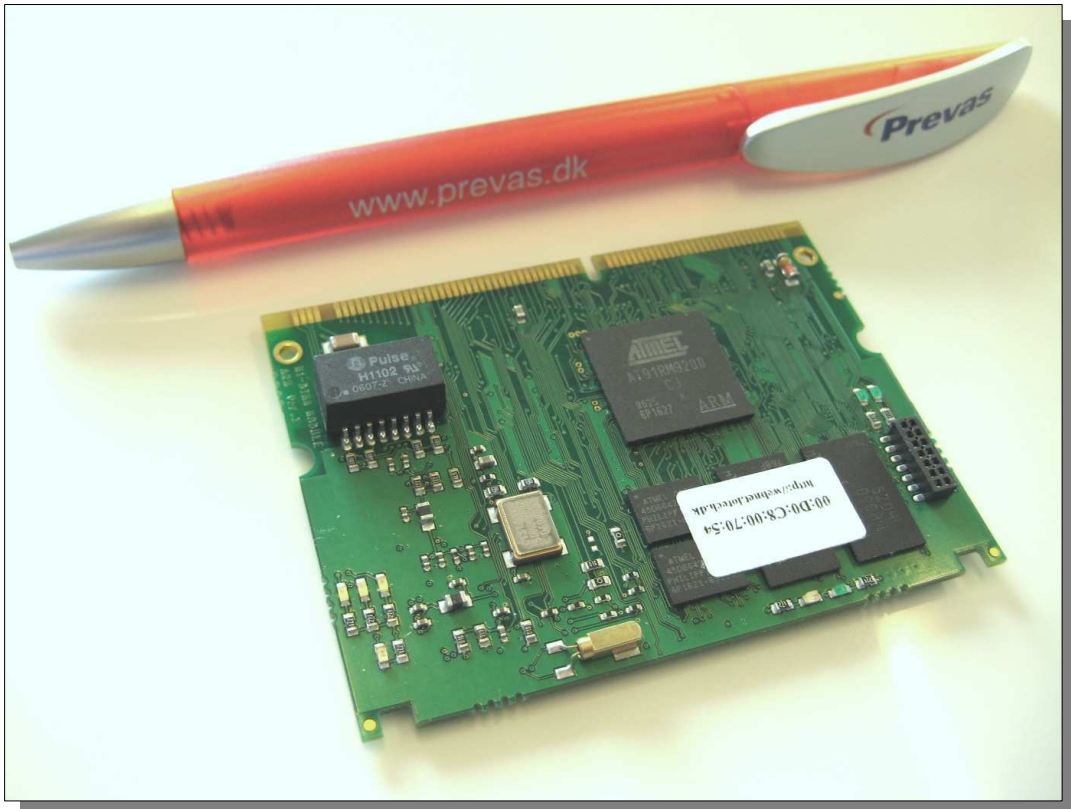


# MM21 Processor Module

- 32 bit CPU system

- Internet interface module



*The MM21-module is a highly integrated Internet Interface Module and Web Server. It contains a complete 32-bit CPU system, based on an ARM9 chip AT91RM9200 with 32/64 MB RAM, 8 to 16 MB FLASH memory and a 10/100 Mbps twisted pair Ethernet interface. The MM21-module is sized as a 144-pin 3.3V SO-DIMM module.*

## At a glance:

- ARM9 processor 180MHz 200MIPS.
- SDRAM 32 or 64MByte.
- FLASH Memory 8 or 16MByte.
- Watchdog.
- Ethernet interface, 10/100Mbit/s and line transformer.
- 3 UART's with TTL levels.
- USB 2.0 host interface (full speed).
- USB 2.0 device interface (full speed).
- GPIO and Interface connections.
- GPIO pins with interrupt capability, at least 32.
- I2C interface.
- Serial debug port (RX, TX) TTL level.
- Watchdog and power-monitoring facility.
- Real Time Clock.
- High-speed address and data bus for supporting external FPGA's or DSP's.
- Linux operating system.
- Windows CE operating system.
- Main board ID used for software update feature.
- Power Supply 400mA@3.3V.
- Operating Temperature [-40;85]°C.
- RoHS Compliant.

## HARDWARE FEATURES

An AT91RM9200 ARM processor, capable of running at a maximum speed of 200 MIPS powers the MM21-module is powered by.

The MM21-module is supplied with 32 or 64 MByte of SDRAM and 8 to 16MByte flash memory for the operating system and user application.

Extended debug features via an AVR controller, Ethernet, USB host and device, I2C bus, SPI bus, 3 UART's (one is with full modem control), Real Time Clock support with calendar and alarm function and a large number of general purpose in-and outputs.

The MM21-module is running a Linux operating system with a wide range of drivers and an application interface for user.

## ARM-Processor AT91RM9200

The ARM-Processor used is the AT91RM9200 LFBGA-254 from Atmel.

The ARM processor is a 200 MIPS processor @ 180Mhz with 16KByte data cache and 16KByte instruction cache.

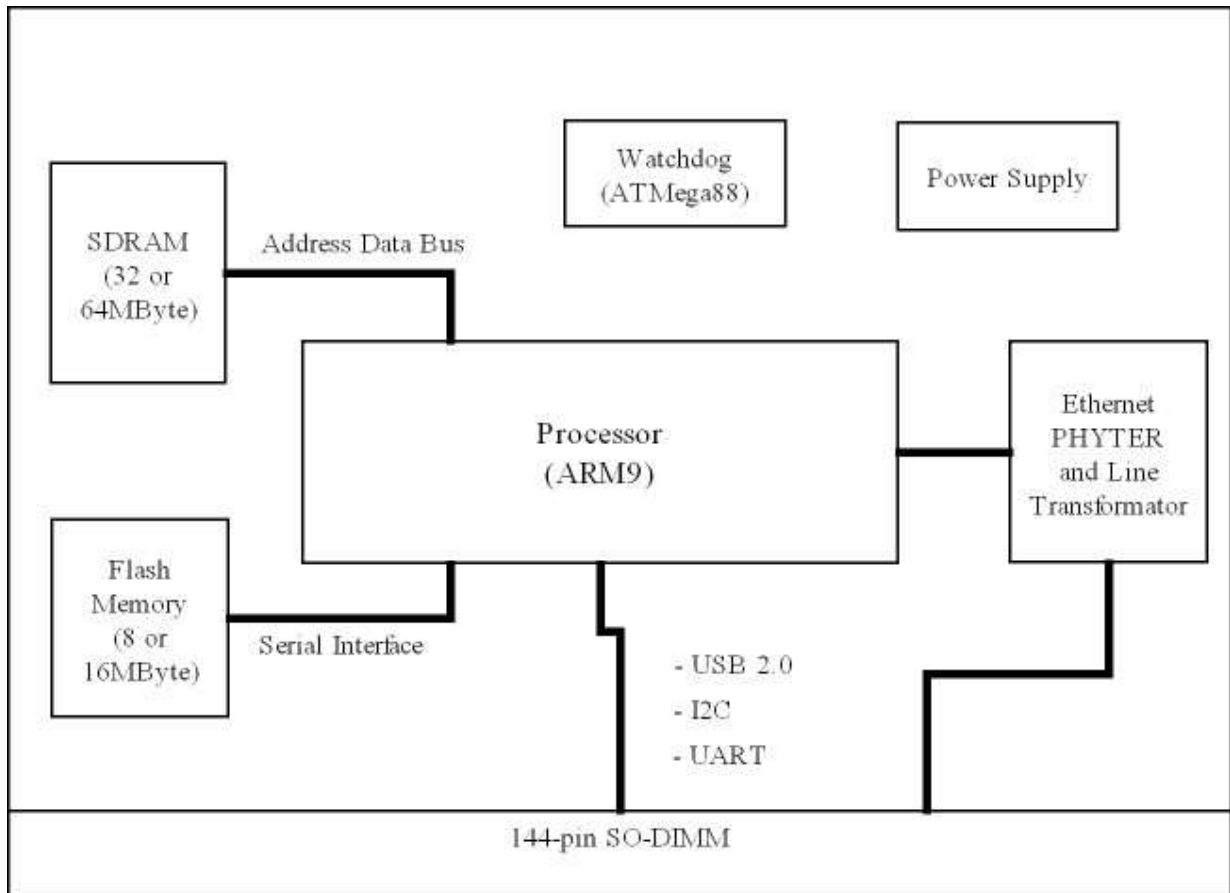
The AT91RM9200 has a low power consumption of 24.5mA in normal mode and 520uA in standby mode.

D0..D16, A0..A21 and bus control signals are available at the DIMM connector. Notice that the MM21 only comprise a 16 bit data bus, as the AT91RM9200 only has a 16 bit external data bus.

The address bus is a byte orientated bus. A0 is always low in 16 bit accesses.

## SDRAM Memory

The SDRAM for the ARM processor is selectable from 32 MByte (16bit) to 64 MByte (32bit).



## Flash Memory

Size of Flash Memory is selectable from 8 MByte to 16MByte.

Flash retention time is 20 years or minimum 100.000 times/ page.

## Debug features

The MM21-module provides different facilities for debugging CPU software. These are the following:

- JTAG interface for the AVR – available as test points on MM21-module.
- A number of LED's for the ARM processor. Gives information to debug channel.
- Serial Port for LINUX kernel messages.

## Watchdog

A dedicated processor (AVR ATmega88) handles watchdog and power facility. This AVR processor handles Power Surveillance, Power-Up Sequence, and an Advanced Debug Facility in case of errors. The AVR processor can implement an "intelligent" watchdog, able to determine the case and cause of a reset or power fail. This AVR information can be read on JTAG interface and gives the user information in case an error or system reset occurs. Key features are:

- The watchdog provides a long power-on time-out and a shorter production time-out. Time-outs can be configured up to at least 10 minutes, and down to at least 1 second.
- The watchdog is operational without any software intervention from the CPU after power-up.
- The watchdog is controlled from the CPU using a simple SPI interface.
- Communication with ARM processor is done through a single pin. Signal must be toggled at a regular interval - otherwise a reset occurs.
- The watchdog is able to reset entire system including external modules.

## Ethernet

The MM21-module comprises Ethernet connections on the DIMM connector.

The Ethernet is available from the ARM processor through the 10/100Mbit/s PHY. All relevant hardware is included on MM21-module except the physical RJ45 connector. This must be placed on external mother board.

It is important to place the actual RJ45 connector as close to the MM21-module as possible in keeping tracks as short as possible.

The LED signals of the Ethernet PHY are available on the DIMM connector.

The used Ethernet PHY is the DP83848IW from National Semiconductor with auto speed detection (10/100 Mbit/s). Operating range is up to 150 meters.

## RS232

The MM21-module comprises 3 UART's. One of UART's contains all modem control lines, these signals are Txd, Rxd, Cts, Dtr, Rts, Dsr, Dcd, RI and SG.

Remaining 2 UART's contain signals relevant for direction control (necessary for RS485).

Logical I/O level is TTL (3.3V).

RS232 Debug port is available on the DIMM connector. The Rxd and Txd signal is used to upload and debug system code in the ARM processor.

The 3 UART's are connected directly to ARM processor - level driver and ESD protection must be placed on external mother board.

## Interface for LED

The MM21-module contains LED for status indication.

LED will be driven by the ARM processor, and is used for debug purposes.

## General Purpose Inputs and Outputs (GPIO)

The MM21-module comprises a number of GPIO pins. These are individually controlled by the ARM processor regarding direction and state.

It is possible to use a number of these GPIOs for interrupting the CPU.

Logical level is TTL level (3.3V).

GPIOs are connected directly to ARM processor - buffers and ESD protection must be placed on external mother board.

## USB 2.0 - host interface

The MM21-module comprises an USB host interfaces. Relevant hardware for USB host is included on the MM21-module except the physical USB connector. This must be placed on external mother board. The main board must also provide the 5V for the USB connector. Key features are:

- Complies with USB 2.0 Low Speed (1.5Mbit/s) and Full Speed (12Mbit/s) standards.
- Root Hub integrated with 2 downstream ports.
- Operates as master on the ASB bus.
- Supports power management.

## USB 2.0 - device interface

The MM21-module comprises USB device interfaces. Relevant hardware for USB device is included on the MM21-module except the physical USB connector. This must be placed on external mother board. Key features are:

- Complies with USB 2.0 Full Speed.
- Embedded USB 2.0 Full Speed transceivers.

## I2C Interface

The MM21-module comprises a standard 2-wire interface (I2C) and is available on the DIMM connector.

The bus has one Clock Line and one Data Line. Speed is up to 400 Kbits/s based on byte-orientated transfer format.

Baud Rate of bus is configurable; this permits the data rate to be adapted to a wide range of core clock frequencies. Key features are:

- Communication with standard 2-wire Serial memory.
- 1 to 3 Bytes of slave address.
- Sequential read/ write operations.

## SPI interface

The ARM processor contains a standard SPI – Serial Peripheral Interface.

The SPI interface is a standard Synchronous Interface. SPI can be used for communication with more of external devices.

The SPI system consists of 2 data lines and 2 control lines. These are MOSI, MISO, SPCK and NNS.

The SPI bus is directly accessible on the DIMM connector. Drivers and ESD protection must be placed on external mother board. Key features are:

- Serial Memory such as Data Flash and 3-wire EEproms.
- Serial Peripherals such as DACs, ADCs, Display Controller, EEproms, etc.
- External Co-Processors.
- Master or Slave Peripherals bus interface.
- 8 to 16 bit programmable data length per chip select.
- Programmable Phase and Polarity per chip select.
- Programmable Transfer Delay.
- Mode Fault Protection.

## Real Time Clock

The ARM processor contains an on chip Real Time Clock (RTC). This combines a Time Clock with Alarm function and a 200 year Gregorian calendar.

Time and calendar values are coded in BCD format, and can run 12 and 24 hour mode. Key features are:

- Low power consumption.
- 200 year calendar.
- Programmable periodic interrupt.
- RTC can be powered by external battery.  
The battery supply line is accessible at the DIMM connector.

## Power Supply

The MM21-module requires a 3.3 VDC  $\pm 10\%$  and is consuming approximately 400mA. This includes 225mA for the USB host interface.

## SOFTWARE OVERVIEW

This section gives a brief overview of the software Prevas supplies with the MM21-module.

### MM21 Software

The MM21-module comes with a complete Linux operating system. It's based on a recent Linux kernel release. In February 2007 the MM21-module is supplied with kernel version 2.6.19 and includes all the drivers distributed with this kernel from [www.kernel.org](http://www.kernel.org).

The MM21-module has device-drivers for the peripherals described in this document and in addition to this, a set of standard applications are included e.g. system shell (ash), an AVR/FPGA loader and various file and communication utilities.

The MM21-module comes with a standard firmware for the AVR controller that makes it easy to take the MM21-module into use.

During boot the system is by default starting a range of services like loading GPIO driver and setting up Ethernet interface. The system also starts telnet, FTP (VSFTPD) and Web Servers (BOA).

This complete SW package on the MM21 makes the MM21-module easy to take into use and to perform customer specific development on.

### MM21 Peripheral interface drivers

The following lists some of the drivers that are included with the software package:

- TTY driver for RS232 and RS45 ports.
- USB host driver with support for memory sticks, USB printer, USB mouse and much more.
- USB device driver with support for serial gadget (emulation of USB-to-serial which can be used in both Windows and Linux).
- Ethernet driver and kernel support for IPv4 and IPv6.
- I2C driver for easy access to the I2C bus from a C user space application.
- GPIO and OPB\_GPIO driver for controlling the CPU from LUA script and C++.
- JFFS2 driver for journaling flash file system support.

## MM21-module applications

The following lists some of the applications included in the sw package.

- Linux Kernel with ARM patches  
The Linux Kernel with patches so it supports ARM processor based machines.
- AVR watchdog firmware
- BOA Web Server  
BOA is an open source tiny Web Server that offers extremely high performance specifically designed to run on Linux and suitable for embedded applications.
- Dropbear SSH server  
SSH (Secure Shell) is a set of standards and an associated network protocol that allows establishing a secure channel between a local and a remote computer. Dropbear is a open source relatively small SSH server and client. Dropbear SSH is particularly useful for "embedded"-type Linux systems.
- VSFTPD FTP server  
VSFTPD is an open source FTP server which is secure and extremely fast. VSFTPD (Very Secure FTP Daemon) is stable and supports IPv6 and SSL.
- Busybox unix tool box  
BusyBox is a software application which provides many standard Unix/Linux tools. BusyBox is designed to be a small executable for use with embedded Linux devices.
- Luacheia LUA distribution  
LUA is a script programming language that prides itself on ANSI C portability, small size, simplicity and ease of embedding. The LuaCheia LUA aim to make a full-featured programming language based on LUA that makes it more usable as a stand-alone language.
- Nano-X window system  
Nano-X Window System is an Open Source project aimed at bringing the features of modern graphical windowing environments to smaller devices and platforms. Nano-X allows applications to be built and tested on the Linux desktop, as well as cross-compiled for the target device.
- Irzsz X/Y/Z modem utilities  
Irzsz is an open source Unix/Linux communication package providing the XMODEM, YMODEM ZMODEM file transfer protocols.
- Netcat network utility  
Netcat is a network utility for reading from and writing to network connections on either TCP or UDP. It is designed in a thin

and simple way, which makes it easy to incorporate in larger applications.

- PPP protocol  
Point-to-Point Protocol (PPP) is commonly used to act as a data link layer protocol for connection over synchronous and asynchronous connection between two nodes.
- Sudo user control system  
Sudo is a program for Unix/Linux that allows users to run programs with the security privileges of another user (normally the system's superuser) in a secure manner.
- Telser terminal program  
Telser is a serial port communication program
- Butler program  
for controlling the external watchdog, battery backed up Real time Clock (RTC), and temperature sensor.
- GDBserver debugger  
GNU debugger Server for remote debugging of the MM21 embedded Linux target. With this server debugging can be done from host PC and a range of debugging features is available. E.g. stop program execution on specified conditions, examine what has happened when your program stopped.

### MM21 specific commands

gpio	Sets/reads value of CPU GPIO.
avrdude	AVR content Downloader/UploADER.
reboot	Reboots the MM21-module.
moduleconf	Shows the MM21-module configuration incl. network parameters.

## SW DEVELOPMENT ON PC

The delivery from Prevas includes a range of tools for developing user applications for the MM21-module on a host PC. This section will give an overview of the tools and development process for making SW development for MM21 on a host PC.

Developing and testing on a host PC makes it fast to do the development for the MM21-module.

### PC OS for MM21 code development

SW developing is easy to do on host PC and then download to MM21 when needed. Since the MM21 platform is using a Linux kernel it is useful to have a Linux OS on the MM21 SW development PC. This can either be obtained by having a PC with a pure Linux OS installed or it can be obtained by running a virtual Linux machine on a Windows based PC. Prevas has instructions and SW image available for getting this virtual Linux machine up and running fast on a Windows PC. Prevas recommend using the user friendly Ubuntu Linux OS distribution which can be found at [www.ubuntu.com](http://www.ubuntu.com).

### MM21 code development

For developing SW for the MM21 on host several tools like compiler, linker, and libraries are needed on the host. All tools needed for development are already pre-installed on the virtual Linux machine image that is available from Prevas.

So after a fast session with host PC setup it is possible to start making and compiling programs on the host for the MM21-module. When the code has been written on the host PC it is cross-compiled for the MM21 ARM9 with Linux OS and transferred to MM21-module where it is executed and debugged if needed.

In some cases it makes sense first to compile it for the host PC and execute the code and debug it on the host PC before it is tried out on the MM21. This makes it possible to use all kinds of PC tools for testing and debugging.

## Webpage development for MM21

The web pages for the MM21 Web Server can also be made, tested and debugged on the host platform. The web pages can be made as normal html pages (with some limitations to advanced html features) by using your favorite web page creator tool.

The MM21 web pages can also be made with LUA scripts. The LUA interpreter is included both in the MM21-module SW and with the Linux image for the PC development host.

LUA scripting provides a fast way to implement, test, debug, modify, and maintain Web Server directly on the MM21-module only by use of a Telnet or serial connection to the MM21-module. Or the LUA scripts has been made and tested on the host PC before they are transferred to the MM21-module without any need for compilation.

Since the LUA script is easy to read and there is no need for compilation. The scripts can be made or modified even on the MM21-module only by use of a Telnet or serial connection to the MM21-module.

For more details on LUA check [www.lua.org](http://www.lua.org)

### ARM SW development framework

Larger SW projects often benefits from using the software framework that is a part of an Integrated Development Platform. For making ARM applications the Eclipse platform can be used. Eclipse is an open source platform-independent software framework. There is a lot of Integrated Development Environments (IDE) available for the Eclipse platform which makes it easy to program in a wide range of programming languages like e.g. C/C++,Java, Photran, PHP, Python, Perl, Ruby, LUA, TCL, and COBOL.

Eclipse is not included with the SW deliveries from Prevas but is available from [www.eclipse.org](http://www.eclipse.org)



## Remote MM21-module debugger

The MM21-module includes a GDB (GNU Debugger) server which makes it possible to debug the MM21-module SW remotely from a host PC. This makes it possible to break code execution, set breakpoints, check stack and memory content of the MM21-module from the debugger on the host PC.

For the host PC several GUI's are available for this remote debugging. Prevas recommend using the Insight GUI which offers all standard features of a modern debugger and it has an easy-to-use graphical user interface and it supports application and system debugging over Ethernet or serial line.

More info on debugging with GDB and Insight can be found at the homepage [sourceware.org/insight](http://sourceware.org/insight).

## MECHANICAL FEATURES

### Board specifications

The MM21-module complies with the JEDEC standard for 3.3V SO-DIMM 144 pin modules.

Connector for external mother board can be sourced from Molex – PN: 54698-7000. Outline of connector is 73.6mm x 30.4mm. Please see datasheet for further details.

The MM21-module itself has dimensions shown in drawing below.

MM21-module has 2 notches in order to fasten the MM21-DIMM module to external mother board. This is to avoid loose connections when the board is placed in rough and vibrating environments.

Notes: Battery is not present on the MM21 module. If module is placed parallel with motherboard non-tented copper-pads should be avoided below crystal (package is metal).

## EMC Specification

### Emission:

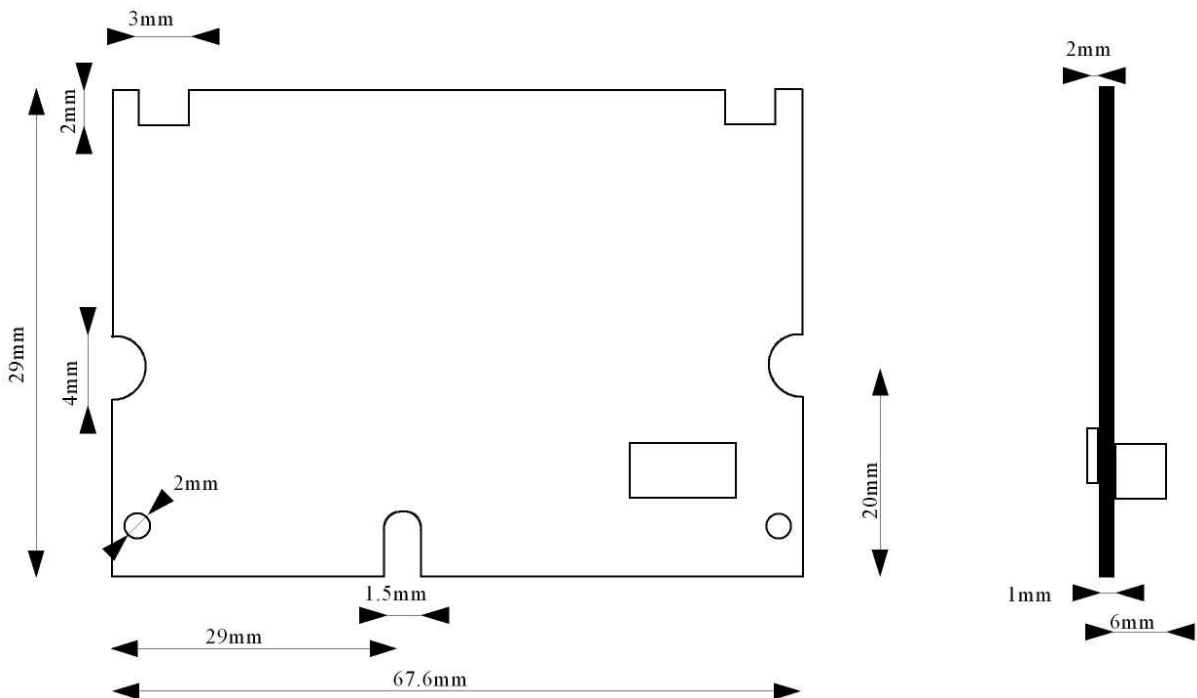
The MM21-module and motherboard has to comply with the EMC standard for light industrial equipment.

### Immunity:

The equipment complies with the EMC standard for heavy industrial equipment.

### ESD:

Motherboard must handle ESD protection for external connections (Power Supply, GPIO, Debug Interfaces etc.).



## CONNECTOR DESCRIPTION

Pin	IO Name	Type	Function	Remarks
1	GND			
2	GND			
3	CPU_DATA0	IO	Data Bus	
4	CPU_ADR0	O	Address Bus	
5	CPU_DATA1	IO	Data Bus	
6	CPU_ADR1	O	Address Bus	
7	CPU_DATA2	IO	Data Bus	
8	CPU_ADR2	O	Address Bus	
9	CPU_DATA3	IO	Data Bus	
10	CPU_ADR3	O	Address Bus	
11	3V3			
12	3V3			
13	CPU_DATA4	IO	Data Bus	
14	CPU_ADR4	O	Address Bus	
15	CPU_DATA5	IO	Data Bus	
16	CPU_ADR5	O	Address Bus	
17	CPU_DATA6	I		
18	CPU_ADR6	O	Address Bus	
19	CPU_DATA7	IO	Data Bus	
20	CPU_ADR7	O	Address Bus	
21	CPU_DATA8	IO	Data Bus	
22	CPU_ADR8	O	Address Bus	
23	CPU_DATA9	IO	Data Bus	
24	CPU_ADR9	O	Address Bus	
25	CPU_DATA10	IO	Data Bus	
26	CPU_ADR10	O	Address Bus	
27	CPU_DATA11	IO	Data Bus	
28	CPU_ADR11	O	Address Bus	
29	CPU_DATA12	IO	Data Bus	
30	CPU_ADR12	O	Address Bus	
31	CPU_DATA13	IO	Data Bus	
32	CPU_ADR13	O	Address Bus	
33	CPU_DATA14	IO	Data Bus	
34	CPU_ADR14	O	Address Bus	
35	GND			
36	GND			
37	CPU_DATA15	IO	Data Bus	
38	CPU_ADR15	O	Address Bus	
39	MAIN_BOARD_ID0	IO	GPIO	GPIOs reserved for main board identification. IO will provide information of what ID to use, on request.
40	CPU_ADR16	O	Address Bus	
41	MAIN_BOARD_ID1	IO		

Pin	IO Name	Type	Function	Remarks
42	CPU_ADR17	O	Address Bus	
43	MAIN_BOARD_ID2	IO		
44	CPU_ADR18	O	Address Bus	
45	3V3			
46	3V3			
47	MAIN_BOARD_ID3	IO		
48	CPU_ADR19	O	Address Bus	
49	MAIN_BOARD_ID4	IO		
50	CPU_ADR20	O	Address Bus	
51	MAIN_BOARD_ID5	IO		
52	CPU_ADR21	O	Address Bus	
53	MAIN_BOARD_ID6	IO		
54	BUS_CTRL2(WBE0)	O	D0..D7 WE	
55	MAIN_BOARD_ID7	IO		
56	BUS_CTRL7(WBE1)	O	D8..D15 WE	
57	CPU_IO0	IO	GPIO	
58	CPU_IO9	IO	GPIO	
59	CPU_IO1	IO	GPIO	
60	CPU_IO10	IO	GPIO	
61	CPU_IO2	IO	GPIO	
62	BUS_CTRL9(nCS2)	O	External CS	Active LO
63	CPU_IO3	IO	GPIO	
64	BUS_CTRL4(nCS0)	O		
65	CPU_IO4	IO	GPIO	
66	BUS_CTRL5(nCS4)	O		
67	CPU_IO5	IO	GPIO	
68	BUS_CTRL6(nCS5)	O		
69	GND			
70	GND			
71	CPU_IO6	IO	GPIO	
72	BUS_CTRL8(nCS7)	O		
73	CPU_CLK	O		[50; 60] Mhz Clock Output
74	EXT_RESET0(RST OUT)	O		
75	BUS_CTRL3(nCS3)	O		
76	CPU_IO11	IO	GPIO	
77	BUS_CTRL1(nOE)	O		
78	BUS_CTRL0(nWAIT)	I		
79	CPU_FLASH0	O	SPI MISO	
80	I2C1(TWCK)	IO		
81	CPU_FLASH1	O	SPI MOSI	
82	3V3			
83	CPU_FLASH2	O	SPI CLK	
84	I2C0(TWD)	IO	I2C	
85	CPU_FLASH5	O	SPI nCS2	
86	ETHERNET1(LED SP)	O	Ethernet Speed	
87	CPU_FLASH6	O	SPI nCS2	
88	ETHERNET0(LED LI)	O	Ethernet Link	
89	CPU_IO7	IO	GPIO	
90	ETHERNET2(LED AC)	O	Ethernet Act/ Col	

Pin	IO Name	Type	Function	Remarks
91	USB0	IO	USB DEVICE M	
92	LED0(SYS LED)	O		
93	USB1	IO	USB DEVICE P	
94	LED1(SYS LED)	O		
95	USB2	IO	USB DEVICE CON	
96	CPU_IO12	IO	GPIO	
97	USB3	IO	USB HOST M	
98	CPU_IO13	IO	GPIO	
99	USB4	IO	USB HOST P	
100	FPGA_CONFIG4(PROG_B)	IO		Used for external FPGA
101	EXT_PWR_SURVAILANCE_0	IO	PWR_FAIL	External power fails
102	FPGA_CONFIG3(DONE)	IO		
103	EXT_PWR_SURVAILANCE_1	IO	External PWR sense	
104	FPGA_CONFIG1(INIT_B)	IO		
105	UART5(TXD1)	IO		
106	CPU_IO14	IO	GPIO	
107	GND			
108	GND			
109	CPU_IO8	IO	GPIO	
110	CPU_IO15	IO	GPIO	
111	UART6(RXD1)	IO		
112	CPU_IO16	IO	GPIO	
113	3V3			
114	3V3			
115	UART9(CTS1)	IO		
116	CPU_IO17	IO	GPIO	
117	UART8(DCD1)	IO		
118	UART3(RTS0)	IO		
119	UART7(SCK1)	IO		
120	UART2(CTS0)	IO		
121	UART13(RXD_D)	IO		
122	CPU_IO18	IO		
123	UART12(TXD_D)	IO		
124	AVR_IO0	IO		
125	UART10(DSR1)	IO		
126	AVR_IO1	IO		
127	UART4(DTR1)	IO		
128	UART11(RTS1)	IO		
129	UART1(RXD0)	IO		
130	FPGA_CONFIG2(CCLK)	IO		
131	UART0(TXD0)	IO		
132	FPGA_CONFIG0(DIN)	IO		
133	Keep clear			
134	EXT_RESET1(RST IN)	I		
135	Keep clear			
136	RTC_BATT	I		
137	TX -	O	Ethernet TX-	

Pin	IO Name	Type	Function	Remarks
138	Keep clear			
139	TX +	O	Ethernet TX+	
140	Keep clear			
141	RX +	I	Ethernet RX+	
142	Chassis GND			Connected to GND in previous WebArm designs
143	RX -	I	Ethernet RX-	
144	Chassis GND			