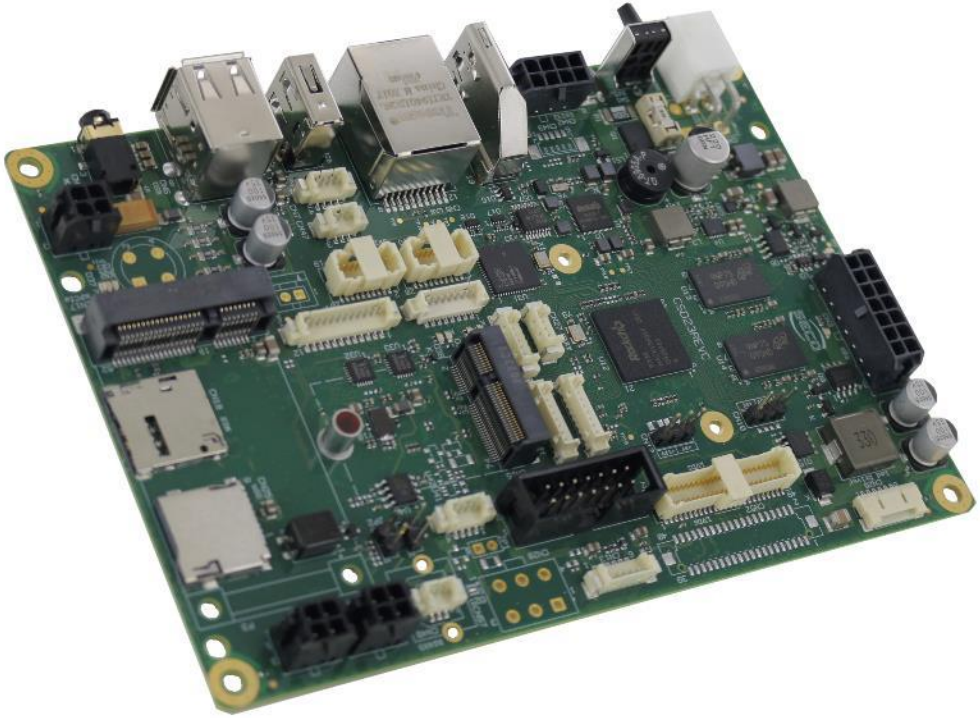
SBC

User Manual



SBC-D23

Single Board Computer
with the Rockchip PX30 SoC
on 3.5” form factor

SECO

www.seco.com

REVISION HISTORY

Revision	Date	Note	Ref
1.0	9 November 2021	First Official Release.	SB

Every effort has been made to ensure the accuracy of this manual. However, SECO S.p.A. accepts no responsibility for any inaccuracies, errors or omissions herein. SECO S.p.A. reserves the right to change precise specifications without prior notice to supply the best product possible.

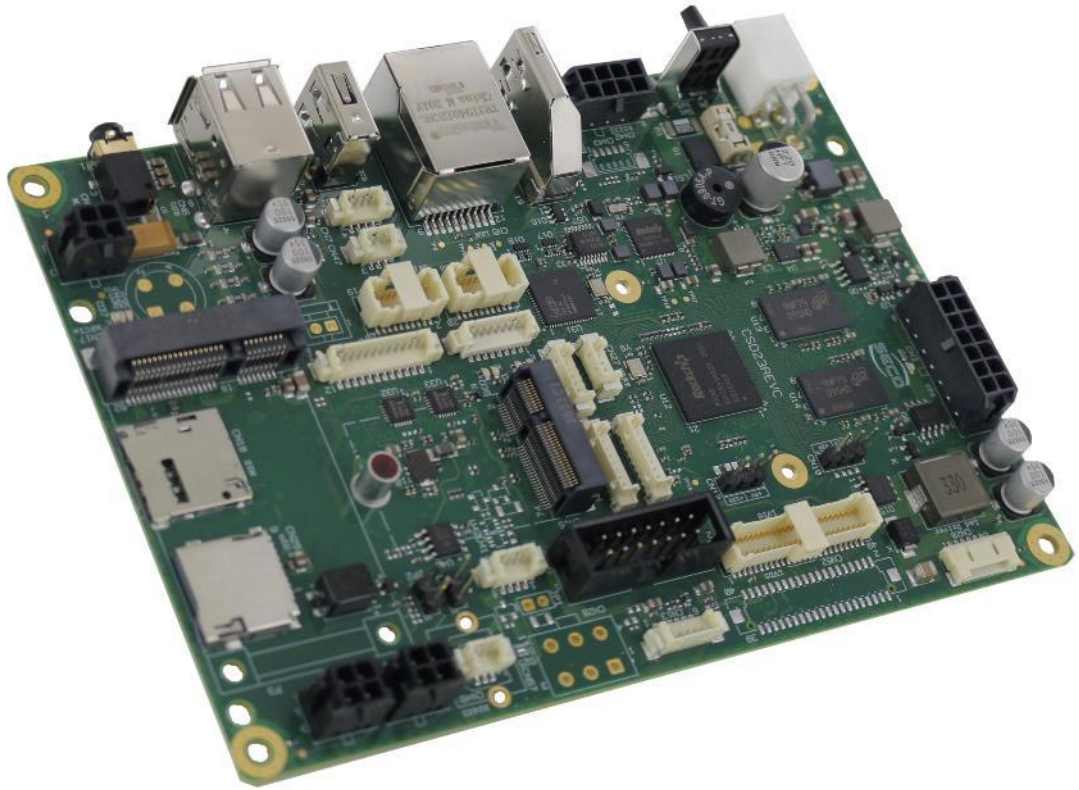
For further information on this module or other SECO products, but also to get the required assistance for any and possible issues, please contact us using the dedicated web form available at http://www.seco.com (registration required).

Our team is ready to assist.

INDEX

Chapter 1.
INTRODUCTION

- Warranty
- Information and assistance
- RMA number request
- Safety
- Electrostatic discharges
- RoHS compliance
- Safety Policy
- Terminology and definitions
- Reference specifications



1.1 Warranty

This product is subject to the Italian Law Decree 24/2002, acting European Directive 1999/44/CE on matters of sale and warranties to consumers.

The warranty on this product lasts for 1 year.

Under the warranty period, the Supplier guarantees the buyer assistance and service for repairing, replacing or credit of the item, at the Supplier's own discretion.

Shipping costs that apply to non-conforming items or items that need replacement are to be paid by the customer.

Items cannot be returned unless previously authorized by the supplier.

The authorization is released after completing the specific form available on the website http://www.seco.com/en/prerma (RMA Online). The RMA authorization number must be put both on the packaging and on the documents shipped with the items, which must include all the accessories in their original packaging, with no signs of damage to, or tampering with, any returned item.

The error analysis form identifying the fault type must be completed by the customer and has must accompany the returned item.

If any of the above-mentioned requirements for the RMA is not satisfied, the item will be shipped back and the customer will have to pay any and all shipping costs.

Following a technical analysis, the supplier will verify if all the requirements, for which a warranty service applies, are met. If the warranty cannot be applied, the Supplier will calculate the minimum cost of this initial analysis on the item and the repair costs. Costs for replaced components will be calculated separately.

Warning!
All changes or modifications to the equipment not explicitly approved by SECO S.p.A. could impair the equipment's functionalities and could void the warranty.

1.2 Information and assistance

What do I have to do if the product is faulty?

SECO S.p.A. offers the following services:

- SECO website: visit http://www.seco.com to receive the latest information on the product. In most cases it is possible to find useful information to solve the problem.
- SECO Sales Representative: the Sales Rep can help to determine the exact cause of the problem and search for the best solution.
- SECO Help-Desk: contact SECO Technical Assistance. A technician is at disposal to understand the exact origin of the problem and suggest the correct solution.

  E-mail: technical.service@seco.com

  Fax (+39) 0575 340434
- Repair centre: it is possible to send the faulty product to the SECO Repair Centre. In this case, follow this procedure:
  - Returned items must be accompanied by a RMA Number. Items sent without the RMA number will be not accepted.
  - Returned items must be shipped in an appropriate package. SECO is not responsible for damages caused by accidental drop, improper usage, or customer neglect.

Note: Please have the following information before asking for technical assistance:

- Name and serial number of the product;
- Description of Customer's peripheral connections;
- Description of Customer's software (operating system, version, application software, etc.);
- A complete description of the problem;
- The exact words of every kind of error message encountered.

1.3 RMA number request

To request a RMA number, please visit SECO's web-site. On the home page, please select "RMA Online" and follow the procedure described.

A RMA Number will be sent within 1 working day (only for on-line RMA requests).

1.4 Safety

The SBC-D23 board uses only extremely low voltages.

While handling the board, please use extreme caution to avoid any kind of risk or damages to electronic components.

Always switch the power off, and unplug the power supply unit, and wait that the board has already cooled down before handling the board and/or connecting cables or other boards.

Avoid using metallic components - like paper clips, screws and similar - near the board when connected to a power supply, to avoid short circuits due to unwanted contacts with other board components.

If the board has become wet, never connect it to any external power supply unit or battery.

Check carefully that all cables are correctly connected and that they are not damaged.

1.5 Electrostatic discharges

The SBC-D23 board, like any other electronic product, is an electrostatic sensitive device: high voltages caused by static electricity could damage some or all the devices and/or components on-board.

Whenever handling an SBC-D23 board, ground yourself through an anti-static wrist strap. Placement of the board on an anti-static surface is also highly recommended.

1.6 RoHS compliance

The SBC-D23 board is designed using RoHS compliant components and is manufactured on a lead-free production line. It is therefore fully RoHS compliant.

1.7 Safety Policy

In order to meet the safety requirements of EN62368-1:2014 standard for Audio/Video, information and communication technology equipment, the SBC-D23 Module shall be:

- used exclusively inside a fire enclosure made of non-combustible material or V-1 material (the fire enclosure is not necessary if the maximum power supplied to the board never exceeds 100 W, even in worst-case fault);
- used inside an enclosure provided with the symbol IEC 60417-5041 (element 1a according to clause 9.5.2 of the IEC 62368-1) on the external part;
- used inside an enclosure compliant with all applicable IEC 62368-1 requirements
- used along with CPU Heatspreader/heatsinks designed according to the thermal characteristics indicated in the par. 2.2 and to the mechanical characteristics indicated in par. 2.4. The board in its enclosure must be evaluated for temperature and airflow considerations.
- installed in a way that prevents the access to the board from children

The manufacturer which include a SBC-D23 module in his end-user product shall:

- verify the compliance with all applicable clauses of the IEC 62368-1 in its own final operating condition;
- check that all connections form or to the board are compliant to ES1 requirements;
- provide an instructional safeguard against thermal injuries, according to clause 9.4.2 of the above mentioned standard. This instructional safeguard must be placed both on end-user product's User Manual and on the products itself (Danger Label, it must be placed near the CPU or its heatsink).

The board shall be powered by a Power Supply Unit separately approved and classified ES1/PS2 according to the requirements of IEC EN 62368-1.

1.8 Terminology and definitions

API	Application Program Interface, a set of commands and functions that can be used by programmers for writing software for specific Operating Systems
CAN Bus	Controller Area network, a protocol designed for in-vehicle communication.
DDR	Double Data Rate, a typology of memory devices which transfer data both on the rising and on the falling edge of the clock.
DDR3L	DDR Low Voltage, 3rd Generation
DVI	Digital Visual Interface, a video-only interface
FFC/FPC	Flexible Flat Cable / Flat Panel Cable
Gbps	Gigabits per second
GND	Ground
GPI/O	General purpose Input/Output
HDMI	High-Definition Multimedia Interface, an audio and video interface
I2C Bus	Inter-Integrated Circuit Bus, a simple serial bus consisting only of data and clock line, with multi-master capability
LVDS	Low Voltage Differential Signaling, a standard for transferring data at very high speed using inexpensive twisted pair copper cables, usually used for video applications
Mbps	Megabits per second
MMC/eMMC	MultiMedia Card / embedded MMC, a type of memory card, having the same interface as the SD card. The eMMC is the embedded version of the MMC. They are devices that incorporate the flash memories on a single BGA chip.
N.A.	Not Applicable
N.C.	Not Connected
OpenCL	Open Computing Language, a software library based on C99 programming language, conceived explicitly to realise parallel computing using Graphics Processing Units (GPU)
OpenVG	Open Vector Graphics, an Open Source API dedicated to hardware accelerated 2D vector graphics
OS	Operating System
OTG	On-the-Go, a specification that allows to USB devices to act indifferently as Host or as a Client, depending on the device connected to the port.
PCI-e	Peripheral Component Interface Express
PHY	Abbreviation of Physical, it is the device implementing the Physical Layer of ISO/OSI-7 model for communication systems
PSU	Power Supply Unit
PWM	Pulse Width Modulation

PWR	Power
RMII	Reduced Media Independent Interface, a standard interface between the Ethernet Media Access Control (MAC) and the Physical Layer (PHY)
SD	Secure Digital, a memory card type
SIM	Subscriber Identity Module, a card which stores all data of the owner necessary to allow him accessing to mobile communication networks
SM Bus	System Management Bus, a subset of the I2C bus dedicated to communication with devices for system management, like a smart battery and other power supply-related devices
SPI	Serial Peripheral Interface, a 4-Wire synchronous full-duplex serial interface which is composed of a master and one or more slaves, individually enabled through a Chip Select line
TBM	To be measured
UART	Universal asynchronous receiver transmitter
USART	Universal Sycnhronous/asynchronous receiver transmitter
UIM	User Identity Module, an extension of SIM modules.
USB	Universal Serial Bus

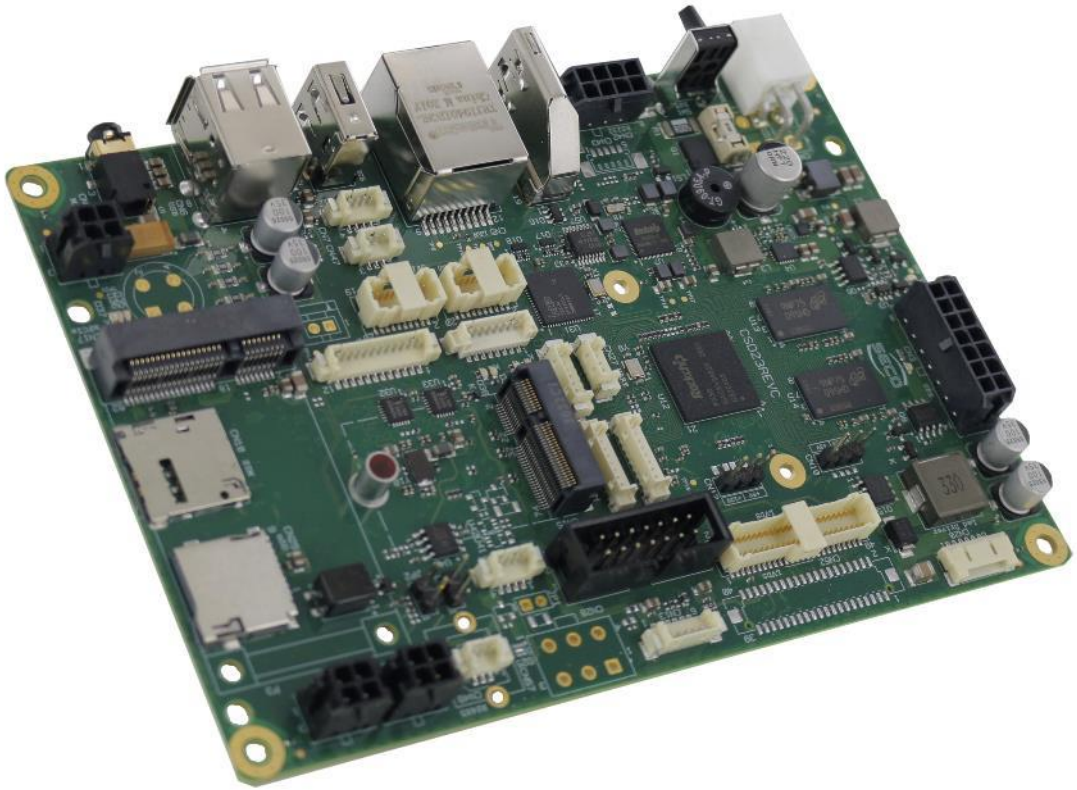
1.9 Reference specifications

Here below it is a list of applicable industry specifications and reference documents.

Reference	Link
CAN Bus	https://www.iso.org/standard/63648.html
eDP	http://www.vesa.org
Fast Ethernet	https://www.ieee802.org/3/
HDMI	https://www.hdmi.org/
I2C	https://www.nxp.com/docs/en/user-guide/UM10204.pdf
I2S	https://www.sparkfun.com/datasheets/BreakoutBoards/I2SBUS.pdf
LVDS	https://www.ti.com/lit/an/snla165/snla165.pdf and https://www.ti.com/lit/ug/snla187/snla187.pdf
MMC/eMMC	https://www.jedec.org/committees/jc-64
OpenGL	http://www.opengl.org
OpenVG	http://www.khronos.org/openvg
Rockchip PX30 processor	https://www.rock-chips.com/a/en/products/rkpower/2018/0709/913.html
SD Card Association	https://www.sdcard.org/home
SDIO	https://www.sdcard.org/developers/overview/sdio
SM Bus	http://www.smbus.org/specs
USB 2.0 and USB OTG	https://www.usb.org/document-library/usb-20-specification

Chapter 2.
OVERVIEW

- Introduction
- Technical specifications
- Electrical specifications
- Mechanical specifications
- Block diagram



2.1 Introduction

SBC-D23 is a Single Board Computer in 3.5" form factor (which is 146 x 102mm) based on embedded Rockchip PX30 Processor, featuring Quad-Core ARM® Cortex®-A35 processor

Graphics features of the board are managed directly by the processor, which integrates a Mali-G31 GPU with High performance dedicated 2D processor, supporting OpenGL® ES 1.1 / 2.0 / 3.2, Vulkan 1.0, OpenCL 2.0 and Open VG 1.1.

HW video decoding of the most common coding standard (i.e., MPEG-4, H.265/HEVC, H.264, VP8, VC-1) is supported. Also H.264 encoding (1x1080p@30fps or 2x 720p@30fps) is supported.

The board is completed with up to 4GB LPDDR4-3200 32-bit bus memory directly soldered on board and one eMMC 5.1 Flash Drive with up to 64GB of capacity. Mass storage capabilities are completed by an optional microSD Card slot.

The board can support 24 bit Single Channel LVDS interface.

The processor offers an RMII interface which, through a dedicated Micrel KSZ8091 Ethernet Transceiver, allows the implementation of a FastEthernet interface.

The networking capabilities of this module can be extended through an M.2 Socket 1 Key E slot with UART + SDIO interface, which allows plugging accessory WiFi+BT M.2 modules.

An additional miniPCI-e slot allows expanding the connectivity possibilities of this board. Since this slot is connected to an on-board microSIM slot, it is possible to equip the board with external modem modules.

The SBC-D23 board offers two USB 2.0 standard Type-A connectors; another USB interface can be available, as a factory alternative, on an internal header or on the LVDS connector. The USB OTG interface is available both on a micro-B connector (client mode) an on an additional Type-A connector. Finally, an additional USB header is available, managed by the on-board microcontroller.

The audio functionalities of this board are managed by the Audio Codec embedded in the RK-809 PMIC, which makes available a stereo output on an internal 3-pin connector. Managed as factory alternatives, there can be TRRS combo jack for Headphone and Mic-in or a class-D amplified Stereo ouput on micro-fit connector.

Many serial ports are available: up to 2x UART/RS-232 (factory alternatives), 1x CAN port, 2x 2-Wire UARTs and 2x 4-Wire UARTs.

SD23 board incorporates HDMI Technology.

Other interfaces available will be thoroughly described in the following chapters.

2.2 Technical specifications

Processors

Rockchip PX30 processor, 4x Cortex®-A35 cores

Memory

Soldered Down DDR3L memory, 32-bit interface, up to 4GB

Graphics

Mali-G31 GPU with High performance dedicated 2D processor
OpenGL ES 1.1 / 2.0 / 3.2, Vulkan 1.0, OpenCL 2.0 , DX11 FL9_3
Embedded VPU, able to support:

- Multi-format 1080P 60fps video decoders (H.265, H.264,VC-1, MPEG-4, VP8)
- H.264 1080p@30fps HW encoding

Support 2 independent video outputs

Video Interfaces

LVDS Single Channel interface
HDMI interface

Video Resolution

HDMI, up to 1920x1080
LVDS, up to 1280x800

Mass Storage

Optional eMMC 5.1 Drive soldered on-board, up to 64GB
Optional microSD slot on board

Networking

1x 10/100 Ethernet port
Optional M.2 Socket 1 Key E Slot for WiFi/BT LE external modules
Optional miniPCI-e slot (USB interface only) for external modem modules

USB

3 x USB 2.0 Host ports on standard Type-A slots
USB recovery internal connector

Audio

PMIC embedded Audio Codec
Stereo audio out on internal header
TRRS combo jack for Headphone and Mic In Line Out audio jack or I2S Audio
Class-D amplifier with stereo out available on internal connector (factory alternatives)
Buzzer on-board

Serial ports

1x TTL or RS-232 port (factory alternative)
1x Debug UART
1x TTL or RS-232 port (factory alternatives to microSD slot)
1x RS-485 port on internal connector
1x CAN port

Other Interfaces

miniSIM Slot for USB Modem modules on miniPCI-e form factor
Optional CSI Camera connector
Ultra-low Power RTC
16x GPIs @3.3V (5V tolerant)
16x GPOs @3.3V
Trusted Secure Element
4-Channel LED Driver connector

Microcontroller Programmable Interfaces

2x 4-Wire UARTs on internal connector
2x 2-Wire UARTs on internal connector
1x SPI connector
2x I2C on internal connector
8-channel timer connector
16x GPOs + 16x GPIs

Power supply voltage: +12V_{DC} .. +24V_{DC}

Operating temperature:

Commercial version 0°C ÷ +60°C **.
Extended Temperature range: -20°C ÷ +85°C **

Dimensions: 142 x 102 mm (3.5” form factor)

Supported Operating Systems: Linux Yocto

! *** Measured at any point of SECO standard heatsink for this product, during any and all times (including start-up). Actual temperature will widely depend on application, enclosure and/or environment. Upon customer to consider application-specific cooling solutions for the final system to keep the heatspreader temperature in the range indicated. Please also check paragraph 4.1*

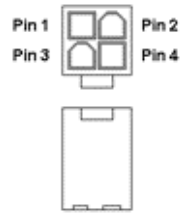
2.3 Electrical specifications

SD23 board can be supplied with any voltage in the range $+12V_{DC}$ ÷ $+24V_{DC}$ range (recommended voltage range)

Power In Connector – CN44			
Pin	**Signal**	**Pin**	**Signal**
1	GND	3	VIN_SYS
2	GND	4	VIN_SYS

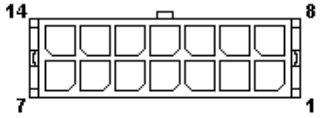
This voltage can be supplied through a Right-angle connector type Molex Mini-Fit Jr, p/n 39-30-0040 or equivalent, with the pinout indicated in the table below.

Mating connector: Molex 39-01-2045 or equivalent with 5566 series female crimp terminal



2.3.1 UPS By-pass connector

The SBC-D23 board allow the possibility of connecting external UPS modules able to supply a 12V Backup, to be used in case that the main power supply is not available



UPS By-Pass Connector – CN3			
Pin	**Signal**	**Pin**	**Signal**
1	---	8	+12V_BACKUP
2	VDD_SYS	9	---
3	---	10	+12V_BACKUP
4	VDD_SYS	11	UPS_BOOST_EN
5	UPS_PFO#	12	GND
6	UPS_BYPASS	13	UPS_EN
7	UPS_INT#	14	GND

For this kind of connection, it is provided a standard Micro-fit 2x7 connector type Molex 43045-1412 or equivalent, with the pinout shown in the table on the left.

Mating connector: MOLEX 43025-1400 or equivalent with 43030 female crimp terminal.

UPS_BYPASS: UPS power rail enable signal. Used to switch between the power rail coming from the external UPS Module and the standard V_{IN} Power Supply. Electrical level +12V_ALW with 100KΩ pull-up resistor

UPS_PFO#: Generic Input. It is managed on the SBC-D23 board by I/O Expander B, Port #0 Pin #0. Electrical level +3P3V_RUN.

UPS_INT#: This signal can be used to serve the interrupt request of the UPS device. It is managed on the SBC-D23 board by I/O Expander B, Port #0 Pin #1. Electrical level +3P3V_RUN.

UPS_EN: IO: Generic UPS Enable signal. It is managed on the SBC-D23 board by I/O Expander A, Port #0 Pin #1. Electrical level +3P3V_RUN

UPS_BOOST_EN: Generic UPS Enable signal. It is managed on the SBC-D23 board by I/O Expander A, Port #0 Pin #0. Electrical level +3P3V_RUN

2.3.2 RTC Battery

For the occurrences when the module is not powered with an external power supply, on board there is a battery holder for coin cell Lithium Battery to supply, with a 3V voltage, the Real Time Clock present on-board.

Battery used is a CR2016 Lithium coin-cell battery, with a nominal capacity of 90mAh.

In case of exhaustion, the battery should only be replaced with devices of the same type. Always check the orientation before inserting and make sure that they are aligned correctly and are not damaged or leaking.

Never allow the batteries to become short-circuited during handling.

! CAUTION: handling batteries incorrectly or replacing with not-approved devices may present a risk of fire or explosion.

Batteries supplied with SD23 are compliant to requirements of European Directive 2006/66/EC regarding batteries and accumulators. When putting out of order SBC-D23, remove the batteries from the board in order to collect and dispose them according to the requirement of the same European Directive above mentioned. Even when replacing the batteries, the disposal has to be made according to these requirements.

2.3.3 Power rails

In all the tables contained in this manual, the power rails are named with the following meaning:

V_{IN}: Power In voltage (in the range $+12V_{DC}$ ..$+24V_{DC}$) directly coming from the Power Supply connectors CN44

+12V_ALW: $+12V_{DC}$ power rail, directly generated from V_{IN} power rail, immediately available when V_{IN} voltage is applied. Please be aware that with V_{IN} voltage is between $+12V_{DC}$ and $+16V_{DC}$, the 12V_ALW will not be equal to $+12V_{DC}$ but it will be equal to V_{IN} Voltage

+12V_BACKUP: external $+12V_{DC}$ power rail which can be supplied by an UPS Module plugged to connector CN3

+5V_STBY: $+5V_{DC}$ power rail, directly generated from VIN power rail, immediately available when VIN voltage is applied.

+5V_SW: main $+5V_{DC}$ power rail generated by the on-board PMIC from 5V_STBY power rail.

+3P3V_RUN: main $+3.3V_{DC}$ power rail generated by the on-board PMIC from 5V_STBY power rail.

+3P3V_SW: main $+3.3V_{DC}$ power rail generated by the on-board PMIC from +3P3V_RUN power rail.

+3P0V_VDD_PMU: generic $+3.0V_{DC}$ power rail, generated by the on-board PMIC from +3P3V_RUN power rail.

+1P8V_VDD: generic $+1.8V_{DC}$ power rail, generated by the on-board PMIC from +3P3V_RUN power rail.

+3V3_MOD: $3.3V_{DC}$ power rail specific for M.2 and miniPCI-e slots, derived from +12V_ALW power rail upon SW enabling.

+3P3V_OUT_EC: 3.3V power rail specific for the I/O connectors managed by the microcontroller, derived from +3P3V_SW power rail upon SW enabling.

+1P5V_PCIE: $+1.5V_{DC}$ power rail dedicated to the miniPCI-e slot, derived automatically from +3P3V_SW power rail

VCC_uSD: dedicated $+3.3V_{DC}$ power rail for microSD slot, generated by the on-board PMIC from +3P3V_RUN power rail.

VDD_TOUCH: dedicated $+5V_{DC}$ power rail for external USB or I2C T/S controller, generated from the +5V_STBY Power rail once the +3P3V_RUN power rail is steady.

2.3.4 Power consumption

The power consumption has been measured on V_{IN} power rail using a $24V_{DC}$ source. Power consumption measurement is performed with DC Power Analyzer Keysight and must be intended as average value (30 seconds acquisition). For peak measurement please refer to following Values, acquired with DC Power Analyzer Keysight.

For measurement, the following configuration has been considered.

Processor: PX30 Commercial temperature range;
RAM: 2GB DDR3L;
Storage: 4GB eMMC;
Video Interface: LVDS + HDMI;
Networking: 1x FastEthernet LAN + Modem module QUECTEL EG25GGB-MINIPCIE + WiFi module Azurwave AW-CM390MA;
Audio: Power Amplifier mounted
Other: no microSD Slot, UART #B RS-232 mode
Commercial Temperature range

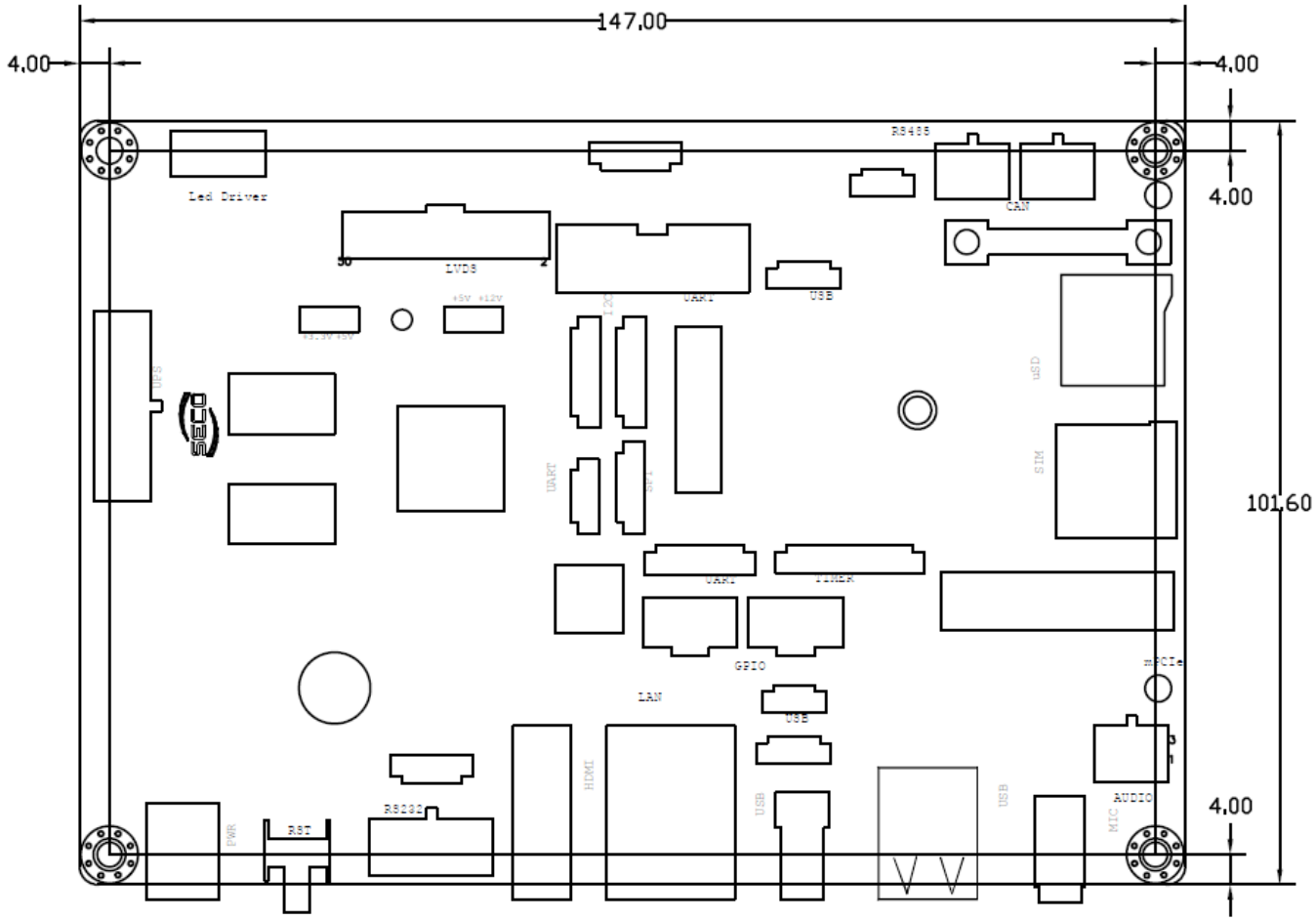
8.0" LVDS Display 1024x600 connected

Status	Configuration #1			
	Average Value (30s)		Peak Value	
U-Boot Idle (Linux)	4.8W	0.200A	3.7W	0.196A
Boot (Linux)			7.51W	0.313A
Idle (Linux)	5.04W	0.210A	5.28W	0.220A
Test Storage Device (3 x USB)			8.09W	0.337A
CPU 100% + GPU 100% + LTE + Wi-Fi	10.97W	0.457A	18.7W	0.779A

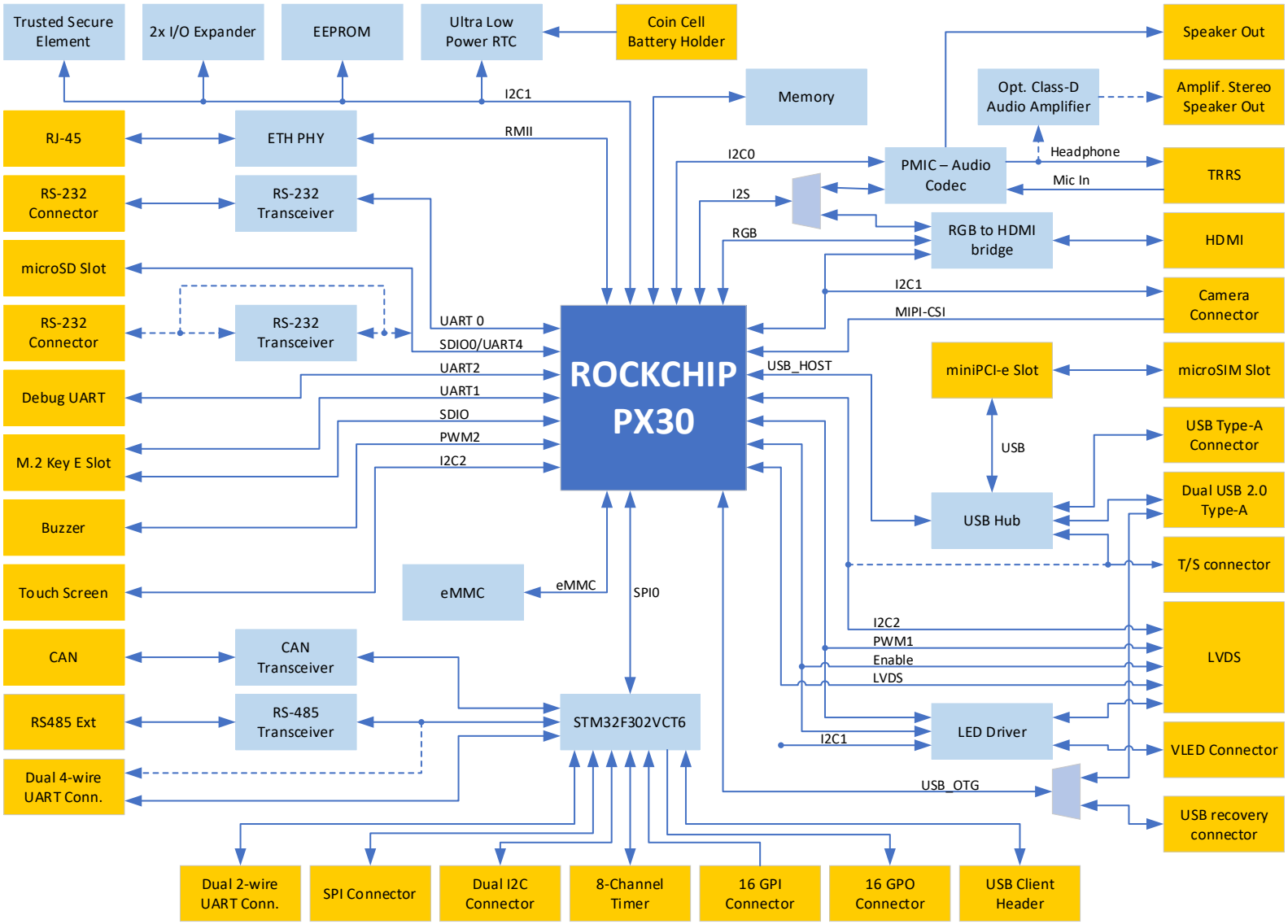
2.4 Mechanical specifications

According to 3.5” form factor, board dimensions are: 147 x 101.6 mm (5.79” x 4.0”).

The printed circuit of the board is made of ten layers, some of them are ground planes, for disturbance rejection.

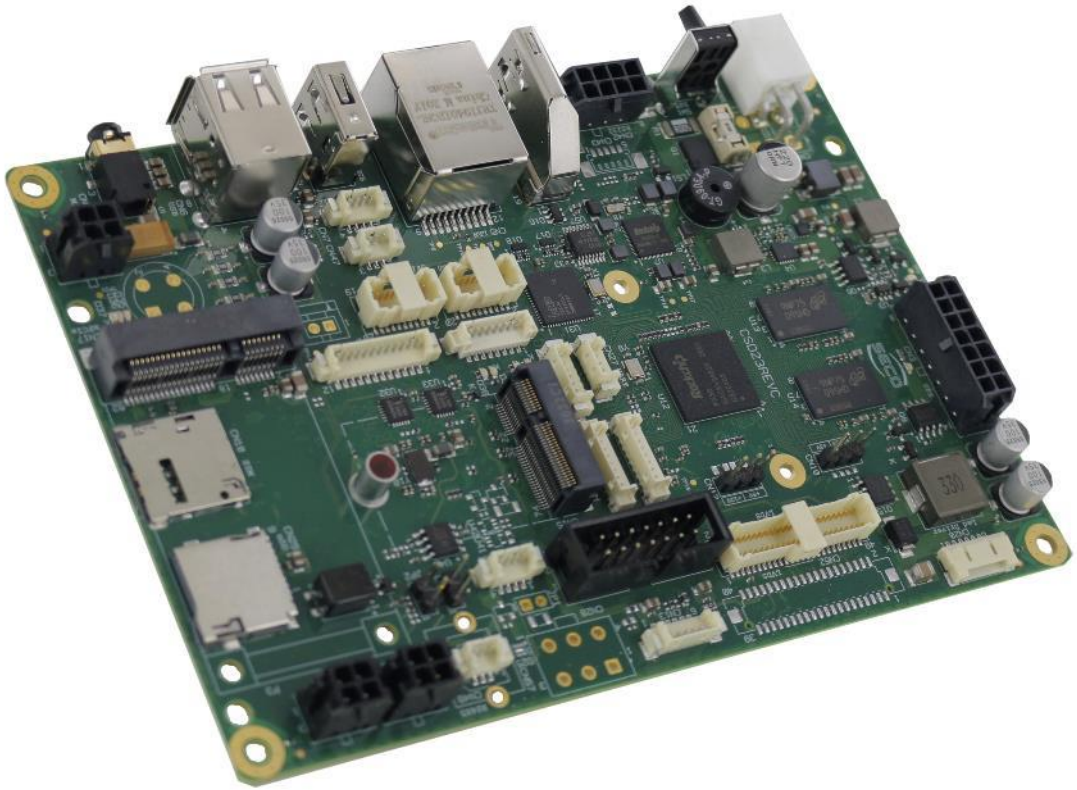


2.5 Block diagram



Chapter 3.
CONNECTORS

- Introduction
- Connectors' overview
- Connectors' description

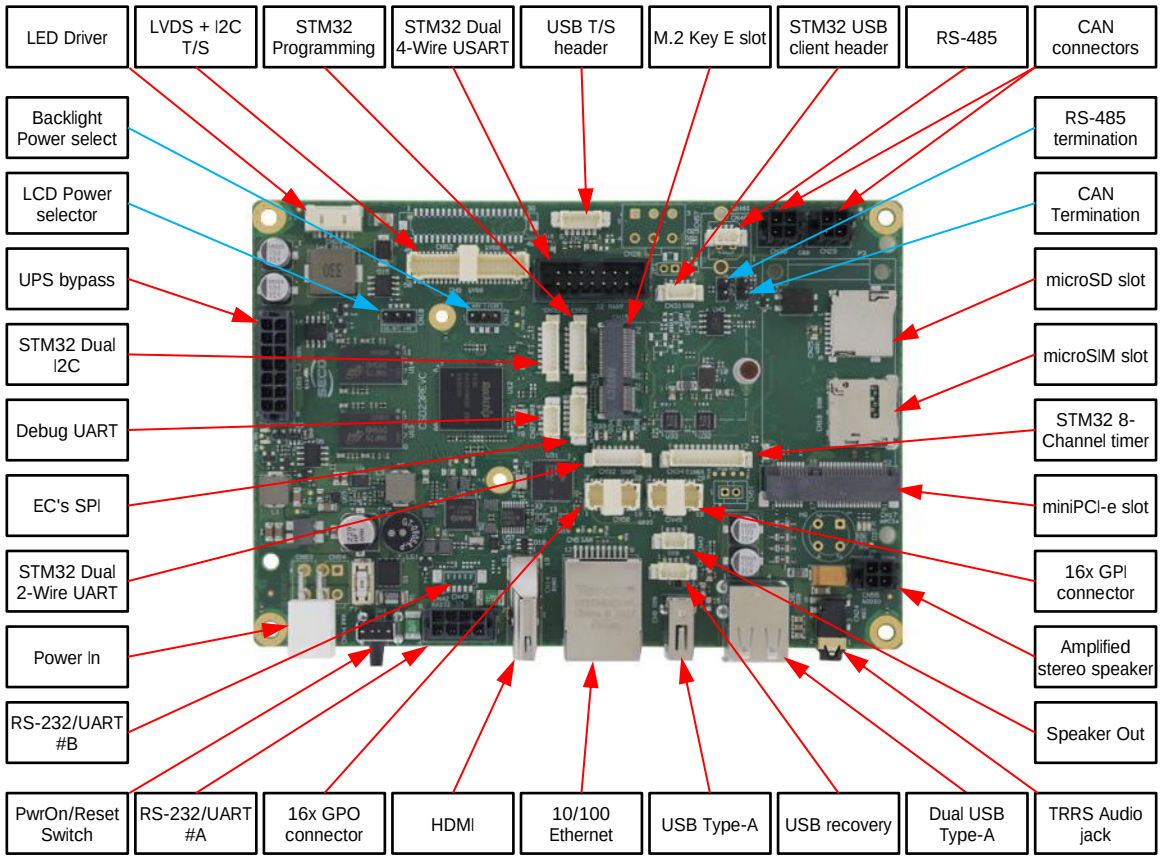


3.1 Introduction

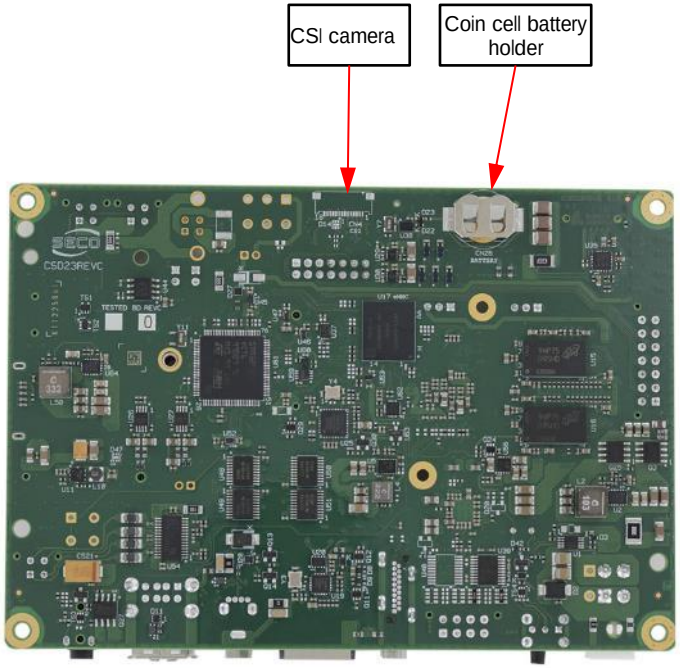
On SBC-D23 board, there are several connectors located on the lower plane. Standard connectors are placed on the same side of PCB, so that it is possible to place them on a panel of an eventual enclosure.

> ! Please be aware that, depending on the configuration purchased, the appearance of the board could be different from the following pictures.

TOP SIDE



BOTTOM SIDE



3.2 Connectors' overview

3.2.1 Connector List

Name	Description	Name	Description
CN3	UPS Bypass	CN29	CAN Connector #1
CN4	CSI Camera connector	CN30	CAN Connector #2
CN5	10/100 RJ-45 Ethernet connector	CN31	STM32 USB client header
CN6	Dual USB Type-A slot	CN32	STM32 Dual 2-Wire UART Connector
CN7	USB recovery connector	CN33	STM32 Dual I2C Connector
CN8	USB Type-A slot	CN34	STM32 8-Channel timer connector
CN9	LVDS + I2C T/S Connector	CN39	STM32 SPI Connector
CN13	USB T/S connector	CN42	RS-232 / UART #A connector
CN14	HDMI Connector	CN43	RS-232 / UART #B connector
CN15	M.2 Key E Slot	CN44	Power In connector
CN17	miniPCI-e slot	CN47	Speaker out connector
CN18	microSIM Slot	CN48	RS-485 Connector
CN20	LED Driver connector	CN49	STM32 16xGPI Connector
CN24	TRRS Audio jack	CN50	STM32 16x GPOs Connector
CN25	microSD Slot	CN55	Amplified Stereo speaker connector
CN26	Battery holder	CN56	STM32 programming
CN27	Debug UART connector	J2	STM32 Dual 4-Wire USART Connector

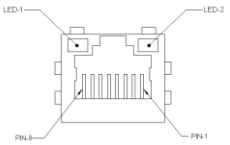
3.2.2 Jumpers List

Name	Description	Name	Description
CN10	LCD Power selector	JP2	CAN Bus Termination
CN12	Backlight Power selector	JP3	RS-485 Bus Termination

3.3 Connectors' description

3.3.1 10/100 Ethernet connector

10/100 Ethernet Port – CN5			
Pin	**Signal**	**Pin**	**Signal**
1	ETH_Tx+	5	---
2	ETH_Tx-	6	ETH_Rx-
3	ETH_Rx+	7	---
4	---	8	---



On board, there is a FastEthernet interface, made available by a Micrel KSZ8091RBA 10Baset-T/100Base-Tx Transceiver interfaced to PX30 RMII interface.

The connector is type TRXCOM p/n TRJ19401BGNL or equivalent, with 2kV decoupling capacitor.

This interface is compatible only with Fast Ethernet (10/100Mbps) Networks. When connected to Gigabit Ethernet Networks, the speed will be limited to 100Mbps.

For the connection, cables category Cat5e or better are required. Cables category Cat6 are recommended for noise reduction and EMC compatibility issues, especially when the length of the cable is significant.

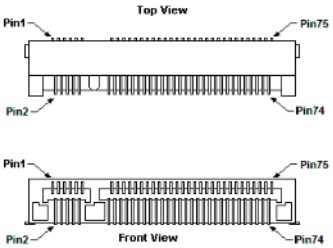
On the connector there are also two LEDs. Left LED is Yellow and shows 10/100 connection. The right LED blinks Green to show ACTIVITY presence.

ETH_Tx+/ ETH_Tx-: Ethernet Transmit differential pair.

ETH_Rx+/ ETH_Rx-: Ethernet Receive differential pair.

3.3.2 M.2 2230 Socket 1 Key E Connectivity Slot

M.2 Connectivity Slot (Socket 1 Key E type 2230) – CN15			
Pin	**Signal**	**Pin**	**Signal**
1	GND	2	+3V3_MOD
3	---	4	+3V3_MOD
5	---	6	LED1#
7	GND	8	---
9	SDIO_CLK	10	---
11	SDIO_CMD	12	---
13	SDIO_DAT0	14	---
15	SDIO_DAT1	16	LED2#
17	SDIO_DAT2	18	+3V3_MOD
19	SDIO_DAT3	20	UART_WAKE#
21	SDIO_WAKE#	22	UART_RXD
23	SDIO_RESET#		
		32	UART_TXD
33	GND	34	UART_CTS
35	---	36	UART_RTS
37	---	38	---
39	GND	40	---
41	---	42	---
43	---	44	---
45	GND	46	---
47	---	48	---
49	---	50	SUSCLK



It is possible to increase the connectivity of the SBC-D23 board by using M.2 Socket 1 Key E connectivity slot.

The connector used for the M.2 Connectivity slot is CN36, which is a standard 75 pin M.2 Key E connector, type LOTES p/n APCI0095-P001A, H=8.5mm, with the pinout shown in the table on the left.

On the SBC-D23 board there is also a Threaded Spacer which allows the placement of M.2 Socket 1 Key E connectivity modules in 2230/3030 size.

This slot only supports M.2 Socket 1 Key E modules using SDIO and UART interfaces; it doesn't support modules requiring PCI-e and/or USB interfaces.

51	GND	52	---
53	---	54	M2_DISABLE2#
55	---	56	M2_DISABLE1#
57	GND	58	---
59	---	60	---
61	---	62	---
63	GND	64	---
65	---	66	---
67	---	68	---
69	GND	70	---
71	---	72	+3V3_MOD
73	---	74	+3V3_MOD
75	GND		

Here following the description of the signals available on this slot

SDIO_CLK: PX30 SDIO interface Clock Line, +1P8V_VDD electrical level Output

SDIO_CMD: PX30 SDIO Command/Response, +1P8V_VDD electrical level bidirectional line.

SDIO_DAT[0..3]: PX30 SDIO Data bus, +1P8V_VDD electrical level bidirectional lines.

SDIO_WAKE#: SDIO Sideband Wake Signal Input, active Low.

SDIO_RESET#: SDIO Sideband Reset Signal output, active Low, electrical level +1P8V_RUN.

LED1#: Active Low signal, can be used by the module to drive a Red LED available on D23 board, specific for M.2 Key E Slot functionalities

LED2#: Active Low signal, can be used by the module to drive a Blue LED available on D23 board, specific for M.2 Key E Slot functionalities

UART_WAKE#: UART Sideband Wake Signal Input, used to wake up the platform.

UART_RXD: PX30 UART port #1 Receive signal, +1P8V_VDD electrical level

UART_TXD: PX30 UART port #1 Transmit signal, +1P8V_VDD electrical level

UART_CTS: PX30 UART port #1 Clear To Send signal, +1P8V_VDD electrical level

UART_RTS: PX30 UART port #1 Request To Send signal, +1P8V_VDD electrical level

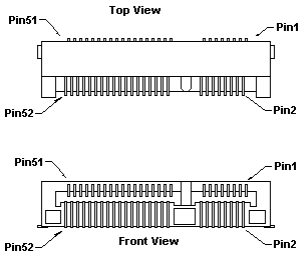
SUS_CLK: Suspend Clock, 32.768kHz clock supply output provided by the Platform to the adapter in order to let it to implement the reduced power consumption modes. Electrical level +3P0V_VDD_PMU with 10kΩ pull-up resistor

M2_DISABLE1#, M2_DISABLE2#: M.2 Module's generic disable signals, managed on the SBC-D23 board by two GPIOs of the on-board I/O Expanders. Electrical level +3P3V_SW.

3.3.3 miniPCI-e WWAN Slot

miniPCI-e Slot - CN17			
Pin	**Signal**	**Pin**	**Signal**
1	mPCIE_WAKE#	2	+3V3_MOD
3	---	4	GND
5	---	6	+1.5V_PCIE
7	---	8	UIM_PWR
9	GND	10	UIM_DATA
11	---	12	UIM_CLK
13	---	14	UIM_RESET
15	GND	16	---
17	---	18	GND
19	---	20	mPCIE_W_DISABLE#
21	GND	22	mPCIE_RST#
23	---	24	+3V3_MOD
25	GND	26	GND
27	GND	28	+1P5V_PCIE
29	---	30	---
31	---	32	---
33	---	34	GND
35	GND	36	USBHUB_P1-
37	GND	38	USBHUB_P1+
39	+3V3_MOD	40	GND
41	+3V3_MOD	42	LED_WPAN#
43	GND	44	LED_WLAN#
45	---	46	LED_WWAN#
47	---	48	+1.5V_S
49	---	50	GND
51	---	52	+3.3V_A

To add communications functionality, or other features not already available, it is possible to use Half-/ Full-size mini-PCI Express cards, using the dedicate connector, CN17, which is a standard 52pin miniPCI Express connector, type LOTES AAA-PCI-047-K01 or equivalent, H=9.0mm, with the pinout shown in the table on the left.



SBC-D23 board allows inserting only modules in Half-mini form factor.

On the slot are also available the signals for interfacing to microSIM cards, so that it is possible to use miniPCI Express card modems requiring USB Only interface (PCI-e interface is not available on this slot).

Signals carried to miniPCI-express slot are the following:

mPCIE_WAKE#: Board's Wake Input, it must be externally driven by the module inserted in the slot when it requires waking up the system.

mPCIE_W_DISABLE#: Wireless Disable signal, managed on the SBC-D23 board by one GPIO of the on-board I/O Expanders. Electrical level +3P3V_SW.

mPCIE_RST#: Reset Signal, managed on the SBC-D23 board by one GPIO of the on-board I/O Expanders. Electrical level +3P3V_SW.

USBHUB_P1+/USBHUB_P1-: USB Hub Downstream Port #1, differential pair

UIM_RST#: Reset signal line, sent from the modem module to the microSIM card.

UIM_DATA: Bidirectional Data line between the modem module and the microSIM card.

UIM_CLK: Clock line, output from the modem module to the microSIM card.

UIM_PWR: Power line for the microSIM card. Can be 1.8V or 3.3V, it is supported by the EG25-G module automatically.

Please be aware that all signals related to User Identity Modules are managed directly by the miniPCI-express card circuitry, they don't involve SBC-D23 board's management. The SBC_D23 board embeds only clamping diodes for ESD protection on UIM signal and voltage lines.

Three SMT RED LEDs are present near this Mini PCI-Express Card Slot to show the presence

of an eventual Wi-Fi PCI-Express Card inserted in the slot. These LEDs can work only if the Wi-Fi Mini PCI Express Card you are using supports and drives them opportunely through the signals LED_WPAN#, LED_WLAN# and LED_WWAN#.

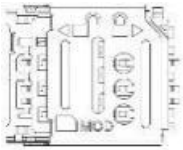
Blue LED D35: Wireless_PAN present (Bluetooth)

Red LED D36: Wireless_LAN present (for wireless networks)

Green LED D37: Wireless_WAN present (for cellular data, like GSM/GPRS/UMTS)

3.3.4 microSIM Card Slot

microSIM Card Slot – CN18			
Pin	**Signal**	**Pin**	**Signal**
1	UIM_PWR	5	GND
2	UIM_RST#	6	---
3	UIM_CLK	7	UIM_DATA
4	---	8	---



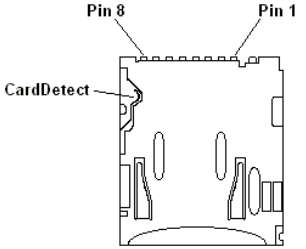
Interfaced to the miniPCI-e slot CN17, there is a microSIM Card Slot, to be used in conjunction with M.2 Socket 2 Key B modems. Here it is possible to insert the microSIM card provided by any telecommunication operator for the connection to their network.

The socket is type TE p/n 2822541-1 or equivalent, with the pinout shown in the table on the left. Signal are described in the above paragraph.

The signals here available are described in the previous paragraph.

3.3.5 microSD Slot

µSD Card Slot – CN25	
Pin	**Signal**
1	SD_DAT2
2	SD_DAT3
3	SD_CMD
4	VCC_uSD
5	SD_CLK
6	GND
7	SD_DAT0
8	SD_DAT1



The PX30 SoCs embeds an SD/MMC controller able to support SD/MMC Cards.

On SBC-D23 board, this controller can manage an optional µSD Card Slot for the use of standard microSD cards, which can be used as Mass Storage and/or Boot Devices.

Please be aware that Hot Plug of the SD card is not supported, it must be plugged before board's boot.

The connector is a microSD connector, push-push type, H=2mm, p/n TFWF1.

SD_CLK: SD Clock Line (output).

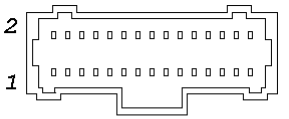
SD_CMD: Command/Response bidirectional line.

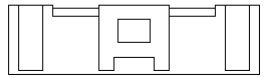
SD_DAT[0÷3]: SD Card data bus. SD_DAT0 signal is used for all communication modes. SD_DAT[1÷3] signals are required for 4-bit communication mode.

microSD Card slot is offered as a factory alternative to RS-232 or TTL COM Port #B available on connector CN43. Please check also par. 3.3.13.

3.3.6 LVDS connector

LVDS connector – CN9			
Pin	**Signal**	**Pin**	**Signal**
1	V_LED1-	2	V_LED+
3	V_LED2-	4	VCC_BKL_SW
5	VCC_LCD_SW	6	VCC_BKL_SW
7	+3P3V_RUN	8	GND
9	GND	10	LVDS_0_TX0+
11	LVDS_0_TX1+	12	LVDS_0_TX0-
13	LVDS_0_TX1-	14	GND
15	GND	16	LVDS_0_TX2+
17	LVDS_0_TX3+	18	LVDS_0_TX2-
19	LVDS_0_TX3-	20	GND
21	GND	22	LVDS_0_CLK+
23	---	24	LVDS_0_CLK-
25	---	26	GND
27	GND	28	---
29	---	30	---
31	---	32	GND
33	GND	34	---
35	---	36	TOUCH_INT#
37	DISPLAY_BKL_CTRL	38	GND
39	GND	40	GND
41	PANEL_ON	42	TOUCH_RST#
43	BKL_EN	44	VDD_TOUCH
45	LVDS_DDC_SCL	46	---
47	LVDS_DDC_SDA	48	---
49	GND	50	GND





SD23 can be interfaced to LCD displays using its LVDS interface, which allows connecting 18 or 24 bit single channel displays. This interface is native of the PX30 Processor, with a maximum supported resolution of 1280x800 @ 60fps.

For the connection, a connector type HR A1014WA-S-2x25P or equivalent (2 x 25p, male, straight, P1, low profile, polarised) is provided.

Mating connector: HR A1014H-2X25P with HR A1014-T female crimp terminals.

Alternative mating connector, MOLEX 501189-5010 with crimp terminals series 501334.

On the same connector are also implemented the signals for direct driving of display's backlight: voltages (VCC_LCD_SW and VCC_BKL_SW) and control signals (LCD enable signal, PANEL_ON, Backlight enable signal, BKL_EN, and Backlight Brightness Control signal with pulse width modulation, DISPLAY_BKL_CTRL).

There are also the signals necessary for driving I2C touchscreens (I2C signals, reset and interrupt request signals).

Through the same connector, it is also possible to connect to display's LED driver interface, using three dedicated signals (V_LED+, V_LED1-, V_LED2-), which are also available on the dedicated LED Driver connector CN20. Please refer to paragraph 3.3.7 for a description of these signals

When building a cable for connection of LVDS displays, please take care of twist as tight as possible differential pairs' signal wires, in order to reduce EMI interferences. Shielded cables are also recommended.

Here following the signals related to LVDS management:

LVDS_0_TX0+/ LVDS_0_TX0-: LVDS Channel differential data pair #0.

LVDS_0_TX1+/ LVDS_0_TX1-: LVDS Channel differential data pair #1.

LVDS_0_TX2+/ LVDS_0_TX2-: LVDS Channel differential data pair #2.

LVDS_0_TX3+/ LVDS_0_TX3-: LVDS Channel differential data pair #3.

LVDS_0_CLK+/LVDS_0_CLK-: LVDS Channel differential Clock.

LVDS_DDC_SDA: DisplayID I2C Data line for LVDS flat Panel detection or for the management of an I2C Touch Screen Controller. Bidirectional signal, electrical level +3P0V_VDD_PMU with a 2k2Ω pull-up resistor.

LVDS_DDC_SCL: DisplayID I2C Clock line for LVDS flat Panel detection or for the management of an I2C Touch Screen Controller. Bidirectional signal, electrical level +3P0V_VDD_PMU with a 2k2Ω pull-up resistor.

BKL_EN: +3P3V_SW electrical level Output with 50kΩ pull-down resistor, Backlight Enable signal. It can be used to turn On/Off the backlight's lamps of connected displays.

PANEL_ON: +3P3V_SW electrical level Output with 100kΩ pull-down resistor, Panel Power Enable signal. It can be used to turn On/Off the connected display.

DISPLAY_BKL_CTRL: this signal can be used to adjust the backlight brightness in displays supporting Pulse Width Modulated (PWM) regulations (+3P0V_VDD_PMU electrical level with 100kΩ pull-down resistor).

TOUCH_RST#: This signal can be used to drive a reset of an eventual external Touch Screen connected to the dedicated I2C interface. It is managed on the SBC-D23 board by one GPIO of the on-board I/O Expanders. Electrical level +3P3V_SW.

TOUCH_INT#: This signal can be used to serve the interrupt request of an eventual external Touch Screen connected to the dedicated I2C interface. It is managed on the SBC-D23 board by one GPIO of the on-board I/O Expanders. Electrical level +3P3V_SW with a 10kΩ pull-down resistor

CN10 position	LCD Power selector
1-2	+3.3V
2-3	+5V

VCC_LCD_SW: LCD switched voltage rail. Its value can be set to +3P3V_SW or +5V_STBY by using dedicated jumper CN10, which is a standard pin header, P2.54mm, 1x3 pin.

CN12 position	Backlight Power selector
1-2	+5V
2-3	+12V

VCC_BKL_SW: Backlight switched voltage rail. Its value can be set to +5V_STBY or +12V_ALW by using dedicated jumper CN12, same type of CN10.

Please be aware that with VIN voltages between +12V and +16VDC, the VCC_BKL_SW will not be equal to +12VDC but it will be equal to VIN Voltage.

Since the use of jumpers in environments with vibrations issues could be a problem, it is possible to provide SD23 boards with the LCD Power and Backlight Power fixed at the desired value. For this purpose, some dedicated 0-Ohm resistors can be mounted (factory default: not available). Please contact your local Sales rep in case you need this special configuration.

3.3.7 LED Driver Connector

Backlight connector – CN20	
Pin	**Signal**
1	V_LED+
2	V_LED+
3	V_LED1-
4	V_LED2-
5	V_LED3-
6	V_LED4-

SD23 board also allow the connection of LVDS Displays requiring a dedicated LED Driver.

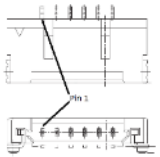
The functionality is implemented using a 4-Channel WLED controller type MPS MP3385GR-.

Through this connector, it is possible to connect up to 4 LED strings requiring a max of 90mA per string (60V max voltage).

The connector is a 4-pin 1.25mm pitch connector, type HR P/N A1253WR-SF-06P, with the pinout indicated in the table on the left.

Mating connector: HR P/N A1253H-06P with female crimp contacts type HR P/N A1253-TPE or A1253-GPE

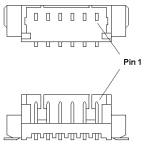
V_LED+: Strings' common LED Anode output



V_LEDx-: LED String x Cathode Input

3.3.8 Touch Screen Connector

Touch Screen connector – CN13	
Pin	**Signal**
1	VDD_TOUCH
2	USBHUB_P4-
3	USBHUB_P4+
4	TOUCH_INT#
5	TOUCH_RST#
6	GND



It is possible to connect an external Touch Screen also using the dedicated connector CN50, whose pinout is described in the table on the left, instead of using the signals available on LVDS Connector.

This connector is a 1.25mm pitch connector type Molex p/n 53398-0671 or equivalent.

Mating connector: MOLEX 51021-0600 receptacle with MOLEX 50079-8000 female crimp terminals.

TOUCH_INT# and TOUCH_RST# signals available on this connector are exactly the same available on LVDS connector CN40. Please look at par. 3.3.6. for their description.

USBHUB_P4+/USBHUB_P4-: USB Hub Downstream Port #4, differential pair

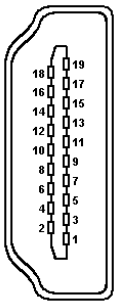
As an alternative, the USB interface on pins #3 and #4 can be replaced by an I2C interface. Please contact your sales rep for more details about this possibility.

3.3.9 HDMI connector

HDMI Connector – CN14			
Pin	**Signal**	**Pin**	**Signal**
1	TMDS_LANE2+	2	GND
3	TMDS_LANE2-	4	TMDS_LANE1+
5	GND	6	TMDS_LANE1-
7	TMDS_LANE0+	8	GND
9	TMDS_LANE0-	10	TMDS_CLK+
11	GND	12	TMDS_CLK-
13	CEC	14	GND
15	SCL	16	SDA
17	GND	18	$+5V_{HDMI}$
19	HPD		

The Rockchip PX30 SoCs offers, for video output, also a parallel RGB, supporting up to 1920x1080 video resolution

To make this interface suitable for the connection of common table-top displays, on SBC-D23 board there is an NXP TDA19988 HDMI 1.4a transmitter



Therefore, on-board it is available a standard certified HDMI connector, upright, type A, WINWIN P/N WHDR-19D1BBNU3N.

Signals involved in HDMI management are the following:

TMDS_CLK+/TMDS_CLK-: TMDS differential Clock.

TMDS_LANE0+/TMDS_LANE0-: TMDS differential pair #0

TMDS_LANE1+/TMDS_LANE1-: TMDS differential pair #1

TMDS_LANE2+/TMDS_LANE2-: TMDS differential pair #2

SDA: DDC Data line for HDMI panel. Bidirectional signal, electrical level $+5V_{HDMI}$ with a 10kΩ pull-up resistor.

SCL: DDC Clock line for HDMI panel. Output signal, electrical level $+5V_{HDMI}$ with a 10kΩ pull-up resistor.

CEC: HDMI Consumer Electronics Control (CEC) Line. Bidirectional signal, electrical level +3P3V_SW with a 27kΩ pull-up resistor and Schottky Diode.

HPD: Hot Plug Detect Input signal. +5V_HDMI electrical level signal.

For ESD protection, on all data and voltage lines are placed clamping diodes for voltage transient suppression.

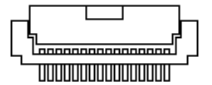
Always use HDMI-certified cables for the connection between the board and the HDMI display; a category 2 (High-Speed) cable is recommended for higher resolutions, category 1 cables can be used for 720p resolution.

Please be aware that only HDMI displays are fully supported through connector CN14. DVI displays, although having a similar TMDS interface, are not supported.

3.3.10 Optional MIPI-CSI2 Connector

MIPI-CSI2 connector– CN4

Pin	Signal	Pin	Signal
1	MIPI_CSI_D3_N	10	MIPI_CSI_D0_N
2	MIPI_CSI_D3_P	11	MIPI_CSI_D0_P
3	MIPI_CSI_D2_N	12	GND
4	MIPI_CSI_D2_P	13	CSI_PWDN#
5	MIPI_CSI_D1_N	14	---
6	MIPI_CSI_D1_P	15	---
7	MIPI_CSI_CLK_N	16	---
8	MIPI_CSI_CLK_P	17	CSI_RST#
9	GND	18	+3P3V_SW



The Rockchip PX30 Processor includes an Image Processing Subsystem, that can be used for video applications, like video-preview, video recording and frame grabbing.

It is possible to access to the video input port through an FFC/FPC connector, type OMRON p/n XF2M-1815-1A which is able to accept 18 poles 0.5mm pitch FFC cables.

CSI_PWDN#: Camera enable output, active low signal, electrical level +3P3V_SW

CSI_RST#: Camera Reset output, active low signal, electrical level +3P3V_SW

MIPI_CSI_D0_P/ MIPI_CSI_D0_N: MIPI CSI Port differential data pair #0.

MIPI_CSI_D1_P/ MIPI_CSI_D1_N: MIPI CSI Port differential data pair #1.

MIPI_CSI_D2_P/ MIPI_CSI_D2_N: MIPI CSI Port differential data pair #2.

MIPI_CSI_D3_P/ MIPI_CSI_D3_N: MIPI CSI Port differential data pair #3.

MIPI_CSI_CLK_P/ MIPI_CSI_CLK_N: MIPI CSI Port differential clock pair.

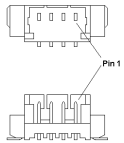
When connecting CSI cameras to CN4 connector, it is strongly recommended to use shielded cable for EMC compatibility.

3.3.11 USB Connectors

The PX30 processor offers an USB 2.0 Host and an USB 2.0 OTG interface.

USB recovery connector – CN7

Pin	Signal
1	VBUS_RECOVERY
2	USB_OTG_C1-
3	USB_OTG_C1+
4	GND



The USB OTG interface is switched between an internal header (CN7, reserved for recovery purposes), and an USB Type-A slot (included in the Dual USB Type-A Slot CN6).

CN7 is a 1.25mm pitch connector type Molex p/n 53398-0471 or equivalent.

Mating connector: MOLEX 51021-0400 receptacle with MOLEX 50079-8000 female crimp terminals.

USB_OTG_C1+/USB_OTG_C1-: USB OTG Port #1 (client mode) differential pair.

On this connector, only client functionality is supported. When an external Host is connected, the presence of an external 5V voltage on pin #1 (i.e. VBUS_RECOVERY) automatically switch the OTG Port to CN7

The USB 2.0 Host interface, instead, is carried to a Microchip USB2514 USB2.0 Hub, which makes available four USB 2.0 downstream host ports.

The USB Downstream port #1 is carried to miniPCIe- slot CN17 (see par. 3.3.3).

USB Type-A Slot – CN8

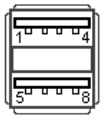
Pin	Signal
1	$+5V_{USB2}$
2	USB_D2-
3	USB_D2+
4	GND

The USB downstream port #2 is carried to connector CN8, which is a standard USB Type A socket, shielded, upright.

USB_D2+/USB_D2-: USB Hub Downstream port #2 differential pair.

Dual USB 2.0 Type-A Socket – CN6

Pin	Signal	Pin	Signal
1	$+5V_{USB3}$	5	$+5V_{USB1}$
2	USB_D3-	6	USB_OTG_H1-
3	USB_D3+	7	USB_OTG_H1+
4	GND	8	GND



The USB downstream port #3 is carried to a double connector, CN6, which is a standard double USB Type A socket, shielded. The other port available on this connector is the USB OTG Port previously described, available only when the recovery mode is not active (i.e. there isn't an USB Host connected to CN7

Since this connector is a standard type-A receptacle, it can be connected to all types of USB 1.1 / USB 2.0 devices using standard-A USB 2.0 plugs

USB_D3+/USB_D3-: USB Hub Downstream port #3 differential pair.

USB_OTG_H1+/USB_OTG_H1-: USB OTG Port #1 (Host mode) differential pair.

The USB Downstream port #4 is connected to the T/S connector CN13 (see par. 3.3.8).

STM32 USB connector – CN31

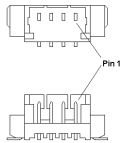
Pin	Signal
1	+5V_USB_EC
2	STM32_USB_D-
3	STM32_USB_D +
4	GND

The board can offer an additional USB Client interface, managed by the STM32F302 microcontroller.

This is available on CN31, which is a 1.25mm pitch connector type Molex p/n 53398-0471 or equivalent.

Mating connector: MOLEX 51021-0400 receptacle with MOLEX 50079-8000 female crimp terminals.

STM32_USB_D1+/STM32_USB_D1-: STM32 USB Controlled Port #1 differential pair.



All USB ports' voltages ($+5V_{USBx}$ and +5V_USB_EC) are derived, through a power switch IC, from +5V_STBY voltages.

Common mode chokes are placed on all USB differential pairs for EMI compliance.

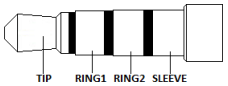
For ESD protection, on all data and voltage lines are placed clamping diodes for voltage transient suppression.

3.3.12 Audio Connectors

TRSS Audio Jack – CN24	
Pin	**Signal**
TIP	Headphone Out Left Channel
RING1	Headphone Out Right Channel
RING2	GND
SLEEVE	Mic In

On SBC-D23 board, audio functionalities are offered directly by the RK809 PMIC, which embeds a high performance Audio Codec.

Always available on all factory configurations of SBC-D23 board, there is a TRRS Combo Audio Socket CN24, i.e. a single socket which offer both stereo Line Out and Mic In functionalities.

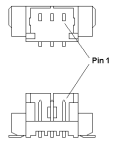


Such TRRS Combo Audio socket can be used with any 4-poles 3.5mm diameter audio jack, with pinout compatible with the most recent Headsets, shown in the table on the left.

Speaker Connector – CN47	
Pin	**Signal**
1	SPKR_OUT+
2	GND
3	SPKR_OUT-

Always available, there is also a dedicated 3-pin connector, type 53398-0371, for the connection of external speakers (earphones)

Mating connector: MOLEX 51021-0300 receptacle with MOLEX 50079-8000 female crimp terminals.

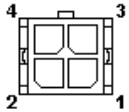


SPKR_OUT+: Amplified speaker Positive Output

SPKR_OUT-: Amplified speaker Negative Output

Amplified stereo speaker connector – CN55	
Pin	**Signal**
1	AMP_OUT_LEFT+
2	AMP_OUT_LEFT-
3	AMP_OUT_RIGHT+
4	AMP_OUT_RIGHT-

As a factory option, the SBC-D23 board can be supplied with a TI TPA3110D2 Class-D amplifier, offering stereo speaker output on a Micro-fit 2x2 connector type Molex 43045-0424 or equivalent, as shown in the figure.



Mating connector: MOLEX 43025-0400 or equivalent with 43030 female crimp terminal

The power output available on this connector is dependent on the value of V_{IN} Power rail. When the board is powered with a 24V voltage, it can reach up to 15W per channel on 8Ohm load @ 10% Total Harmonic Distortion + Noise (THDN+N)

Please be aware that the optional audio amplifier will exclude the headphone out (right and left) on TRRS connector, since this interface is needed as an input to the amplifier.

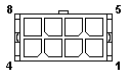
3.3.13 Serial Ports Connectors

The PX30 Processor supports up to six UART Interfaces. Four of them are used on SBC-D23 board.

RS-232 Port #A Connector – CN42

Pin	Signal	Pin	Signal
1	RS232_A_CTS	5	RS232_A_TXD
2	RS232_A_RTS	6	RS232_A_RXD
3	V_{IN}	7	GND
4	+5V_STBY	8	GND

UART Port #0 is made available, through a dedicated RS-232 transceiver on a dedicated Micro-fit 2x4 connector type Molex 43045-0812 or equivalent, with the pinout shown in the table on the left.



Mating connector: MOLEX 43025-0800 or equivalent with 43030 female crimp terminal.

RS232_A_TX: COM Port #0 RS-232 Mode Transmit data

RS232_A_RX: COM Port #0 RS-232 Mode Receive data

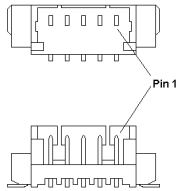
RS232_A_CTS: COM Port #0 RS-232 Mode Request to Send handshaking signal.

RS232_A_RTS: COM Port #0 RS-232 Mode Request to Send handshaking signal.

RS-232 / UART Port #B Connector – CN43

Pin	Signal
1	RS232_B_TX
2	RS232_B_RX
3	RS232_B_RTS
4	RS232_B_CTS
5	GND

On Connector CN43, instead, it is available the UART Port #4, which can be available with RS-232 or TTL interface (factory options).



For this purpose, a dedicated 5-pin connector, Type MOLEX p/n 53398-0571 or equivalent is provided. Mating connector: MOLEX 51021-0500 receptacle with MOLEX 50079-8000 female crimp terminals.

UART Port #4 is managed as a factory alternative to microSD Slot, i.e. boards having this port available (either in RS-232 or in UART TTL mode) will not have the microSD slot mounted.

RS232_B_TX: COM Port #4 RS-232 Mode Transmit data

RS232_B_RX: COM Port # RS-232 Mode Receive data

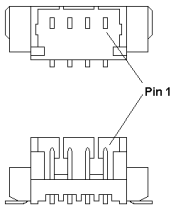
RS232_B_CTS: COM Port #4 RS-232 Mode Request to Send handshaking signal.

RS232_B_RTS: COM Port #4 RS-232 Mode Request to Send handshaking signal.

Debug UART Connector – CN27

Pin	Signal
1	+3P3V_SW
2	DUART_RX
3	DUART_TX
4	GND

The connector CN27, instead carries out signals related to UART #2 interface from PX30 processor. This interface can be used for the debugging of the processor.



The connector is type MOLEX p/n 53398-0471 or equivalent. Mating connector: MOLEX 51021-0400 receptacle with MOLEX 50079-8000 female crimp terminals.

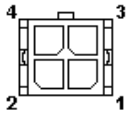
DUART_TX: UART port #2 Transmit signal, +3P3V_SW electrical level

DUART_RX: UART port #2 Receive signal, +3P3V_SW electrical level

3.3.14 CAN Connectors

CAN Bus Connectors – CN29, CN30	
Pin	**Signal**
1	GND
2	CAN_H
3	CAN_L
4	+5V_SW

SBC-D23 board can offer a single CAN Bus duplicated on two connectors, in order to connect directly to two devices simultaneously using the same Bus.



The CAN Bus controller is programmed inside the on-board microcontroller, while the physical interface comes through a High-Speed CAN transceiver, type NXP TJA1051, which offers also improved EMC and ESD performances.

The two CAN Bus Connectors are 4-pin Micro-fit 2x2 connector type Molex 43045-0424 or equivalent, as shown in the figure.

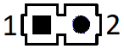
Mating connector: MOLEX 43025-0400 or equivalent with 43030 female crimp terminal

Mating connector: MOLEX 51021-0300 receptacle with MOLEX 50079-8000 female crimp terminals.

A 120Ω termination resistor can be placed between CAN_H and CAN_L signals. It can be connected or disconnected from the line by using JP2 jumper (Jumper inserted = termination connected).

Signals Description:

CAN_H: High-Level CAN bus line

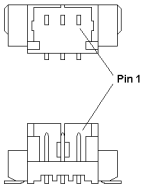


CAN_L: Low-Level CAN bus line

3.3.15 RS-485 Connector

SBC-D23 board offers also dedicated RS-485 interface, which is programmed inside the on-board microcontroller, while the physical interface comes through a ±15kV ESD protected RS-485 transceiver, type Analog Devices ADM3485E.

RS-485 Connector – CN48	
Pin	**Signal**
1	RS485_D+
2	GND
3	RS485_D -

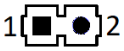


Always available, there is also a dedicated 3-pin connector, type 53398-0371, for the connection of external speakers (earphones)

Mating connector: MOLEX 51021-0300 receptacle with MOLEX 50079-8000 female crimp terminals.

Signals Description:

RS485_D+/ RS485_D-: microcontroller's UART_3, RS-485 Mode, Differential Pair



A 120Ω termination resistor can be placed between RS485_D+ and RS485_D- signals. It can be connected or disconnected from the line by using JP3 jumper (Jumper inserted = termination connected).

When this port is available (Factory option), then USART Port #3 will not be available on connector J2. Please check also par. 3.3.16

3.3.16 Microcontroller's programmable connectors

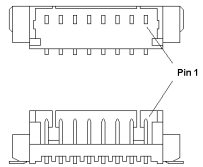
The SD23 board is completed by a series of connectors with various interfaces managed by the microcontroller STM32F302VCT6. All signals available on these connectors can be used as generic I/Os, but upon specific FW programming, they can be easily adapted to implement other interfaces, all of them described in the following tables.

All signals, unless differently specified, are at 3P3V_RUN Voltage.

Dual 2-Wire UART connector – CN32

Pin	Signal
1	+3P3V_OUT_EC
2	EC_UART1_TX
3	EC_UART1_RX
4	GND
5	+3P3V_OUT_EC
6	EC_UART5_TX
7	EC_UART5_RX
8	GND

It is possible to have two 2-Wire UARTs on an 8-pin 1.25mm pitch connector type Molex p/n 53398-0871 or equivalent.



Mating connector: MOLEX 51021-0800 receptacle with MOLEX 50079-8000 female crimp terminals.

EC_UART1_TX: microcontroller UART port #1, Transmit signal. Connected to microcontroller's port C, pin #4.

EC_UART1_RX: microcontroller UART port #1, Receive signal. Connected to microcontroller's port C, pin #5.

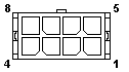
EC_UART5_TX: microcontroller UART port #5, Transmit signal. Connected to microcontroller's port C, pin #12.

EC_UART5_RX: microcontroller UART port #5, Receive signal. Connected to microcontroller's port D, pin #3.

Dual 4-Wire USART connector – J2

Pin	Signal	Pin	Signal
1	+3P3V_OUT_EC	2	+3P3V_OUT_EC
3	EC_UART2_TX	4	EC_UART3_TX
5	EC_UART2_RX	6	EC_UART3_RX
7	EC_UART2_RTS/DE	8	EC_UART3_RTS/DE
9	EC_UART2_CTS	10	EC_UART3_CTS
11	EC_UART2_CLK	12	EC_UART3_CLK
13	GND	14	GND

Two others Synchronous UARTs can be made available on dedicated connector J2, which is an internal 14-pin dual row p.2.54 mm header (type MOLEX p/n 70246-1404 or equivalent).



Mating connector: MOLEX 22552141 Crimp Housing with MOLEX 70058 female crimp terminals series

EC_UART2_TX: microcontroller USART port #2, Transmit signal. Connected to microcontroller's port D, pin #5.

EC_UART2_RX: microcontroller USART port #2, Receive signal. Connected to microcontroller's port D, pin #6.

EC_UART2_RTS/DE: microcontroller USART port #2, Request To Send / Data Enable signal. Connected to microcontroller's port D, pin #4.

EC_UART2_CTS: microcontroller USART port #2, Clear To Send signal. Connected to microcontroller's port D, pin #3.

EC_UART2_CLK: microcontroller USART port #2, Clock signal. Connected to microcontroller's port D, pin #7.

EC_UART3_TX: microcontroller USART port #3, Transmit signal. Connected to microcontroller's port C, pin #10.

EC_UART3_RX: microcontroller USART port #3, Receive signal. Connected to microcontroller's port C, pin #11.

EC_UART3_RTS/DE: microcontroller USART port #3, Request To Send / Data Enable signal. Connected to microcontroller's port D, pin #12.

EC_UART3_CTS: microcontroller USART port #3, Clear To Send signal. Connected to microcontroller's port D, pin #11.

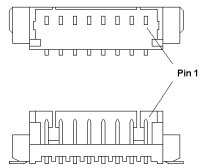
EC_UART3_CLK: microcontroller USART port #3, Clock signal. Connected to microcontroller's port D, pin #10.

Please be aware that UART port #3 on this connector is factory alternative to the RS-485 port available on connector CN48, i.e. board's equipped with RS-485 will not have the signals EC_UART3_TX, EC_UART3_RX and EC_UART_RTS/DE connected to J2.

Dual I2C connector – CN33

Pin	Signal
1	+3P3V_OUT_EC
2	I2C_OUT2_SDA
3	I2C_OUT2_SCL
4	GND
5	+3P3V_OUT_EC
6	I2C_OUT1_SDA
7	I2C_OUT1_SCL
8	GND

It is possible to have two dedicated I2C interfaces on an 8-pin 1.25mm pitch connector type Molex p/n 53398-0871 or equivalent.



Mating connector: MOLEX 51021-0800 receptacle with MOLEX 50079-8000 female crimp terminals.

I2C_OUT1_SDA: microcontroller I2C port #1 Data Signal. Connected to microcontroller's port B, pin #7.

I2C_OUT1_SCL: microcontroller I2C port #1 Clock Signal. Connected to microcontroller's port B, pin #6.

I2C_OUT2_SDA: microcontroller I2C port #2 Data Signal. Connected to microcontroller's port A, pin #10.

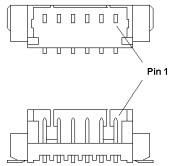
I2C_OUT2_SCL: microcontroller I2C port #2 Clock Signal. Connected to microcontroller's port A, pin #9.

These two I2C ports are made available on the CN33 connector through as many Dual I2C Bidirectional I2C bus voltage level translators, NXP PCA9306GF.

SPI connector – CN39

Pin	Signal
1	+3P3V_OUT_EC
2	EC_SPI2_CS#
3	EC_SPI2_CLK
4	EC_SPI2_MISO
5	EC_SPI2_MOSI
6	GND

Another possible programmable interface is SPI, available on a 6-pin 1.25mm pitch connector type Molex p/n 53398-0671 or equivalent.



Mating connector: MOLEX 51021-0600 receptacle with MOLEX 50079-8000 female crimp terminals.

EC_SPI2_CS#: microcontroller SPI port #2, Chip Select Signal. Connected to microcontroller's port B, pin #12.

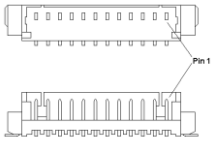
EC_SPI2_CLK: microcontroller SPI port #2 Clock Signal. Connected to microcontroller's port B, pin #13.

EC_SPI2_MISO: microcontroller SPI port #2 Master In Slave Out Signal. Connected to microcontroller's port B, pin #14.

EC_SPI2_MOSI: microcontroller SPI port #2 Master Out Slave In Signal. Connected to microcontroller's port B, pin #15.

8-Channel Timer connector – CN34

Pin	Signal	Pin	Signal
1	+3P3V_OUT_EC	7	EC_TIM1_CH4
2	EC_TIM1_CH1	8	EC_TIM4_CH2
3	EC_TIM1_CH1#	9	EC_TIM4_CH3
4	EC_TIM1_CH2	10	EC_TIM4_CH4
5	EC_TIM1_CH2#	11	EC_MC_OUT
6	EC_TIM1_CH3	12	GND



It is also possible to implement many dedicated Timers on the microcontroller, which will then available on dedicated connector CN34, which is 12-pin 1.25mm pitch connector type Molex p/n 53398-1271 or equivalent.

Mating connector: MOLEX 51021-1200 receptacle with MOLEX 50079-8000 female crimp terminals.

EC_TIM1_CH1: microcontroller Advanced Timer #1, First Channel Output. Connected to microcontroller's port E, pin #9.

EC_TIM1_CH1#: microcontroller Advanced Timer #1, First Channel Complementary Output. Connected to microcontroller's port E, pin #10.

EC_TIM1_CH2: microcontroller Advanced Timer #2, Second Channel Output. Connected to microcontroller's port E, pin #11.

EC_TIM1_CH2#: microcontroller Advanced Timer #2, Second Channel Complementary Output. Connected to microcontroller's port E, pin #12.

EC_TIM1_CH3: microcontroller Advanced Timer #1, Third Channel Output. Connected to microcontroller's port E, pin #13.

EC_TIM1_CH4: microcontroller Advanced Timer #1, Fourth Channel Output. Connected to microcontroller's port 14, pin #14.

EC_TIM4_CH2: microcontroller Advanced Timer #4, Second Channel Output. Connected to microcontroller's port D, pin #13.

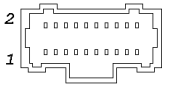
EC_TIM4_CH3: microcontroller Advanced Timer #4, Third Channel Output. Connected to microcontroller's port D, pin #14.

EC_TIM4_CH4: microcontroller Advanced Timer #4,0 Fourth Channel Output. Connected to microcontroller's port D, pin #15.

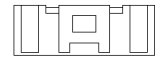
EC_MC_OUT: microcontroller Main Clock Output. Connected to microcontroller's port A, pin #8.

3.3.17 GPI and GPO Specific connectors

The SD23 board is completed by two specific connectors for General Purpose Inputs and General Purpose Outputs, managed through dedicated octal bus buffers (SN74LVC44A), which make the GPIs 5V tolerant and the GPOs able to drive outputs with up to 24mA.



These specific connectors are both type HR A1014WVA-S-2x10P or equivalent (2 x 10p, male, straight, P1, low profile, polarised) is provided, with the pin-out indicated in the following tables (different configurations are shown).



Mating connector: HR A1014H-2X10P with HR A1014-T female crimp terminals.

Alternative mating connector, MOLEX 501189-2010 with crimp terminals series 501334.

16x GPO connector – CN49

Pin	Signal	Pin	Signal
1	+3P3V_OUT_EC	2	+3P3V_OUT_EC
3	GPIO_OUTA_1	4	GPIO_OUTB_1
5	GPIO_OUTA_2	6	GPIO_OUTB_2
7	GPIO_OUTA_3	8	GPIO_OUTB_3
9	GPIO_OUTA_4	10	GPIO_OUTB_4
11	GPIO_OUTA_5	12	GPIO_OUTB_5
13	GPIO_OUTA_6	14	GPIO_OUTB_6
15	GPIO_OUTA_7	16	GPIO_OUTB_7
17	GPIO_OUTA_8	18	GPIO_OUTB_8
19	GND	20	GND

GPIO_OUTA_1: GP Output Port #A Out 1. Managed by microcontroller's port A, pin #0.

GPIO_OUTA_2: GP Output Port #A Out 2. Managed by microcontroller's port A, pin #1.

GPIO_OUTA_3: GP Output Port #A Out 3. Managed by microcontroller's port A, pin #2.

GPIO_OUTA_4: GP Output Port #A Out 4. Managed by microcontroller's port A, pin #3.

GPIO_OUTA_5: GP Output Port #A Out 5. Managed by microcontroller's port B, pin #0.

GPIO_OUTA_6: GP Output Port #A Out 6. Managed by microcontroller's port B, pin #1.

GPIO_OUTA_7: GP Output Port #A Out 7. Managed by microcontroller's port B, pin #2.

GPIO_OUTA_8: GP Output Port #A Out 8. Managed by microcontroller's port B, pin #10.

GPIO_OUTB_1: GP Output Port #B Out 1. Managed by microcontroller's port B, pin #11.

GPIO_OUTB_2: GP Output Port #B Out 2. Managed by microcontroller's port C, pin #0.

GPIO_OUTB_3: GP Output Port #B Out 3. Managed by microcontroller's port C, pin #1.

GPIO_OUTB_4: GP Output Port #B Out 4. Managed by microcontroller's port C, pin #2.

GPIO_OUTB_5: GP Output Port #B Out 5. Managed by microcontroller's port C, pin #3.

GPIO_OUTB_6: GP Output Port #B Out 6. Managed by microcontroller's port C, pin #6.

GPIO_OUTB_7: GP Output Port #B Out 7. Managed by microcontroller's port A, pin #5.

GPIO_OUTB_8: GP Output Port #B Out 8. Managed by microcontroller's port A, pin #6.

16x GPI connector – CN50			
Pin	**Signal**	**Pin**	**Signal**
1	+3P3V_OUT_EC	2	+3P3V_OUT_EC
3	GPIO_INPUTA_1	4	GPIO_INPUTB_1
5	GPIO_INPUTA_2	6	GPIO_INPUTB_2
7	GPIO_INPUTA_3	8	GPIO_INPUTB_3
9	GPIO_INPUTA_4	10	GPIO_INPUTB_4
11	GPIO_INPUTA_5	12	GPIO_INPUTB_5
13	GPIO_INPUTA_6	14	GPIO_INPUTB_6
15	GPIO_INPUTA_7	16	GPIO_INPUTB_7
17	GPIO_INPUTA_8	18	GPIO_INPUTB_8
19	GND	20	GND

GPIO_INPUTA_1: GP Input Port #A Out 1. Managed by microcontroller's port C, pin #7.

GPIO_INPUTA_2: GP Input Port #A Out 2. Managed by microcontroller's port C, pin #8.

GPIO_INPUTA_3: GP Input Port #A Out 3. Managed by microcontroller's port C, pin #9.

GPIO_INPUTA_4: GP Input Port #A Out 4. Managed by microcontroller's port C, pin #13.

GPIO_INPUTA_5: GP Input Port #A Out 5. Managed by microcontroller's port D, pin #1.

GPIO_INPUTA_6: GP Input Port #A Out 6. Managed by microcontroller's port E, pin #0.

GPIO_INPUTA_7: GP Input Port #A Out 7. Managed by microcontroller's port E, pin #1.

GPIO_INPUTA_8: GP Input Port #A Out 8. Managed by microcontroller's port E, pin #2.

GPIO_INPUTB_1: GP Input Port #B Out 1. Managed by microcontroller's port E, pin #3.

GPIO_INPUTB_2: GP Input Port #B Out 2. Managed by microcontroller's port E, pin #4.

GPIO_INPUTB_3: GP Input Port #B Out 3. Managed by microcontroller's port E, pin #5.

GPIO_INPUTB_4: GP Input Port #B Out 4. Managed by microcontroller's port E, pin #6.

GPIO_INPUTB_5: GP Input Port #B Out 5. Managed by microcontroller's port F, pin #9.

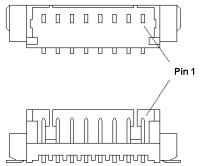
GPIO_INPUTB_6: GP Input Port #B Out 6. Managed by microcontroller's port F, pin #10.

GPIO_INPUTB_7: GP Input Port #B Out 7. Managed by microcontroller's port E, pin #8.

GPIO_INPUTB_8: GP Input Port #B Out 8. Managed by microcontroller's port A, pin #7.

3.3.18 STM32 Programming Connector

STM32 Programming connector – CN56	
Pin	**Signal**
1	+3P3V_RUN
2	DBG_TXD
3	DBG_RXD
4	BOOT0
5	SWDIO/JTMS
6	SWCLK/JTCK
7	EC_RST#
8	GND



Since many features of the board depends on its FW programming, it is given the possibility to the user to program it by themselves using connector CN56, which is an 8-pin 1.25mm pitch connector type Molex p/n 53398-0871 or equivalent.

Mating connector: MOLEX 51021-0800 receptacle with MOLEX 50079-8000 female crimp terminals.

SWDIO/JTMS: Serial Wire Debug/JTAG TMS input

SWDIO/JTCLK: Serial Wire Debug/JTAG TCK input

BOOT_0: Boot selection pin. Electrical Level +3P0V_VDD_PMU with 10KΩ pull-down resistor, directly connected to microcontroller's pin BOOT0

EC_RST#: microcontroller's reset input, also driven by the PX30 processor. Electrical Level +3P0V_VDD_PMU with 10KΩ pull-up resistor

DBG_TXD: microcontroller's Debug UART transmit signal (only in case that corresponding STM32 signal is not used as I2C_OUT2_SCL signal on CN33 connector).

DBG_RXD: microcontroller's Debug UART receive signal (only in case that corresponding STM32 signal is not used as I2C_OUT2_SDA signal on CN33 connector).

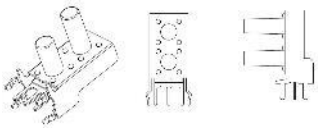
Please be aware that using some programmers it could arise electrical incompatibilities on EC_RST#signal. In these cases, please set "Software Reset" in the programming tool.

3.3.19 ON/OFF and Reset Connector

SD23 board can offer a dual push-button switch (P/N HY-1102HLT-A95B50) for the On/Off and System Reset functionalities.

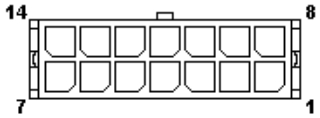
Upper push button is used for On/Off, while lower push button is used for Reset.

Please be aware that the dual push button switch is available only on board in commercial temperature range, since it cannot sustain the full industrial temperature range.



3.3.20 UPS By-pass connector

The SBC-D23 board allow the possibility of connecting external UPS modules able to supply a 12V Backup, to be used in case that the main power supply is not available



UPS By-Pass Connector – CN3

Pin	Signal	Pin	Signal
1	---	8	+12V_BACKUP
2	VDD_SYS	9	---
3	---	10	+12V_BACKUP
4	VDD_SYS	11	UPS_BOOST_EN
5	UPS_PFO#	12	GND
6	UPS_BYPASS	13	UPS_EN
7	UPS_INT#	14	GND

For this kind of connection, it is provided a standard Micro-fit 2x7 connector type Molex 43045-1412 or equivalent, with the pinout shown in the table on the left.

Mating connector: MOLEX 43025-1400 or equivalent with 43030 female crimp terminal.

UPS_BYPASS: UPS power rail enable signal. Used to switch between the power rail coming from the external UPS Module and the standard V_{IN} Power Supply. Electrical level +12V_ALW with 100KΩ pull-up resistor

UPS_PFO#: Generic Input. It is managed on the SBC-D23 board by I/O Expander B, Port #0 Pin #0. Electrical level +3P3V_RUN.

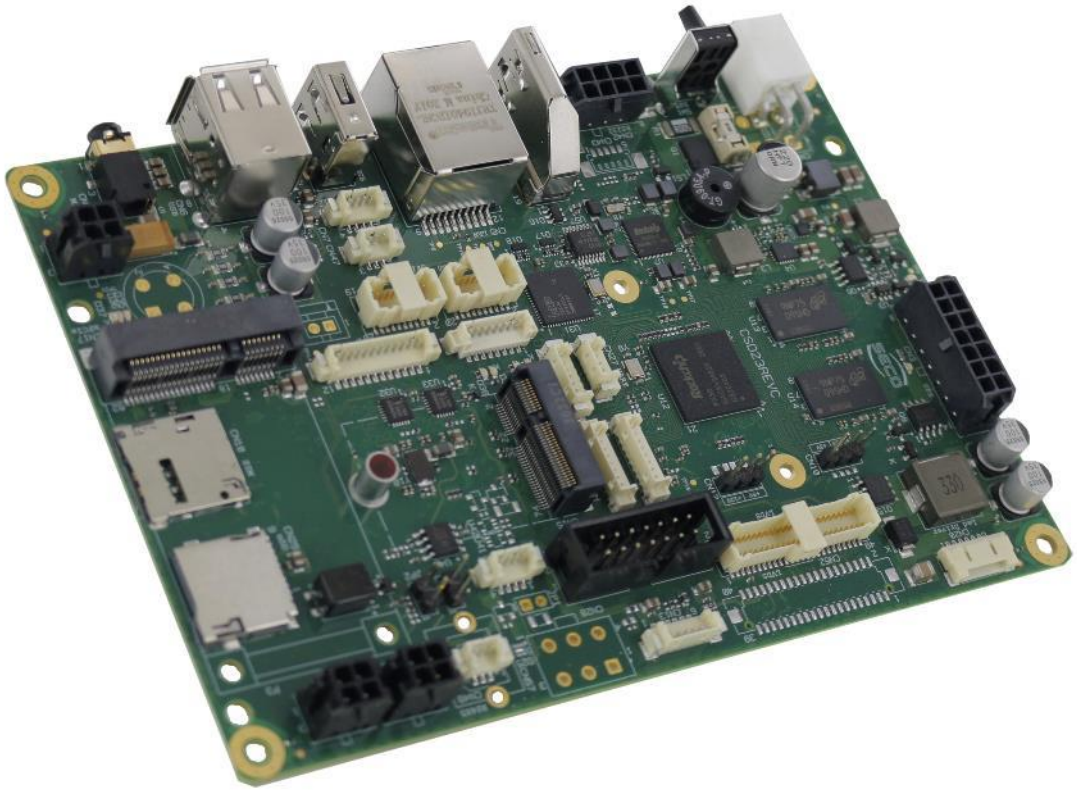
UPS_INT#: This signal can be used to serve the interrupt request of the UPS device. It is managed on the SBC-D23 board by I/O Expander B, Port #0 Pin #1. Electrical level +3P3V_RUN.

UPS_EN: IO: Generic UPS Enable signal. It is managed on the SBC-D23 board by I/O Expander A, Port #0 Pin #1. Electrical level +3P3V_RUN

UPS_BOOST_EN: Generic UPS Enable signal. It is managed on the SBC-D23 board by I/O Expander A, Port #0 Pin #0. Electrical level +3P3V_RUN

Chapter 4.
APPENDICES

- Thermal Design



4.1 Thermal Design

A parameter that has to be kept in very high consideration is the thermal design of the system.

Highly integrated modules, like SBC-D23 board, offer to the user very good performances in minimal spaces, therefore allowing the system's minimization. On the counterpart, the miniaturizing of IC's and the rise of operative frequencies of processors lead to the generation of a big amount of heat, that must be dissipated to prevent system hang-off or faults.

The board can be used along with specific heatspreaders, but please remember that they will act only as thermal coupling device between the board itself and an external dissipating surface/cooler. The heatspreader also needs to be thermally coupled to all the heat generating surfaces using a thermal gap pad, which will optimize the heat exchange between the module and the heatspreader.

The heatspreader is not intended to be a cooling system by itself, but only as means for transferring heat to another surface/cooler, like heatsinks, fans, heat pipes and so on.

When using SBC-D23 boards, it is necessary to consider carefully the heat generated by the module in the assembled final system, and the scenario of utilization.

Until the board is used on a laboratory shelf, on free air, just for software development and system tuning, then a heatsink with integrated fan could be sufficient for board's cooling. Anyhow, please remember that all depends also on the workload of the processor. Heavy computational tasks will generate much heat with all SOCs versions.

Therefore, it is always necessary that the customer studies and develops accurately the cooling solution for his system, by evaluating processor's workload, utilization scenarios, the enclosures of the system, the air flow and so on.

SECO can provide SBC-D23 specific passive heatsinks, but please remember that their use must be evaluated accurately inside the final system, and that they should be used only as a part of a more comprehensive ad-hoc cooling solutions.

Ordering Code	Description
ASK-948	Heatsink unit for SD23 board

Warning!

The thermal solutions available with SECO boards are validated and certificated according to IEC 62368-1 in the temperature range [-40°C-75°C], without housing and inside climatic chamber. Therefore, the customer is suggested to study, develop and validate the cooling solution for his system, considering ambient temperature, processor's workload, utilisation scenarios, enclosures, air flow and so on.

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