MBa62xx
User's Manual

MBa62xx UM 0100
29.04.2024

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REVISION HISTORY

Rev.	Date	Name	Pos.	Modification
0100	29.04.2024	M. Kreuzer	All	First issue

1. ABOUT THIS MANUAL

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1.5   Tips on safety

Improper or incorrect handling of the product can substantially reduce its life span.

1.6   Symbols and typographic conventions

Table 1:   Terms and Conventions

Symbol	Meaning
⚠ (ESD)	This symbol represents the handling of electrostatic-sensitive modules and / or components. These components are often damaged / destroyed by the transmission of a voltage higher than about 50 V. A human body usually only experiences electrostatic discharges above approximately 3,000 V.
⚠ (voltage)	This symbol indicates the possible use of voltages higher than 24 V. Please note the relevant statutory regulations in this regard. Non-compliance with these regulations can lead to serious damage to your health and also cause damage / destruction of the component.
⚠	This symbol indicates a possible source of danger. Acting against the procedure described can lead to possible damage to your health and / or cause damage / destruction of the material used.
⚠ (i)	This symbol represents important details or aspects for working with TQ-products.
`Command`	A font with fixed-width is used to denote commands, file names, or menu items.

1.7   Handling and ESD tips

General handling of your TQ-products

⚠	The TQ-product may only be used and serviced by certified personnel who have taken note of the information, the safety regulations in this document and all related rules and regulations. A general rule is: do not touch the TQ-product during operation. This is especially important when switching on, changing jumper settings or connecting other devices without ensuring beforehand that the power supply of the system has been switched off. Violation of this guideline may result in damage / destruction of the MBa62xx and be dangerous to your health. Improper handling of your TQ-product would render the guarantee invalid.

Proper ESD handling

⚠ (ESD)	The electronic components of your TQ-product are sensitive to electrostatic discharge (ESD). Always wear antistatic clothing, use ESD-safe tools, packing materials etc., and operate your TQ-product in an ESD-safe environment. Especially when you switch modules on, change jumper settings, or connect other devices.

1.8   Naming of signals

A hash mark (#) at the end of the signal name indicates a low-active signal.
Example: RESET#

If a signal can switch between two functions and if this is noted in the name of the signal, the low-active function is marked with a hash mark and shown at the end.
Example: C / D#

If a signal has multiple functions, the individual functions are separated by slashes when they are important for the wiring.
The identification of the individual functions follows the above conventions.
Example: WE2# / OE#

1.9   Further applicable documents / presumed knowledge

- **Specifications and manual of the modules used:**
  These documents describe the service, functionality and special characteristics of the module used (incl. BIOS).
- **Specifications of the components used:**
  The manufacturer's specifications of the components used, for example CompactFlash cards, are to be taken note of.
  They contain, if applicable, additional information that must be taken note of for safe and reliable operation.
  These documents are stored at TQ-Systems GmbH.
- **Chip errata:**
  It is the user's responsibility to make sure all errata published by the manufacturer of each component are taken note of.
  The manufacturer's advice should be followed.
- **Software behaviour:**
  No warranty can be given, nor responsibility taken for any unexpected software behaviour due to deficient components.
- **General expertise:**
  Expertise in electrical engineering / computer engineering is required for the installation and the use of the device.

The following documents are required to fully comprehend the following contents:

- MBa62xx circuit diagram
- TQMa62xx User's Manual
- Sitara AM62 Data Sheets
- U-Boot documentation: www.denx.de/wiki/U-Boot/Documentation
- PTXdist documentation: www.ptxdist.de
- TQ-Support Wiki: support.tq-group.com/doku.php?id=en:arm:tqma62xx

2.   BRIEF DESCRIPTION

The MBa62xx is designed as a carrier board for the TQMa62xx and TQMa62xxL All TQMa62xx interfaces are available on the MBa62xx. The AM62x CPU characteristics can be evaluated, and therefore the software development for a TQMa62xx project can be started immediately. This User's Manual specifies the hardware of the MBa62xx mainboard in revision Rev.020x.

The MBa62xx supports all TQMa62xx as well as TQMa62xxL (via adapter TQMa62xxL-ADAP) modules. In the further course of this User's Manual, only the TQMa62xx module is mentioned for the sake of simplicity - however, all statements apply accordingly to the TQMa62xxL module as well.
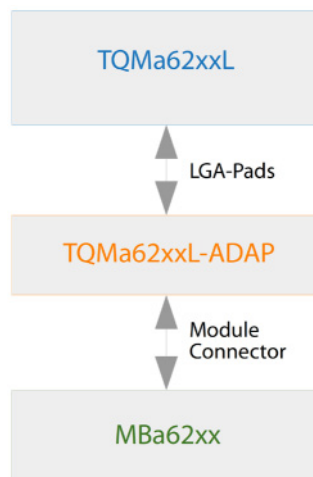
Figure 1: Block diagram TQMa62xx – TQMa62xxL-ADAP – MBa62xx

3.   TECHNICAL DATA

3.1   System architecture and functionality

3.1.1   Block diagram
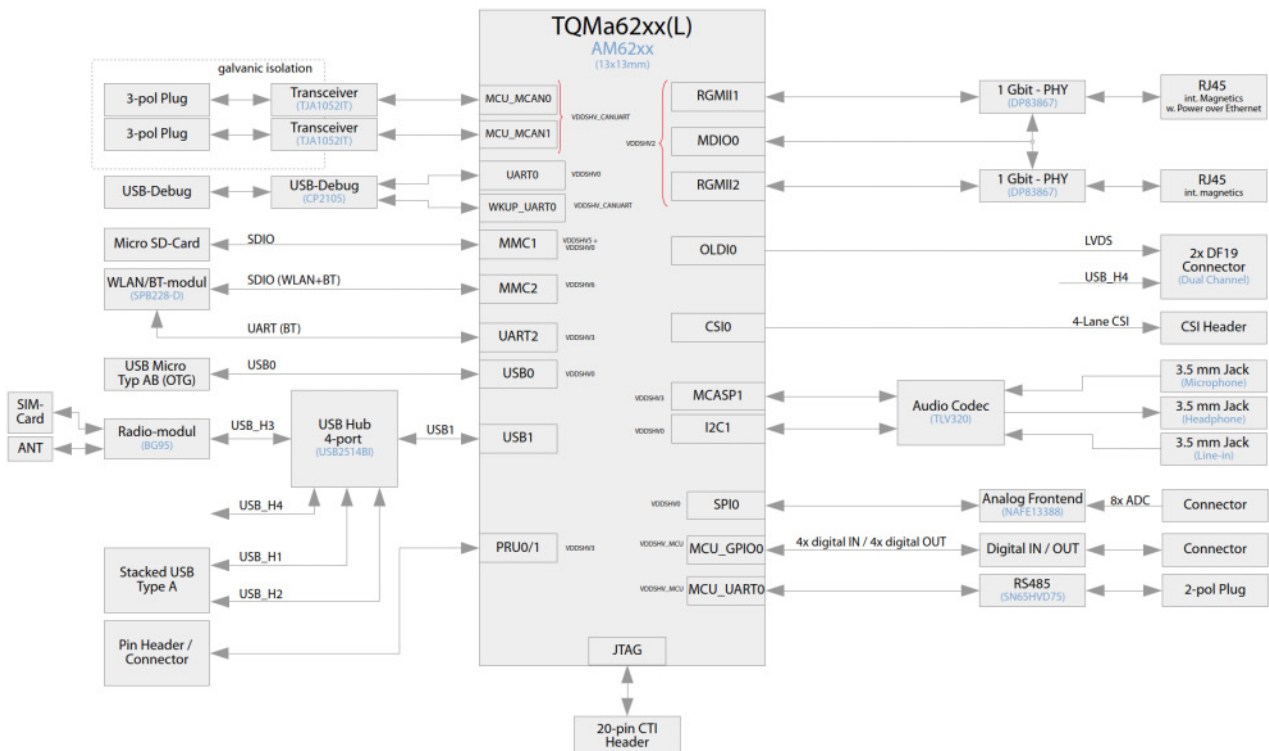
Figure 2:   Block diagram MBa62xx

3.1.2 Functionality

The system core is the TQMa62xx processor module with Texas Instruments Sitara AM62x CPU.

The TQMa62xx connects all peripheral components to each other.

In addition to the standard communication interfaces like USB, Ethernet, RS485 etc. all other available signals of the TQMa62xx are routed to standard headers.

The following interfaces / functions and user's interfaces are provided on the MBa62xx:

Table 2:   Overview interfaces

Interface	Qty.	Type of connector	Remark
Ethernet	1	RJ45 receptacle	Receptacle with integrated magnetics and PoE+
1000BASE-T	1	RJ45 receptacle	Receptacle with integrated magnetics
CAN	2	Phoenix basic housing	gal. separated, 3-pole
USB2.0 OTG	1	USB receptacle Type AB (Micro)	USB2.0 OTG
USB 2.0 Host	2	USB receptacle Type A (stacked)	max. 500 mA per port
Debug-USB	1	USB receptacle Type Micro B	2 x COM ports for Debug-UART
Analogue IN	1	Phoenix basic housing	Lay flat version, 8x ADC
Digital IOs	1	Phoenix basic housing	Lay flat version, 4x IN, 4x OUT, 24 V output for mainboard supply, 24 V input for HSS
WLAN module	1	2 x u.FL	Antennas for WLAN and wireless mobile
Radio module	1	2 x u.FL	SIM card holder, antennas for GNSS / Main
RS485	1	Phoenix basic housing	2-pole
SD card	1	Push-Push-Type (Micro)	SDR104 Speed-grade (UHS-I)
Audio	3	Jack socket 3.5 mm	1x Line-Out (Stereo, green) 1x Line-In (Stereo, blue) 1x MIC-In (Mono, pink)
LVDS	2	DF19 hearder	Dual LVDS data (2x 4 lanes), LVDS control signals (USB2.0, backlight control)
CSI	1	PCB connector	TQ uniform CSI pinout (1x 4 lanes / 1x 2 lanes).
Headers	2	Header, 2.54 mm pitch	1 x PRG0 interface 1 x Factory tests connector Control signals
Header	1	Header, 1.27 mm pitch	1x SEC (Interface of TQMa62xx)
Battery holder	1	CR2032 holder	Backup battery RTC of TQMa62xx

Table 3:   Overview diagnose and user's interfaces

Interface	Qty.	Component	Remark
Status-LEDs	2	LED blue	Input supply 24 V – Power IN USB debug interface
	1	LED yellow	GPIO-LED
	2	LED green / red	PGOOD (of module and mainboard)
	1	LED orange	Input supply 24 V – Power PoE
	2	LED green / yellow	Ethernet LEDs (activity / speed)
	5	LED green	IoT Net Status WLAN Wireless mobile Analog Frontend status GPIO-LED
Reset buttons	2	Push button	PMIC power button CPU / module reset (cold)
User buttons	2	Push button	CPU Reset (warm) GPIO (user button)
Boot-Mode configuration	4	DIP switch	4 x Boot mode configuration
CAN termination	2	DIP switch	120 Ohm termination
RS485 termination	1	DIP switch	120 Ohm termination
JTAG	1	20-pole header, 1.27 mm pitch	cTI 20-pin header, Pin 6 is keyed
Fan	1	Header 2.54 mm pitch	4-pole header for PWM control
Power In	1	Jack socket (2.5 mm / 5.5 mm, X5) Screw terminal 2-pole (X6)	16 V to 30 V

4.   ELECTRONICS

4.1   System components

4.1.1   TQMa62xx
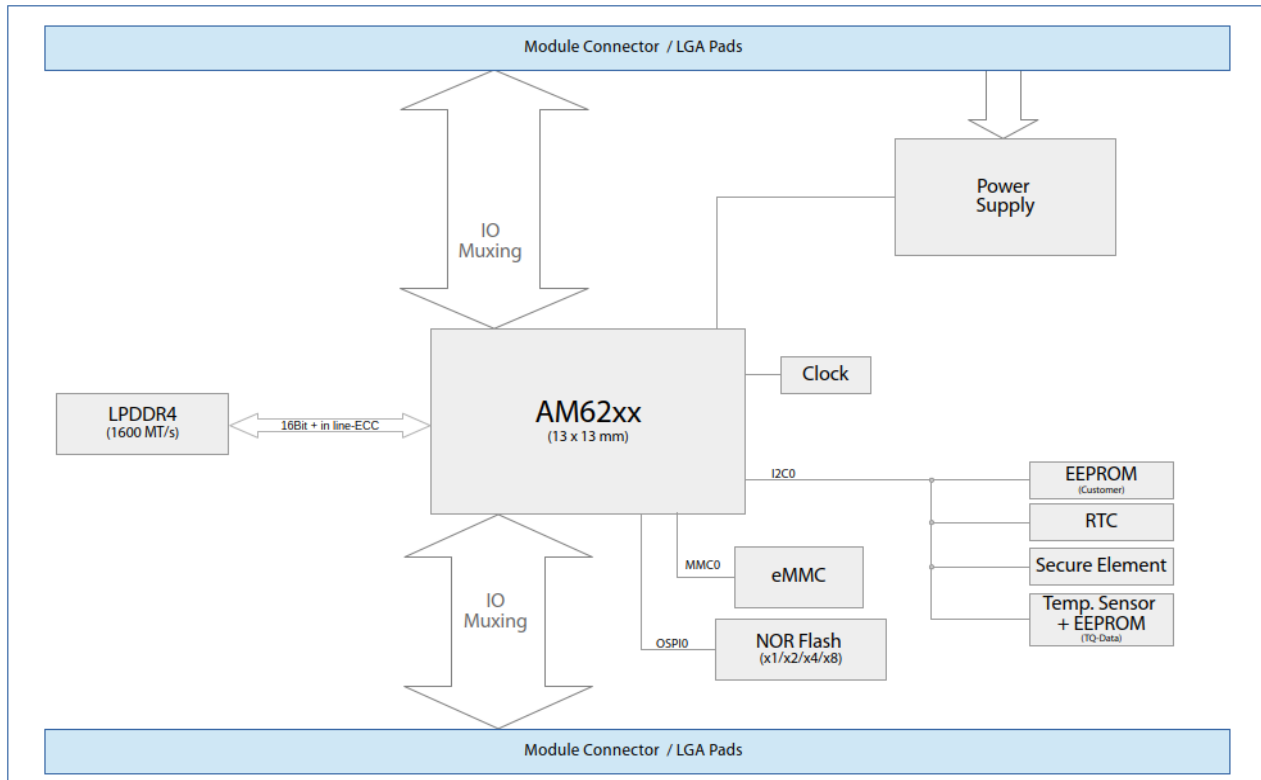
Figure 3:   Block diagram TQMa62xx

The TQMa62xx with the AM62x CPU is the central system component. It provides LPDDR4 SDRAM, eMMC, NOR flash and EEPROM memory.

The available signals are routed to module connector pins. When using the processor signals, it is essential to observe the multiple assignment of the pins by different processor-internal function units (multiplexing). More detailed information is to be taken from the accompanying TQMa62xx User's Manual.

The TQMa62xx boot behaviour can be customised.

To use the LGA module TQMa62xxL on the MBa62xx an additional adapter board, TQMa62xxL-ADAP, is required. The adapter board serves as an intermediate board which passes the signals from the LGA pads directly to the connectors.

Attention: Destruction or malfunction
⚠ To avoid damage due to mechanical stresses, the module may only be removed from the mainboard using the MOZIA62X extraction tool.

4.1.2   I²C address mapping

The accessible I²C buses depend on the pin multiplexing. Only the I2C1 bus is used by the module on the MBa62xx. On the TQMa62xx or TQMa62xxL the I2C0 bus is permanently provided for its I2C devices. The following devices are connected on the MBa62xx:
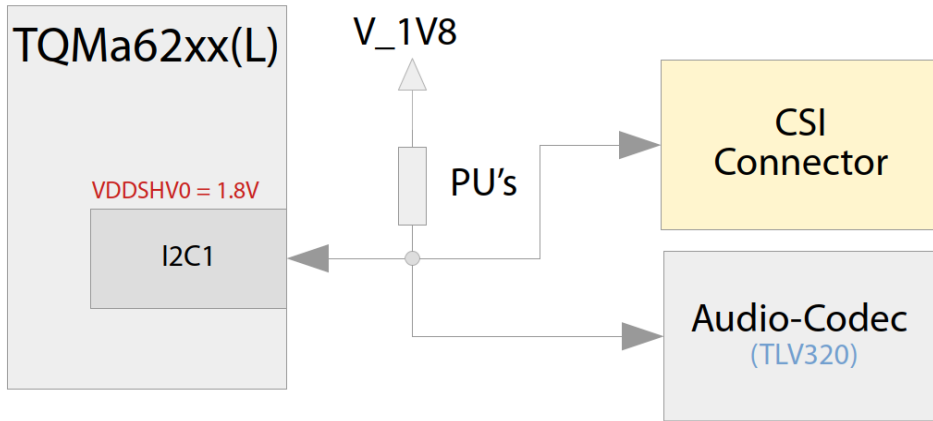
Figure 4:   Block diagram I²C bus of the TQMa62xx module

The following table shows the used addresses of all I²C buses:

Table 4:   I2C1 slave address mapping of the TQMa62xx module

Bus	Component	Address	Note
I2C1	CSI	depends on Usage	X20
	Audio codec	`0x18 / 001 1000b`	

4.1.3   RTC backup supply

For the backup supply of the RTC on the TQMa62xx a lithium battery (3 V coin cell type CR2032) with very low self-discharge is used on the MBa62xx. The TQMa62xx is supplied via pin V_RTC_IN.
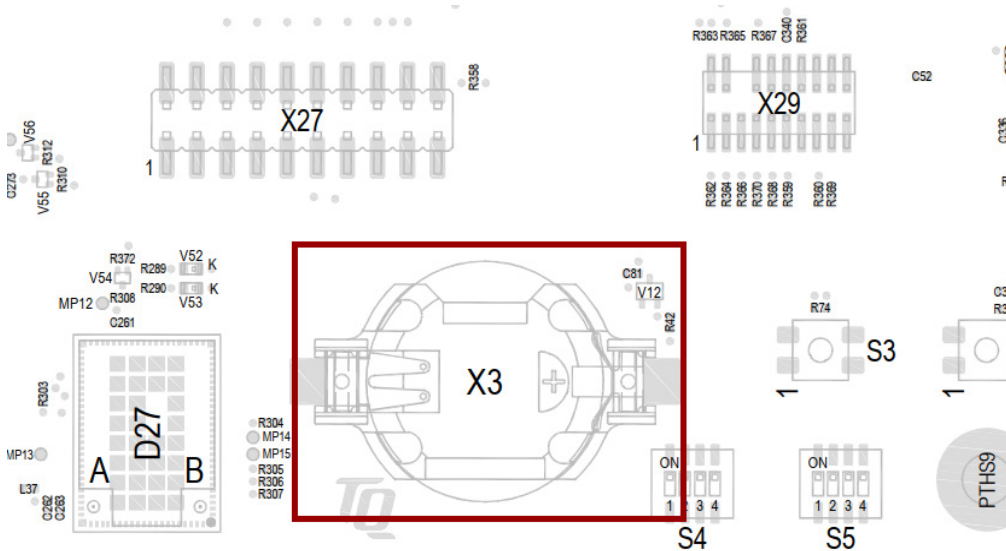
Figure 5: Placement battery holder X3

4.1.4   Reset structure

On the MBa62xx different possibilities are available for a complete or partial reset (periphery) of the module.
The following signals from the TQMa62xx are used on the MBa62xx:

Table 5:   Reset signals

Signal	Type	Level	Description
TQMa62xx_HARD_RST#	I	3.3 V	• Activates power sequencing on module after approx. 200 ms delay (LOW --> HIGH) • Pull-up on module • Connect to GND to activate (e.g. push button)

TQMa62xx_PWRBT#	I	3.3 V	• PMIC Push-Button monitor input:
			   o 600 ms HIGH = ON request
			   o 8 s LOW = OFF request
			 • Pull-up on module

MCU_PORz	I	1.8 V	• Control of a cold reset • Pull-up on module • Connect to GND to activate (e.g. push button)
MCU_RESETz	I	1.8 V	• Control of a warm reset of the MCU domain • Pull-up on module • Connect to GND to activate (e.g. push button)
RESET_REQz	I	1.8 V	• Control of a warm reset of the main domain • Pull-up on module • Connect to GND to activate (e.g. push button)
TRST#	I	1,8 V	• Connects directly to the TRST# of the module • Pull-down on module
PORz_OUT	O	1.8 V	• Status signal for a cold reset of the main domain • Driver on module
MCU_RESETSTATz	O	1.8 V	• Status signal for a warm reset of the MCU domain • Pull-down on module
RESETSTATz	O	1.8 V	• Status signal for a warm reset of the main domain • Pull-down on module
TQMa62xx_PGOOD	O	1.8 V	• Status signal that is used to indicate the power sequencing on the module
GPIOx	O	1.8 V	• Activates RESET of various peripherals on the mainboard • Is controlled by software

Attention: Damage	
⚠	The periphery on the base board should never be supplied before the module, otherwise the module may be damaged. This is ensured by the signal PGOOD.

4.1.5   Power supply

The main supply of the MBa62xx is VIN via connector X5 (Type: CUI INC PJ-102BH) or X6 (Type: Lumberg KRM02), optionally the MBa62xx can be supplied as a powered device via Power Over Ethernet (X14) by a suitable switch (PSE).

Attention: Malfunction	
⚠	The grouping of Power Over Ethernet is PoE+. This means that the MBa62xx is supplied with a maximum of 25 W via PoE+. This means that not all interfaces can be used at the same time.
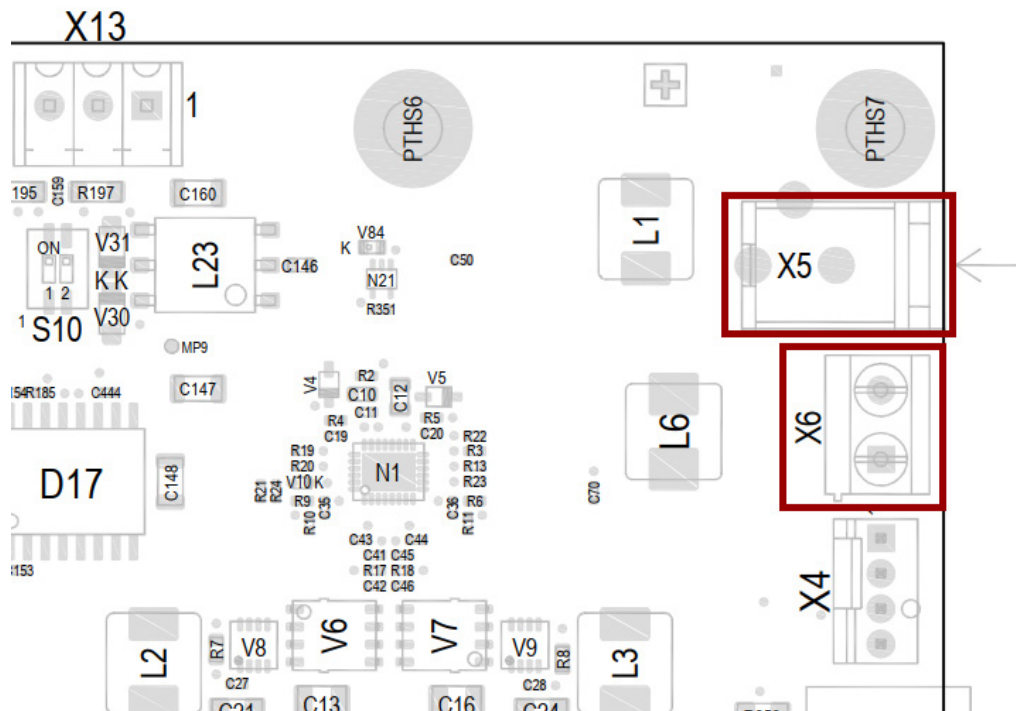
Figure 6: Position X5 and X6

On the MBa62xx there is a two part supply:

- 5V supply
    - Permanently activated as soon as the MBa62xx is supplied
    - Module supply / Reset button / LED
- Remaining Power Supply
    - Supply of the periphery
    - Switched by PGOOD
    - Switched off if PGOOD is not present on the module

The following figure shows all voltage rails on the mainboard. In order to comply with the required power sequencing, the signal PGOOD is used to control the respective rails.
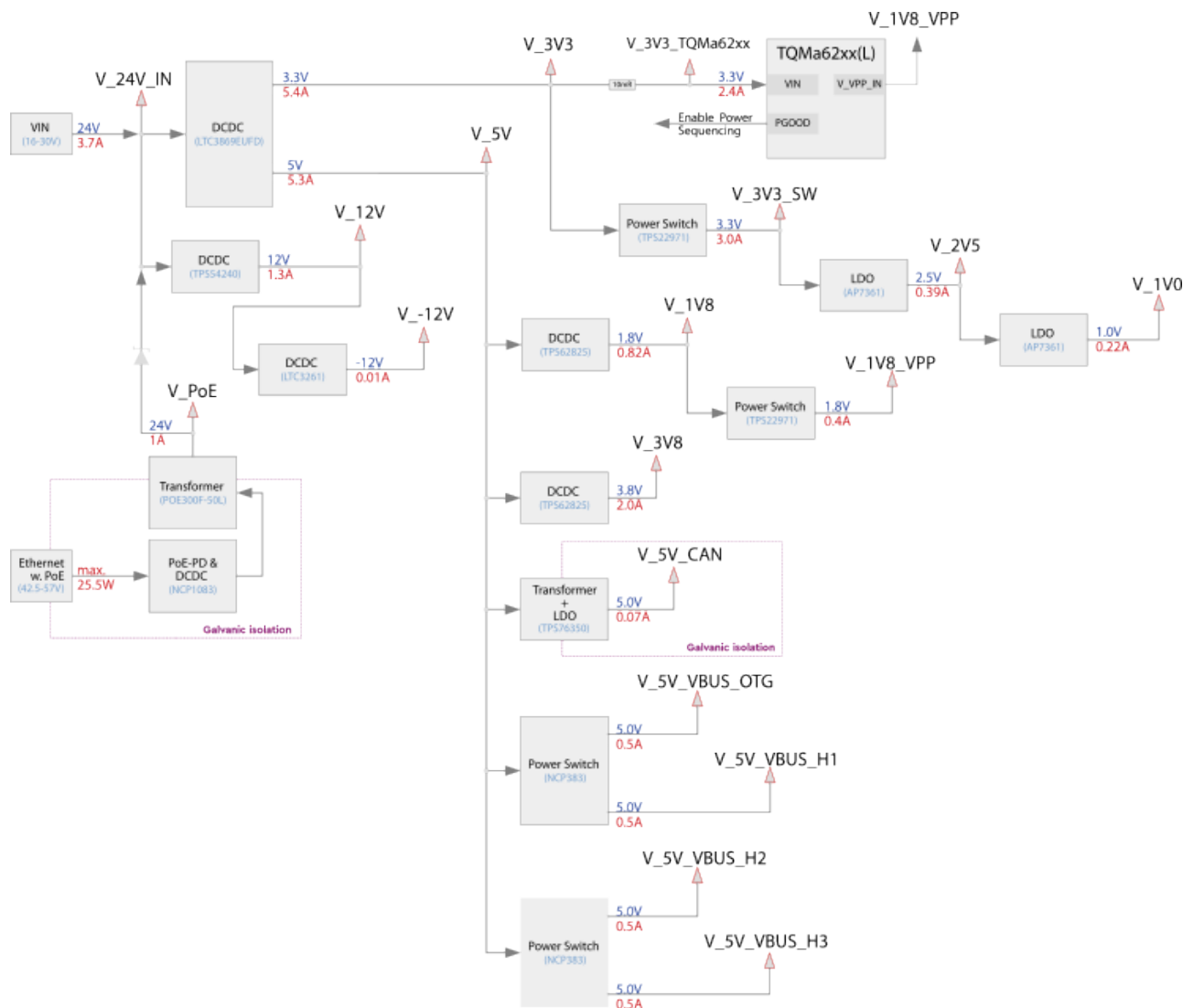
Figure 7:   Block diagram power supply chain

The following protective circuits are implemented for the input voltage of the MBa62xx:

- Fuse 5A, slow blow
- Excess voltage protection diode
- PI filter
- Inverse-polarity protection
- Capacitors for voltage smoothing
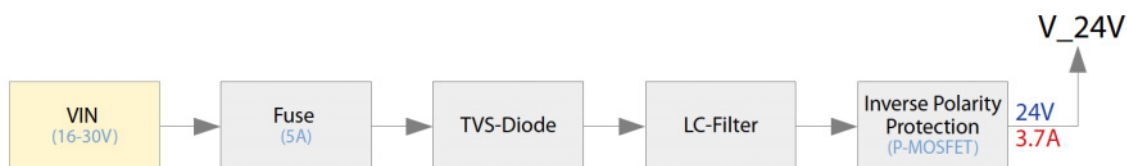
Figure 8: MBa62xx Input circuit

The overvoltage limitation is 31.1 V to 34.4 V.

The mainboard MBa62xx, including TQMa62xx, consumes 86 W under full load (all supply voltages are loaded with maximum current, e.g. by connecting external modules to the pin headers). The power supply used must be selected accordingly. In most applications, however, the power consumption will be significantly lower.

Attention: Overload

⚠️	The internal voltages (3.3 V, 1.8 V) provided at the starter kit pin headers are not additionally protected. Technically, an overload of the fuse is therefore possible. The resulting total current consumption of the MBa62xx should be observed.

Table 6:   Electrical parameters of the supply voltages

Parameter	Min.	Typ.	Max.	Unit	Remark
V_5V0					
Output voltage	4.941	5	5.059	V	
Max. load current			5.3	A	
Current Limit			8.3	A	
V_3V8					
Output voltage	3.756	3.8	3.844	V	
Max. load current			2	A	
Current Limit			3.9	A	
V_3V3					
Output voltage	3.276	3.3	3.354	V	
Max. load current			5.4	A	
Current Limit			7.9	A	
V_3V3_SW					
Output voltage	3.276	3.3	3.354	V	
Max. load current			3.0	A	
Current Limit			3	A	
V_1V8					
Output voltage	1.758	1.8	1.842	V	
Max. load current			0.82	A	
Current Limit			3.9	A	
V_2V5					
Output voltage	2.442	2.5	2.560	V	
Max. load current			0.39	A	
V_1V0					
Output voltage	1.044	1.0	1.076	V	
Max. load current			0.22	A	
V_12V					
Output voltage	11.858	11.995	12.143	V	
Max. load current			1.3	A	
Current Limit			6.1	A	
V_-12V					
Output voltage		-12		V	
Max. load current			0.01	A	
V_5V0_VBUS_OTG / V_USB_Hx_VBUS					
Output voltage		5.0		V	
Max. load current			0.5	A	
Current Limit	0.5			A	
V_1V8_VPP					
Output voltage	1.758	1.8	1.842	V	
Max. load current			0.4	A	
V_5V_CAN					
Output voltage	4.825	5.0	5.175	V	
Max. load current			0.07	A	

The power sequencing of the mainboard MBa62xx is defined as following:
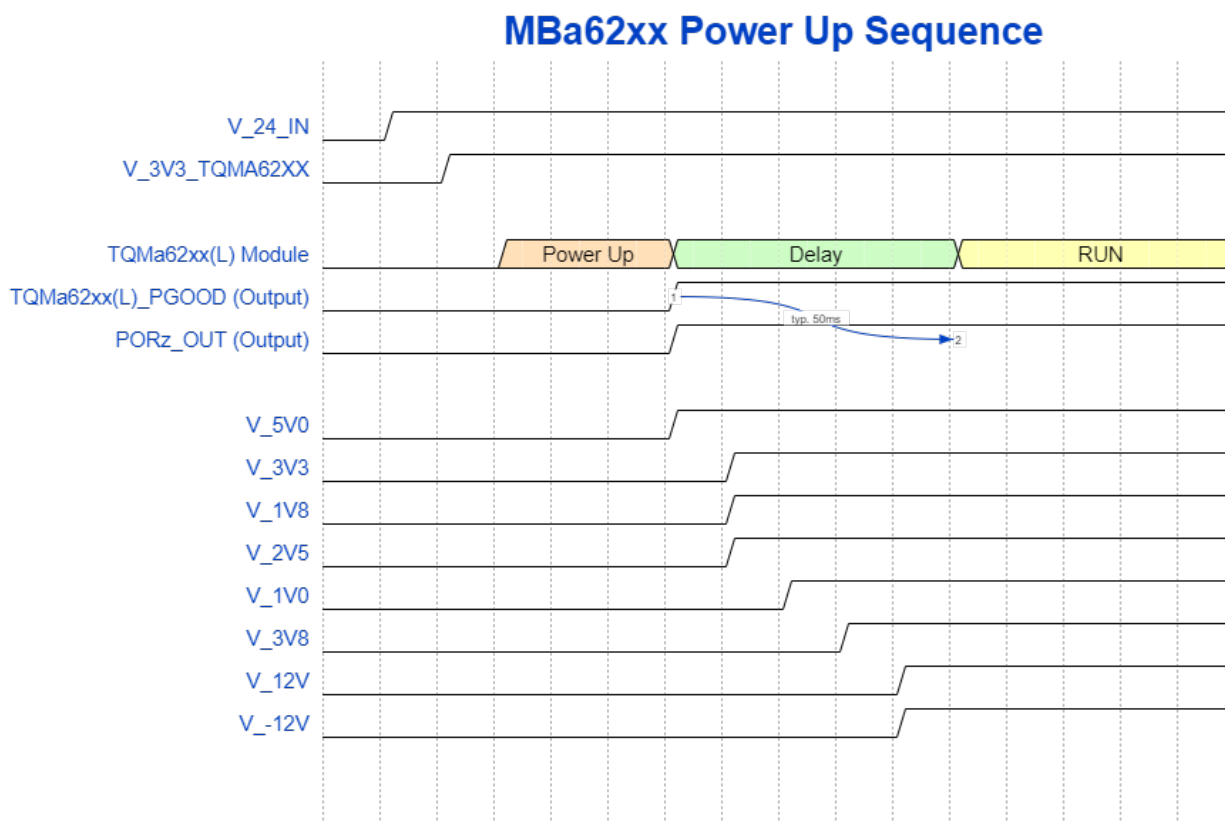
Figure 9: MBa62xx Power up sequenz

- The 3.3 V for the TQMa62xx is permanently on - so "always" ON.
- The TQMa62xx executes the power sequencing independently and returns a PGOOD signal for the MBa62xx.
- As soon as the PGOOD signal is present, the MBa62xx performs the power sequencing independently. The used switching regulators / LDOs are controlled by EN and PGOOD signals.
- The time constant between PGOOD and reset of the CPU is approx. 50 ms.

4.2   Communication interfaces

4.2.1   UART- / Debug-interface

To get debug outputs of the CPU, the UART0 and WKUP_UART0 interface of the CPU is used. The used UART of the CPU is connected to a Micro USB connector (X7) via a USB-to-UART bridge.
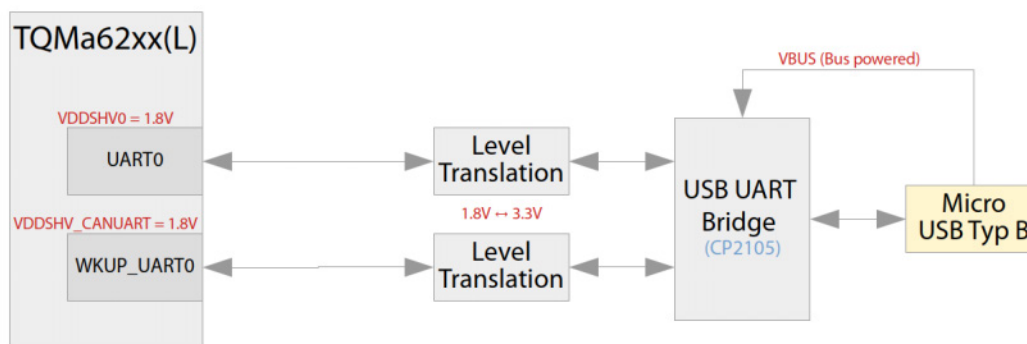
Figure 10:   Block diagram UART- / Debug-interface
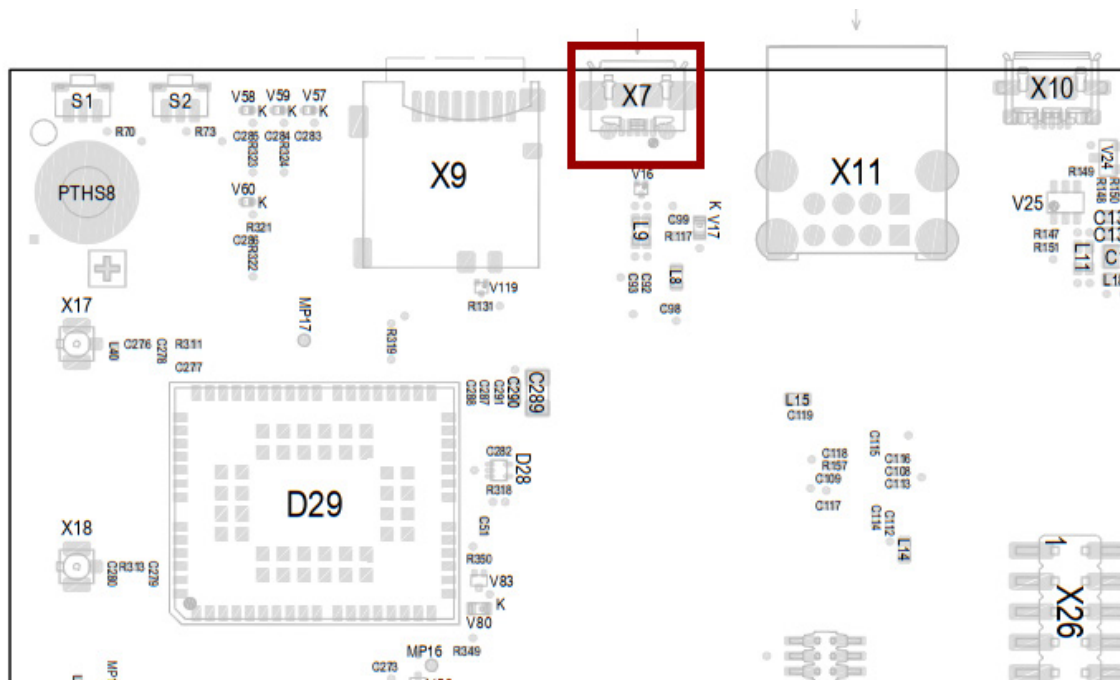
Figure 11:   Position X7

4.2.2   USB interface

4.2.2.1   **USB OTG**

The MBa62xx provides a USB2.0 OTG interface. The USB2.0 interface also serves as boot source (see also chapter 4.3.5).

- Protection circuit for USB0_VBUS according to Reference Manual (1).
- 5V power switch depending on the USB ID (GPIO) pin.
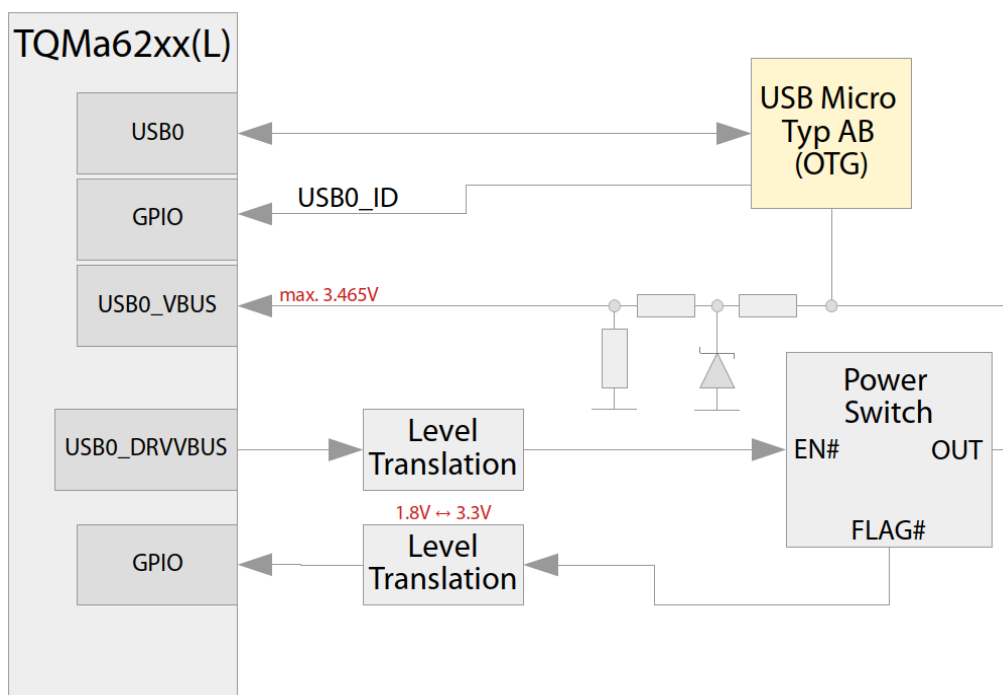
Figure 12:   Block diagram USB OTG interface
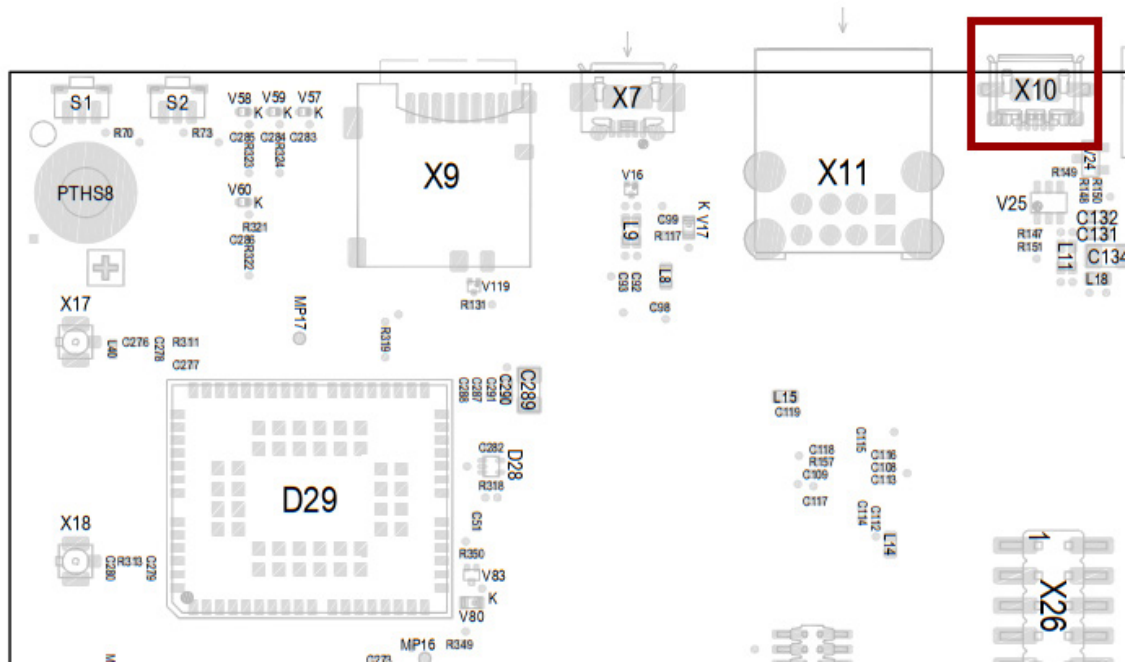
Figure 13:   Position of USB interface

4.2.2.2   USB Hub

The MBa62xx also provides a 4-port USB host via USB1 of the CPU. This results in a double socket (X11) for the use of USB host (e.g. USB stick) as well as the use of the IoT radio module and the LVDS display.

Protective circuit for USB1_VBUS according to Reference Manual (1).
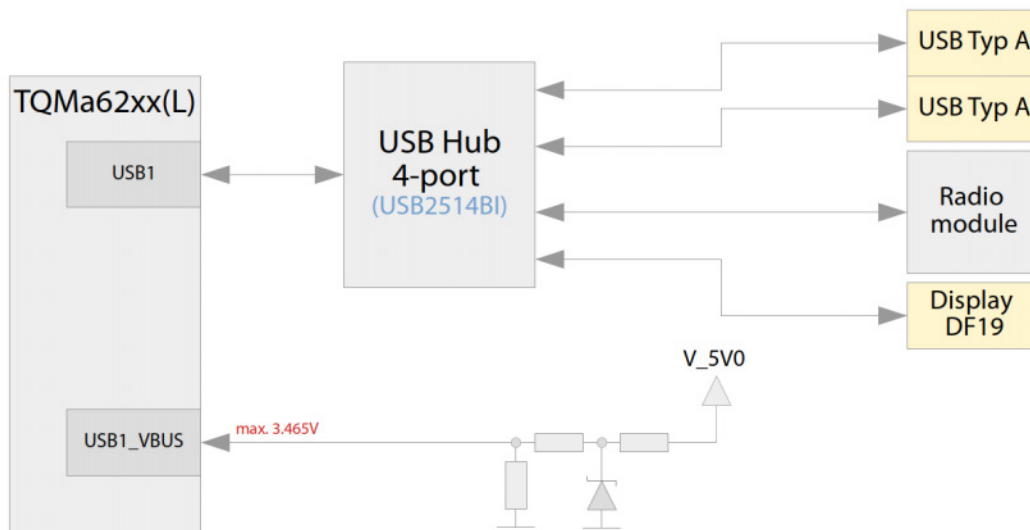
Figure 14:   Block Diagram USB hub
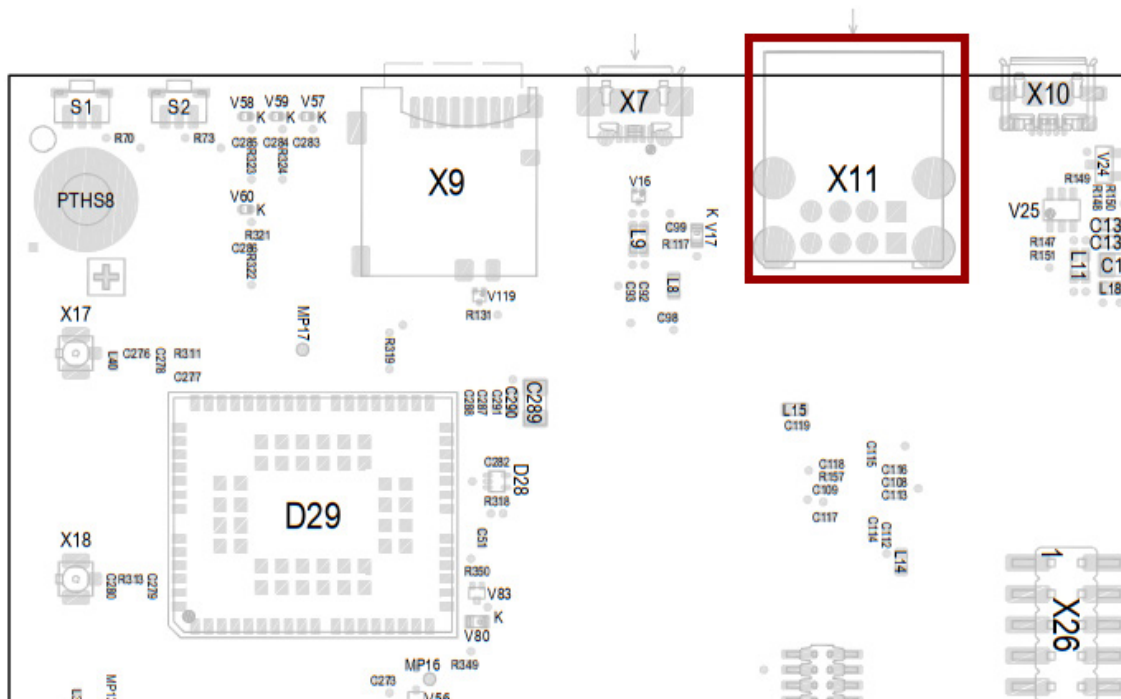
Figure 15:   Position USB, X11

4.2.3   Ethernet interface

There are two Ethernet interfaces on the MBa62xx. The PHY DP83867ISRZGZ from TI is used for all interfaces. The PHY supports IEEE 802.3 10BASE-Te,100BASE-TX, and 1000BASE-T. The following interfaces are used:

- RGMII1 at connector X14
  - With additional PoE+ function to supply the mainboard
- RGMII at connector X15
-
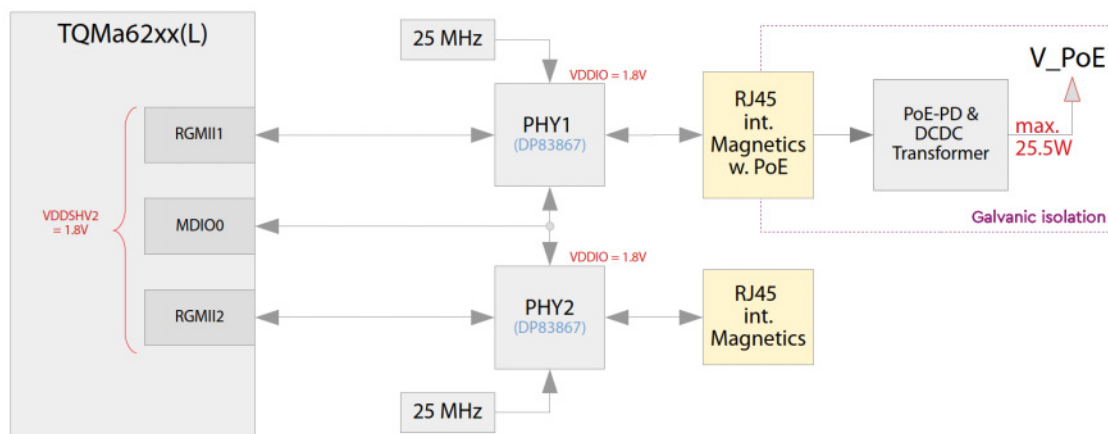
Figure 16:   Block diagram Ethernet interface

Figure 17:   Position of X14 and X15

4.2.4   LVDS

The OLDI interface (OLDI0) of the TQMa62xx is provided with the two single-link Open LVDS Display Interface (4 lanes + 1 clock per channel) on the MBa62xx at connector X21 and X22.

Figure 18:   Block diagram LVDS

The selection of the connectors (Type: Hirose DF19G-30P-1H(52) and Hirose DF19G-20P-1H(52)) and the pin assignment correspond to the TQ-specific specifications for the uniform design of the interface, which ensures the connection of dedicated LVDS displays.

Table 7:   LVDS pinout X21

Pin	Signal	Type	Level	Note
1	OLDI0_A0N	O	1.8 V	OLDI0-Interface 1 (Lane 0)
2	OLDI0_A0P	O	1.8 V	
3	OLDI0_A1N	O	1.8 V	OLDI0-Interface 1 (Lane 1)
4	OLDI0_A1P	O	1.8 V	
5	OLDI0_A2N	O	1.8 V	OLDI0-Interface 1 (Lane 2)
6	OLDI0_A2P	O	1.8 V	
7	DGND	P	0 V	Ground
8	OLDI0_CLK0N	O	1.8 V	OLDI0-Interface 1 (Clock)
9	OLDI0_CLK0P	O	1.8 V	
10	OLDI0_A3N	O	1.8 V	OLDI0-Interface 1 (Lane 3)
11	OLDI0_A3P	O	1.8 V	
12	OLDI0_A4N	O	1.8 V	OLDI0-Interface 2 (Lane 0)
13	OLDI0_A4P	O	1.8 V	
14	DGND	P	0 V	Ground
15	OLDI0_A5N	O	1.8 V	OLDI0-Interface 2 (Lane 1)
16	OLDI0_A5P	O	1.8 V	
17	DGND	P	0 V	Ground
18	OLDI0_A6N	O	1.8 V	OLDI0-Interface 2 (Lane 2)
19	OLDI0_A6P	O	1.8 V	
20	OLDI0_CLK1N	O	1.8 V	OLDI0-Interface 2 (Clock)
21	OLDI0_CLK1P	O	1.8 V	
22	OLDI0_A7N	O	1.8 V	OLDI0-Interface 2 (Lane 3)
23	OLDI0_A7P	O	1.8 V	
24	DGND	P	0 V	Ground
25	V_5V_LVDS0	P	5 V	5 V supply voltage (filtered from V_5V0)
26	V_5V_LVDS0	P	5 V	
27	V_5V_LVDS0	P	5 V	
28	V_3V3_LVDS0	P	3.3 V	3.3 V supply voltage (filtered from V_3V3_SW)
29	V_3V3_LVDS0	P	3.3 V	
30	V_3V3_LVDS0	P	3.3 V	
M1, M2	DGND	P	0 V	Ground

Table 8:   LVDS pinout X22)

Pin	Signal	Type	Level	Note
1	V_12V	P	12 V	12 V supply voltage (filtered)
2	V_12V	P	12 V	
3	V_12V	P	12 V	
4	DGND	P	0 V	Ground
5	DGND	P	0 V	
6	DGND	P	0 V	
7	V_5V0	P	5 V	5 V supply voltage
8	V_5V0	P	5 V	
9	DGND	P	0 V	Ground
10	DGND	P	0 V	
11	V_USB_H4_VBUS	P	5 V	VBUS voltage USB Host 4 (filtered)
12	DGND	P	0 V	Ground
13	USB_H4_DN	I/O	3.3 V	Data lines USB Host 4
14	USB_H4_DP	I/O	3.3 V	
15	DGND	P	0 V	Ground
16	LVDS0_RESET#	O	1.8 V	Reset (GPIO0_36), Pulldown on MBa62xx
17	LVDS0_BLT_EN	O	1.8 V	Backlight-Enable (GPIO0_38), Pulldown on MBa62xx
18	LVDS0_PWR_EN	O	1.8 V	Power-Enable (GPIO0_61), Pulldown on MBa62xx
19	LVDS0_PWM	O	1.8 V	PWM for contrast/brightness adjustment (EHRPWM1_B
20	DGND	P	0 V	Ground
M1, M2	DGND	P	0 V	
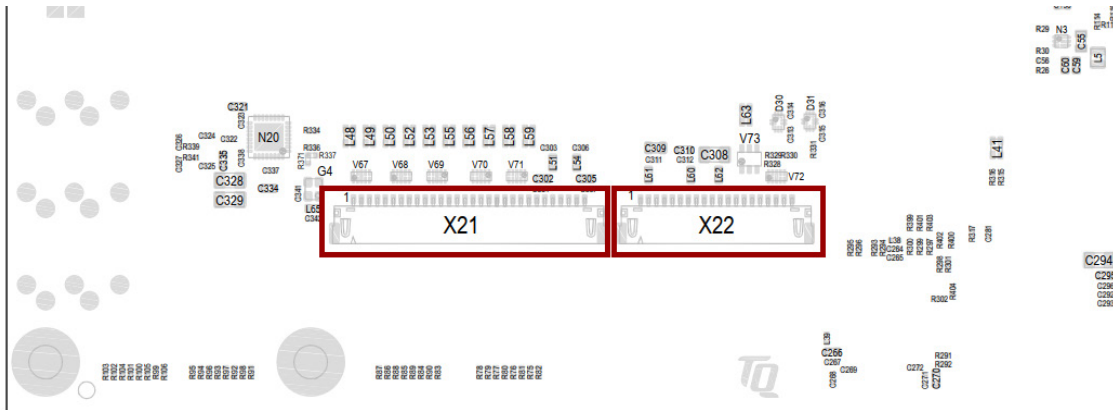
Figure 19:   Position X21 and X22

4.2.5   MIPI-CSI

The Camera Serial Interface (CSI) of the TQMa62xx and TQMa62xxL is available with 4 lanes on the MBa62xx at connector X20.
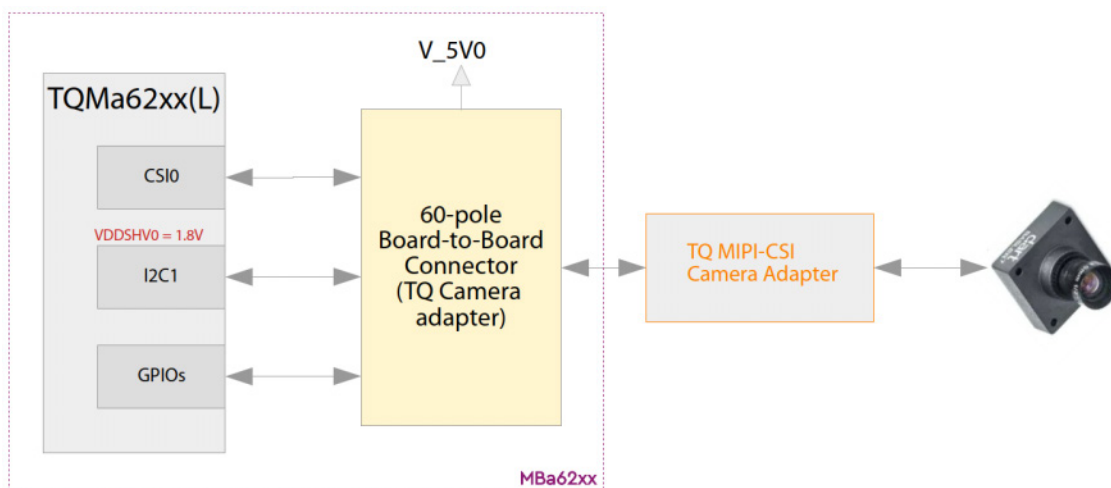
Figure 20:   Block diagram MIPI-CSI interface

The selection of the connector (Type: TE 5177986-2) and the pin assignment correspond to the TQ-specific specifications for the uniform design of the interface which enables the connection of the TQ camera adapter. The camera adapter enables the connection of dedicated cameras.

Table 9: MIPI-CSI pinout X20

Pin	Signal	Type	Level	Note
1	DGND	P	0 V	Ground
2	DGND	P	0 V	
3	MIPI_CSI0_EN	O	1.8 V	CSI-Enable, Pull-down on MBa62xx
4	NC	-	-	Not connected
5	MIPI_CSI0_RST#	O	1.8 V	Reset, Pull-down on MBa62xx
6	NC	-	-	Not connected
7	MIPI_CSI0_TRIGGER	I	1.8 V	General Purpose Input (e.g.: Trigger input)
8	NC	-	-	Not connected
9	MIPI_CSI0_SYNC	I	1.8 V	General Purpose Input (e.g.: Sync input)
10	NC	-	-	Not connected
11	NC	-	-	
12	NC	-	-	
13	DGND	P	0 V	Ground
14	DGND	P	0 V	
15	CSI0_RXN3	I	1.8 V	CSI interface (Lane 3)
16	NC	-	-	Not connected
17	CSI0_RXP3	I	1.8 V	CSI interface (Lane 3)
18	NC	-	-	Not connected
19	DGND	P	0 V	Ground
20	DGND	P	0 V	
21	CSI0_RXN2	I	1.8 V	CSI interface (Lane 2)
22	NC	-	-	Not connected
23	CSI0_RXP2	I	1.8 V	CSI interface (Lane 2)
24	NC	-	-	Not connected
25	DGND	P	0 V	Ground
26	DGND	P	0 V	
27	CSI0_RXN1	I	1.8 V	CSI interface (Lane 1)
28	NC	-	-	Not connected
29	CSI0_RXP1	I	1.8 V	CSI interface (Lane 1)
30	NC	-	-	Not connected
31	DGND	P	0 V	Ground
32	DGND	P	0 V	
33	CSI0_RXN0	I	1.8 V	CSI interface (Lane 0)
34	NC	-	-	Not connected
35	CSI0_RXP0	I	1.8 V	CSI interface (Lane 0)
36	NC	-	-	Not connected
37	DGND	P	0 V	Ground
38	DGND	P	0 V	
39	CSI0_RXCLKN	I	1.8 V	CSI interface (Clock)
40	NC	-	-	Not connected
41	CSI0_RXCLKP	I	1.8 V	CSI interface (Clock)
42	NC	-	-	Not connected
43	DGND	P	0 V	Ground
44	DGND	P	0 V	
45	I2C1_SDA	I/O	1.8 V	Data for I2C configuration interface
46	NC	-	-	Not connected
47	I2C1_SCL	O	1.8 V	Clock for I2C configuration interface
48	NC	-	-	Not connected
49	DGND	P	0 V	Ground
50	NC	-	-	Not connected
51	EHRPWM1_A	O	1,8 V	Master clock (PWM signal of AM62x)
52	NC	-	-	Not connected
53	DGND	P	0 V	Ground
54	DGND	P	0 V	
55	NC	-	-	Not connected
56	V_5V0	P	5 V	5 V supply voltage (filtered from V_5V)
57	NC	-	-	Not connected
58	V_5V0	P	5 V	5 V supply voltage (filtered from V_5V)
59	NC	-	-	Not connected
60	V_5V0	P	5 V	5 V supply voltage (filtered from V_5V)
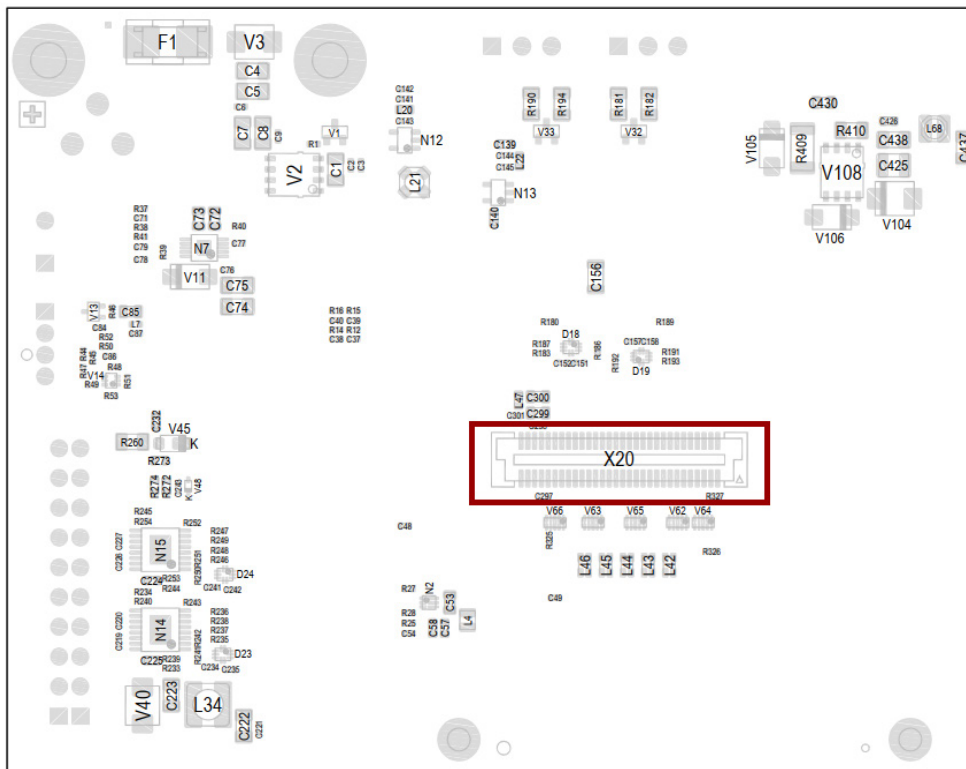
Figure 21:   Position X20

4.2.6   CAN

Two CAN interfaces are implemented on MBa62xx according to the ISO 11898 standard. The signals are each provided on a 3-pin socket X12 and X13 (Type: Phoenix Contact MCV 1,5/ 3-G-3,5).
Both interfaces are galvanically isolated with an isolation voltage of 1 kV, but not from each other.
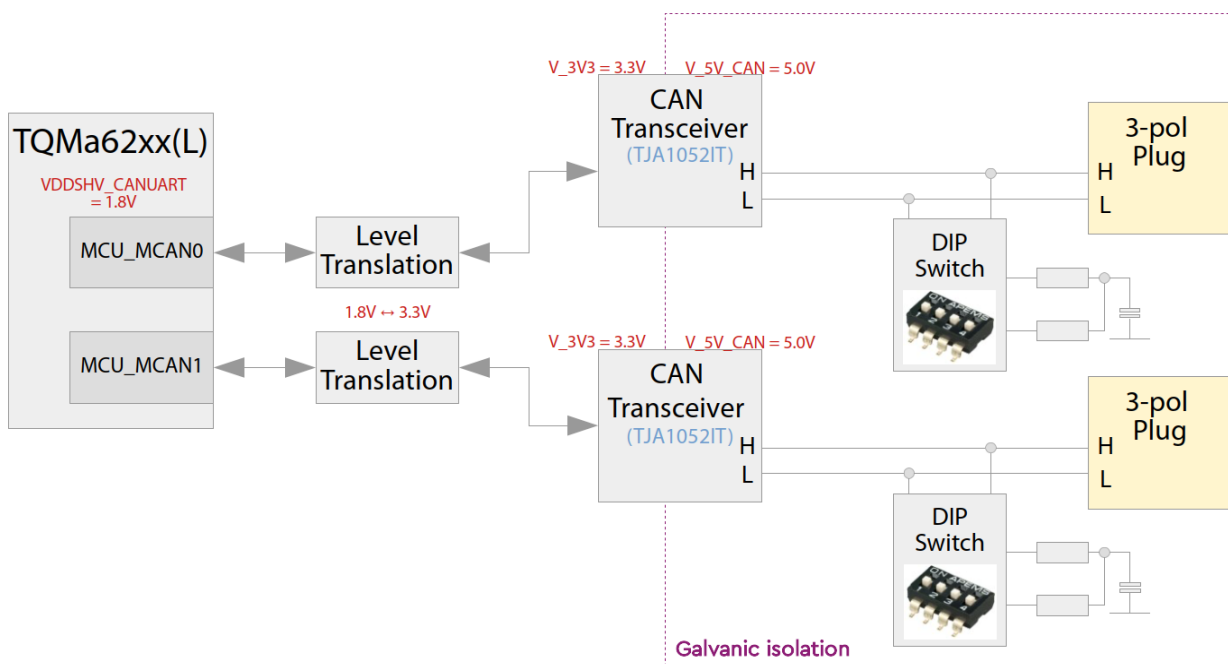
Figure 22:   Block diagram CAN

The following tables show the pin assignment of the CAN connectors and the DIP switch for the 120 Ω CAN signal termination:

Table 10: CAN0 pinout (X12)

Pin	Pin name	Signal	I/O	Note
1	CAN_H	CAN0_H	I/O	galvanically isolated
2	CAN_L	CAN0_L	I/O	galvanically isolated
3	DGND	DGND_CAN	P	galvanically isolated

Table 11: CAN1 pinout (X13)

Pin	Pin name	Signal	I/O	Note
1	CAN_H	CAN1_H	I/O	galvanically isolated
2	CAN_L	CAN1_L	I/O	galvanically isolated
3	DGND	DGND_CAN	P	galvanically isolated

Table 12: CAN termination

DIP-Switch	Interface	ON	OFF
S9	CAN0	Termination CAN0 with 120 Ω	No termination CAN0
S10	CAN1	Termination CAN1 with 120 Ω	No termination CAN1
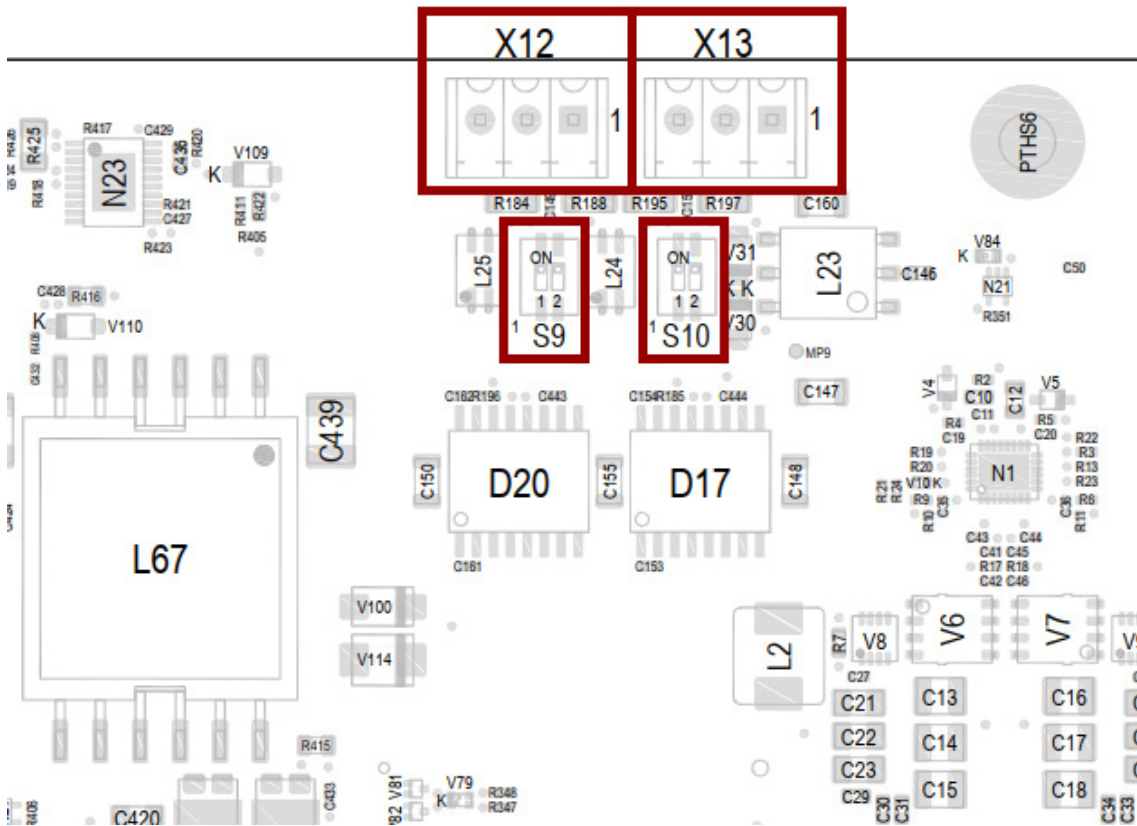
Figure 23: Position of CAN connectors and DIP switch

4.2.7   RS485

On the MBa62xx a RS485 interface on connector X8 (Type: Phoenix Contact MC1,5/2-G-3,5) with automatic direction switching is realized, which allows the use of Profibus. The direction switching is done via GPIO.

Figure 24:   Block diagram RS485

Figure 25:   Position of RS485, X8

4.2.8   WLAN module

A WiFi module SPB228-D from H&D Wireless is integrated on the MBa62xx:

- IEEE 802.11 a/b/g/n/ac (2.4 GHz, 5 GHz) - Dual band
  - 20/40/80 MHz bandwidth (PHY data rate 866.7 Mbps)
  - Dynamic Rapid Channel Switching (DRCS) on two different channels 2.4 GHz / 5 GHz
  - Co-Existance is supported
- Interfaces
  - WiFi: SDIO via MMC2
  - Wireless mobile: UART via UART2
- The WLAN module has two antenna connectors (u.FL sockets)

Figure 26:   Block diagram WLAN module
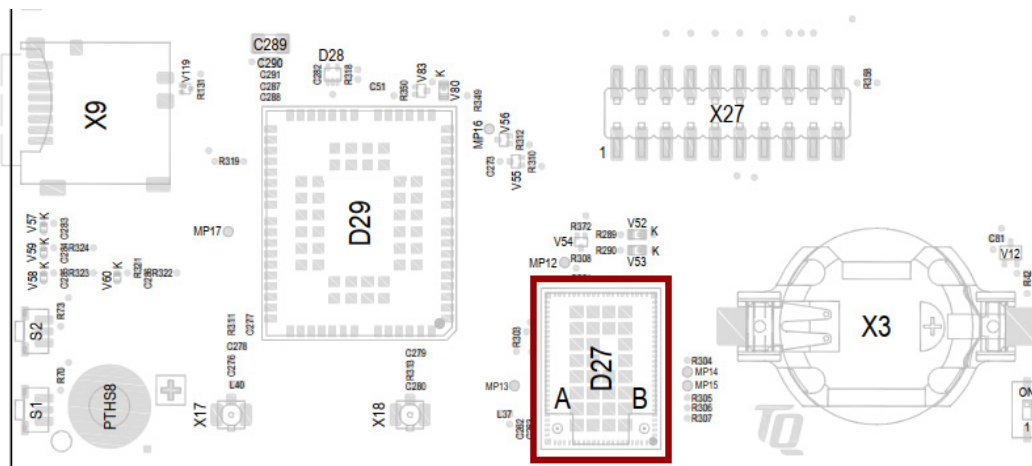
Figure 27:   Position WLAN module and antenna sockets ANT1 and ANT2

4.2.9   IoT radio module + SIM card

Quectel's BG95-M4 IoT radio module provides NB-IoT and GNSS functionality on the MBa62xx:

- LTE: CAT M1 (max. 588 DL / 1119 UL), CAT NB2 (max. 127 DL / 158.5 UL)
- VoLTE for CAT M1 (planned by Quectel)
- GNSS: GPS, GLONLASS, BeiDou, Galileo, QZSS
- 2 antenna ports
- 1 Micro-SIM connector:
    o 1.8V type
    o Card Detect available
- The USB port serves as the main communication and is connected to USB_H3.
- Optional the MAIN_UART is connected to UART5.
- Optional the GNSS_UART is connected to UART1.
- The control signals can be controlled via GPIOs of the TQMa62xx.
- NET_STATUS_LED:
    o Flicker slow (200 ms / 1800 ms) – Network searching
    o Flicker slow (1800 ms / 200 ms) – Idle
    o Flicker Quick (125 ms / 125 ms) – Data transfer
    o Always High – Voice call
- BG95_STATUS: HIGH when module is on
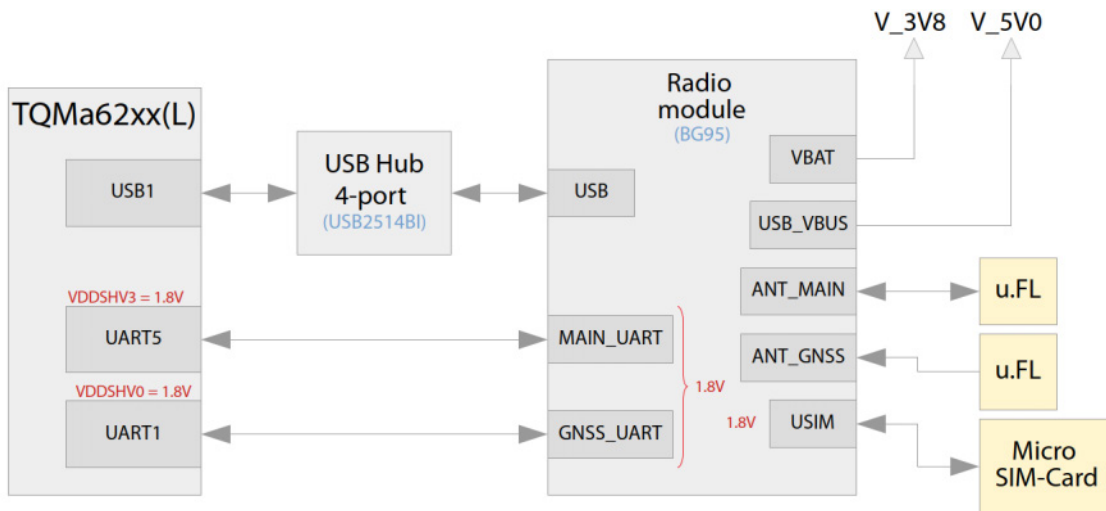
Figure 28:   Block diagram IoT radio module

Figure 29:   Position IoT radio module + u.FL + Micro-SIM card port
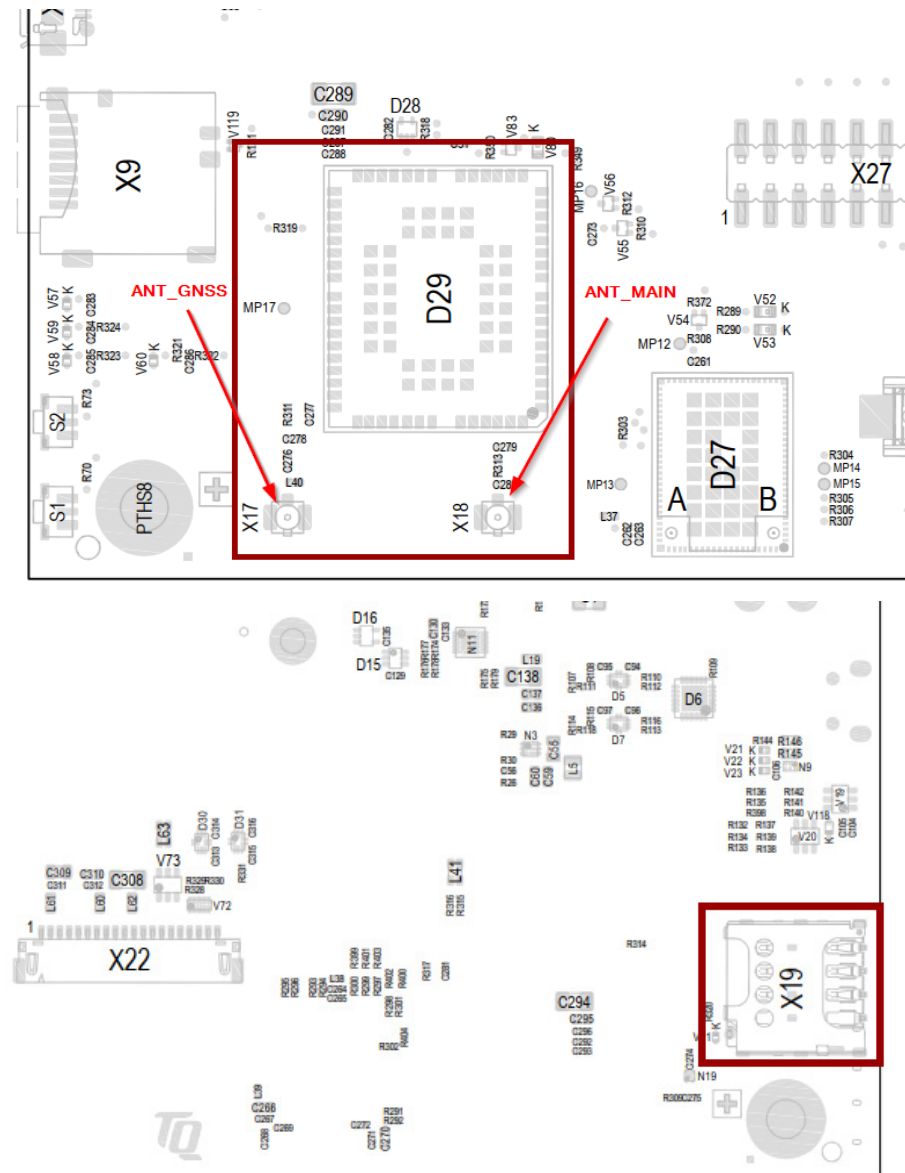
4.2.10   SD card

On the MBa62xx a SDIO (MMC1) interface of the CPU is implemented for a SD card connection (connector X9):

- MMC1 interface with 4 bit bus width

- Module provides an adapted supply voltage VDDSHV5 (1.8 V / 3.3 V) depending on the mode

- VDDSHV5 can be used for pull-up supply

- Power switch (3.3 V) provided for SD card supply

    o   Power Cycle at PORz_OUT and RESETSTATz or via GPIO (MMC1_SD_EN)
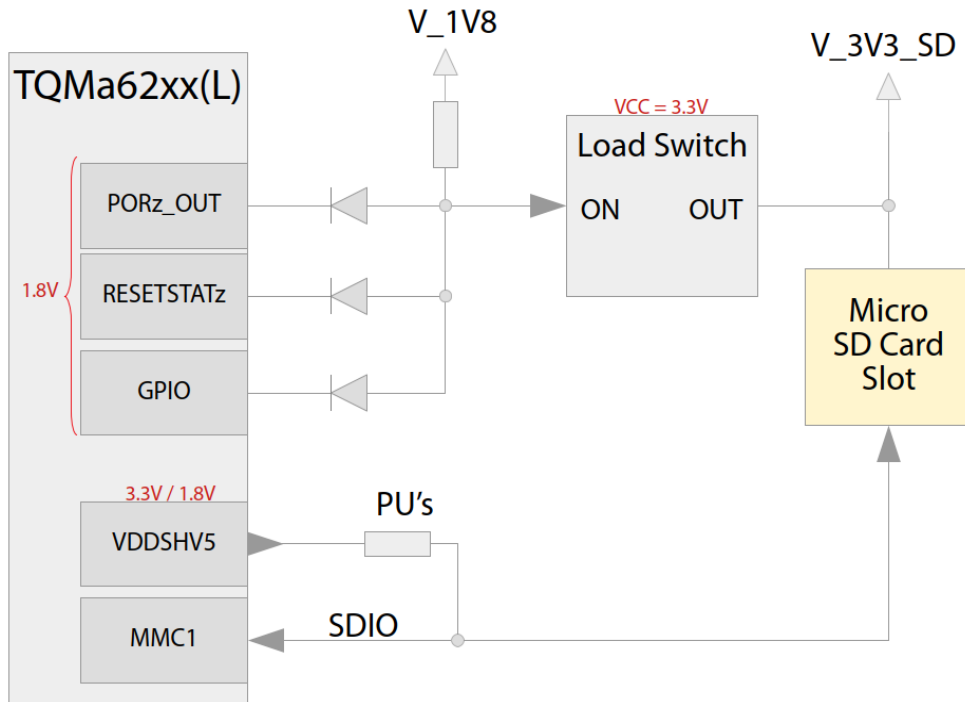
Figure 30:   Block diagram SD card slot, X3

Figure 31:   Position SD-Card, X9
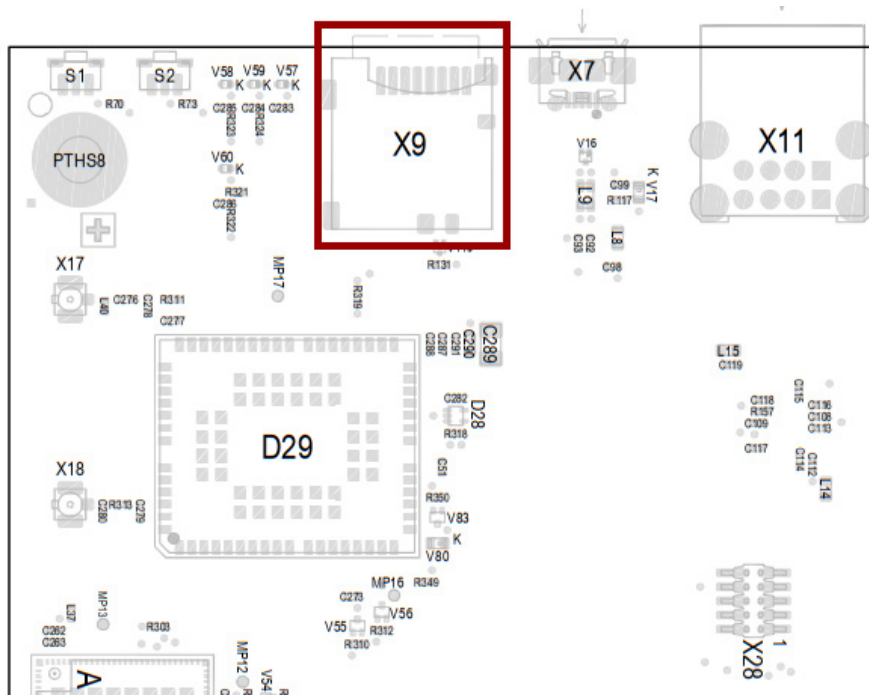
4.2.11　PRU

To use a part of the PRU interface from the TQMa62xx, signals of the PR0 Interface were led to the pin header X27. The IO logic of the interface is 1.8V.

4.2.12　JTAG interface

The JTAG signals of the CPU are provided on the 20-pin header X29.
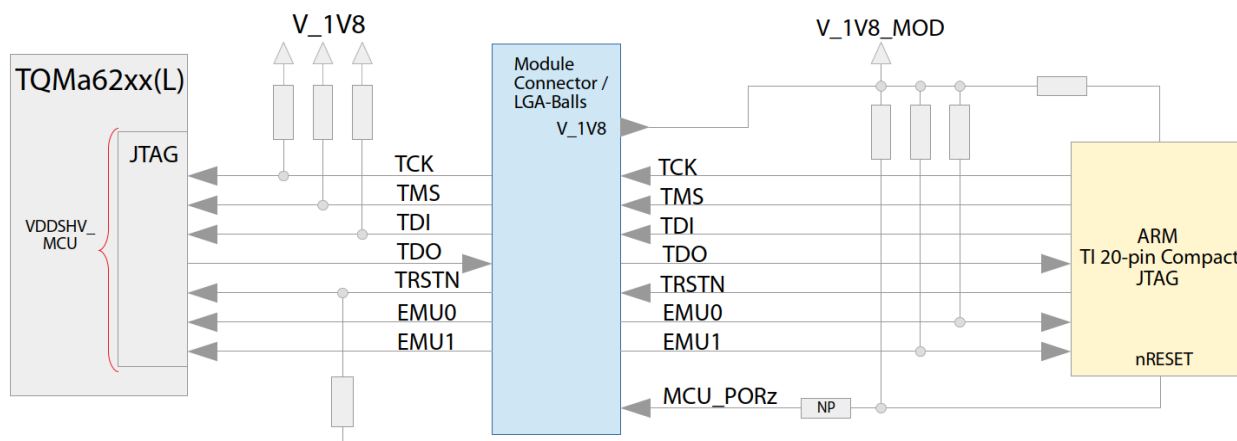
Figure 32:　　　　Block diagram JTAG

Table 13: JTAG signals

Signal / Multiplexing	I/O	Power group	Note
TCK	I		10 kΩ Pull-Up on module
TDI	I		10 kΩ Pull-Up on module
TDO	O	VDDSHV_MCU (1.8 V)	
TMS	I		10 kΩ Pull-Up on module
TRST#	I		4.7 kΩ Pull-Up on module
EMU[1:0]	IO		Optional signals, not required for JTAG

Table 14: Pinout JTAG interface X29 (Segger TI-CTI-20 Adapter)

Signal	Pin	Pin	Signal
TMS	1	2	TRST
TDI	3	4	GND
VTref	5		NC (Key)
TDO	7	8	GND
RTCK	9	10	GND
TCK	11	12	GND
EMU0	13	14	EMU1
NSRST	15	16	GND
NC	17	18	NC
NC	19	20	GND

Figure 33:   Position of JTAG, X29

4.3   Audio

The MBa62xx provides one microphone, line-in and line-out interface each. The signals can be tapped via 3.5 mm jack sockets, which are provided by an audio code via SAI and I2C interfaces by the TQMa62xx.

Figure 34:   Block diagram audio interface

Optionally, the line-out interface can also be configured as a headphone output. Further details can be found in the following table:

Table 15: Placement ootions for audio interface

Mode	R340	R342	R343	R344	Note
Headphone	n.p.	n.p.	0R	0R	
Line-out	0R	0R	n.p.	n.p.	Default option

4.4   Analog Frontend

For the processing of analog inputs, an 8-channel analog frontend is available on the MBa62xx at connector X30 (Type: Phoenix DMC 1,5/ 8-G1F-3,5-LR P20THR).

- 24 V compatible
- Data rates: 7.5 SPS - 288 kSPS, Simultaneous 50 Hz / 60 Hz line rejection, ENOB: 17-bit at 72 kSPS
- High accuracy of data evaluation: ±0.01% (at room temperature)
- Temperature sensor
- Up to 30 MHz SPI interface
- Calibration and diagnostic capabilities
- Analog inputs
  - o   Input AI1P/N can be used for current measurement by changing the configuration.
  - o   Input AI3P/N and AI4P/N can be used as differential inputs by changing of placement.
- GPIO0 and GPIO1 are used as analog inputs
- Communication via SPI0
- Voltage converter for all signals from / to TQMa62xx
- Analog inputs available at X30
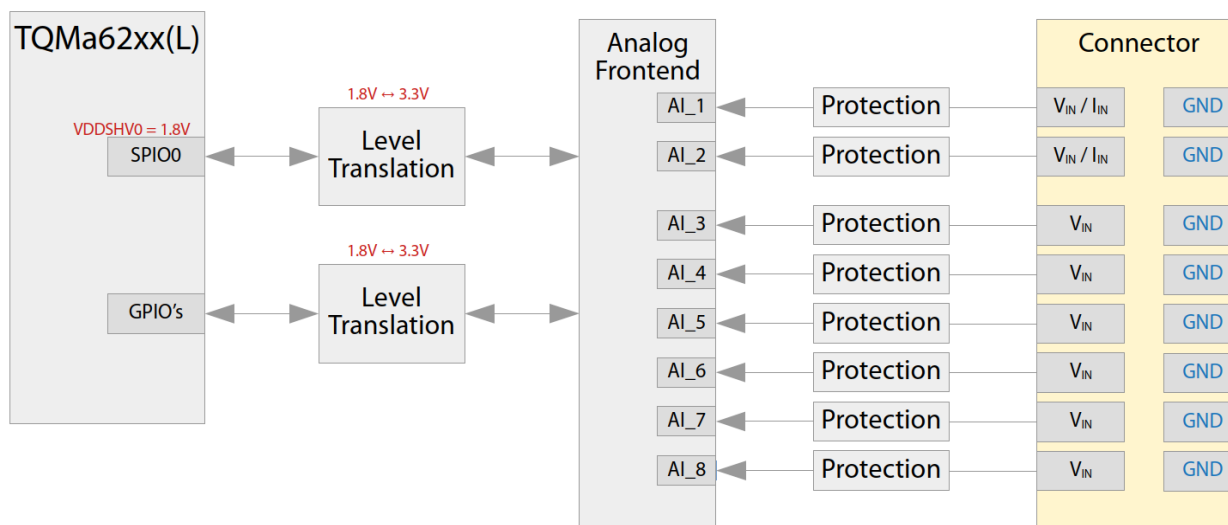
Figure 35:   Block diagram Analog Frontend

The following tables show the pin assignment of the Analog Frontend at X30:

Table 16: Pinout X30

Pin	Signal	I/O	Note
1A	AI1P	I	Can be used for current measurement with AI1N by changing the placement
1B	DGND	P	
2A	AI1N	I	Can be used for current measurement with AI1P by changing the placement
2B	DGND	P	
3A	AI2P	I	
3B	DGND	P	
4A	AI2N	I	
4B	DGND	P	
5A	AI3P	I	Can be used as differential inputs with AI3N by changing the placement
5B	DGND	P	
6A	AI3N	I	Can be used as differential inputs with AI3P by changing the placement
6B	DGND	P	
7A	AI4P	I	Can be used as differential inputs with AI4N by changing the placement
7B	DGND	P	
8A	AI4N	I	Can be used as differential inputs with AI4P by changing the placement
8B	DGND	P	

Figure 36:   Position X30

Measurement options:

• Standard circuit for voltage and current measurement:
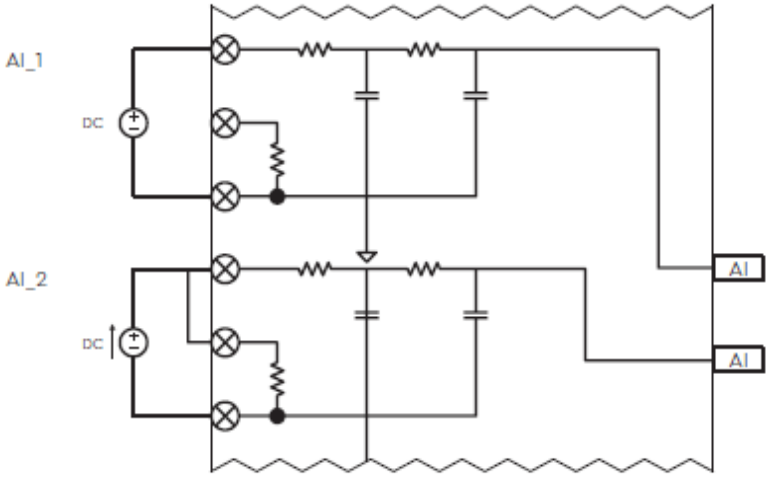
Figure 37:   Analogue interface voltage-current measurement

• Standard voltage measurement:
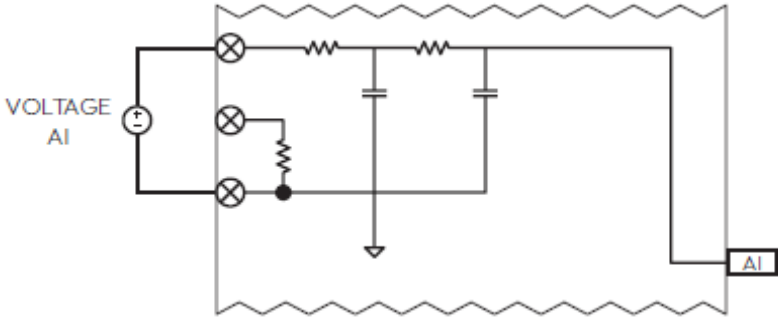
Figure 38:   Analogue interface voltage

• RTD measurement (resistance thermometer). AFE can provide current source:
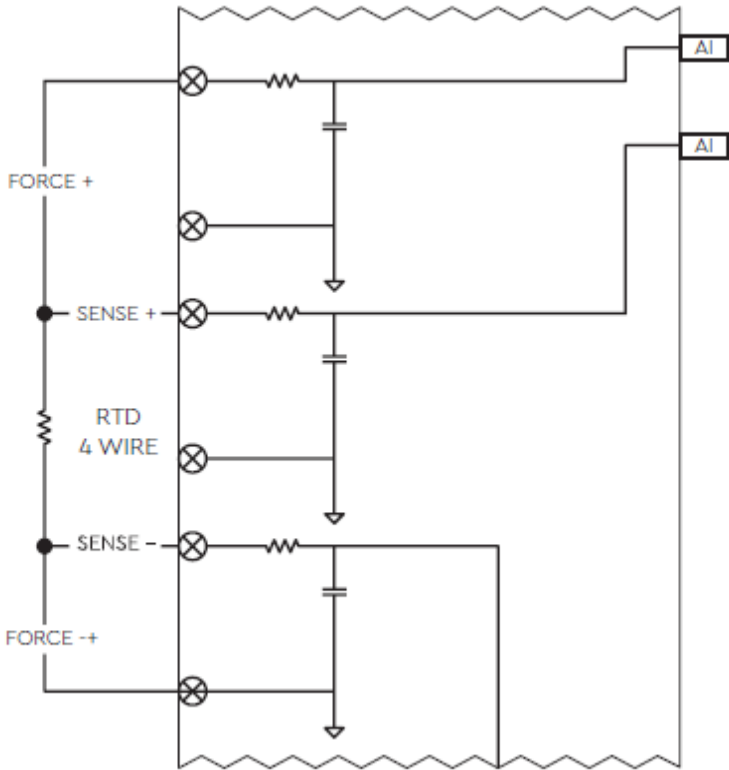
Figure 39:   Analogue interface RTD measurement

• TC measurement (thermocouple) via differential measurement:
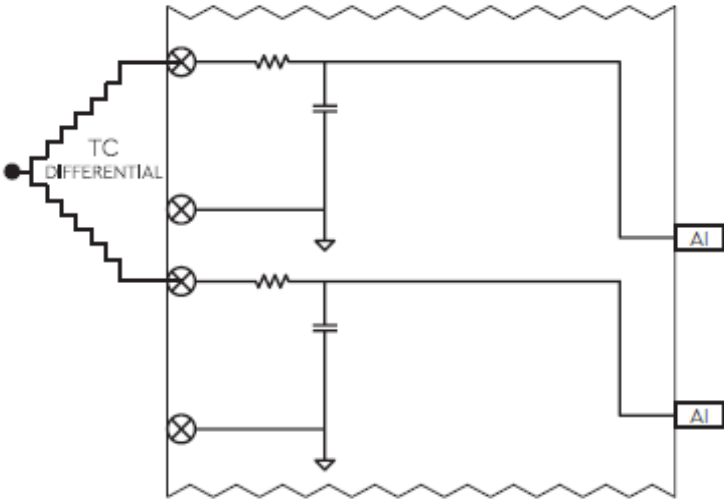
Figure 40:   Analogue interface TC measurement

4.4.1 Digital IOs

The MBa62xx provides four digital inputs and outputs each, which are 24 V compatible, at connector X16.
- The digital outputs are switched via high-side switches. The input voltage V_24V_IN or an external voltage V_24V_HSS_IN (default) can be switched.
- The power switches are controlled via GPIOs of the CPU.
- The digital inputs are connected to the TQMa62xx via protection circuit and comparators.
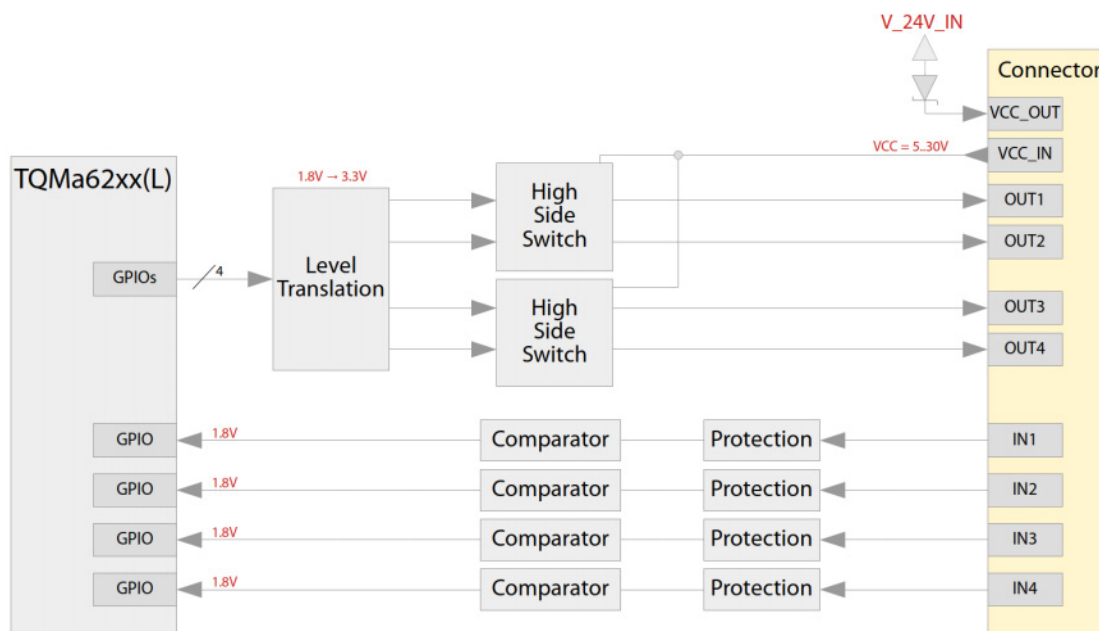
Figure 41:   Block diagram Digital IOs

The following tables show the pin assignment of the digital IOs at X16:

Table 17: Pinout Digital IOs, X16

Pin	Signal	I/O	Note
1A	V_24_IN	I	Is the mainboard input voltage, which can be used as a loop for V_24V_HSS_IN to supply the high-side switches.
1B	DGND	P	
2A	V_24_V_HSS_IN	I	Serves to supply the high-side switches.
2B	DGND	P	
3A	DIG_OUT_1	O	
3B	DGND	P	
4A	DIG_OUT_2	O	
4B	DGND	P	
5A	DIG_OUT_3	O	
5B	DGND	P	
6A	DIG_OUT_4	O	
6B	DGND	P	
7A	DIG_IN_1	I	
7B	DGND	P	
8A	DIG_IN_2	I	
8B	DGND	P	
9A	DIG_IN_3	I	
9B	DGND	P	
10A	DIG_IN_4	I	
10B	DGND	P	

Figure 42:   Position X16

A suitable mating connector for X16 is the DFMC 1,5/10-STF-3,5 from Phoenix.

4.4.2   Headers X26, X27, X28

Control signals, GPIOs or factory test signals are routed to pin headers as follows:

- GPIOs at X27
- SEC interface at X28
- Control signals at X26 and X27
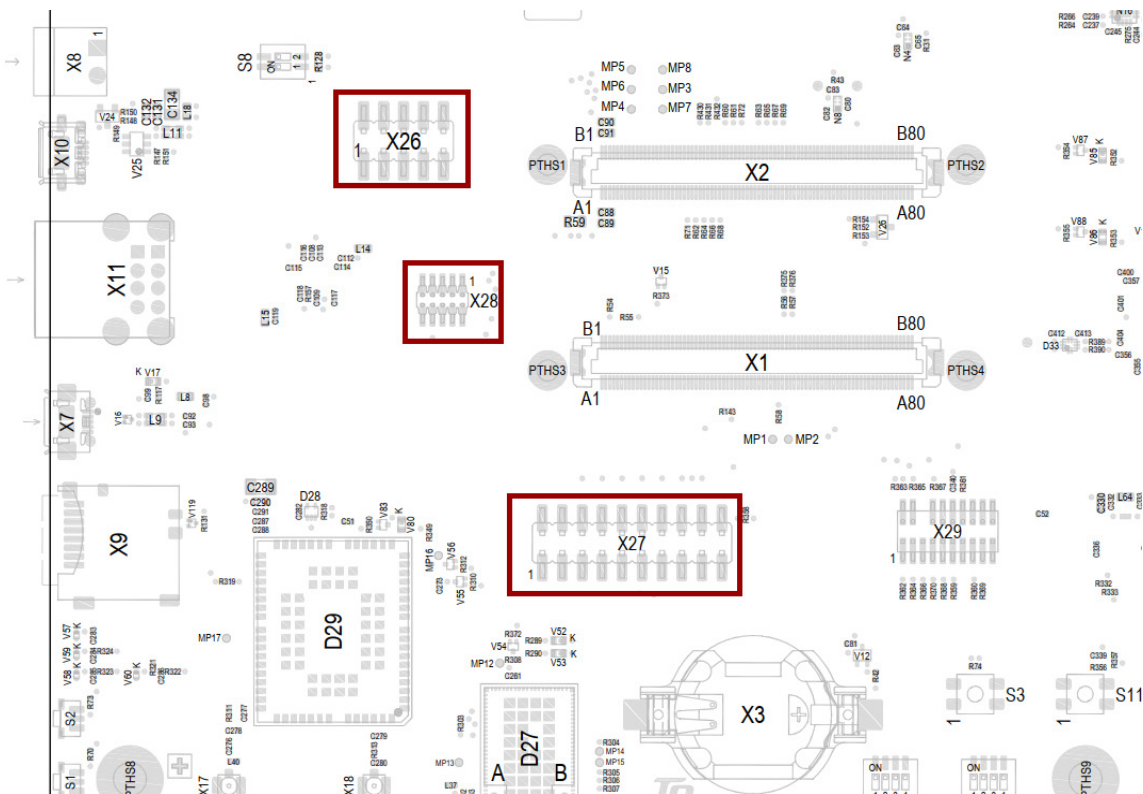
Figure 43:   Position of headers X26, X27, X28

Table 18:   Pinout header X26

Pin	Signal	I/O	Note
1	TQMa62xx_HARD_RST#	I	
2	V_1V8	P	
3	MCU_PORz	I	
4	PORz_OUT	O	
5	MCU_RESETz	I	
6	MCU_RESETSTATz	O	
7	RESET_REQz	I	
8	RESETSTATz	O	
9	TQ_EEPROM_WC#	I	Data EEPROM (Do not connect)
10	DGND	P	

Table 19:   Pinout header X27

Pin	Signal	I/O	Note
1	V_3V3_SW	P	
2	V_1V8	P	
3	DGND	P	
4	DGND	P	
5	PR0_UART0_TXD	I/O	GPIO
6	PR0_PRU0_GPO2	I/O	GPIO
7	PR0_UART0_RXD	I/O	GPIO
8	PR0_PRU0_GPO3	I/O	GPIO
9	PR0_PRU1_GPI2	I/O	GPIO
10	PR0_PRU0_GPO4	I/O	GPIO
11	PR0_PRU1_GPI3	I/O	GPIO
12	PR0_PRU0_GPO5	I/O	GPIO
13	PR0_PRU1_GPI4	I/O	GPIO
14	RTC_CLKOUT	O	
15	PR0_PRU1_GPI5	I/O	GPIO
16	RTC_INT#	O	GPIO
17	CUST_EEPROM_WC#	I	
18	TEMP_ALERT	O	
19	TQMa62xx_PGOOD	O	
20	MCU_SAFETY_ERROR#	I/O	

Table 20: Pinout header X28

Pin	Signal	I/O	Note
1	V_3V3_SW	P	
2	V_1V8	P	
3	SE_7816_IO1	I/O	
4	SE_14443_LA	I/O	
5	SE_7816_IO2	I/O	
6	SE_14443_LB	I/O	1.8 V IO logic
7	SE_7816_CLK	I	
8	SE_ENA	I	
9	SE_7816_RST#	I	
10	DGND	P	

4.5　Diagnosis- and user interfaces

4.5.1　Diagnosis LEDs

The MBa62xx provides the following status LEDs to indicate the system condition:

Table 21:　　Status LEDs

Reference	Description	Control signal	Colour
V76	TQMa62xx PGOOD	TQMa62xx _PGOOD	Green / Red
V79	MBa62xx PGOOD	PGOOD_V_12V	Green / Red
V84	Power X5 / X6	V_24V_IN	Blue
V115	Power X14	V_PoE	Orange
V85	User LED 1	USER_LED_1 (GPIO0_41)	Green
V86	User LED 2	USER_LED_2 (GPIO0_42)	Yellow
V80	Net status of IoT radio module	BG95_NET_STATUS	Green
X14 / X15	Activity / Link LED (Ethernet)	PHY LED signal	Green / Yellow
V17	USB Debug Self-Power (5V)	5 V Input of X2	Blue
V52	WLAN Active	SPB228_LED_WLAN#	Green
V53	Wireless mobile active	SPB228_LED_BT#	Green
V117	Analog Frontend Status	GPIO9_AFE	Green

4.5.2　Navigation button

A navigation button (user button) is available to the user on the MBa62xx.
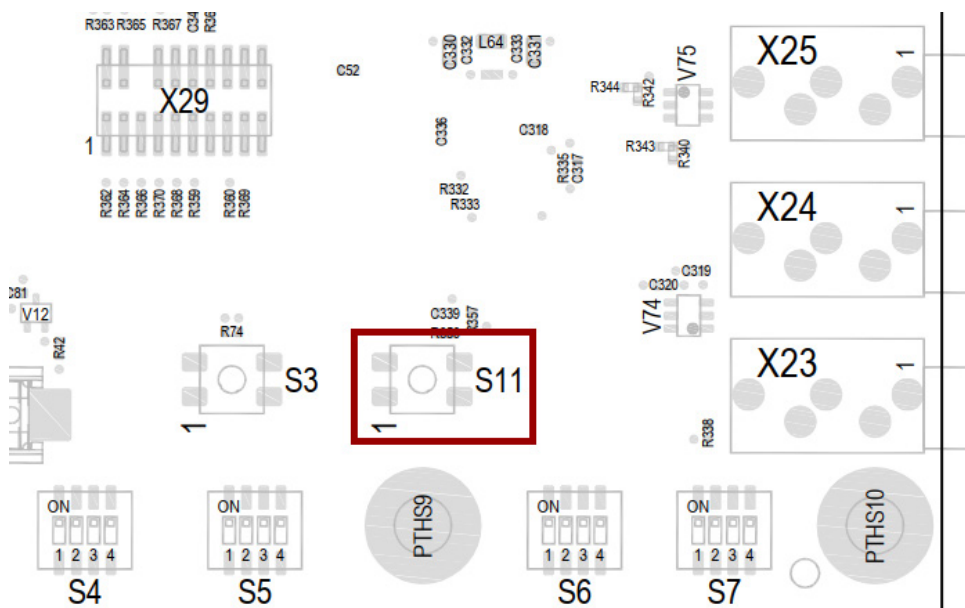
Figure 44:　　　　Position of navigation buttons S11

4.5.3   Reset buttons

Two reset buttons are available to the user on the MBa62xx.

Table 22: Reset buttons

Reference	Description	Control signal
S1	PMIC Push-Button monitor input	TQMa62xx_PWRBT#
S2	Activates the power sequencing on the module	TQMa62xx_HARD_RST#
S3	Cold reset	MCU_PORz
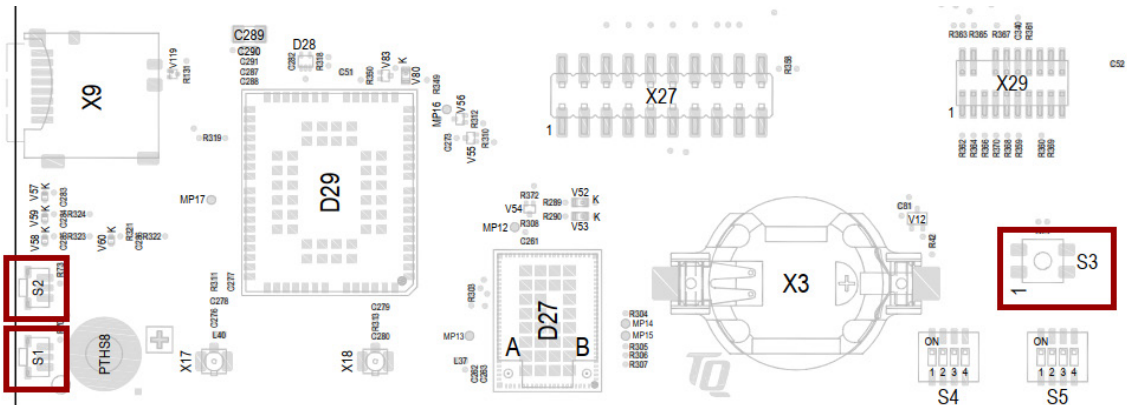
Figure 45:   Position Reset buttons S1 / S2 / S3

4.5.4   Boot-Mode configuration

The MBa62xx supports the following boot sources of the TQMa62xx:

- eMMC Flash (internal to module)
- QSPI-NOR flash (internal to module)
- UART (external host) via Debug-USB (X7)
- USB slave (USB boot from external host) via USB-OTG (X10)
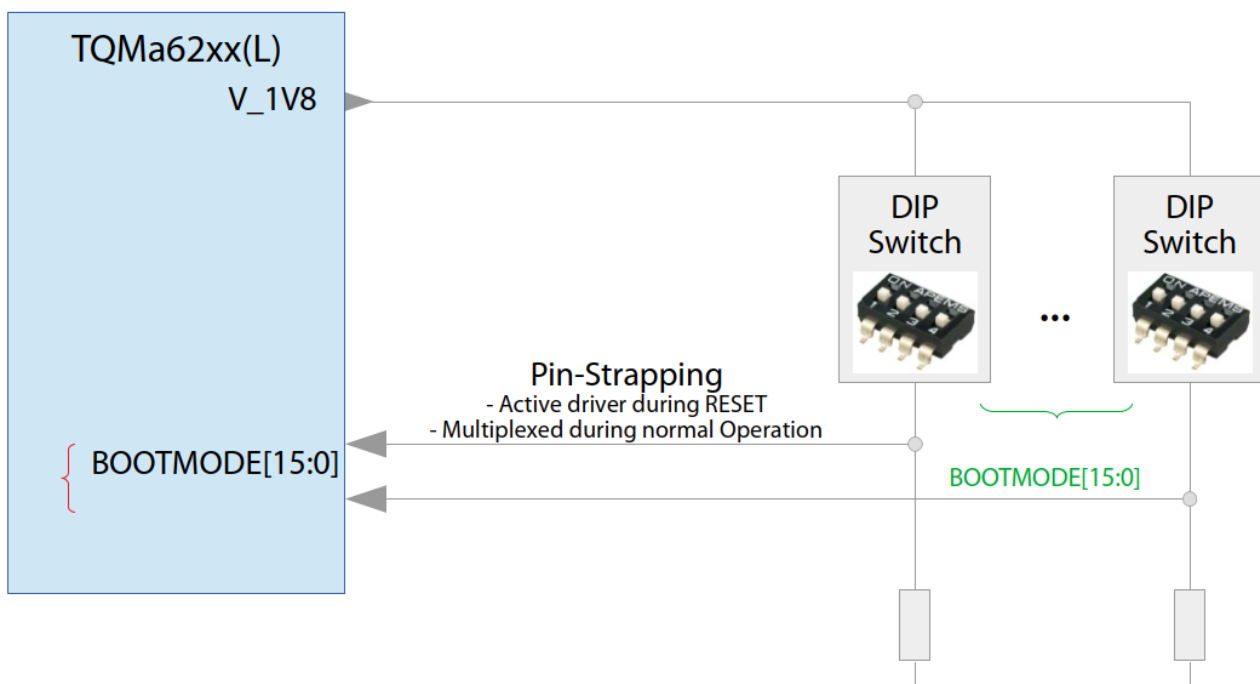
Figure 46:   Block diagram boot source

The boot source is selected via the corresponding boot strap pins which can be set via DIP switches. The following table shows the settings of the DIP switch configuration.

Table 23: Boot mode configuration

DIP-Switch		Signal	eMMC	QSPI-NOR	SD-Card	UART	USB
S4	1	BOOTMODE00	ON	ON	ON	ON	ON
	2	BOOTMODE01	ON	ON	ON	ON	ON
	3	BOOTMODE02	OFF	OFF	OFF	OFF	OFF
	4	BOOTMODE03	OFF	ON	OFF	ON	OFF
S5	1	BOOTMODE04	OFF	ON	OFF	ON	ON
	2	BOOTMODE05	OFF	OFF	OFF	ON	OFF
	3	BOOTMODE06	ON	OFF	ON	OFF	ON
	4	BOOTMODE07	OFF	OFF	OFF	Don't care	OFF
S6	1	BOOTMODE08	OFF	ON	OFF	Don't care	OFF
	2	BOOTMODE09	OFF	Don't care	ON	Don't care	OFF
	3	BOOTMODE10	Don't care	Don't care	Don't care	Don't care	Don't care
	4	BOOTMODE11	Don't care	Don't care	Don't care	Don't care	Don't care
S7	1	BOOTMODE12	Don't care	Don't care	Don't care	Don't care	Don't care
	2	BOOTMODE13	Don't care	Don't care	Don't care	Don't care	Don't care
	3	BOOTMODE14	OFF	OFF	OFF	OFF	OFF
	4	BOOTMODE15	OFF	OFF	OFF	OFF	OFF
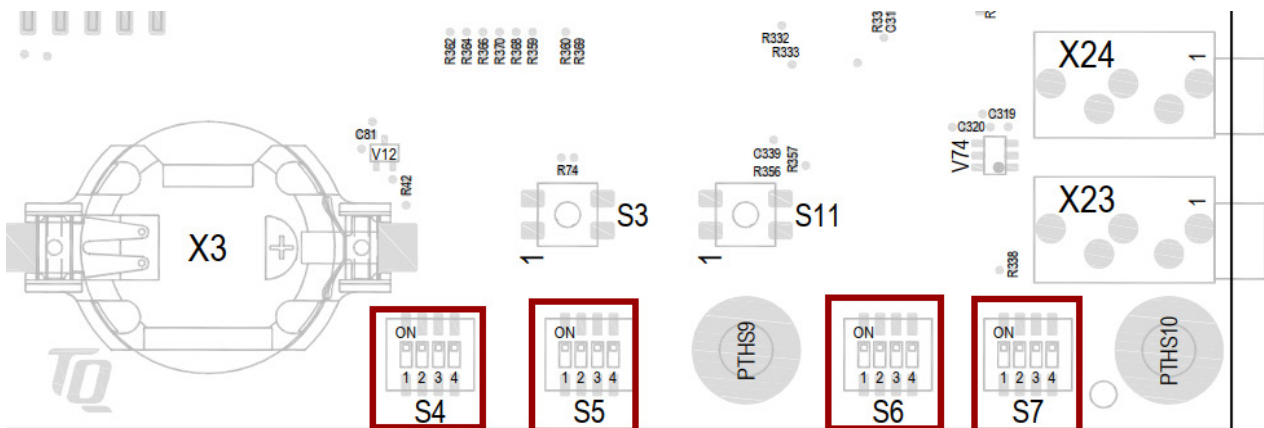
Figure 47:   Placement DIP switches for boot source

5.   SOFTWARE

No software is required for the MBa62xx.

Suitable software is only required on the module TQMa62xx and is not a part of this specification.

More information can be found in the Support Wiki for the TQMa62xx.

6.   MECHANICS

6.1   Dimensions

The MBa62xx has overall dimensions (length × width) of 170 mm × 170 mm (± 0.1 mm).

There are holes for 6 housing fixings with 4.2 mm Ø each and 4 holes with 2.7 mm Ø each for heat sink fixings.

6.2   Thermal management

Depending on the application, the power consumption of the CPU makes it necessary to ensure a cooling of the CPU. For this a 4-pin connector X4 (Type: Molex 47053-1000) is provided on the MBa62xx for a standard fan. For more information, please refer to the TQMa62xx User's Manual.
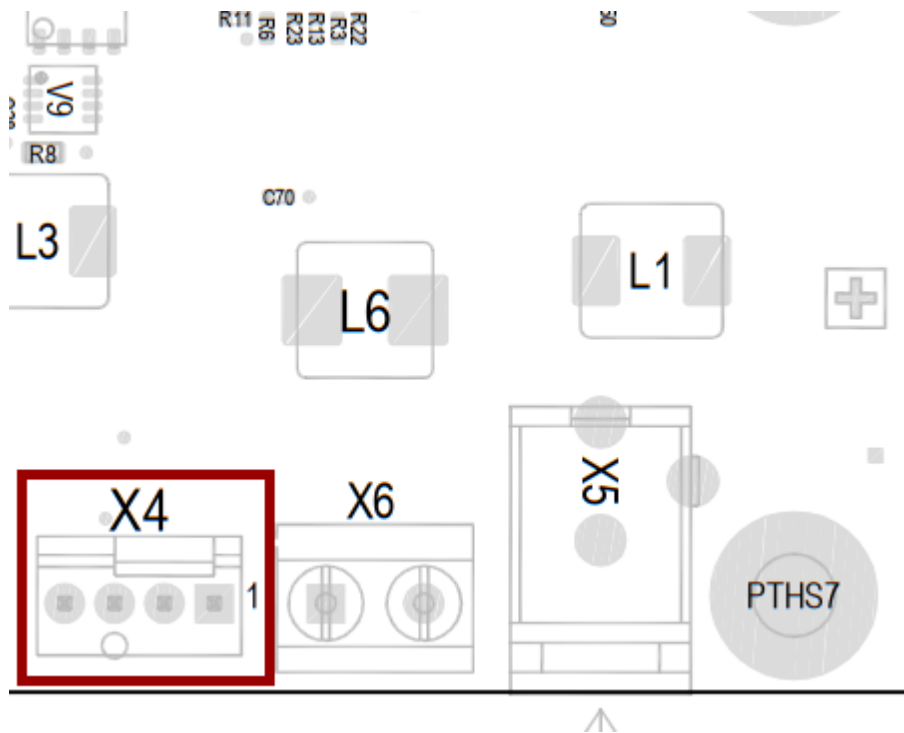
Figure 48:   Position X4

Table 24: Pinout X33

Pin	Signal	Note
1	DGND	
2	V_FAN	Imax: 100 mA @ 12 V
3	FAN_RPM	
4	FAN_PWM	

6.3   MBa62xx assembly
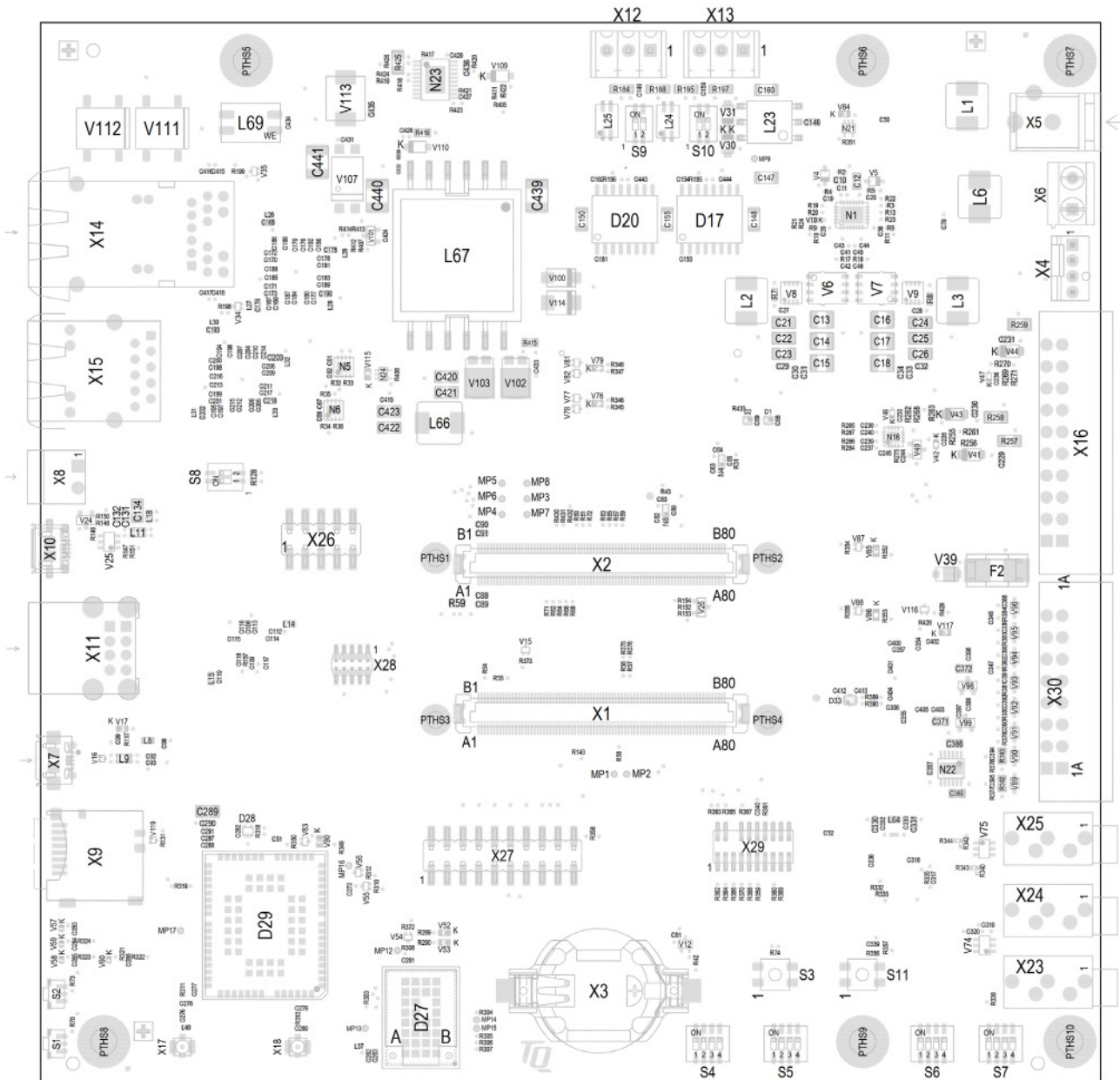
Figure 49:   MBa62xx, component placement top
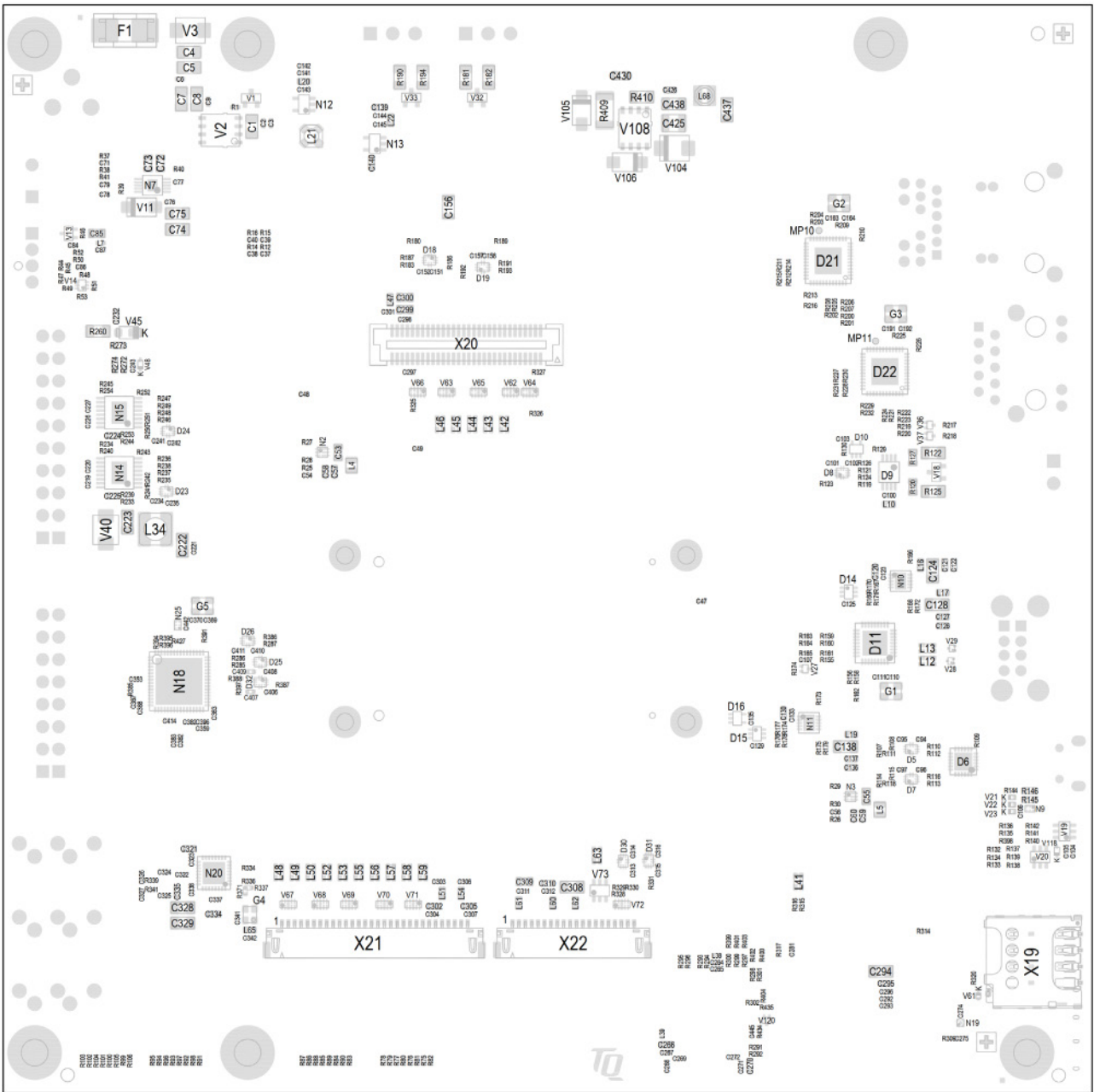
Figure 50:   MBa62xx, component placement bottom

6.4 Label placement
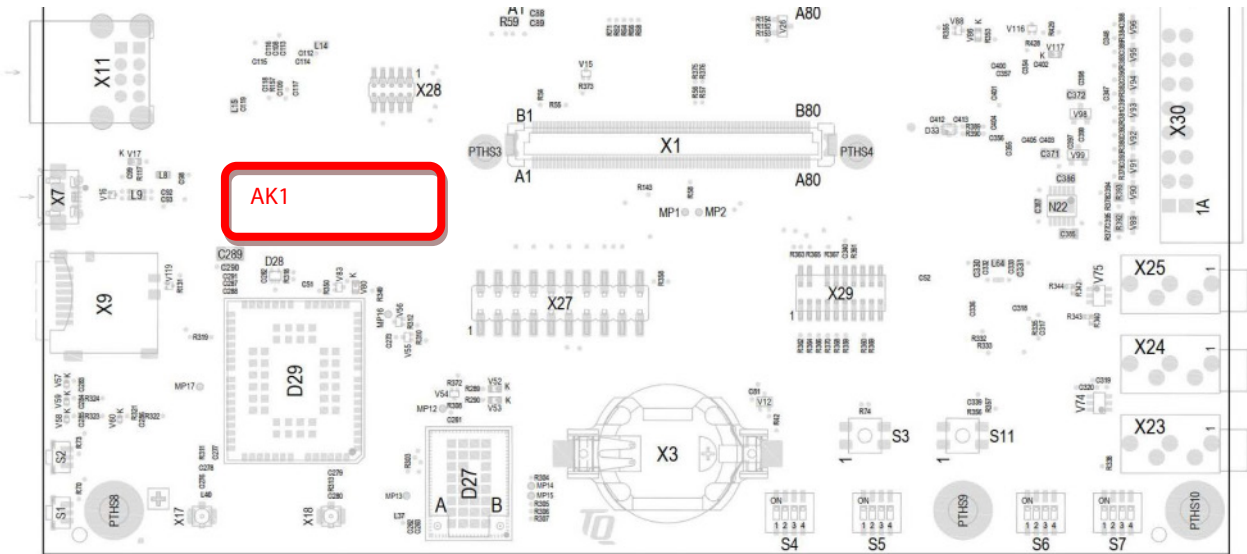
Figure 51: Label placement

Table 25: Labels

Name	Note
AK1	TQ Serial number and article description

7.   SAFETY REQUIREMENTS AND PROTECTIVE REGULATIONS

7.1   EMC

The MBa62xx was developed according to the requirements of electromagnetic compatibility (EMC). Depending on the target system, anti-interference measures may still be necessary to guarantee the adherence to the limits for the overall system.

Following measures are recommended:

- Robust ground planes (adequate ground planes) on the printed circuit board
- A sufficient number of blocking capacitors in all supply voltages
- Fast or permanently clocked lines (e.g., clock signals) should be kept short; avoid interference of other signals by distance and/or shielding, also pay attention to frequencies and signal rise times
- Filtering of all signals, which can be connected externally (also "slow signals" and DC can radiate RF indirectly)
- Direct signal routing without stubs for multi-pole interfaces (e.g. LC display)

7.2   ESD

In order to avoid interspersion on the signal path from the input to the protection circuit in the system, the protection against electrostatic discharge should be provided directly at the inputs of a system. As these measures always have to be implemented on the carrier board, no special protective measures were provided on the MBa62xx.

The following measures are recommended for a carrier board:

- Generally applicable: Shielding of inputs (shielding connected well to ground / housing on both ends)
- Supply voltages: Suppressor diodes
- Slow signals: RC filtering, Zener diodes
- Fast signals: Protection components, e.g., suppressor diode arrays

7.3   Operational safety and personal security

Due to the occurring voltages (≤30 V DC), tests with respect to the operational and personal safety haven't been carried out.

7.4   Intended Use

TQ DEVICES, PRODUCTS AND ASSOCIATED SOFTWARE ARE NOT DESIGNED, MANUFACTURED OR INTENDED FOR USE OR RESALE FOR THE OPERATION IN NUCLEAR FACILITIES, AIRCRAFT OR OTHER TRANSPORTATION NAVIGATION OR COMMUNICATION SYSTEMS, AIR TRAFFIC CONTROL SYSTEMS, LIFE SUPPORT MACHINES, WEAPONS SYSTEMS, OR ANY OTHER EQUIPMENT OR APPLICATION REQUIRING FAIL-SAFE PERFORMANCE OR IN WHICH THE FAILURE OF TQ PRODUCTS COULD LEAD TO DEATH, PERSONAL INJURY, OR SEVERE PHYSICAL OR ENVIRONMENTAL DAMAGE. (COLLECTIVELY, "HIGH RISK APPLICATIONS")

You understand and agree that your use of TQ products or devices as a component in your applications are solely at your own risk. To minimize the risks associated with your products, devices and applications, you should take appropriate operational and design related protective measures.

You are solely responsible for complying with all legal, regulatory, safety and security requirements relating to your products. You are responsible for ensuring that your systems (and any TQ hardware or software components incorporated into your systems or products) comply with all applicable requirements. Unless otherwise explicitly stated in our product related documentation, TQ devices are not designed with fault tolerance capabilities or features and therefore cannot be considered as being designed, manufactured or otherwise set up to be compliant for any implementation or resale as a device in high risk applications. All application and safety information in this document (including application descriptions, suggested safety precautions, recommended TQ products or any other materials) is for reference only. Only trained personnel in a suitable work area are permitted to handle and operate TQ products and devices. Please follow the general IT security guidelines applicable to the country or location in which you intend to use the equipment.

7.5   Export Control and Sanctions Compliance

The customer is responsible for ensuring that the product purchased from TQ is not subject to any national or international export/import restrictions. If any part of the purchased product or the product itself is subject to said restrictions, the customer must procure the required export/import licenses at its own expense. In the case of breaches of export or import limitations, the customer indemnifies TQ against all liability and accountability in the external relationship,irrespective of the legal grounds. If there is a transgression or violation, the customer will also be held accountable for any losses, damages or fines sustained by TQ. TQ is not liable for any delivery delays due to national or international export restrictions or for the inability to make a delivery as a result of those restrictions. Any compensation or damages will not be provided by TQ in such instances.

The classification according to the European Foreign Trade Regulations (export list number of Reg. No. 2021/821 for dual-use-goods) as well as the classification according to the U.S. Export Administration Regulations in case of US products (ECCN according to the U.S. Commerce Control List) are stated on TQ´s invoices or can be requested at any time. Also listed is the Commodity code (HS) in accordance with the current commodity classification for foreign trade statistics as well as the country of origin of the goods requested/ordered.

7.6   Warranty

TQ-Systems GmbH warrants that the product, when used in accordance with the contract, fulfills the respective contractually agreed specifications and functionalities and corresponds to the recognized state of the art.

The warranty is limited to material, manufacturing and processing defects. The manufacturer's liability is void in the following cases:

- •   Original parts have been replaced by non-original parts.
- •   Improper installation, commissioning or repairs.
- •   Improper installation, commissioning or repair due to lack of special equipment.
- •   Incorrect operation
- •   Improper handling
- •   Use of force
- •   Normal wear and tear

8.   CLIMATIC AND OPERATIONAL CONDITIONS

The permissible temperature range of the module depends strongly on the installation situation (heat dissipation through heat conduction and convection) and the use. Therefore, no fixed value can be given for the entire module group. In general, reliable operation is ensured if the following conditions are met:

Table 26:   Climatic and operational conditions MBa62xx

Parameter	Range	Remark
Environmental temperature	-40 °C to +85 °C	Without Lithium battery
Storage temperature	-40 °C to +100 °C	–
Relative air humidity (operation / storing)	10 % to 90 %	Not condensing

Attention:	
⚠	The CPU belongs to a performance category in which a cooling system may be essential in certain applications. It is the user's responsibility to define a suitable cooling method depending on the specific mode of operation (e.g., dependence on clock frequency, stack height, airflow, and software). When connecting the heat sink, special attention must be paid to the tolerance chain (PCB thickness, PCB curvature, BGA balls, BGA package, thermopad, heat sink). The CPU is not the highest component in every case. A defective cooling connection can lead to overheating of the module and thus to malfunctions, premature aging or destruction.

8.1   Protection against external effects

Protection class IP00 was defined for the MBa62xx. There is no protection against foreign objects, touch or humidity.

8.2   Reliability and service life

No detailed MTBF calculation has been done for the MBa62xx.
The MBa62xx is designed to be insensitive to vibration and impact.
Service life limiting components such as electrolytic capacitors were not used.

9.   ENVIRONMENT PROTECTION

9.1   RoHS

The MBa62xx is manufactured RoHS compliant.
- All components and assemblies are RoHS compliant
- The soldering processes are RoHS compliant

9.2   WEEE®

The final distributor is responsible for compliance with the WEEE® regulation.
Within the scope of the technical possibilities, the MBa62xx was designed to be recyclable and easy to repair.

9.3   REACH®

The EU-chemical regulation 1907/2006 (REACH® regulation) stands for registration, evaluation, certification and restriction of substances SVHC (Substances of very high concern, e.g., carcinogen, mutagen and/or persistent, bio accumulative and toxic). Within the scope of this juridical liability, TQ-Systems GmbH meets the information duty within the supply chain with regard to the SVHC substances, insofar as suppliers inform TQ-Systems GmbH accordingly.

9.4   EuP

The Ecodesign Directive, also Energy using Products (EuP), is applicable to products for the end user with an annual quantity >200,000. The MBa62xx must therefore always be seen in conjunction with the complete device.
The available standby and sleep modes of the components on the MBa62xx enable compliance with EuP requirements for the MBa62xx.

9.5   Statement on California Proposition 65

California Proposition 65, formerly known as the Safe Drinking Water and Toxic Enforcement Act of 1986, was enacted as a ballot initiative in November 1986. The proposition helps protect the state's drinking water sources from contamination by approximately 1,000 chemicals known to cause cancer, birth defects, or other reproductive harm ("Proposition 65 Substances") and requires businesses to inform Californians about exposure to Proposition 65 Substances.
The TQ device or product is not designed or manufactured or distributed as consumer product or for any contact with end-consumers. Consumer products are defined as products intended for a consumer's personal use, consumption, or enjoyment. Therefore, our products or devices are not subject to this regulation and no warning label is required on the assembly.
Individual components of the assembly may contain substances that may require a warning under California Proposition 65. However, it should be noted that the Intended Use of our products will not result in the release of these substances or direct human contact with these substances. Therefore you must take care through your product design that consumers cannot touch the product at all and specify that issue in your own product related documentation.
TQ reserves the right to update and modify this notice as it deems necessary or appropriate.

9.6   Packaging

By environmentally friendly processes, production equipment and products, we contribute to the protection of our environment. To be able to reuse the MBa62xx, it is produced in such a way (a modular construction) that it can be easily repaired and disassembled. The energy consumption of this subassembly is minimised by suitable measures. The MBa62xx is delivered in reusable packaging.

9.7   Batteries

9.7.1   General notes

Due to technical reasons a battery is necessary for the MBa62xx. Batteries containing mercury (Hg), cadmium (Cd) or lead (Pb) are not used.
If this is for technical reasons unavoidable, the device is marked with the corresponding hazard note.
To allow a separate disposal, batteries are generally only mounted in sockets.

9.7.2   Lithium batteries

The requirements concerning special provision 188 of the ADR (section 3.3) are complied with for Lithium batteries.
There is therefore no classification as dangerous goods:
- Basic lithium content per cell not more than 1 g
  (except for lithium ion and lithium polymer cells for which a lithium content of not more than 1.5 g per cell applies (equals 5 Ah)).

- Basic lithium content per battery not more than 2 g
  (except for lithium ion batteries for which a lithium content of not more than 8 g per cell applies (equals 26 Ah)).
- Lithium cells and batteries are examined according to UN document ST/SG/AC.10-1.

During transport a short circuit or discharging of the socketed lithium battery is prevented by extricable insulating foils or by other suitable insulating measures.

9.8   Other entries

By environmentally friendly processes, production equipment and products, we contribute to the protection of our environment. To be able to reuse the MBa62xx, it is produced in such a way, that it can be easily repaired and disassembled. The energy consumption of this subassembly is minimised by suitable measures. Due to the fact that at the moment there is still no technical equivalent alternative for printed circuit boards with bromine-containing flame protection (FR-4 material), such printed circuit boards are still used. No use of PCB containing capacitors and transformers (polychlorinated biphenyls). These points are an essential part of the following laws:

- The law to encourage the circular flow economy and assurance of the environmentally acceptable removal of waste as at 27.9.94
  (Source of information: BGBl I 1994, 2705)
- Regulation with respect to the utilization and proof of removal as at 1.9.96
  (Source of information: BGBl I 1996, 1382, (1997, 2860))
- Regulation with respect to the avoidance and utilization of packaging waste as at 21.8.98
  (Source of information: BGBl I 1998, 2379)
- Regulation with respect to the European Waste Directory as at 1.12.01
  (Source of information: BGBl I 2001, 3379)

This information is to be seen as notes. Tests or certifications were not carried out in this respect.

10. APPENDIX

10.1 Acronyms and definitions

The following acronyms and abbreviations are used in this document.

Table 27:   Acronyms

Acronym	Meaning
ADC	Analog/Digital Converter
BIOS	Basic Input/Output System
BSP	Board Support Package
CAN	Controller Area Network
CPU	Central Processing Unit
DDR3L	DDR3 Low Voltage
DIN	German industry standard (Deutsche Industrie Norm)
DIP	Dual In-line Package
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
eMMC	embedded Multimedia Card (Flash)
EN	European standard (Europäische Norm)
ESD	Electrostatic Discharge
EuP	Energy using Products
FET	Field Effect Transistor
FFC	Flat Flex Cable
FR-4	Flame Retardant 4
GPIO	General Purpose Input/Output
HP	Headphone
I/O	Input/Output
I²C	Inter-Integrated Circuit
IEEE®	Institute of Electrical and Electronics Engineers
IP00	Ingress Protection 00
JTAG®	Joint Test Action Group
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LSB	Least Significant Bit
LVDS	Low Voltage Differential Signal
MCASP	Multichannel Audio Serial Port
MII	Media Independent Interface
MMC	Multimedia Card
MSB	Most Significant Bit
MTBF	Mean operating Time Between Failures

Table 27:   Acronyms (continued)

Acronym	Meaning
n.c.	Not Connected
NOR	Not-Or
NP	Not Placed
OTG	On-The-Go
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect express
PCMCIA	People Can't Memorize Computer Industry Acronyms
PD	Pull-Down
PHY	Physical (OSI model layer)
PMIC	Power Management Integrated Circuit
PRU	Programmable Real-Time Unit
PU	Pull-Up
REACH®	Registration, Evaluation, Authorisation (and restriction of) Chemicals
RGMII	Reduced Gigabit Media Independent Interface
RJ45	Registered Jack 45
RMS	Root Mean Square
RoHS	Restriction of (the use of certain) Hazardous Substances
RS-232, RS-485	Recommended Standard (serial interface)
RTC	Real-Time Clock
SD card	Secure Digital card
SD/MMC	Secure Digital Multimedia Card
SDRAM	Synchronous Dynamic Random Access Memory
SIM	Subscriber Identification Module
SMD	Surface-Mounted Device
SMT	Surface-Mount Technology
SPI	Serial Peripheral Interface
THD	Through-Hole Device
THT	Through-Hole Technology
UART	Universal Asynchronous Receiver/Transmitter
UIM	User Identity Module
USB	Universal Serial Bus
WEEE®	Waste Electrical and Electronic Equipment
WLAN	Wireless Local Area Network
WP	Write-Protection
WPAN	Wireless Personal Area Network
WWAN	Wireless Wide Area Network

10.2   References

Table 28:   Further applicable documents

No.	Name	Rev. / Date	Company
(1)	AM62x Processors Silicon Revision 1.0 Technical Reference Manual	A / Nov. 2022	[Texas Instruments](#)
(2)	AM62x Sitara Processors Datasheet	A / Nov. 2022	[Texas Instruments](#)
(3)	TQMa62xx User's Manual	– current –	[TQ-Systems](#)
(4)	Support-Wiki for the TQMa62xx	– current –	[TQ-Systems](#)

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