

# ***SoM-250GS***

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*October 2019*

*REV 1.20*

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*EMAC, Inc.*

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## 1 Introduction

This document provides information regarding EMAC's SoM-250GS System-on-Module Carrier Board. The SoM-250GS is a versatile SoM Carrier board ideal for evaluation and early development work. This Carrier works with all EMAC 200-pin SODIMM type SoMs although not all functionality of a particular module may be supported by the carrier board.

The SoM-250GS provides access to virtually all of the 200-pin Module's I/O through on-board connectors as well as a number of additional I/O expansion blocks such as Digital I/O, Audio, and MMC/SD flash disk. Full schematics of the SoM-250GS are provided giving the user a solid base with which to design their own SoM Carrier.

Although a good deal of customers will want a carrier that is unique and is designed specifically for their application, the SoM-250GS, when coupled with a SODIMM SoM makes for a powerful yet affordable Graphic User Interface (GUI) with USB and Ethernet capabilities. This allows the user to gather data and respond with control commands via the Internet. Enclosure and power supplies are available options for the SoM-250GS.

When a unique custom board is needed, the amount of design work required is greatly minimized by the SoM approach. The custom carrier designer does not have to worry about the processor, memory, and standard I/O functions and can concentrate on the I/O and dimensional aspects required for the application.

In situations where a custom carrier is required but the customer does not have the capability to design such a board in-house, EMAC's Custom to Order Services (COS) can be utilized. Using COS the customer can select from a library of standard I/O blocks. These blocks can be put together quickly into a form-factor of the customer's choosing, providing prototypes in as little as 30 days.

## 1.1 Features

- 200-Pin SODIMM SoM Connector
- Inexpensive Open-Frame Design
- 10/100/1000 BaseT Ethernet
- 3 RS232 & 1 RS232/422/485 Port
- 2 USB 2.0 (High Speed) Host Ports
- 1 USB 2.0 (High Speed) OTG Port
- 1 CAN 2.0B Port
- Socketed Battery
- 1 SD/MMC Flash Card Socket
- 1 I2S Audio CODEC with Line-in/Line-out
- 1 Audio Beeper
- Operating Voltage of 12 to 28 VDC
- 800 X 480 (WVGA) or 1024 X 600 (WSVGA) LCD with LED Backlight
- Touchscreen Interface and Software Controlled Backlight On/Off & Brightness
- Free Qt Creator IDE with GCC & GDB Development Tools

## 1.2 On-Board Options

- Wireless-802.11b/g/n
- Wide Temperature Range -20°C to 70°C (limited by LCD)

## 2 Hardware

### 2.1 Specifications

#### LCD – 7” LCD (SoM-250GS-000)

- **Display Type:** 7” TFT Color LCD
- **Resolution:** 800 X 480 WVGA @ 256K Colors
- **Dot Pitch:** 0.19mm X 0.19mm
- **Luminance:** 800 (cd/m<sup>2</sup>)
- **Viewing Angle:** 55°
- **Brightness:** Software Controlled
- **Backlight:** White LED (33 LEDs)
- **Light Transparency:** 80%
- **Durability:** Over one million touches

#### LCD – 10” LCD (SoM-250GS-001)

- **Display Type:** 10” TFT Color LCD
- **Resolution:** 1024 X 600 WSVGA @ 262K Colors
- **Dot Pitch:** 0.22mm X 0.22mm
- **Luminance:** 460 (cd/m<sup>2</sup>)
- **Viewing Angle from Center:** From Top and Bottom, 40° min. (45° typ.), From Right, 10° min. (15° typ.), From Left, 30° min. (35° typ.)
- **Brightness:** Software Controlled
- **Backlight:** White LED
- **Durability:** Over one million touches

#### Touchscreen Controller

- **Type:** 4 wire resistive touch
- **Resolution:** Continuous
- **Controller:** Part of SoM which is sold separately.

**Ethernet Interface**

- **Type:** 10/100/1000 BaseT Ethernet
- **Interface:** On-Board RJ-45 Connector

**Solid-State Flash Disk**

- **Removable:** 8GB of SD,MMC, or SDHC Flash Disk

**Mechanical and Environmental**

- **Dimensions:** 7.55" X 4.15" X 1.5" (L X W X H)
- **Weight:** 1.06 lbs
- **Power Supply Voltage:** +12 to +28 VDC
- **Power Consumption:** Typical ~200 mA @ 24 VDC
- **Operating Temperature:** 0°C to 60°C (32°F to 140°F)

**Standard Parts Inventory (SoM-250GS-000)**

- SoM-250GS Assembly with 7" Touchscreen LCD
- Stainless-Steel Mounting Bracket
- Three Serial Port Cables
- Info Sheet with links to Manuals, Schematics, and Drivers



## 2.2 Jumper Configuration

Table 1 indicates the default jumper settings in case you want to revert back to the factory settings. Be sure to read all safety precautions before you begin any configuration procedure. See Appendix A for connector pinouts and Appendix B for Jumper Settings.

**Table 1: Jumpers (see SoM manual for correct Boot settings)**

Label	Function	Default
JB1	Boot0 Source Selection	Position A
JB2	Boot1 Source Selection	Position A
JB3	Resident Flash Write Protect	Position B
JB4	RTC Battery On/Off	ON
JB5	Serial Port RS422/485 Tx Enable	422
JB6	Serial Port RS232 or 422/485 Mode	232
JB7	Ethernet Primary Tap	OPN
JB8	External SPI Interface Voltage	5V
JB9	External I2C Interface Voltage	5V

## 2.3 Power Connectors

The SoM-250GS provides two power connectors. JK1 is a standard 5.5mm barrel jack with an inner diameter of 2.1mm with a center V+ connection. This jack allows for easy connection to a wall mount power supply (see SoM-250GS product page for available power supply options). HDR1 is a three-pin TE Connectivity locking power connector (part number 640445-3) that mates with a TE Connectivity part number 3-640600-3 power connector. Using this power input provides for a more rugged/industrial locking connection. The SoM-250GS's power input uses a switching regulator and allows a voltage input of +12VDC to +28VDC

The pinout for the HDR1 power connector is as follows:

Pin	Signal
1	+Vin (+12VDC to 28VDC)
2	Chassis GND
3	System GND

## 2.4 Other Connectors

Table 2 lists the functions of the various connectors. See Appendix A for connector pinouts.

**Table 2: Connectors**

Label	Function
CN1	7" LCD Backlight Connector
CN2	Serial Port COM A
CN3	10" Touch Screen Connector
CN4	7" Touch Screen Connector
CN5	CAN Port
JK1	Vin DC Barrel Jack
JK2	USB OTG Port C
JK3	Ethernet RJ45
JK4	Dual USB Host Ports A & B
JK5	Audio Input Jack
JK6	Audio Output Jack
HDR1	Vin DC Connector
HDR2	Serial Port COM D
HDR3	Serial Port COM B
HDR4	Serial Port COM C
HDR5	Bulkhead USB Connector Port A & B
HDR6	LVDS Connector
HDR7	Misc. I/O Connector
SOK1	MicroSD Card Socket
SOK2	200 pin SoM Socket

## 2.5 Ethernet

The SoM-250GS provides 10/100/1000 BaseT Full Duplex Ethernet and uses a standard RJ-45 connector (JK3). It can be connected straight to a hub with a straight-through Ethernet cable, or to another computer via a crossover Ethernet cable. The Ethernet MAC & PHY are integrated into the SoM processor module (sold separately). Activity and Link LEDs are integrated into the RJ-45 Connector. Jumper JB7 will need to be set to 'OPN' for 1000 BaseT Ethernet and set to '3P3' for 10/100 BaseT Ethernet.

## 2.6 Serial Ports

The SoM-250GS is equipped with four serial ports, one of which terminates to a male DB9 and the other three which terminate to 10-pin header connectors. Most product variations include three 10-pin header to male DB9 connector cables, giving easy access to these ports. Baud Rate, stop bits, etc. are all programmable for each port via software.

COM A is an RS232 compatible port with a full complement of handshaking lines allowing communication with modems and other devices requiring hardware flow control.

COM B is an RS232 port. This port offers no handshake lines.

COM C can be configured to RS232, RS422, or RS485 via two jumpers. To select RS232 set jumper JB6 to 232 (default). For RS422 set jumper JB6 to 4xx and jumper JB5 to 422. To select RS485, set jumper JB6 to 4xx and jumper JB5 to 485

When using COM C in the RS422/485 mode, a terminating resistor ( $\sim 120 \Omega$ ) is recommended on the two far ends of the network.

COM D is an RS232 port. This port offers no handshake lines.

**Table 3: COM A Pinout**

Pin	Pin Description for DB9 Connector
1	DCD
2	RxD
3	TxD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI
10	Shield

Table 4: COM B Pinout

Pin	Pin Description for 10-pin Header	Pin Description for DB9 Connector
1	NC	NC
2	NC	RxD
3	RxD	TxD
4	NC	NC
5	TxD	GND
6	NC	NC
7	NC	NC
8	NC	NC
9	GND	NC
10	NC	N/A

Table 5: COM C Pinout

Pin	Pin Description for 10-pin Header	Pin Description for DB9 Connector
1	422/485 Tx-	422/485 Tx-
2	NC	232 Rx, 422/485 Tx+
3	232 Rx, 422/485 Tx+	232 Tx, 422/485 Rx+
4	RTS	422/485 Rx-
5	232 Tx, 422/485 Rx+	GND
6	CTS	NC
7	422/485 Rx-	RTS
8	NC	CTS
9	GND	NC
10	NC	N/A

Table 6: COM D Pinout

Pin	Pin Description for 10-pin Header	Pin Description for DB9 Connector
1	NC	NC
2	NC	RxD
3	RxD	TxD
4	NC	NC
5	TxD	GND
6	NC	NC
7	NC	NC
8	NC	NC
9	GND	NC
10	NC	N/A

## 2.7 CAN

The SoM-250GS CAN 2.0B port (CN5) utilizes the TI SN65HVD232 CAN Transceiver (or equivalent). Note the SoM used with the carrier must have a built-in CAN controller in order to have CAN functionality. The pinout for the CN5 CAN Connector is as follows:

Pin	Signal
1	GND
2	CAN_L
3	CAN_H

## 2.8 USB

The SoM-250GS provides two USB 2.0 (Port A and Port B) high-speed host ports (JK4). USB Port A and Port B can be accessed from the bulkhead connector (HDR5). EMAC can provide a cable (CAB-40-004) to access these ports.

In addition to the two USB Host ports, the SoM-250GS provides a USB On-the-Go (OTG) port. This port can be used as either a USB Host or USB Device port.

Note: When sizing a power supply, make sure to allow for USB Device consumption. A device can potentially draw 500mA.

## 2.9 WiFi [optional]

The SoM-250GS utilizes the Silicon Labs Blue Giga WiFi Module (part number WF111-E-V1). The WF111 is a fully integrated single 2.4GHz band 802.11 b/g/n module.

Features:

- IEEE 802.11 b/g/n radio
  - Single Stream 2.4 GHz band
  - Bit rates up to 72.2 Mbps
- Integrated U.FL Connector
- Hardware support for WEP, WPA and WPA2 encryption
- SDIO Host Interface

EMAC provides an antenna kit included with the WiFi option: 2.4GHz Duck Antenna RP-SMA and U.FL (IPEX) to RP-SMA male pigtail cable that plugs into the WiFi Module's integrated U.FL Connector.

The SoM-250GS provides a Green WiFi Activity LED (LD10) that is active when data is transmitted or received from the WiFi Module.

## 2.10 Audio

The SoM-250GS provides Audio Line-Out and Line-In capability through two standard audio jacks (JK5 & JK6). Audio Jack JK5 is stereo line-level input and Audio Jack JK6 is stereo line-level output. The processor interfaces to the Audio CODEC through its I<sup>2</sup>S interface. Command control of the CODEC is done using the processor's I<sup>2</sup>C interface. The CODEC is the NXP SGTL5000NLA3, which is a High Performance 24-bit Low Power Stereo CODEC offering superior sound quality.

## 2.11 LCD Brightness

The SoM-250GS offers software controllable LCD brightness via the PWM signal on the LVDS Connector. The LED backlight can be turned on or off via the SoM's GPIO-0. This will allow for screensaver software to automatically turn off the backlight when the unit is not being used and turn on the backlight when LCD interaction proceeds.

## 2.12 Analog Inputs

The analog inputs are available on HDR7 (see table 7 below) and are labeled as analog\_4, analog\_5, analog\_6 and analog\_7.

### 2.13 I/O Expansion

The SoM-250GS provides access to additional SoM I/O lines on connector HDR7. This 44-pin dual row header contains GPIO lines, SPI bus, I<sup>2</sup>C bus, A/D lines, interrupts and power pins. Signal names listed in the table below are the SoM names as defined in the SoM-200 pin specification. Note that not all SoMs will have the same set of features available on this header.

**Table 7: I/O Expansion**

Pin	Signal	Pin	Signal
1	3.3V	2	3.3V
3	GPIO1	4	GPIO4
5	GPIO2	6	GPIO5
7	GPIO3	8	GPIO6
9	INT0	10	GPIO7
11	INT1	12	INT2
13	OSC0	14	GND
15	OSC1	16	GND
17	ADC4	18	GPIO8
19	ADC5	20	GPIO9
21	ADC6	22	GPIO10
23	ADC7	24	GND
25	SPI_MISO	26	GND
27	SPI_MOSI	28	GND
29	SPI_CLK	30	GND
31	SPI_CS3	32	GND
33	SPI_CS1	34	GND
35	I <sup>2</sup> C_CLK	36	GND
37	I <sup>2</sup> C_DAT	38	GND
39	SoM_RSTOUT!	40	GND
41	5V_VCC	42	5V_VCC
43	GND	44	GND

### 2.14 Real-Time Clock

The SoM-250GS is equipped with an external battery for backing up the module's Real-Time Clock (RTC). Drivers to access the RTC are incorporated in the operating system. Jumper JB4 should be placed in the ON position in order to retain system time when powered down.

### 2.15 Reset

The SoM-250GS provides a Reset Button (PB1). Pressing this button will cause the system to reset.



## 3 Software

The SoM-250GS offers a wide variety of software support from both open source and proprietary sources. All of EMAC's SoM Modules are supported by Linux.

For more information on Linux Software Support, please visit the EMAC Wiki Software Section at:

[http://wiki.emacinc.com/wiki/Product\\_wiki](http://wiki.emacinc.com/wiki/Product_wiki)

### 3.1 Das U-Boot

EMAC utilizes Das U-Boot for its ARM based products. U-Boot is an open source/cross-architecture platform independent bootloader. It supports reading and writing to the flash, auto-booting, environmental variables, and TFTP. Das U-boot can be used to upload and run and/or reflash the OS or to run stand-alone programs without an OS. Products are shipped with a valid MAC address installed in flash in the protected U-boot environmental variable "ethaddr". At boot time U-Boot automatically stores this address in a register within the MAC, which effectively provides it to any OS loaded after that point.

### 3.2 Embedded Linux

EMAC Open Embedded Linux (EMAC OE Linux) is an open source Linux distribution for use in embedded systems. The EMAC OE Linux Build is based on the Open Embedded ([www.openembedded.org](http://www.openembedded.org)) and Yocto ([www.yoctoproject.org](http://www.yoctoproject.org)) Linux build systems. Open Embedded is a superior Linux distribution for embedded systems. Custom Linux builds are also available on request.

The distribution contains everything a user could expect from a standard Linux kernel: powerful networking features, advanced file system support, security, debugging utilities, and countless other features.

The basic root file system includes:

- Busybox
- Hotplugging support
- APM utilities for power management
- Openssh SSH server
- lighttpd HTTP server
- JIFS2 or EXT4 file system with utilities

#### 3.2.1 Linux with Xenomai Real Time Extensions

Xenomai provides real time extensions to the kernel and can be used to schedule tasks with hard deadlines and  $\mu$ s latencies. The Xenomai build is an additional module that can be added to the standard Linux kernel and is available for a one-time inexpensive support/installation fee.

<http://www.xenomai.org/>

### **3.2.2 Linux Packages**

EMAC provides support for many Linux Packages such as: PHP, SQLite, Perl, SNMP, DHCP Server, etc. As with the Xenomai Package, other Packages can be added to the standard Linux file system and are available for a one-time inexpensive support/installation fee.

### **3.2.3 Linux Patches**

In addition to standard Embedded Linux support, EMAC has released a number of patches and device drivers from the open source community and from internal EMAC engineering into its standard distribution. Along with kernel patches, EMAC provides the binaries for the kernel and root file system.

## **3.3 Qt Creator**

Qt Creator is a cross-platform IDE (Integrated Development Environment) tailored to the needs of Qt developers but works well for Headless applications as well. EMAC provides sample code as projects that can be imported into Qt Creator. Qt Creator supports remote deployment and source debugging.

<http://wiki.qt.io/Main>

## **3.4 ARM EABI Cross Compiler**

The popular open source gcc compiler has a stable build for the ARM family. EMAC uses the 4.9.1 version of the ARM EABI compiler. The Embedded Linux kernel and EMAC Qt Creator projects use this compiler for building ARM stand alone, and OS specific binaries. The EMAC Qt Creator provides source level debugging over Ethernet or serial using gdbserver. The Linux binaries for the ARM EABI cross compiler are available online along with the SDK. See the EMAC wiki for further information.

## 4 Appendix A: Connector Pinouts

### 4.1 7" LCD Backlight Connector (CN1)

Pin	Signal
1	VOUT
2	Switched GND

### 4.2 Serial Port COM A (CN2)

Pin	Signal
1	DCD
2	RxD
3	TxD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

### 4.3 10" Touch Screen Connector (CN3)

Pin	Signal
1	X-
2	Y-
3	X+
4	Y+
5	GND
6	GND

#### 4.4 7" Touch Screen Connector (CN4)

Pin	Signal
1	X-
2	Y-
3	X+
4	Y+
5	GND
6	GND

#### 4.5 CAN Port (CN5)

Pin	Signal
1	GND
2	CAN_L
3	CAN_H

#### 4.6 Vin DC Barrel Jack (JK1)

Pin	Signal
Center	Vin
Barrel	GND

#### 4.7 USB OTG Port C (JK2)

Pin	Signal
1	USB_VBUS
2	USB_DATA-
3	USB_DATA+
4	USB_ID
5	GND

#### 4.8 Ethernet RJ-45 (JK3)

Pin	Signal
1	MX1+
2	MX1-
3	MX2+
4	MX3+
5	MX3-
6	MX2-
7	MX4+
8	MX4-

#### 4.9 Dual USB Host Ports A & B (JK4)

Pin	Signal
T1	HostA_PWR
T2	HostA_Data-
T3	HostA_Data+
T4	GND
B1	HostB_PWR
B2	HostB_Data-
B3	HostB_Data+
B4	GND
9	Chassis_GND
10	Chassis_GND
11	Chassis_GND
12	Chassis_GND
13	Chassis_GND

#### 4.10 Audio Input Jack (JK5)

Pin	Signal
1	GND
2	LINEIN_L
3	LINEIN_R

#### 4.11 Audio Output Jack (JK6)

Pin	Signal
1	GND
2	HP_L
3	HP_R

#### 4.12 Vin DC Connector (HDR1)

Pin	Signal
1	Vin
2	Chassis_GND
3	GND

#### 4.13 Serial Port COM D (HDR2)

Pin	HDR2 Signal	DB9 Signal
1	NC	NC
2	NC	RxD
3	RxD	TxD
4	NC	NC
5	TxD	GND
6	NC	NC
7	NC	NC
8	NC	NC
9	GND	NC
10	NC	N/A

#### 4.14 Serial Port COM B (HDR3)

Pin	Pin Description for 10-pin Header	Pin Description for DB9 Connector
1	NC	NC
2	NC	RxD
3	RxD	TxD
4	NC	NC
5	TxD	GND
6	NC	NC
7	NC	NC
8	NC	NC
9	GND	NC
10	NC	N/A

#### 4.15 Serial Port COM C (HDR4)

Pin	Pin Description for 10-pin Header	Pin Description for DB9 Connector
1	422/485 Tx-	422/485 Tx-
2	NC	232 Rx, 422/485 Tx+
3	232 Rx, 422/485 Tx+	232 Tx, 422/485 Rx+
4	RTS	422/485 Rx-
5	232 Tx, 422/485 Rx+	GND
6	CTS	NC
7	422/485 Rx-	RTS
8	NC	CTS
9	GND	NC
10	NC	N/A

#### 4.16 Bulkhead USB Connector Port A & B (HDR5)

Pin	Signal	Pin	Signal
1	HostA_PWR	2	HostB_PWR
3	HostA_Data-	4	HostB_Data-
5	HostA_Data+	6	HostB_Data+
7	GND	8	GND
9	Chassis_GND	10	NC



## 4.17 LVDS Connector (HDR6)

Pin	Signal	Pin	Signal
1	Chassis_GND	2	Chassis_GND
3	3.3V	4	3.3V
5	Red-	6	Red+
7	GND	8	GND
9	Green-	10	Green+
11	GND	12	GND
13	Blue-	14	Blue+
15	GND	16	GND
17	Clock-	18	Clock+
19	VLED_5V	20	VLED_5V
21	Brightness	22	GND
23	I <sup>2</sup> C_Data	24	I <sup>2</sup> C_Clock
25	3.3V	26	VLED_5V
27	NC	28	NC
29	NC	30	NC
31	GND	32	GND
33	NC	34	NC

## 4.18 Miscellaneous I/O Connector (HDR7)

Pin	Signal	Pin	Signal
1	3.3V	2	3.3V
3	GPIO1	4	GPIO4
5	GPIO2	6	GPIO5
7	GPIO3	8	GPIO6
9	INT0	10	GPIO7
11	INT1	12	INT2
13	OSC0	14	GND
15	OSC1	16	GND
17	ADC4	18	GPIO8
19	ADC5	20	GPIO9
21	ADC6	22	GPIO10
23	ADC7	24	GND
25	SPI_MISO	26	GND
27	SPI_MOSI	28	GND
29	SPI_CLK	30	GND
31	SPI_CS3	32	GND
33	SPI_CS1	34	GND
35	I <sup>2</sup> C_CLK	36	GND
37	I <sup>2</sup> C_DAT	38	GND
39	SoM_RSTOUT!	40	GND
41	5.0V	42	5.0V
43	GND	44	GND

#### 4.19 MicroSD Card Socket (SOK1)

Pin	Signal
1	Data2
2	Data3
3	CMD
4	3.3V
5	SCLK
6	GND
7	Data0
8	Data1
9	SD Card Detect
10	GND

#### 4.20 200-pin SoM Socket (SOK2)

(See the 200-pin SoM Pin Specification and Schematics)

## 5 Appendix B: Jumper Settings

(See SoM Manual for correct Boot Jumper settings)

### JB1 Boot0 Source Selection

Jumper	Position	Setting
Pins 2 & 3*	A	Line pulled LOW
Pins 1 & 2	B	Line pulled HIGH

\* Default setting

### JB2 Boot1 Source Selection

Jumper	Position	Setting
Pins 2 & 3*	A	Line pulled LOW
Pins 1 & 2	B	Line pulled HIGH

\* Default setting

### JB3 Flash Write Protect

Jumper	Position	Setting
Pins 2 & 3*	A	Resident Flash Disable
Pins 1 & 2	B	Resident Flash Enable

\* Default setting

### JB4 RTC Battery Enable

Jumper	Position	Setting
Pins 2 & 3*	ON	Enable Battery Backup
Pins 1 & 2	OFF	Disable Battery Backup

\* Default setting

### JB5 RS485/RS422 Select

Jumper	Position	Setting
Pins 1 & 2	485	Select RS485
Pins 2 & 3*	422	Select RS422

\* Default setting

## JB6 RS232/RS4xx Select

<b>Jumper</b>	<b>Position</b>	<b>Setting</b>
Pins 1 & 2*	232	Select RS232
Pins 2 & 3	4xx	Select either RS422 or RS485

\* Default setting

## JB7 Ethernet Primary Tap

<b>Jumper</b>	<b>Position</b>	<b>Setting</b>
Pins 1 & 2*	OPN	Select 1000BaseT Ethernet
Pins 2 & 3	3P3	Select 10/100BaseT Ethernet

\* Default setting

## JB8 External SPI Interface Voltage

<b>Jumper</b>	<b>Position</b>	<b>Setting</b>
Pins 1 & 2*	5V	Select 5V SPI Interface
Pins 2 & 3	3V	Select 3.3V SPI Interface

\* Default setting

JB9 External I<sup>2</sup>C Interface Voltage

<b>Jumper</b>	<b>Position</b>	<b>Setting</b>
Pins 1 & 2*	5V	Select 5V I <sup>2</sup> C Interface
Pins 2 & 3	3V	Select 3.3V I <sup>2</sup> C Interface

\* Default setting

## 6 Appendix C: Mechanical Drawing

