TQMa62xx
Preliminary User's Manual

TQMa62xx UM 0003
21.11.2023

TABLE OF CONTENTS

TABLE DIRECTORY

FIGURE DIRECTORY

REVISION HISTORY

Rev.	Date	Name	Pos.	Modification
0001	29.06.2023	M. Kreuzer	All	Initial release
0002	14.09.2023	M.Kreuzer	Table 13 3.2.9.3.2	VSEL_SD changed to 3.3 V
0003	21.11.2023	M.Kreuzer	Table 6 Table 7 Table 11 5.1 Figure 15	eMMC-Flash modes added NOR-Flash modes added Current consumption added Mass added Dimensions added

1. ABOUT THIS MANUAL

1.1 Copyright and license expenses

This Preliminary User's Manual may not be copied, reproduced, translated, changed or distributed, completely or partially in electronic, machine readable, or in any other form without the written consent of TQ-Systems GmbH.

The drivers and utilities for the components used as well as the BIOS are subject to the copyrights of the respective manufacturers. The licence conditions of the respective manufacturer are to be adhered to.

Bootloader-licence expenses are paid by TQ-Systems GmbH and are included in the price.

Licence expenses for the operating system and applications are not taken into consideration and must be calculated / declared separately.

1.2 Registered trademarks

TQ-Systems GmbH aims to adhere to copyrights of all graphics and texts used in all publications, and strives to use original or license-free graphics and texts.

All brand names and trademarks mentioned in this Preliminary User's Manual, including those protected by a third party, unless specified otherwise in writing, are subjected to the specifications of the current copyright laws and the proprietary laws of the present registered proprietor without any limitation. One should conclude that brand and trademarks are rightly protected by a third party.

1.3 Disclaimer

TQ-Systems GmbH does not guarantee that the information in this Preliminary User's Manual is up-to-date, correct, complete or of good quality. Nor does TQ-Systems GmbH assume guarantee for further usage of the information. Liability claims against TQ-Systems GmbH, referring to material or non-material related damages caused, due to usage or non-usage of the information given in this Preliminary User's Manual, or due to usage of erroneous or incomplete information, are exempted, as long as there is no proven intentional or negligent fault of TQ-Systems GmbH.

TQ-Systems GmbH explicitly reserves the rights to change or add to the contents of this Preliminary User's Manual or parts of it without special notification.

Important Notice:

Before using the Starterkit MBa62xx or parts of the schematics of the MBa62xx, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. TQ-Systems GmbH makes no other warranties including, but not limited to, any implied warranty of merchantability or fitness for a particular purpose. Except where prohibited by law, TQ-Systems GmbH will not be liable for any indirect, special, incidental or consequential loss or damage arising from the usage of the Starterkit MBa62xx or schematics used, regardless of the legal theory asserted.

1.4 Imprint

TQ-Systems GmbH
Gut Delling, Mühlstraße 2
D-82229 Seefeld

Tel: +49 8153 9308–0
Fax: +49 8153 9308–4223
E-Mail: Info@TQ-Group
Web: TQ-Group

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
	This symbol represents the handling of electrostatic-sensitive devices 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.
	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.
	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 TQMa62xx and be dangerous to your health. Improper handling of your TQ-product would render the guarantee invalid.

Proper ESD handling

	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 power up the TQMa62xx or the Starterkit, 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 manuals 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
- MBa62xx User's Manual
- Sitara™ AM62x Data Sheet
- 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:tqmax62xx

2. BRIEF DESCRIPTION

The TQMa62xx is a universal TQ-LGA mini module based on the TI Sitara family AM62x with ARM Cortex A53 and Cortex M4F cores.

This Preliminary User's Manual describes the hardware of the TQMa62xx Rev.010x and refers to some software settings.
It does not replace the AM62x Reference Manual (2).

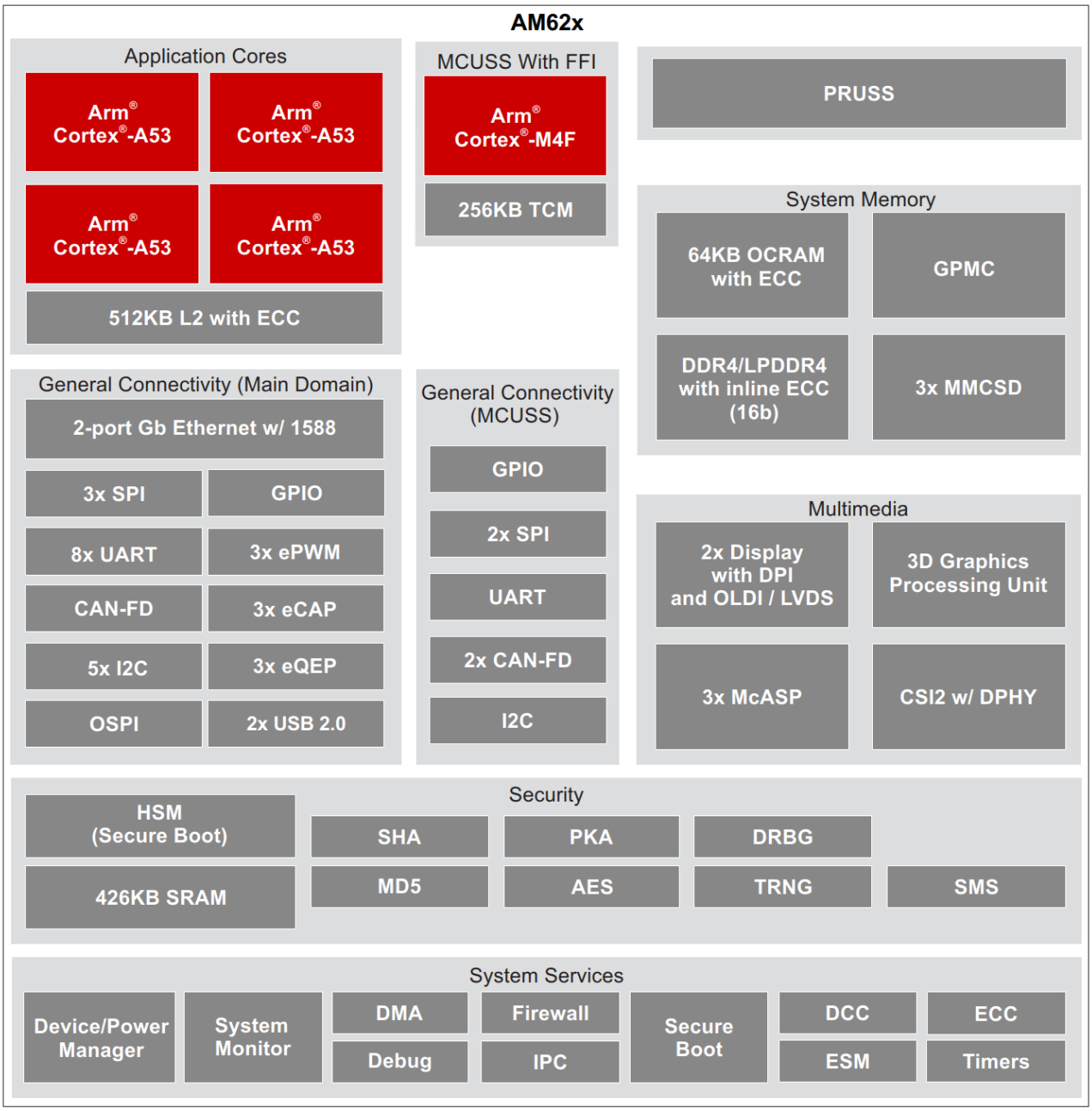


Figure 1: Block diagram AM62x

(Source: Texas Instruments)

All useful AM62x signals are routed to the TQMa62xx connectors (2 x 160 pins). There are no restrictions for customers using the TQMa62xx with respect to an integrated customised design.

Please take note of that not all interfaces can be used simultaneously.

3. ELECTRONICS

The information provided in this User's Manual is only valid in connection with the tailored boot loader, which is preinstalled on the TQMa62xx, and the BSP provided by TQ-Systems GmbH, see also section 4.

3.1 System overview

3.1.1 System architecture / block diagram

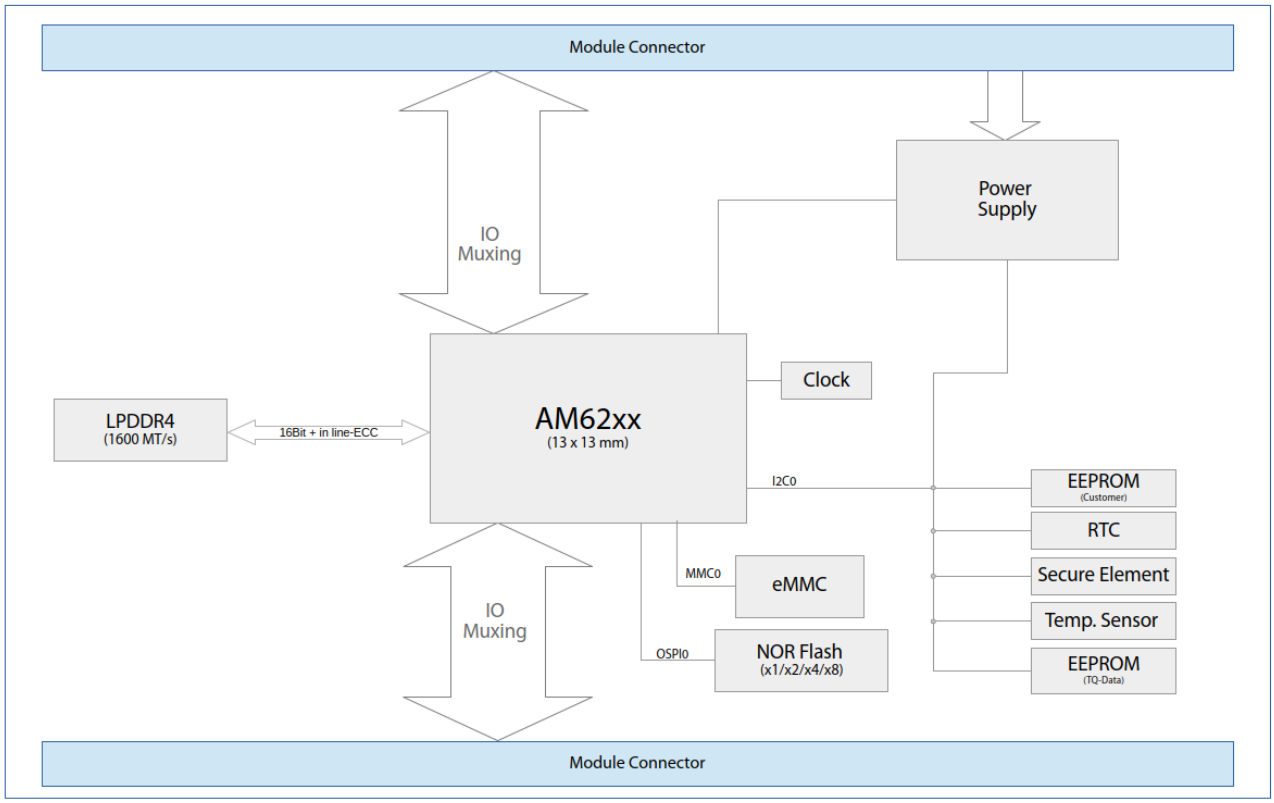


Figure 2: Block diagram TQMa62xx

3.1.2 Functionality

The following key functions are implemented on the TQMa62xx:

- Minimodule in form factor 58 mm x 32 mm
- AM62x CPU (up to 4x A53 and/ 1x M4F)
- 16-bit LPDDR4 memory
- 1x eMMC NAND-Flash 5.1
- 1x QSPI-NOR-Flash (optional)
- Clock supply
- EEPROM (optional)
- Real-time clock (optional)
- Secure Element chip (optional)
- Temperature sensor (optional)
- EEPROM (TQ-Data)
- Supervisor
- Single Power Supply 3.3 V
- Availability of all essential signals of the CPU at the module connector (2 x 160-pin)

3.1.3 Pin multiplexing

The pin multiplexing of the AM62x permits to use many pins for different interfaces.
The information provided in this User's Manual is based on the BSP provided by TQ-Systems GmbH.

Attention: Destruction or malfunction	
	Many AM62x pins can be configured as different function. Please take note of the information in the AM62 data sheet (1) concerning the configuration of these pins before integration / start-up of your carrier board / Starter kit. Please also take note of the latest AM62x errata (3).

3.2 System components

3.2.1 Processor derivatives

Depending on the TQMa62xx version, one of the following AM62x derivatives is assembled:
AM6254 / AM6252 / AM6251 / AM6234 / AM6232 / AM6231

Table 2: AM62x derivatives (Source: Texas Instruments)

FEATURES	REFERENCE NAME	AM625			AM623		
		AM6254	AM6252	AM6251	AM6234	AM6232	AM6231
CTRLMMR_WKUP_JTAG_DEVICE_ID[31:13] DEVICE_ID register bit field value(1)		C: 0x1D123 G: 0x1D127	C: 0x1D0A3 G: 0x1D0A7	G: 0x1D067	C: 0x1D103 G: 0x1D107	C: 0x1D083 G: 0x1D087	G: 0x1D047
PROCESSORS AND ACCELERATORS							
Speed Grades (See Table 7-1)		T, S, K, G					
Arm Cortex-A53 Microprocessor Subsystem	Arm A53	Quad Core	Dual Core	Single Core	Quad Core	Dual Core	Single Core
Arm Cortex-M4F in MCU domain	Arm M4F	Single Core Functional Safety Optional(5)					
3D Graphics Engine (OpenGL ES 3.1, Vulkan 1.2)	3D Graphics engine	Yes	Yes	Yes	No	No	No
Device Management Subsystem	WKUP_R5F	Single core					
Crypto Accelerators	Security	Yes					
PROGRAM AND DATA STORAGE							
On-Chip Shared Memory (RAM) in MAIN Domain	OCSRAM	64KB (with SECDED ECC)					
On-Chip Shared Memory (RAM) in M4F Domain	MCU_MSRAM	256KB					
DDR4/LPDDR4 DDR Subsystem	DDRSS	16-bit data with inline ECC; up to 8GB using DDR4 or 4GB using LPDDR4					
General-Purpose Memory Controller	GPMC	Up to 1GB with ECC					
PERIPHERALS							
Display Subsystem	DSS	1x DPI					
		1x LVDS					
Modular Controller Area Network Interface with Full CAN-FD Support	MCAN	3					
General-Purpose I/O	GPIO	Up to 170					
Inter-Integrated Circuit Interface	I2C	6					
Multichannel Audio Serial Port	MCASP	3					
Multichannel Serial Peripheral Interface	MCSPI	5					
Multi-Media Card/ Secure Digital Interface	MM/CSD	1x eMMC (8-bits)					
		2x SD/SDIO (4-bits)					
Flash Subsystem (FSS)(2)	OSPI0/QSPI0	Yes(2)					
Programmable Real-Time Unit Subsystem(3)	PRUSS	2x PRU Cores (Optional)					
Industrial Communication Subsystem Support(4)	PRUSS	No					
Gigabit Ethernet Interface	CPSW3G	Yes					
General-Purpose Timers	TIMER	12 (4 in MCU Channel)					
Enhanced Pulse-Width Modulator Module	EPWM	3					
Enhanced Capture Module	ECAP	3					
Enhanced Quadrature Encoder Pulse Module	EQEP	3					
Universal Asynchronous Receiver and Transmitter	UART	9					
CSI2-RX Controller with DPHY	CSI-RX	1					
USB2.0 Controller with PHY	USB 2.0	2					

3.2.2 Booting

3.2.2.1 Boot source

The boot source is selected via the boot strapping pins of the AM62x. The signals are directly routed to the module connectors and will be available again as GPIO after reading the boot configuration.

After the release of MCU_PORz the boot configuration is read in at the BOOTMODE[15:0] pins. Independent of the boot device, the ROM bootloader is executed first, which assists in reading and executing the application code. The data can be read and loaded either directly from the memory device or by a peripheral.

The following figure shows the implementation of boot strapping on the module:

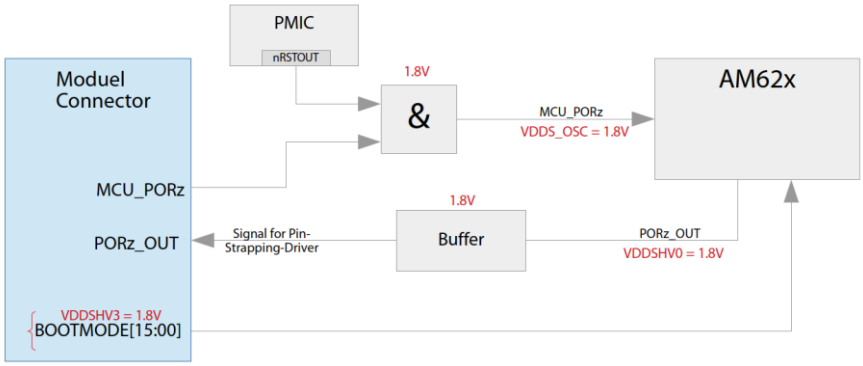


Figure 3: Block diagram boot strapping

According to the Reference Manual (2) the general boot configuration at the TQMa62xx can be set as follows:

Table 3: Selecting the General Boot Configuration

Boot configuration pin	Setting	TQMa62xx
BOOTMODE[15:14]	Reserved, fixed to 0	00
BOOTMODE[13:10]	Select the backup boot mode, if primary boot device failed	Don't care
BOOTMODE[9:3]	See following chapters for boot devices	-
BOOTMODE[2:0]	Ref Clock Select: 000 = 19.2 MHz 001 = 20 MHz 010 = 24 MHz 011 = 25 MHz 100 = 26 MHz 101 = 27 MHz 110 = Reserved 111 = Reserved	011

Attention: Malfunction	
	All BOOTMODE[15:00] signals must have either a pullup (to V_1V8) or pulldown (to Ground). Undefined levels can lead to a malfunction during booting.

3.2.2.2 Boot device eMMc

Table 4: Boot device selection eMMC

Boot configuration pin	Setting	TQMa62xx
BOOTMODE[9]	Port: MMCSD Port 0 (8 bit width) This bit must be set to 0	000
BOOTMODE[8]	Reserved	
BOOTMODE[7]	0 = Filesystem Mode 1 = Raw Mode	
BOOTMODE[6:3]	Primary Boot Mode: 0000 = Reserved 0001 = OSPI 0010 = QSPI 0011 = SPI 0100 = Ethernet RGMII 0101 = Ethernet RMII 0110 = I2C 0111 = UART 1000 = MMCSD boot 1001 = eMMC 1010 = USB 1011 = GPMC NAND 1100 = GPMC NOR 1101 = PCIe 1110 = xSPI 1111 = No-boot/Dev boot	1000

3.2.2.3 Boot device NOR-flash

Table 5: Selection of the boot device NOR flash

Boot configuration pin	Setting	TQMa62xx
BOOTMODE9	Reserved, fixed to 0	Don't Care
BOOTMODE8	SPI mode: 0 = SPI Mode 0 1 = SPI Mode 3	1
BOOTMODE7	Chip-Select: 0 = Boot-Flash is on CS0 1 = Boot-Flash is on CS1	0
BOOTMODE[6:3]	Primary Boot Mode: 0000 = Reserved 0001 = OSPI 0010 = QSPI 0011 = SPI 0100 = Ethernet RGMII 0101 = Ethernet RMII 0110 = I2C 0111 = UART 1000 = MMCSD card 1001 = eMMC 1010 = USB 1011 = GPMC NAND 1100 = GPMC NOR 1101 = PCIe 1110 = xSPI 1111 = No-boot/Dev boot	0011

Further boot configurations can be found in the Reference Manual (2).

Besides the mentioned boot configurations above, it is recommended to consider an alternative boot source during development, e.g. USB boot or no-boot mode for JTAG debug.

Note: Update	
	When designing a mainboard, it is recommended to plan a redundant update concept for software updates in the field. Furthermore, it is recommended to switch the conversion of the boot strap pins to high impedance after reading in.

3.2.3 Memory

3.2.3.1 LPDDR4 SDRAM

The TQMa62xx has an LPDDR4 memory with the use of in-line ECC:

- 16-bit bus width with optional ECC (8-bit data + 8-bit ECC)
- Up to 1600 Mbps = 800 MHz
- 1 GByte (=8 Gbit) / 2 GByte (=16 Gbit)

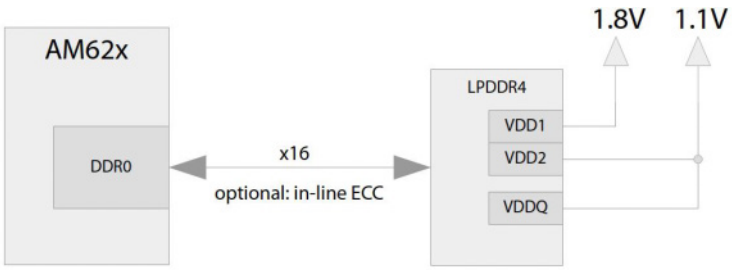


Figure 4: Block diagram DDR3L SDRAM connection

3.2.3.2 eMMC

An eMMC is available to the TQMa62xx as non-volatile data memory for programs and data (e.g. boot loader, operating system). The used MMC0 signals are not available to the Pinout.

- MMC0 Interface is connected to the eMMC Flash
- 8 / 16 / 32 / 64 GByte

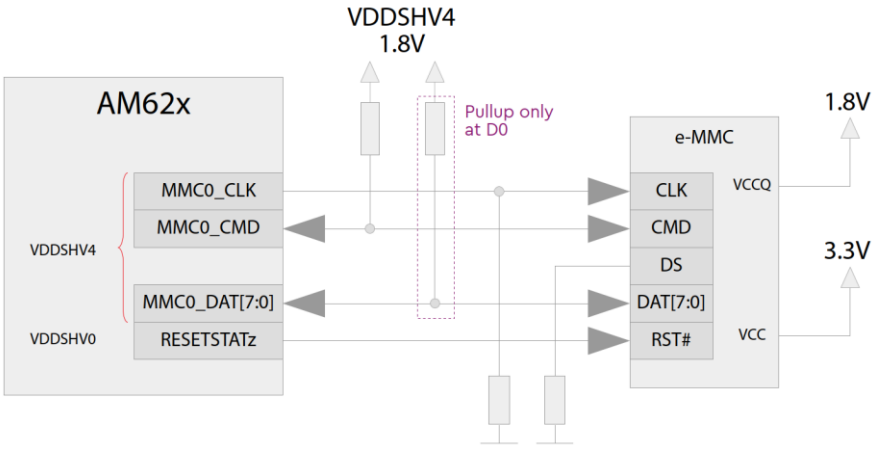


Figure 5: Block diagram eMMC flash interface

The TQMa62xx supports the following transmission modes:

Table 6: eMMC Flash modes

Mode	1-bit	4-bit	8-bit	Note
Default Speed	n/a	n/a	n/a	
High Speed	n/a	n/a	Yes	Boot process
HS200	n/a	n/a	Yes	U-boot / Linux
HS400	n/a	n/a	n/a	MMCSD not supported features

3.2.3.3 NOR-Flash

A NOR-Flash on the TQMa62xx is available as non-volatile memory. The used OSPI0 signals are not available to the pinout.

- OSPI0 Interface is connected to the NOR Flash
- The NOR-Flash variants Quad SPI Flash and Octal SPI Flash are usable
- 512 / 1024 / 2048 Mbit

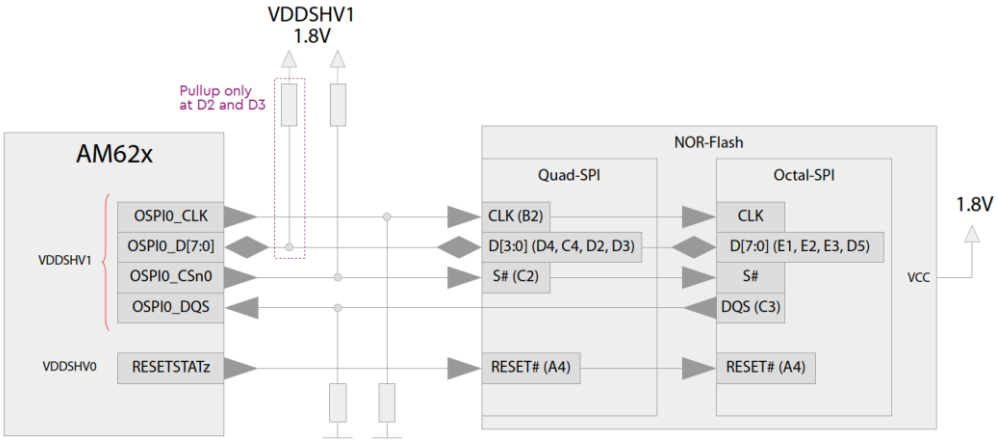


Figure 6: Block diagram NOR-Flash

The NOR-Flash variants Quad SPI Flash and Octal SPI Flash are usable. The TQMa62xx supports the following transmission modes:

Table 7: NOR-Flash modes

Mode	Read	Write	Note
Extended SPI (SDR)	1-4-4	1-4-4	Clock = max. 83.33 MHz

3.2.3.4 EEPROMs

I²C EEPROMs are provided on the TQMa62xx for non-volatile storage. A distinction is made here between:

- Customer data, freely accessible
- TQ manufacturing data (Serial Number, MAC, ...)

All I²C slave address and bus structure are summarized in chapter 3.2.8.3.

3.2.4 Clock supply

The clock supply of the TQMa62xx is represented as follows:

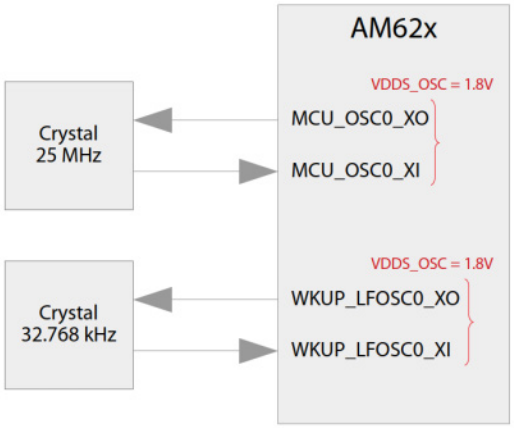


Figure 7: Block diagram clock supply

To get the module executable only with a 3.3 V supply, MCU_OSC0_XO / XI and WKUP_LFOSC_XO / XI were implemented as clock on the module. The remaining clock inputs can either be derived from the system clock or fed externally via the module connectors, as an example the following clocks can be fed externally:

- EXT_REFCLK1
- MCU_EXT_REFCLK0 (optional external System Clock inputs)
- CPTS0_RFT_CLK (optional CPTS Reference Clock input)
- AUDIO_EXT_REFCLK0/1 (optional, External Clock input to McASP)

Further information can be obtained from the associated data sheets (1).

3.2.5 RTC

An optional RTC (NXP PCF85063A) can be equipped on the TQMa62xx. The connection is realized as follows:

- The RTC can be supplied from the base board via V_RTC_IN. V_RTC_IN = 2.0 V to 5.5V
- RTC_INT# and RTC_CLKOUT is accessible at the module connectors.
- RTC_CLKOUT is only activated as soon as the TQMa62xx is supplied with V_3V3_IN.
- I2C is connected via I2C0 (I^2C addresses are described in chapter 3.2.8.3)

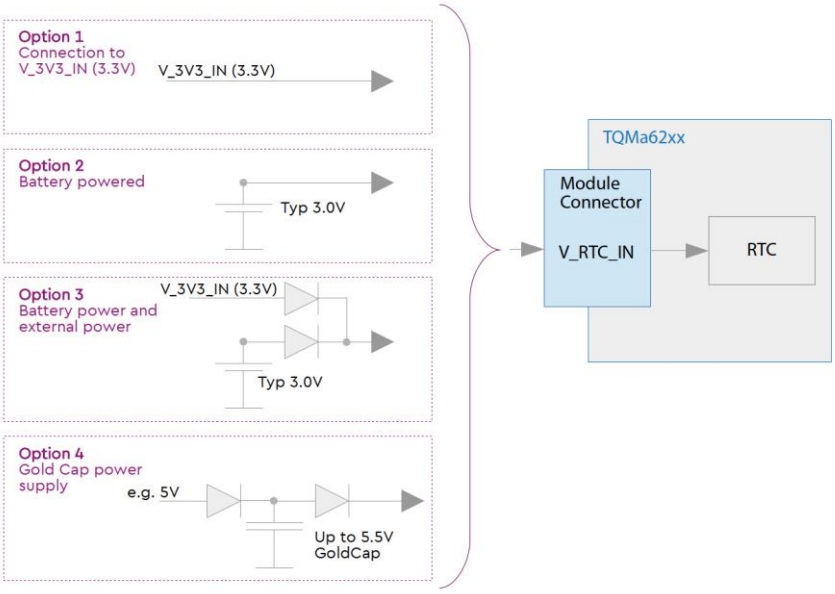


Figure 8: Block diagram RTC

Note: Equipping the base board	
	The RTC is supplied internally by a LDO (1.8V) via V_RTC_IN. This allows the user an easy use of Gold-Caps or Coin cells on the main board.

3.2.6 Secure Element

A Secure Element Chip can optionally be fitted on the TQMa62xx. The connection can be seen in the following figure:

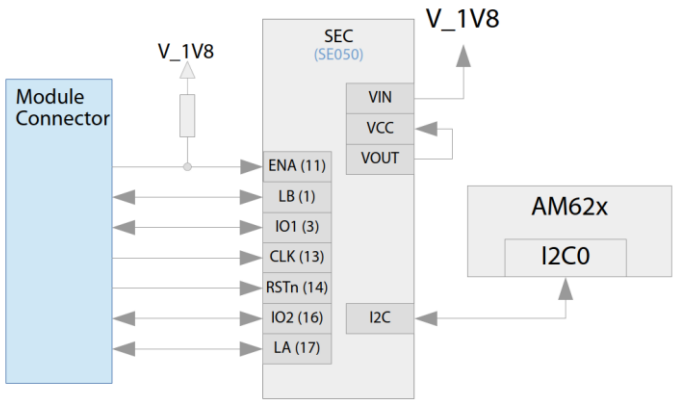


Figure 9: Block diagram SEC

The SE050E2HQ1/Z01Z3 from NXP is used as the secure element. All I²C addresses are described in chapter 3.2.8.3.

3.2.7 Temperature sensor

A temperature sensor (TI TMP1075DSGR) is placed on the TQMa62xx to monitor the module temperature.
The over temperature output (TEMP_ALERT) of the sensor is available at the module connectors as an open drain output.
The I²C addresses are described in chapter 3.2.8.3.

3.2.8 Interfaces

In general, except for the memory connection, all IO pins of the CPU are provided at the module connectors.
For further information about the interfaces and the pin multiplexing refer to the CPU Reference Manual (2).

3.2.8.1 GPIO

Besides their interface function, most AM62x pins can also be used as GPIOs. Details are to be taken from the AM62x Data Sheet (1).

3.2.8.2 JTAG

The CPU has a JTAG interface that is directly accessible at the module connectors. The following default configuration is provided on the TQMa62xx:

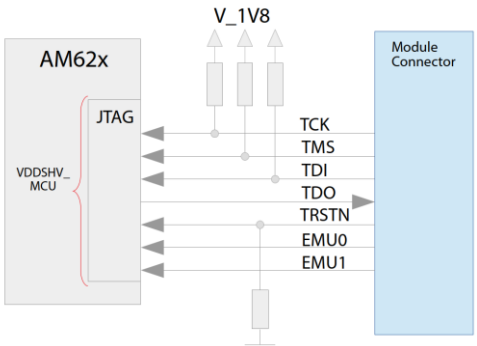


Figure 10: Block diagram JTAG

The following table shows the signals used by the JTAG interface.

Table 8: JTAG signals

Signal / Multiplexing	I/O	Power domain	Note
TCK	I	VDDSHV_MCU (1,8 V)	10 kΩ Pull-up on module
TDI	I		10 kΩ Pull-up on module
TDO	OZ		Three-state output
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

For more information please refer to the Reference Manual (2).

3.2.8.3 I²C

The accessible I²C buses depend on the pin multiplexing. To use the internal I²C devices, the I2C0 bus is permanently provided on the TQMa62xx. The following devices are connected to the module:

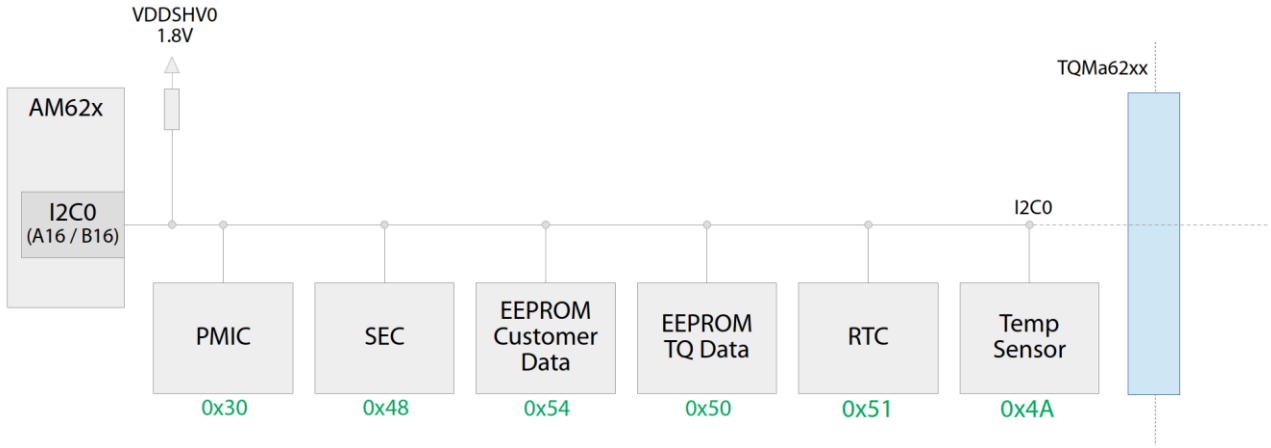


Figure 11: Block diagram I2C bus on the TQMa62xx

Table 9: I2C address assignment on the module

Bus	Component	Address	Note
I2C0	Temperature sensor TMP1075	0x4A / 0b100 1010	
	EEPROM M24C02	0x50 / 0b101 0000	TQ-Data
	EEPROM M24C64	0x54 / 0b101 0100	Customer EEPROM
	RTC PCF85063ATL	0x51 / 0b101 0001	
	SEC	0x48 / 0b100 1000	
	PMIC TPS6521902	0x30 / 0b011 0000	

If additional devices should be connected to this bus, optional external pullups should be provided to improve the rise / fall times. I2C0 relates to 1.8V.

3.2.8.4 UART

UART0 is routed to the TQMa62xx pins as primary functions.

3.2.8.5 EXTINT#

The signal EXTINT# of the AM62x is routed to TQMa62xx pin X2-B32 as primary function.

3.2.9 Reset

The following figure describes the implementation of the reset structure of the TQMa62xx:

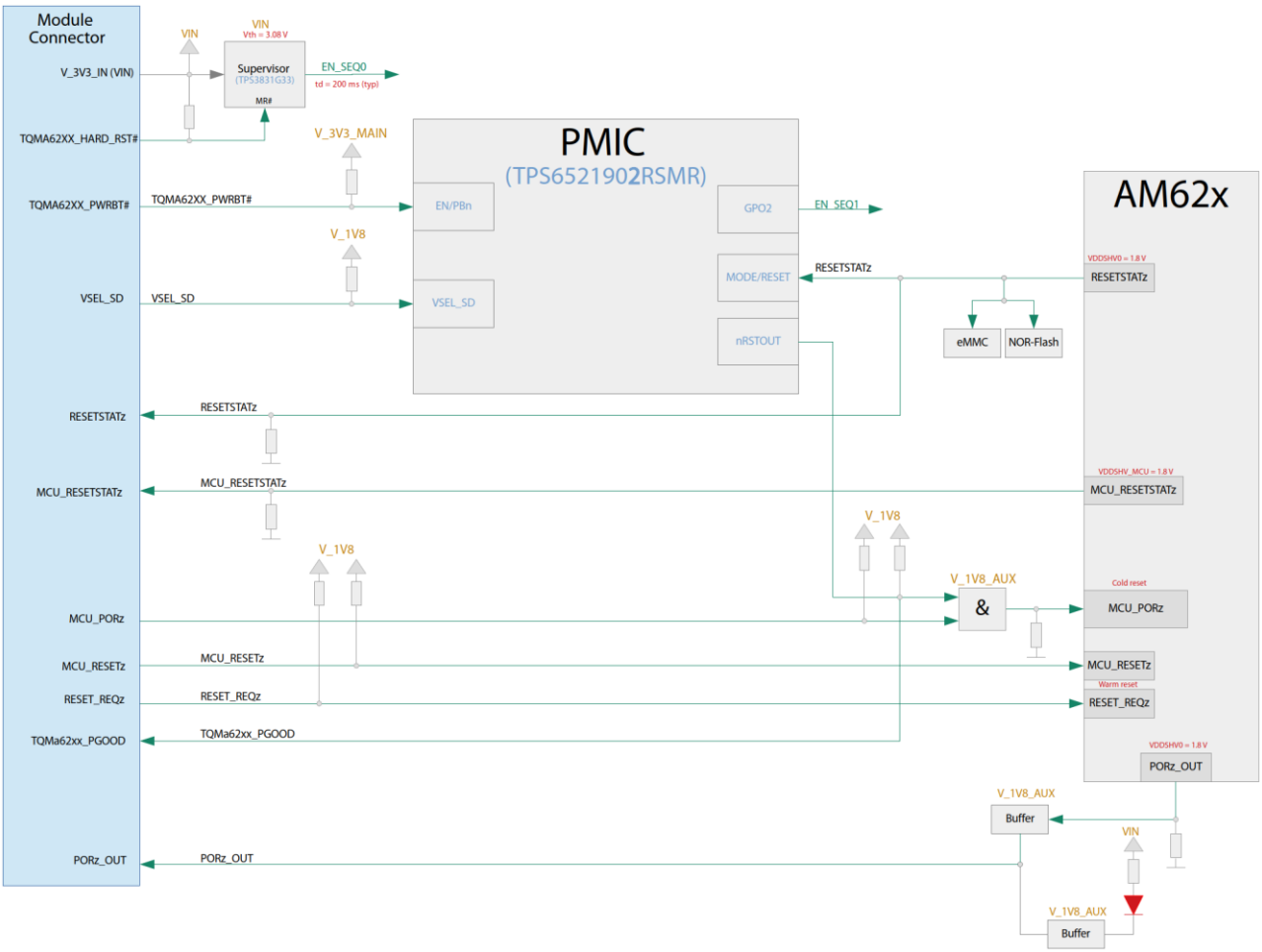


Figure 12: Block diagram Reset

3.2.9.1 Reset Options (Input)

3.2.9.1.1 TQMa62xx_HARD_RST#

The input signal TQM62xx_HARD_RST# is used to control the entire module. Coming from the module connectors a reset with power cycle of the module is executed. As soon as the signal becomes HIGH, the power-up sequencing takes place after a delay of approx. 200 ms.

Per default the signal is connected with a pullup to V_3V3_IN (3.3 V), therefore only a LOW can reset the module with power cycle.

3.2.9.1.2 TQMa62xx_PWRBT#

The input signal TQMa62xx_PWRBT# is used to control the entire module. Coming from the module connector an ON/OFF request at the PMIC is performed by the signal. An 8 s LOW level event leads to an OFF request of the PMIC. A 600 ms HIGH level event leads to an ON request of the PMIC.

It must be ensured that the "First Supply Detection" is activated on the PMIC. The TQMa62xx_PWRBT# signal is only ignored during the first power-up of the module.

Per default the signal is connected with a pullup to V_3V3_IN (3.3 V), therefore only a LOW can reset the module with power cycle.

3.2.9.1.3 MCU_PORz

The MCU_PORz signal is used to control a cold reset. Between the module connector signal MCU_PORz and the AM62x MCU_PORz signal is an AND element and a PMIC, which keeps the signal at LOW during power sequencing and pulls it HIGH afterwards.

By default the signal is connected with a pullup to 1.8 V, so only a LOW can trigger a cold reset of the module.

3.2.9.1.4 MCU_RESETz

The MCU_RESETz signal is used to control a warm reset of the MCU domain of the AM62x.

By default the signal is connected to a pullup to 1.8 V, so only a LOW can trigger a warm reset of the MCU domain on the module.

3.2.9.1.5 RESET_REQz

The RESET_REQz signal is used to control a warm reset of the main domain of the AM62x.

By default the signal is connected to a pullup to 1.8 V, so only a LOW can trigger a warm reset of the main domain on the module.

3.2.9.2 Reset Status (Output)

3.2.9.2.1 PORz_OUT

The PORz_OUT signal serves as status signal for a cold reset of the main domain of the AM62x.

By default the signal is driven via a buffer with 1.8 V.

3.2.9.2.2 MCU_RESETSTATz

The MCU_RESETSTATz signal serves as a status signal for a warm reset of the MCU domain.

By default the signal is connected with a pulldown to ground.

3.2.9.2.3 RESETSTATz

The RESETSTATz signal serves as a status signal for a warm reset of the main domain.

By default the signal is connected with a pulldown to ground.

3.2.9.3 Control signals

3.2.9.3.1 TQMa62xx_PGOOD

TQMa62xx_PGOOD serves as a status signal to the base board that the voltages on the main board can now be switched on. Power GOOD (PGOOD) is only active when the power sequencing on the module has been successfully completed.

3.2.9.3.2 VSEL_SD

VSEL_SD is used to select the V_VDDSHV5 supply voltage:

- LOW: V_VDDSHV5 = 1.8 V
- HIGH: V_VDDSHV5 = 3.3 V

By default the signal is connected with a pullup to 3.3 V, thus initially V_VDDSHV5 is always supplied with 3.3 V.

3.2.10 Watchdog

The AM62 provides a Watchdog Timer. If the Watchdog Timer is active and not reset within the specified time, triggers a Warm-Reset. For more information, refer to the AM62 Reference Manual (2).

3.2.11 Power supply

3.2.11.1 Main power supply

The main supply of the TQMa62xx is defined to typ. 3.3 V. By applying the 3.3 V voltage the module generates all required voltages.

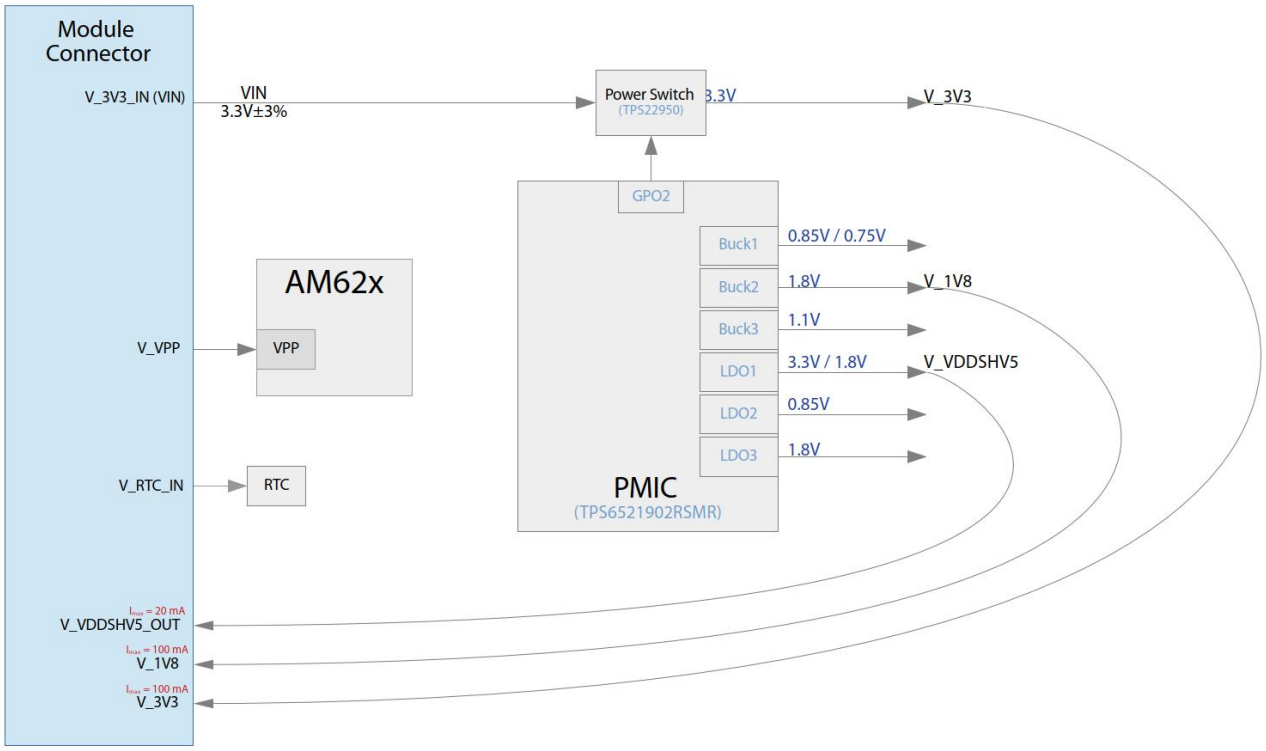


Figure 13: Block diagram power supply

3.2.11.2 Overview TQMa62xx supply

The following table shows all relevant supply voltages of the TQMa62xx.

Table 10: Supply voltages

Module pin / Signal	Voltage	Current	Use
V_3V3_IN	3.201 V to 3.399 V	see Table 11	Input: module supply
V_3V3	3.201 V to 3.399 V	max. 100 mA	Output
V_1V8	1.746 V to 1.854 V	max. 100 mA	Output: for boot configuration
V_VDDSHV5	1.8 V / 3.3 V	< 10 mA	Output: MMC1 IO-Bank supply
V_RTC_IN	2.0 V to 5.5 V	See 3.2.5	Input: supply for module RTC
V_VPP	1.8 V	max. 400 mA	Input: supply for eFuse programming
USB0_VBUS USB1_VBUS	typ. 5 V	< 1 mA	Input: Used to detect the USB-VBUS voltage and is usually supplied with the VBUS voltage switched by the USB host. External circuitry is required – see (2).

Attention: Malfunction	
	If the absolute maximum voltages of the CPU are exceeded, malfunctions and component failures may occur. The mentioned outputs may not be supplied externally under any circumstances.

3.2.11.3 Power sequenzing

After switching on the module supply V_3V3_IN and TQMa62xx_HARD_RST# to HIGH the power-up sequence starts. With completion of the power sequencing the supply of the external mainboard components is signaled via TQM62xx_PGOOD. The following figure shows the chronological sequence of the signals involved.

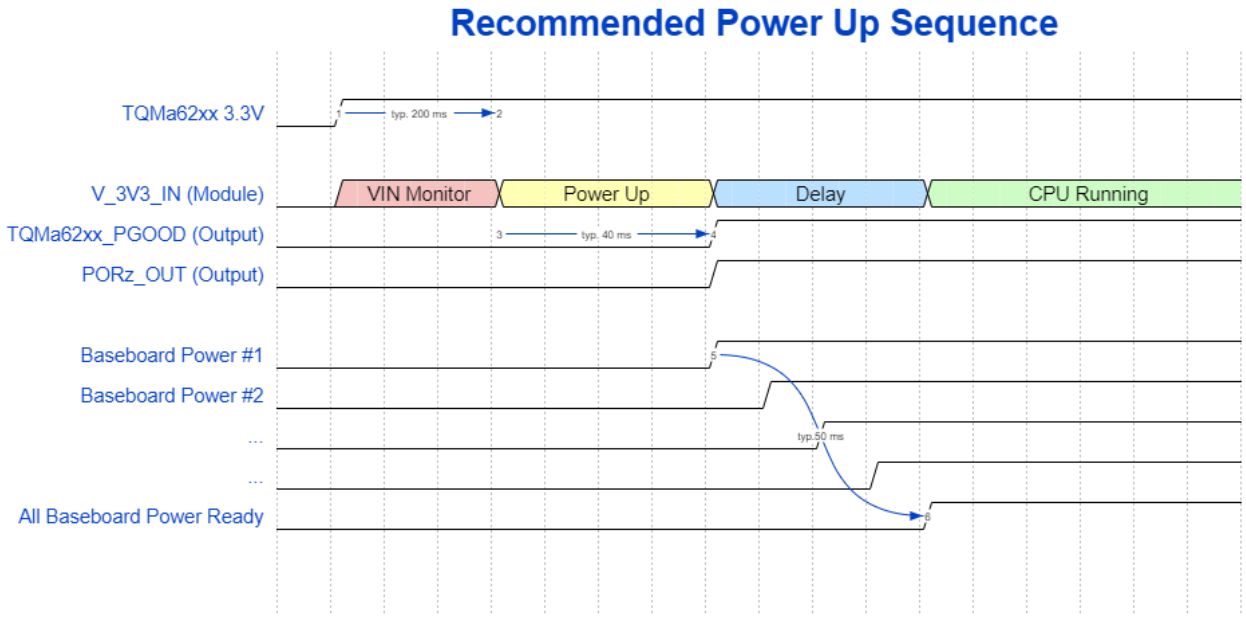


Figure 14: Recommended power up sequence

Attention: Malfunction	
	To avoid cross-supply and errors in the power-up sequence, no I/O pins may be driven by external components until the power-up sequence is completed. The end of the power-up sequence is signaled by a high level of the TQM62xx_PGOOD signal.

3.2.11.4 Power modes

The TQMa62xx has the following power modes:

- Active Mode - The module is powered and everything is active.

Depending of the CPU, the following low power modes can be provided:

- Deep Sleep Mode
  - Module is completely powered
  - All power domains - except GP_Core_CTL - and all clocks OFF
  - DDR interface in self-refresh
- MCU Only
  - Module is completely supplied
  - All power domains - except GP_Core_CTL - and all clocks ON
  - DDR interface in self-refresh

- Standby
  - Module is completely supplied
  - All power domains and clocks ON
  - DDR interface in self-refresh

More information can be found in the AM62x Reference Manual (2).

Independent of the CPU, the following low power modes can be provided:

- Module RTC Mode
  - Module is no longer supplied via V_3V3_IN
  - Only the V_RTC_IN remains supplied and active
  - The current consumption is then only determined by the current consumption of the RTC.
- Self-Refresh Mode (Suspend to RAM)
  - The LPDDR4 memory can be put into self-refresh mode by an SRE command.
  - IDD6 is specified in self-refresh, typ. current consumption at 25 °C ambient temperature is approx. 0.4 mA to 2.7 mA

3.2.11.5 Power consumption

The following table lists some technical parameters of the module supply. The specified current consumptions are to be regarded as a guide value. Since the current consumption of the TQMa62xx can differ greatly depending on the application, modes and operating system, the values listed here should only be used for a performance estimate.

Table 11: Current consumption TQMa62xx

TQMa6442L		
Current consumption Power OFF	11 mA	TQMa62xx_HARD_RST# = LOW
Current consumption Reset mode	79 mA	MCU_PORz = LOW
Current consumption Power Down	10 mA	TQMa62xx_PWRBT# = LOW
Current consumption theoretical worst case	2.4 A	Current consumption @ 3.3 V
Current consumption U-Boot prompt	264 mA	U-Boot Idle
Current consumption Linux prompt	261 mA	Linux Idle
Current consumption Linux (stressapptest -W -s 31536000 -M 256 -m 4 -C 4 -i 4 stress-ng --cpu-load 100 --cpu 4 --timeout 31536000)	391 mA	Higher current consumption must be expected when using additional interfaces in parallel

3.3 TQMa62xx interface

3.3.1 Pin assignment

The TQMa62xx has a total of 320 pins, divided between two module connectors X1 and X2 (each EPT 402-51301-5). Possible connector counterparts for the base board are EPT 401-51301-51 and EPT 401-55301-51 which provide a board-to-board distance of 5 mm and 8 mm.

The electrical and pin characteristics are to be taken from the AM62x (1) **Error! Reference source not found.**.

Attention: Destruction or malfunction	
	The multiple pin configurations of all AM62x internal function units must be taken note of. The pin assignment shown in Table 13 / 14 refers to the corresponding BSP provided by TQ-Systems GmbH.

3.3.2 Pinout TQMa62xx

Table 12: Pinout X1

CPU Ball	IO	Level	Group	Signal	Pin	Pin	Signal	Group	Level	IO	CPU Ball
AC24	O	1.8 V	VOUT0	VOUT0_PCLK	X1-A1	X1-B1	DGND			P	-
-	P			DGND	X1-A2	X1-B2	VOUT0_DATA0	VOUT0	1.8 V	O	U22
AB24	O	1.8 V	VOUT0	VOUT0_HSYNC	X1-A3	X1-B3	VOUT0_DATA1	VOUT0	1.8 V	O	V24
AC25	O	1.8 V	VOUT0	VOUT0_VSYNC	X1-A4	X1-B4	VOUT0_DATA2	VOUT0	1.8 V	O	W25
Y20	O	1.8 V	VOUT0	VOUT0_DE	X1-A5	X1-B5	VOUT0_DATA3	VOUT0	1.8 V	O	W24
-	P			DGND	X1-A6	X1-B6	DGND			P	-
V21	O	1.8 V	VOUT0	VOUT0_DATA8	X1-A7	X1-B7	VOUT0_DATA4	VOUT0	1.8 V	O	Y25
W21	O	1.8 V	VOUT0	VOUT0_DATA9	X1-A8	X1-B8	VOUT0_DATA5	VOUT0	1.8 V	O	Y24
V20	O	1.8 V	VOUT0	VOUT0_DATA10	X1-A9	X1-B9	VOUT0_DATA6	VOUT0	1.8 V	O	Y23
AA23	O	1.8 V	VOUT0	VOUT0_DATA11	X1-A10	X1-B10	VOUT0_DATA7	VOUT0	1.8 V	O	AA25
-	P			DGND	X1-A11	X1-B11	DGND			P	-
AB25	O	1.8 V	VOUT0	VOUT0_DATA12	X1-A12	X1-B12	GPMC0_AD8	GPMC0	1.8 V	IO	R24
AA24	O	1.8 V	VOUT0	VOUT0_DATA13	X1-A13	X1-B13	GPMC0_AD9	GPMC0	1.8 V	IO	R25
Y22	O	1.8 V	VOUT0	VOUT0_DATA14	X1-A14	X1-B14	GPMC0_AD10	GPMC0	1.8 V	IO	T25
AA21	O	1.8 V	VOUT0	VOUT0_DATA15	X1-A15	X1-B15	GPMC0_AD11	GPMC0	1.8 V	IO	R21
-	P			DGND	X1-A16	X1-B16	DGND			P	-
M25	IO	1.8 V	GPMC0	GPMC0_AD0	X1-A17	X1-B17	GPMC0_AD12	GPMC0	1.8 V	IO	T22
N23	IO	1.8 V	GPMC0	GPMC0_AD1	X1-A18	X1-B18	GPMC0_AD13	GPMC0	1.8 V	IO	T24
N24	IO	1.8 V	GPMC0	GPMC0_AD2	X1-A19	X1-B19	GPMC0_AD14	GPMC0	1.8 V	IO	U25
N25	IO	1.8 V	GPMC0	GPMC0_AD3	X1-A20	X1-B20	GPMC0_AD15	GPMC0	1.8 V	IO	U24
-	P			DGND	X1-A21	X1-B21	DGND			P	-
P24	IO	1.8 V	GPMC0	GPMC0_AD4	X1-A22	X1-B22	GPMC0_CS0#	GPMC0	1.8 V	O	M21
P22	IO	1.8 V	GPMC0	GPMC0_AD5	X1-A23	X1-B23	GPMC0_CS1#	GPMC0	1.8 V	O	L21
P21	IO	1.8 V	GPMC0	GPMC0_AD6	X1-A24	X1-B24	GPMC0_CS2#	GPMC0	1.8 V	O	K22
R23	IO	1.8 V	GPMC0	GPMC0_AD7	X1-A25	X1-B25	GPMC0_CS3#	GPMC0	1.8 V	O	K24
-	P			DGND	X1-A26	X1-B26	DGND			P	-
K25	O	1.8 V	GPMC0	GPMC0_WP#	X1-A27	X1-B27	GPMC0_CLK	GPMC0	1.8 V	O	P25
U23	I	1.8 V	GPMC0	GPMC0_WAIT0	X1-A28	X1-B28	DGND			P	-
V25	I	1.8 V	GPMC0	GPMC0_WAIT1	X1-A29	X1-B29	GPMC0_BE0#_CLE	GPMC0	1.8 V	O	M24
L24	O	1.8 V	GPMC0	GPMC0_OE#_RE#	X1-A30	X1-B30	GPMC0_ADV#_ALE	GPMC0	1.8 V	O	L23
L25	O	1.8 V	GPMC0	GPMC0_WE#	X1-A31	X1-B31	GPMC0_BE1#	GPMC0	1.8 V	O	N20
-	P			DGND	X1-A32	X1-B32	GPMC0_DIR	GPMC0	1.8 V	O	M22
D17	I	1.8 V / 3.3 V	MMC1	MMC1_SDCD	X1-A33	X1-B33	DGND			P	-
C17	I	1.8 V / 3.3 V	MMC1	MMC1_SDWP	X1-A34	X1-B34	MMC2_SDCD	MMC2	1.8 V	I	A23
A21	IO	1.8 V / 3.3 V	MMC1	MMC1_CMD	X1-A35	X1-B35	MMC2_SDWP	MMC2	1.8 V	I	B23
-	P			DGND	X1-A36	X1-B36	DGND			P	-
B22	IO	1.8 V / 3.3 V	MMC1	MMC1_CLK	X1-A37	X1-B37	MMC2_CLK	MMC2	1.8 V	IO	D25
-	P			DGND	X1-A38	X1-B38	DGND			P	-
A22	IO	1.8 V / 3.3 V	MMC1	MMC1_DAT0	X1-A39	X1-B39	MMC2_DAT0	MMC2	1.8 V	IO	B24
B21	IO	1.8 V / 3.3 V	MMC1	MMC1_DAT1	X1-A40	X1-B40	MMC2_DAT1	MMC2	1.8 V	IO	C25

3.3.2 Pinout TQMa62xx (Table continued)

CPU Ball	IO	Level	Group	Signal	Pin	Pin	Signal	Group	Level	IO	CPU Ball
C21	IO	1.8 V / 3.3 V	MMC1	MMC1_DAT2	X1-A41	X1-B41	MMC2_DAT2	MMC2	1.8 V	IO	E23
D22	IO	1.8 V / 3.3 V	MMC1	MMC1_DAT3	X1-A42	X1-B42	MMC2_DAT3	MMC2	1.8 V	IO	D24
-	P			DGND	X1-A43	X1-B43	DGND			P	-
B20	IO	1.8 V	MCASP0	MCASP0_ACLKX	X1-A44	X1-B44	MMC2_CMD	MMC2	1.8 V	IO	C24
-	P			DGND	X1-A45	X1-B45	DGND			P	-
A20	IO	1.8 V	MCASP0	MCASP0_ACLKR	X1-A46	X1-B46	I2C0_SCL	I2C0	1.8 V	IO	B16
E19	IO	1.8 V	MCASP0	MCASP0_AFSR	X1-A47	X1-B47	I2C0_SDA	I2C0	1.8 V	IO	A16
-	P			DGND	X1-A48	X1-B48	I2C1_SDA	I2C1	1.8 V	IO	A17
D20	IO	1.8 V	MCASP0	MCASP0_AFSX	X1-A49	X1-B49	I2C1_SCL	I2C1	1.8 V	IO	B17
-	P			DGND	X1-A50	X1-B50	DGND			P	-
B19	IO	1.8 V	MCASP0	MCASP0_AXR3	X1-A51	X1-B51	UART0_CTS#	UART0	1.8 V	I	A15
A19	IO	1.8 V	MCASP0	MCASP0_AXR2	X1-A52	X1-B52	UART0_RTS#	UART0	1.8 V	O	B15
B18	IO	1.8 V	MCASP0	MCASP0_AXR1	X1-A53	X1-B53	UART0_RXD	UART0	1.8 V	I	D14
E18	IO	1.8 V	MCASP0	MCASP0_AXR0	X1-A54	X1-B54	UART0_TXD	UART0	1.8 V	O	E14
-	P			DGND	X1-A55	X1-B55	DGND			P	-
E15	I	1.8 V	MCAN0	MCAN0_RX	X1-A56	X1-B56	SPI0_CLK	SPI0	1.8 V	IO	A14
C15	O	1.8 V	MCAN0	MCAN0_TX	X1-A57	X1-B57	SPI0_D0	SPI0	1.8 V	IO	B13
-	P			DGND	X1-A58	X1-B58	SPI0_D1	SPI0	1.8 V	IO	B14
C13	IO	1.8 V	SPI0	SPI0_CS1	X1-A59	X1-B59	SPI0_CS0	SPI0	1.8 V	IO	A13
B10	I	1.8 V	Debug	TRST#	X1-A60	X1-B60	DGND			P	-
A11	I	1.8 V	Debug	TDI	X1-A61	X1-B61	MCU_I2C0_SCL	MCU_I2C0	1.8 V	IO	A8
B11	I	1.8 V	Debug	TMS	X1-A62	X1-B62	MCU_I2C0_SDA	MCU_I2C0	1.8 V	IO	D10
D12	OZ	1.8 V	Debug	TDO	X1-A63	X1-B63	WKUP_I2C0_SDA	WKUP_I2C0	1.8 V	IO	A9
A10	I	1.8 V	Debug	TCK	X1-A64	X1-B64	WKUP_I2C0_SCL	WKUP_I2C0	1.8 V	IO	B9
-	P			DGND	X1-A65	X1-B65	DGND			P	-
E12	IO	1.8 V	Debug	EMU0	X1-A66	X1-B66	MCU_MCAN0_RX	MCU_MCAN0	1.8 V	I	B3
C11	IO	1.8 V	Debug	EMU1	X1-A67	X1-B67	MCU_MCAN0_TX	MCU_MCAN0	1.8 V	O	D6
-	P			DGND	X1-A68	X1-B68	MCU_MCAN1_RX	MCU_MCAN1	1.8 V	I	D4
A7	IO	1.8 V	MCU_SPI0	MCU_SPI0_CLK	X1-A69	X1-B69	MCU_MCAN1_TX	MCU_MCAN1	1.8 V	O	E5
-	P			DGND	X1-A70	X1-B70	DGND			P	-
D9	IO	1.8 V	MCU_SPI0	MCU_SPI0_D0	X1-A71	X1-B71	WKUP_UART0_RXD	WKUP_UART0	1.8 V	I	B4
C9	IO	1.8 V	MCU_SPI0	MCU_SPI0_D1	X1-A72	X1-B72	WKUP_UART0_TXD	WKUP_UART0	1.8 V	O	C5
E8	IO	1.8 V	MCU_SPI0	MCU_SPI0_CS0	X1-A73	X1-B73	WKUP_UART0_CTS#	WKUP_UART0	1.8 V	I	C6
B8	IO	1.8 V	MCU_SPI0	MCU_SPI0_CS1	X1-A74	X1-B74	WKUP_UART0_RTS#	WKUP_UART0	1.8 V	O	A4
-	P			DGND	X1-A75	X1-B75	DGND			P	-
B5	I	1.8 V	MCU_UART0	MCU_UART0_RXD	X1-A76	X1-B76	OSPI0_CS1#	OSPI0	1.8 V	O	G21
A5	O	1.8 V	MCU_UART0	MCU_UART0_TXD	X1-A77	X1-B77	OSPI0_CS2#	OSPI0	1.8 V	O	H21
A6	I	1.8 V	MCU_UART0	MCU_UART0_CTS#	X1-A78	X1-B78	OSPI0_CS3#	OSPI0	1.8 V	O	E24
B6	O	1.8 V	MCU_UART0	MCU_UART0_RTS#	X1-A79	X1-B79	DGND			P	-
-	P			DGND	X1-A80	X1-B80	OSPI0_LBCLKO	OSPI0	1.8 V		G25

Table 13: Pinout X2

CPU Ball	IO	Level	Group	Signal	Pin	Pin	Signal	Group	Level	IO	CPU Ball
-	P	3.3 V	Power	V_3V3_IN	X2-A1	X2-B1	V_3V3_IN	Power	3.3 V	P	-
-	P	3.3 V	Power	V_3V3_IN	X2-A2	X2-B2	V_3V3_IN	Power	3.3 V	P	-
-	P	3.3 V	Power	V_3V3_IN	X2-A3	X2-B3	V_3V3_IN	Power	3.3 V	P	-
-	P			DGND	X2-A4	X2-B4	DGND			P	-
-	P	2.0 V… 5.5 V	RTC	V_RTC_IN	X2-A5	X2-B5	V_VDDSHV5	Power	1.8 V / 3.3 V	O	G17
-	P			DGND	X2-A6	X2-B6	DGND			P	-
-	P	1.8 V	-	V_RTC	X2-A7	X2-B7	V_3V3	Power	3.3 V	O	-
-	P			DGND	X2-A8	X2-B8	V_1V8	Power	1.8 V	O	-
-	P	0.85 V	-	V_0V85	X2-A9	X2-B9	DGND			P	-
-	P			DGND	X2-A10	X2-B10	TQ_EEPROM_WC#	-	1.8 V	I	-
-	IO	1.8 V	Secure	SE_ISO7816_IO1	X2-A11	X2-B11	V_1V1	-	1.1 V	P	-
-	IO	1.8 V	Secure	SE_ISO7816_IO2	X2-A12	X2-B12	V_VDD_CORE	-	0.75 V / 0.85 V	P	-
-	I	1.8 V	Secure	SE_ISO7816_RST#	X2-A13	X2-B13	DGND			P	-
-	P			DGND	X2-A14	X2-B14	V_1V8_AUX	-	1.8 V	P	-
-	I	1.8 V	Secure	SE_ISO7816_CLK	X2-A15	X2-B15	VSEL_SD	System	3.3 V	I	-
-	P			DGND	X2-A16	X2-B16	DGND			P	-
-	IO	1.8 V	Secure	SE_ISO14443_LA	X2-A17	X2-B17	TQMa62xx_HARD_RST#	Reset	3.3 V	I	-
-	IO	1.8 V	Secure	SE_ISO14443_LB	X2-A18	X2-B18	MCU_PORz	Reset	1.8 V	I	D2
-	P			DGND	X2-A19	X2-B19	MCU_RESETz	Reset	1.8 V	I	E11
-	I	1.8 V	Secure	SE_ENA	X2-A20	X2-B20	RESET_REQz	Reset	1.8 V	I	F20
-	P			DGND	X2-A21	X2-B21	PORz_OUT	Reset	1.8 V	O	E21
AE19	IO	1.8 V	RGMII1	RGMII1_TXC	X2-A22	X2-B22	MCU_RESETSTATz	Reset	1.8 V	O	B12
-	P			DGND	X2-A23	X2-B23	RESETSTATz	Reset	1.8 V	O	F22
AD19	O	1.8 V	RGMII1	RGMII1_TX_CTL	X2-A24	X2-B24	TQMa62xx_PGOOD	System	1.8 V	O	-
AE20	O	1.8 V	RGMII1	RGMII1_TD0	X2-A25	X2-B25	TQMa62xx_PWRBT#	System	3.3 V	I	-
-	P			DGND	X2-A26	X2-B26	DGND			P	-
AD20	O	1.8 V	RGMII1	RGMII1_TD1	X2-A27	X2-B27	RTC_CLKOUT	RTC	1.8 V	O	-
AE18	O	1.8 V	RGMII1	RGMII1_TD2	X2-A28	X2-B28	DGND			P	-
AD18	O	1.8 V	RGMII1	RGMII1_TD3	X2-A29	X2-B29	RTC_INT#	RTC	1.8 V / 3.3 V	O	-
-	P			DGND	X2-A30	X2-B30	TEMP_ALERT	TEMP	1.8 V / 3.3 V	O	-
AD17	I	1.8 V	RGMII1	RGMII1_RXC	X2-A31	X2-B31	CUST_EEPROM_WC#	EEPROM	1.8 V	I	-
-	P			DGND	X2-A32	X2-B32	EXTINT#	System	1.8 V	I	D16
AE17	I	1.8 V	RGMII1	RGMII1_RX_CTL	X2-A33	X2-B33	MCU_ERROR#	System	1.8 V	IO	D1
AB17	I	1.8 V	RGMII1	RGMII1_RD0	X2-A34	X2-B34	DGND			P	-
AC17	I	1.8 V	RGMII1	RGMII1_RD1	X2-A35	X2-B35	MDIO0_MDIO	MDIO0	1.8 V	IO	AB22
-	P		-	DGND	X2-A36	X2-B36	DGND			P	-
AB16	I	1.8 V	RGMII1	RGMII1_RD2	X2-A37	X2-B37	MDIO0_MDC	MDIO0	1.8 V	O	AD24
AA15	I	1.8 V	RGMII1	RGMII1_RD3	X2-A38	X2-B38	DGND			P	-
-	P			DGND	X2-A39	X2-B39	RGMII2_TXC	RGMII2	1.8 V	IO	AE21
AB14	I	1.8 V	CSI0	CSI0_RXN0	X2-A40	X2-B40	DGND			P	-
AC15	I	1.8 V	CSI0	CSI0_RXP0	X2-A41	X2-B41	RGMII2_TX_CTL	RGMII2	1.8 V	O	AA19
-	P			DGND	X2-A42	X2-B42	RGMII2_TD0	RGMII2	1.8 V	O	Y18
AD14	I	1.8 V	CSI0	CSI0_RXN1	X2-A43	X2-B43	DGND			P	-
AE14	I	1.8 V	CSI0	CSI0_RXP1	X2-A44	X2-B44	RGMII2_TD1	RGMII2	1.8 V	O	AA18
-	P			DGND	X2-A45	X2-B45	DGND			P	-
AD15	I	1.8 V	CSI0	CSI0_RXCLKN	X2-A46	X2-B46	RGMII2_TD2	RGMII2	1.8 V	O	AD21

3.3.2 Pinout TQMa62xx (Table continued)

CPU Ball	IO	Level	Group	Signal	Pin	Pin	Signal	Group	Level	IO	CPU Ball
AE15	I	1.8 V	CSI0	CSI0_RXCLKP	X2-A47	X2-B47	DGND			P	-
-	P			DGND	X2-A48	X2-B48	RGMII2_TD3	RGMII2	1.8 V	O	AC20
AD13	I	1.8 V	CSI0	CSI0_RXN2	X2-A49	X2-B49	DGND			P	-
AE13	I	1.8 V	CSI0	CSI0_RXP2	X2-A50	X2-B50	RGMII2_RXC	RGMII2	1.8 V	I	AD23
-	P			DGND	X2-A51	X2-B51	DGND			P	-
AB12	I	1.8 V	CSI0	CSI0_RXN3	X2-A52	X2-B52	RGMII2_RX_CTL	RGMII2	1.8 V	I	AD22
AC13	I	1.8 V	CSI0	CSI0_RXP3	X2-A53	X2-B53	RGMII2_RD0	RGMII2	1.8 V	I	AE23
-	P	1.8 V	-	V_1V8A	X2-A54	X2-B54	RGMII2_RD1	RGMII2	1.8 V	I	AB20
-	P			DGND	X2-A55	X2-B55	DGND			P	-
-	-	1.8 V	-	RFU1	X2-A56	X2-B56	RGMII2_RD2	RGMII2	1.8 V	I	AC21
-	P			DGND	X2-A57	X2-B57	DGND			P	-
A12	O	1.8 V	WKUP	WKUP_CLKOUT0	X2-A58	X2-B58	RGMII2_RD3	RGMII2	1.8 V	I	AE22
-	P			DGND	X2-A59	X2-B59	DGND			P	-
A18	I	1.8 V	EXT	EXT_REFCLK1	X2-A60	X2-B60	USB0_DP	USB0	1.8 V	IO	AD11
-	P			DGND	X2-A61	X2-B61	USB0_DM	USB0	1.8 V	IO	AE11
AC11	I	max. 3.6 V	USB0	USB0_VBUS	X2-A62	X2-B62	DGND			P	-
C20	O	1.8 V	USB0	USB0_DRVVBUS	X2-A63	X2-B63	USB1_DP	USB1	1.8 V		AE9
AB10	I	max. 3.6 V	USB1	USB1_VBUS	X2-A64	X2-B64	USB1_DM	USB1	1.8 V		AD10
-	P			DGND	X2-A65	X2-B65	DGND			P	-
F18	O	1.8 V	USB1	USB1_DRVVBUS	X2-A66	X2-B66	V_VPP	Power	1.8 V	P	J8
AE7	IO	-	OLDI0	OLDI0_A7P	X2-A67	X2-B67	OLDI0_A3P	OLDI0	1.8 V	IO	AA7
AD8	IO	-	OLDI0	OLDI0_A7N	X2-A68	X2-B68	OLDI0_A3N	OLDI0	1.8 V	IO	AB6
-	P			DGND	X2-A69	X2-B69	DGND			P	-
AD5	IO	-	OLDI0	OLDI0_CLK1P	X2-A70	X2-B70	OLDI0_CLK0P	OLDI0	1.8 V	IO	AE3
AE4	IO	-	OLDI0	OLDI0_CLK1N	X2-A71	X2-B71	OLDI0_CLK0N	OLDI0	1.8 V	IO	AD4
-	P			DGND	X2-A72	X2-B72	DGND			P	-
AD7	IO	-	OLDI0	OLDI0_A6P	X2-A73	X2-B73	OLDI0_A2P	OLDI0	1.8 V	IO	AA8
AE6	IO	-	OLDI0	OLDI0_A6N	X2-A74	X2-B74	OLDI0_A2N	OLDI0	1.8 V	IO	Y8
-	P			DGND	X2-A75	X2-B75	DGND			P	-
AD6	IO	-	OLDI0	OLDI0_A5P	X2-A76	X2-B76	OLDI0_A1P	OLDI0	1.8 V	IO	AB4
AE5	IO	-	OLDI0	OLDI0_A5N	X2-A77	X2-B77	OLDI0_A1N	OLDI0	1.8 V	IO	AD3
-	P			DGND	X2-A78	X2-B78	DGND			P	-
AC5	IO	-	OLDI0	OLDI0_A4P	X2-A79	X2-B79	OLDI0_A0P	OLDI0	1.8 V	IO	Y6
AC6	IO	-	OLDI0	OLDI0_A4N	X2-A80	X2-B80	OLDI0_A0N	OLDI0	1.8 V	IO	AA5

4. SOFTWARE

TheTQMa62xx is shipped with a specially adapted bootloader, which is configured for use on an MBa62xx.
This bootloader contains module specific as well as board specific adjustments like e.g.

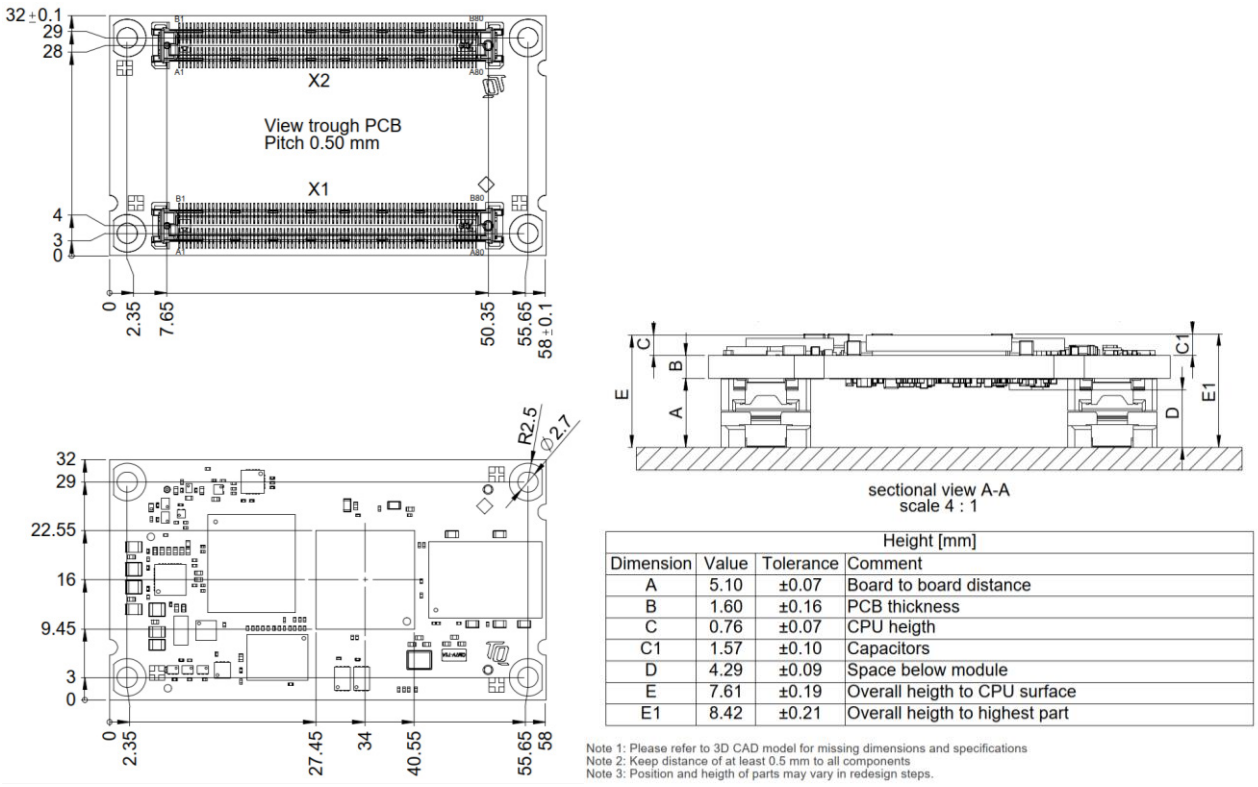
- CPU configuration
- RAM configuration / timing
- Muxing
- Clocks
- Driver strengths

When using a different bootloader this data has to be adapted. Details can be requested from TQ support. More information can be found in the Support Wiki for the TQMa62xx.

5. MECHANICS

5.1 TQMa62xx dimensions and footprint

The overall dimensions (length × width) of the TQMa62xx are 58.0 mm × 32.0 mm (± 0.1 mm).
Mounting hole: 4 x 2.7 mm (diameter).
The mass of TQMa62xx is 11 g (± 2 g).



Height [mm]			
Dimension	Value	Tolerance	Comment
A	5.10	±0.07	Board to board distance
B	1.60	±0.16	PCB thickness
C	0.76	±0.07	CPU heigth
C1	1.57	±0.10	Capacitors
D	4.29	±0.09	Space below module
E	7.61	±0.19	Overall heigth to CPU surface
E1	8.42	±0.21	Overall heigth to highest part

Note 1: Please refer to 3D CAD model for missing dimensions and specifications
Note 2: Keep distance of at least 0.5 mm to all components
Note 3: Position and heigth of parts may vary in redesign steps.

Figure 15: Dimensions

5.2 TQMa62xx component placement and labeling

The label AK1 includes TQ serial number, MAC address, and product name.

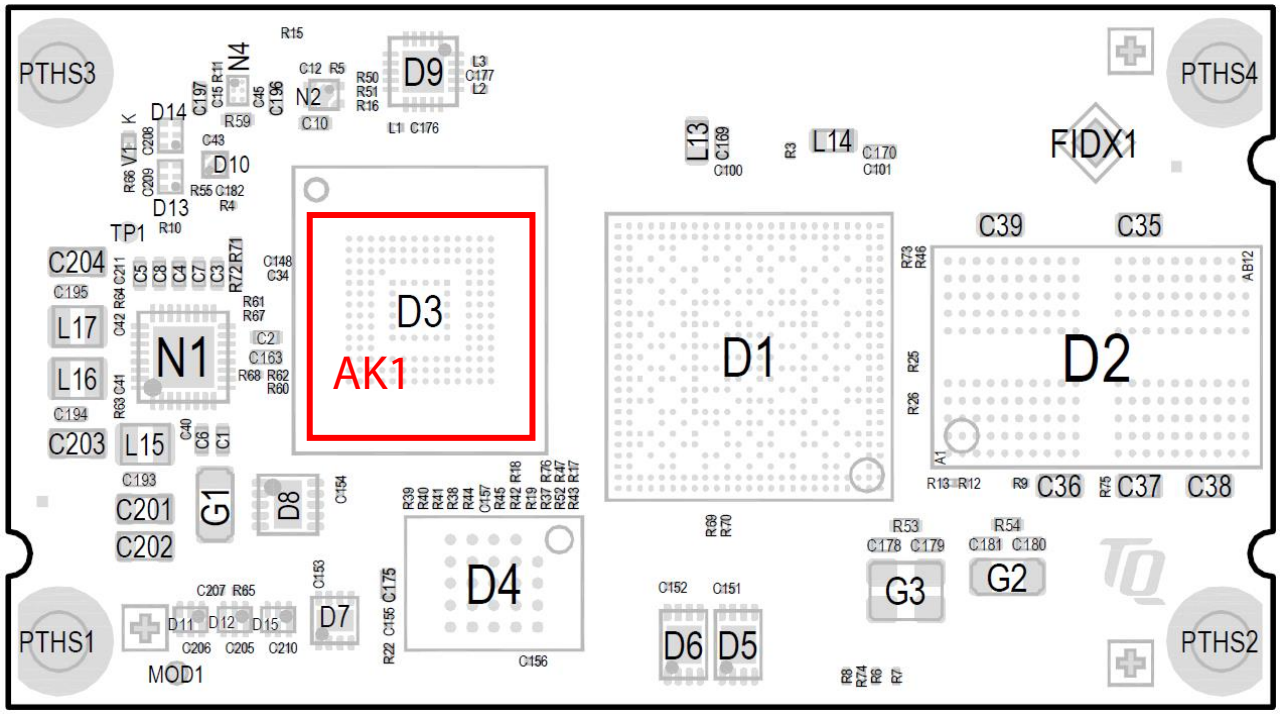


Figure 16: TQMa62xx top view

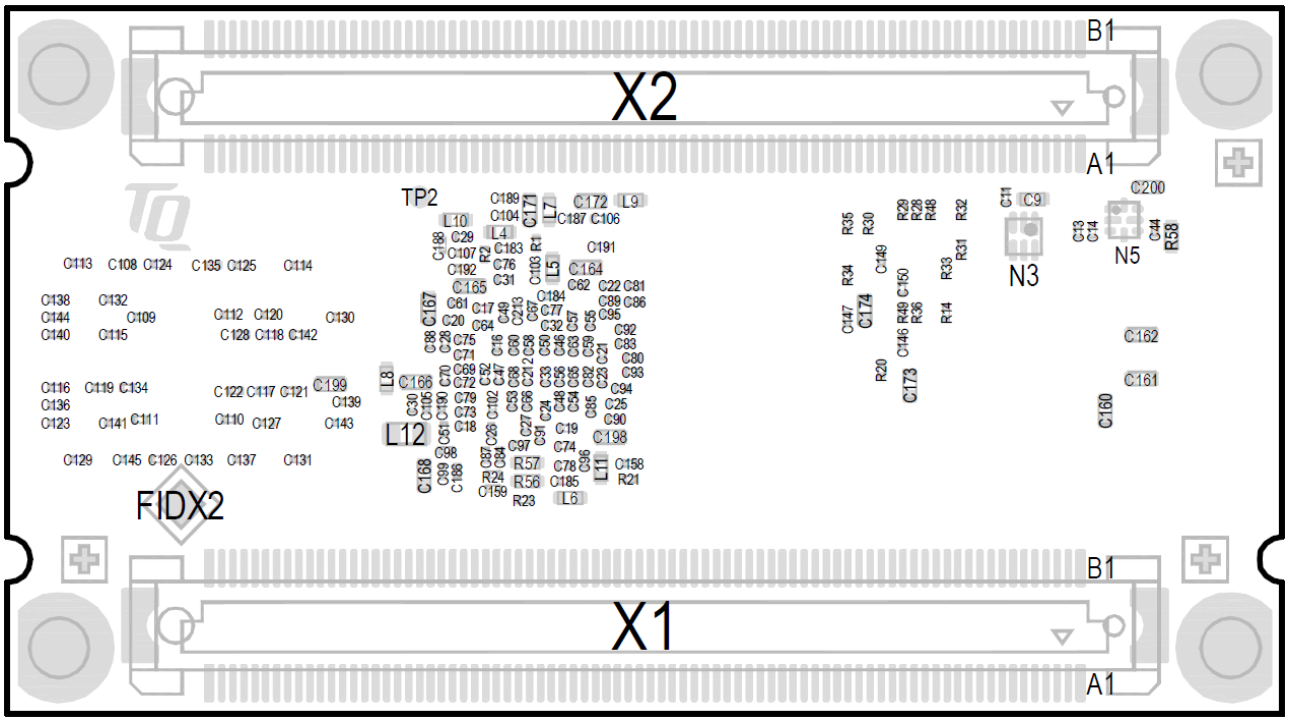


Figure 17: TQMa62xx bottom view

5.3 Protection against external effects

As an embedded module the TQMa62xx is not protected against dust, external impact and contact (IP00).
Adequate protection has to be guaranteed by the surrounding system.

5.4 Thermal management

The power dissipation mainly depends on the software used and can vary according to the application. The power dissipation mainly arises at the processor, the switching regulators and the LPDDR4 devices. It is the customer's responsibility to define a suitable cooling method for his use case.

Attention: Destruction or malfunction, TQMa62xx cooling	
	The AM62x belongs to a performance category in which a cooling system is essential. It is the user's sole responsibility to define a suitable heat sink (weight and mounting position) depending on the specific mode of operation (e.g., dependence on clock frequency, stack height, airflow, and software). Particularly the tolerance chain (PCB thickness, board warpage, BGA balls, BGA package, thermal pad, heatsink) as well as the maximum pressure on the AM62x must be taken into consideration when connecting the heat sink, see **Error! Reference source not found.**. The AM62x is not necessarily the highest component. Inadequate cooling connections can lead to overheating of the TQMa62xx and thus malfunction, deterioration or destruction.

5.5 Structural requirements

The TQMa62xx is held in the connectors with a considerable holding force. It is recommended to use a pulling tool to avoid damaging the connectors of the TQMa62xx as well as those of the base board when removing the TQMa62xx.
If the requirements for vibration and shock resistance are high, a module holder must be provided in the final application to additionally hold the TQMa62xx in position. Since no heavy and large components are used, no further requirements are needed.

6. SAFETY REQUIREMENTS AND PROTECTIVE REGULATIONS

6.1 EMC

The TQMa62xx 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 permanent clocked lines (e.g., clock) should be kept short; avoid interference of other signals by distance and/or shielding besides, take note of not only the frequency, but also the signal rise times
- Filtering of all signals, which can be connected externally (also "slow signals" and DC can radiate RF indirectly)

6.2 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 arranged directly at the inputs of a system.
As these measures always have to be implemented on the carrier board, no special preventive measures were planned on the TQMa62xx.
Following measures are recommended for a carrier board:

- Generally applicable: Shielding of the inputs (shielding connected well to ground / housing on both ends)
- Supply voltages: Protection by suppressor diode(s)
- Slow signal lines: RC filtering, Zener diode(s)
- Fast signal lines: Integrated protective devices (e.g., suppressor diode arrays)

6.3 Operational safety and personal security

Due to the occurring voltages (≤ 3.3 V DC), tests with respect to the operational and personal safety haven't been carried out.

6.4 Climatic and operational conditions

The temperature range, in which the TQMa62xx works reliably, strongly depends on the installation situation (heat dissipation by heat conduction and convection); hence, no fixed value can be given for the whole assembly.
In general, a reliable operation is given when following conditions are met:

Table 14: Climate and operational conditions industrial temperature range

Parameter	Range	Remark
Environmental temperature	–40 °C to +85 °C	With appropriate cooling
Permitted storage temperature	–40 °C to +100 °C	–
Relative humidity (operating / storage)	10 % to 90 %	Not condensing

6.5 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.

6.6 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.

6.7 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

6.8 Reliability and service life

For the TQMa62xx, a constant error rate results in an MTBF of approximately 1,044,757 hours (TQMa6254).

Attention must be paid to a construction that is insensitive to vibration and shock.

Service life-limiting components such as electrolytic capacitors were not used.

6.9 Environment protection

6.9.1 RoHS

The TQMa62xx is manufactured RoHS compliant.

- All components and assemblies are RoHS compliant
- The soldering processes are RoHS compliant

6.9.2 WEEE®

The final distributor is responsible for compliance with the WEEE® regulation.

Within the scope of the technical possibilities, the TQMa62xx was designed to be recyclable and easy to repair.

6.10 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.

6.11 EuP

The Ecodesign Directive, also Energy using Products (EuP), is applicable to products for the end user with an annual quantity >200,000. The TQMa62xx must therefore always be seen in conjunction with the complete device.

The available standby and sleep modes of the components on the TQMa62xx enable compliance with EuP requirements for the TQMa62xx.

6.12 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.

6.13 Battery

No batteries are used on the TQMa62xx.

6.14 Packaging

By environmentally friendly processes, production equipment and products, we contribute to the protection of our environment. To be able to reuse the TQMa62xx, 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 TQMa62xx is delivered in reusable packaging.

6.15 Other entries

The energy consumption of this subassembly is minimised by suitable measures.

Because currently 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.

7. APPENDIX

7.1 Acronyms and definitions

The following acronyms and abbreviations are used in this document:

Table 15: Acronyms

Acronym	Meaning
ADC	Analog/Digital Converter
AIN	Analog In
ARM®	Advanced RISC Machine
AVS	Adaptive Voltage Scaling
BIOS	Basic Input/Output System
BSP	Board Support Package
CAN	Controller Area Network
DC	Direct Current
DDR3L	Double Data Rate Type three Low voltage
DIN	Deutsche Industrie Norm
DVS	Dynamic Voltage Scaling
EEPROM	Electrically Erasable Programmable Read-only Memory
EMC	Electro-Magnetic Compatibility
eMMC	embedded Multi-Media Card
EN	Europäische Norm
ESD	Electro-Static Discharge
EU	European Union
EuP	Energy using Products
FR-4	Flame Retardant 4
GMII	Gigabit Media Independent Interface
GPIO	General Purpose Input/Output
GPMC	General Purpose Memory Controller
I2C	Inter-Integrated Circuit
I2S	Inter-Integrated Sound
IP	Ingress Protection
JTAG	Joint Test Action Group
LCD	Liquid Crystal Display
MAC	Media Access Control
MCASP	Multichannel Audio Serial Port
MCSPI	Multichannel Serial Port Interface
MD	Management Data
MII	Media-Independent Interface
MMC	Multi-Media Card
MTBF	Mean operating Time Between Failures

7.1 Acronyms and definitions (continued)

Table 15: Acronyms (continued)

Acronym	Meaning
n.a.	Not Available
NC	Not Connected
PCB	Printed Circuit Board
PCMCIA	People Can't Memorize Computer Industry Acronyms
PD	Pull-Down
PHY	Physical (layer of the OSI model)
PMIC	Power Management Integrated Circuit
PRCM	Power and Clock Management
PU	Pull-Up
PWM	Pulse-Width Modulation
RC	Resistor-Capacitor
REACH®	Registration, Evaluation, Authorisation (and restriction of) Chemicals
RF	Radio Frequency
RFU	Reserved for Future Usage
RGB	Red Green Blue
RGMII	Reduced Gigabit Media Independent Interface
RMII	Reduced Media Independent Interface
RoHS	Restriction of (the use of certain) Hazardous Substances
ROM	Read-Only Memory
RTC	Real-Time Clock
SD	Secure Digital
SDIO	Secure Digital Input Output
SDRAM	Synchronous Dynamic Random Access Memory
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
UM	User's Manual
USB	Universal Serial Bus
WEEE®	Waste Electrical and Electronic Equipment
WP	Write-Protection
WXGA	Wide Extended Graphics Array

7.2 References

Table 16: Further applicable documents

No.	Name	Rev. / Date	Company
(1)	AM62x Sitara Processors Datasheet	A / Nov. 2022	Texas Instruments
(2)	AM62x Processors Silicon Revision 1.0 Technical Reference Manual	A / Nov 2022	Texas Instruments
(3)	AM62x Processor Errata	A / Jul. 2022	Texas Instruments
(4)	MBa62xx User's Manual	– current –	TQ-Systems
(5)	Support-Wiki for the TQMa62xx	– current –	TQ-Systems
(6)	Processing instructions for TQMa62xx	– current –	TQ-Systems

TQ-Systems GmbH
Mühlstraße 2 I Gut Delling I 82229 Seefeld
Info@TQ-Group | TQ-Group

Technology in Quality