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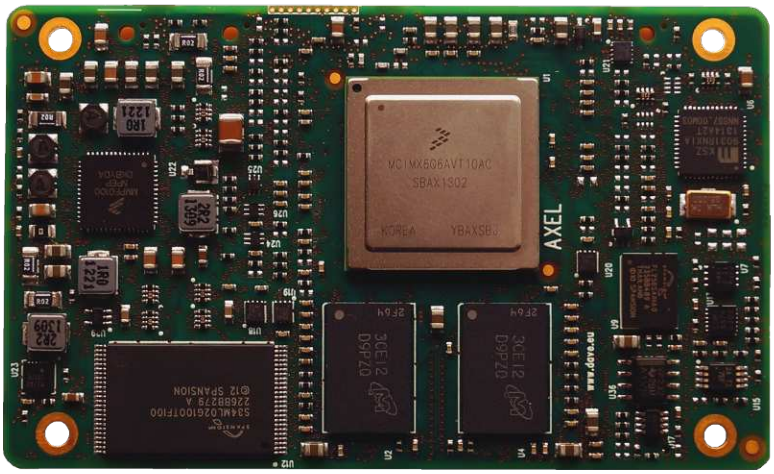
AXEL ULTRA

Solo / Dual / Quad
ARM Cortex-A9 MPCore
CPU Module

ULTRA Line

HARDWARE MANUAL



DAVE Embedded Systems www.dave.eu info@dave.eu

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1 Preface

1.1 About this manual

This Hardware Manual describes the AXEL CPU module design and functions.
Precise specifications for the NXP/Freescale i.MX6 processor can be found in the CPU datasheets and/or reference manuals.

1.2 Copyrights/Trademarks

1.3 Standards

DAVE Embedded Systems is certified to ISO 9001 standards.

1.4 Disclaimers

DAVE Embedded Systems does not assume any responsibility about availability, supplying and support regarding all the products mentioned in this manual that are not strictly part of the AXEL CPU module.
AXEL CPU Modules are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. **DAVE Embedded Systems** customers who are using or selling these products for use in such applications do so at their own risk and agree to fully indemnify **DAVE Embedded Systems** for any damage resulting from such improper use or sale.

1.5 Warranty

AXEL is warranted against defects in material and workmanship for the warranty period from the date of shipment. During the warranty period, **DAVE Embedded Systems** will at its discretion decide to repair or replace defective products. Within the warranty period, the repair of products is free of charge as long as warranty conditions are observed.
The warranty does not apply to defects resulting from improper or

inadequate maintenance or handling by the buyer, unauthorized modification or misuse, operation outside of the product's environmental specifications or improper installation or maintenance.
DAVE Embedded Systems will not be responsible for any defects or damages to other products not supplied by **DAVE Embedded Systems** that are caused by a faulty AXEL module.

1.6 Technical Support

We are committed to making our product easy to use and will help customers use our CPU modules in their systems. Technical support is delivered through email to our valued customers. Support requests can be sent to support-axel@dave.eu.
Software upgrades are available for download in the restricted access download area of **DAVE Embedded Systems** web site: http://www.dave.eu/reserved-area. An account is required to access this area and is provided to customers who purchase the development kit (please contact support-axel@dave.eu for account requests)..
Please refer to our Web site at http://www.dave.eu/dave-cpu-module-imx6-axel.html for the latest product documentation, utilities, drivers, Product Change Notifications, Board Support Packages, Application Notes, mechanical drawings and additional tools and software.

1.7 Related documents

Document	Location
DAVE Embedded Systems Developers Wiki	http://wiki.dave.eu/index.php/Main_Page
NXP/Freescale i.MX6 Dual/ 6Quad Applications Processor Reference Manual	http://cache.freescale.com/files/32bit/doc/ref_manual/IMX6DQRM.pdf?fpsp=1&WT_TYPE=Reference%20Manuals&WT_VENDOR=FREESCALE&WT_FILE_FORMAT=pdf&WT_ASSET=Documentation

Tab. 1: Related documents

1.8 Conventions, Abbreviations, Acronyms

Abbreviation	Definition
i.MX6 APRM	i.MX6 Application Processor Reference Manual
IPU	Image Processing Unit
GPI	General purpose input
GPIO	General purpose input and output
GPO	General purpose output
PCB	Printed circuit board
RTC	Real time clock
SOM	System on module
TRM	Technical Reference Manual
XELK	AXEL Embedded Linux Kit

Tab. 2: Abbreviations and acronyms used in this manual

Revision History

Version	*Date*	*Notes*
0.9.0	October 2013	First Draft
1.0.0	November 2013	First official release with XELK 1.0.0
1.0.1	January 2014	Minor fixes
1.0.2	August 2014	Minor fixes Fixed power-up sequence diagram
1.0.3	November 2014	Minor fixes Released with XELK 2.0.0
1.0.4	April 2015	Minor fixes Added BOARD_PGOOD info Notes on NVCC_EIM_EXT Released with XELK 2.1.0
1.0.5	September 2016	Minor fixes

2 Introduction

AXEL is the new top-class Solo/Dual/Quad core ARM Cortex-A9 CPU module by **DAVE Embedded Systems**, based on the recent NXP/Freescale i.MX6 application processor.

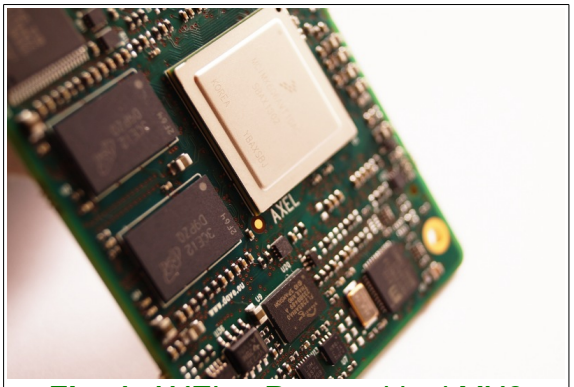


Fig. 1: AXEL – Powered by i.MX6 processor

Thanks to **AXEL**, customers have the chance to save time and resources by using a compact solution that permits to reach scalable performances that perfectly fits the application requirements avoiding complexities on the carrier board.

The use of this processor enables extensive system-level differentiation of new applications in many industry fields, where high-performance and extremely compact form factor (85mm x 50mm) are key factors. Smarter system designs are made possible, following the trends in functionalities and interfaces of the new, state-of-the-art embedded products. **AXEL** offers great computational power, thanks to the rich set of peripherals, the Scalable ARM Cortex-A9 together with a large set of high-speed I/Os (up to 5GHz).

AXEL enables designers to create smart products suitable for harsh mechanical and thermal environments, allowing the development of high computing and reliable solutions. Thanks to the tight integration between the ARM Core-based processing system, designers are able to share the application through the multicore platform and/or to divide the task on different cores in order to match with specific application requirements (AMP makes possible the creation of applications where RTOS and Linux work together on different cores).Thanks to **AXEL**, customers are going to save time and resources by using a powerful and scalable compact solution, avoiding complexities on the carrier PCB.

AXEL is designed and manufactured according to **DAVE Embedded Systems ULTRA Line** specifications, in order to guarantee premium quality and technical value for customers who require top performances and flexibility. **AXEL** is suitable for high-end applications such as medical

instrumentation, advanced communication systems, critical real-time operations and safety applications.

2.1 Product Highlights

- Unmatched performances thanks to Solo / Dual / Quad Core @ 1.2 GHz
- All memories you need on-board
- Boot from NOR for safe applications
- Enabling massive computing applications thanks to wide range DDR3 RAM memory up to 4GB
- Wide range PSU input from 2.8V to 4.5V
- High mechanical retention - 100G shock - thanks to 3x140pins and 4 screw holes
- Reduced carrier complexity: dual CAN, USB, Ethernet GB, PCIe, SATA and native 3.3V I/O
- Suitable for Asymmetric Multicore Processing
- A timing application thanks to on-board 5ppm RTC

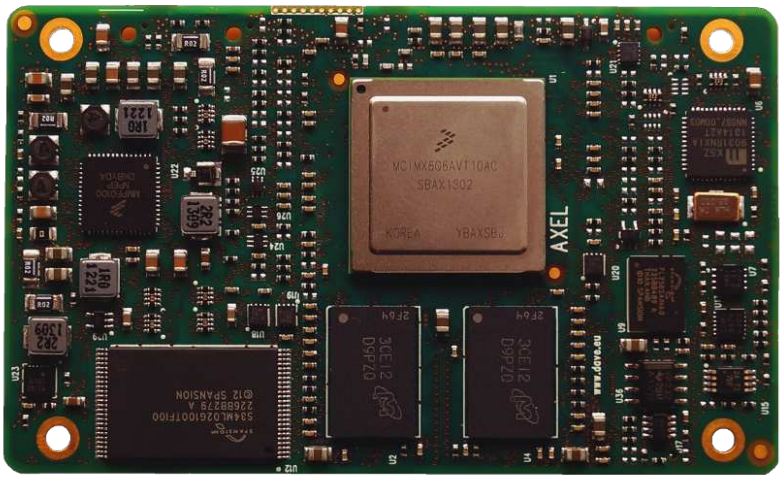
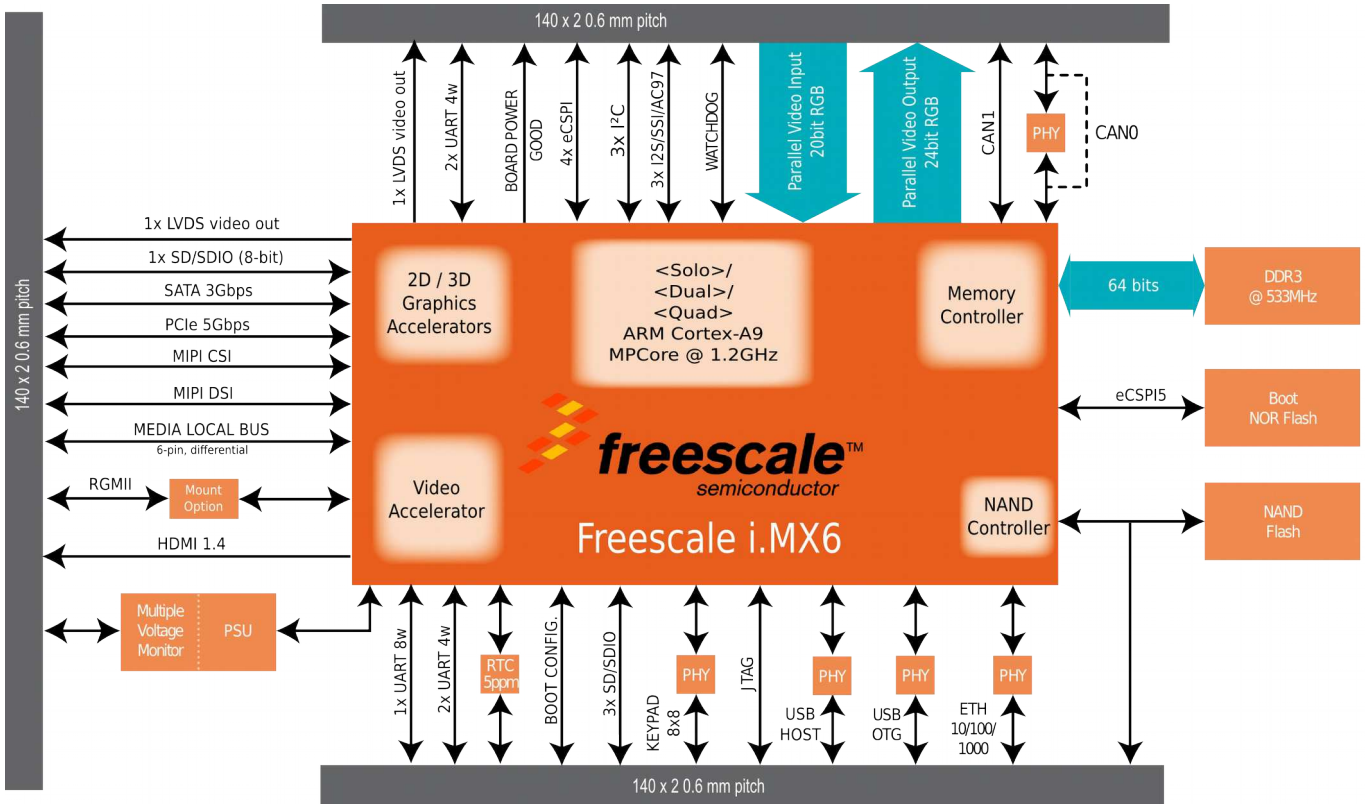


Fig. 2: AXEL SOM (top view)

2.2 Block Diagram



2.3 Feature Summary

Feature	Specifications	Options
CPU	NXP/Freescale i.MX6 ARM Cortex A9 MPCore™ Solo, Dual or Quad core @ 1.2 GHz	
Cache	L1: 32Kbyte instruction, 32Kbyte data L2: Unified instruction and data, 1MByte	
RAM	DDR3 SDRAM @ 533 MHz Up to 4 GB, x64 data bus width	
Storage	Flash NOR SPI (8, 16, 32, 64 MB) Flash NAND (all sizes, on request)	
Expansion bus	One PCI Express 2.0 lane with integrated PHY (5.0 GT/s Endpoint/Root Complex operations)	

Tab. 3: CPU, Memories, Buses

Feature	Specifications	Options
Graphics Controller	16-/24-bit HD Display Port 1x HDMI 1.3 channel + DDC 1x TFT/RGB output port 1x MIPI DSI port 2x LVDS output ports	
2D/3D Engines	GPU2D cores for raster (R2D, Vivante GC320) and vector (V2D, Vivante GC355) graphics acceleration GPU3D core (Vivante GC2000) for OpenGL/OpenGL ES/OpenVG/OpenCL API acceleration	
Video capture	1x 20bit video input 1x MIPI CSI port	
Video processing	High performance, multi-standard VPU Up to 1080p60 H264 decode Up to 1080p30 H264 encode	
Coprocessors	Media Processing Engine with NEON™ & VFPv3-D32 Floating-Point Unit	
USB	1x USB OTG 2.0 with integrated PHY 1x USB Host 2.0 with integrated PHY	
UARTs	5x UART ports (1x full, 4x four-wires)	
GPIO	Up to 206 lines, shared with other functions	

Feature	Specifications	Options
	(interrupts available)	
Networks	Gigabit Ethernet 10/100/1000 Mbps with integrated PHY	
CAN	2x CAN 2.0B ports (1x with integrated PHY)	
SD/MMC	4x SD 3.0 /SDIO 3.0/MMC 4.x compliant controllers	
Storage	Serial ATA II 3.0 Gbps with integrated PHY	
Serial buses	5x full-duplex SPI ports with four peripheral chip selects 3x master and slave I²C interfaces	
Audio	3x I²S/SSI/AC97 interfaces	
Timers	Enhanced Periodic Interrupt Timer General Purpose Timer	
RTC	On board, ±3.5ppm (DS3232), external battery powered	
Watchdog	On board, configurable timeout (MAX6373)	
Debug	JTAG IEEE 1149.1 Test Access Port CoreSight™ and Program Trace Macrocell (PTM)	

Tab. 4: Peripherals

Feature	Specifications	Options
Supply Voltage	2.8-4.5V wide range input, voltage regulation on board	
Active power consumption	See section 8.3 - Power consumption	
Dimensions	85mm x 50mm	
Weight	<tbd>	
MTBF	<tbd>	
Operating temperature range	Commercial: 0°C / +70°C Industrial: -40°C / +85°C	
Shock	100 G	
Vibration	<tbd>	
Connectors	3 x 140 pins 0.6mm pitch	
Connectors	<tbd>	

Feature	Specifications	Options
insertion / removal		

Tab. 5: Electrical, Mechanical and Environmental Specifications

3 Design overview

The heart of AXEL module is composed by the following components:

- NXP/Freescale i.MX6 Solo / Dual / Quad core SoC application processor
- Power supply unit
- DDR memory banks
- NOR and NAND flash banks
- 3x 140 pin connectors with interfaces signals

This chapter shortly describes the main AXEL components.

3.1 NXP/Freescale i.MX6 application processor

The i.MX6 Solo/Dual/Quad processors feature NXP/Freescale's advanced implementation of the ARM® Cortex®-A9 MPCore, which operates at speeds up to 1.2 GHz. They include 2D and 3D graphics processors, 1080p video processing, and integrated power management. As a result, the i.MX6 devices are able to serve a wide range of applications including:

- Automotive driver assistance, driver information, and infotainment
- Multimedia-centric smart mobile devices
- Instrument clusters, and portable medical devices.
- E-Readers, smartbooks, tablets
- Intelligent industrial motor control, industrial networking, and machine vision
- IP and Smart camera
- Human-machine interfaces
- Medical diagnostics and imaging
- Digital signage
- Video and night vision equipment
- Multimedia-focused products
- Entertainment and gaming appliances

The i.MX6 application processor is composed of the following major functional blocks:

- ARM Cortex-A9 MPCore 2x/4x CPU Processor, featuring:
  - 1 Megabyte unified L2 cache shared by all CPU cores
  - NEON MPE coprocessor
  - General Interrupt Controller (GIC) with 128 interrupt support
  - Snoop Control Unit (SCU)
  - External memories interconnect
- Hardware accelerators, including:
  - VPU -Video Processing Unit
  - Two IPUv3H -Image Processing Unit (version 3H)
  - 2D/3D/Vector graphics accelerators
- Connectivity peripherals, including
  - PCIe
  - SATA
  - SD/SDIO/MMC
  - Serial buses: USB, UART, I^2C, SPI, ...

AXEL can mount three versions of the i.MX6 processor. The following table shows a **comparison** between the processor models, highlighting the differences:

Processor	# cores	Clock	L2 cache	DDR3	Graphics acceleration	IPU	VPU	SATA-II
i.MX6 Solo	1	800 MHz 1 GHz	512 KB	32 bit @ 400 MHz	*3D*: Vivante GC880 *2D*: Vivante GC320 *Vector*: N.A.	1x	1x	N.A.
i.MX6 Dual	2	850 MHz 1 GHz 1.2 GHz	1 MB	64 bit @ 533 MHz	*3D*: Vivante GC2000 *2D*: Vivante GC320 *Vector*: Vivante GC335	2x	2x	Yes
i.MX6 Quad	4	850 MHz 1 GHz 1.2 GHz	1MB	64 bit @ 533 MHz	*3D*: Vivante GC2000 *2D*: Vivante GC320 *Vector*: Vivante GC335	2x	2x	Yes

Tab. 6: i.MX6 comparison

3.2 DDR3 memory bank

DDR3 SDRAM memory bank is composed by 4x 16-bit width chips resulting in a 64-bit combined width bank.
The following table reports the SDRAM specifications:

CPU connection	Multi-mode DDR controller (MMDC)
Size min	512 MB
Size max	4 GB
Width	64 bit
Speed	533 MHz

Tab. 7: DDR3 specifications

3.3 NOR flash bank

NOR flash is a Serial Peripheral Interface (SPI) device. This device is connected to the eCSPI channel 5 and by default it acts as boot memory.
The following table reports the NOR flash specifications:

CPU connection	eCSPI channel 5
Size min	8 MByte
Size max	64 MByte
Chip select	ECSPI5_SS0
Bootable	Yes

Tab. 8: NOR flash specifications

3.4 NAND flash bank

On board main storage memory is a 8-bit wide NAND flash connected to the CPU's Raw NAND flash controller. Optionally, it can act as boot peripheral.
The following table reports the NAND flash specifications:

CPU connection	Raw NAND flash controller
Page size	512 byte, 2 kbyte or 4 kbyte
Size min	128 MByte
Size max	2 GByte
Width	8 bit
Chip select	NANDF_CS0
Bootable	Yes

Tab. 9: NAND flash specifications

3.5 Memory Map

For detailed information, please refer to chapter 2 “Memory Maps” of the i.MX Applications Processor Reference Manual.

3.6 Power supply unit

AXEL, as the other ULTRA Line CPU modules, embeds all the elements required for powering the unit, therefore power sequencing is self-contained and simplified. Nevertheless, power must be provided from carrier board, and therefore users should be aware of the ranges power supply can assume as well as all other parameters. For detailed information, please refer to Section 5.1.

3.7 CPU module connectors

All interface signals AXEL provides are routed through three 140 pin 0.6mm pitch stacking connectors (named J1, J2 and J3). The dedicated carrier board must mount the mating connectors and connect the desired peripheral interfaces according to AXEL pinout specifications.
For mechanical information, please refer to Section 4 (Mechanical specifications). For pinout and peripherals information, please refer to Sections 6 (Pinout table) and 7 (Peripheral interfaces).

4 Mechanical specifications

This chapter describes the mechanical characteristics of the AXEL module.

Mechanical drawings are available in DXF format from the AXEL page on DAVE Embedded Systems website (http://www.dave.eu/products/som/freescale/imx6_axel-ultra).

4.1 Board Layout

The following figure shows the physical dimensions of the AXEL module:

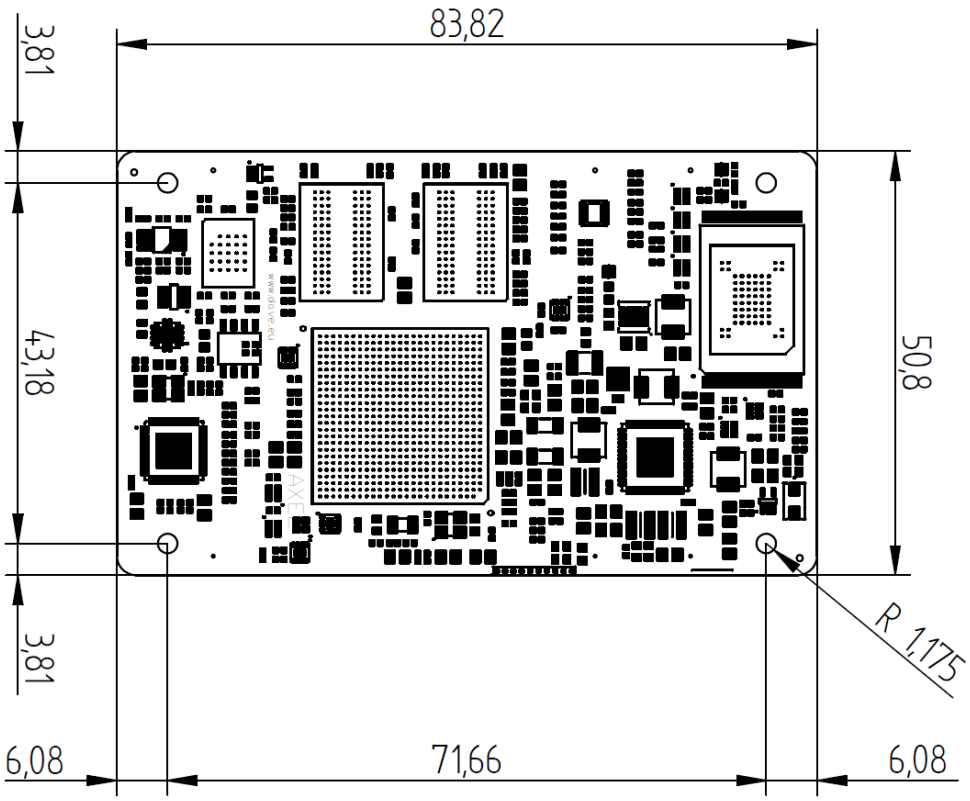


Fig. 3: Board layout - Top view

- Board height: 50.8 mm

- Board width: 83.8 mm
- Maximum components height is 2 mm (top) and 4 mm (bottom)
- PCB thickness is 1.9 mm

The following figure highlights the maximum components' heights on AXEL module:

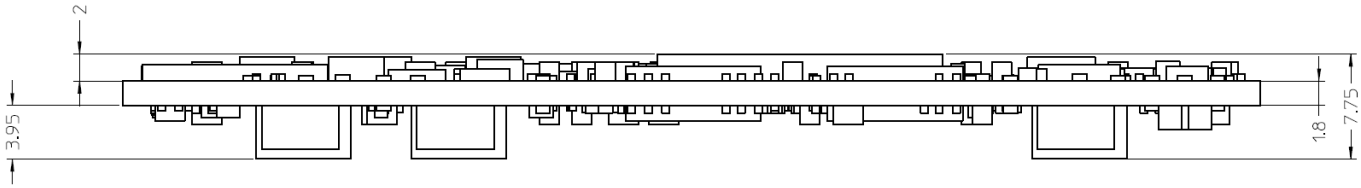


Fig. 4: Board layout - Side view

4.2 Connectors

The following figure shows the AXEL connectors layout:

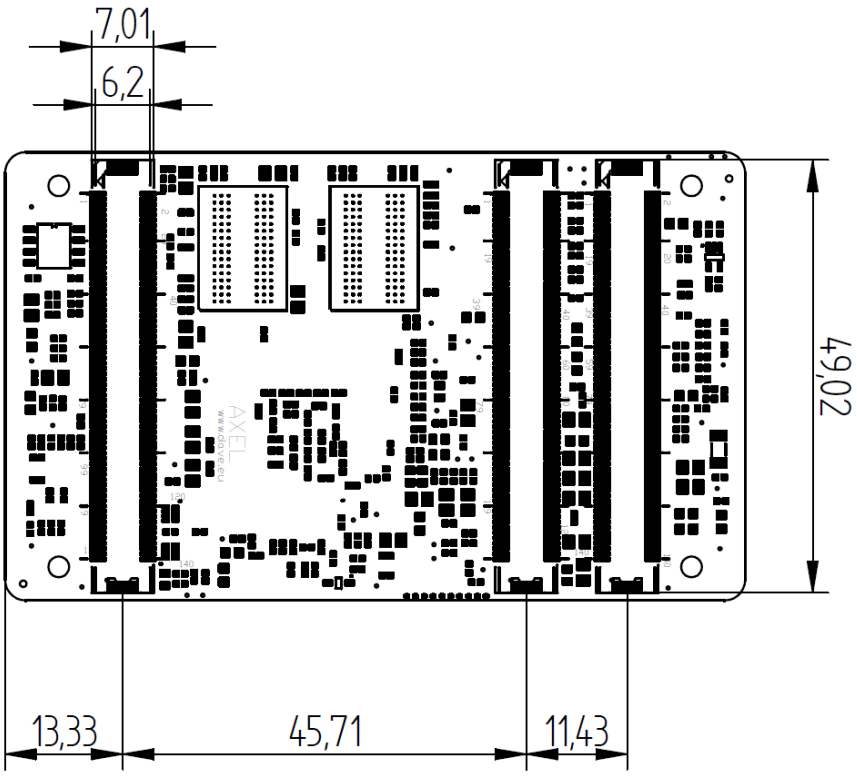


Fig. 5: Connectors layout

The following table reports connectors specifications:

Part number	Hirose FX8C-140S-SV
Height	5.1 mm
Length	48.6 mm
Depth	4.0 mm
Mating connectors	Hirose FX8C-140P-SV (5 mm board-to-board height) Hirose FX8C-140P-SV1 (6 mm board-to-board height) Hirose FX8C-140P-SV2 (7 mm board-to-board height) Hirose FX8C-140P-SV4 (9 mm board-to-board height) Hirose FX8C-140P-SV6 (11 mm board-to-board height)

5 Power, reset and control

5.1 Power Supply Unit (PSU) and recommended power-up sequence

Implementing correct power-up sequence for i.MX6 processors is not a trivial task because several power rails are involved. AXEL SOM simplifies this task and embeds all the needed circuitry. The following picture shows a simplified block diagram of PSU/voltage monitoring circuitry: