# TS6

# EMBER® EM35XX BREAKOUT BOARD TECHNICAL SPECIFICATION

Silicon Labs' Ember EM35xx Breakout Board contains the hardware peripherals for the development and deployment of a low-data-rate, low-power Zigbee application on the EM300 series System-on-Chips (SoCs). The SoC is part of the four-layer (FR4-based) module that connects to the EM35xx Breakout Board through the board-to-board connectors. The EM35xx Breakout Board hardware stimuli include a temperature sensor, two buttons, a piezo buzzer, two LEDs, and a 2" x 2" through-hole prototyping area. In addition, the EM35xx Breakout Board contains a USB transceiver with USB connector, a RS-232 transceiver with DB-9 connector, Data Emulation Interface (DEI), Packet Trace Port programming interface, and regulated power planes. Revision B0 and later of the EM35xx Breakout Board include an optional interface to 2 MB external DataFlash in support of the Zigbee OTA Profile for over-the-air (OTA) application bootloader purposes. Revision C0 and later of the EM35xx Breakout Board includes a dedicated USB connector for EM358x USB, Embedded Trace Module (ETM) interface for EM358x via third-party debuggers, and an optional interface to 8 MB external DataFlash in support of OTA application bootloader purposes via either EM35xx SC1 or SC2. Details contained within this document refer to revision C0 and later unless otherwise noted.

You can obtain the EM35xx Breakout Board voltage supply from one of five sources: Ember Debug Adapter (ISA3) (through the Packet Trace Port), external VDC supply, two USB ports (EM358x and SC1 UART), or AAA battery pack. The various voltage supplies offer a degree of flexibility when testing different network topologies.

This document provides the technical specification for the EM35xx Breakout Board. It describes the board-level interfaces as well as the key performance parameters. In addition, it provides the necessary information for developers to validate their application designs using the EM35xx Breakout Board.

**New in This Revision**

Updated based on revision C2 updates in support of EM358x.

**Contents**

# 1 Breakout Board Features

The EM35xx Breakout Board offers:

- Configurable hardware support for application development

  Temperature sensor (connects to EM35xx GPIO)
  Two buttons (connect to EM35xx GPIO)
  Piezo buzzer (connect to EM35xx GPIO)
  Two LEDs (connect to EM35xx GPIO)
- RS-232 transceiver with DB-9 connector for serial communication (with hardware (HW) handshake support)
- USB transceiver with USB connector (Type B)
- USB connector for EM358x USB interface (Type B) (Revision C only)
- 2 MB external DataFlash for Zigbee OTA Profile support via EM35xx SC2 (Revision B only)
- 8 MB external DataFlash for Zigbee OTA Profile support via EM35xx SC1 or SC2 (Revision C only)
- Control Interface for the EM35xx Radio Communications Module (RCM)

  RCM RESET button
  Voltage Supply connection (VBRD)
- 2" x 2", 0.1" pitch prototyping area
- 26-pin, 0.1" pitch, dual-row logic-analyzer shrouded connector
- 10-pin, 0.05" pitch, dual-row Packet Trace Port connector
- 20-pin, 0.05" pitch, dual-row ARM-compatible Embedded Trace Module (ETM) connector (interfaces with third-party debuggers) (Revision C only)
- 12-pin, 0.1” pitch, dual-row, data emulation interface (DEI) with configuration header
- 14-pin, 0.05” pitch, single-row along with a 19-pin 0.05” pitch, single-row, board-to-board connector for the module
- Selection pins for DC power source selection (either external DC power supply, USB, Debug Adapter (ISA3), or AAA battery pack). LEDs indicate which power supply has been selected.
- 2-pin module VDC pin for connection of an ammeter for module current measurements
- 2-pin jumpers for each of the HW application peripherals, buzzer, buttons, piezo, temperature sensor, and LEDs
- 3-pin selection jumpers for connection to the EM35xx UART (SC1). The selection jumpers route signals (RXD, TXD, nRTS, and nCTS) to either an USB transceiver, RS-232 transceiver, or allow access to the TTL levels.

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Table 1 lists the DC electrical characteristics of the EM35xx Breakout Board.

**Table 1. DC electrical characteristics**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| VDD supply | | | | |
| External DC Supply (J1 / J32) | 4 | | 20[1] | V |
| USB Host | 4.5 | 5 | | V |
| Debug Adapter (ISA3) | 3.1 | 3.3V | 3.5 | V |
| Battery | 2.1 | | 3.6 | |
| External DC supply (J3.2) | 3.1 | 3.3 | 3.5 | V |
| **Current draw (peripherals)** | | | | |
| Piezo buzzer | | | 10 | mA |
| Buttons (enabled) | | | 6 | mA |
| Temperature sensor (enabled) | | | 5 | mA |
| **Current draw (miscellaneous)** | | | | |
| RS-232 transceiver | | | 4 | mA |
| USB transceiver (for SC1 UART) | | | 15 | mA |
| LDO distribution | | | 10 | mA |
| Operating temperature | 0 | | + 55 | C |

[1] Maximum external DC supply voltage is 15 V for revisions B1 and earlier of the EM35xx Breakout Board. See document TS12, *Errata EM35xx Breakout Board Technical Specification,* for more information.

# 2 Components

Figure 1 illustrates the components on layer 1 (top side).

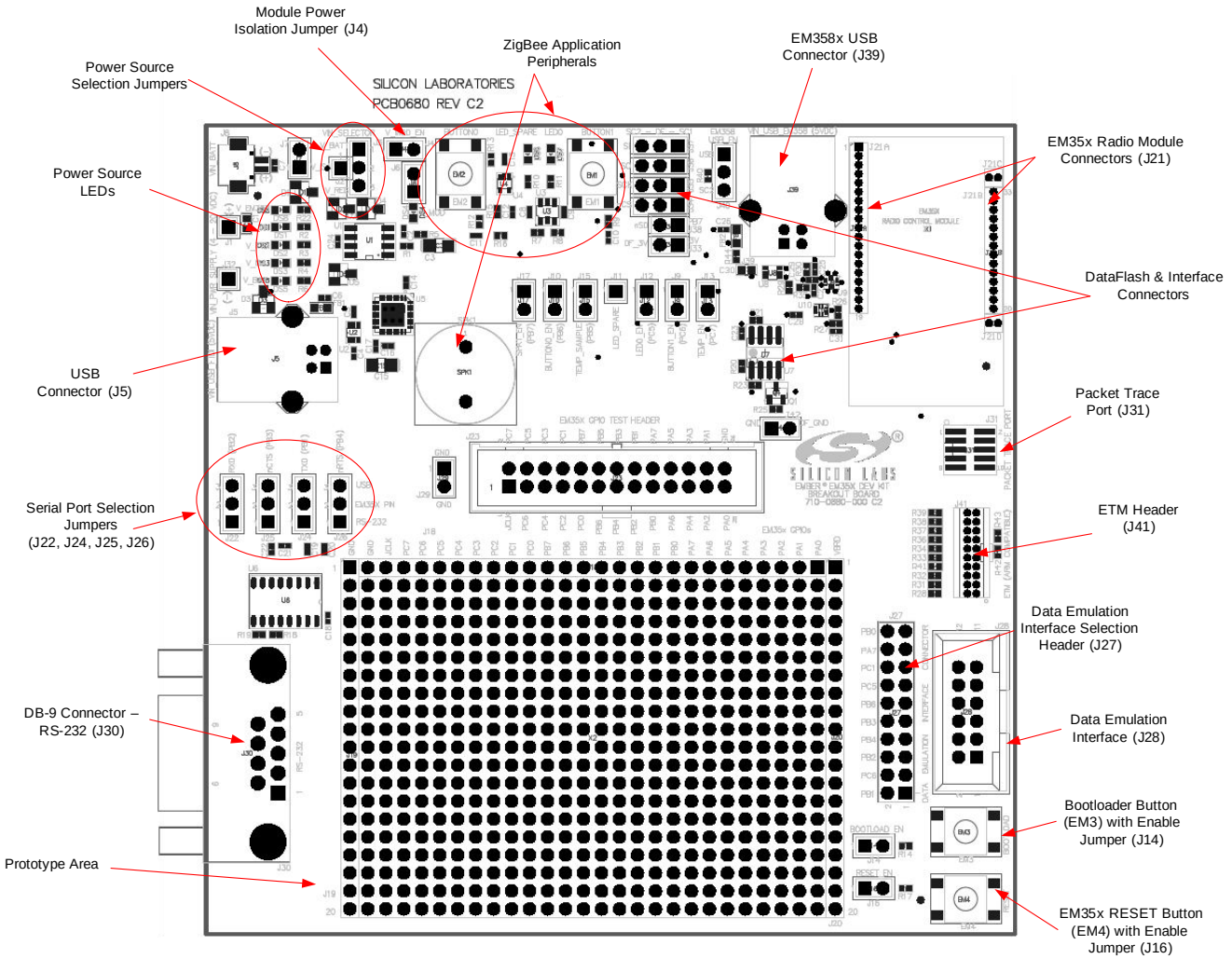



**Figure 1. Assembly Print for Layer 1**

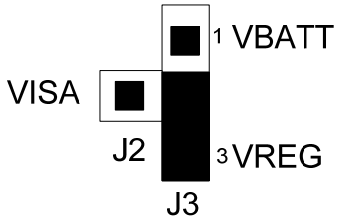
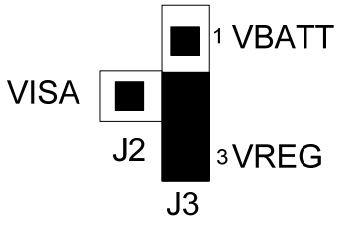
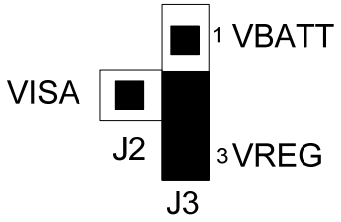
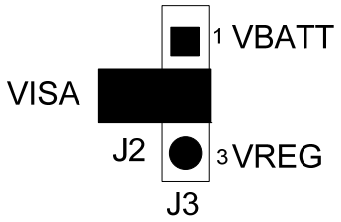
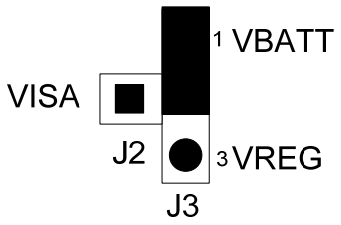
## 2.1 Power Supply and Distribution

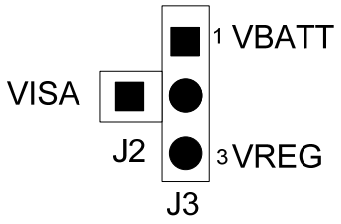
The EM35xx Breakout Board can be powered from one of six sources:

- 4V to 20V External DC Power supply (Positive connected J1 and Ground connected to J32)
- Battery pack connector (J8)
- USB Host (J5, via Wall wart or PC connection)
- EM358x USB Host (J39, via Wall wart or PC connection) (Revision C only)
- Debug Adapter (ISA3) (through Packet Trace Port, J31)
- 2.1 to 3.6V External DC Power supply (Positive connected to J3.2 and Ground connected to J32)

The EM35xx Breakout Board contains power source selection jumpers (J2 and J3) which allows only one DC source to power the board. This eliminates the possibility of overcurrent resulting from power supply contention. Table 2 illustrates the connection scheme and LED indication for each power source.

**Table 2: Power Supply Connections**

| Power Source | Selection Scheme (J2 and J3) | LED Indicator |
|---|---|---|
| **High Voltage External supply (4 V to 20 V)**<br><br>*Connect VDD to J1 and GND to J32.* |  | |
| **USB Host**<br><br>*Connect USB cable to J5.* |  | |
| **EM358x USB Host**<br><br>*Connect USB cable to J39.* |  | |
| **Debug Adapter (ISA3)**<br><br>*Connect ISA3 to J31.* |  | |
| **Battery pack**<br><br>*Connect AAA battery pack (supplied by Silicon Labs).* |  | |

| | | |
|---|---|---|
| **Low Voltage External DC supply (3.1 to 3.5)**<br><br>*Connect directly to J3.2 with Ground connected to J32.* |  | |

### 2.1.1 External DC Power Supply (J1 and J32 or J3.2 and J32)

The EM35xx Breakout Board allows two easy to use connections to an external power supply.

- The first connection (Low Voltage) allows for a 3.1 to 3.5 V DC external supply to be connected to J3.2 (positive) and J32 (Ground). The power supply should be able to source up to 250 mA at the set voltage. When using a power supply in this mode, there should be no jumpers on J2 or J3 as shown in Table 2.
- The second connection (High Voltage) allows for a 4 V to 20 V DC external supply to be connected to J1 (positive) and J32 (Ground). The power supply should be able to source up to 300 mA at the set voltage. When using a power supply in this mode, there should be a jumper connecting J3.3 and J3.2 as shown in Table 2.

### 2.1.2 Battery Connector (J8)

The 2-pin, keyed battery connector (Hirose, P/N: DF13-2P-1.25H(50)) allows for connection to a DC power supply or battery pack. The EM35xx Breakout Board is shipped with a 2-AAA battery pack with appropriate mating connector for easy attachment. Batteries are sold separately. When using a battery pack, a jumper must be connected between J3.1 and J3.2 as shown in Table 2.

### 2.1.3 Packet Trace Port (J31)

The EM35xx Breakout Board can also be powered from a Debug Adapter (ISA3). To enable this power supply, simply connect the Debug Adapter (ISA3) to the Packet Trace Port (J31) and connect the power selection jumper between J2 and J3.2 as shown in Table 2. In addition, the Debug Adapter (ISA3) selection toggle switch must be put in the INT position. The Debug Adapter (ISA3) provides a target voltage of 3.3 V and sources as much as 250 mA. See document TS7, *Ember Debug Adapter (ISA3) Technical Specification,* for more details on the Debug Adapter (ISA3).

**Note:** If the Debug Adapter (ISA3) is connected directly to the Packet Trace Port on the Module, the jumper at J4 must be connected as well as the jumper across J2 and J3.2.

### 2.1.4 USB Host (J5)

The EM35xx Breakout Board can also be powered by a USB Host (PC or Silicon Labs-supplied USB power supply). To operate in this mode, a USB Host must be connected to J5 and the power selection jumper must be connected between J3.2 and J3.3 as shown in Table 2.

### 2.1.5 EM358x USB Host (J39)

The EM35xx Breakout Board can also be powered by an EM358x USB Host (PC or Silicon Labs-supplied USB power supply). To operate in this mode, the EM358x USB Host must be connected to J39 and the power selection jumper must be connected between J3.2 and J3.3 as shown in Table 2.

## 2.2 Deep Sleep Testing of the Ember Module

To allow for accurate deep sleep current measurements, the EM35xx Breakout Board isolates the module VDD power supply from the regulated power domain on the EM35xx Breakout Board. The only connection point between the module power supply and the EM35xx Breakout Board supply is through the VMOD_EN header (J4).

By isolating the module power supply in this manner, an ammeter can be placed across J4 to monitor the current sourced to the module. To perform accurate deep sleep measurements, configure the EM35xx Breakout Board as follows:

- Confirm J40 is configured for SC2 and not USB.
- Remove J4 and place ammeter across this jumper.
- Remove J6 so the V_MOD LED DS4 is not driven. If supplying voltage by J8 battery connector, also remove J7 so the V_BATT LED DS5 is not driven.
- Remove J33-J38 jumpers to isolate DataFlash IC from circuit.
- Issue "shutdown" in nodetest.
- Once command is issued and node is asleep, remove J22 and J24-J26 (UART jumpers).
- Make sure the Packet Trace Port cable, DEI cable, and RS-232 cable are all detached from the EM35xx Breakout Board.

This connection scheme offers the highest degree of power supply flexibility. Wake the EM35xx from deep sleep by pressing either Button 0 or Button 1.

**Note:** The use of virtual UART port 4900 is not recommended when interfacing to nodetest for deep sleep testing, because this does not allow for proper configuration of the EM35xx for deep sleep measurements. Therefore, use either pass-through UART port 4901, USB, or RS-232 to interface to the nodetest application.

## 2.3 Zigbee Application Peripherals

As previously mentioned, the EM35xx Breakout Board offers six peripherals to assist in Zigbee application development including:

- Temperature sensor
- Two (2) “normally open” buttons
- 4 kHz piezo buzzer
- Two (2) LEDs
- External DataFlash

Each peripheral connects to an EM35xx GPIO through a two-pin peripheral header. Because each peripheral header on the EM35xx Breakout Board ships with a jumper in place, the peripherals default to “HW Enabled.” If application development does not require the peripheral, simply remove the jumper.

**Note:** Each peripheral consumes power. Be sure to factor this into the current consumption equations when testing the module in deep sleep mode or if using the battery pack to power the EM35xx Breakout Board.

### 2.3.1 Temperature Sensor (U4)

The temperature sensor is an off-the-shelf component from National Semiconductor (MFG P/N: LM20BIM7). The temperature sensor requires an enable signal to be asserted (active high) prior to generating an analog voltage proportional to the ambient temperature of the EM35xx Breakout Board. Therefore, two EM35xx GPIO signals, PC7 and PB5, are routed to pin 2 of peripheral headers J13 and J15, respectively.

- PC7 enables the temperature sensor when asserted (active high), when a jumper is installed at J13.

- PB5 contains the analog temperature information from the sensor, when it is enabled and a jumper is installed at J15.

Due to the EM35xx ADC voltage reference at 1.2 V, the temperature sensor output is scaled to between 0 and 1.2 V through a resistive voltage divider. If you want to connect a temperature sensor from a different manufacturer, scale the output in a similar manner.

The EM35xx Breakout Board is shipped with a jumper installed at J13 and J15. If the jumpers are removed, a different compatible device can be attached to pin 2 of both J13 and J15.

For more information on the temperature sensor, refer to its data sheet (http://www.ti.com/product/LM20).

### 2.3.2 Buttons (EM1, EM2)

Two programmable, normally-open buttons are provided for software debugging and application development. When either button is pressed, the connected net is driven low. A single-pole RC filter minimizes the effects of switching noise.

These buttons map to the backchannel button commands as follows:

- EM2: controlled by the `button 0` command
- EM1: controlled by the `button 1` command

For information about the `button` command, see document UG1110, *EM35xx Development Kit User Guide*.

Two EM35xx GPIO signals, PB6 and PC6, are routed from the EM35xx Module to pin 2 of peripheral headers J9 and J10, respectively. In the default configuration of the EM35xx Breakout Board, jumpers are positioned across J9 and J10 to enable buttons EM1 and EM2, respectively. If the jumpers are removed, different compatible devices can be attached to pin 2 of breakout headers J9 and J10 instead of the buttons.

### 2.3.3 Buzzer (SPK1)

A programmable buzzer is provided for software debugging and application development. An EM35xx GPIO signal, PB7, is routed to pin 2 of peripheral header J17. In the default configuration of the EM35xx Breakout Board, a jumper is positioned across J17 to enable use of the buzzer. The buzzer installed on the EM35xx Breakout Board is from CUI (MFG P/N: CEP-1160). For more information on the buzzer, refer to its data sheet (http://www.cui.com/Product/Resource/PDFRedirect/110/CEP-1160.pdf).

### 2.3.4 LEDs (DS6 and DS7)

The EM35xx Breakout Board contains two LEDs for software debugging and application development. Each LED is buffered (non-inverting) to allow for connection to any EM35xx GPIO. One EM35xx GPIO, PC5, is routed to pin 2 of header J12. To turn on DS7 (RED) from the EM35xx RCM, install a jumper at J12, configure PC5 as an output and drive it low. To turn on DS6 (GREEN), make a physical connection between an unused EM35xx GPIO and J11 (single pin header). Once this is done, then that GPIO must be configured as an output and driven low to illuminate DS6.

### 2.3.5 External DataFlash (U7)

The external DataFlash is an off-the-shelf component. Revision B boards have 2 MB components from Adesto (MFG P/N: AT45DB021D-SSH-B), while revision C boards have 8 MB components from WinBond (MFG P/N: W25Q80BVSNIG). The DataFlash is used in cases where Zigbee OTA Profile application bootloader is required. Note that the DataFlash is included on EM35xx Breakout Board revision B0 and later. The DataFlash is connected to the EM35xx RCM through jumpers J33-J38. The EM35xx Breakout Board is shipped with jumpers installed for interfacing with EM35xx SC1. If all six jumpers are installed properly at J33-J38, the external DataFlash connects to the EM35xx SC1 or SC2 for application bootloading. Figure 2 illustrates the jumper configuration for the DataFlash

interface. Connect J34-J37 on the left-hand side for interfacing to EM35xx SC2 and on the right-hand side for EM35xx SC1.

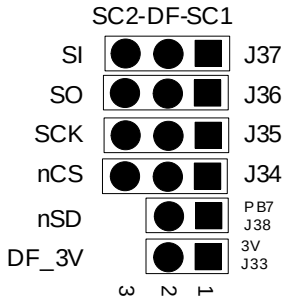



**Figure 2. Jumper for DataFlash Connections**

For more information on the DataFlash, refer to its data sheet (http://www.adestotech.com/sites/default/files/datasheets/doc3638.pdf for the Revision B Adesto part, and http://www.winbond.com/NR/rdonlyres/4D2BF674-7427-4FC8-AEF0-1A534DF74F16/0/W25Q80BV.pdf for the Revision C WinBond part).

## 2.4 Serial Communication for EM35xx SC1 UART

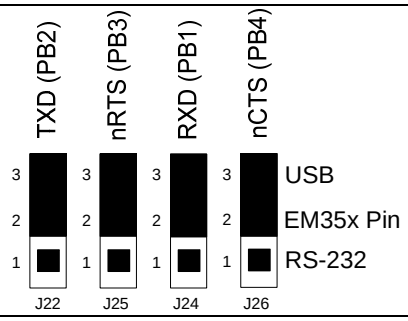
To enhance the software development experience, access to the EM35xx SC1 UART is available directly from the EM35xx Breakout Board or by telnetting into port 4901 of an ISA3 connected to an Ethernet network. On the EM35xx Breakout Board, it is available as RS-232, USB and TTL-compliant signal levels.

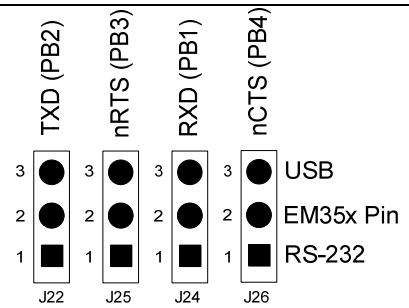
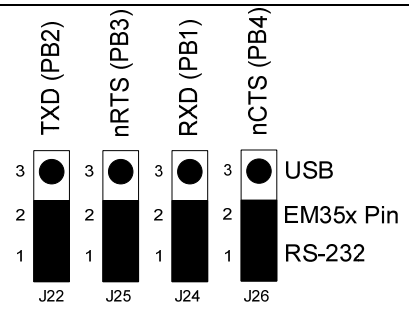
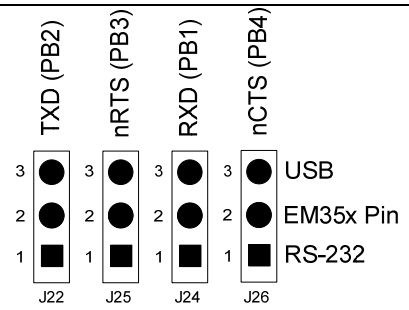
To minimize current consumption and allow for the different configuration options, the EM35xx Breakout Board individually routes the EM35xx SC1 UART signals TXD (EM35xx PB2), RXD (EM35xx PB1), nRTS (EM35xx PB3), and nCTS (EM35xx PB4) to pin 2 of headers J22, J24, J25 and J26 respectively. TTL-level access to these UART signals is available at pin 2 of these headers. To route the UART signals to the USB transceiver, connect the jumpers between pins 3 and 2 to each of the headers. Placing the jumpers across pins 1 and 2 route the UART signals to the RS-232 transceiver. To access the EM35xx UART SC1 with an ISA3, remove the jumpers on J22, J24, J25 and J26 and place them on the DEI jumper connector (J27) as summarized below and shown in Figure 3.

- TXD: J27.1 to J27.2
- RXD: J27.5 to J27.6
- nRTS: J27.7 to J27.8
- nCTS: J27.9 to J27.10

Each jumper configuration is shown in Table 3.

**Table 3: Serial Communication Selection Jumpers**

| UART Path | Selection Scheme (J22, J25, J24 and J26) |
|---|---|
| **EM35xx SC1 to USB** |  |

| | |
|---|---|
| **EM35xx SC1 to TTL** |  |
| **EM35xx SC1 to RS-232** |  |
| **EM35xx SC1 over Debug Adapter (ISA3)**<br><br>*Connect DEI cable to J28.* |  |

**Note** To connect to the EM35xx UART over a Debug Adapter (ISA3), the Debug Adapter (ISA3) must be connected to an Ethernet connection. It can be accessed by selecting “Serial 1” within the Console view of the Ember Desktop or by telnetting to Port 4901.

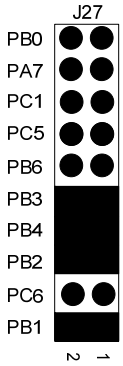



**Figure 3. Jumper Settings Required for EM35xx SC1 UART Access by Debug Adapter**

## 2.5 Data Emulation Interface (J28)

The 12-pin, dual-row, data emulation interface contains 10 EM35xx GPIO signals, as well as voltage (VBRD) and ground (GND) connections. When connected to the Debug Adapter (ISA3), the connector provides additional debug features to software developers.

One feature involves the port 4901 UART connection via Debug Adapter (ISA3). To enable the UART connection to the EM35xx UART signals, install four jumpers on J27 as shown in Figure 3.

Another feature involves manipulation of BUTTON0 and BUTTON1 GPIO signals. To enable GPIO manipulation of BUTTON0 and BUTTON1, install jumpers on J27 at PB6 and PC6, respectively.

## 2.6 EM358x USB Interface (J39)

Access to the EM358x USB com port is available directly from the EM35xx Breakout Board via the USB connector J39. To access EM358x USB, J40 must be installed with the shorting jumper configured as USB rather than SC2, and the firmware application must be built for using USB (nodetest-usb, for example). With J40 configured as SC2, SC2 pins are available for general I/O or external DataFlash uses. With J40 configured as USB, SC2 pins are dedicated to USB and not available for other uses. See **Error! Not a valid bookmark self-reference.** for these corresponding jumper configurations.

**Table 4: USB Enable Selection Jumper**

| Mode Selection | Jumper Configuration |
|---|---|
| **EM358x SC2 for USB** | |
| **EM358x SC2 for general I/O or DataFlash uses** | |

For additional information on EM358x USB, refer to AN740, *Using the Ember ® EM358x USB*.

## 2.7 EM35xx Module Interface Connector (J21)

Two single-row, 0.05” pitch, connectors make up the EM35xx module interface to the EM35xx Breakout Board. In addition, two single-row, guide connectors assist with connecting the EM35xx module to the EM35xx Breakout Board. The board-to-board connector scheme allows access to all EM35xx GPIO as well as nRESET and the JCLK signals. The connector is illustrated in Figure 4, while the dimensions are listed in Figure 5.

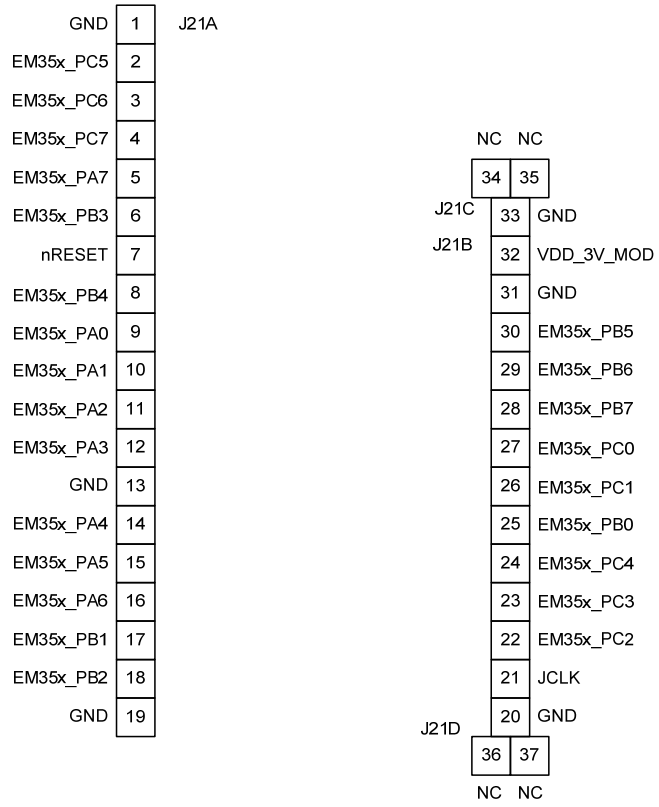



**Figure 4. Board-to-Board Connector for the EM35xx Module**

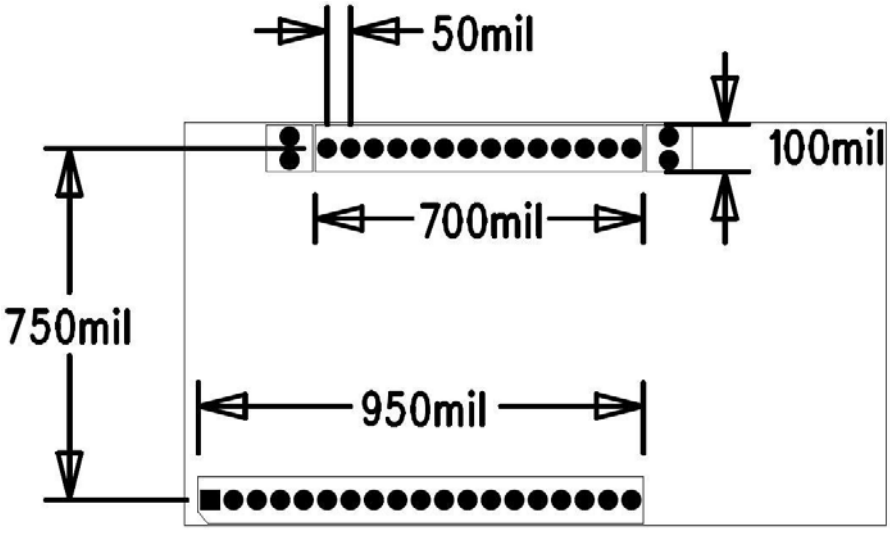



**Figure 5. Board-to-Board Connector Dimensions for the EM35xx Module**

Table 5 describes the pinout and signal names at both J21. The EM35xx GPIOs are exposed on the EM35xx Breakout Board at the 26-pin, dual row, 0.1” pitch GPIO connector (J23) for application development. For more information on the alternate functions of the GPIO connector, refer to document 120-035X-000, *EM35xx Data Sheet*.

**Table 5. Pinout and Signal Names of the Interface Connector**

| Pin # | Signal name | Direction[2] | Connector | Description |
|---|---|---|---|---|
| 1 | GND | Power | J21A | Ground Connection |
| 2 | PC5 | I/O | J21A | EM35xx GPIO |
| 3 | PC6 | I/O | J21A | EM35xx GPIO |
| 4 | PC7 | I/O | J21A | EM35xx GPIO |
| 5 | PA7 | I/O | J21A | EM35xx GPIO |
| 6 | PB3 | I/O | J21A | EM35xx GPIO |
| 7 | nRESET | I/O | J21A | Active low chip reset (internal pull-up on EM35xx) |
| 8 | PB4 | I/O | J21A | EM35xx GPIO |
| 9 | PA0 | I/O | J21A | EM35xx GPIO |
| 10 | PA1 | I/O | J21A | EM35xx GPIO |
| 11 | PA2 | I/O | J21A | EM35xx GPIO |
| 12 | PA3 | I/O | J21A | EM35xx GPIO |
| 13 | GND | Power | J21A | Ground connection |
| 14 | PA4 | I/O | J21A | EM35xx GPIO |
| 15 | PA5 | I/O | J21A | EM35xx GPIO |
| 16 | PA6 | I/O | J21A | EM35xx GPIO |
| 17 | PB1 | I/O | J21A | EM35xx GPIO |
| 18 | PB2 | I/O | J21A | EM35xx GPIO |
| 19 | GND | Power | J21A | Ground connection |
| 20 | GND | Power | J21B | Ground connection |
| 21 | JCLK | Input | J21B | JTAG interface, serial clock |
| 22 | PC2 | I/O | J21B | EM35xx GPIO |
| 23 | PC3 | I/O | J21B | EM35xx GPIO |
| 24 | PC4 | I/O | J21B | EM35xx GPIO |
| 25 | PB0 | I/O | J21B | EM35xx GPIO |
| 26 | PC1 | I/O | J21B | EM35xx GPIO |
| 27 | PC0 | I/O | J21B | EM35xx GPIO |
| 28 | PB7 | I/O | J21B | EM35xx GPIO |
| 29 | PB6 | I/O | J21B | EM35xx GPIO |
| 30 | PB5 | I/O | J21B | EM35xx GPIO |
| 31 | GND | Power | J21B | Ground connection |
| 32 | VDD | Power | J21B | 2.1 to 3.6V Module Power Domain |
| 33 | GND | Power | J21B | Ground connection |
| 34 | NC | N/A | J21C | Not connected; guide pin |
| 35 | NC | N/A | J21C | Not connected; guide pin |
| 36 | NC | N/A | J21D | Not connected; guide pin |
| 37 | NC | N/A | J21D | Not connected; guide pin |

[2] with respect to the RCM

## 2.8 Prototyping Area

The 2.8" x 2" (0.1” pitch) prototyping area on the EM35xx Breakout Board offers software developers an extra degree of flexibility. As shown in Figure 4, it allows access to VBRD, GND, and each of the 24 EM35xx GPIOs. Therefore, you can solder any sensor or input device to the prototyping area and connect it to the EM35xx GPIO for development and debugging.

As shown in Figure 6, the leftmost column is connected to GND and the rightmost column to VBRD. The top row is connected to the EM35xx GPIOs. Included in the top row are additional GND and JCLK connections. The remainder of the array is available for application development.

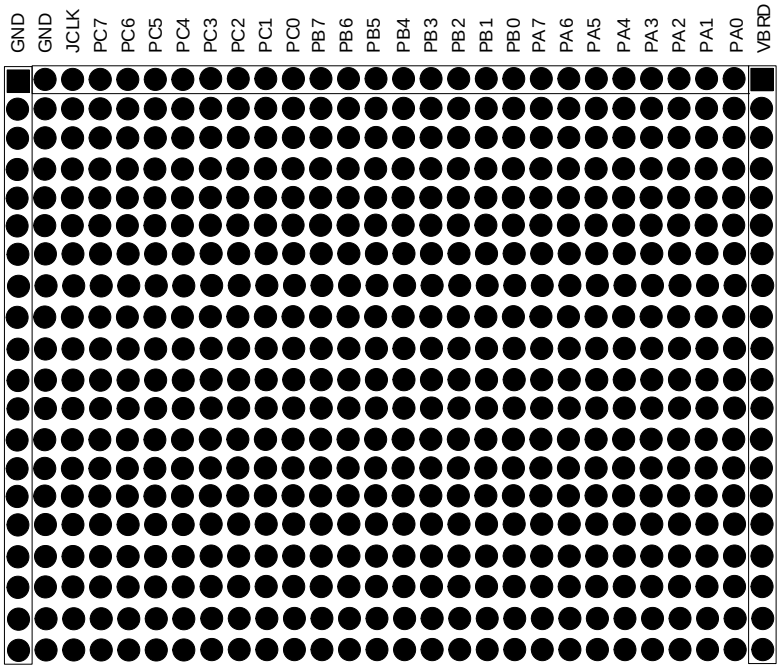
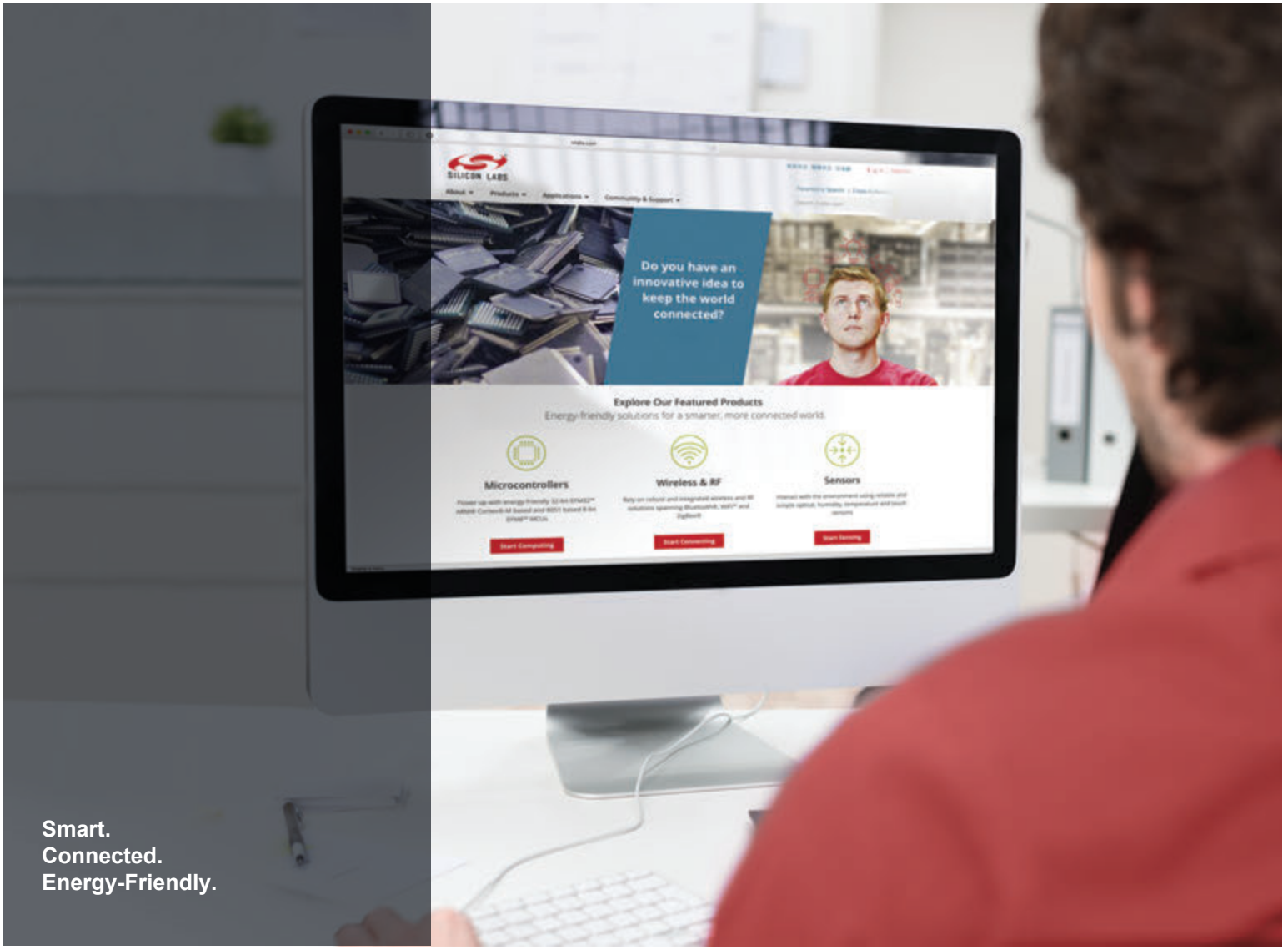



**Figure 6. EM35xx Breakout Board Prototyping Area**

# 3 EM35xx Breakout Board Schematic

The EM35xx Breakout Board schematic is included at the end of this document.

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