{4.2V}$
max. power to VIN2 (3.6V):	$P_{MAX\_VIN2} = I_{F1}1.7U_{MAX\_VIN2} = \underline{0.89W}$

8.2. General conditions

All following calculations are based on ambient air unless otherwise specified.

For applying T4 rule, table 2a) in EN60079-11:2007 with an ambient temperature of 80℃ the max power per component is limited to 1.0W.

Local ambient temperature:	$T_a = 80℃$
General ambient temperature range:	$T_{amin} = -40℃$ $T_{amax} = 80℃$
Maximum power loss for T_a:	$P_{maxT4} = 1.0$ W

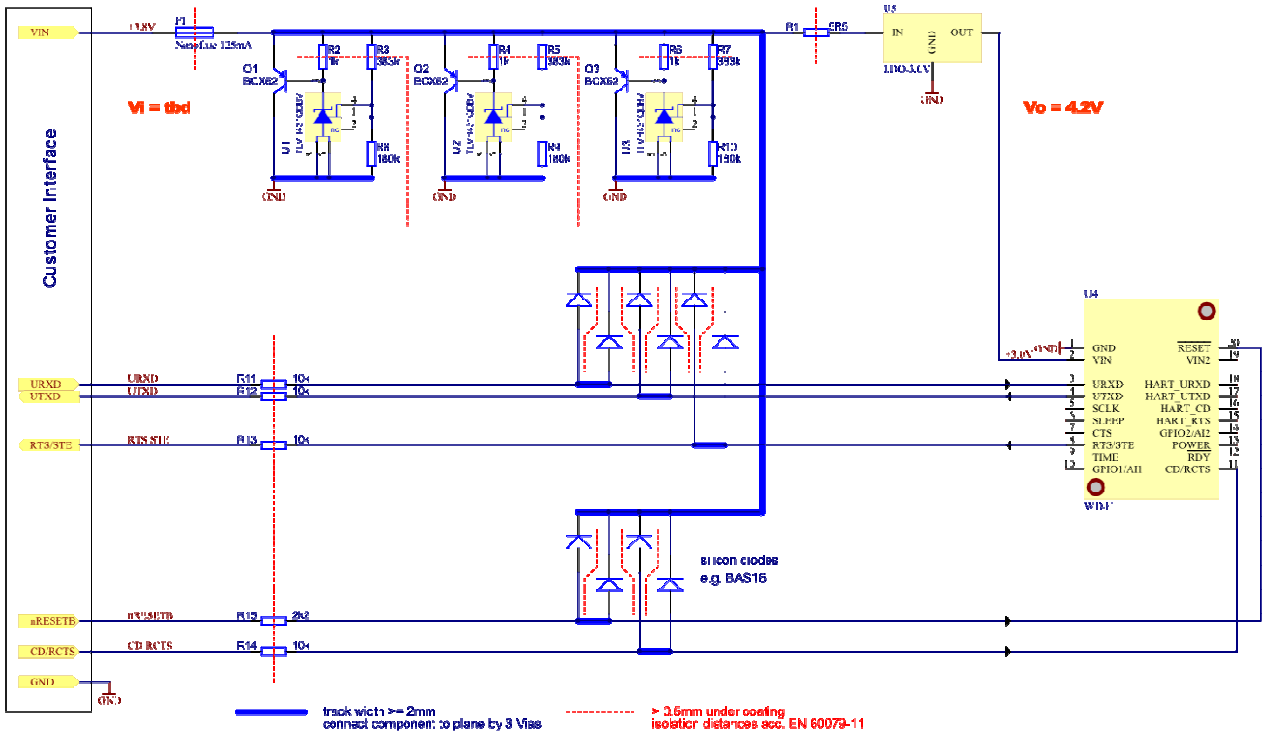
There are no hotspots on the board for igniting because the whole board is potted with a height of at least 1mm above critical components. These critical components are described in the following chapters.

Temperature limits of compound material: $T_{cmin} = -45℃$ $T_{cmax} = 200℃$

The component surface temperature under compound does not exceed the maximum service temperature of the compound.

Temperature limit acc. to T4 rule table 2a) in EN60079-11:2007 for small components is T = 275℃, with maximum service temperature of the compound limit is reduced to: $T_{Ozul} = 200$ ℃

8.3. Schematics of the limiting circuit



8.4. Calculation of components

8.4.1. Fuse F1 (451 Series Fuse from Littlefuse)

Temperature range: -55 to 125℃:
Ampere rating: 125mA
DC resistance: 1.7 Ohms
Interrupt rating: 50A at 125VAC/VDC, 300A at 32VDC
Creepage distance between pads: 2.95mm

Rated current: $I_{F1} = 0.125$ A
Safety factor: $f_{sich} = 1.7$
Safety relevant max current: $I_{MAX} = I_{F1} * f_{sich} = \underline{0.2125A}$

- Fuse F1 must be potted for Ex ia (ATEX requirement)

8.4.2. Voltage limiting circuit – 4.2V

This circuit consists of 3 separate voltage limitation circuits:

Circuit 1: Q1, U1, R2, R3, R8.
Circuit 2: Q2, U2, R4, R5, R9.
Circuit 3: Q3, U3, R6, R7, R10.

Each element consists of one PNP transistor, one reference diode and three resistors.
The following calculations are made for Circuit 1. The calculations for circuit 2 and 3 are the same.

8.4.2.1. Mode of operation

Precision diode U1 - TLVH431 is adjusted by R3 and R8 to a voltage of nominal 3.76V
R2 is needed to provide a cathode current for U1.
Q1 - BCX52 is used to increase the current capabilities of U1.

The following calculations contain the influences of component tolerances:

The following calculations contain the influences of component tolerances

$R_3 := 383 \cdot k\Omega$ $R_8 := 180 \cdot k\Omega$

$V_{refTLV431} := 1.24\,V$ $I_{ref} := 0.5 \cdot 10^{-6}\,A$

Tolerance TLVH431I = 1.5%

$$V_{max3V} := V_{refTLV431} \cdot 1.015 \left(1 + \frac{R_3 \cdot 1.01}{R_8 \cdot 0.99}\right) + I_{ref} R_3 \cdot 1.01 \qquad V_{max3V} = 4.18\,V$$

$$V_{min3V} := V_{refTLV431} \cdot 0.985 \left(1 + \frac{R_3 \cdot 0.99}{R_8 \cdot 1.01}\right) + I_{ref} R_3 \cdot 0.99 \qquad V_{min3V} = 3.96\,V$$

better class of precision diode, tolerance 0.5% versus 1.5%

Tolerance TLVH431BIDBZ = 0.5%

$$V_{1\%max3V} := V_{refTLV431} \cdot 1.005 \left(1 + \frac{R_3 \cdot 1.01}{R_8 \cdot 0.99}\right) + I_{ref} R_3 \cdot 1.01 \qquad V_{1\%max3V} = 4.14\,V$$

$$V_{1\%min3V} := V_{refTLV431} \cdot 0.995 \left(1 + \frac{R_3 \cdot 0.99}{R_8 \cdot 1.01}\right) + I_{ref} R_3 \cdot 0.99 \qquad V_{1\%min3V} = 4\,V$$

8.4.2.2. Thermal calculation

Shunt regulator U1:

Package: SOT23-5 or SOT 23-3
Temperature range: -40 to 125℃
Thermal resistance: R_{th_U1} = 206℃/W
Package area: approx. 18.67 mm^2 < $20mm^2$

Current through U1 is limited by R2 (1k) and R3 (360k).

With U_{MAX_VIN2} = 4.0V the maximum V_{REF_U1} is: V_{REF_U1} = 1.33V
$U_{R3} = U_{MAX\_VIN2} - V_{REF\_U1}$ = 2.67V; $P_{R3\_MAX} = U_{R3}^2/R3*0.99$ = 20µW

$I_{MAX\_U1} = U_{MAX\_VIN2}/(1k*0.99)$ = 4.04mA
V_{BE_Q1} = 0.4V; $V_{MAX\_U1} = U_{MAX\_VIN2} – V_{BE\_Q1}$ = 3.6V

Error view:
Maximum power to U1 is: $P_{MAX\_U1} = I_{MAX\_U1}*V_{MAX\_U1}$ = 0.015W

Max. temperature rise: $\Delta\theta_{U1} = P_{MAX\_U1}*R_{th\_U1}$ =3.09℃

$T_{U1} = \Delta\theta_{U1} + T_a$ = 83.09℃

- T_{U1} < 200℃ => Potting is NOT required for thermal rea sons.

Resistors R2 and R3

Package: 0603
Temperature range: -55 to 125℃
Thermal resistance: R_{th_R0603} = 680℃/W
Max power: 0.063W
Max voltage: 50V

Minimum creepage distance between conductive parts is 1.5mm in air and 0.5mm under coating.
Resistors which are smaller than SMD1206 must be potted/coated.

Error view:
$P_{MAX\_R2} = I_{MAX\_U1}^{2*}R2*1.01$ = 0.0163W
$P_{MAX\_R3} = U_{R3}^2/(R3*0.99)$ = 20µW

Max. temperature rise: $\Delta\theta_{R2} = P_{MAX\_R2}*R_{th\_R0603}$ = 11.1℃
Max. temperature rise: $\Delta\theta_{R3} = P_{MAX\_R3}*R_{th\_R0603}$ = 0.014℃

$T_{R2} = \Delta\theta_{R2} + T_a$ = 91.1℃
$T_{R3} = \Delta\theta_{R3} + T_a$ = 80.014℃

- TR2 and TR3 < 200℃ => Potting is NOT required for thermal reasons. R2 and R3 are infallible current limiters for U1 and creepage for 0603 is 0.5mm => Potting is required! If R2 and R3 are SMD 1206 chips => Potting is NOT required.

Transistor Q1:

Package: SOT89
Temperature range: -65 to 150℃
Thermal resistance: R_{th_Q1} = 230℃/W
Package area: approx. 43.5mm^2 > 20mm^2

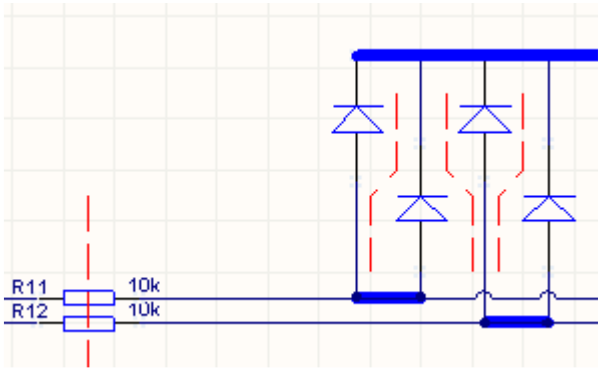
Error view:
Maximum power to Q1 is: $P_{MAX\_VIN2} = I_{F1}1.7U_{MAX\_VIN2}$ = 0.89W

Max. temperature rise: $\Delta\theta_{Q1} = P_{MAX\_VIN2} * R_{th\_Q1}$ =204.7 ℃

$T_{Q1} = \Delta\theta_{Q1} + T_a$ = 275.5℃

- TQ1 > 200℃ => Potting is required. Temperature me asurement must be performed to verify the thermal resistance when potted.

8.4.2.3. Limiting series resistors



The clamping diodes, e.g. silicon diodes of type BAS16, clamp incoming voltage to the protected voltage rail (see chapter 4.2.1)

Each interface signal line is protected by two separate diodes.
Current through each diode is limited by a series resistor, e.g. R11.

Max. Current to the WD-H via R11 to R14 with e.g. Uin = 24V via 10k series resistors is limited to

$I_{R11\text{-}R14}$ = 2.4mA.

Maximum additional power to the WD-H $P_{R11\text{-}R14}$ = 4 * 5V * 2.4mA = 48mW

Series Resistor for Reset Signal R15 = 2k2 Ohm

I_{R15} = 10.9mA

Maximum additional power to the WD-H P_{R15} = 5V * 10.9mA = 54.5mW

In sum maximum additional power to the WD-H $P_{R11\text{-}R15\text{-}to\text{-}WD\text{-}H}$ approx. 100mW.

Max power dissipation on the used diodes and resistors must be observed.

8.4.3. Limiting resistor R1

This resistor is an infallible current limiter to the WD-H module. This power limiting for RF signals to max 1.6W is required from ATEX.

A minimum creepage distance between conductive parts of 1.5mm in air, respectively 0.5mm under coating is required.

$P_{MAX\_WD\text{-}H} = 0.5*P_{MAX\_R1}$ = 1.6W (impedance matching)
⇨ P_{MAX_R1} = 3.2W

$U_{MAX\_R1} = U_{MAX\_VIN2}$ = 4.2V

$P_{MAX\_R1} = U_{MAX\_R1}^2/R1$ = 3.2W
⇨ R1 = 5.5 Ω

Thermal calculation:

Maximum power to R1 is: P_{MAX_VIN2} = 0.89W
With a safety factor of 1.5: $P_{MAX\_R1} = 1.5 * P_{MAX\_VIN2}$ = 1.335W

Package: 2512
Operating temperature range T_J = -55 to +125℃
Thermal resistance: R_{th_Q2} = 55℃/W
Max. voltage: 250V
Max. power: 1W @ 125℃, 2W @ 180℃ (70℃ ambient)

Error view:
Max. temperature rise: $\Delta\theta_{R1} = P_{MAX\_R1}*R_{th\_R1}$ =73℃

$T_{R1} = \Delta\theta_{R1} + T_a$ = 153℃

- T_{R1} > 200℃ => Potting is NOT required for thermal rea sons.

Steady state:

Maximum Power to the WD-H in steady state:

$P_{R1\text{-}series} = (I_{F1} * 1.7)^2 * R_1$ = 0.25W
$P_{MAX\_WD\text{-}H} = U_{MAX\_VIN2} * I_{F1} * 1.7 - P_{R1}$ = 0.64W

8.4.4. Low-dropout regulator U5

The LDO Regulator regulates the voltage to the WD-H to +3.0V. The Regulator LT1762EMS8-3 form Linear Technology should be used, with C_{IN} = 10µF, C_{OUT} = 10µF and C_{BYP} = 0.01µF ceramic capacitors with X7R dielectric.

Thermal calculation:

Package: MSOP8
Temperature range: -40 to 125℃
Thermal resistance: R_{th_U1} = 125℃/W
Package area: approx. 30 mm^2 < 1cm^2

Error view:
Maximum power to U5 is: $P_{MAX\_U5} = P_{MAX\_WD\text{-}H} = \underline{0.64W}$

Max. temperature rise: $\Delta\theta_{U5} = P_{MAX\_U5} * R_{th\_U5} = \underline{80℃}$

$T_{U5} = \Delta\theta_{U5} + T_a = \underline{160℃}$

- T_{U5} < 200℃ => Potting is NOT required for thermal rea sons.

8.4.5. Power to WD-H

Steady state calculation with calculated figures from above chapters.

Max. Power to WD-H $P_{max\text{-}WD\text{-}H} = P_{MAX\_WD\text{-}H} + P_{R11\text{-}R15\text{-}to\text{-}WD\text{-}H} = 0.74W$

9. Low power operation

*Wireless*HART is designed to enable low power battery operated devices. For this, the WD-H enables automatic low power operation for the *Wireless*HART protocol. The average power to operate the WD-H cannot be predicted or given because it only relies on the configuration of the *Wireless*HART protocol. The network manager (typically residing inside a *Wireless*HART gateway) configures and manages the *Wireless*HART protocol and control load-balance and communications between devices.

10. Safety Requirements

The WD-H module must be supplied by a limited power source according to EN 60950-1.

The clearance and creepage distances required by the end product must be withheld when the module is installed.

The cooling of the end product shall not negatively be influenced by the installation of the module.

11. Regulatory and standards compliance

Please see website to view certificates.

11.1. FCC Compliance

This device complies with part 15 of a FCC rules. Operation is subject to the following two conditions:
(1) This device may not cause interference, and
(2) This device must accept any interference,
including interference that may cause undesired operation of this device.
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules.
These limits are designed to provide reasonable protection against harmful interference in a residential installation.
This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/ TV technician for help.

“Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment“

Caution: Exposure to Radio Frequency Radiation

To comply with RF exposure compliance requirements, a separation distance of at least 20 cm must be maintained between the antenna of this device and all persons.
This device must not be co-located or operating in conjunction with any other antenna or transmitter.
To prevent radio interference to the licensed service, this device is intended to be operated indoors and away from windows to provide maximum shielding. Equipment (or its transmit antenna) that is installed outdoors is subject to licensing.

11.1.1. FCC Testing

Reference: MDE_SOFT_1002_FCCb
According to
Title 47 CFR chapter I part 15 subpart C

1 Administrative Data

1.1 Project Data

Project Responsible:	Patrick Lomax
Date Of Test Report:	2011/12/02
Date of first test:	2011/08/25
Date of last test:	2011/11/15

1.2 Applicant Data

Company Name:	Softing Industrial Automation GmbH
Street:	Richard-Reitzner-Allee 6
City:	85540 Haar
Country:	Germany
Contact Person:	Mr. Thomas Hilz
Function:	Product Manager Wireless
Phone:	+49 (89) 456 56-238
Fax:	+49 (89) 456 56-488
E-Mail:	thomas.hilz@softing.com

1.3 Test Laboratory Data

The following list shows all places and laboratories involved for test result generation:

7 layers DE

Company Name :	7 layers AG
Street :	Borsigstrasse 11
City :	40880 Ratingen
Country :	Germany
Contact Person :	Mr. Michael Albert
Phone :	+49 2102 749 201
Fax :	+49 2102 749 444
E Mail :	michael.albert@7Layers.de

Laboratory Details

Lab ID	*Identification*	*Responsible*	*Accreditation Info*
Lab 1	Conducted Emissions	Mr. Robert Machulec Mr. Andreas Petz	DAkkS-Registration no. D-PL-12140-01-01
Lab 2	Radiated Emissions	Mr. Robert Machulec Mr. Andreas Petz	DAkkS-Registration no. D-PL-12140-01-01
Lab 3	Regulatory Bluetooth RF Test Solution	Mr. Jimmy Chatheril Mr. Sören Berentzen	DAkkS-Registration no. D-PL-12140-01-01

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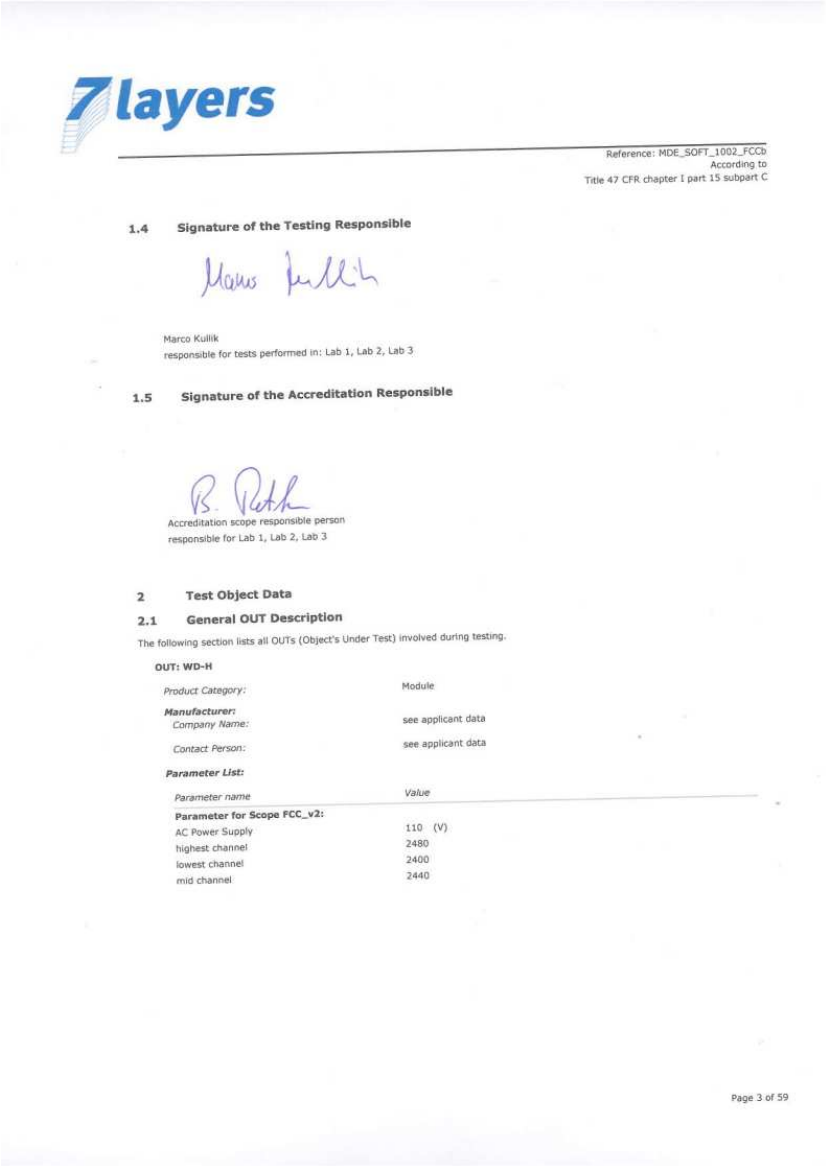

7layers

Reference: MDE_SOFT_1002_FCCb
According to
Title 47 CFR chapter I part 15 subpart C

1.4 Signature of the Testing Responsible

Marco Kullik
responsible for tests performed in: Lab 1, Lab 2, Lab 3

1.5 Signature of the Accreditation Responsible

Accreditation scope responsible person
responsible for Lab 1, Lab 2, Lab 3

2 Test Object Data

2.1 General OUT Description

The following section lists all OUTs (Object's Under Test) involved during testing.

OUT: WD-H

Product Category:	Module
Manufacturer:	
Company Name:	see applicant data
Contact Person:	see applicant data
Parameter List:	
Parameter name	*Value*
Parameter for Scope FCC_v2:	
AC Power Supply	110 (V)
highest channel	2480
lowest channel	2400
mid channel	2440

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11.1.2. FCC-approved Antennas

Antennas must be installed to provide at least 20cm separation distance from the transmitting antenna to the body of user during normal operating condition.
The antenna(s) used for this transmitter must not be collocated or operating in conjunction with any other antenna or transmitter within a host device, except in accordance with FCC multi-transmitter product procedures.
Only those antennas with same type and lesser gain filed under this FCC ID number can be used with this device.

11.2. OEM Labelling Requirements

A type label is fixed on the topside of the metal housing (alternatively a direct print on the metal body of the device is also possible) and has the following marking:

1. Manufacturer
2. Type
3. Hardware revision
4. Serial number
5. FCC ID
6. F-No[1] and Ex-Logo
7. CE-Symbol and label „Made in Germany“

Sample label:

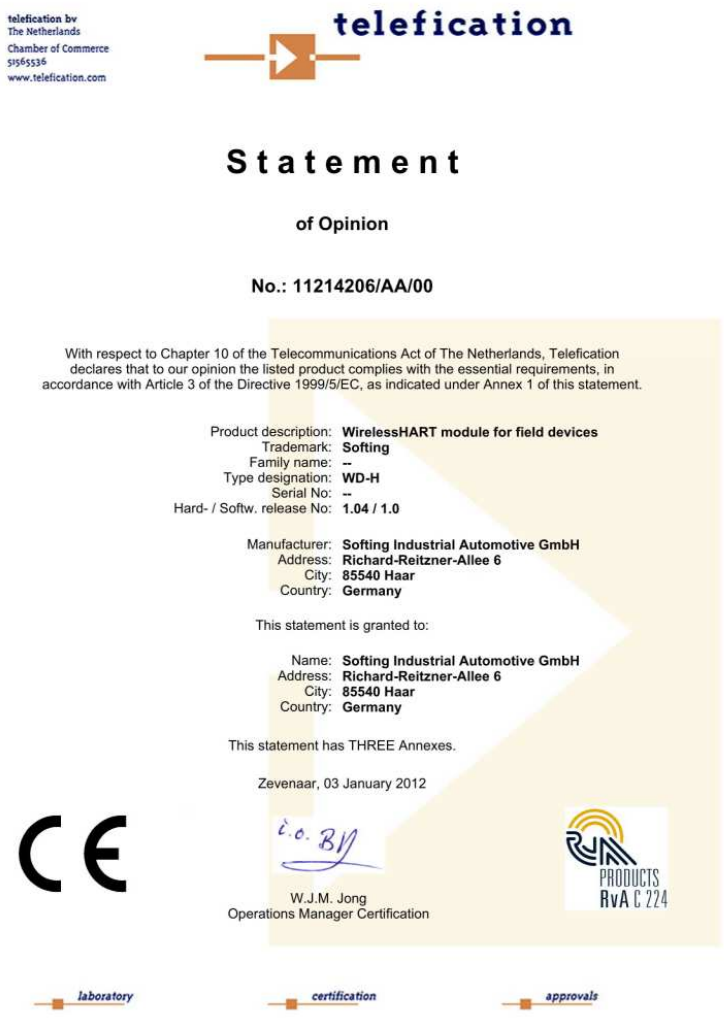
The label consists of one of the following materials

- Polyester silver
- Polyester white

If the WD-H is installed in a system, the label on the final system must include the statement: “Contains FCC ID: NH9WDH-V1” or using electronic labelling method as documented in KDB 784748.

[1] In der F-Nr. ist das Herstelljahr verschlüsselt / production year is coded in the F-No

11.3. CE Compliance



telefication bv
The Netherlands
Chamber of Commerce
51565536
www.telefication.com

telefication

Statement

of Opinion

No.: 11214206/AA/00

With respect to Chapter 10 of the Telecommunications Act of The Netherlands, Telefication declares that to our opinion the listed product complies with the essential requirements, in accordance with Article 3 of the Directive 1999/5/EC, as indicated under Annex 1 of this statement.

Product description:	**WirelessHART module for field devices**
Trademark:	**Softing**
Family name:	**--**
Type designation:	**WD-H**
Serial No:	**--**
Hard- / Softw. release No:	**1.04 / 1.0**
Manufacturer:	**Softing Industrial Automotive GmbH**
Address:	**Richard-Reitzner-Allee 6**
City:	**85540 Haar**
Country:	**Germany**

This statement is granted to:

Name:	**Softing Industrial Automotive GmbH**
Address:	**Richard-Reitzner-Allee 6**
City:	**85540 Haar**
Country:	**Germany**

This statement has THREE Annexes.

Zevenaar, 03 January 2012

CE

i.o. BJ

W.J.M. Jong
Operations Manager Certification

RvA PRODUCTS RvA C 224

laboratory certification approvals

11.4. Electromagnetic Compatibility

7layers

0. Testplan / Summary

Standard EN 301 489-1 04/2008 v1.8.1

Chapter 9.2			
RF-Electromagnetic Field		Basic Standard: EN 61000-4-3 +A1	05/2006 *
Testparameter:	3 V/m, 80-1000 MHz; 1.4-2.7 GHz; 80% AM, log 1%		
OP-Mode	Setup	Port	Final Result
WH_RX	setup_01a	Enclosure	passed
WH_TX	setup_01a	Enclosure	passed
Testparameter:	6 V/m, 80-1000 MHz; 1.4-2.7 GHz; 80% AM, log 1%		
OP-Mode	Setup	Port	Final Result
WH_StBy	setup_02a	Enclosure	passed

Chapter 9.3			
ESD Indirect Contact Discharge		Basic Standard: EN 61000-4-2 +A1 +A2	03/1995
Testparameter:	4 kV		
OP-Mode	Setup	Port	Final Result
WH_RX	setup_01c	Enclosure	passed
WH_StBy	setup_02c	Enclosure	passed
WH_TX	setup_01c	Enclosure	passed

* deviation from standard: for details see chapter 3. Test details

Part 1 of EN 301 489 together with the product related part 17 (V2.1.1, 2009-05) specify the applicable EMC tests, the methods of measurement, the limits and the performance criteria. In case of differences between these parts, part 17 takes precedence.

Not all tests were performed which are applicable for the device. The conducting surface as well as the isolating surface is usually covered by a housing after integration in end-user products. No ESD tests with direct contact discharge and air discharge were performed.

The applicant has specified that a loss of function during the transient phenomena and to recover the function by the operator after the transient phenomena is acceptable.

Responsible for Accreditation Scope: B. Roth

Responsible for Test Report: A. Bek

Test Report Reference: MDE_SOFT_1002_EMCa Page 2 of 19

11.5. Safety Tests

See Website:
http://www.softing-ia.com/en/products/product/?lang=0&tx_tvmatrix_pi3[node]=91&tx_tvmatrix_pi3[action]=feShow&tx_tvmatrix_pi3[controller]=Node&cHash=ad480bd4d833b72c88bf352fd4489d4f

Annex A

A.1 HART command #64525: Write *Wireless*HART power settings

Write *Wireless*HART power settings which are used in wireless command #777 and #778.

Request

Byte	Format	Description
0	uint8_t	Power source (see HART common table 44)
1 - 4	time	Duration at peak packet load before power drain (set to 24 h if not applicable).
5 - 8	time	Time to recover from power drain (set to zero if not applicable).
9 - 10	uint16_t	Battery life remaining in days

Response

Byte	Format	Description
0	uint8_t	Power source (see HART common table 44)
1 - 4	time	Duration at peak packet load before power drain (set to 24 h if not applicable).
5 - 8	time	Time to recover from power drain (set to zero if not applicable).
9 - 10	uint16_t	Battery life remaining in days

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors
1 - 127		Undefined

A.2 HART command #64530: Set/clear write protect

Set or clear write protect flag of the WD-H.

Request

Byte	Format	Description
0	uint8_t	Switch write protect on (=1) or off (=0).

Response

Byte	Format	Description
0	uint8_t	Current write protect state: on (=1) or off (=0).

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too few data bytes received.
6-127		Undefined

A.3 HART command #64531: Read write protect

Read current state of write protect flag.

Request

Byte	Format	Description
-	-	-

Response

Byte	Format	Description
0	uint8_t	Current write protect state: on (=1) or off (=0).

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors
1 - 127		Undefined

A.4 HART command #64535: Read burst mode module configuration

Read a burst mode configuration item form the WD-H burst mode module. At the moment the only configuration item is whether the internal burst mode implementation is enabled or disabled.

Request

Byte	Format	Description
0	uint8_t	Configuration item. Currently only one item is supported: 0: Enable / Disable

Response

Byte	Format	Description
0	uint8_t	Configuration item (e.g. for enable/disable this is 0)
1 - n		Value of the configuration item. (e.g. for enabled this is 1, for disabled the value is 0).

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1		Undefined
2	Error	Invalid selection.
3 -127		Undefined.

A.5 HART command #64536: Write burst mode module configuration

Write a burst mode configuration item to the WD-H burst mode module. At the moment the only configuration item is whether the internal burst mode implementation is enabled or disabled.
The new configuration takes effect after a restart of the WD-H.

Request

Byte	Format	Description
0	uint8_t	Configuration item. Currently only one item is supported: 0: Enable / Disable
1 - n		Value of the configuration item (0 for disable and 1 for enable).

Response

Byte	Format	Description
0	uint8_t	Configuration item.
1 - n		Value of the configuration item.

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1		Undefined
2	Error	Invalid selection.
3 -127		Undefined.

A.6 HART command #64537: External request service

Requests a service from the *Wireless*HART network manager using command 799. Behaves exactly the same as this command with the exception that an internal error while sending the requests results in an 'device specific error' response.

Request

Byte	Format	Description
0	uint8_t	Service ID (0x00 - 0x7F)
1	bits	Service Request Flags (Common Table 39)
2	enum	Service Application Domain (Common Table 40)
3-4	uint16_t	Nickname of peer (usually *Wireless*HART Gateway)
5-8	time	Period

Response

Byte	Format	Description
0	uint8_t	Service ID (0x00 - 0x7F)
1	bits	Service Request Flags (Common Table 39)
2	enum	Service Application Domain (Common Table 40)
3-4	uint16_t	Nickname of peer (usually *Wireless*HART Gateway)
5-8	time	Period
9	uint8_t	Route ID for this service ID

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1 - 3		Undefined
4	Error	Passed parameter too small.
5	Error	Too Few Data Bytes Received
6	Error	Device Specific Command Error
7		Undefined
8	Warning	Set To Nearest Possible Value
9 - 13		Undefined
14	Warning	Communication bandwidth supplied significantly less than requested.
15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 64		Undefined
65	Error	Service Request denied
66	Error	Unknown service flag
67	Error	Unknown application domain
68	Error	Unknown nickname
69	Error	Invalid service ID
70 - 127		Undefined

A.7 HART command #64538: External delete service

Deletes a service from the *Wireless*HART network manager using command 801. Behaves exactly the same as this command with the exception that an internal error while sending the requests results in an 'device specific error' response.

Request

Byte	Format	Description
0	uint8_t	Service ID (0x00 - 0x7F)
1	uint8_t	Reason (Common Table 49)

Response

Byte	Format	Description
0	uint8_t	Service ID (0x00 - 0x7F)
1	uint8_t	Reason (Common Table 49)
2	uint8_t	Number of Service entries remaining.

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1 - 4		Undefined
5	Error	Too few data bytes received
6	Error	Device Specific Command Error
7 - 15		Undefined
16	Error	Access restricted
17 - 32		Undefined
33	Error	DR Initiated
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 64		Undefined.
65	Error	Entry not found
66	Error	Invalid reason code
67	Error	Reason code rejected, service not deleted
68	Error	Delete not allowed
69 - 127		Undefined

A.8 HART command #64539: Publish on *Wireless*HART

Publishes a HART command response over the *Wireless*HART network. An existing service must be used.

Request

Byte	Format	Description
0	uint8_t	Service ID used
1 – 2	uint16_t	HART command number
3	uint8_t	HART response code
4- n		HART command payload

Response

Byte	Format	Description
0	uint8_t	Service ID used
1 – 2	uint16_t	HART command number
3	uint8_t	HART response code
4- n		HART command payload

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors.
1 – 4		Undefined
5	Error	Too few data bytes received
6 – 64		Undefined
65	Error	No buffers available.
66 - 127		Undefined

A.9 HART command #64600: Read diagnostic information

With this command a group of diagnostic parameters can be read from the Softing *Wireless*HART stack. The parameters are grouped together in a sensible way which minimizes network traffic for the major diagnostic use cases.

Note: Some diagnostic information is already available through Health Reports (command #779, #780 and #787). These parameter need not necessarily be read with this command.

Request

Byte	Format	Description
0	uint8_t	Diagnostic parameter group to read: 0 DLL transmission channel diagnostics 1 DLL packets sent 2 DLL packets received 3 DLL error packets 4 Authentication 5 Connection quality 6 Average time accuracy 7 Worst time accuracy 8 Transport layer diagnostics 9 Latency 10 Join process diagnostics 11 CPU and RF load

Response: Diagnostic group 0

Byte	Format	Description
0 – 1	uint16_t	Packets received by the *Wireless*HART data link layer on frequency channel 0.
2	uint8_t	Packet with wrong checksum received by the *Wireless*HART data link layer on frequency channel 0.
3 – 44		Repeat bytes 0 - 2 for the remaining 14 channels.

Response: Diagnostic group 1

Byte	Format	Description
0 – 1	uint16_t	Packets sent to the neighbor with neighbor list index 0.
2 – 63		Repeat bytes 0 - 1 for the remaining 31 neighbor list entries.

Response: Diagnostic group 2

Byte	Format	Description
0 – 1	uint16_t	Packets received from the neighbor with neighbor list index 0.
2 – 63		Repeat bytes 0 - 1 for the remaining 31 neighbor list entries.

Response: Diagnostic group 3

Byte	Format	Description
0 – 1	uint16_t	Packets received from neighbor with neighbor list index 0 indicating a communication error on the *Wireless*HART data link layer (NACK).
2 – 63		Repeat bytes 0 - 1 for the remaining 31 neighbor list entries.

Response: Diagnostic group 4

Byte	Format	Description
0 – 1	uint16_t	Number of packets generated by the WD-H.
2 – 3	uint16_t	Number of packets destined to the WD-H.
4	uint8_t	Packets with CRC error received.
5	uint8_t	Packets with wrong MIC received.
6	uint8_t	Packets with a wrong nonce counter received.

Response: Diagnostic group 5

Byte	Format	Description
0	int8_t	Average receive signal level in dBm of all packets received from the neighbor with neighbor list index 0.
1 – 31		Repeat byte 0 for the remaining 31 neighbor list entries.

Response: Diagnostic group 6

Byte	Format	Description
0 – 1	uint16_t	If neighbor 0 is a time source the average absolute time shift in *µs* is returned. Otherwise `0xFFFF` is returned.
2 – 63		Repeat bytes 0 - 1 for the remaining 31 neighbor list entries.

Response: Diagnostic group 7

Byte	Format	Description
0 – 1	int16_t	If neighbor 0 is a time source the absolute maximum time shift in *µs* is returned. Otherwise `0x7FFF` is returned.
2 – 63		Repeat bytes 0 - 1 for the remaining 31 neighbor list entries.

Response: Diagnostic group 8

Byte	Format	Description
0 – 1	uint16_t	Number of transmit request retries on transport layer
2 – 3	uint16_t	Number of transmit response to gateway retries on transport layer.
4 – 5	uint16_t	Number of transmit response to NM retries on transport layer.

Response: Diagnostic group 9

Byte	Format	Description
0 – 3	uint32_t	Average latency of packets to/from the gateway in *ms*.
4 – 7	uint32_t	Maximum latency of packets to/from the gateway in *ms*.
8 – 11	uint32_t	Average latency of packets to/from the NM in *ms*.
12 – 15	uint32_t	Maximum latency of packets to/from the NM in *ms*.

Response: Diagnostic group 10

Byte	Format	Description
0 – 1	uint16_t	Number of join requests.
2 – 3	uint16_t	Number of failed join requests.
4	uint8_t	Average number of neighbors during join process.

Response: Diagnostic group 11

Byte	Format	Description
0 – 3	uint32_t	Time [μs] the CPU was in sleep mode.
4 – 7	uint32_t	Time [μs] the CPU was active.
8 – 11	uint32_t	Time [μs] the RF transceiver was receiving.
12 – 15	uint32_t	Time [μs] the RF transceiver was transmitting.

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors
1		Undefined
2	Error	Invalid selection.
3 – 4		Undefined
5	Error	Too few data bytes received
6 – 127		Undefined

A.10 HART command #64601: Reset diagnostic information

With this command a group of diagnostic parameters can be reset. The request and response are the same as for the "Read diagnostic information" command. After the response with the latest diagnostic parameter values is sent those values are reset.

Annex B

B.1 HART command #64518: Status change indication (WD-H to field device controller)

Device status, extended device status, configuration change counter and the additional wireless status internally hold by the WD-H are indicated to the field device controller whenever they change. The field device controller may synchronize to the status by setting its internal device status accordingly, see also chapter “Synchronization”.

Request

Byte	Format	Description
0	uint8_t	Device status (without cold start and configuration changed flags)
1	uint8_t	Extended device status
2	uint8_t	Standardized status 3
3-4	uint16_t	Configuration changed counter
5	uint8_t	Configuration changed and cold start flags - 0x01 cold start - 0x02 configuration changed The flags contained in this field shall only be triggered once when a particular event occurs. They are used to set the according master flags on the other side, but they are not reset if the next indication is received without the flags set (this can only be achieved with incoming commands from a particular master, e.g. any command to reset cold start flag and command 38 to reset configuration changed flag).

Response

The values of the response represent the current state of the request’s receiver and may also be used by the issuer of the indication request to synchronize its remote status.

Byte	Format	Description
0	uint8_t	Device status
1	uint8_t	Extended device status
2	uint8_t	Standardized status 3
3-4	uint16_t	Configuration changed counter
5	uint8_t	Configuration changed and/or cold start flag

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors. Field device synchronized to the status indicated.
1-5		Undefined

6	Error	Device specific command error
7-127	uint16_t	Undefined

B.2 HART command #64519: *Wireless*HART connection indication

Whenever the wireless operation mode of the WD-H changes it sends an indication to the field device. This information can be used to display the wireless operation mode or change the mode of operation of the field device.

Request

Byte	Format	Description
0	uint8_t	Wireless operation mode (see HCF common table 51)

Response

Byte	Format	Description
0	uint8_t	Wireless operation mode (see HCF common table 51)

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors
1 – 127		Undefined

B.3 HART command #64520: Status change indication (command to WD-H)

Request

Byte	Format	Description
0	uint8_t	Device status (without cold start and configuration changed flags)
1	uint8_t	Extended device status
2	uint8_t	Standardized status 3
3-4	uint16_t	Configuration changed counter
5	uint8_t	Configuration changed and cold start flags - 0x01 cold start - 0x02 configuration changed The flags contained in this field shall only be triggered once when a particular event occurs. They are used to set the according master flags on the other side, but they are not reset if the next indication is received without the flags set (this can only be achieved with incoming commands from a particular master, e.g. any command to reset cold start flag and

		command 38 to reset configuration changed flag).

Response

The values of the response represent the current state of the request's receiver and may also be used by the issuer of the indication request to synchronize its remote status.

Byte	Format	Description
0	uint8_t	Device status
1	uint8_t	Extended device status
2	uint8_t	Standardized status 3
3-4	uint16_t	Configuration changed counter
5	uint8_t	Configuration changed and/or cold start flag

Command-specific response codes

Code	Class	Description
0	Success	No command-specific errors. Field device synchronized to the status indicated.
1-5		Undefined

Table of figures