

# *CutiPy™*

## User Manual

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*Revision 2.10*

(for use with Rev 4 Boards)

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## Table of Contents

|          |                                                         |               |
|----------|---------------------------------------------------------|---------------|
| <b>1</b> | <b>Introduction .....</b>                               | <b>- 4 -</b>  |
| 1.1      | ....Features .....                                      | - 4 -         |
| 1.2      | ....CutiPy Specifications .....                         | - 5 -         |
| 1.3      | ....LCD .....                                           | - 5 -         |
| 1.4      | ....Serial Interfaces.....                              | - 5 -         |
| 1.5      | ....Mechanical and Environmental .....                  | - 5 -         |
| <b>2</b> | <b>CutiPy Product Details.....</b>                      | <b>- 6 -</b>  |
| 2.1      | ....Jumper Configuration & Connector Descriptions ..... | - 6 -         |
| 2.2      | ....Power Connectors .....                              | - 7 -         |
| 2.3      | ....Battery Operation and Charging.....                 | - 7 -         |
| 2.4      | ....Serial Ports .....                                  | - 9 -         |
| 2.5      | ....USB Ports.....                                      | - 11 -        |
| 2.6      | ....MicroSD Card Socket.....                            | - 12 -        |
| 2.7      | ....LCD (Optional).....                                 | - 12 -        |
| 2.8      | ....CAN Port.....                                       | - 12 -        |
| 2.9      | ....Real-Time Clock.....                                | - 12 -        |
| 2.10     | ..Temperature Sensors .....                             | - 12 -        |
| 2.11     | ..Reset.....                                            | - 13 -        |
| 2.12     | ..Wireless (Optional) .....                             | - 13 -        |
| 2.13     | ..I/O Expansion .....                                   | - 14 -        |
| 2.14     | ..I2C .....                                             | - 16 -        |
| 2.15     | ..SPI.....                                              | - 16 -        |
| 2.16     | ..Analog to Digital Converter .....                     | - 16 -        |
| 2.17     | ..Digital to Analog Converter .....                     | - 16 -        |
| 2.18     | ..Timers/Counters.....                                  | - 17 -        |
| 2.19     | ..JTAG/SWD .....                                        | - 17 -        |
| <b>3</b> | <b>Software.....</b>                                    | <b>- 18 -</b> |
| 3.1      | ....MicroPython.....                                    | - 18 -        |
| 3.1.1    | Mu IDE.....                                             | - 18 -        |
| 3.2      | ....FreeRTOS.....                                       | - 18 -        |

|          |                                                      |               |
|----------|------------------------------------------------------|---------------|
| 3.2.1    | STM32CubeIDE .....                                   | - 19 -        |
| <b>4</b> | <b>Appendix A: Connector Pinouts .....</b>           | <b>- 20 -</b> |
| 4.1      | ....Main Battery Connector (CN1).....                | - 20 -        |
| 4.2      | ....Serial Port UART2 (HDR10) .....                  | - 20 -        |
| 4.3      | ....I/O Header 1 (HDR1) .....                        | - 20 -        |
| 4.4      | ....I/O Header 2 (HDR2) .....                        | - 21 -        |
| 4.5      | ....Vin Power Header (HDR3).....                     | - 22 -        |
| 4.6      | ....CAN 2.0 Port (HDR4) .....                        | - 22 -        |
| 4.7      | ....Serial Port UART3 (HDR5) .....                   | - 22 -        |
| 4.8      | ....JTAG/SWD Header (HDR6).....                      | - 22 -        |
| 4.9      | ....MicroSD Card Socket (SOK1) .....                 | - 23 -        |
| <b>5</b> | <b>Appendix B: Microcontroller Unit Pinout .....</b> | <b>- 24 -</b> |
| 5.1      | ....STM32F407IGH6 – MCU Pinout (U3) .....            | - 24 -        |
| 5.2      | ....LDx Pinout .....                                 | - 26 -        |
| 5.3      | ....PBx Pinout .....                                 | - 26 -        |
| <b>6</b> | <b>Appendix B: Jumper Settings .....</b>             | <b>- 27 -</b> |
| 6.1      | ....JB1 (Boot Mode 1 Selection) .....                | - 27 -        |
| 6.2      | ....JB2 (Boot Mode 0 Selection) .....                | - 27 -        |
| 6.3      | ....JB3 (RTC & RAM Retention Battery).....           | - 27 -        |
| 6.4      | ....JB4 (CAN Termination) .....                      | - 27 -        |
| 6.5      | ....JB5 (High Drive Voltage Selection) .....         | - 27 -        |
| <b>7</b> | <b>Appendix C: Dimensions.....</b>                   | <b>- 28 -</b> |

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## **1 Introduction**

This document describes EMAC's CutiPy Industrial IoT microcontroller. The CutiPy is a Low Power Industrial IoT device that was designed to simplify connecting devices and machines to the multitude of systems you find in the Industrial environment. This module is built around the STMicroelectronics STM32 microcontroller, which provides several of its key features.

The CutiPy provides a number of features that are native to the board (Internal) and a number of features that are accessed through two 50 Pin Header Connectors that are referred to as External.

In addition to the features listed below, the CutiPy also features a fast 32-bit core, open source software support, and a wide range of controller I/O pins.

### **1.1 Features**

- **Low Power Industrial IoT**
- **STMicroelectronics ARM Cortex-M4 168MHz**
- **Up to 1M of Flash & 192 Kbytes of SRAM**
- **1x microSD Card Slot**
- **1x CAN 2.0B Port (Internal provided w/Transceiver, External provided w/o Transceiver)**
- **2x USB 2.0 Ports (1x Full Speed Device w/ PHY, 1x Full/High-Speed Device)**
- **4x Serial Ports**
  - **1x RS232 & 1x RS232/422/485 (Internal)**
  - **2x TTL (External)**
- **1x SPI Port**
- **2x I2C Ports**
- **25x Timer/Counters/PWM/Capture**
- **RTC with on-board battery backup**
- **Internal & External Temperature Sensors**
- **External Li-Ion Battery with charging from USB or 5V Power Supply Header**
- **1x Reset Button**
- **13x A/D Channels with 12-bit Resolution (3 Unique A/Ds)**
- **2x D/A Channels with 12-bit Resolution**
- **16x External Dedicated GPIOs (64x fully allocated)**
- **8x High-Drive Open Collector Outputs**
- **2x 50-Pin Expansion Headers**
- **OS/Language: MicroPython or FreeRTOS**
- **Graphic 128x32 LCD with 4x pushbuttons & 4x LEDs (optional)**
- **Silicon Labs RS9116 (BT/Wi-Fi) with on board antenna (optional)**
  - **802.11 a/b/g/n Wi-Fi**
  - **802.15.1 Bluetooth**

## 1.2 CutiPy Specifications

- **CPU:** STM32F407IGH6 ARM Cortex-M4 w/Math Coprocessor
- **Flash:** Up to 1MB of Flash
- **RAM:** 192 KB of SRAM
- **Flash Disk:** Micro SD Card Socket
- **System Reset:** Supervisor with external Reset Button provision
- **RTC:** Battery backed Real Time Clock
- **Timer/Counters:** 25x Timer/Counter/PWM/Capture
- **Digital I/O:** 16x External Dedicated GPIOs (64x fully allocated)
- **Analog I/O:**
  - 13x A/D Channels with 12-bit Resolution (3 Unique A/Ds)
  - 2x D/A Channels with 12-bit Resolution
- **Power:**
  - 5V Power Supply Header
  - USB Device Port
  - Li-Ion Battery
- **JTAG:** Processor JTAG Supporting Programming, Trace, and Boundary Scan

## 1.3 LCD

**LCD – 36 x 12 mm Graphic LCD (NHD-C12832A1Z-FSW-FBW-3V3):**

- **Display Type:** Film Super-Twisted Nematic
- **Resolution:** 128 x 32 pixels
- **Dot pitch:** 0.25mm x 0.25mm
- **Viewing Angle:**
  - **Θ-right:** 40°
  - **Θ-left:** 40°
  - **Θ-top:** 20°
  - **Θ-bottom:** 40°
- **Backlight:** White LED

## 1.4 Serial Interfaces

- **UARTS:** 1x RS232, 1x RS232/422/485, 2x TTL
- **SPI:** 1x SPI Ports
- **USB:** 2x USB 2.0 Ports
  - 1x Full-Speed Device terminating to an USB-C connector
  - 1x Full-Speed/High-Speed Device terminating to a header connector
- **I2C:** 2x I2C hardware Ports

## 1.5 Mechanical and Environmental

- **Dimensions:** 2.3" x3.5" (58.42mm x 88.9mm)
- **Power Supply Voltage:** 5 Vdc

- **Power Requirements (typical):**
  - 5.0 Volts @ 50mA (0.25 watts)
  - Typical Running Current Consumption: ~50mA
  - Sleep mode current: ~100μA
- **Operating Temperature:** -40 ~ 85° C (-40 ~ 185 ° F)
  - LCD: -20 ~ 70° C (optional)
- **Operating Humidity:** 0% ~ 90% relative humidity, non-condensing

## 2 CutiPy Product Details

### 2.1 Jumper Configuration & Connector Descriptions

The CutiPy comes factory configured. In the event that jumpers need to be verified or modified, this section provides the information required including instructions on setting jumpers and connecting peripherals, switches, and indicators. Be sure to read all the safety precautions before you begin any configuration procedure. See Appendix A for connector pinouts and Appendix B for Jumper Setting descriptions.

**Table 1: Jumpers**

| Label             | Function                     | Default |
|-------------------|------------------------------|---------|
| <b>JB1 (HDR7)</b> | Boot1 Source Selection       | ROM     |
| <b>JB2 (HDR7)</b> | Boot0 Source Selection       | FLS     |
| <b>JB3 (HDR8)</b> | RTC & RAM Retention Battery  | OFF     |
| <b>JB4 (HDR8)</b> | CAN Termination              | TRM     |
| <b>JB5 (HDR9)</b> | High Drive Voltage Selection | ExHD    |

**Table 2: Connectors**

| Label        | Function                                       |
|--------------|------------------------------------------------|
| <b>CN1</b>   | Main Battery Connector                         |
| <b>HDR1</b>  | I/O Header 1                                   |
| <b>HDR2</b>  | I/O Header 2                                   |
| <b>HDR3</b>  | Vin Power 4-Pin Male Header (Floppy Connector) |
| <b>HDR4</b>  | CAN 2.0 Port (CAN-1)                           |
| <b>HDR5</b>  | Serial Port UART3                              |
| <b>HDR6</b>  | JTAG Header                                    |
| <b>HDR7</b>  | Boot Configuration                             |
| <b>HDR8</b>  | CAN Termination / RTC Retention                |
| <b>HDR10</b> | Serial Port UART2                              |
| <b>HDR11</b> | Programming Header                             |
| <b>JK1</b>   | USB-C Connector                                |
| <b>SOK1</b>  | MicroSD Card Socket                            |

## 2.2 Power Connectors

The CutiPy provides one power connector. HDR3 is a TE Connectivity AMP 4-pin male connector (Part # 640456-4) and mates with TE Connectivity AMP 4-pin female socket (Part # 1375820-4). As an alternative, the CutiPy can also be powered through the USB-C connector located at JK1. This connector is an Amphenol right angle connector (Part# 12401610E4#2A).

The CutiPy only requires 5Vdc to operate. Vin (HDR3 pin 4) is not utilized on the CutiPy and is simply routed to Expansion Connectors HDR1 & HDR2 (pin 5). However, the pullup option for the HiDrive Outputs is routed to HDR1 (pin 6) and therefore Vin can be used to pull-up HiDrive Outputs by connecting HDR1 pin 5 and pin 6 together.

**Table 3: Power (Floppy) Connector Pinout (HDR3)**

| Pin | Signal    |
|-----|-----------|
| 1   | +Vin ~12V |
| 2   | GND       |
| 3   | GND       |
| 4   | +Vin 5V   |

## 2.3 Battery Operation and Charging

The CutiPy can be operated off of a Lithium Ion Battery as a main power source or backup power source. The battery is to be connected to CN1 (connector type JST - S2B-PH-SM4-TB(LF)(SN)). Note: if a Li-Ion battery is used, the battery may limit the operation temperature of the system.

The CutiPy utilizes a Texas Instruments I2C Power Manager chip (BQ27Z746Y : I2C 0x55) & a Lithium Ion Battery charger chip (BQ25619R : I2C 0x6A). These devices seamlessly will take power from one of three power sources: USB, 5-volt (Mini-Floppy) power connector, or external Battery, and supply whichever power source is most appropriate to the rest of the CutiPy's internal power distribution.

Internal power can be visualized as a diode-OR arrangement where any one of three power sources can power the CutiPy so long as any one of them is active. The junction where all three meet may have a wide voltage variation from just at or below 5 volts, all the way down to 3 volts depending on conditions. The junction of all three power sources is had by intelligent switching of Mosfets and is fed to a boost-buck switching regulator that will buck voltages higher than 3.3 volts down or boost voltages lower than 3.3V up to the normal system voltage of 3.3 volts.

While functioning in boost mode the boost-buck switcher allows the system maximum “hang-time”, when the system is running from an external battery whose voltage may be falling as the battery approaches discharge.

Internal power distribution priority is as follows:

Floppy 5V power 1<sup>st</sup>: 5V floppy power goes to the Texas Instrument BQ25619 Battery Charger and to Utility header's 5V I/O pins. 5 volts power can be provided through the Utility I/O just as easily as through the floppy power connector.

USB 5V power 2<sup>nd</sup>: if Floppy power is absent. This is not directly fed to the Utility Header's 5V I/O.

Battery power 3<sup>rd</sup>: if both Floppy and USB power is absent. This is also not directly fed to the Utility Header's 5V I/O.

Whichever of (or all three) power sources are present, they are seamlessly switched by Mosfets to a single, combined power supply node which feeds a LO-drop Lo-quiescent current switching Regulator, an On-Semi FAN49100. This boost-buck switching regulator takes whatever actual voltage is present at the combined power supply node (3 to 5 volts) and provides a regulated 3.3 volts to the CutiPy's main power bus.

If a charged external battery is present at header connector CN1, the BQ25619 will charge this battery from either the USB power or the Mini-Floppy connector; HDR3. The flexibility provided with the BQ25619 along with the low basic power requirements of the CutiPy allow the system to be powered by the USB alone if only a USB host is powering the unit.

If a stand-alone 5-volt power source is present and connected to the +5 and GND pins of HDR1, the BQ25619 will preferentially take power from it instead, which normally takes precedence over the USB power source.

The USB power input is set by the BQ25619 to limit the input current to no more than 500 mA total, as 500 mA is the usual current limit providable by a USB Host. This internal limit prevents overloading of a typical USB port. Should the load current taken by the CutiPy plus the battery charge current attempt to exceed the 500 mA USB limit, the battery charge current will be automatically reduced to compensate, keeping the USB port current below 500 mA. This will of course increase the time required for full battery recharge.

The Floppy provided 5 volts has essentially higher limit for those rare cases where a CutiPy might be connected to a larger system that uses higher currents, but this is an exceptional case. The Floppy power input is limited to 1.1 amps with a polyfuse.

EMAC can provide a 3.7 volt @ 1.2 Amp-hour Lithium-Ion rechargeable battery (EMAC Part#: PER-PWR-0101PRO). This battery also has a 2mm pitched two position receptacle that perfectly mates to the External Battery connector CN1. Because the CutiPy and the BQ25619 can and expects to charge a Li-Ion battery, only an Li-Ion battery should ever be connected to the External Battery connector CN1. Although Li-Ion batteries similar to PER-PWR-0101PRO (Li-Ion single cell) with higher or lower Amp-Hour capacities can be used, **never connect a battery of different voltage or another kind of rechargeable or primary battery to CN1!**

PER-PWR-0101PR0, does not have any internal battery protection circuitry, which is recommended for production use. However, the BQ25619 Battery Charger chip does automatically reduce the Battery charge current such that the sum of the load current and charge current does not exceed the programmed input current limit (the battery charge current goes to zero when load current exceeds the programmed input current limit) and has Current Limit & Charger Undervoltage Lockouts.

The BQ25619 has been programmed to recharge the external battery (when used) with a current of 250 mA, given the PER-PWR-0101PR0's 1200 mAh (1.2 Amps) capacity a typical recharge from near dead to fully charged takes around 4 and  $\frac{3}{4}$  hours for this battery. If another Li-Ion battery of different capacity is used instead, one can easily recalculate that battery's charge time by dividing the battery capacity in mAh by 250.

The BQ25619 will terminate the battery charge cycle when the battery reaches 4.2 volts. Logic pins are connected to the CutiPy's MPU so the CutiPy can know the status of the charge cycle.

A voltage measurement analog point is provided by other CutiPy circuitry to measure the external battery's voltage, it can be used to predict battery charge lifetime.

**Table 4: Power Connector Pinout (CN1)**

| Pin | Signal    |
|-----|-----------|
| 1   | Battery + |
| 2   | Battery - |

## 2.4 Serial Ports

The CutiPy is equipped with four serial ports. One RS-232 terminates to a 10-pin header connector (UART2), one RS-232/422/485 terminating to another 10-pin header connector (UART3), and two TTL accessed through Utility I/O header 2 (HDR2).

- The RS-232 serial port (UART2) terminates to a 10-pin header connector located at HDR10. The RS-232 Transceiver (U6) limits the maximum throughput to 250 kb/s. The transceiver can be placed in standby mode by holding GPIO PE1 low. In standby mode the transceiver will typically draw 1μA. When the device is powered down, the receivers remain active and the drivers are placed in a high-impedance state.
- RS-232/422/485 (software-configurable) serial port (UART3) terminates to a 10-pin header located at HDR5. By default, the RS-232 transceiver (U10) and the RS-422/485 transceiver (U9) are in standby mode. In standby mode, the RS-232 transceiver typically draws 1μA and the RS-422/485 transceiver typically draws 0.1μA. Both devices' driver and receiver output(s) will be high-impedance while in standby mode. To configure RS-232 mode, PE2 should be held high. The maximum throughput for RS-232 is 250 Kb/s. To configure RS-422/485 mode, PF11 should be held high and the maximum throughput in this mode is 2.62Mb/s (Oversampling by 16) and 5.25 Mb/s (Oversampling by 8). When in RS422/485 mode there a software programmable Terminating Resistor that can be activated by asserting PF0 high.

- The TTL serial ports (UARTs 1 & 6) terminates to Utility I/O header 2 (HDR2). UART1 provides for bidirectional communication offering Tx and Rx lines with a maximum bit rate of 10.5 Mb/s. UART6 provides for bidirectional communication offering Tx, Rx, CTS, RTS, and CK lines with Synchronous Mode and Hardware Flow Control Mode. The maximum bit rate for this is 10.5Mb/s. These also support LIN, Smartcard Protocol, and IrDA.

**Table 5: Serial Port-UART2 (HDR10)**

| Pin | 10-Pin Header: Description |
|-----|----------------------------|
| 1   | NC                         |
| 2   | NC                         |
| 3   | RXD                        |
| 4   | RTS                        |
| 5   | TXD                        |
| 6   | CTS                        |
| 7   | NC                         |
| 8   | NC                         |
| 9   | GND                        |
| 10  | NC                         |

**Table 6: Serial Port-UART3 (HDR5)**

| Pin | 10-Pin Header: Description<br>(RS-232) | 10-Pin Header Description<br>(RS-485/422) |
|-----|----------------------------------------|-------------------------------------------|
| 1   | NC                                     | TX-                                       |
| 2   | NC                                     | NC                                        |
| 3   | RXD                                    | TX+                                       |
| 4   | RTS                                    | NC                                        |
| 5   | TXD                                    | RX+                                       |
| 6   | CTS                                    | NC                                        |
| 7   | NC                                     | RX-                                       |
| 8   | NC                                     | NC                                        |
| 9   | GND                                    | GND                                       |
| 10  | NC                                     | NC                                        |

**Table 7: Serial Port-UART1 & UART6 TTL (HDR2)**

| Pin | Utility I/O 2 Pinout |
|-----|----------------------|
| 38  | USART1_TXD_3V        |
| 39  | USART1_RXD_3V        |
| 40  | USART6_CLK_3V        |
| 41  | USART6_TXD_3V        |
| 42  | USART6_RXD_3V        |
| 43  | USART6_CTS_3V        |
| 44  | USART6_RTS_3V        |

## 2.5 USB Ports

The CutiPy provides for two USB 2.0 ports. The STM32 features one OTG FS core, one OTG HS core, and one OTG FS PHY where only 1 core can utilize the internal OTG FS PHY at a time. If both USB interfaces are to be utilized, an external PHY will need to be implemented. Additionally, the HS mode will require an external HS PHY connected to the STM32's ULPI interface.

One port is a USB 2.0 Full-Speed (FS) Device and can be accessed via an USB-C connector located at JK1. This USB Full-Speed port supports 12Mb/s transfers in device mode.

The second port is a USB 2.0 High-Speed (HS) OTG Port which can also be used as a Full Speed OTG Port and is accessed through the Utility I/O Header 1 located at HDR1. To use the HS USB as a Full-Speed Port all that is required is the connection of a USB Connector to pins 45 – 48 (see below). However, to use the HS USB as High-Speed Port an external HS USB PHY is required as well as a USB Connector. This port could be used as OTG (Device or Host), but would require external VBUS switch circuitry. Both USB Ports support the Sessions Request Protocol (SRP) and soft disconnect features.

The Table below calls out the necessary connections for the USB\_HS\_OTG Port.

**Table 8: USB HS Port Pin Assignments (HDR1 & HDR2)**

| Pin                   | CutiPy Pin Name                     | USB ULPI Pin Name |
|-----------------------|-------------------------------------|-------------------|
| <b>HDR2: 34 or 15</b> | ADC123_IN12 (PC2)                   | OTG_HS_ULPI_DIR   |
| <b>HDR2: 16 or 24</b> | ADC123_IN13 (PC3) or I2C2_SCL (PH4) | OTG_HS_ULPI_NXT   |
| <b>HDR2: 14</b>       | ADC123_IN10 (PC0)                   | OTG_HS_ULPI_STP   |
| <b>HDR2: 21</b>       | DAC_OUT2 (PA5)                      | OTG_HS_ULPI_CK    |
| <b>HDR2: 7</b>        | ADC123_IN3 (PA3)                    | OTG_HS_ULPI_D0    |
| <b>HDR2: 18</b>       | ADC12_IN8 (PB0)                     | OTG_HS_ULPI_D1    |
| <b>HDR2: 19</b>       | ADC12_IN9 (PB1)                     | OTG_HS_ULPI_D2    |
| <b>HDR1: 16</b>       | TIM2_CH3 (PB10)                     | OTG_HS_ULPI_D3    |
| <b>HDR1: 17</b>       | TIM2_CH4 (PB11)                     | OTG_HS_ULPI_D4    |
| <b>HDR2: 32</b>       | SPI-1_MOSI (PB5)                    | OTG_HS_ULPI_D7    |
| <b>HDR1: 45</b>       | CAN2_RX (PB12)                      | OTG_HS_ULPI_D5    |
| <b>HDR1: 46</b>       | CAN2_TX (PB13)                      | OTG_HS_ULPI_D6    |
| <b>HDR1: 47</b>       | USB_OTG_HS_D_N (PB14)               | *OTG_HS_DM        |
| <b>HDR1: 48</b>       | USB_OTG_HS_D_P (PB15)               | *OTG_HS_DP        |

\* indicates Full-Speed lines

## 2.6 MicroSD Card Socket

The CutiPy provides a high capacity MicroSD socket. This socket is hot-swappable and can accept a wide variety of Flash Cards. A card that is written to by the CutiPy can be read by another computer using a MicroSD card reader. The MicroSD interface is compatible with Standard and High Capacity MicroSD cards.

## 2.7 LCD (Optional)

The CutiPy can be equipped with an LCD that includes 4x user pushbuttons and LEDs on the top side of the board. The LCD is a 128x32 pixel Graphic Newhaven Display Intl NHD-C12832A1Z-FSW-FBW-3V3 with 4-Line SPI MCU interfaces.

## 2.8 CAN Port

The CutiPy provides a CAN 2.0B port utilizing the TI TCAN334GDCNT Transceiver chip. The CAN port is accessible via a 3-pin header located at HDR4 (TE Connectivity PN 640456-3). Jumper JB4 should be placed in the TRM position to Terminate the CAN network if the Node exists at either network endpoint. In standby mode, the transceiver will typically draw ~17.5µA. During standby mode, the CAN driver and main receiver are turned off and bi-directional CAN communication is not possible. The low power receiver and bus monitor are enabled to allow for RXD Wake Requests via the CAN bus. MCU pin PG4 should be set High to enable standby mode while PG3 should be set High to enable shutdown mode. Setting the same pins Low will disable the low power mode for the CAN transceiver chip. In MicroPython, the standby mode is disabled/enabled automatically by initializing/de-initializing the CAN class. MicroPython CAN instructions can be found in the Software Section in this manual.

**Table 9: Pinout for the CAN-1 2.0 Port (HDR4)**

| Pin | Signal  |
|-----|---------|
| 1   | CAN1_HI |
| 2   | CAN1_LO |
| 3   | GND     |

## 2.9 Real-Time Clock

The CutiPy is equipped with a battery-backed (B1) Real Time Clock (RTC) located in the STM32 microcontroller. Jumper JB3 should be placed in the ON position at HDR8 in order to retain system time when powered down.

## 2.10 Temperature Sensors

The CutiPy is equipped with an internal temperature sensor located in the STM32 microcontroller that can be used to measure the ambient temperature of the device. ADC1\_IN16 channel is used to convert the sensor output voltage to a digital value.

An external on-board Temperature Sensor (ADT7410TRZ) is also provided and can be accessed at I2C address 0x4B on I2C port I2C2.

### 2.11 Reset

The CutiPy is equipped with a reset button located at PB5. Pressing this button will cause the system to reset.

### 2.12 Wireless (Optional)

The CutiPy, Silicon Labs RS9116 Wireless Radio Module, provides both an internal on-board antenna and an external antenna provision. This module by default utilizes the on-board chip antenna but offers a U.FL connector for external antenna connection with a Software option to select either Antenna option. EMAC can provide an antenna kit that plugs into the chip's antenna U.FL jack.

The Silicon Labs Wireless Module offers high throughput and extended range along with Wi-Fi and Bluetooth (BT) coexistence in a power-optimized design.

The BT Radio is connected to UART1 and utilizes CTS and RTS Handshake lines. The Wi-Fi Radio is connected to SPI2 and utilizes PIO as the Chip Select line. Radio Wakeup uses PG10 and Radio IRQ is PG12.

Some of the features include:

Wi-Fi:

- Compliant to single-spatial stream IEEE 802.11 b/g/n, 802.11j with single band support
- Support for 20 MHz and 40 MHz channel bandwidths
- Operating Frequency Range: 2412 MHz - 2484 MHz
- Transmit power up to +20dBm with integrated PA
- Receive sensitivity as low as -97 dBm

Bluetooth:

- Compliant to dual-mode Bluetooth 5
- Operating Frequency Range: 2.402 GHz - 2.480 GHz
- Receive sensitivity as low as -104 dBm

RF Features:

- Integrated baseband processor with calibration memory, RF transceiver, high-power amplifier, balun and T/R switch
- Integrated Antenna and u.FL connector

## 2.13 I/O Expansion

The CutiPy provides access to a number of I/O lines on connectors HDR1 and HDR2. The 50-pin dual row headers contain GPIO lines, USB, UART, SPI bus, I<sup>2</sup>C bus, CAN bus, A/D lines, interrupts, high drive outputs, and power pins. The tables below list the pinouts, MCU pin designations, and the corresponding signals for both I/O headers.

**Table 10: I/O Header (HDR1)**

| Pin# | Signal     | MCU Pin Name | MCU Pin Number | Pin# | Signal     | MCU Pin Name | MCU Pin Number |
|------|------------|--------------|----------------|------|------------|--------------|----------------|
| 1    | GND        | N/A          | N/A            | 2    | GND        | N/A          | N/A            |
| 3    | 3P3_VCC    | N/A          | N/A            | 4    | 5V_JACK    | N/A          | N/A            |
| 5    | 12V_VIN    | N/A          | N/A            | 6    | V_HIDRV    | N/A          | N/A            |
| 7    | TIM1_ETR   | PE7          | R8             | 8    | TIM1_CH1N  | PE8          | P8             |
| 9    | TIM1_CH1   | PE9          | P9             | 10   | TIM1_CH2N  | PE10         | R9             |
| 11   | TIM1_CH2   | PE11         | P10            | 12   | TIM1_CH3N  | PE12         | R10            |
| 13   | TIM1_CH3   | PE13         | N11            | 14   | TIM1_CH4   | PE14         | P11            |
| 15   | TIM1_BKIN  | PE15         | R11            | 16   | TIM2_CH3   | PB10         | R12            |
| 17   | TIM2_CH4   | PB11         | R13            | 18   | TIM3_CH2   | PC7          | G15            |
| 19   | TIM4_CH2   | PD13         | M15            | 20   | TIM4_ETR   | PE0          | A4             |
| 21   | TIM4_CH3   | PD14         | M14            | 22   | GND        | N/A          | N/A            |
| 23   | TIM5_CH1   | PH10         | L13            | 24   | TIM4_CH4   | PD15         | L14            |
| 25   | TIM5_CH3   | PH12         | K12            | 26   | TIM5_CH2   | PH11         | L12            |
| 27   | TIM8_CH3N  | PH15         | D13            | 28   | TIM8_CH2N  | PH14         | E13            |
| 29   | TIM8_CH1   | PI5          | C4             | 30   | TIM8_BKIN  | PI4          | D4             |
| 31   | TIM8_CH3   | PI7          | C2             | 32   | TIM8_CH2   | PI6          | C3             |
| 33*  | HD_GPIO_A1 | GPIO_A1      | U16-16         | 34*  | HD_GPIO_A0 | GPIO_A0      | U16-15         |
| 35*  | HD_GPIO_A3 | GPIO_A3      | U16-18         | 36*  | HD_GPIO_A2 | GPIO_A2      | U16-17         |
| 37*  | HD_GPIO_A5 | GPIO_A5      | U16-20         | 38*  | HD_GPIO_A4 | GPIO_A4      | U16-19         |
| 39*  | HD_GPIO_A7 | GPIO_A7      | U16-22         | 40*  | HD_GPIO_A6 | GPIO_A6      | U16-21         |
| 41   | GPIO_B0    | GPIO_B0      | U16-24         | 42   | GPIO_B1    | GPIO_B1      | U16-1          |
| 43   | GPIO_B2    | GPIO_B2      | U16-2          | 44   | GPIO_B3    | GPIO_B3      | U16-3          |
| 45   | CAN2_RX    | PB12         | P12            | 46   | CAN2_TX    | PB13         | P13            |
| 47   | USB_HS_D_N | PB14         | R14            | 48   | USB_HS_D_P | PB15         | R15            |
| 49   | GND        | N/A          | N/A            | 50   | GND        | N/A          | N/A            |

\*High drive outputs. A GPIO Expander (MCP23018T) signal feeds the high drive open collector darlington driver, which in turn outputs to the indicated header Pin#.

**Table 11: I/O Connector (HDR2)**

| Pin# | Signal      | MCU Pin Name | MCU Pin Number | Pin# | Signal      | MCU Pin Name | MCU Pin Number |
|------|-------------|--------------|----------------|------|-------------|--------------|----------------|
| 1    | GND         | N/A          | N/A            | 2    | GND         | N/A          | N/A            |
| 3    | 3P3_VIN     | N/A          | N/A            | 4    | 5V_JACK     | N/A          | N/A            |
| 5    | 12V_IN      | N/A          | N/A            | 6    | 12V_IN      | N/A          | N/A            |
| 7    | ADC123_IN3  | PA3          | R2             | 8    | ADC3_IN4    | PF6          | K2             |
| 9    | ADC3_IN5    | PF7          | K1             | 10   | ADC3_IN6    | PF8          | L3             |
| 11   | ADC3_IN7    | PF9          | L2             | 12   | ADC3_IN8    | PF10         | L1             |
| 13   | ADC3_IN9    | PF3          | J2             | 14   | ADC123_IN10 | PC0          | M2             |
| 15   | ADC123_IN12 | PC2          | M4             | 16   | ADC123_IN13 | PC3          | M5             |
| 17   | ADC12_IN6   | PA6          | P3             | 18   | ADC12_IN8   | PB0          | R5             |
| 19   | ADC12_IN9   | PB1          | R4             | 20   | DAC_OUT1    | PA4          | N4             |
| 21   | DAC_OUT2    | PA5          | P4             | 22   | GND         | N/A          | N/A            |
| 23   | AVDD        | N/A          | R1             | 24   | I2C2_SCL    | PH4          | H4             |
| 25   | I2C2_SDA    | PH5          | J4             | 26   | I2C2_SMBA   | PH6          | M11            |
| 27   | I2C3_SCL    | PH7          | N12            | 28   | I2C3_SDA    | PH8          | M12            |
| 29   | I2C3_SMBA   | PH9          | M13            | 30   | SPI-1_SCK   | PB3          | A10            |
| 31   | SPI-1_MISO  | PB4          | A9             | 32   | SPI-1_MOSI  | PB5          | A6             |
| 33   | SPI-1_NSS   | PA15         | A13            | 34   | GPIO_B4     | GPIO_B4      | U16-4          |
| 35   | GPIO_B5     | GPIO_B5      | U16-5          | 36   | GPIO_B6     | GPIO_B6      | U16-6          |
| 37   | GPIO_B7     | GPIO_B7      | U16-7          | 38   | USART1_TX   | PB6          | B6             |
| 39   | USART1_RX   | PB7          | B5             | 40   | USART6_CK   | PG7          | J14            |
| 41   | MDM_TXD_3V  | PC6          | H15            | 42   | MDM_RXD_3V  | PG9          | C10            |
| 43   | MDM_CTS_3V  | PG15         | B7             | 44   | MDM_RTS_3V  | PG8          | H14            |
| 45   | PH13        | PH13         | E12            | 46   | PI9         | PI9          | D3             |
| 47   | WKUP        | PA0          | N3             | 48   | RTC_TAMP/TS | PI8          | D2             |
| 49   | GND         | N/A          | N/A            | 50   | GND         | N/A          | N/A            |

## 2.14 I2C

The CutiPy provides for two I2C hardware ports located on I/O header 2 (HDR2). Both can support a bit rate up to 100 kb/s (Standard mode) and 400 kb/s (Fast mode) with 7/10 bit addressing mode and a 7-bit addressing mode (as slave). By default, the I2C interface operates in Slave mode.

**Table 12: I2C (HDR2)**

| Pin# | Port Line | Description                             |
|------|-----------|-----------------------------------------|
| 24   | I2C2_SCL  | I2C2 Clock signal                       |
| 25   | I2C2_SDA  | I2C2 Data signal                        |
| 26   | I2C2_SMBA | I2C2 System Management Bus Alert signal |
| 27   | I2C3_SCL  | I2C3 Clock signal                       |
| 28   | I2C3_SDA  | I2C3 Data signal                        |
| 29   | I2C3_SMBA | I2C3 System Management Bus Alert signal |

## 2.15 SPI

The CutiPy is equipped with one Serial Peripheral Interface bus communicating up to 42 Mbits/s. This provides for half/full duplex synchronous transfers with external devices with an 8 or 16-bit transfer frame format selection.

**Table 13: Serial Peripheral Interface SPI-1 (HDR2)**

| Pin# | Port Line  | Description               |
|------|------------|---------------------------|
| 30   | SPI-1_SCK  | SPI 1 Serial Clock        |
| 31   | SPI-1_MISO | SPI 1 Master In Slave Out |
| 32   | SPI-1_MOSI | SPI 1 Master Out Slave In |
| 33   | SPI-1_NSS  | SPI 1 Slave Select        |

## 2.16 Analog to Digital Converter

The CutiPy has 13 A/D input channels with 3 unique A/Ds available on the Utility I/O header 2 (HDR2). Voltages applied to the inputs must be in the range of 0 - 3.3V with reference to ground. For additional information please reference the STM32F407IGH6 User Manual. See Table 11 in the I/O Expansion section for pinout details.

## 2.17 Digital to Analog Converter

The CutiPy comes equipped with 2 D/A converters. These converters run directly from the ST Processor and are routed to Utility header 2 (HDR2). The output of the converters is 0 to 3.3V depending on digital count written to the D/A converter. For additional information please reference the STM32F407IGH6 User Manual. See Table 11 in the I/O Expansion section for pinout details.

## 2.18 Timers/Counters

The CutiPy is equipped with 25 timers and counters and are located on Utility I/O header 1 (HDR1). TIM1 and TIM8 are advanced control timers that are 16-bit auto-reload counter driven by a programmable prescaler. TIM2 - TIM5 are general purpose timers that consist of 16-bit or 32-bit auto reload counter driven by a programmable prescaler. These timers can be used for generating output waveforms or for measuring pulse lengths of input signals and are completely independent and do not share any resources. See Table 10 in the I/O expansion section for pinout details.

## 2.19 JTAG/SWD

The CutiPy provides for JTAG/SWD capabilities through the STM32 MCU. A 10-pin male connector located at HDR6 provides access to the JTAG/SWD lines which is an Amphenol GRPB052VWVN-RC. This connection will allow the ability to program and debug software.

**Table 14: JTAG/SWD (HDR6)**

| Pin# | Signal  | Description                   | MCU Pin Name | MCU Pin Number |
|------|---------|-------------------------------|--------------|----------------|
| 1    | 3P3_VCC | 3.3 Volts                     | N/A          | N/A            |
| 2    | SWDIO   | Serial Wire Data Input/Output | PA13         | A15            |
| 3    | GND     | Ground                        | N/A          | N/A            |
| 4    | SWDCLK  | Serial Wire Clock             | PA14         | A14            |
| 5    | GND     | Ground                        | N/A          | N/A            |
| 6    | SWO     | Serial Wire Output            | PB3          | A10            |
| 7    | GND     | Ground                        | N/A          | N/A            |
| 8    | TDI     | JTAG Test Data Input          | PA15         | A13            |
| 9    | GND     | Ground                        | N/A          | N/A            |
| 10   | nRESET  | JTAG Test nReset              | NRST         | J1             |

### 3 Software

The CutiPy offers the ability to use different operating systems to meet different customer needs. There are available board support packages for the CutiPy from EMAC that uses MicroPython and FreeRTOS. EMAC provides a fully functional MicroPython and FreeRTOS BSPs loaded on the CutiPy at no additional charge. Middleware has been added to compliment the already available middleware supplied by the developers at STM to make these packages available for easy integration into user developed applications targeted for the CutiPy.

For more information on software support, please visit the EMAC Wiki CutiPy Section at:

[http://wiki.emacinc.com/wiki/Cutipy\\_Getting\\_Started](http://wiki.emacinc.com/wiki/Cutipy_Getting_Started)

#### 3.1 MicroPython

MicroPython is one of the packages that is offered for the CutiPy. It is an implementation of the Python 3 programming language optimized to run on microcontrollers in a constrained environment. The CutiPy can be preloaded with the MicroPython BSP at no charge.

For more information on MicroPython support, please visit the EMAC Wiki MicroPython Section at:

<http://wiki.emacinc.com/wiki/Micropython>

##### 3.1.1 Mu IDE

EMAC utilizes the Mu IDE for the MicroPython development which is a simple Python editor that is quick and easy to learn. The minimal setup makes it easy to use so the user can jump right in to developing. It has a built in REPL (Read Evaluate Print Loop) console window for easy command input and debugging.

<https://codewith.mu/en/>

#### 3.2 FreeRTOS

FreeRTOS is one of the many packages available for application development that can be included when using the STM32CubeIDE code generation tool. Optionally, the FreeRTOS package can be downloaded from <https://www.freertos.org/>. FreeRTOS has their own board support package for many of the available STM32 development platforms. When using the STM32CubeIDE code generator, a wrapper is provided for most of the FreeRTOS functionality to make development even more simple.

[https://www.freertos.org/FreeRTOS-Plus/BSP\\_Solutions/ST/index.html](https://www.freertos.org/FreeRTOS-Plus/BSP_Solutions/ST/index.html)

Amazon provides Amazon Web Services (AWS) cloud support for FreeRTOS. For further information go to: <https://aws.amazon.com/freertos/getting-started/>

### 3.2.1 STM32CubeIDE

EMAC utilizes the STM32CubeIDE all-in-one multi OS development tool which is an advanced C/C++ development platform with IP configuration, code generation, code compilation, and debug features for STM32 microcontrollers. The STM32CubeIDE integrates all STM32CubeMX functionalities to offer an all-in-one tool experience while saving installation and development time. The CutiPy board support package includes the STM32CubeIDE project that can be used to tailor the FreeRTOS build to the customer's exact needs.

<https://www.st.com/en/development-tools/stm32cubeide.html>

#### 3.2.1.1 STM32CubeMX

The STM32CubeMX is used to configure the processor for the CutiPy board. This tool allows for the configuration of all processor pins as well as adding, removing, and configuring middleware packages that are available through the STM32CubeMX code generation tool. One of the benefits of using the code generation tool is that it will automatically pull in and use the most current software updates from the upstream repository. Some of the middleware packages that are available and are supported by the CutiPy are as follows;

- FatFS
- FreeRTOS
- LwIP
- MBEDTLS
- USB Device
- USB Host
- Silicon Labs APIs

<http://www.st.com/en/development-tools/stm32cubemx.html>

#### 3.2.1.2 STM32CubeMX Expansion Software

Additional software and expansion packs are available through STMicro for use with the STM32CubeMX code generation utility. Software expansion packs may need to be tailored specifically to work with the CutiPy board, however, they are a useful starting point for incorporating various sensors and peripherals to the CutiPy board.

<http://www.st.com/en/ecosystems/stm32cube-expansion-software.html?querycriteria=productId=SC2005>

## 4 Appendix A: Connector Pinouts

### 4.1 Main Battery Connector (CN1)

| Pin | Signal    |
|-----|-----------|
| 1   | BATT_VOLT |
| 2   | GND       |

### 4.2 Serial Port UART2 (HDR10)

| Pin | 10-Pin Header: Description |
|-----|----------------------------|
| 1   | NC                         |
| 2   | NC                         |
| 3   | RXD                        |
| 4   | RTS                        |
| 5   | TXD                        |
| 6   | CTS                        |
| 7   | NC                         |
| 8   | NC                         |
| 9   | GND                        |
| 10  | NC                         |

### 4.3 I/O Header 1 (HDR1)

| Pin# | Signal     | MCU Pin Name | MCU Pin Number | Pin# | Signal     | MCU Pin Name | MCU Pin Number |
|------|------------|--------------|----------------|------|------------|--------------|----------------|
| 1    | GND        | N/A          | N/A            | 2    | GND        | N/A          | N/A            |
| 3    | 3P3_VCC    | N/A          | N/A            | 4    | 5V_JACK    | N/A          | N/A            |
| 5    | 12V_VIN    | N/A          | N/A            | 6    | V_HIDRV    | N/A          | N/A            |
| 7    | TIM1_ETR   | PE7          | R8             | 8    | TIM1_CH1N  | PE8          | P8             |
| 9    | TIM1_CH1   | PE9          | P9             | 10   | TIM1_CH2N  | PE10         | R9             |
| 11   | TIM1_CH2   | PE11         | P10            | 12   | TIM1_CH3N  | PE12         | R10            |
| 13   | TIM1_CH3   | PE13         | N11            | 14   | TIM1_CH4   | PE14         | P11            |
| 15   | TIM1_BKIN  | PE15         | R11            | 16   | TIM2_CH3   | PB10         | R12            |
| 17   | TIM2_CH4   | PB11         | R13            | 18   | TIM3_CH2   | PC7          | G15            |
| 19   | TIM4_CH2   | PD13         | M15            | 20   | TIM4_ETR   | PE0          | A4             |
| 21   | TIM4_CH3   | PD14         | M14            | 22   | GND        | N/A          | N/A            |
| 23   | TIM5_CH1   | PH10         | L13            | 24   | TIM4_CH4   | PD15         | L14            |
| 25   | TIM5_CH3   | PH12         | K12            | 26   | TIM5_CH2   | PH11         | L12            |
| 27   | TIM8_CH3N  | PH15         | D13            | 28   | TIM8_CH2N  | PH14         | E13            |
| 29   | TIM8_CH1   | PI5          | C4             | 30   | TIM8_BKIN  | PI4          | D4             |
| 31   | TIM8_CH3   | PI7          | C2             | 32   | TIM8_CH2   | PI6          | C3             |
| 33*  | HD_GPIO_A1 | GPIO_A1      | U16-16         | 34*  | HD_GPIO_A0 | GPIO_A0      | U16-15         |

|            |            |         |        |            |            |         |        |
|------------|------------|---------|--------|------------|------------|---------|--------|
| <b>35*</b> | HD_GPIO_A3 | GPIO_A3 | U16-18 | <b>36*</b> | HD_GPIO_A2 | GPIO_A2 | U16-17 |
| <b>37*</b> | HD_GPIO_A5 | GPIO_A5 | U16-20 | <b>38*</b> | HD_GPIO_A4 | GPIO_A4 | U16-19 |
| <b>39*</b> | HD_GPIO_A7 | GPIO_A7 | U16-22 | <b>40*</b> | HD_GPIO_A6 | GPIO_A6 | U16-21 |
| <b>41</b>  | GPIO_B0    | GPIO_B0 | U16-24 | <b>42</b>  | GPIO_B1    | GPIO_B1 | U16-1  |
| <b>43</b>  | GPIO_B2    | GPIO_B2 | U16-2  | <b>44</b>  | GPIO_B3    | GPIO_B3 | U16-3  |
| <b>45</b>  | CAN2_RX    | PB12    | P12    | <b>46</b>  | CAN2_TX    | PB13    | P13    |
| <b>47</b>  | USB_HS_D_N | PB14    | R14    | <b>48</b>  | USB_HS_D_P | PB15    | R15    |
| <b>49</b>  | GND        | N/A     | N/A    | <b>50</b>  | GND        | N/A     | N/A    |

*\*High drive outputs. A GPIO Expander (MCP23018T) signal feeds the high drive open collector darlington driver, which in turn outputs to the indicated header Pin#.*

#### 4.4 I/O Header 2 (HDR2)

| Pin#      | Signal      | MCU Pin Name | MCU Pin Number | Pin#      | Signal      | MCU Pin Name | MCU Pin Number |
|-----------|-------------|--------------|----------------|-----------|-------------|--------------|----------------|
| <b>1</b>  | GND         | N/A          | N/A            | <b>2</b>  | GND         | N/A          | N/A            |
| <b>3</b>  | 3P3_VIN     | N/A          | N/A            | <b>4</b>  | 5V_JACK     | N/A          | N/A            |
| <b>5</b>  | 12V_IN      | N/A          | N/A            | <b>6</b>  | 12V_IN      | N/A          | N/A            |
| <b>7</b>  | ADC123_IN3  | PA3          | R2             | <b>8</b>  | ADC3_IN4    | PF6          | K2             |
| <b>9</b>  | ADC3_IN5    | PF7          | K1             | <b>10</b> | ADC3_IN6    | PF8          | L3             |
| <b>11</b> | ADC3_IN7    | PF9          | L2             | <b>12</b> | ADC3_IN8    | PF10         | L1             |
| <b>13</b> | ADC3_IN9    | PF3          | J2             | <b>14</b> | ADC123_IN10 | PC0          | M2             |
| <b>15</b> | ADC123_IN12 | PC2          | M4             | <b>16</b> | ADC123_IN13 | PC3          | M5             |
| <b>17</b> | ADC12_IN6   | PA6          | P3             | <b>18</b> | ADC12_IN8   | PB0          | R5             |
| <b>19</b> | ADC12_IN9   | PB1          | R4             | <b>20</b> | DAC_OUT1    | PA4          | N4             |
| <b>21</b> | DAC_OUT2    | PA5          | P4             | <b>22</b> | GND         | N/A          | N/A            |
| <b>23</b> | AVDD        | N/A          | R1             | <b>24</b> | I2C2_SCL    | PH4          | H4             |
| <b>25</b> | I2C2_SDA    | PH5          | J4             | <b>26</b> | I2C2_SMBA   | PH6          | M11            |
| <b>27</b> | I2C3_SCL    | PH7          | N12            | <b>28</b> | I2C3_SDA    | PH8          | M12            |
| <b>29</b> | I2C3_SMBA   | PH9          | M13            | <b>30</b> | SPI-1_SCK   | PB3          | A10            |
| <b>31</b> | SPI-1_MISO  | PB4          | A9             | <b>32</b> | SPI-1_MOSI  | PB5          | A6             |
| <b>33</b> | SPI-1_NSS   | PA15         | A13            | <b>34</b> | GPIO_B4     | GPIO_B4      | U16-4          |
| <b>35</b> | GPIO_B5     | GPIO_B5      | U16-5          | <b>36</b> | GPIO_B6     | GPIO_B6      | U16-6          |
| <b>37</b> | GPIO_B7     | GPIO_B7      | U16-7          | <b>38</b> | USART1_TX   | PB6          | B6             |
| <b>39</b> | USART1_RX   | PB7          | B5             | <b>40</b> | USART6_CK   | PG7          | J14            |
| <b>41</b> | MDM_TXD_3V  | PC6          | H15            | <b>42</b> | MDM_RXD_3V  | PG9          | C10            |
| <b>43</b> | MDM_CTS_3V  | PG15         | B7             | <b>44</b> | MDM_RTS_3V  | PG8          | H14            |
| <b>45</b> | PH13        | PH13         | E12            | <b>46</b> | PI9         | PI9          | D3             |
| <b>47</b> | WKUP        | PA0          | N3             | <b>48</b> | RTC_TAMP/TS | PI8          | D2             |
| <b>49</b> | GND         | N/A          | N/A            | <b>50</b> | GND         | N/A          | N/A            |

## 4.5 Vin Power Header (HDR3)

| Pin | Signal    |
|-----|-----------|
| 1   | +Vin ~12V |
| 2   | GND       |
| 3   | GND       |
| 4   | +Vin 5V   |

## 4.6 CAN 2.0 Port (HDR4)

| Pin | Signal  |
|-----|---------|
| 1   | CAN1_HI |
| 2   | CAN1_LO |
| 3   | GND     |

## 4.7 Serial Port UART3 (HDR5)

| Pin | 10-Pin Header: Description<br>(RS-232) | 10-Pin Header Description<br>(RS-485/422) |
|-----|----------------------------------------|-------------------------------------------|
| 1   | NC                                     | TX-                                       |
| 2   | NC                                     | NC                                        |
| 3   | RXD                                    | TX+                                       |
| 4   | RTS                                    | NC                                        |
| 5   | TXD                                    | RX+                                       |
| 6   | CTS                                    | NC                                        |
| 7   | NC                                     | RX-                                       |
| 8   | NC                                     | NC                                        |
| 9   | GND                                    | GND                                       |
| 10  | NC                                     | NC                                        |

## 4.8 JTAG/SWD Header (HDR6)

| Pin# | Signal  | Description                   | MCU Pin Name | MCU Pin Number |
|------|---------|-------------------------------|--------------|----------------|
| 1    | 3P3_VCC | 3.3 Volts                     | N/A          | N/A            |
| 2    | SWDIO   | Serial Wire Data Input/Output | PA13         | A15            |
| 3    | GND     | Ground                        | N/A          | N/A            |
| 4    | SWDCLK  | Serial Wire Clock             | PA14         | A14            |
| 5    | GND     | Ground                        | N/A          | N/A            |
| 6    | SWO     | Serial Wire Output            | PB3          | A10            |
| 7    | GND     | Ground                        | N/A          | N/A            |
| 8    | TDI     | JTAG Test Data Input          | PA15         | A13            |
| 9    | GND     | Ground                        | N/A          | N/A            |
| 10   | nRESET  | JTAG Test nReset              | NRST         | J1             |

#### 4.9 MicroSD Card Socket (SOK1)

| Pin | Signal   | MCU Pin Number | MCU Pin Name |
|-----|----------|----------------|--------------|
| 1   | SDIO_D2  | B14            | PC10         |
| 2   | SDIO_D3  | B13            | PC11         |
| 3   | SDIO_CMD | D12            | PD2          |
| 4   | 3P3_VCC  | N/A            | N/A          |
| 5   | SDIO_CLK | A12            | PC12         |
| 6   | GND      | N/A            | N/A          |
| 7   | SDIO_D0  | G14            | PC8          |
| 8   | SDIO_D1  | F14            | PC9          |
| 9   | CARD_DET | D1             | PC13         |
| 10  | GND      | N/A            | N/A          |

## 5 Appendix B: Microcontroller Unit Pinout

### 5.1 STM32F407IGH6 – MCU Pinout (U3)

| MCU Pin#   | MCU Pin Name        | Signal          | MCU Pin#   | MCU Pin Name          | Signal          |
|------------|---------------------|-----------------|------------|-----------------------|-----------------|
| <b>D6</b>  | BOOT0               | BOOT0           | <b>M3</b>  | PC1                   | LCD_Csn         |
| <b>L4</b>  | BYPASS_REG          | Strapped to GND | <b>B14</b> | PC10                  | SDIO_D2         |
| <b>J1</b>  | NRST                | nRESET          | <b>B13</b> | PC11                  | SDIO_D3         |
| <b>N3</b>  | PA0/WKUP (PA0)      | WKUP            | <b>A12</b> | PC12                  | SDIO_CLK        |
| <b>N2</b>  | PA1                 | BATT_SENV+      | <b>D1</b>  | PC13                  | CARD_DET        |
| <b>D15</b> | PA10                | USB_FS_ID       | <b>E1</b>  | PC14/OSC32_IN (PC14)  | E1 (Ext_OSC32)  |
| <b>C15</b> | PA11                | USB_FS_D_N      | <b>F1</b>  | PC15/OSC32_OUT (PC15) | F1 (Ext_OSC32)  |
| <b>B15</b> | PA12                | USB_FS_D_P      | <b>M4</b>  | PC2                   | ADC123_IN12     |
| <b>A15</b> | PA13 (JTMS-SWDIO)   | SWDIO           | <b>M5</b>  | PC3                   | ADC123_IN13     |
| <b>A14</b> | PA14 (JTCK/SWCLK)   | SWDCLK          | <b>N5</b>  | PC4                   | LCD_A0          |
| <b>A13</b> | PA15 (JTDI)         | TDI/SPI-1_NSS   | <b>P5</b>  | PC5                   | LCD_RSTn        |
| <b>P2</b>  | PA2                 | BAT_SENV-       | <b>H15</b> | PC6                   | MDM_TXD_3V      |
| <b>R2</b>  | PA3                 | ADC123_IN3      | <b>G15</b> | PC7                   | TIM3_CH2        |
| <b>N4</b>  | PA4                 | DAC_OUT1        | <b>G14</b> | PC8                   | SDIO_D0         |
| <b>P4</b>  | PA5                 | DAC_OUT2        | <b>F14</b> | PC9                   | SDIO_D1         |
| <b>P3</b>  | PA6                 | ADC12_IN6       | <b>B12</b> | PD0                   | CAN1_RX         |
| <b>R3</b>  | PA7                 | USR_PB1         | <b>C12</b> | PD1                   | CAN1_TX         |
| <b>F15</b> | PA8                 | USR_PB2         | <b>N15</b> | PD10                  | PB4_LEDKn       |
| <b>E15</b> | PA9                 | VBUS_SENSE      | <b>N14</b> | PD11                  | COMB_CTS        |
| <b>R5</b>  | PB0                 | ADC12_IN8       | <b>N13</b> | PD12                  | COMB_RTS        |
| <b>R4</b>  | PB1                 | ADC12_IN9       | <b>M15</b> | PD13                  | TIM4_CH2        |
| <b>R12</b> | PB10                | TIM2_CH3        | <b>M14</b> | PD14                  | TIM4_CH3        |
| <b>R13</b> | PB11                | TIM2_CH4        | <b>L14</b> | PD15                  | TIM4_CH4        |
| <b>P12</b> | PB12                | CAN2_RX         | <b>D12</b> | PD2                   | SDIO_CMD        |
| <b>P13</b> | PB13                | CAN2_TX         | <b>D11</b> | PD3                   | COMA_CTS        |
| <b>R14</b> | PB14                | USB_HS_D_N      | <b>D10</b> | PD4                   | COMA_RTS        |
| <b>R15</b> | PB15                | USB_HS_D_P      | <b>C11</b> | PD5                   | COMA_TXD        |
| <b>M6</b>  | PB2/BOOT1 (PB2)     | BOOT1           | <b>B11</b> | PD6                   | COMA_RXD        |
| <b>A10</b> | PB3 (JTDO/TRACESWO) | SWO/SPI_SCK     | <b>A11</b> | PD7                   | LCD_BKLEN       |
| <b>A9</b>  | PB4 (NJTRST)        | SPI-1_MISO      | <b>P15</b> | PD8                   | COMB_TXD        |
| <b>A6</b>  | PB5                 | SPI-1_MOSI      | <b>P14</b> | PD9                   | COMB_RXD        |
| <b>B6</b>  | PB6                 | USART1_TX       | <b>C6</b>  | PDR_ON                | 3P3_VCC         |
| <b>B5</b>  | PB7                 | USART1_RX       | <b>A4</b>  | PE0                   | TIM4_ETR        |
| <b>A5</b>  | PB8                 | I2C1_SCL        | <b>A3</b>  | PE1                   | RS232_A_SHUTDN# |
| <b>B4</b>  | PB9                 | I2C1_SDA        | <b>R9</b>  | PE10                  | TIM1_CH2N       |
| <b>M2</b>  | PC0                 | ADC123_IN10     | <b>P10</b> | PE11                  | TIM1_CH2        |

## STM32F407IGH6 – MCU (U3) (cont.)

| MCU Pin#   | MCU Pin Name | Signal            | MCU Pin#   | MCU Pin Name      | Signal       |
|------------|--------------|-------------------|------------|-------------------|--------------|
| <b>R10</b> | PE12         | TIM1_CH3N         | <b>L15</b> | PG2               | CHR_INT#     |
| <b>N11</b> | PE13         | TIM1_CH3          | <b>K15</b> | PG3               | CAN1_SDN     |
| <b>P11</b> | PE14         | TIM1_CH4          | <b>K14</b> | PG4               | CAN1_SBY     |
| <b>R11</b> | PE15         | TIM1_BKIN         | <b>K13</b> | PG5               | USB_FS_OVC   |
| <b>A2</b>  | PE2          | RS232_B_SHUTDOWN# | <b>J15</b> | PG6               | USB_FS_INT#  |
| <b>A1</b>  | PE3          | RADIO_RSTn        | <b>J14</b> | PG7               | USART6_CK    |
| <b>B1</b>  | PE4          | RADIO_IRQ         | <b>H14</b> | PG8               | MDM_RTS_3V   |
| <b>B2</b>  | PE5          | RADIO_PS_SLP_0    | <b>C10</b> | PG9               | MDM_RXD_3V   |
| <b>B3</b>  | PE6          | RADIO_LP_WAKEUP   | <b>G1</b>  | PH0/OSC_IN (PH0)  | G1 (Ext_OSC) |
| <b>R8</b>  | PE7          | TIM1_ETR          | <b>H1</b>  | PH1/OSC_OUT (PH1) | H1 (Ext_OSC) |
| <b>P8</b>  | PE8          | TIM1_CH1N         | <b>L13</b> | PH10              | TIM5_CH1     |
| <b>P9</b>  | PE9          | TIM1_CH1          | <b>L12</b> | PH11              | TIM5_CH2     |
| <b>E2</b>  | PF0          | RS4XX_B_TERM      | <b>K12</b> | PH12              | TIM5_CH3     |
| <b>H3</b>  | PF1          | USR_PB3           | <b>E12</b> | PH13              | PH13         |
| <b>L1</b>  | PF10         | ADC3_IN8          | <b>E13</b> | PH14              | TIM8_CH2N    |
| <b>R6</b>  | PF11         | RS4XX_B_RXEN#     | <b>D13</b> | PH15              | TIM8_CH3N    |
| <b>P6</b>  | PF12         | GPIO_INT_A        | <b>F4</b>  | PH2               | No Connect   |
| <b>N6</b>  | PF13         | GPIO_INT_B        | <b>G4</b>  | PH3               | No Connect   |
| <b>R7</b>  | PF14         | STAT_LED          | <b>H4</b>  | PH4               | I2C2_SCL     |
| <b>P7</b>  | PF15         | No Connect        | <b>J4</b>  | PH5               | I2C2_SDA     |
| <b>H2</b>  | PF2          | TEMP_CT           | <b>M11</b> | PH6               | I2C2_SMBA    |
| <b>J2</b>  | PF3          | ADC3_IN9          | <b>N12</b> | PH7               | I2C3_SCL     |
| <b>J3</b>  | PF4          | TEMP_INT          | <b>M12</b> | PH8               | I2C3_SDA     |
| <b>K3</b>  | PF5          | USR_PB4           | <b>M13</b> | PH9               | I2C3_SMBA    |
| <b>K2</b>  | PF6          | ADC3_IN4          | <b>E14</b> | PI0               | RADIO_CSELn  |
| <b>K1</b>  | PF7          | ADC3_IN5          | <b>D14</b> | PI1               | RADIO_SPCLK  |
| <b>L3</b>  | PF8          | ADC3_IN6          | <b>E3</b>  | PI10              | No Connect   |
| <b>L2</b>  | PF9          | ADC3_IN7          | <b>E4</b>  | PI11              | No Connect   |
| <b>N7</b>  | PG0          | CHR_STAT          | <b>C14</b> | PI2               | RADIO_MISO   |
| <b>M7</b>  | PG1          | CHR_EN#           | <b>C13</b> | PI3               | RADIO_MOSI   |
| <b>B10</b> | PG10         | RADIO_ULP_WAKEUP  | <b>D4</b>  | PI4               | TIM8_BKIN    |
| <b>B9</b>  | PG11         | PB1_LEDKn         | <b>C4</b>  | PI5               | TIM8_CH1     |
| <b>B8</b>  | PG12         | RADIO_WAKE_IRQ    | <b>C3</b>  | PI6               | TIM8_CH2     |
| <b>A8</b>  | PG13         | PB2_LEDKn         | <b>C2</b>  | PI7               | TIM8_CH3     |
| <b>A7</b>  | PG14         | PB3_LEDKn         | <b>D2</b>  | PI8               | RTC_TAMP/TS  |
| <b>B7</b>  | PG15         | MDM_CTS_3V        | <b>D3</b>  | PI9               | PI9          |

## STM32F407IGH6 – MCU (U3) (cont.)

| MCU Pin#   | MCU Pin Name | Signal                       | MCU Pin#   | MCU Pin Name | Signal       |
|------------|--------------|------------------------------|------------|--------------|--------------|
| <b>C1</b>  | VBAT         | VSTDBY                       | <b>C5</b>  | VDD          | 3P3_VCC      |
| <b>M10</b> | VCAP_1       | connected as specified in DS | <b>R1</b>  | VDDA         | AVDD/3P3_VCC |
| <b>F13</b> | VCAP_2       | connected as specified in DS | <b>N1</b>  | VREF-        | GND          |
| <b>F3</b>  | VDD          | 3P3_VCC                      | <b>P1</b>  | VREF+        | 3P3_VCC      |
| <b>G3</b>  | VDD          | 3P3_VCC                      | <b>F2</b>  | VSS          | GND          |
| <b>K4</b>  | VDD          | 3P3_VCC                      | <b>G2</b>  | VSS          | GND          |
| <b>N8</b>  | VDD          | 3P3_VCC                      | <b>M8</b>  | VSS          | GND          |
| <b>N9</b>  | VDD          | 3P3_VCC                      | <b>M9</b>  | VSS          | GND          |
| <b>N10</b> | VDD          | 3P3_VCC                      | <b>H12</b> | VSS          | GND          |
| <b>J12</b> | VDD          | 3P3_VCC                      | <b>G12</b> | VSS          | GND          |
| <b>J13</b> | VDD          | 3P3_VCC                      | <b>F12</b> | VSS          | GND          |
| <b>H13</b> | VDD          | 3P3_VCC                      | <b>D9</b>  | VSS          | GND          |
| <b>G13</b> | VDD          | 3P3_VCC                      | <b>D8</b>  | VSS          | GND          |
| <b>C9</b>  | VDD          | 3P3_VCC                      | <b>D7</b>  | VSS          | GND          |
| <b>C8</b>  | VDD          | 3P3_VCC                      | <b>D5</b>  | VSS          | GND          |
| <b>C7</b>  | VDD          | 3P3_VCC                      | <b>M1</b>  | VSSA         | GND          |

## 5.2 LDx Pinout

| LED        | MCU Number | MCU Pin Name | Signal    |
|------------|------------|--------------|-----------|
| <b>LD1</b> | B9         | PG11         | PB1_LEDKn |
| <b>LD2</b> | A8         | PG13         | PB2_LEDKn |
| <b>LD3</b> | A7         | PG14         | PB3_LEDKn |
| <b>LD4</b> | N15        | PD10         | PB4_LEDKn |

## 5.3 PBx Pinout

| Push Button | MCU Number | MCU Pin Name | Signal  |
|-------------|------------|--------------|---------|
| <b>PB1</b>  | R3         | PA7          | USR_PB1 |
| <b>PB2</b>  | F15        | PA8          | USR_PB2 |
| <b>PB3</b>  | H3         | PF1          | USR_PB3 |
| <b>PB4</b>  | K3         | PF5          | USR_PB4 |
| <b>PB5</b>  | J1         | NRST         | nRESET  |

## 6 Appendix B: Jumper Settings

### 6.1 JB1 (Boot Mode 1 Selection)

| Jumper                 | Position | Setting    |
|------------------------|----------|------------|
| <b>Pins 1 &amp; 2</b>  | RAM      | Select RAM |
| <b>Pins 2 &amp; 3*</b> | ROM      | Select ROM |

\*Default Setting

### 6.2 JB2 (Boot Mode 0 Selection)

| Jumper                 | Position | Setting    |
|------------------------|----------|------------|
| <b>Pins 1 &amp; 2</b>  | RXM      | Select RXM |
| <b>Pins 2 &amp; 3*</b> | FLS      | Select FLS |

\*Default Setting

When JB2 is in the RXM position and JB1 is in the ROM position, the system will Boot from the ST bootloader. This bootloader will allow the programming of the Main Flash Memory by a number of various serial peripherals (USART, CAN, USB, I2C, SPI, etc.). Care must be exercised when using this jumper option as any program currently in Flash can be erased or corrupted. For additional information please reference the STM32F407IGH6 User Manual.

### 6.3 JB3 (RTC & RAM Retention Battery)

| Jumper                 | Position | Setting         |
|------------------------|----------|-----------------|
| <b>Pins 1 &amp; 2</b>  | ON       | Enable Battery  |
| <b>Pins 2 &amp; 3*</b> | OFF      | Disable Battery |

\*Default Setting

### 6.4 JB4 (CAN Termination)

| Jumper                 | Position | Setting        |
|------------------------|----------|----------------|
| <b>Pins 1 &amp; 2*</b> | TRM      | Line Pulled HI |
| <b>Pins 2 &amp; 3</b>  | OPN      | Line Pulled LO |

\*Default Setting

### 6.5 JB5 (High Drive Voltage Selection)

| Jumper                 | Position | Setting |
|------------------------|----------|---------|
| <b>Pins 2 &amp; 4*</b> | ExHD-HDV |         |
| <b>Pins 3 &amp; 4</b>  | 5V-HDV   |         |
| <b>Pins 4 &amp; 6</b>  | 12V-HDV  |         |

\*Default Setting

## 7 Appendix C: Dimensions

