TWN4

System Overview

DocRev7, September 12, 2014

Elatec GmbH

Contents

1 What is TWN4?

TWN4 is the name of a powerful and versatile series of RFID readers and writers. Here are some of the outstanding features:

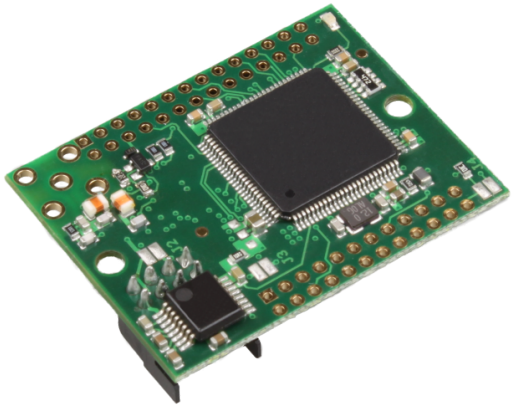
- Operation in two frequencies bands: 13.56 MHz (HF) and 125 kHz / 134.2 kHz (LF)
- Modular concept consisting of core modules, carrier boards, antennas and complete devices in housing.
- Security features such as slots for secure access modules or cryptogrphic functions.
- Possibility to write programs which are running on TWN4 itself (Apps).
- Standalone or host-based operation.

2 Products

2.1 TWN4 Core Module

The TWN4 family of RFID readers/writers is built around the TWN4 Core Module.

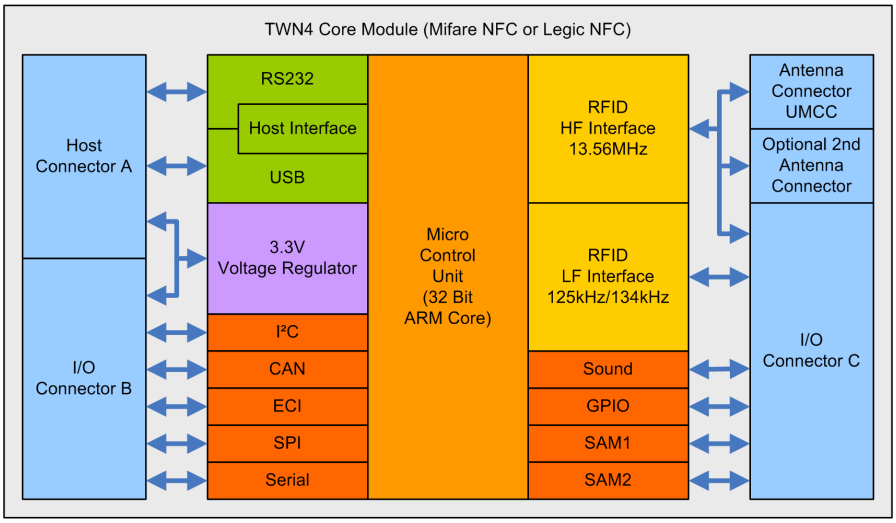
Here is a picture of the TWN4 Core Module MIFARE NFC:



There are two different core modules available:

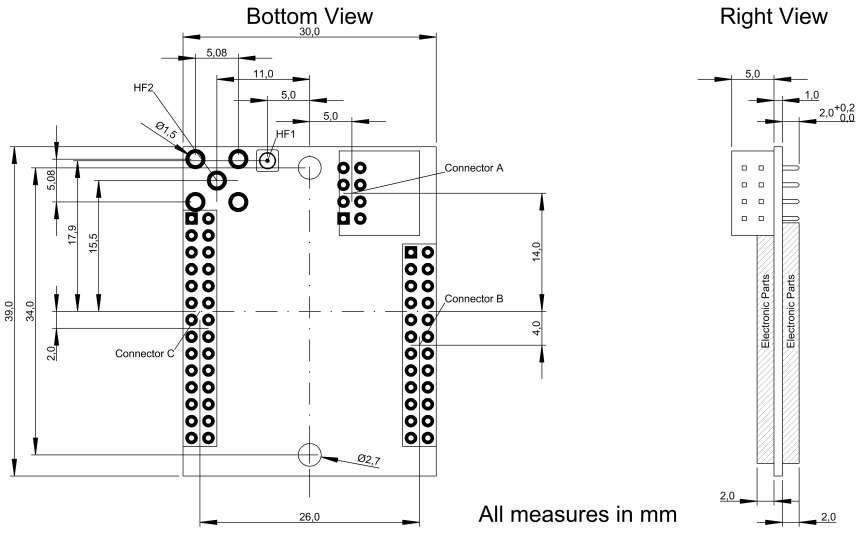
- TWN4 Core Module MIFARE NFC
- TWN4 Core Module LEGIC NFC

The core module contains voltage regulator, control unit, RFID front ends and communication interfaces.



2.1.1 Dimensions

The dimensions of TWN4 Core Module are as follows.:



2.1.2 Connectors

The TWN4 Core Module has several connectors on-board. There are three connectors (A, B and C) which connect either to a carrier board or to a host. Furthermore, there is a antenna connector and a optional position for placing a coaxial connector.

The connectors A, B and C have identical pitch. Following type of connector is recommended:

- Dual row header
- Pitch 2.0mm
- Pin shape square
- Pin width 0.5mm x 0.5mm
- Length of pins appropriate to custom requirements

2.1.2.1 Connector A

The connector A is intended for connecting a cable to the TWN4 core module, which allows communication with a host. Typically, such a cable is either type USB or RS232. Various appropriate USB and RS232 cables are available from stock.

There is a right-angle connector mounted on-board, which is type Hirose, DF11 series.

Pin	Pin Name	Function
A1	UGND	USB Ground
A2	USB_D+	USB Data +
A3	UVCC	USB VCC
A4	USB_D-	USB Data -
A5	V24_RXD	RS232 RXD (Input)
A6	GND	Ground
A7	V24_TXD	RS232 TXD (Output)
A8	MGND	Cable Sense

Note:

If pin A6 and A8 are connected to each other this has two effects:

1. The firmware of TWN4 changes host channel to RS232
2. The integrated circuit, which is interfacing to voltage levels of RS232 is powered up.

Following order codes for connector A and mating parts:

- Pin header on TWN4 Core Module: Hirose DF11-8DP-2DS(24)
- Mating part (crimping socket): Hirose DF11-8DS-2C
- Mating part (crimping contact): Hirose DF11-22SC (22 AWG)

2.1.2.2 Connector B

Pin	Pin Name	Function
B1	GND	Ground
B2	VIN	Unregulated input to on-board voltage regulator
B3	VREG	3.3V output from on-board voltage regulator
B4	VCC	3.3V power supply input
B5	RESET-	Low active TTL input with internal pull-up resistor for hard reset.
B6	PWRDWN-	Low active TTL input with internal pull-up resistor for turning off the voltage regulator.
B7	COM1_RX-	Low active TTL input with internal pull-up resistor of asynchronous RXD to COM1.
B8	COM1_TX-	Low active TTL output (push/pull) of asynchronous TXD from COM1.
B9	I2C_SDA	Data pin of I2C interface. No internal pull up.
B10	I2C_SCL	Clock pin of I2C interface. No internal pull up.
B11	CAN_RX	TTL RX pin of CAN interface. A external interface circuit is required.
B12	CAN_TX	TTL TX pin of CAN interface. A external interface circuit is required.
B13	ECI_MOSI	Pin MOSI of ECI
B14	ECI_MISO	Pin MISO of ECI.
B15	ECI_CLK	Pin CLK of ECI.
B16	ECI_ATTN-	Pin ATTN- of ECI.
B17	GND	Ground
B18	Res.	This pin is reserved for future purposes.
B19	SPI_MOSI	Pin MOSI of SPI interface
B20	SPI_MISO	Pin MISO of SPI interface
B21	SPI_SCK	Pin SCK of SPI interface
B22	SPI_SS-	Pin SS- of SPI interface
B23	Res.	This pin is reserved for future purposes.
B24	Res.	This pin is reserved for future purposes.

2.1.2.3 Connector C

Pin	Pin Name	Function
C1	GND	Ground
C2	ANT_HF	Together with pin C1, this pin builds a 50 ohm output for connecting external 13.56MHz antennas
C3	ANT_LF1	Output 1 for connecting external 125 kHz / 134.2 kHz antennas.
C4	ANT_LF2	Output 2 for connecting external 125 kHz / 134.2 kHz antennas.
C5	Res.	This pin is reserved for future purposes.
C6	SPK+	Digitally modulated output for a speaker. Second connection for the speaker is ground. The impedance of the speaker should be greater than 24 ohm.
C7	IO0	GPIO0, I/O pin for general purposes.
C8	IO1	GPIO1, I/O pin for general purposes.
C9	IO2	GPIO2, I/O pin for general purposes.
C10	IO3	GPIO3, I/O pin for general purposes.
C11	IO4	GPIO4, I/O pin for general purposes.
C12	IO5	GPIO5, I/O pin for general purposes.
C13	IO6	GPIO6, I/O pin for general purposes.
C14	IO7	GPIO7, I/O pin for general purposes.
C15	SAM1_CLK	Clock output for SAM1
C16	GND	Ground
C17	SAM1_IO	I/O line for SAM1
C18	SAM1_RST	Reset output for SAM1
C19	SAM2_CLK	Clock output for SAM2
C20	GND	Ground
C21	SAM2_IO	I/O line for SAM2
C22	SAM2_RST	Reset output for SAM2

continued on next page. . .

Pin	Pin Name	Function
C23	COM2_RX-	Low active TTL input with internal pull-up resistor of asynchronous RXD to COM2.
C24	COM2_TX-	Low active TTL output (push/pull) of asynchronous TXD from COM2.
C25	Res.	This pin is reserved for future purposes.
C26	Res.	This pin is reserved for future purposes.
C27	Res.	This pin is reserved for future purposes.
C28	VCC	3.3V power supply input or output for supplying external components. Internally connected to B4.

Note:

- The nominal inductance for an external 125 kHz/134.2 kHz antenna is 490 µH. The series resistance of the antenna should be lower than 10 ohms.

2.1.2.4 Connector HF1

HF connector 1 is a UMCC series 50-ohms output, which is connected internally in parallel to pins C1 and C2.

2.1.2.5 Connector HF2

Position of HF2 offers the possibility to place another 50-ohm connector. It is connected internally in parallel to pins C1 and C2. There are several series of RF connectors, which can be used for position HF2, like SMA, SMB, SMC, MCX.

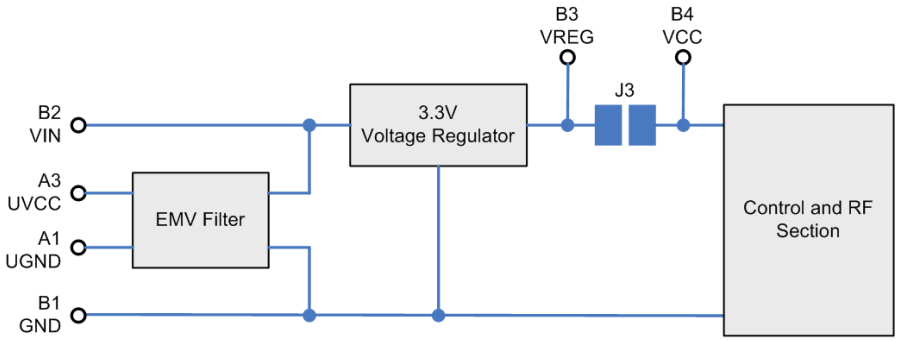
2.1.3 Jumpers

There are several jumpers on-board of the TWN4 Core Module. Depending on the requirements these jumpers can be soldered together.

Jumper	Function
J1	The function is identical to pins A6 and A8. If J1 is closed, the RS232 interface is turned on and the host channel is assumed to be RS232.
J2	Same function like J1 but other side of PCB.
J3	This jumper must be closed, if TWN4 Core Module is powered via connector A, e.g. from USB. It connects VCC from the Core Module to the on-board voltage regulator, which is supplied from connector A. If TWN4 Core Module is mounted on a carrier board, this connection can be avoided by connecting pins B3 and B4 at the carrier board, which results in exactly the same functionality.
J4	This jumper is for internal purposes only.

2.1.4 Power Supply

The picture below is showing, how power is routed through TWN4 Core Module:



2.2 TWN4 OEM PCBs

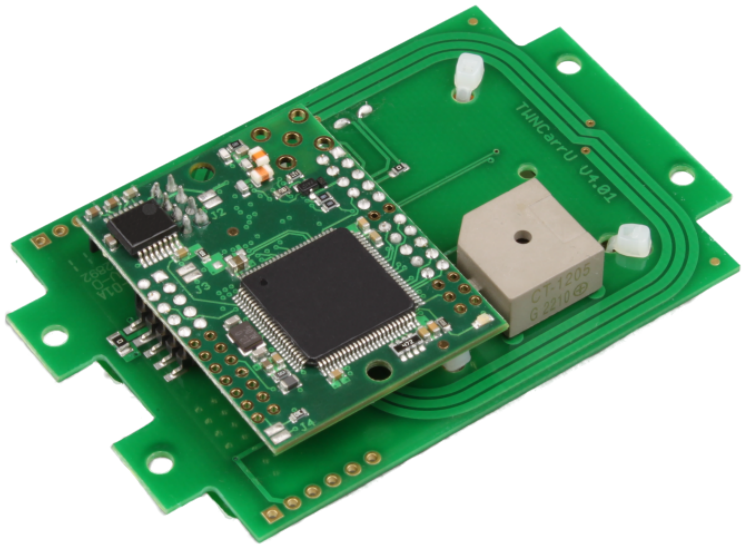
An OEM PCB combines all components including antennas and core module, which are required to build a full functional device. A OEM PCB consists of a carrier board, where all other parts ar placed. Only cable and power supply is required to bring device into operation.

Following OEM PCBs are available:

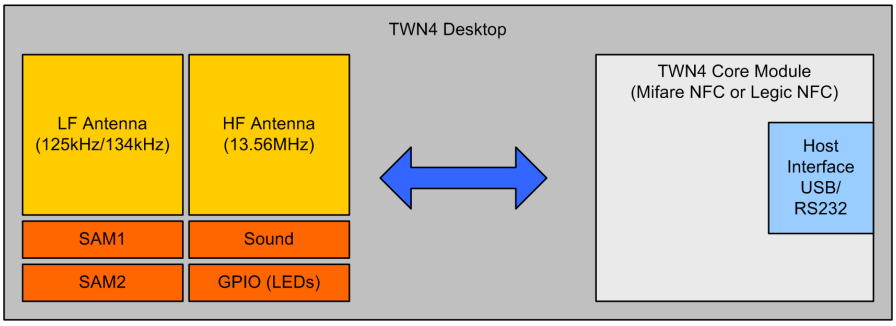
- TWN4 MIFARE NFC OEM PCB (Desktop)
- TWN4 LEGIC NFC OEM PCB (Desktop)
- TWN4 MIFARE NFC OEM PCB (Panel)
- TWN4 LEGIC NFC OEM PCB (Panel)

2.2.1 TWN4 Desktop OEM PCB

Here is a picture of a TWN4 Desktop OEM PCB (it is a MIFARE NFC):



The block diagram looks as follows:



2.2.1.1 Dimensions & Pinout

The dimensions and pinout of TWN4 OEM PCB as follows.:

Connector CNA*	
Pin	Signal
1	USB/Supply Ground (black Wire)
2	USB Data+ (green Wire)
3	USB/Supply 5V (red Wire)
4	USB Data- (white Wire)
5	RX232 RxD (Input)
6	J2-1**
7	RX232 TxD (Output)
8	J2-2**

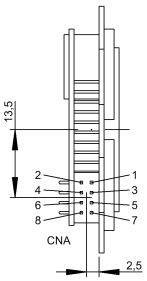
* Hirose DF11 series, 2mm pitch

** RS232 operation is achieved by either closing jumper J2 on the PCB or by connecting pin 6 and pin 8 of CNA.

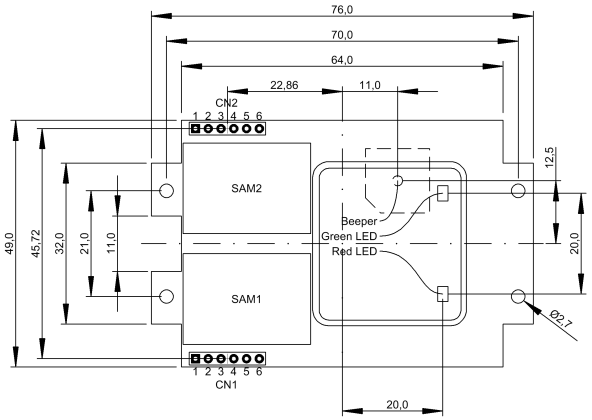
Connector CN1	
Pin	Signal
1	Supply Ground
2	5V Supply
3	Logic Input RxD (active low)
4	Logic Output TxD (active low)
5	GPIO2
6	GPIO3

Connector CN2	
Pin	Signal
1	Supply Ground
2	3.3V Supply
3	SCL (I²C)
4	SDA (I²C)
5	RESET (active low)
6	POWERDOWN (active low)

Bottom View

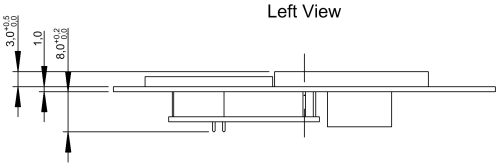


Top View



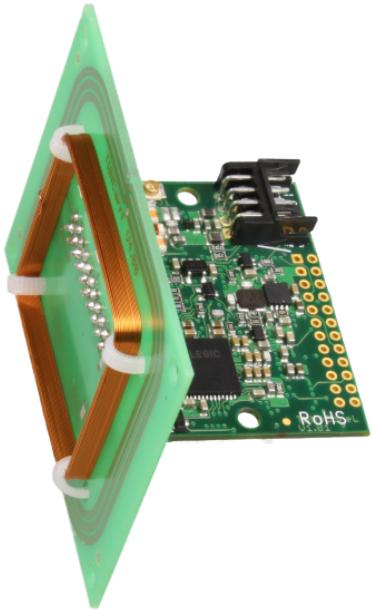
All measures in mm

Left View

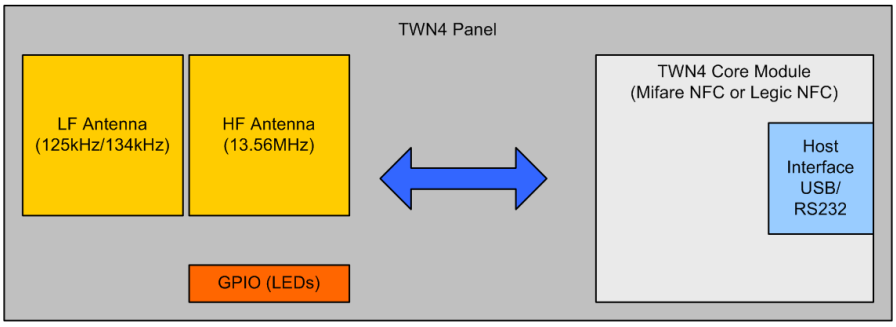


2.2.2 TWN4 Panel OEM PCB

Here is a picture of TWN4 Panel OEM PCB:



The block diagram looks as follows:

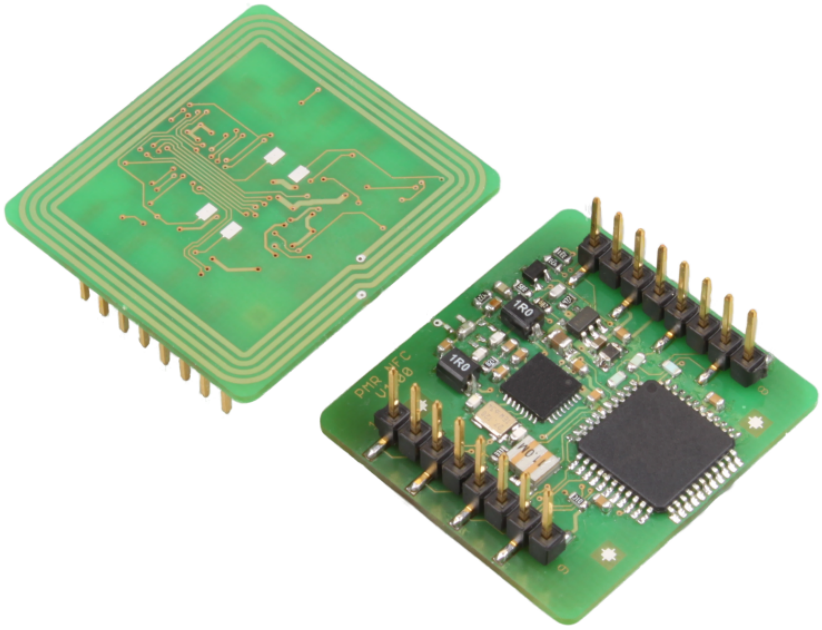


2.3 TWN4 Desktop

A TWN4 Desktop is a device, which contains TWN4 Desktop OEM PCB, housing and USB or RS232 cable for host connection. It is available either in black or white.

2.4 TWN4 Mini Reader

TWN4 Mini Reader is a module to be integrated on custom PCB. It has a built-in HF antenna and subset of IOs compared to TWN4 Core Module. TWN4 Mini Reader is currently available as version TWN4 Mini Reader MIFARE NFC.



2.4.1 Connectors

The TWN4 Mini Reader has two on-board single row headers with 8 positions each. The pins of these two connectors are together enumerated from 1 to 16.

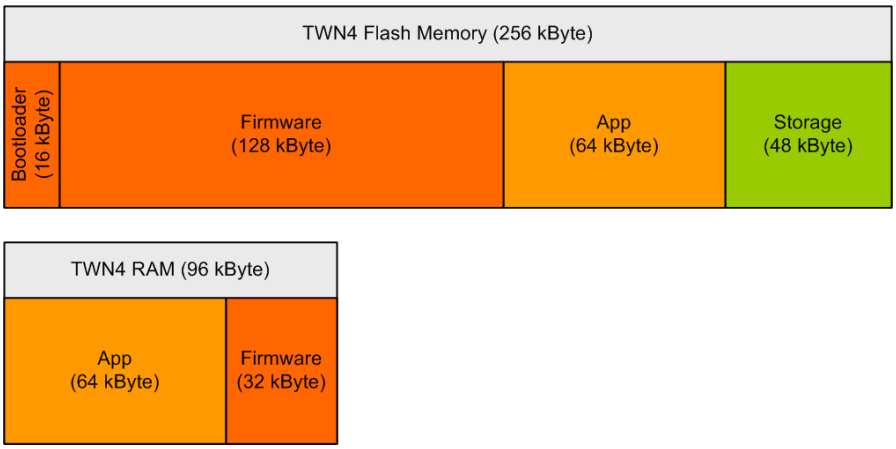
- Single row header
- Pitch 2.54mm
- Pin shape square 0.635mm

Pin	Pin Name	Function
1	RESET-	Low active TTL input with internal pull-up resistor for hard reset.
2	PWRDWN-	Low active TTL input with internal pull-up resistor for turning off the voltage regulator.
3	GND	Ground
4	VIN	Unregulated input to on-board voltage regulator
5	RXD-	Low active TTL input with internal pull-up resistor of asynchronous RXD to COM1.
6	TXD-	Low active TTL output (push/pull) of asynchronous TXD from COM1.
7	Res.	Reserved for future use (intended for SCK from SPI host interface).
8	Res.	Reserved for future use (intended for SS- from SPI host interface).
9	VCC	Internaly regulated 3.0V power supply. To be used for SAM1.
10	SAM_IO	I/O line for SAM1.
11	GPIO3	GPIO3, I/O pin for general purposes.
12	GPIO2	GPIO2, I/O pin for general purposes.
13	GPIO1	GPIO1, I/O pin for general purposes.
14	GPIO0	GPIO0, I/O pin for general purposes.
15	SAM_CLK	Clock output for SAM1
16	SAM_RST	Reset output for SAM1

3 Firmware

3.1 Memory View

The TWN4 Core Module has internal 256 kBytes of flash and 96 kBytes of RAM. The memory is devided into several sections as shown in the following diagram:



3.1.1 Boot Loader

The boot loader is the entry point for the firmware after powering up TWN4 or after a reset.

Only the boot loader provides functions for programming new firmware or Apps. This means in order to program either a new firmware or another App, the boot loader must be entered.

3.1.2 Firmware

The firmware occupies most space in flash memory. It provides functions for accessing IO or doing RFID operations. Furthermore, the execution of an App is controlled by the firmware.

The firmware cannot be read back from a TWN4.

3.1.3 App

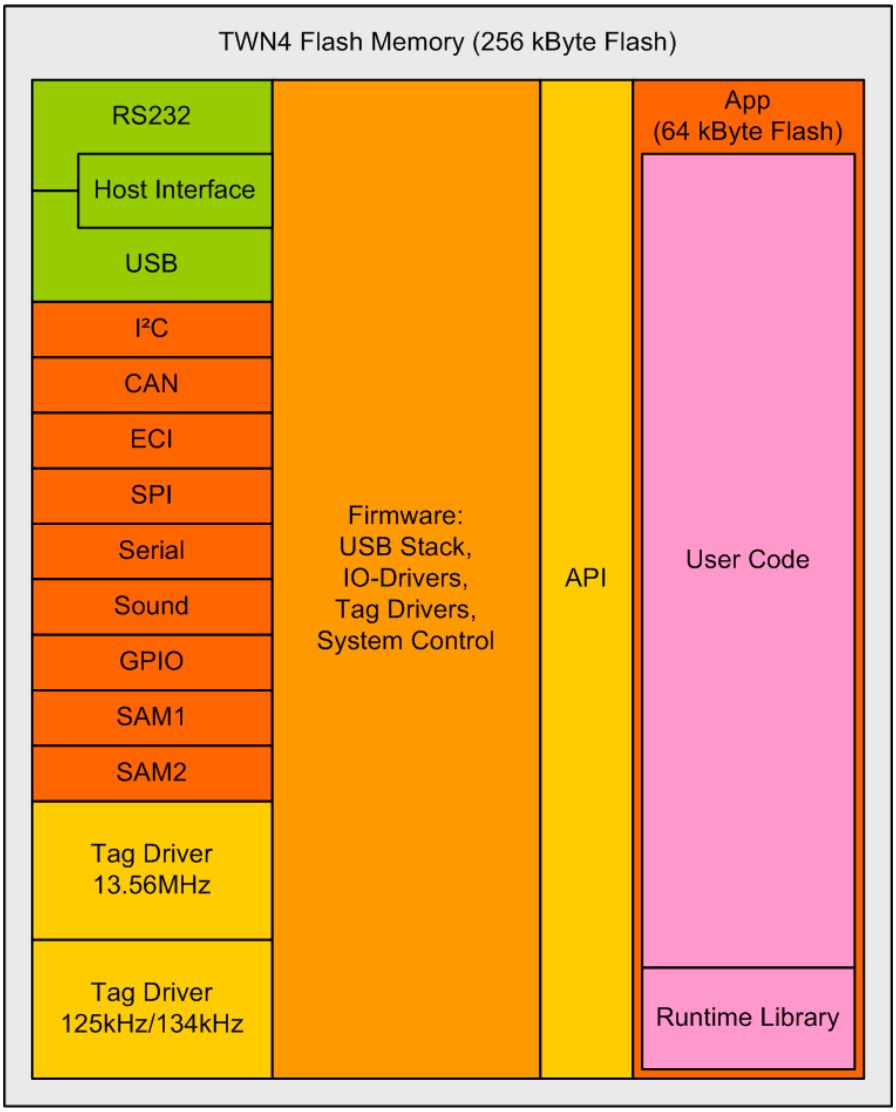
The App is the part of flash memory, which specifies the behaviour of a TWN4. Due to this, the programmer of the App has full control over the behaviour of the final application. An App can be programmed by the customer. In order to do so, an appropriate developer pack is provided.

An App cannot be read back from a TWN4. This allows to store secret keys and other cryptographic functionality as part of an App. Furthermore, the possibility to clone a device is avoided and the intellectual property is protected.

3.1.4 Storage

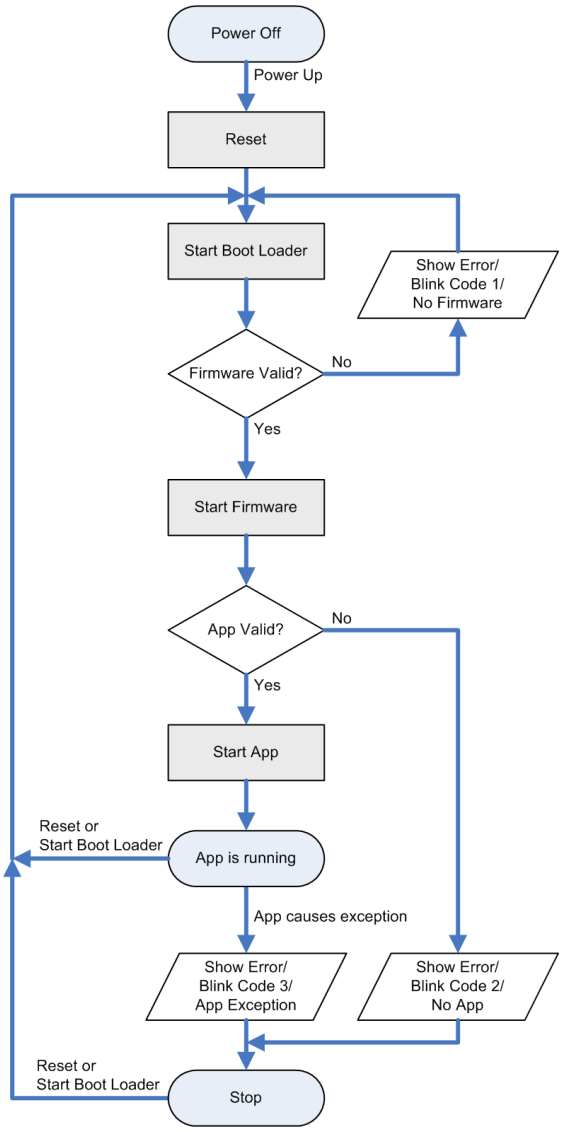
Storage is the section, where data is stored, which can be accessed via the storage functions. In other words, in this aera, the file system is located.

3.2 Functional Units



3.3 Firmware Startup Sequence

The diagram below is showing the sequence of how boot loader, firmware and App are started:



3.4 Firmware Error Conditions

There are several reasons, because the firmware may run into a unwanted condition. If this happens, the condition is shown by a on-board diagnostic red LED of the TWN4 Core Module. The LED is signalling the error code by a number of flashes separated by a pause.

This signalling is called blink code. Following blink codes are defined:

- Flash 1 time: There is no valid firmware installed on TWN4. This might be caused, if programming a new firmware onto TWN4 is interrupted by a power failure. In this case, the programming must be started from the beginning.
- Flash 2 times: There is no valid App installed on TWN4. This might be caused, if programming a new App onto TWN4 is interrupted by a power failure. In this case, the programming must be started from the beginning.
- Flash 3 times: The running App caused an exception. A exception is a invalid memory access or invalid program instruction. An App is allowed to access it's own memory space only (64kByte ROM/64kByte RAM).

3.5 Backdoor for Starting the Boot Loader

During development of new Apps and under undefined circumstances, the situation might arise, the starting the boot loader is not possible anymore. In such a situation, it is useful to start the boot loader manually. This can be achieved by connecting two pins of the TWN4 core module together and do a power cycle or reset. The two pins, which have to be connected together are C25 and C28 of the TWN4 Core Module.

3.6 App & Firmware Images

Several firmware images are provided to the customer. App and firmware images can be distginguished by the extension of their filename.

3.6.1 App Images

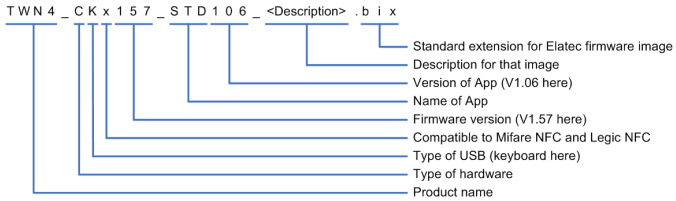
An App image has the extension .t4a. This extension replaces the older version .twn4.app, which leaded to some inconvenience when sent through the Internet. After compiling source code, the result is an App image with that extension. It can be programmed using AppBlaster into TWN4.

3.6.2 Firmware Images

A firmware image has the extension .bix. Normally, such a file contains a firmware for TWN4 and an appropriate App for the intended purpose.

3.6.2.1 Naming Scheme

There is a standard naming scheme for firmware images, which are given to the customer. This is how the name of a firmware image is constructed:



Two types of hardware must be distinguished:

- 'C', "Core Module": All products, which operate a TWN4 Core Module, like TWN4 Desktop, TWN4 OEM PCB, TWN4 Panel
- 'M', "Mini Reader": This is related to the TWN4 Mini Reader only

There are several types of USB stacks available:

- 'K': USB HID device (keyboard)
- 'C': USB CDC device class (virtual COM port)
- 'H': USB HID device (reports)

A USB stack is combined with an App. This might be either an App made by the customer or an App provided by the manufacturer. Several Apps are available:

- "STD": Standard App, TWN4 is searching for transponder and forwarding the ID to the host
- "PRS": Simple Protocol, TWN4 is running under the control by a host. TWN4 executes commands, sent by the host and returns response. In this way, nearly all TWN4 system functions can be execute remotely by the host. There is separate documentation and software available for using this mode of operation.

4 TWN4 Developer Pack

The TWN4 developer pack contains all software and documents necessary to operate, program and configure TWN4. Please see separate document for a detailed description of the program AppBlaster, which is used to prepare TWN4 for operation according to your requirements.

4.1 Installation

You received the TWN4 developer pack as zip file. In order to install the package, please follow these steps:

- Create a empty directory on your hard disk
- Unzip the entire content of the zip file into this empty directory
- You're done!

4.2 System Requirements

These are the minimum system requirements for a serious use of the TWN4 Developer Pack:

- Operating system: Microsoft Windows XP or later, 32 or 64 bit
- Microsoft .NET Framework 3.5
- Processor (CPU): 2 GHz
- Hard Disk: 200 MB
- RAM: 2 GB

5 Compatibility

The table below is giving an overview about compatibility of TWN4 to various platforms and their requirements.

System	Mode	Supported	Driver	Remark
Windows XP Windows 7 32/64 Bit Windows 8 32/64 Bit	RS232	Yes	Supported by OS	Port: e.g. COM1:
	USB HID Keyboard	Yes	Supported by OS	
	USB CDC (Virtual COM Port)	Yes	Available	Drivers are part of the developer pack
Linux 32/64 Bit (Ubuntu 10/11/12/13)	RS232	Yes	Supported by OS	Device: e.g. /dev/ttyS0
	USB HID Keyboard	Yes	Supported by OS	
	USB CDC (Virtual COM Port)	Yes	Supported by OS	Device: e.g. /dev/ttyACM0
Linux (ARM Platform)	RS232	No	N/A, platform dependent	
	USB HID Keyboard	Yes	Supported by OS	
	USB CDC (Virtual COM Port)	Yes	Supported by OS	Device e.g. /dev/ttyACM0
Windows CE	RS232	Yes	Supported by OS	Port: e.g. COM1:
	USB HID Keyboard	Yes	Supported by OS	
	USB CDC (Virtual COM Port)	No	N/A, platform dependent	

6 History of Changes

6.1 TWN4 Firmware

6.1.1 Firmware V1.23

- Initially released version.

6.1.2 Firmware V1.40

Firmware:

- LEGIC: System functions `SM4200_xxx` were renamed to `SM4X00` due to support of LEGIC chip SM4500 with identical API. Old style of functions is still available via macros.
- LEGIC: New system functions for reprogramming OS of LEGIC SM4200 or SM4500.
- USB CDC: No modprobe required anymore under Linux.
- USB CDC: TWN4 is mounted as /dev/ttyACMx instead of /dev/ttyUSBx.
- New system functions `Sleep`, `GetDeviceUID`, `SetParameters`.
- Options to keep communication port closed in order to reduce power consumption.
- Option to start an App independent of the current USB enumeration status (standalone applications).
- Support new USB class CCID in various flavours. Please contact your reseller for these features.
- New API ISO7816 for accessing two SAM slots (e.g. on the TWN4 OEM PCB).
- Random number generator, which is available via read to `CHANNEL_RNG`.
- Support for new transponders: AWID, G-Prox, Pyramid and Keri.
- Reworked crypto API with new functionality for cyphered block chaining (CBC).
- Improved (parallel) reading of LF transponders.

- Cotag: Improved reading with the additional option to turn off verify, which further speeds up recognition speed at still reliable reading performance
- Cotag: Decoded reading of ID data instead of a hash value.
- Inditag: Second read mode made available as known from TWN3 system function `IndiTagSearch2`
- Honeytag: Decoded reading of ID data instead of a hash value.
- iCLASS: Support for SIO in a SAM slot.
- iCLASS: Support for reading of PAC from appropriate transponders.
- iCLASS: Support for iCLASS type ISO15693 in addition to ISO14443B.
- MIFARE NFC ISO15693: Improved reading performance.
- New API ISO14443 with new functions for transparent communication to transponder types ISO14443A and ISO14443B.

6.1.3 Firmware V1.47

Firmware:

- Support NFC Peer-to-Peer
- Support ISO FDX-B
- Support EM4x50
- API for AT55xx
- Cotag: Improved reading including start bit
- G-Prox: Modified hash value for improved compatibility
- HITAG 2: Fix bug in Hitag2_SetPassword
- TIRIS: Relaxed read for better support of type multi page.
- App LEGIC Transparent: Support of digital I/O command
- App LEGIC Transparent: Receive-timeout of 1 second for messages
- App Tracer: Support new transponder types + receive of NDEF messages
- App Standard: Support new transponder types + receive of NDEF messages

Runtime environment:

- Optional definition of a manifest, which allows to modify parameters, before the App is started.

- Functions `memcmp`, `memcpy`, `memset` are made available to Apps.
- Definition for `NULL`
- API for using the Simple Protocol from own Apps.
- Function `SetHostChannel` for redirecting output to other than default host port.

6.1.4 Firmware V1.48

Firmware:

- Mifare NFC: Support HF frontend V2
- Mifare NFC: Reset ATS incase of newly found transponder
- Fix issue in EM4150_WritePassword which caused an exception
- Cotag: Improved reading speed
- Cotag: Option for delivering 48 bits instead of 32 bits

Runtime environment:

- More flexible API for Simple Protocol including support of optional transmission of an CRC

6.1.5 Firmware V1.49

Firmware:

- Mifare NFC: Hotfix for support of ISO15693
- Legic NFC: Hotfix for envelope command timeout issue

6.1.6 Firmware V1.57

Firmware:

- Support TWN4 Mini Reader Mifare NFC
- Support TWN4 SmartCard
- ISO7816: New system functions `ISO7816_GetSlotStatus`, `ISO7816_IccPowerOn`, `ISO7816_IccPowerOff`
- ISO14443A: New system functions `ISO14443A_GetATQA`, `ISO14443A_GetSAK`
- ISO14443-4: Fix 14443-4 timeout issue

- ISO7816: Fix T=0 speed/timeout issue
- AT55xx: Fix support of bit rates below f/64

6.1.7 Firmware V1.64

- Hitag 1/S: Increased dynamic range
- Hitag 1/S, Hitag 2: Adjustable timing via parameters
- Hitag S: Read UID of transponders, which are operating in encrypted mode
- DESfire: System function `DESfire_ChangeKey`: Bugfix regarding PICCMasterKey and Application MasterKey
- ISO14443B: Support transparent communication
- ISO14443B: New system functions `ISO14443B_GetATQB`, `ISO14443B_GetAnswerToATTRIB`
- ISO14443: Support high baudrates including parameters for setting up behaviour
- New system function `GetLastError` including error codes
- New API, which provides functions for access of internal flash storage
- MIFARE NFC: Improved reading of ISO15693
- Runtime lib: Systemfunctions `HostTestChar`, `HostWriteByte`, `HostReadByte` are now part of the runtime library
- Runtime lib: Changed naming scheme of all host communication functions by adding a leading "Host"
- Runtime lib: `HostWriteVersion` can handle version strings with up to 50 characters
- ISO7816: Rework and improved API
- LEGIC NFC: Support of system functions `ISO14443A_GetATS`, `ISO14443A_GetATQA`, `ISO14443A_GetSAK`

6.2 AppBlaster

6.2.1 AppBlaster V1.03

- Initially released version.

6.2.2 AppBlaster V1.40

- New work flow based on projects and templates.
- Save and load of projects.
- Support for all new transponder types of TWN4.
- Support for iCLASS PAC.
- Possibility to generate production images.

6.2.3 AppBlaster V1.47

- Support of new types of transponders including NFC

6.2.4 AppBlaster V1.49

- Support for Cotag 48 bits

6.2.5 AppBlaster V1.57

- Include correct App name and version into firmware image
- Support TWN4 Mini Reader Mifare NFC

6.2.6 AppBlaster V1.64

- Use of C99 language standard

6.3 Director

6.3.1 Director V1.00

- Initially released version.

6.3.2 Director V1.06

- Support system functions of TWN4 firmware V1.40
- Baud rate of serial communication can be adjusted
- "Simple Test": Selectable output format
- "Simple Test": Copy ID in clip board
- "Simple Test": Beep button is removed
- "Simple Test": Allow director to beep if needed
- "Simple Test": Only transponders, which are supported by TWN4 are selectable
- "Simple Test": Transponders, which are supported by TWN4 are selectable
- "Simple Test": Combo box is set up with currently configured transponders
- "Function Test": Possibility to enter a function call manually

6.3.3 Director V1.10

- Support of new transponder types and system functions according to TWN4 firmware version 1.47.
- Support bytes arrays which contain 0(!) bytes

6.3.4 Director V1.11

- Improved GUI
- Support firmware V1.48

6.3.5 Director V1.12

- Improved communication interface
- Support firmware V1.49

6.3.6 Director V1.14

- Support firmware V1.57
- Support of Simple Protocol, ASCII or binary, with or without CRC

- Support of USB HID reports
- Support of TWN4 SmartCard (slot ID-1, ID-0/SAM, slot 3 and 4)
- Support extended version string (Core Module or Mini Reader)

6.3.7 Director V1.16

- Support firmware V1.64
- Resizeable and scrollable history list
- Defined minimum size of main window
- Improved connecting mechanism and behaviour
- Colourful feedback of result of call of system functions
- Simplification of entering parameters for structure TDESFireFileSettings
- Manual input of system calls
- Many minor improvements

6.4 General

6.4.1 TWN4DevPack147

- Stripped down tool chain

6.4.2 TWN4DevPack148

- Link of correct libgcc.a

7 Regulatory Information

7.1 FCC Statement

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Section 15.21 Information to user Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment

Section 15.105 (b) Note: 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.

7.2 IC (Industry Canada) Statement

This device complies with Industry Canada licence-exempt RSS standard(s). 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 the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

8 Trademarks

All referenced brands, product names, service names and trademarks mentioned in this document are the property of their respective owners.