RTKA489204DK0000BU

Overview

The RTKA489204DK0000BU is an evaluation kit that facilitates testing of the RAA489204 Li-ion battery pack analog front-end ICs. The RAA489204 monitors cell voltage and temperature, and provides 14-bit digital values, cell balance control, and significant fault detection. The RAA489204 also contains daisy chain hardware to provide robust board-to-board communication.

The evaluation kit operates as a stand-alone monitor or, combined with additional boards, creates a daisy chained application. One board operating alone allows testing of up to 14-cell series-connected Li-ion battery packs by using a standard USB interface to a PC. Up to 30 boards cascade (with daisy chain communication from board-to-board) to test systems with up to 420 cells.

Specifications

This board is configured and optimized for the following operating conditions:

- V_{BAT} = 12V to 65V
- Cell voltage -5V to +5V (Note: No cell voltage can go below pack ground or above 65V.)
- External inputs ExT1 to ExT4 = 0V to 2.5V (external temperature measurement thermistors on board)
- Two GPIO ports to monitor temperature (default) or general-purpose input or output.

Board Contents

The RTKA489204DK0000BU evaluation kit contains:

- RTKA489204DE0000BU RevB evaluation board
- MCB_PS4_Z multi-cell power supply test board
- RTKA489204MICROZ communications board
- USB cable that connects PC to evaluation board
- One twisted pair daisy chain cable
- One RJ45 daisy chain cable

Features

- Supports both stand-alone and daisy chained configurations
- Daisy chain capacitively coupled (direct board-to-board or cable connected) or transformer coupled cable connected (capacitor or transformer selected by jumper)
- External cell balance operation
- Cell voltages monitored after balance resistor to meet safety fault detection goals.
- GUI provided export option for generation of detailed register, voltage, and/or SPI communications log files
- USB microcontroller dongle runs HID firmware for enumeration and communications with Windows platforms
- Evaluation kit includes a resistor divider power supply board for cell voltage generation

Board Requirements

The following instruments are required to perform testing:

- 63V/1A adjustable power supply
- Wires to connect power supply to MCB_PS4_Z board
- Precision multimeter
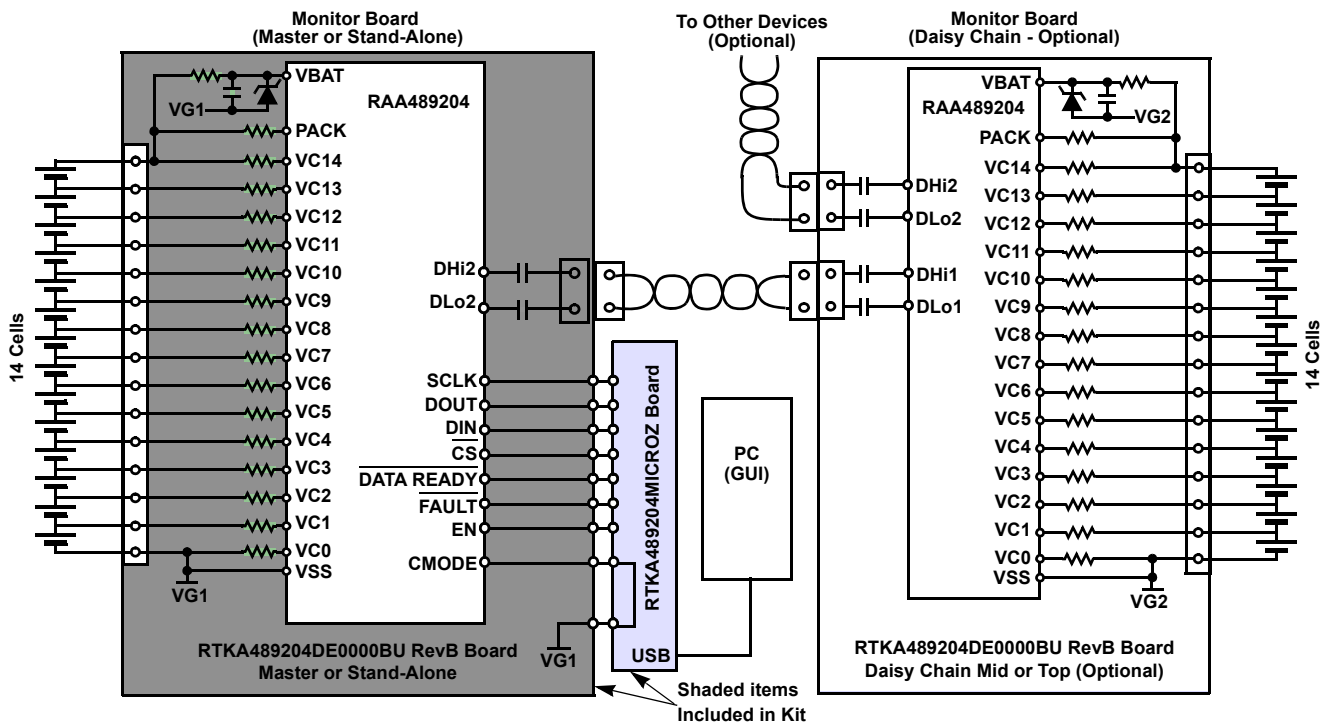- Windows computer with USB port

Contents

Figure 1. Typical Application

1. Functional Description

The RTKA489204DK0000BU evaluation kit in use with the associated GUI allows you to become familiar with the instructions, capability, and operation of the device. A single RAA489204 Li-ion battery manager IC supervises up to 14 series-connected cells. The device provides accurate monitoring, cell balancing, and extensive system diagnostics functions.

The kit enables you to activate and data log voltage and temperature measurements. Cell voltages are supplied using a resistor ladder network in the MCB_PS4_Z multi-cell power supply test board.

The RAA489204 has three cell balancing modes incorporated: Manual Balance mode, Timed Balance mode, and Auto Balance mode. The Auto Balance mode terminates balancing functions when a charge transfer value specified by the host microcontroller has been met.

Note: Cell balancing requires the removal of the MCB_PS4_Z multi-cell power supply test board and requires the attachment of either cells or a power supply with the capability of sourcing the cell balance current.

The PCB has the components populated for external cell balancing. The external balance circuit provides a balance current of 40mA at a cell voltage of 4V.

The RAA489204 communicates to a host microcontroller through an SPI interface and to other RAA489204 devices using a robust, two-wire daisy chain system. Using the evaluation kit requires no special settings to select between a stand-alone system and a daisy chain system, and no special settings are required to select the top device. The master daisy chain IC is selected by connecting the RTKA489204MICROZ board.

By default, the daisy chain is configured for capacitor coupled communication. By moving jumpers, the daisy chain communicates through transformer coupling. All the components for both capacitor and transformer coupling are provided on the PCB.

Connecting multiple Renesas boards allows you to set up communications and measurement capability of many packs and up to 420 battery cells. However, review the Quick Hardware Setup Guide because there are safety concerns as voltage levels increase with multiple packs.

Note: The RAA489204 is an industrial/commercial version of the Automotive ISL78714. For this reason, the RAA489204 uses the same GUI and bare evaluation board PCB as the ISL78714, so images of the GUI and PCBs within this document may include either product number. The RAA489204 is not intended for Automotive applications.

1.1   Software Installation

Note: The software version supplied with the kit only supports the RAA489204 device.

Install the GUI software with the following steps:

1. Unzip the RAA489204 User Interface Rev9.0 folder to the local drive.
2. Confirm that the folder contains:
    a. RAA489204 user interface Rev9.0.exe
    b. ISLABHIDDevice.dll
    c. DeviceID.txt
    d. LabVIEW85RuntimeEngineFull.exe
3. Install LabVIEW85RuntimeEngineFull.exe.
    The RAA489204 User Interface Rev9.0 is now available to use.

1.2   Quick Hardware Setup Guide

1.2.1   Single Board

Set up the hardware with the following steps:

1. Before connecting the power supply to the boards, set the power supply voltage to 49V (3.5V per cell). If there are fewer cells being tested, reduce the power supply voltage so that it equals 3.5V times the number of cells.
2. Connect and check the power supply to the MCB_PS4_Z board. The positive terminal is J_5/J_{5A} and the negative terminal is J_6/J_{6A}. Check that the voltages on the J_2 connector are 3.5V from pin to pin. Ground should be on the pin labeled "0" and "G".

    If there is no voltage on J_2, check that the switches are all set to ON. Also, confirm that there is no jumper on JP_2 of the MCB_PS4_Z board to select the 14-cell option, because this puts the proper voltage on the VBAT pin.
3. Turn off the power to the power supply.
4. Connect RTKA489204DE0000BU connector J_3 to the MCB_PS4_Z board connector J_1.
    Check the jumpers and switches. Ensure the RTKA489204DE0000BU board is configured so that LEDEN contains a jumper.
5. For stand-alone operation, the Daisy jumpers can be removed or connected to the CAP position (see Figure 2). Connect the microcontroller board (RTKA489204MICROZ) connector JP_3 to the RTKA489204DE0000BU board connector JP_6 (see Figure 3).

Figure 2. Daisy Jumper Settings

6. Connect the USB port of the PC to the USB port of the RTKA489204DE0000BU board.

7. Turn on the MCB_PS4_Z power supply. Two green LEDs (V3P3 and V3P3x) turn on to indicate that the LDO regulators on the RAA489204 are operating.

8. Run the GUI (see Quick GUI Setup Guide.) Use the software to connect the board. Because there is a watchdog timer on the RAA489204 that waits close to a minute before powering down, perform the following steps with the GUI as soon as possible after powering the boards.

    a. Click **Roll Call**. (The GUI should have a green indicator and show the number of connected boards.)

    b. Click **WDTM to MAX.** (This sets the watchdog timers to a maximum setting so that there is time to evaluate the system.)

9. When the RTKA489204DE0000BU is powered, there should be instances of the following board voltages:
    V3P3 = 3.3V ±3%
    VCC = ~3.3V ±5% (a little lower than V3P3)
    V2P5 = 2.5V ±2%
    VREF = 2.5005V ±0.5mV

10. See the Quick GUI Setup Guide. Use the software to read the cell voltages.

11. Compare the voltages at the board input with the readings provided by the GUI. Use a meter to measure each of the cell voltages on the RTKA489204DE0000BU board J_7 connector, because the MCB_PS4_Z board may not accurately divide the voltages into equal 3.3V steps. Also, measure the voltage from cell to cell, not cell to ground to get the best accuracy. The meter reading and the GUI readout voltages should closely match (within ±2.5mV at 3.3V and room temperature).
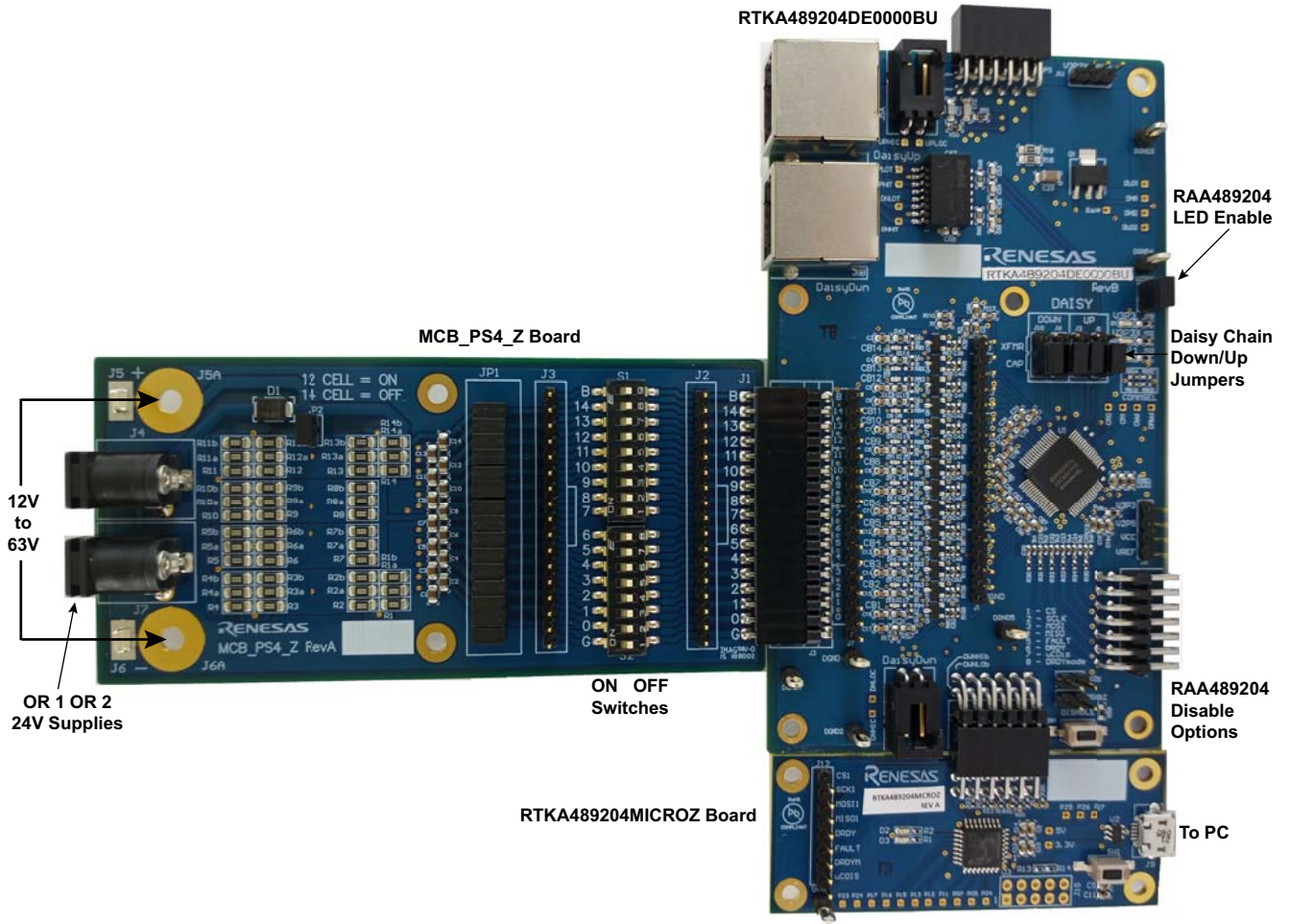
Figure 3. RTKA489204DK0000BU RevB Single Board Setup

1.2.2   Daisy Chain

Set up the hardware with the following steps:

1. Before connecting the power supply to the boards, set the power supply voltage to 49V (3.5V per cell). If fewer cells are being tested, reduce the power supply voltage so that it equals 3.5V times the number of cells.

2. Connect the power supply to all MCB_PS4_Z boards in parallel, that is, all ground pins are tied together and all VBAT pins are tied together. See Figure 4 (Option A). This is not typical of a battery installation, where the ground of one board is the V_{BAT} of another, but it easily facilitates testing of the communication and allows a safer environment for initial testing. Alternatively, power supplies can be stacked to better represent an actual implementation. See Figure 4 (Option B or C).

USE CAUTION when connecting the MCB_PS4_Z boards in series, because voltages quickly reach hazardous levels. **BE CAREFUL!**

A convenient and safe way to evaluate multiple daisy connected boards is to connect the ground pin of all MCB_PS4_Z boards together, so no board has more than 63V present.

A

B

C
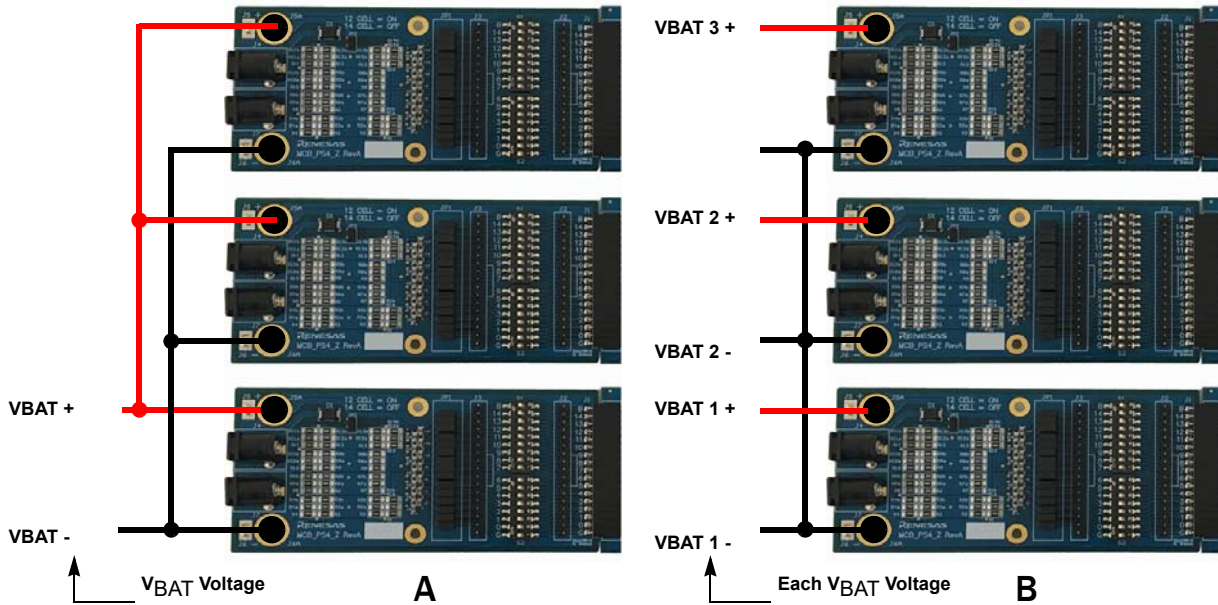
Stack the supplies to mimic typical Battery voltages

CAUTION: STACKING POWER SUPPLIES RESULTS IN DANGEROUSLY HIGH VOLTAGE.

A: Preferred Test Connection

This is the simplest and safest connection for initial testing, system evaluation or software review or generation, because it has the lowest voltage and minimum number of connection wires.

B: Alternate Test Connection

This alternative also keeps cell voltages within safe limits, but allows the evaluation of system performance with different voltages on each device input. This allows an analysis to more easily confirm that the RAA489204 devices are not all reading the same values.

C: Battery Typical Connection

This connection stacks power supplies to generate a pack voltage of up to 189V. This is an unsafe condition, so care is needed when working with this setup. It is also important to check on whether the supplies can handle terminal voltages this high above ground. This connection is not recommended, because it offers little benefit over connecting actual cells, in which case, the MCB_PS4_Z boards are not needed.
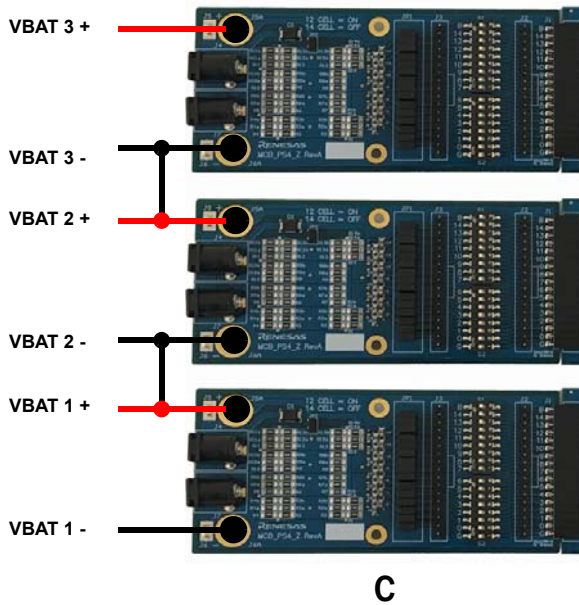
Figure 4. RTKA489204DK0000BU Battery Cell Emulation MCB-PS4-Z Alternative Connections

There should be one MCB_PS4_Z board for every evaluation board. The positive terminal of the MCB_PS4_Z board is J_5/J_{5A} and the negative terminal is J_6/J_{6A}. Check that the voltages on the J_3 connectors of all boards are 3.3V from pin to pin. Ground should be on the pin labeled "0" or "GND".

3. Turn off the power to the power supply.

4. Connect each RTKA489204DE0000BU board connector J_3 to an MCB_PS4_Z board connector J_1.

5. Connect the daisy chain by using either capacitor isolation or transformer isolation.

   a. With capacitor isolation, the boards connect together directly (Figure 5) or with cables (Figure 6), or they connect using a combination of direct and cable connections.

   b. With transformer isolation, the boards are connected as shown in Figure 7. When using cables, connect the wires as shown in Table 1. (**Note**: The boards are configured to prevent both direct connection and twisted pair cable connection on the same port.)

Table 1. Daisy Chain Connection Using Cables[1]

Daisy Chain Board	RAA489204 DaisyDwn	RAA489204 DaisyUp
Master	NC	Connect to DaisyDwn of board above
Middle	Connect to DaisyUp of board below	Connect to DaisyDwn of board above
Top	Connect to DaisyUp of board below	NC

1. NC = No connection

6. Check the jumpers and switches on the boards. Because this is a daisy chain configuration, each board should be configured as follows:

   a. LEDEN contains a jumper.

   b. The master (the board connected to the RTKA489204MICROZ board) must have the DAISY DOWN jumpers removed or set to the CAP setting.

   c. For the Master UP jumpers and all other boards, the DAISY jumpers can be set as CAP or XFMR (transformer) coupling. See Figure 2.

      i. When the boards are daisy chained using the capacitor coupling, connect the boards directly together or with the provided twisted pair cables.

      ii. When the boards are daisy chained using the transformer setting, connect the boards using the RJ45 cables.

7. Connect microcontroller board (RTKA489204MICROZ) connector JP_3 to the master RTKA489204DE0000BU board connector JP_6.

8. Connect the USB port of the PC to the USB port of the RTKA489204MICROZ daisy chain master board.

9. Turn on the power supply. The two green LEDs (V3P3 and V3P3x) turn on to indicate that the LDO regulators are operating on the RAA489204s.

   a. Run the GUI (see Quick GUI Setup Guide). Use the software to connect the board. Because there is a Watchdog timer on the RAA489204 that waits close to a minute before powering down, perform the following steps on the GUI as soon as possible after powering the boards.

   b. Start the GUI.

   c. Click on **Roll Call**. The GUI should have a green indicator and show the number of connected boards.

   d. Click on **Set WDT to MAX**. This sets the watchdog timers to a maximum setting so that there is time to evaluate the system.

10. When the RTKA489204DE0000BU is powered, there should be instances of the following board voltages:
    V3P3 = 3.3V ±3%
    VCC = ~3.3V ±5% (a little lower than V3P3)
    V2P5 = 2.5V ±2%
    VREF = 2.5005V ±0.5mV

11. See Quick GUI Setup Guide. Use the software to read the cell voltages.

12. Compare the voltages at the board input with the readings provided by the GUI. Use a meter to measure the voltages on the J_7 connector on the RTKA489204DE0000BU boards, because the MCB_PS4_Z board might not accurately divide the voltages into equal 3.3V steps. Measure the voltage from cell to cell, not cell to ground

to get the best accuracy. The meter reading and the GUI readout voltages should closely match (within ±2.5mV at 3.3V and room temperature).
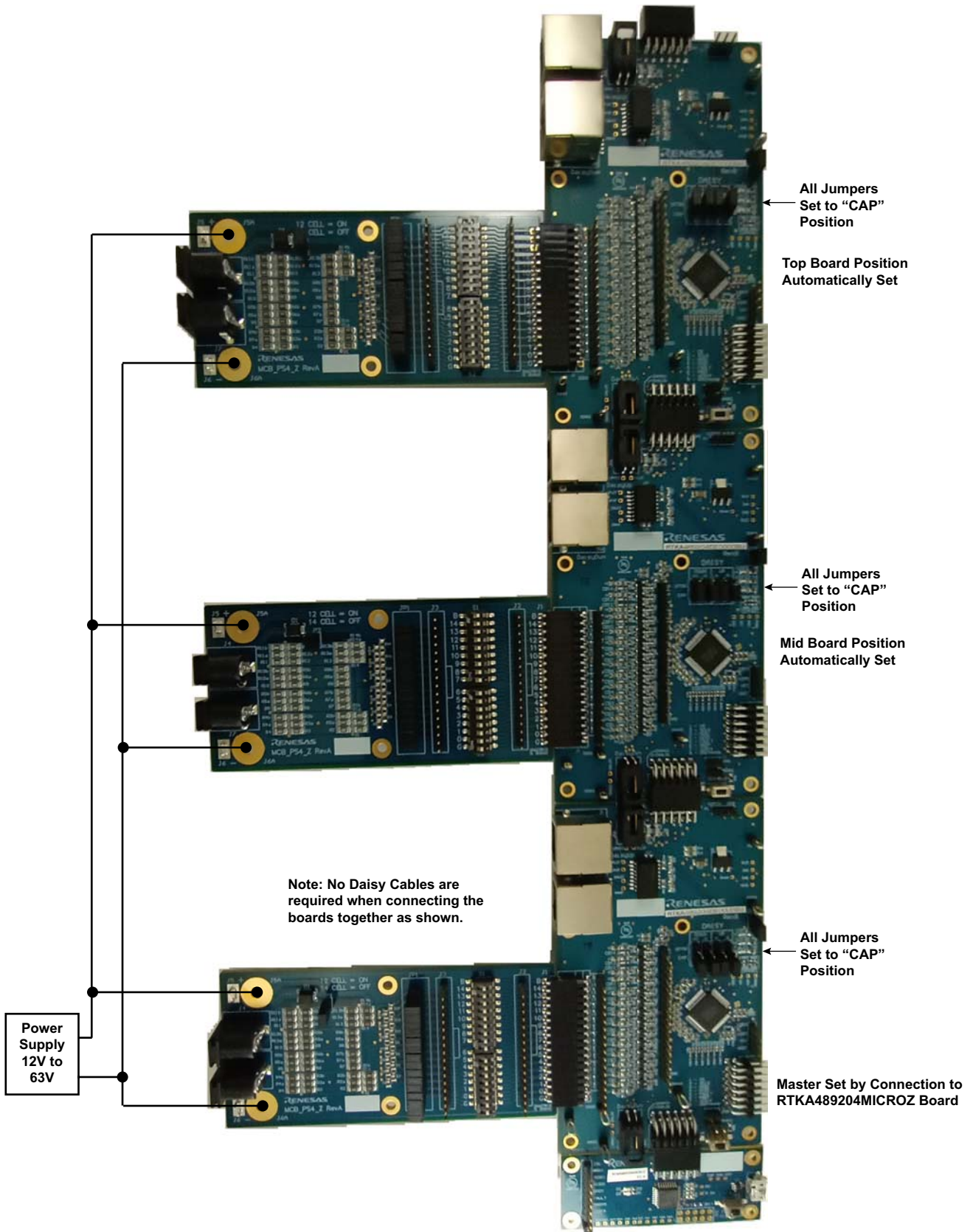

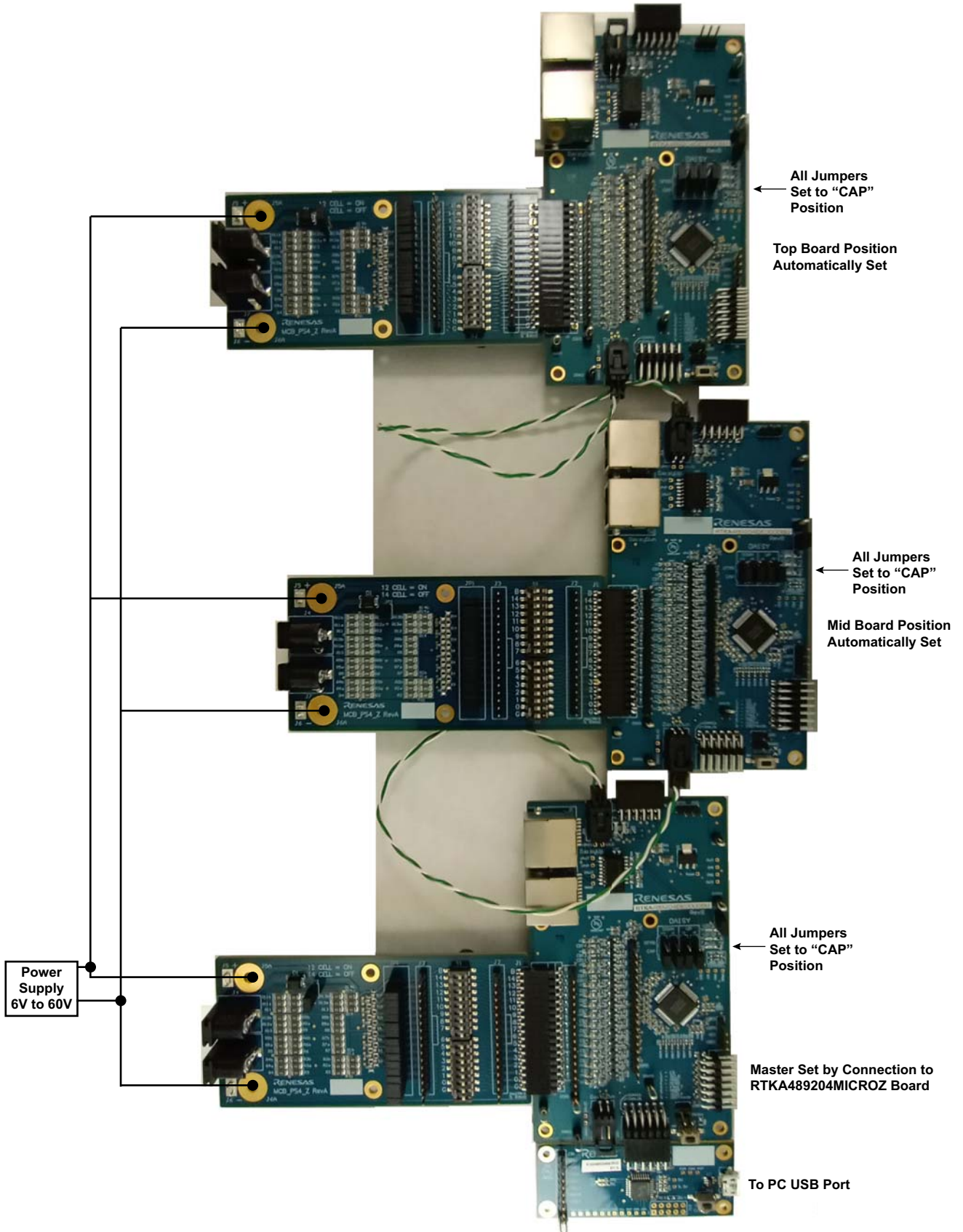**Figure 5. RTKA489204DK0000BU RevB in 36-Cell Direct Connect Daisy Chain Configuration (Capacitor)**

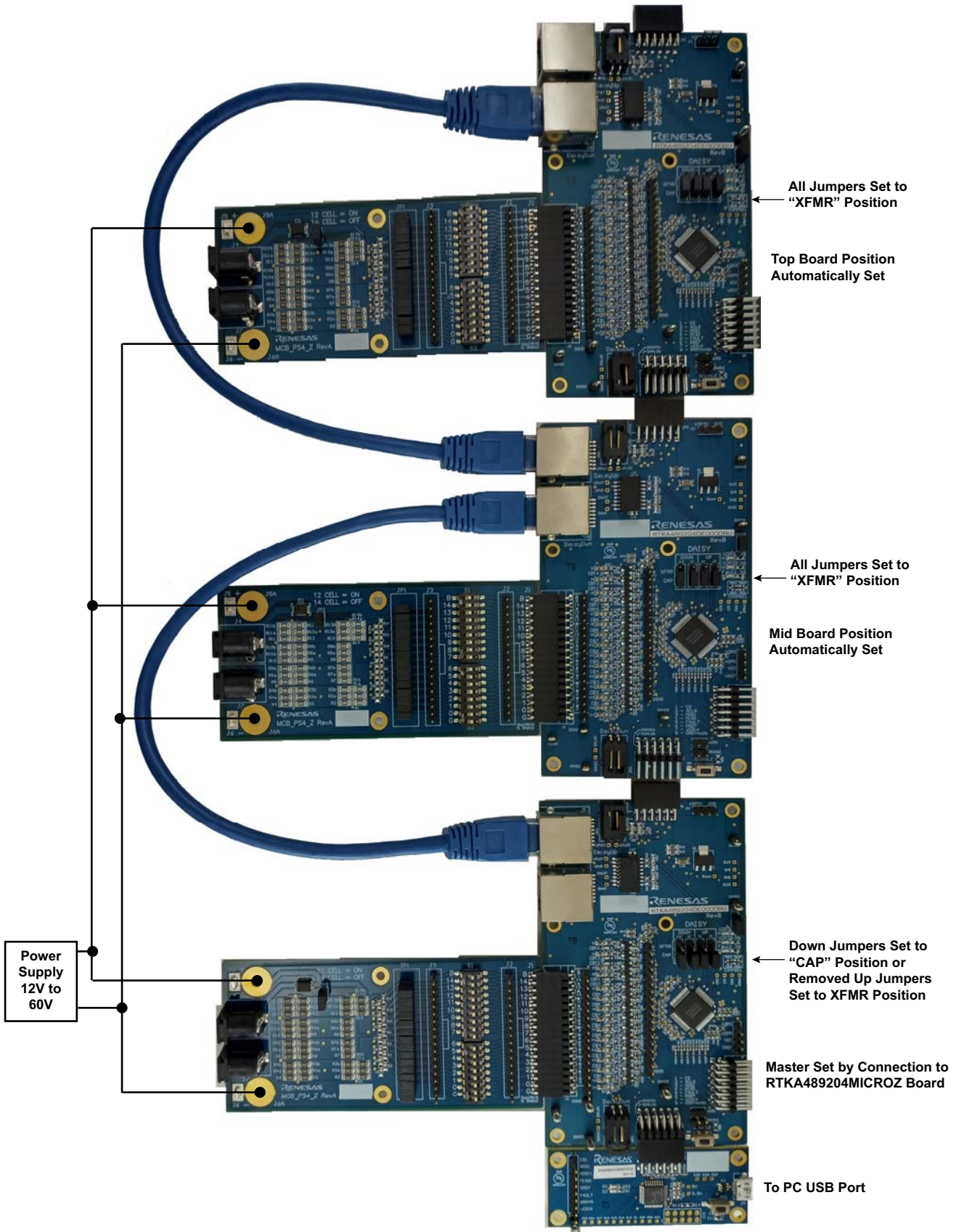**Figure 6. RTKA489204DK0000BU RevB in 36-Cell Cable Connect Daisy Chain Configuration (Capacitor)**

All Jumpers Set to
"XFMR" Position

Top Board Position
Automatically Set

All Jumpers Set to
"XFMR" Position

Mid Board Position
Automatically Set

Down Jumpers Set to
"CAP" Position or
Removed Up Jumpers
Set to XFMR Position

Master Set by Connection to
RTKA489204MICROZ Board

To PC USB Port

Power
Supply
12V to
60V

Figure 7. RTKA489204DK0000BU RevB in 36-Cell Cable Connect Daisy Chain Configuration (Transformer)

1.3 Quick GUI Setup Guide

1. Connect the RTKA489204MICROZ board to the PC USB port.

2. Run the GUI program.

3. Click **STOP GUI**. Next, click the arrow in the upper left of the screen to restart the GUI (see Figure 8). The GUI firmware window shows the firmware revision, and the green LED on the microcontroller board is illuminated.

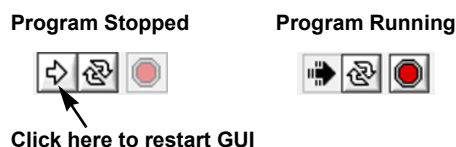**Program Stopped**   **Program Running**

Click here to restart GUI

Figure 8. Restarting the GUI

4. Power up the RTKA489204DE0000BU boards.

5. Within one minute of powering the boards, the boards must be identified, and the Watchdog timers must be reset.

   By default, the boards enter sleep close to one minute after no communications; although OK, this event complicates the initial power-up. If the boards do not all have two lit green LEDs, power the boards off and repeat steps 4 and 5.

6. There are two ways to initialize the devices in the daisy chain stack.

   a. Click on **Connect**. This step performs a Roll Call operation, sets the Watchdog timers on all devices to Max, and clears all Faults. For the first time powering the system, **Connect** might generate the pop up message: RAA489204 Device #1 Comm NACK. This message is OK; simply close the box by clicking **OK**. Finally, click **OK** in the Initialization Complete box.

   b. Or perform the following steps in sequence: (1) Click on **Roll Call**, (2) Click on **WDTM to Max**, and (3) Click on **Clear all Faults**.

7. The box next to the **Roll Call** button indicates the number of boards connected in the daisy chain, but if this is not correct, repeat steps 6a or 6b. However, if the number of boards remains incorrect, repeat steps 4, 5, and 6. See Questions and Answers if the problem continues.

8. Click the **Scan Voltages** button. (**Note**: Step 8 and 9 are a quick way to validate that the system is connected and operating correctly.)

9. Click the **Read Volts** button. The voltage values read in step 8 are displayed. See Figure 9 for a typical setup with three boards in the daisy chain.
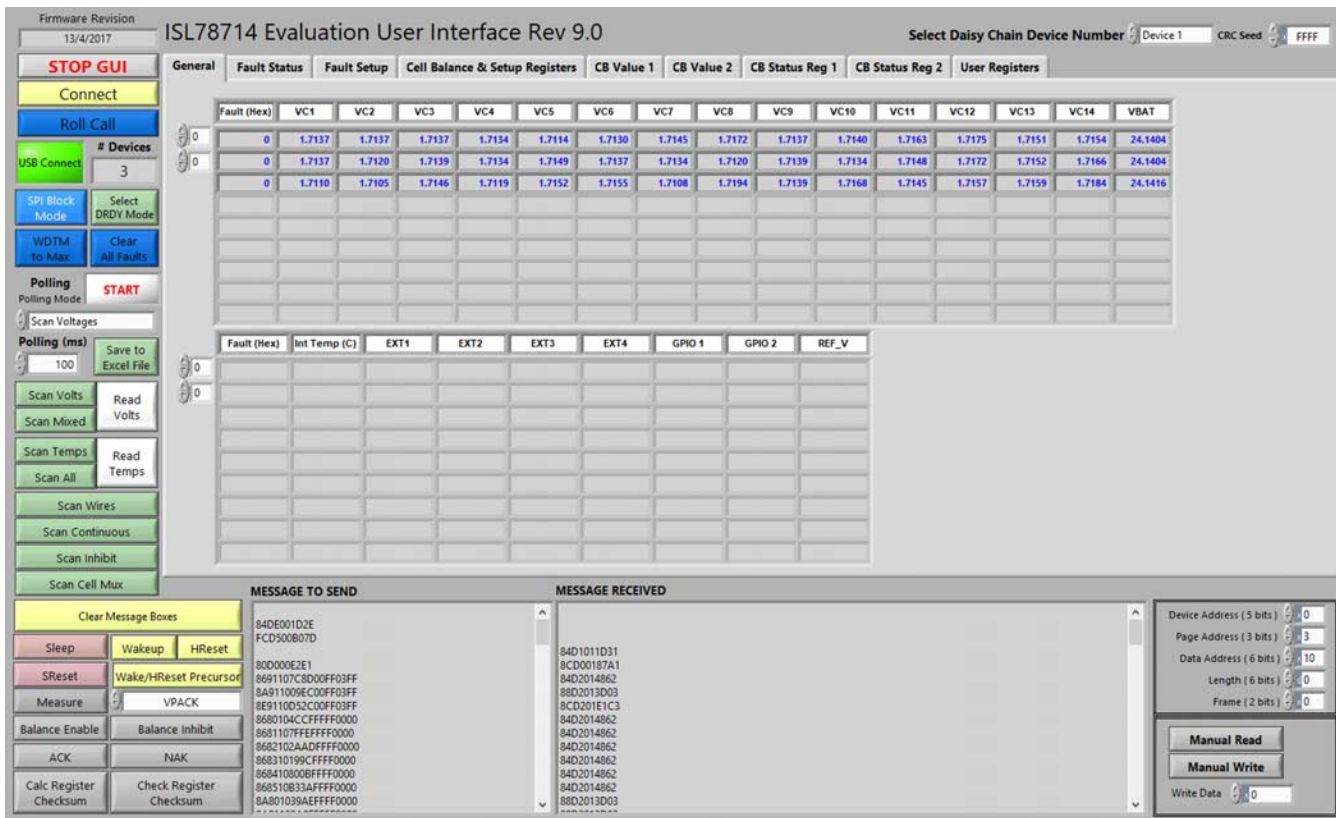
Figure 9. Main GUI Window

2. Using the RAA489204 GUI

2.1 Main GUI Screen

Figure 9 shows the GUI Main screen. The primary control elements and commands are on the left. The tab structure (along the top) provides information about the operation of the pack, the setup of each device in the stack, and various other monitor functions. The two message windows at the bottom keep track of and display messages transferred between the GUI and the RAA489204. Finally, in the lower right of the Main screen is an area that allows you to test any specific command that is not provided by the GUI.

Note: In the upper right corner of the GUI screen is a box titled CRC Seed. This value for this revision of the RAA489204 silicon should always be 'FFFF'. If it is not, there can be problems with communication between the GUI and the devices.

Note: The RAA489204 is an industrial/commercial version of the Automotive ISL78714. For this reason, the RAA489204 uses the same GUI as the ISL78714, so images of the GUI within this document may Indicate ISL78714. The RAA489204 is not intended for Automotive applications.

2.2 Main GUI Screen Operation

2.2.1 Start Up

When the program starts, the GUI opens the USB port and checks the revision of the microcontroller code on the kit dongle. To do this, the GUI sends a command to the microcontroller to read the firmware version number. This message is not passed along to the RAA489204.

2.2.2   Idle State

When there is no activity either in response to a user button press or from polling, the GUI is in the Idle state. While in this state, the GUI monitors the USB port for unprompted responses from the RAA489204 evaluation board and microcontroller. If the USB buffer is empty, there is no action. If there is data in the USB buffer, the message is received and the decoded response is shown in a pop-up window.

Pressing any button causes the GUI to perform the operation of the button specified. During this operation, the Idle scan is suspended.

2.2.3   Message Recording

For every command sent and every response received, a record is placed in the Message Boxes. In one box, the messages are sent. In the other box, the messages are received. These both contain a Hex representation of the information. See examples in Table 2 and Table 3.

Table 2. Messages Sent format

Command	Message Sent
Roll Call	80D0002E7D
Write WDT register	8691100B0100FF1EF0

Table 3. Messages Received format

Command	Message Recorded
Roll Call	A4D001545A
Write WDT register	84D20184FE

2.2.4   Stop GUI

STOP GUI

The STOP GUI button exits the program. This method is preferred for exiting the program (rather than clicking the stop sign icon in the menu bar), because it performs some clean-up in the USB connection to the microcontroller dongle.

2.2.5   Roll Call

Roll Call

\# Devices

0
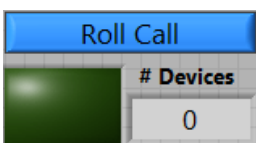
Important: The roll call operation, or **Connect**, must be the first operation.

The **Roll Call** button sends a Roll Call command to the evaluation boards using a Roll Call command. No other commands work until the stack is identified.

The Roll Call command is made up of five bytes and is similar to most other commands. For information on the structure of a command, see the RAA489204 datasheet.

The Roll Call command passes through each device in the daisy chain. The devices self identify, and the top device sends a Roll Call response back to the GUI. After receiving the response, the GUI knows the number of devices that are in the stack, inputs that value into the **# Devices** window, and illuminates the green USB **Connect** indicator.
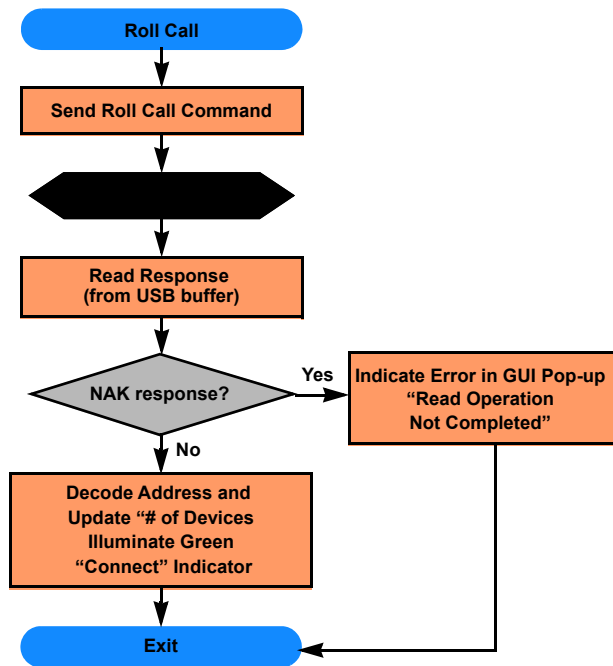
Figure 10. Roll Call Operation

If no devices (or fewer number of devices than expected) are identified following a press of the **Roll Call** button, complete the following steps:

1. Confirm that the cables are connected firmly and that the boards are powered.
   You should see two green LEDs illuminated on each board. If any board has only one LED illuminated, follow this procedure:

   a. If you either have (1) one evaluation board with one green LED or (2) a Master board with one green LED while the other boards have none, check to see that the switches on the MCB_PS4_Z boards are set to ON. Next, follow either step i or ii.

      i. Cycle the power on all of the evaluation boards.

      ii. Or, click the **Wakeup/HReset Precursor** button; next, click the **Wake** button. The master wakes up (both green LEDs on plus a red LED).

   b. Click **Roll Call** again.

2. If step 1 does not work, click **STOP GUI**. Next, click the arrow in the upper left of the screen to restart the GUI. See Figure 11. The GUI indicators change, and the green LED on the microcontroller board is illuminated.

Figure 11. Restarting the GUI

3. If communications still do not work, check that the daisy chain jumpers are set correctly. The jumpers on the main board (the one connected to the microcontroller) should be set to CAP or removed for the DWN setting.

4. If step 3 does not work, power down the board, remove the USB connection, and reconnect everything (confirm that all connections are good) and power up again (connect one board for simplicity, if possible.)

5. If the problem persists, use a different board or contact Customer Support.

2.2.6 WDTM to Max
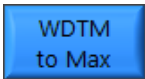
This button sends a message to every device in the stack to set the Watchdog timeout value to Maximum. This action is a good thing to do in an evaluation environment, because the default WDT value is about one minute. If no actions are taken during this time period, devices go to sleep.

The **WDTM to Max** button sends a series of individual write operations to set the maximum WDT value in the WDT/BAL TIME register in each device, see Figure 15. If nine devices are identified in the Roll Call command, this command is sent nine times, once for each IC.

At the end of each write operation, the GUI receives an ACK that it has received this command. If it does not, a pop-up window indicates the NAK response.
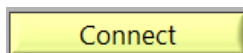
2.2.7 Clear All Faults
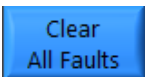
This button sends a message to every device in the stack to clear all of the Fault registers; this event consists of a series of individual Multi-register write operations to each device. Six contiguous registers present fault information. This button writes ones to all register bits ("0xFFFF") in every Fault register to clear the faults.

If nine devices are identified in the Roll Call command, then this multi-register command is sent nine times, once for each board. At the end of each write operation, the GUI receives an ACK that it has received this command. If it did not, there is a pop-up window indicating the NAK response.

2.2.8 Connect

This button tells the GUI to perform the **Roll Call**, **WDTM to Max**, and the **Clear All Faults** commands in sequence. When running this command on a stack of boards directly after the board are powered, there might be an error message "RAA489204 Device #1 Comm NACK". This is OK. Close this box by clicking **OK**. When this command is complete, an Initialization Complete pop up box appears. Click OK to close this box. During the operation, the message boxes show the various commands and responses associated with this operation.
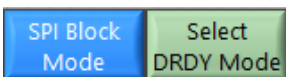
The **SPI Block Mode** and **Select DRDY Mode** buttons allow you to set the SPI mode of operation as either Block transfer or Byte transfer. A Block transfer sets the SPI $\overline{CS}$ pin low at the start of an operation and brings it high at the end, regardless of how many bytes are in the data transfer. The Byte transfer mode brings the SPI $\overline{CS}$ line high between each byte. The GUI automatically controls the RAA489204 DRDY Mode pin to correspond to the chosen SPI mode selected.
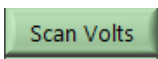
To use these buttons, click **SPI Block Mode** to select the required mode, then click **Select DRDY Mode** to actually send the command to the microcontroller. No data is sent to the RAA489204 with this command.
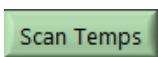
2.2.9 Scan Volts
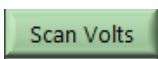
The **Scan Volts** button forces a Scan Volts command to all devices. The command uses an Address All device address.
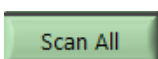
2.2.10 Scan Mixed

The **Scan Mixed** button forces a Scan Mixed command to all devices. The command uses an Address All device address.

2.2.11 Scan Temps

The **Scan Temps** button forces a Scan Temperature command to all devices. This command uses an Address All device address.

2.2.12 Scan All

The **Scan All** button forces a Scan All command to all devices. In one operation, the command executes together the Scan Volts, Scan Wires, and Scan Temps commands, and the command

uses an Address All device address. The Scan All operation, when using the MCB_PS4_Z boards with the RTKA489204DE0000BU revB boards, produces an Open Wire error on Cell1. This is a result of a voltage drop caused by the MCB_PS4_Z resistor divider, the input filter on the RTKA489204DE0000BU board, the open wire current, and the open wire threshold detection level on VC1. This combination produces a fault. Using a power supply or batteries to power the board prevents this fault condition during Scan All.

2.2.13 Read All Volts
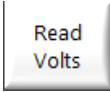
The **Read All Volts** button successively reads the voltage values for all devices and puts the values into the table in the **General** tab. The GUI decodes the Hex values in the volts (except for the Fault Status, which remains in HEX).

2.2.14 Read Temps
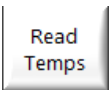
The **Read Temps** button successively reads the temperature Values for all devices and inputs the values into the table in the **General** tab. The GUI decodes the Hex values into volts (except for both the Fault Status that remains in HEX and the Internal Temp value that is converted to °C).
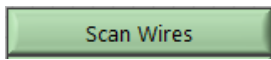
2.2.15 Scan Wires
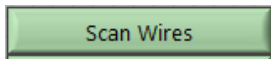
The **Scan Wires** forces a Scan Wires command to all devices. This command checks whether there are any open inputs. This command uses an Address All device address.
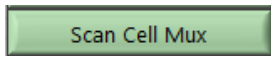
2.2.16 Scan Continuous
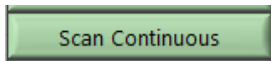
The **Scan Continuous** button sends a Scan Continuous command to all devices. The command uses an Address All device address.
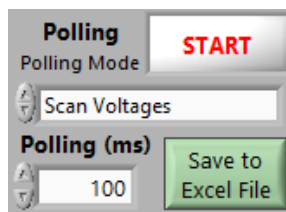
2.2.17 Scan Inhibit

The **Scan Inhibit** button forces a Scan Inhibit command to all devices. The command uses an Address All device address.

2.2.18 Scan Cell MUX

The **Scan Cell MUX** button forces a Scan MUX command to all devices. This command uses an Address All device address.

2.2.19 Polling

Select the desired Scan Mode to be used when performing the polling operation. Select Scan Voltages, Scan Mixed, or Scan All using arrow keys or clicking on the options box.

Select the polling interval with the Polling (ms) value. If the polling operation takes more time than this setting, the polling essentially becomes continuous with a new operation starting after the previous one completes.

Click the **Start** button to start polling. While polling, the button illuminates and shows **Stop**. The data collected fills a data array that can be loaded to Excel when polling stops. Export the data by stopping the scan and then pressing **Save to Excel File**.

Scan All polling forces measurement of the cell voltages, Pack voltage, the temperatures, and checks for open wires. The **Scan All** command is sent one time for each polling loop to all stack devices using **Address All** addressing. Polling using Scan All generates an Open Wire fault on cell1. (See Scan All).

The **Scan Volts** option scans the cell voltages, the Pack Voltage and the internal temperature.

Scan Mixed polling is the same as the Scan Volts option, but it scans the ExT1 input midway through the Cell Voltage scan.

The polling operation follows the scan command with a read of voltages, faults, and temperatures. The operation processes using read commands for each device to request the contents of the voltage, temperature, and fault registers.

When the data is returned, the GUI extracts the information from the buffer to populate the screen and the data collection array. When populating the display, the cell voltage, pack voltage, and internal temperature registers are converted from the Hex value in the returned message to either a voltage or temperature for display. The external temperature inputs are only converted to a voltage. Converting the External Temperature inputs to a temperature value is decided by the user and is dependent on the external resistor/thermistor divider arrangement. See also the RAA489204 datasheet, Data Registers section.

With fewer than 14 cells connected (and with the Cell Setup Register set to ignore the missing cells), the missing cells are depicted with a blank (or a value of 0) in the results table. See Figure 12 for an example of a stack of 9 boards.

Device	Fault (Hex)	VC1	VC2	VC3	VC4	VC5	VC6	VC7	VC8	VC9	VC10	VC11	VC12	VC13	VC14
Master	0	2.1532	2.1556	2.1533									2.1538	2.1542	2.1527
2	0	2.1535	2.1542	2.1521	2.1519	2.1542	2.1544	2.1541	2.1533	2.1536	2.1542	2.1535	2.1555	2.1548	2.1548
3	0	2.1436	2.1448	2.1455	2.1489	2.1486	2.1498	2.1547	2.1512	2.1544	2.1564	2.1571	2.1593	2.1600	2.1614
4	0	2.1442	2.1445	2.1446	2.1487	2.1483				2.1553	2.1559	2.1579	2.1596	2.1609	2.1608
5	0	2.1432	2.1448	2.1455	2.1492	2.1487	2.1500	2.1547	2.1513	2.1544	2.1558	2.1562	2.1588	2.1596	2.1599
6	0	2.1429	2.1443	2.1451	2.1478	2.1487	2.1498	2.1545	2.1527	2.1545	2.1564	2.1571	2.1594	2.1608	2.1600
7	0	2.1436	2.1443	2.1455	2.1494	2.1478	2.1498	2.1545	2.1512	2.1545	2.1556	2.1568	2.1584	2.1602	2.1606
8	0	2.1451	2.1448	2.1451					2.1529	2.1544	2.1553	2.1573	2.1591	2.1606	2.1599
	0	2.1426	2.1439	2.1445	2.1481	2.1489	2.1495	2.1541	2.1521	2.1544	2.1552	2.1567	2.1588	2.1603	2.1600

| Device	Fault (Hex)	Int Temp (C)	EXT1	EXT2	EXT3	EXT4	GPIO 1	GPIO 2	REF_V
Master	0	25.9375	0.0153	1.2709	1.2975	1.3002	1.2819	2.4998	1.2497
2	0	28.8750	0.0168	1.2874	1.3161	1.2680	1.2961	2.4998	1.2503
3	0	28.3437	0.0165	1.2888	1.2845	1.2856	1.2808	2.4998	1.2495
4	0	26.2500	1.2906	1.2843	1.2903	1.2933	1.2894		1.2521
5	0	27.7812	1.3043	1.2949	1.2909	1.2833	1.2939		1.2498
6	0	28.1875	1.3013	1.3028	1.2701	1.2849	1.2926	1.3121	1.2521
7	0	24.3750	1.2921	1.2820	1.2976	1.3049	1.2939	1.2939	1.2493
8	0	23.8125	1.2804	1.2822	1.2939	1.2845	1.2836	1.2968	1.2502
	0	23.9375	0.0143	1.2885	1.2830	1.2946	1.2927	2.4998	1.2504

Figure 12. Proposed General Tab Showing a 6-Cell, 10-Cell, 11-Cell, and 14-Cell Configurations

2.2.20 Measure

The **Measure** button sends a Measure command to tell the devices to measure the voltage specified in the adjacent selection box. Use the up/down arrows to select the item to measure, or better, click on the box to bring up a menu selection. The Measure command uses an Address All device address.
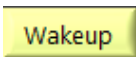
2.2.21 Sleep
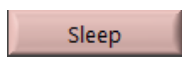
Clicking on the **Sleep** button sends a Sleep command. This command uses an Address All device address.

2.2.22 SReset
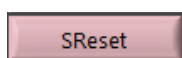
The **SReset** button sends an SReset command. This command uses an Address All device address. After sending an SReset command, it is necessary to go through the **Roll Call** + **WDTM to Max** (or Connect) sequence again.
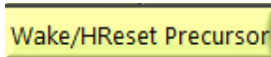
2.2.23 Wakeup

The **Wakeup** button sends a Wakeup command. The command uses an Address All device address. The **Wake/Reset Precursor** command should be sent prior to a Wakeup command.
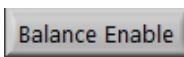
2.2.24 HReset

The **HReset** button forces an HReset command to all devices. This command uses an Address All device address. The **Wake/Reset Precursor** command should be sent prior to this command. After sending an HReset command, it is necessary to go through the **Roll Call** + **WDTM to Max** (or Connect) sequence again.

2.2.25 Wake/HReset Precursor

Clicking on the **Wake/HReset Precursor** button sends a Wake/HReset Precursor command to the Master device. This command goes only to the Master device (not to the daisy chain) and instructs the Master to wake up (if not already awake). It prepares the Master to properly send the next command. If the next command is not a Wake or HReset command, the host receives a NAK response.
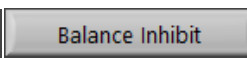
2.2.26 Balance Enable

This button issues a Balance Enable command.

This command starts the balance operation. (Balance does not start, unless it is setup using other registers). This command uses an Address All device address. This command set the BEN bit in the Cell Balance Setup register.

2.2.27 Balance Inhibit

This button issues a command that stops the balance operation. This command uses an Address All device address. This command clears the BEN bit in the Cell Balance Setup register.
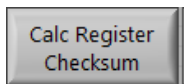
2.2.28 ACK

This button sends an ACK command through the daisy chain. The command expects an ACK response and only uses the address of the selected device.
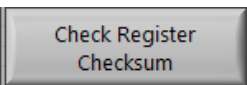
2.2.29 NAK

This button sends a NAK command through the daisy chain. The command expects an ACK response and only uses the address of the selected device.

2.2.30 Calc Register Checksum

Clicking on this button sends a command to perform a calculation of the register checksum. The command expects an ACK response and uses an Address All device address. Typically, this command is used to update the register checksum following a change to settings in the volatile memory area that controls fault monitoring, such as changes to the overvoltage, undervoltage, and external temperature limits.

2.2.31 Check Register Checksum

Clicking on this button sends a command to perform a check of the register checksum. The command expects an ACK response and uses an Address All device address. If there is an error, that is, if the checksum returned from this operation does not match the calculated checksum, a Fault condition is set automatically. Read the Fault Status registers to see the fault condition.

2.2.32   Manual Read/Write
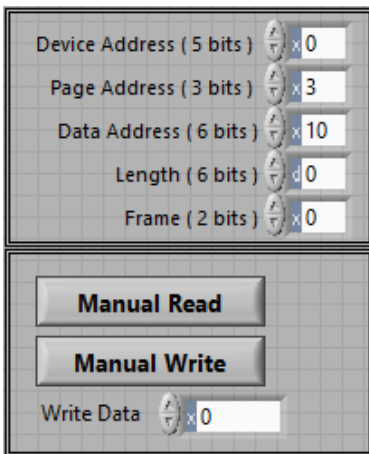
The Manual Read/Write section allows you to create your own command by setting the Device Address, Page Address, Data Address, Length, and Frame. Click **Manual Read** or **Manual Write**, and the GUI calculates CRC values, completes the command, and sends it across the USB port to the RAA489204.

Note: This manual operation only performs reads or writes on a single register and does not do error checking, so it is possible to read and write registers that are not defined. Renesas recommends against experimenting in this way, though there are no known problems associated with actions involving undefined registers.

2.3   Fault Status Tab

The Fault Status tab holds the contents of the Cell Setup, Scan Count, and Fault registers.

To set bits 2 to 14 in the Cell Setup register, click on the bits to set, and click **Write**. Bit 1 cannot be set. This disables the selected cells from the scan operation.

The Scan Count bits cannot be set or cleared. These are indications only (despite the Write button next to this register.)

The Fault Status Register bits (except PAR, OW, UV, OV, OT, and BUFERR), all of the bits in the OV Fault, UV Fault, OW Fault, OT Fault, and the General Fault registers are cleared by clicking on the Write button on each register or by using the Write Page button. The bits are cleared by writing a "1" back to the bit that is set to "1".

The PAR, OW, UV, OV, OT, and BUFERR bits are simply a logical OR of the respective bits in the other registers.

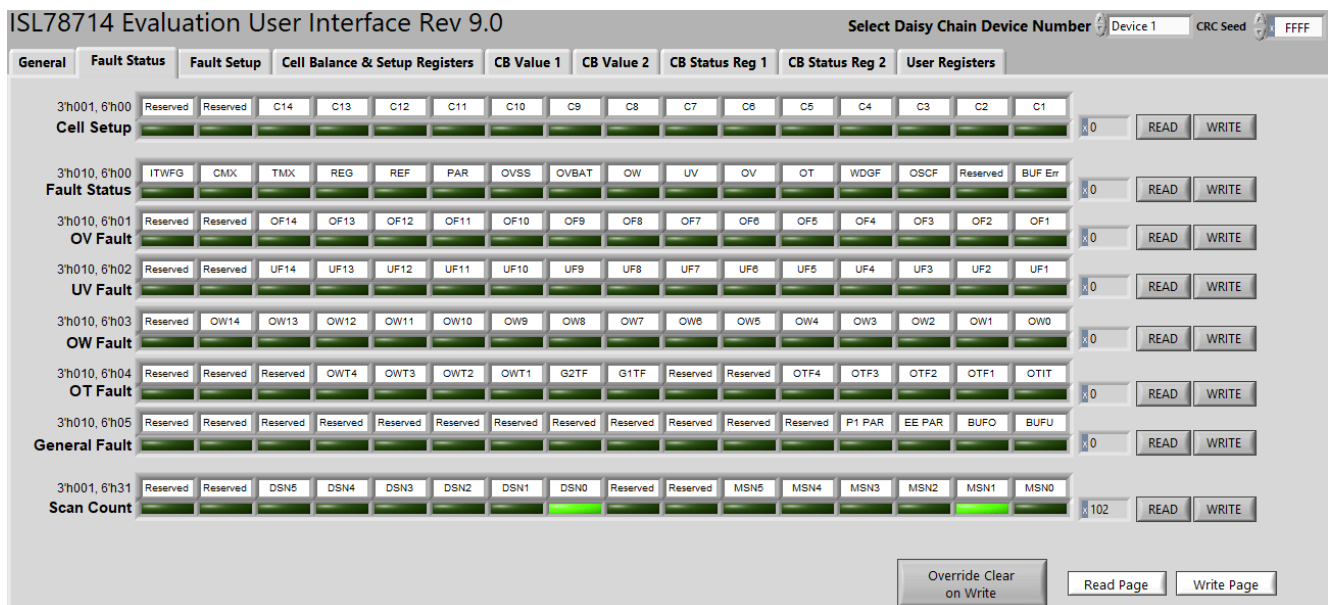**Figure 13. Fault Status Tab Layout**

The bits in the Fault Registers can also be set to a "1" by setting the bit in the register, clicking on the **Override Clear on Write** button, and clicking on the **Write** button for that register. The **Clear Override on Write** button must precede each register **Write** where a bit is set to "1". The write command cannot be the **Write Page** button.

The PAR, OW, UV, OV, OT, and BUFERR bits cannot be set by this sequence of operations. To set these bits, set the underlying bits in their respective registers.

Because these operations are for a single device only, the Daisy Chain Device Number must first be selected at the upper right in the window.

2.4   Fault Setup Tab

The registers shown in Figure 14 configure and monitor the Fault operation of the device.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

The registers on this page can all be read or written individually, with the **Read** button or **Write** button on the right, or together, using a **Read Page** or **Write Page** buttons.

For a Page Read/Write, the GUI handles the details, but since all the registers are in contiguous locations, the GUI uses a multi-register read operation, reading all registers in a single operation. The Write Page operation performs a separate write for each register. This could have been done using a single write command but was not implemented in this GUI.

Performing a Read operation returns the value(s) of the register(s). The contents of each bit are shown as indicators as well as in the value box provided at the right. The bit indicators and the value are also inputs, so you can click on a bit to change the setting or write a new value in the box. Then, clicking the Write button sends the command to the device. For registers that set voltage thresholds, the value in the box is decoded from the hex value. To change a voltage threshold, it is necessary to change the bit values to see the voltage reflected in the box at the right. It is not possible to directly write the voltage in the box.
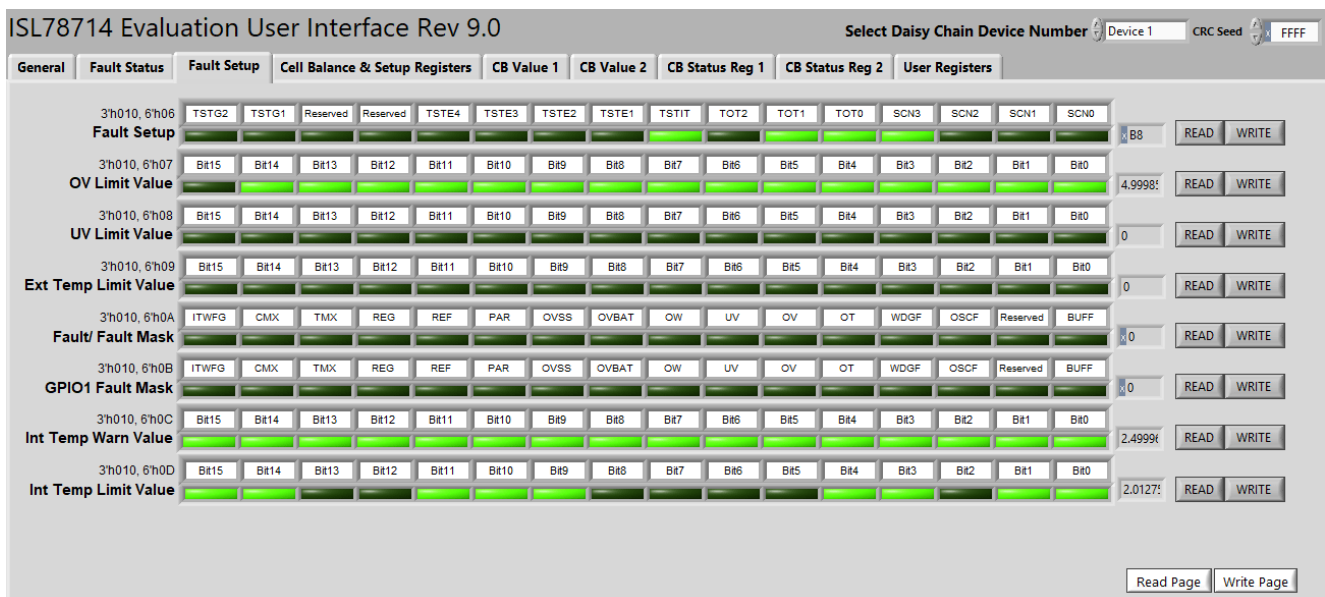
Figure 14. Fault Setup Tab Layout

2.5   Cell Balance and Setup Tab

Use the registers shown in Figure 15 to configure the Device Setup parameters and some of the Cell Balance parameters of the device. These registers also include CB enabled status and the device Serial Number.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

As with other tabs, each bit has an indicator/control and there is a value box on the right. For registers that are Read only, there is no Write button on the right, and a Write Page skips these registers.

Figure 15. Cell Balance & Setup Tab Layout

2.6   CB Value 1 Tab

The registers shown in Figure 16 are used to configure the Cell Balance operation of the device.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

As with other tabs, each bit has an indicator/control, and there is a value box on the right.

Figure 16. CB Value 1 Tab Layout

2.7   CB Value 2 Tab

The registers shown in Figure 17 are used to configure the Cell Balance operation of the device.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

As with other tabs, each bit has an indicator/control, and a value box is on the right.
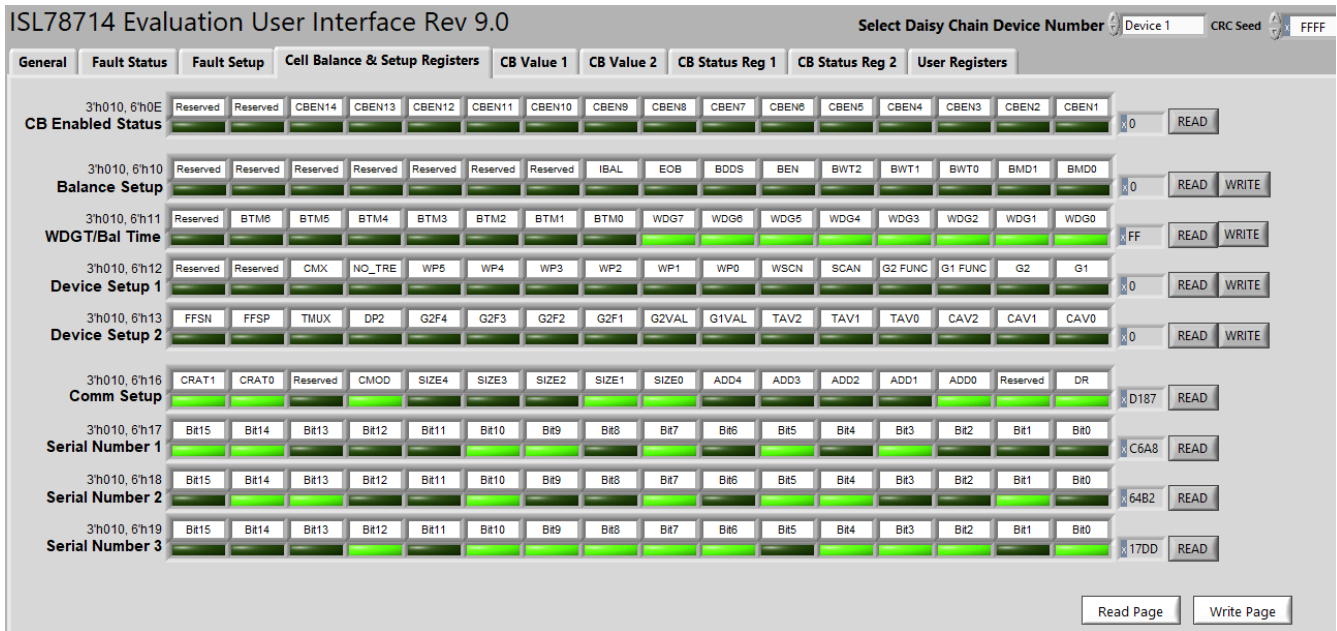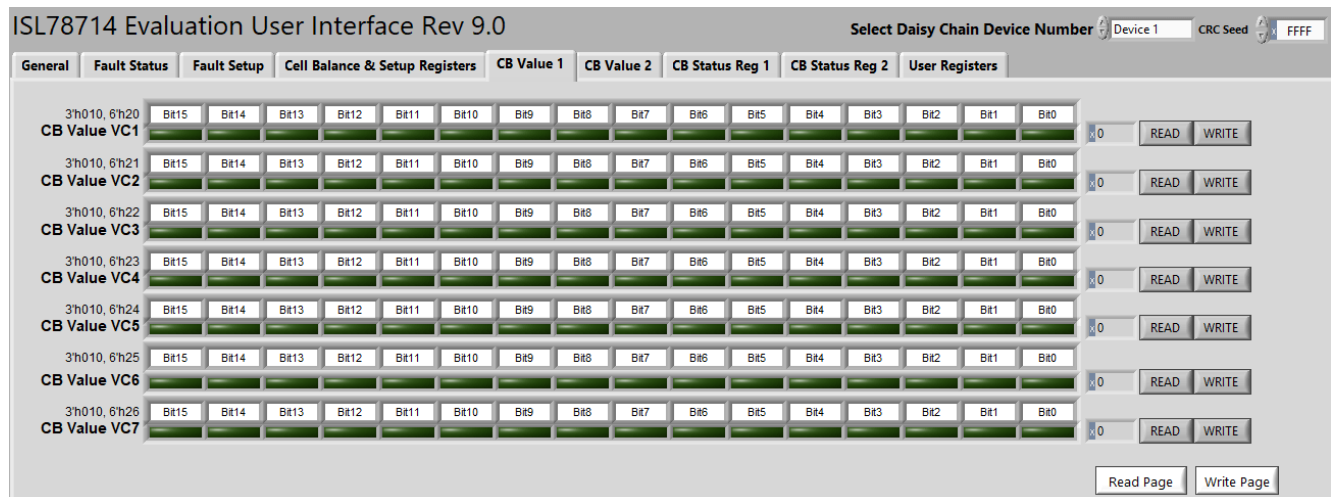
Figure 17. CB Value 2 Tab Layout

2.8   CB Status Reg 1 Tab

The registers shown in Figure 18 are used to configure the Cell Balance operation of the device.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

As with other tabs, each bit has an indicator/control, and a value box is on the right.

When changing the cells that are being balanced in Manual Mode, (1) send a **Balance Inhibit** command; (2) change the contents of the CB Status Register 1; and (3) click on **Balance Enable**.
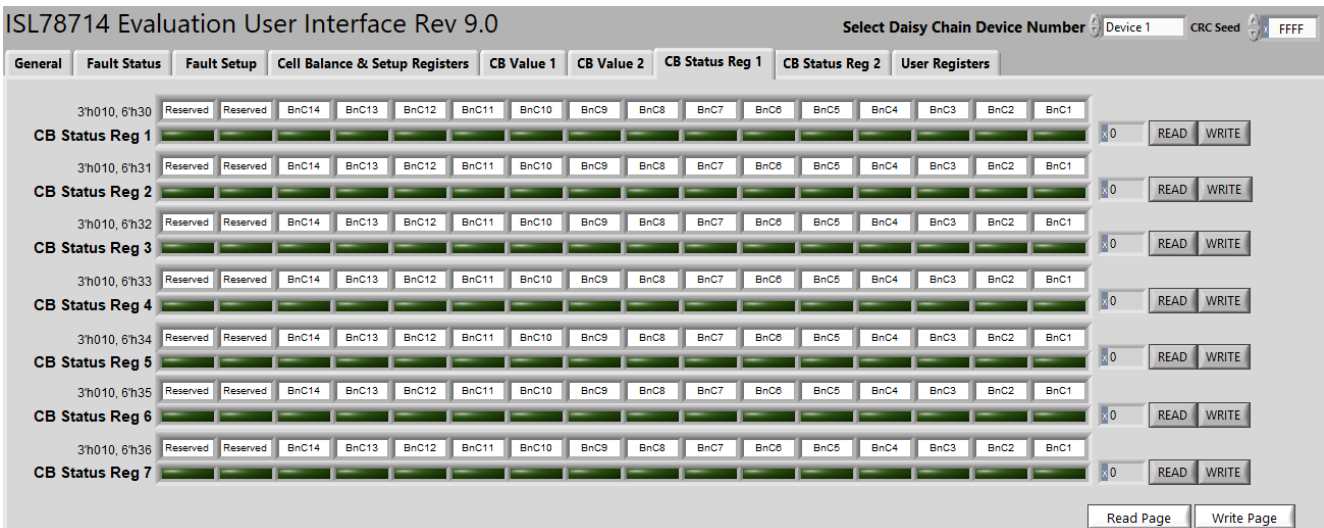
Figure 18. CB Status Reg 1 Tab Layout

2.9   CB Status Reg 2 Tab

The registers shown in Figure 19 are used to configure the Cell Balance operation of the device.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

As with other tabs, each bit has an indicator/control, and a value box is on the right.
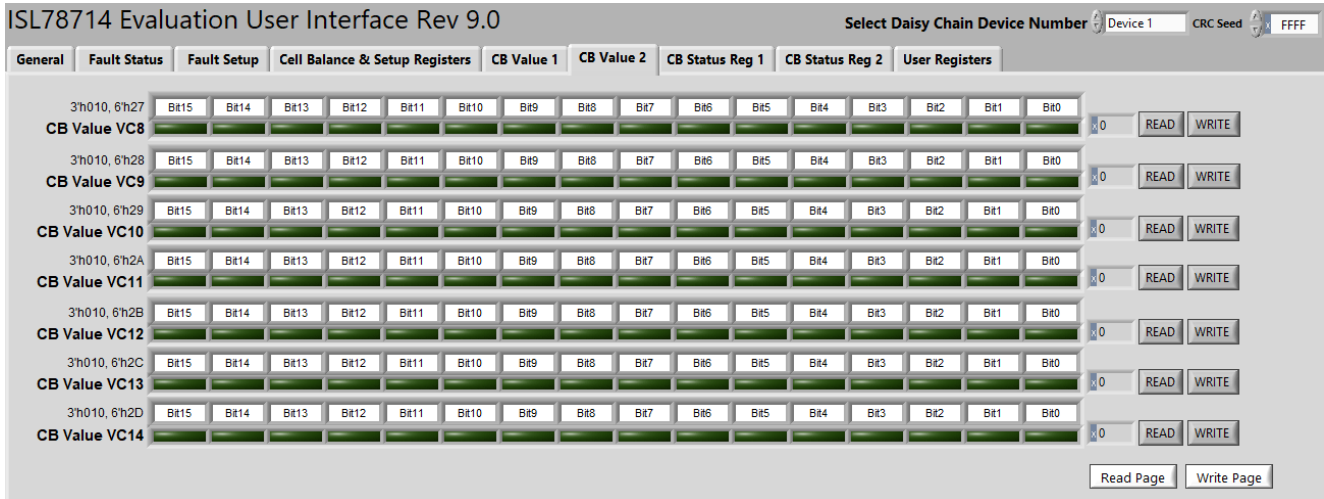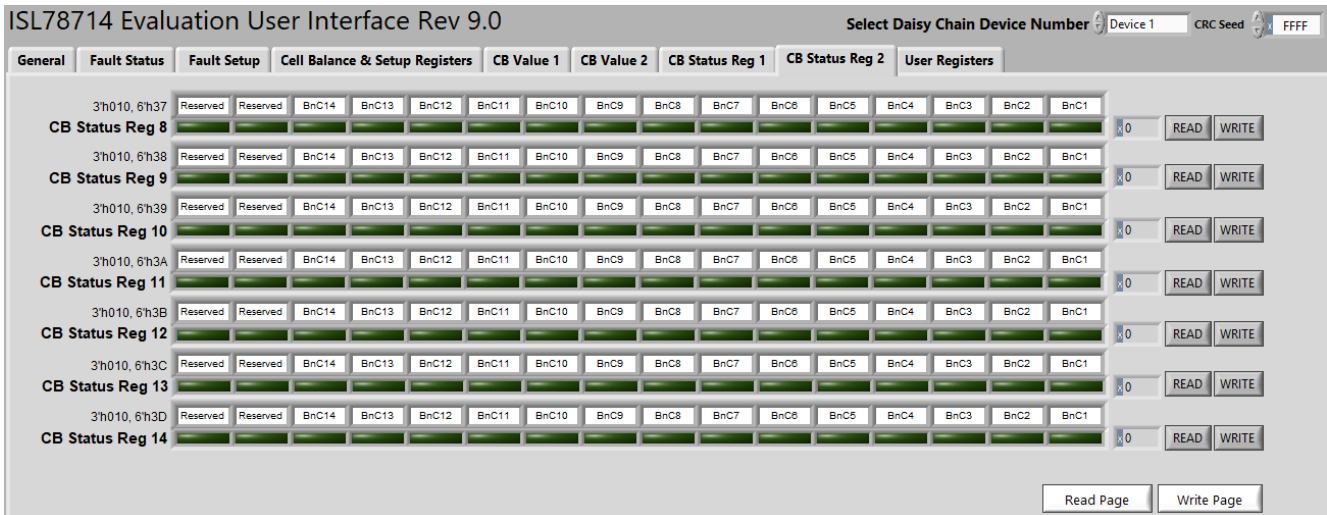
Figure 19. CB Status Reg 2 Tab Layout

2.10 User Registers Tab

The registers shown on Figure 20 provide access to some of the User Registers, the EEPROM checksum registers, and some miscellaneous registers. All of these registers are volatile, meaning that when the device is reset, the values are reset to default conditions.

Because these operations are for a single device only, the Daisy Chain Device Number is selected at the upper right in the window.

Registers without a Write button are read only.

As with other tabs, each bit has an indicator/control, and a value box is on the right.

Figure 20. User Registers and EEPROM Tab Layout

3. RTKA489204DE0000BU Evaluation Boards

3.1 PCB View
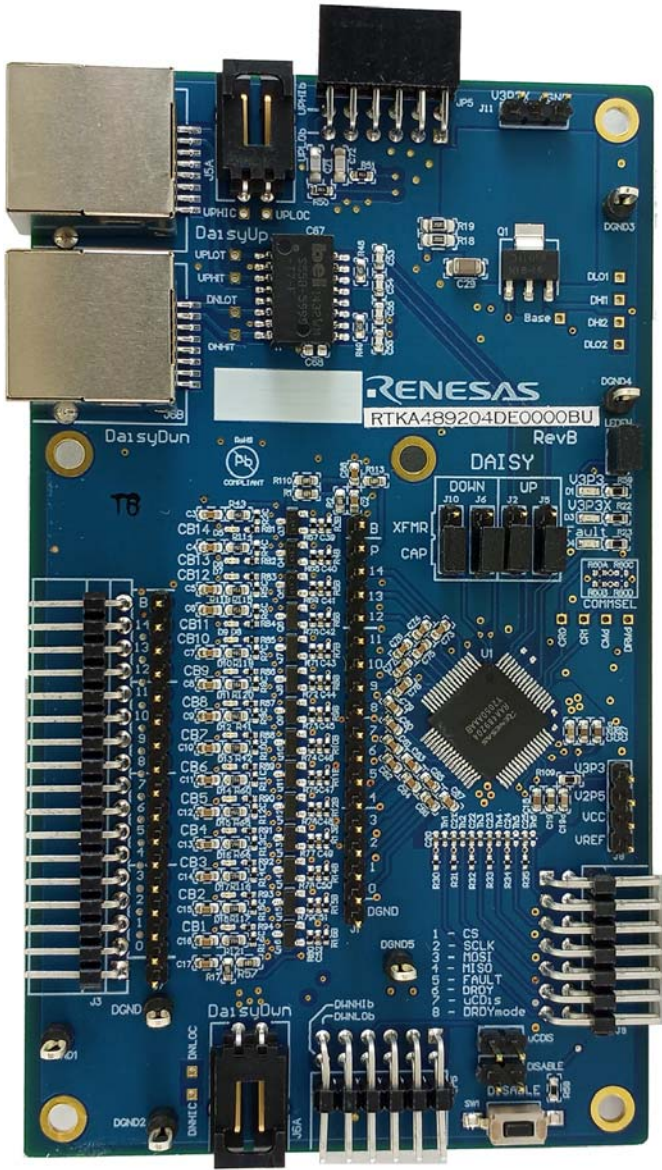
Figure 21. Top View
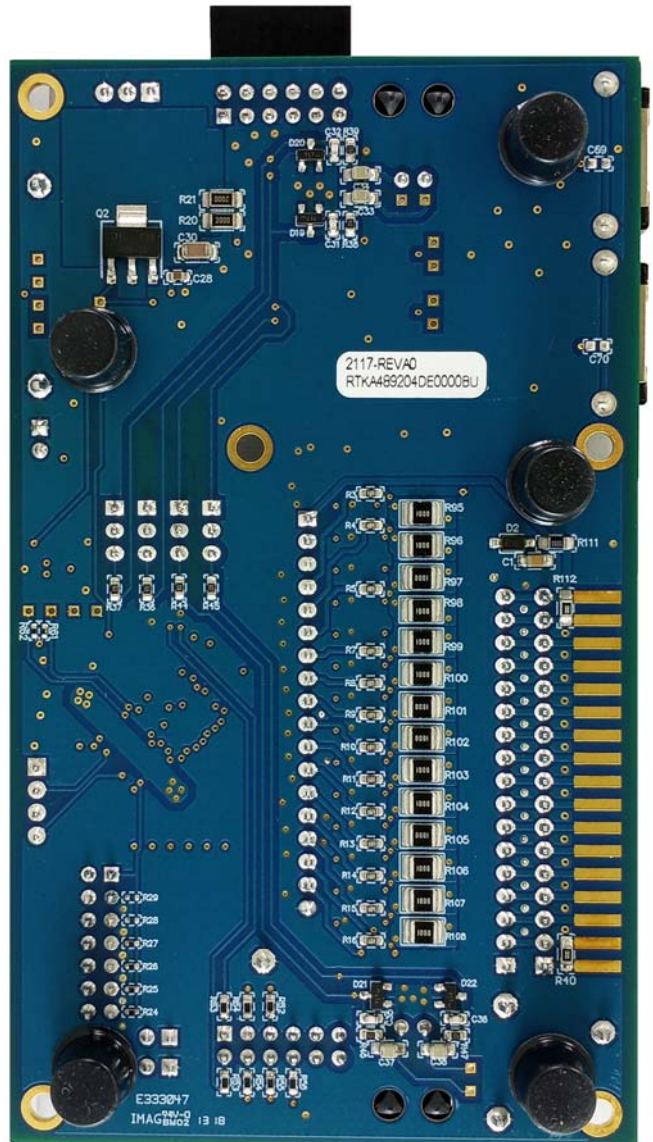
Figure 22. Bottom View

3.2   Schematics

3.2.1   RTKA489204DE0000BU

Front End
AFE.Sch

Communications
Comm.Sch

Connections
BatCon.Sch

Cell Balance
CBAL.Sch

Unshielded twisted Pair (2 pin Molex connectors populated)

or

Shielded or Unshielded Ethernet Cable (8 pin RJ45 connectors populated)
(note: Shielded cable only for use when boards are populated with Daisy Transformer isolation.)

Two External Temperature board options.
1) 6 thermistor
2) 16 thermistor
These plug into the same

Microcontroller board

Figure 23. RTKA489204DE0000BU RevB Board Block Diagram

Figure 24. RTKA489204DE0000BU RevB Board AFE Schematic

N-channel FETs (x9)
DMN6140L   Diodes, Inc
DMN6075S   Diodes, Inc
SSM3K318R   Toshiba

P-Channel FETs (x3)
FDN5618PTR   Fairchild
CPH3351   On Semi
RQ5L015SPTL   Rohm

C73-C86 = 100V rating
C2-C17= 100V rating
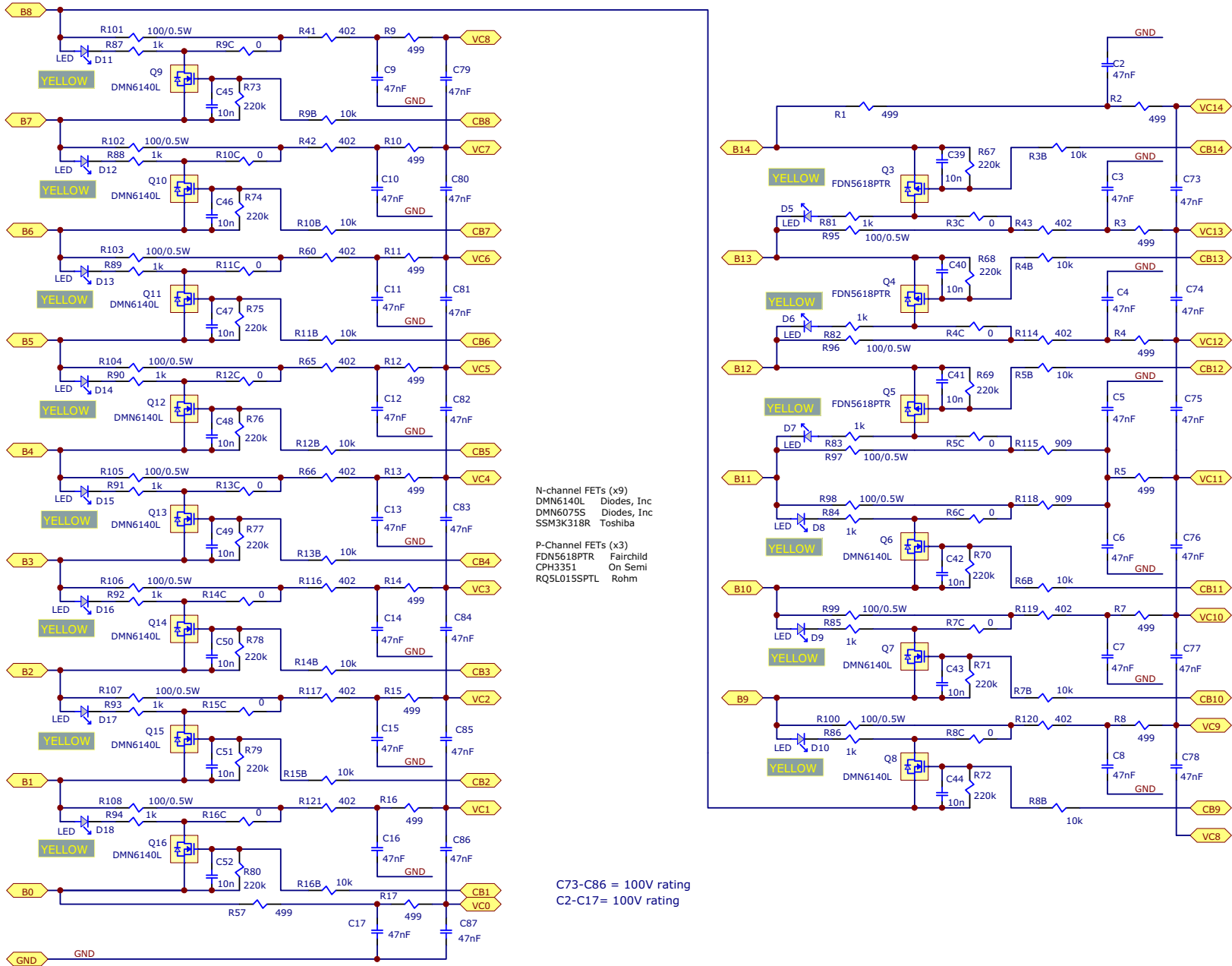
Figure 25. RTKA489204DE0000BU RevB Board Cell Balance Schematic

JP5

CONNUP
Female

1	2
3	4
5	6
7	8
9	10
11	12

UPLO-B

UPHI-B

Transformer:
Dual (QTY one):

Halo: TG110-AEX50N5LF
Bel: S558-5999-T7-F

RJ45 Connectors (J5 & J6):
TE Connectivity: 5558178-1
Amphenol: RJLSE4238101

Daisy Connectors (J10 & J11):
Molex: 70555-0036

Daisy Chain Transformer Coupled

X2
C53 220pF
GND
C54 220pF
X1

R48 200
C67 DNP

T1   DUAL XFMR (DNP)

16
15
14

X4
C55 220pF
GND
C56 220pF
X3

R49 200
C68 DNP

GND

11
10
9

1
2
3

6
7
8

C69 DNP
C2
C1

C70 DNP
C2
C1

J5B

DaisyUP

UPLOT
UPLOT

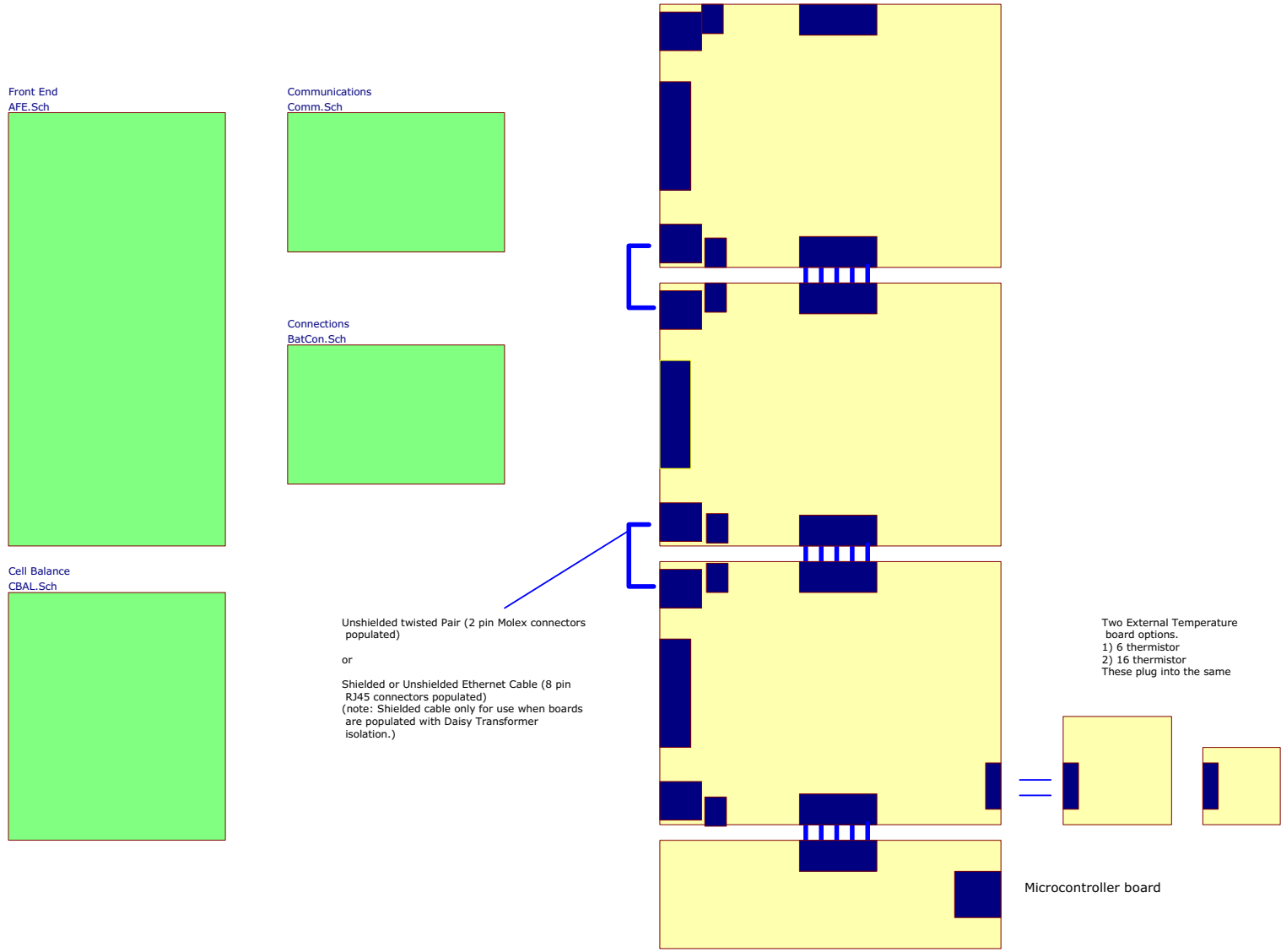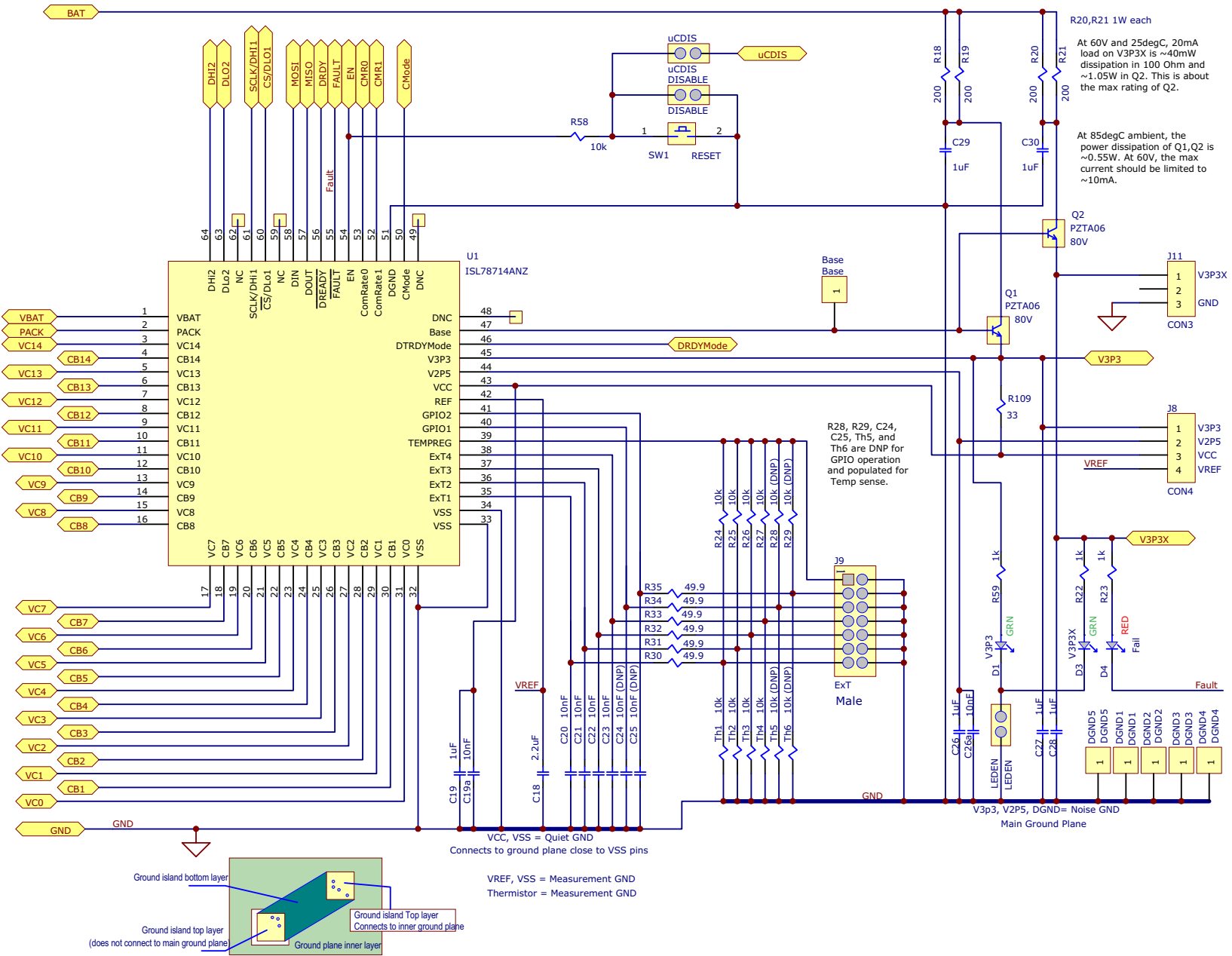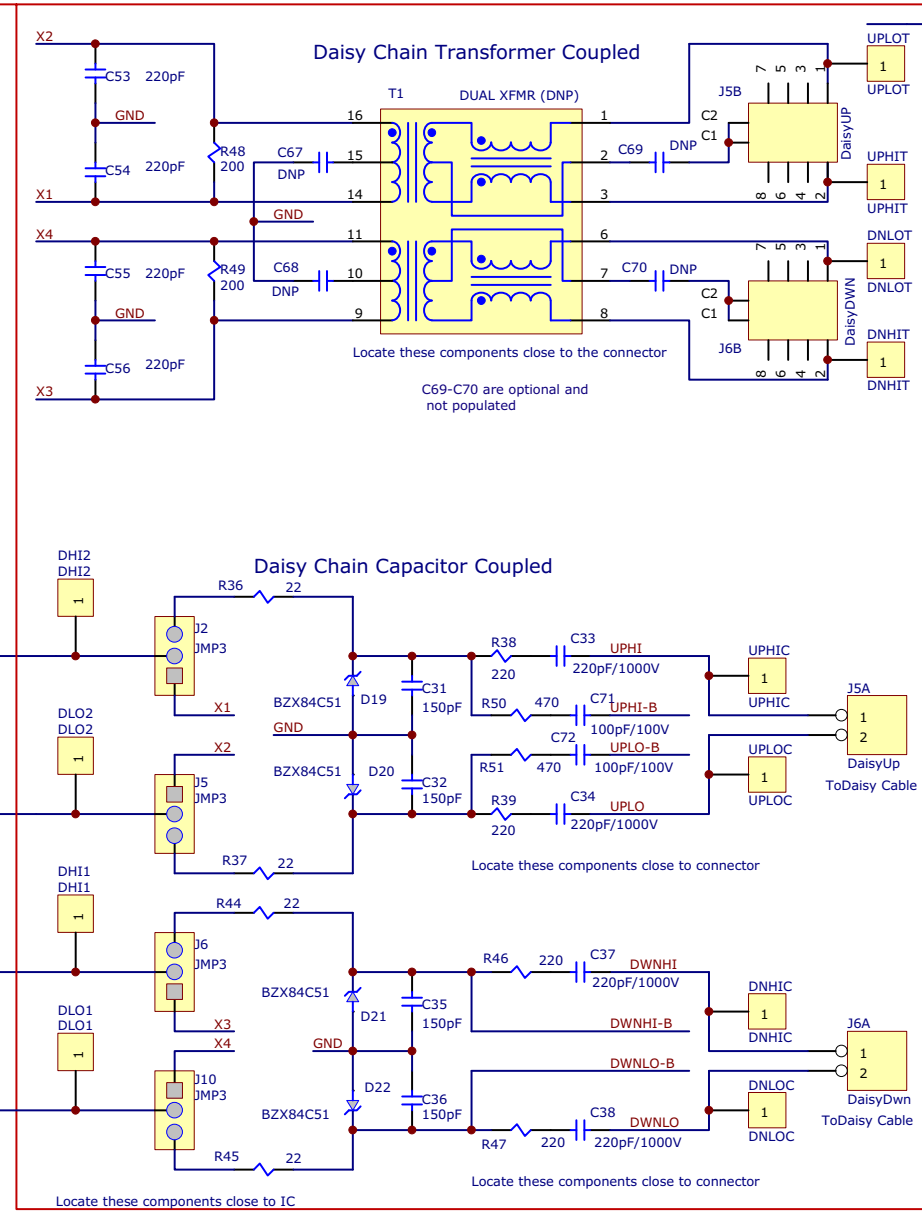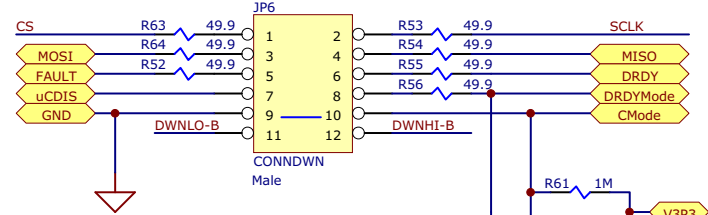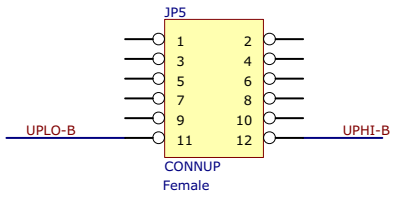UPHIT
UPHIT

J6B

DaisyDWN

DNLOT
DNLOT

DNHIT
DNHIT

Locate these components close to the connector

C69-C70 are optional and
not populated

JP6

CS R63 49.9	1	2	R53 49.9 SCLK
MOSI R64 49.9	3	4	R54 49.9 MISO
FAULT R52 49.9	5	6	R55 49.9 DRDY
uCDIS	7	8	R56 49.9 DRDYMode
GND	9	10	CMode
DWNLO-B	11	12	DWNHI-B

CONNDWN
Male

R61 1M
R62 1M
V3P3

DRMd DRMd
CMd CMd

uC can set DRDYMode = LOW = Byte-by-Byte SPI.
Default: DRDYMode = V3P3 = Queued SPI.

uC board ties CMode to GND to set Master.

V3P3

R60A 100k   R60B 100k

CMR0
CMR1

R60C DNP   R60D DNP

GND   GND

CR0
CR0

CR1
CR1
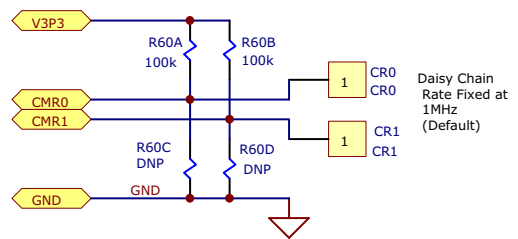
Daisy Chain
Rate Fixed at
1MHz
(Default)

Daisy Chain Capacitor Coupled

DHI2
DHI2

DHI2

J2
JMP3

X1

R36 22

R38 220
C33 220pF/1000V

UPHI

UPHIC
UPHIC

DLO2
DLO2

DLO2

J5
JMP3

X2

BZX84C51 D19
GND
BZX84C51 D20

C31 150pF
C32 150pF

R50 470
C71 UPHI-B 100pF/100V
R51 470
C72 UPLO-B 100pF/100V

J5A
1
2
DaisyUp
ToDaisy Cable

R37 22

R39 220
C34 220pF/1000V

UPLO

UPLOC
UPLOC

Locate these components close to connector

SCLK

DHI1
DHI1

DHI1

J6
JMP3

X3

R44 22

R46 220
C37 220pF/1000V

DWNHI

DNHIC
DNHIC

SCLK/DHI1

SCLK/DHI1

BZX84C51 D21
GND

C35 150pF

DWNHI-B

CS

DLO1
DLO1

DLO1

J10
JMP3

X4

BZX84C51 D22

C36 150pF

DWNLO-B

J6A
1
2
DaisyDwn
ToDaisy Cable

CS/DLO1

CS/DLO1

R45 22

R47 220
C38 220pF/1000V

DWNLO

DNLOC
DNLOC

Locate these components close to connector

Locate these components close to IC

Changes

Figure 26. RTKA489204DE0000BU RevB Board Communications Schematic
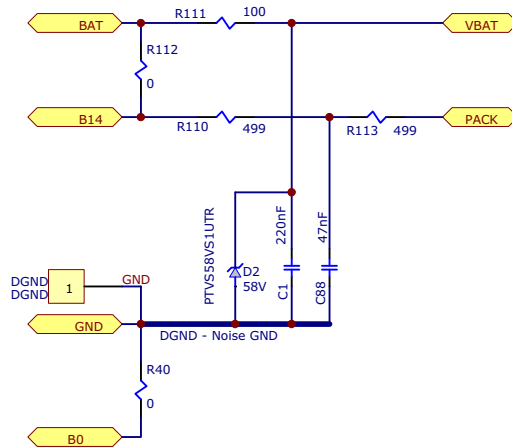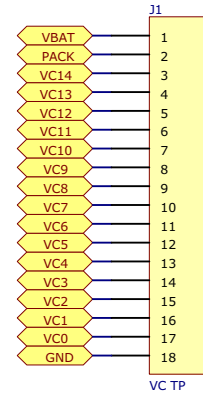
C1, C2= 100V rating

PTVS58VS1UTR breakdown = 64.4V to 71.2V

Changes: Rev B:
Input Resistors changed (PACK) to 499 Ohm (VBAT) to 100 Ohm
0 Ohm resistors added between VBATand VC14 - and between VSS and VC0
VBAT cap changed to 220nF

J3 = Sullins, P/N: STC02SYAN
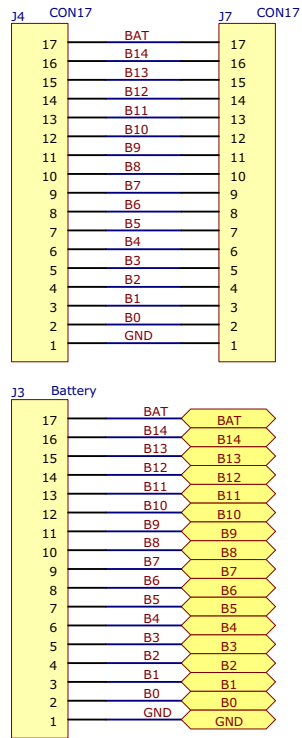   Mates to PCB Socket, Sullins P/N: NPTC171LGBN-RC
    or, Mates to cable connector, Molex P/N: 0050579017
    or, Mates to cable connector, TE Connectivity P/N: 3-87499-2

J3 = TE Connectivity (R/A connector), P/N: 6-104935-6
    Mates to cable connector: TE Connectivity P/N: 1-104257-6

Cable wire 3M 8124 Series
Cable Pins: TE Connectivity: P/N: 1-104480-7
Cable Pins: Molex: P/N: 0016020086

Figure 27. RTKA489204DE0000BU Board Battery and Power Supply Connection Schematic
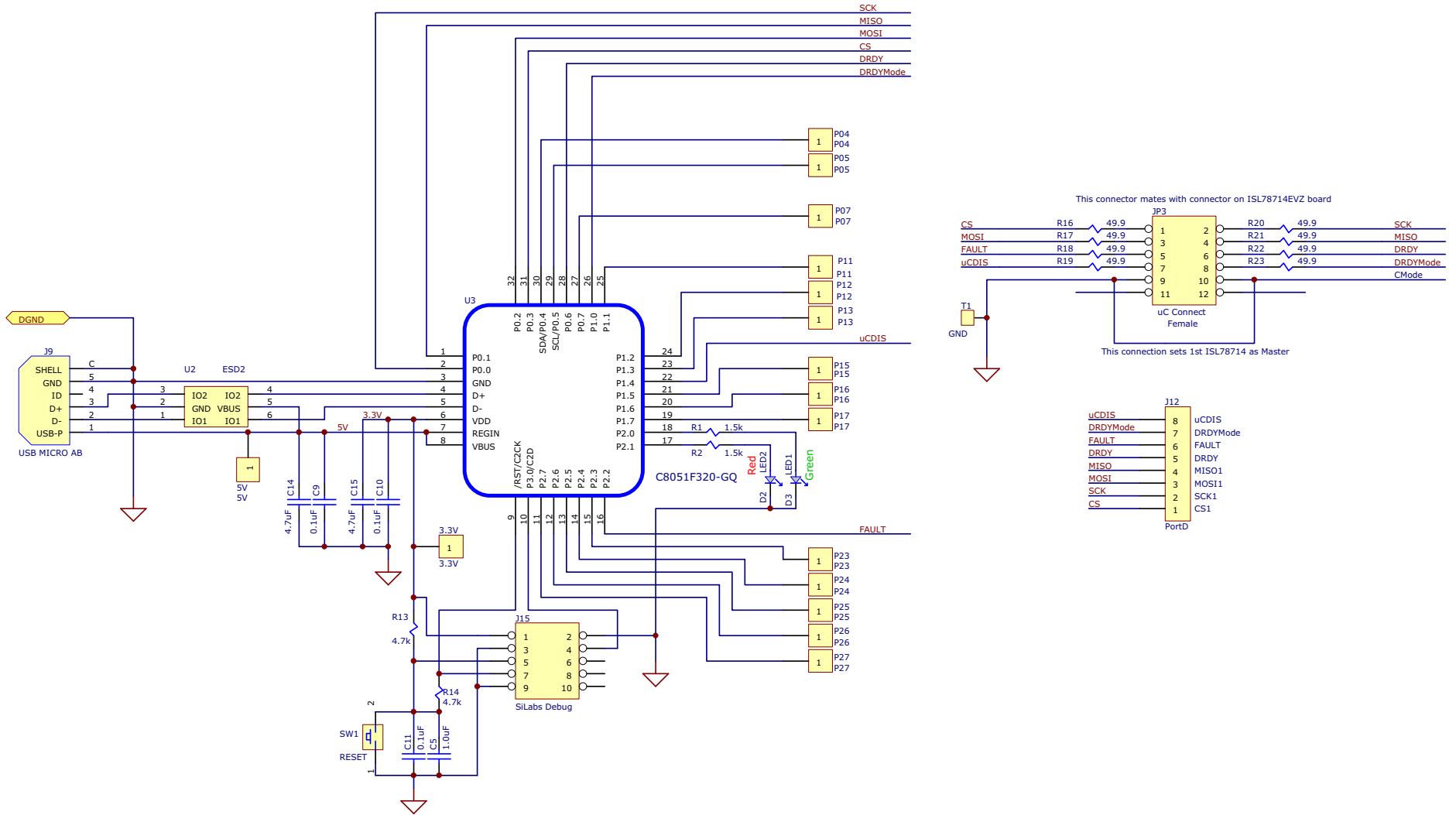
3.2.2 RTKA489204MICROZ

Figure 28. RTKA489204MICROZ RevD Microcontroller Schematic
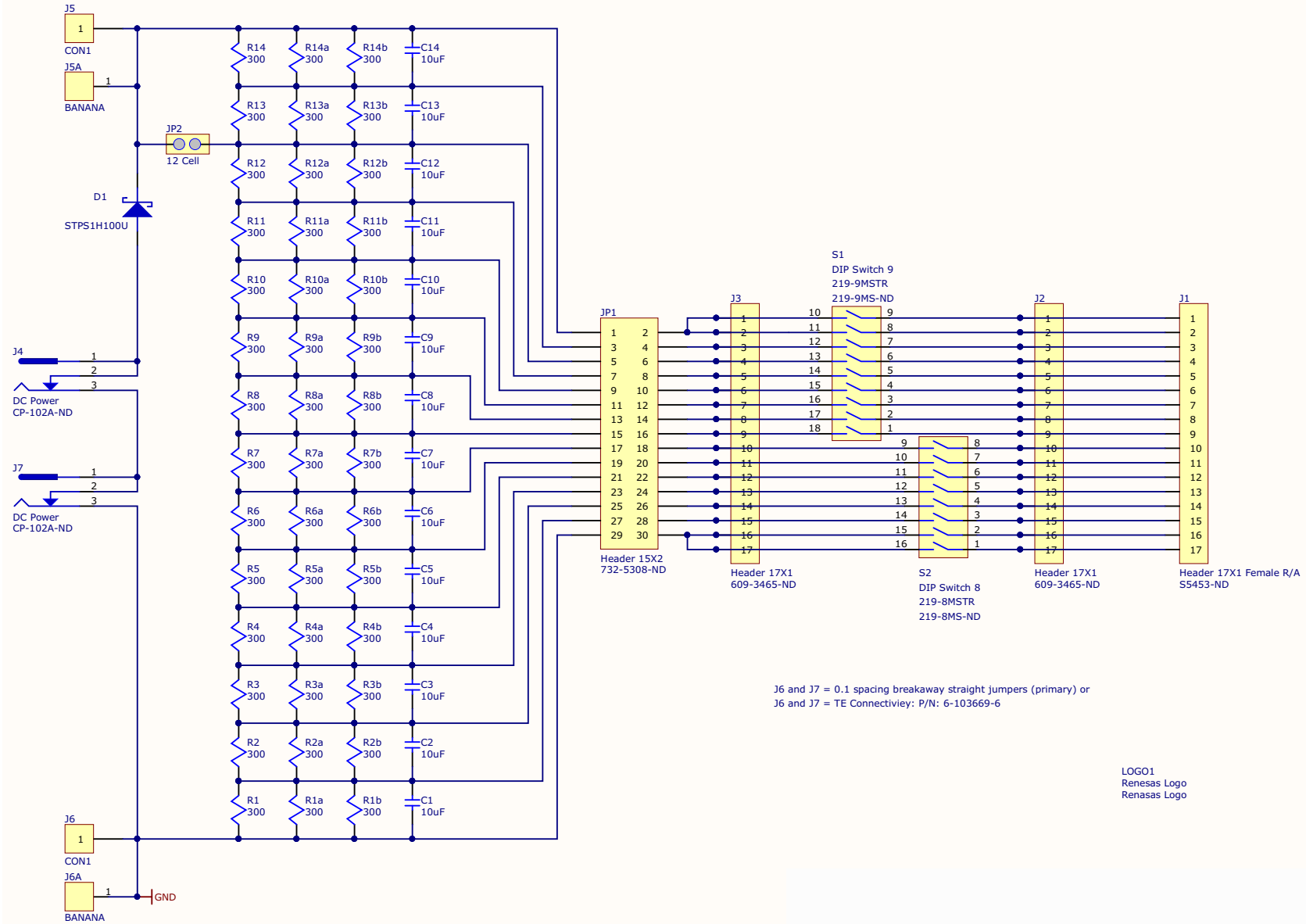
3.2.3   MCB_PS4_Z Power Supply

Figure 29. MCB_PS4_Z Power Supply Board Schematic

3.3   Bill of Materials

3.3.1   RTKA489204DE0000BU RevB Evaluation Board

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1		PWB-PCB, RTKA489204DE0000BU, REVB, ROHS	Imagineering Inc	RTKA489204DE0000BUREVBPCB
1	C18	CAP, SMD, 0603, 2.2µF, 10V, 10%, X7R, ROHS	Murata	GRM188R71A225KE15D
20	C20-C25, C39-C52	CAP, SMD, 0402, 0.01µF, 50V, 10%, X7R, ROHS	Venkel	C0402X7R500-103KNE
2	C19a, C26a	CAP, SMD, 0603, 0.01µF, 16V, 10%, X7R, ROHS	Venkel	C0603X7R160-103KNE
4	C19, C26, C27, C28	CAP, SMD, 0603, 1.0µF, 10V, 10%, X7R, ROHS	AVX	0603ZC105KAT2A
4	C31, C32, C35, C36	CAP, SMD, 0603, 150pF, 100V, 5%, C0G/NP0, ROHS	TDK	C1608C0G2A151J080AA
4	C53, C54, C55, C56	CAP, SMD, 0603, 200pF, 100V, 5%, C0G/NP0, ROHS	Samsung	CL10C201JB8NNNC
30	C2-C17, C73-C88	CAP, SMD, 0603, 0.047µF, 100V, 10%, X7R, ROHS	Kemet	C0603C473K1RACTU
0	C67-C70	CAP, SMD, 0603, DNP-PLACE HOLDER, ROHS		
2	C71, C72	CAP, SMD, 0805, 100pF, 100V, 5%, C0G, ROHS	Venkel	C0805C0G101-101JNE
1	C1	CAP, SMD, 0805, 0.22µF, 100V, 10%, X7R, ROHS	Kemet	C0805C224K1RACAUTO
2	C29, C30	CAP, SMD, 1206, 1µF, 100V, 10%, X7R, ROHS	Venkel	C1206X7R101-105KNE
4	C33, C34, C37, C38	CAP, SMD, 0805, 220pF, 1000V, 5%, C0G, ROHS	Vishay/Vitramon	VJ0805A221JXGAT5Z
6	DGND, DGND1-DGND5	CONN-MULTI-PURPOSE TEST PT, BLK, ROHS	Keystone	5011
4	D19-D22	DIODE-ZENER, 51V, 6%, 225mW, SMD, 3P, SOT23, ROHS	ON Semiconductor	BZX84C51LT1G
1	D2	TVS-ZENER DIODE, AEC-Q101, SMD, SOD-123W, 58V, 4.3A, 400W, ROHS	NXP Semiconductor	PTVS58VS1UTR,115
2	D1, D3	LED-SMART, SMD, 0603, GREEN, 1.7V, 2mA, 570nm, 3.9mcd, ROHS	Osram	LGL29K-G2J1-24-Z
1	D4	LED-SMART, SMD, 0603, 2P, RED, 1.8V, 2mA, 630nm, 4.5mcd, ROHS	Osram	LSL29K-G1J2-1-0-2-R18-Z
14	D5-D18	LED, SMD, 0402, YELLOW/CLEAR, 1.9V, 1mA, 586nm, 7.6mcd, ROHS	ROHM	SML-P11YTT86
2	J7	CONN-HEADER, 1x17, BREAKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
2	J1	CONN-HEADER, 1x18, BRKAWY 1x36, 2.54mm, VERTICAL, ROHS	Berg/FCI	68000-236HLF
3	DISABLE, V3P3LEDEN, uCDIS	CONN-HEADER, 1x2, BRKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
5	J2, J5, J6, J10, J11	CONN-HEADER, 1x3, BREAKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1	J8	CONN-HEADER, 1x4, BRKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
2	J5A, J6A	CONN-HEADER, SHROUDED, TH, 2POS, 2.54mm, R/A, ROHS	Molex	70555-0036
1	JP6	CONN-HEADER, 2x6, BRKAWY-2x36, R/A, 2.54mm, ROHS	Sullins	PEC36DBAN-2X6
1	J9	CONN-HEADER, 2x7, BRKAWY-2x36, R/A, 2.54mm, ROHS	Sullins	PEC36DBAN
1	J3	CONN-HEADER, 1x17, BRKAWY 1x36, R/A, 2.54mm, GOLD, ROHS	Sullins	PEC36SBAN
1	JP5	CONN-SOCKET, TH, 12P, 2x6, R/A, INSULATED, 2.54mm, ROHS	Sullins	PPTC062LJBN-RC
2	J5B, J6B	CONN-MODULAR JACK, RJ45, SMD, 8POS, R/A, SHIELDED, ROHS	Amphenol	RJLSE4238101T
2	Q1, Q2	TRANSISTOR, NPN, 4P, SOT-223, 80V, 1A, 1W, ROHS	Diodes, Inc.	DCP56-16-13
11	Q6-Q16	TRANSISTOR-MOS, N-CHANNEL, SMD, SOT23, 60V, 1.6A, ROHS	Diodes Inc.	DMN6140L-7
3	Q3, Q4, Q5	TRANSISTOR-MOS, P-CHANNEL, SMD, SSOT3, -60V, -1.2A, ROHS	Fairchild	FDN5618P
14	R3C-R16C	RES, SMD, 0402, 0Ω, 1/16W, 5%, TF, ROHS	Venkel	CR0402-16W-00T
15	R81-R94	RES, SMD, 0402, 1k, 1/16W, 1%, TF, ROHS	Venkel	CR0402-16W-1001FT
18	R3B-R16B, R24-R27	RES, SMD, 0402, 10k, 1/16W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1002X
2	R60A, R60B	RES, SMD, 0402, 100k, 1/16W, 1%, TF, ROHS	Panasonic	ERJ2RKF1003
2	R61, R62	RES, SMD, 0402, 1MEG, 1/16W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1004X
14	R67-R80	RES, SMD, 0402, 220k, 1/16W, 1%, TF, ROHS	Samsung	RC1005F224CS
6	R30-R35	RES, SMD, 0402, 49.9Ω, 1/16W, 1%, TF, ROHS	Panasonic	ERJ-2RKF49R9X
0	R60C, R60D, R28, R29	RES, SMD, 0402, DNP, DNP, DNP, TF, ROHS		
4	R36, R37, R44, R45	RES, SMD, 0603, 22Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-0722RL
1	R109	RES, SMD, 0603, 33Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-33R0FT
3	R22, R23, R59	RES, SMD, 0603, 1k, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-3EKF1001V
1	R58	RES, SMD, 0603, 10k, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-1002FT
2	R48, R49	RES, SMD, 0603, 200Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-2000FT
4	R38, R39, R46, R47	RES, SMD, 0603, 220Ω, 1/10W, 1%, TF, ROHS	Yageo	RC0603FR-07220RL
12	a) R41, R42, R43, R60, R65, R66, R114, R116,	RES, SMD, 0603, 402Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-4020FT
0	b) R117, R119, R120, R121	RES, SMD, 0603, 402Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-4020FT

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
2	R50, R51	RES, SMD, 0603, 470Ω, 1/10W, 1%, TF, ROHS	ROHM	MCR03EZPFX4700
19	R1-R5, R7-R17, R57, R110, R113	RES, SMD, 0603, 499Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-4990FT
7	R52, R53, R54, R55, R56, R63, R64	RES, SMD, 0603, 49.9Ω, 1/10W, 1%, TF, ROHS	Venkel	CR0603-10W-49R9FT
2	R115, R118	RES, SMD, 0603, 909Ω, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-3EKF9090V
2	R40, R112	RES, SMD, 0805, 0Ω, 1/8W, TF, ROHS	Yageo	RC0805JR-070RL
1	R111	RES, SMD, 0805, 100Ω, 1/2W, 1%, TF, ROHS	Panasonic	ERJ-P6WF1000V
2	R18, R19	RES, SMD, 0805, 200Ω, 1/8W, 1%, TF, ROHS	Panasonic	ERJ-6ENF2000V
2	R20, R21	RES, SMD, 1206, 200Ω, 1/2W, 1%, TF, ROHS	Panasonic	ESR18EZPF2000
14	R95-R108	RES, SMD, 1210, 100Ω, 1/2W, 1%, TF, ROHS	Panasonic	ERJ-14NF1000U
1	SW1	SWITCH-TACTILE, SMD, 6x3.5, 12V, 0.05A, SPST-NO, ROHS	TE Connectivity	FSMSMTR
1	T1	TRANSFORMER-MODULE, 350uH, SMD, 12.3x7.2, LAN 10/100B-TX, ROHS	Bel Fuse Inc.	S558-5999-T7-F
4	Th1, Th2, Th3, Th4	THERMISTOR-NTC, SMD, 0402, 10k, 1/10W, 5%, ROHS	Murata	NCP15XH103J03RC
1	U1	IC-Li-ION BATTERY MANAGER, 64P, TQFP, 10x10, ROHS	Renesas	RAA489204ANZ
5	Bottom PCB locations identified	BUMPONS, .311inW x .375inH, CYLINDRICAL, PCB SPACERS, BLACK	3M	SJ-67A4
5	LEDEN, [J2, J5, J6, J10] on "CAP" side	CONN-JUMPER, SHORTING, 2PIN, BLACK, GOLD, ROHS	Sullins	SPC02SYAN
0	Th5, Th6 (NCP15XH103J03RC-T)	DO NOT POPULATE OR PURCHASE		
0	a) UPLOC-UPHIC, UPLOT-UPHIT, DNLOT-DNHIT,	DO NOT POPULATE OR PURCHASE		
0	b) DNLOC-DNHIC, DHI1-DHI2-DLO1-DLO2,	DO NOT POPULATE OR PURCHASE		
0	c) CR1-CR0-CMd-DRMd	DO NOT POPULATE OR PURCHASE		

3.3.2   RTKA489204MICROZ RevE Microcontroller Board

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1		PWB-PCB, RTKA489204MICROZ, REVE, ROHS	Imagineering Inc	RTKA489204MICROZREVEPCB
3	C9, C10, C11	CAP, SMD, 0603, 0.1µF, 10V, 10%, X7R, ROHS	Kemet	C0603C104K8RACTU
1	C5	CAP, SMD, 0603, 1.0µF, 10V, 10%, X7R, ROHS	AVX	0603ZC105KAT2A
2	C14, C15	CAP, SMD, 0603, 4.7µF, 10V, 10%, X5R, ROHS	Venkel	C0603X5R100-475KNE
1	D2	LED-SMART, SMD, 0603, 2P, RED, 1.8V, 2mA, 630nm, 4.5mcd, ROHS	Osram	LSL29K-G1J2-1-0-2-R18-Z
1	D3	LED-SMART, SMD, 0603, GREEN, 1.7V, 2mA, 570nm, 3.9mcd, ROHS	Osram	LGL29K-G2J1-24-Z
1	GND	CONN-MULTI-PURPOSE TEST PT, BLK, ROHS	Keystone	5011
1	J12	CONN-HEADER, 1x8, BRKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
1	JP3	CONN-SOCKET, TH, 12P, 2x6, R/A, INSULATED, 2.54mm, ROHS	Sullins	PPTC062LJBN-RC
1	J9	CONN-RECEPTACLE, R/A MICRO USB AB, SMD, 5P, ROHS	Molex	47589-0001
2	R1, R2	RES, SMD, 0402, 1.5k, 1/16W, 1%, TF, ROHS	Venkel	CR0402-16W-1501FT
2	R13, R14	RES, SMD, 0402, 4.7k, 1/16W, 1%, TF, ROHS	Venkel	CR0402-16W-4701FT
8	R16-R23	RES, SMD, 0402, 49.9Ω, 1/16W, 1%, TF, ROHS	Panasonic	ERJ-2RKF49R9X
1	SW1	SWITCH-TACTILE, SMD, 6x3.5, 12V, 0.05A, SPST-NO, ROHS	TE Connectivity	FSMSMTR
1	U2	IC-TVS, ESD PROTECTOR, SMD, 6P, SOT-23-6L, 3pF, 6V, ROHS	STMicroelectronics	USBLC6-2SC6
1	U3	IC-USB uCONTROLLER, 32P, LQFP, HID-REV2.4 PROGRAM, ROHS	Silicon Laboratories	C8051F320-GQ
1	BAG & SHIP W/BOARD	CABLE-USB TYPE A MALE to TYPE MICRO-B MALE, 3FT, ROHS	Qualtek Electronics	3025010-03
3	Apply to bottom of board where indicated.	BUMPONS, .311inW x 0.375inH, CYLINDRICAL, PCB SPACERS, BLACK	3M	SJ-67A4
0	J15 (67996-272HLF-2x5)	DO NOT POPULATE OR PURCHASE		
0	P25, P26, P27 (800-10-064-10-001000-1x3)	DO NOT POPULATE OR PURCHASE		
0	P3.3, P5 (800-10-064-10-001000-1x2)	DO NOT POPULATE OR PURCHASE		

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
0	P04, P05, P07, P11, P12, P13, P15, P16, P17,	DO NOT POPULATE OR PURCHASE		
0	P23, P24 (800-10-064-10-001000-1x11)	DO NOT POPULATE OR PURCHASE		

3.3.3   MCB_PS4_Z RevA Power Supply Board

| Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1		PWB-PCB, MCB-PS4-Z, REVA, ROHS	Imagineering Inc	MCB-PS4-ZREVAPCB
14	C1-C14	CAP, SMD, 0805, 10µF, 16V, 10%, X5R, ROHS	Venkel	C0805X5R160-106KNE
1	D1	DIODE-SCHOTTKY, SMD, 2P, SMB, 100V, 1A, ROHS	STMicroelectronics	STPS1H100U
2	J5, J6	CONN-COMPACT TEST POINT, SMD, ROHS	Keystone	5016
1	JP1	CONN-HEADER, 2x15, BRKAWY-2x36, 2.54mm, ROHS	Berg/FCI	67996-272HLF
2	J2, J3	CONN-HEADER, 1x17, BREAKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
1	JP2	CONN-HEADER, 1x2, BRKAWY 1x36, 2.54mm, ROHS	Berg/FCI	68000-236HLF
2	J4, J7	CONN-DC PWR JACK, PCB MNT, 2.1mm, BLACK, R/A, ROHS	CUI Inc	PJ-102A
1	J1	CONN-RECEPTACLE, TH, 1x17, 2.54mm, R/A, TIN, ROHS	Sullins	PPTC171LGBN-RC
16	JP1-Pos 1-15, JP2	CONN-JUMPER, SHORTING, 2PIN, BLACK, GOLD, ROHS	Sullins	SPC02SYAN
42	R1-R14, R1a-R14a, R1a-R14a	RES, SMD, 1206, 300Ω, 1/4W, 1%, TF, ROHS	Stackpole	RMCF1206FT300R
1	S2	SWITCH-DIP, SMD, 8P, SPST, 24V, 25mA, TOP ACTUATE, ROHS	E-Switch	KAE08LGGT
1	S1	SWITCH-DIP, SMD, 9P, SPST, 24V, 25mA, TOP ACTUATE, ROHS	E-Switch	KAE09LGGT
4	Apply to bottom of board where indicated.	BUMPONS, 0.311inW x .375inH, CYLINDRICAL, PCB SPACERS, BLACK	3M	SJ-67A4
0	J5A (111-0702-001)	DO NOT POPULATE OR PURCHASE		
0	J6A (111-0703-001)	DO NOT POPULATE OR PURCHASE		

4. PCB Layout
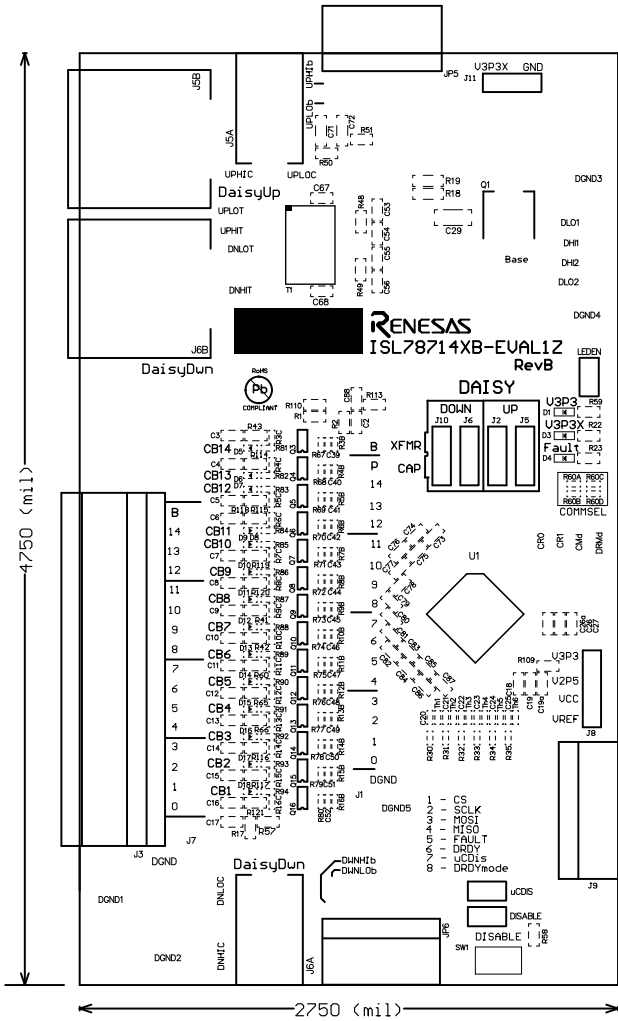
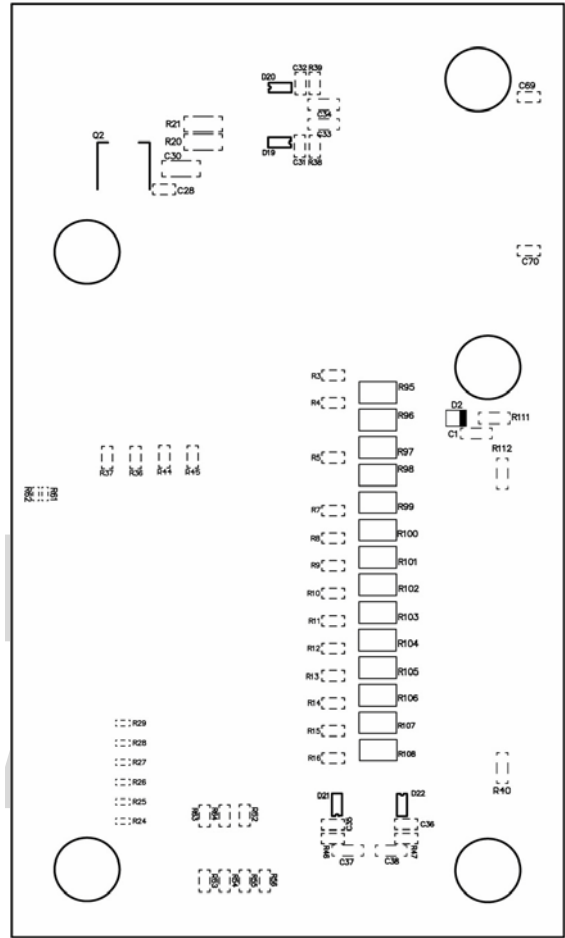**Figure 30. RTKA489204DE0000BU RevB Top Overlay**

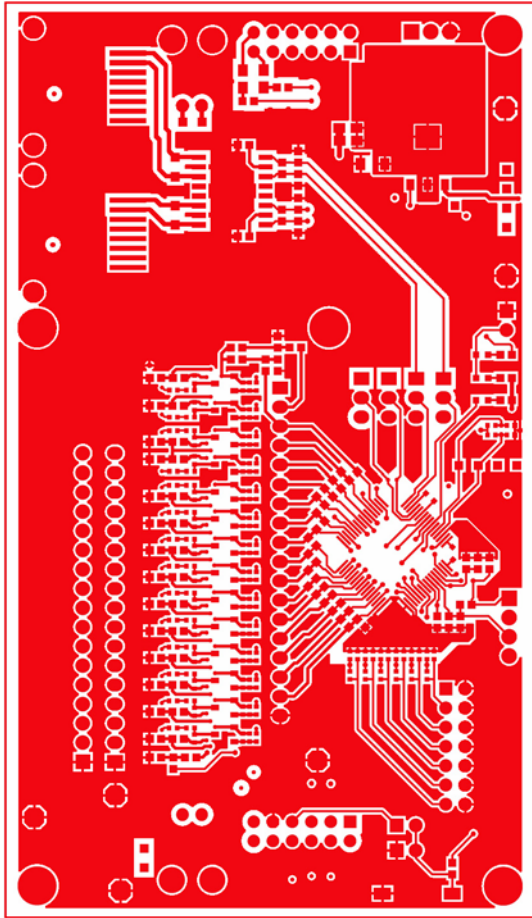**Figure 31. RTKA489204DE0000BU RevB Bottom Overlay**

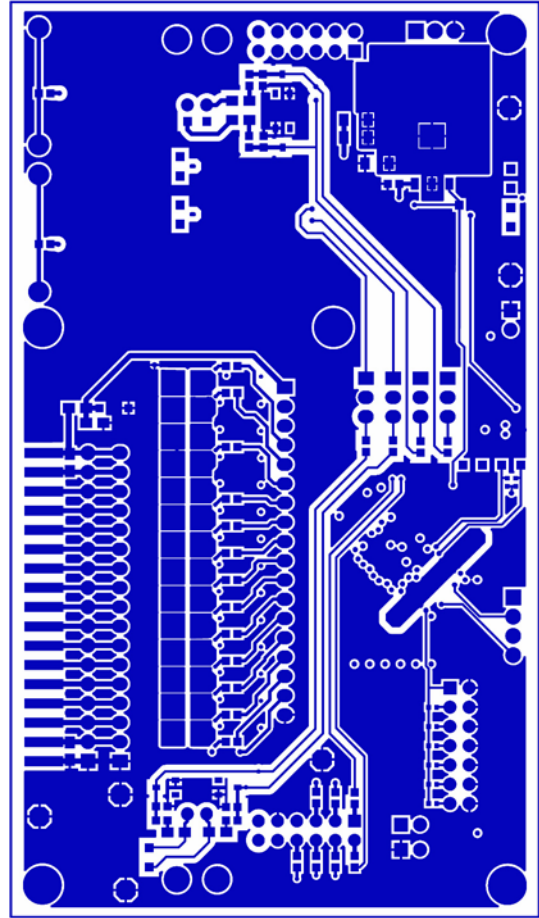Figure 32. RTKA489204DE0000BU RevB Top Layer
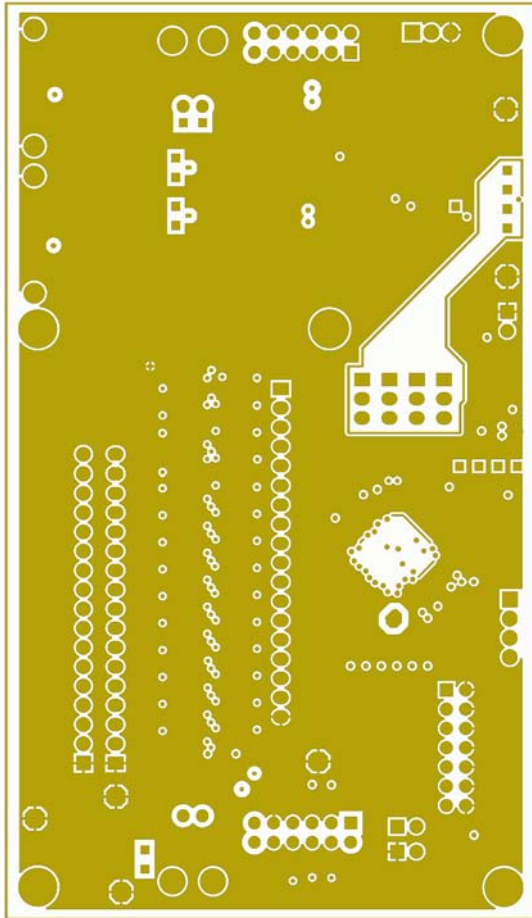

Figure 33. RTKA489204DE0000BU RevB Bottom Layer

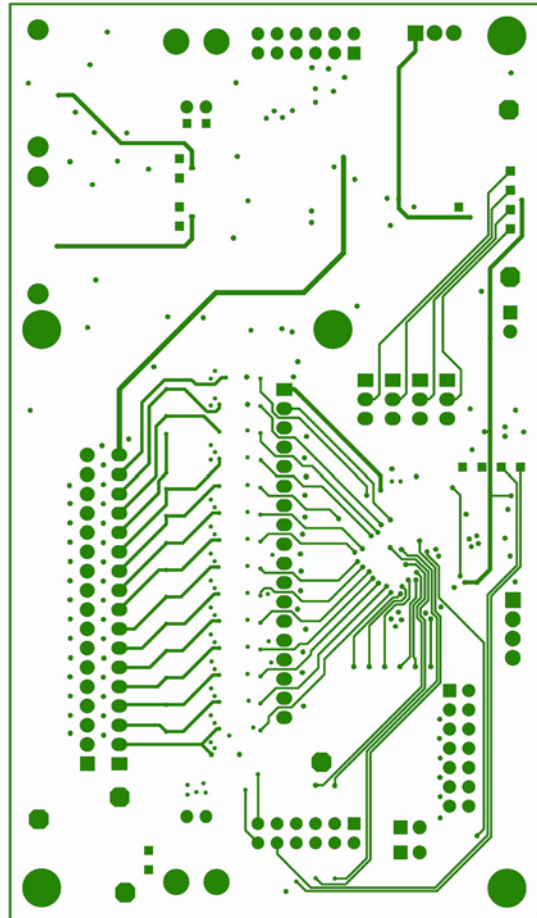Figure 34. RTKA489204DE0000BU RevB Mid 1 Layer

Figure 35. RTKA489204DE0000BU RevB Mid 2 Layer

4.1 PCB Design Guidelines

Figure 25 and Figure 27 (battery connection circuits) show that the first stage of the input filter provides protection against transients and EMI for the cell inputs. The circuits carry the loop currents produced by EMI and should be placed as close to the connector as possible. The ground terminals of the capacitors should be connected directly to a solid ground plane. Do not use vias to connect these capacitors to the input signal path or to ground. Any vias should be placed in line to the signal inputs so that the inductance of these forms a low-pass filter with the grounded capacitors.

In Figure 26, the daisy chain components are shown at the right of the drawing. The components are split into two sections. Components to the right should be placed close to the board connector with the ground terminals of capacitors connected directly to a solid ground plane, which is the same ground plane that serves the cell inputs. Components to the left of this section should be placed as closely to the device as possible.

The battery connector and daisy chain connectors should be placed close to each other on the same edge of the board to minimize any loop current area.

This schematic identifies three grounds that are nominally referred to as noisy, measurement, and quiet grounds. The noisy ground carries the EMI loop currents and digital ground currents, and it consists of a significant ground plane. The quiet ground is used for decoupling of the V_{CC} voltage and two of the three VSS pins. The measurement ground reference is for decoupling the external temperature inputs, the voltage reference, and the remaining VSS pin. The measurement ground is (an island) isolated from the other grounds except for the one connection point to the other grounds near the VSS pins.

The main reason for these connections is to isolate the IC ground from induced currents caused by EMI. The separation of Quiet and Measurement grounding (where the three VSS pins connect at different points on the ground plane) is to minimize, the effect of the IC ground current on the device measurements.

The circuits shown at the bottom of Figure 24 provide external temperature inputs; these inputs are designed to operate with on-board NTC thermistors. To facilitate the use of external thermistors, the circuits include a 49.9Ω series resistor and capacitors to ground. The filter helps protect the IC from ESD at the temperature pins. If external thermistors are required, either remove the on-board thermistors or replace them with 10k resistors.

Each of the external inputs has an internal pull-up resistor connected by a switch to the VCC pin whenever the TEMPREG output is active. This arrangement results in an open input being pulled up to the V_{CC} voltage.

4.2   Component Selection

Certain failures associated with external components can lead to unsafe conditions in electronic modules, for example, a component connected between high energy signal sources that fail short. Such a condition can easily lead to the component overheating and to damage of the board and other components in its proximity.

In using external circuits, you must consider the RAA489204 capacitors that are connected to the cell monitoring inputs. These capacitors are normally protected by the series protection resistors, but they could present a safety hazard in the event of a dual point fault where both the capacitor and associated series resistor fail short. Also, a short in one of these capacitors would dissipate the charge in the battery cell if left uncorrected for an extended period. Renesas recommends selecting fail safe or open mode types for the input capacitors that connect directly to ground. An alternative strategy is to replace each of these capacitors with two devices in series, each with double the value of the single capacitor.

A dual point failure in the balancing resistors of Figure 25 and associated balancing MOSFET could also give rise to a shorted cell condition. In a production environment, Renesas recommends replacing the single balancing resistor with two resistors in series.

The layout of the RTKA489204DE0000BU board attempts the following:

▪ Minimize the placement of signals on inner layers that might exceed the voltage limits on the board. Specifically, these include the daisy chain signals on the cable side of the isolation capacitors. Inner layers do not have as much isolation as external layers.

▪ Minimize the placement on outer layers and the traces carrying signals to and from the RAA489204. This placement is to minimize the potential effects of EMC generated voltages.

▪ The area directly under the RAA489204 IC (on the top layer) is not immediately surrounded by a ground plane. However, the bottom layer does contain a ground plane. The absence of ground on the top layer under the IC is to minimize the effect of temperature induced stress on the IC during soldering.

▪ Extra space is allowed around the daisy chain signals that might experience higher voltages when the boards are cascaded, and extra space can minimize capacitance on the daisy chain signals.

4.3   Evaluation Board Design Details

In the RTKA489204DK0000BU evaluation kit:

1. The microcontroller board is split from the evaluation board.

    a. The microcontroller board is designed to automatically sets the connected evaluation board as the master. To do this, the mode select pin CMODE on the RTKA489204DE0000BU board is pulled up to ground when the µC board connects to the evaluation board.
        The position of other daisy chain devices is determined by the software Roll Call procedure.

    b. If the system uses an external controller, simply eliminate the Renesas microcontroller; eliminate the microcontroller when connecting an external microcontroller by connecting pins 9 and 10 together from the RTKA489204DE0000BU board at connector JP_6. Also, if using an external controller, you must also connect the DATAREADY signal to the external microcontroller in addition to the SPI signals.

2. The CMR1 and CMR0 inputs are set to "1" by on-board resistors. These set the daisy chain speed to 1MHz. If slower speeds are required, these resistors need to change. Remember that changing daisy speeds requires changes to the capacitors in the daisy chain link. To switch to slower daisy chain speeds, check the datasheet for changes to the daisy chain capacitor values for the selected changes to the CMR resistors. These changes require removal and replacement of soldered components on the PCB.

3. Renesas recommends that the daisy chain clock speed remain at 1MHz for transformer coupled connections.

4. Daisy chain capacitor connected operation can be set up with direct board-to-board connection of the boards or with daisy chain cables. These connections use different circuits. The direct connection method mimics a solution where all components for different devices are on the same board. The cable connection circuits use the recommended components for off-board configuration.

5. The external MCB_PS4_Z board has power switches. These can be used to experiment with open wire conditions.

6. The power supply board (MCB_PS4_Z) to evaluation board connection provides direct connection to the RTKA489204DE0000BU board without a cable. If a cable connection between the evaluation board and a battery stack is needed, remove the J_3 connector on the evaluation board and replace it with a different type. One recommended option for cable connection components is shown as follows:

    Vendor: TE connectivity
    PCB connector part number: 6-104935-6
    Mates to cable connector part number: 1-104257-6
    Cable connector pins part number: 1-104480-7
    Cable wire: 3M 8124 series

7. The MCB_PS4_Z board was designed to allow connection of two 24V regulators. When two regulators connect, the evaluation board is powered by 48V. The connectors used have a break-before-make configuration, so removing or adding a second supply causes a power interruption and board reset.

8. This evaluation board monitors the cells after the cell balance resistor.

9. In this condition, turning on a cell balance input pulls the input voltage low, so monitoring that input returns near 0V. This configuration is preferred for safety coverage, because the system can check this voltage to confirm that the input circuit and cell balance components are working correctly.
    Note: Cell Balance operation is not possible when the evaluation board is powered by the MCB_PS4_Z board, because the cell balance current disrupts the voltage divider on the power supply board. To test cell balance operation (without connecting a power supply or batteries), the 0Ω resistors R_{3C} to R_{16C} can be removed. In this case, the balance LEDs show the balance operation, but the balance current is only the LED current (about 3mA to 4mA), which still changes the measured cell voltage by 300mA to 400mA, however, the input voltage does not go to zero.

10. The RTKA489204DE0000BU board has a resistor divider and thermistors on the board for external temperature measurement on ExT1 to ExT4, but not for GPIO1 and GPIO2. The resistor divider is set up for the specific Murata thermistor specified in the BOM. If it is required to connect thermistors off board, remove thermistors (Th_1 to Th_4) or replace them with resistors equal in value to the external thermistors. Also, if the external thermistors differ in room temperature resistance, it might also be necessary to replace the upper resistor in the divider (R_{24} to R_{27}) with more appropriate valued ones.

11. If using the ExTn inputs for monitoring a voltage, remove the on-board thermistors (Th_1 to Th_4) and the upper divider resistors (R_{24} to R_{27}), and apply a voltage (between 0V and 2.5V) directly to the pins on J_8. Measurement happens in response to a Scan Temperatures command.

12. The GPIO pins can be used as inputs to monitor a voltage or outputs (to show internal signals). They can also be used as temperature inputs, but it would be necessary to add in the pull-up resistors ($R2_8$, $R2_9$) and (if required) thermistors (TH_5 and TH_6).

4.4 Questions and Answers

Q: When the GUI starts up it appears that nothing happens.

A: The most common problem encountered when setting up the boards is a connection error. When the GUI powers up correctly and connects to the microcontroller dongle, the green LED on the microcontroller board lights up. If it does not, click the **STOP GUI** button, then click on the arrow in the upper left of the GUI until it shows a multiple black arrow (see Figure 36.)

Program Stopped   Program Running

Click here to restart GUI

Figure 36. Restarting the GUI

If the green LED on the microcontroller board still does not work, try this step again, but press the microcontroller board reset button first.

When the LED on the microcontroller board is green, press the **Roll Call** button. If communication is successful, the indicator in the GUI turns green and the number of devices shows non-zero.

If you are still having trouble, check below:

Q: The LED on the microcontroller board shows green, but I still have no communication with the GUI.

A: Verify that the cables are connected properly.

▪ Make sure that the µC board is plugged into the evaluation board correctly.

▪ Check that the evaluation board is powered up (the Evaluation board should show two green LEDs.)

▪ When both LEDs turn on, the part is powered for about a minute, unless there is communication to the board. So, when both LEDs are on, click **Roll Call** on the GUI within one minute, then click **Set WDT to Max** to set the sleep timer to its maximum value.

▪ Check that the DAISY DOWN jumpers are set to CAP or disconnected.

▪ For a daisy chain configuration, make sure the daisy chain jumpers are set correctly on all boards for the board connect method chosen.

▪ Make sure that the daisy chain cables connect to the proper device. That is, the DaisyUp on one board connects to DaisyDwn on the one above. Make sure that the connections look like those in Figure 5, Figure 6, or Figure 7.

▪ Check that the V_{BAT} voltages are all within specified limits.

▪ Check that the CRC Seed value in the upper right side of the GUI is set to 'FFFF'.

Q: I expect to see two green LEDs illuminated on the board(s), but there is only one LED (or no LEDs) illuminated.

A1: If only one LED is on:
If the V3P3 LED is on, but the V3P3X LED is off, the device is most likely in a sleep state.

▪ Cycle the power on the evaluation boards. If the both LEDs turn on when doing this, then it is likely that the ICs were all sleeping,

▪ Or, press the DISABLE button on the evaluation board momentarily to disable, then re-enable, the part. If both LEDs come on, then it is likely that the device was in a sleep state.

▪ If there is only one evaluation board, or if there is only one green LED on the Master board, then check to see that the switches on the MCB_PS4_Z board is set to ON. (The master/standalone board LED might be on because of its connection to the microcontroller board, but the board may not be powered.)

▪ Click on the **Wakeup/HReset Precursor** button, followed by a click on the **Wake** button. This should wake the boards (both green LEDs on plus a red LED). The red LED would typically indicate a WDT timeout fault. If the LEDs turn on after this step, it is also an indication that the ICs were sleeping.

- Click the **Wake/HRESET Precursor** button then click the **HRESET** button. If this works to restore communications, then it is likely a combination of devices sleeping and one or more devices in an unknown state.
- If the attempts to wake the boards are not solved by the procedures above, check the voltage on the V3P3 and VREF pins. V3P3 should be 3.3V when operating or about 2.7V when asleep. VREF should be 2.5V when operating and off when asleep. If the voltages are different from these, then there could be a board problem and you should contact your Renesas representative.

A2: If both LEDs are off, the board is not powered or the LEDEN jumper is missing. Check that the MCB_PS4_Z board is connected to the Evaluation board and to a power supply and that the switches on the power supply board are set to ON. Check the voltage on the B pin on jumper J7. This should equal the external power supply voltage. If this voltage is good and if the LEDEN jumper is in place, there could be a board problem and you should contact your Renesas representative.

Q: I have three boards connected, but the GUI shows only two.

A: This indicates that there is a problem with the top board or the connection between the second and third boards. Check that the daisy cable connects to the proper place and that the jumpers are correct for the required connection. If this does not work, swap the cables between the three boards. If the GUI then shows only one board, there is a bad cable.

Q: I am trying to program set the Internal Balance bit, IBAL, but I cannot set it?

A: Unfortunately, the board connected is populated with an RAA489204 device that was factory programmed as external balance only. This should not be a problem, because this board was set up as an external balance board. re-configuring the hardware for internal balance would entail a lot of board changes and expose the RAA489204 to potential hot plug issues if the changes are done incorrectly. If an internal balance configuration is required, contact your Renesas representative.

Q: Communication has stopped, and the Roll Call operation does not work.

A1: There is a condition that can arise in which daisy chained boards go to sleep and the master device is reset (power cycled or EN toggled). In this case, it is necessary to perform a **Wakeup_HReset Precursor** command, followed by a **Wakeup** command before performing a Roll Call command to re-establish communications.

A2: If the host microcontroller and SPI software is customer specific and is not the dongle that comes from the kit, then try pressing and releasing the Disable button on the Master device and re-try Roll Call. If the SPI communications are too slow, it is possible the Master gets an extra byte in the buffer which prevents it from recognizing subsequent commands. If this solves the problem, this is an issue with the Master only, it is not necessary to reset.

4.5 Errata

At the time of release, there are no known errors in the design/operation of the evaluation board.

5.   Typical Performance Charts

Unless noted: V$_{BAT}$ 30V, T$_A$ = +25°C. The waveforms in Figure 37 through Figure 44 are based on signals captured by an oscilloscope, or they are from exported data from the RAA489204 GUI software and charted in Excel. Measurements are captured from three RAA489204 devices operating in daisy chain mode, and measurements are taken as time assigned as the x-axis, which provides information regarding the typical subsystem reading variation. Some graphs also provide device-to-device comparisons.
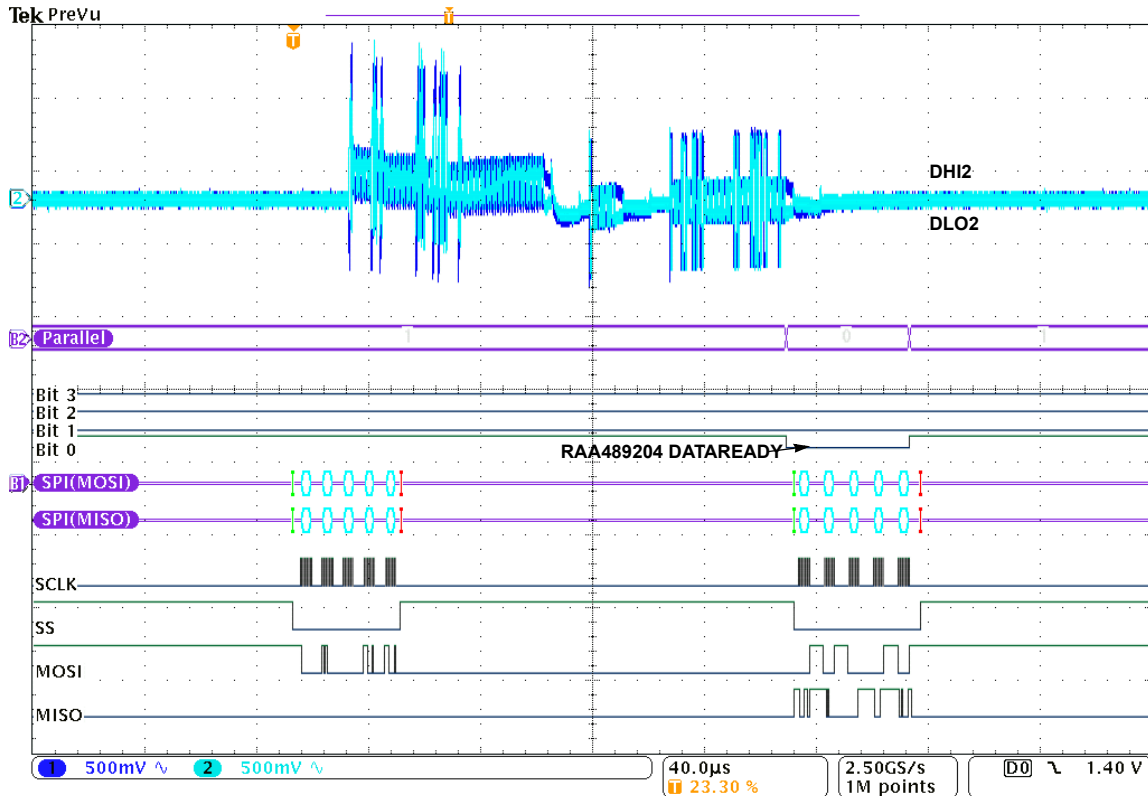
Figure 37. SPI/Daisy Chain Full Roll Call Command and Response (3 Device Stack)
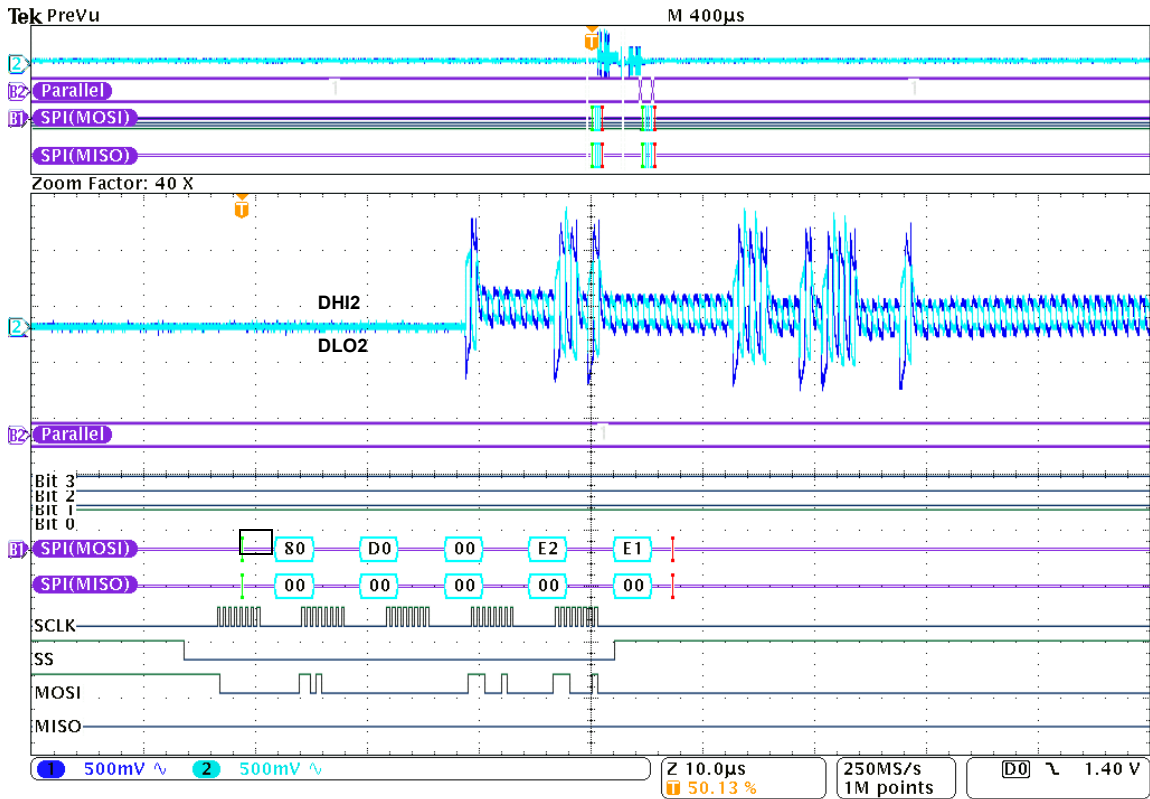
Figure 38. SPI/Daisy Chain Roll Call Command
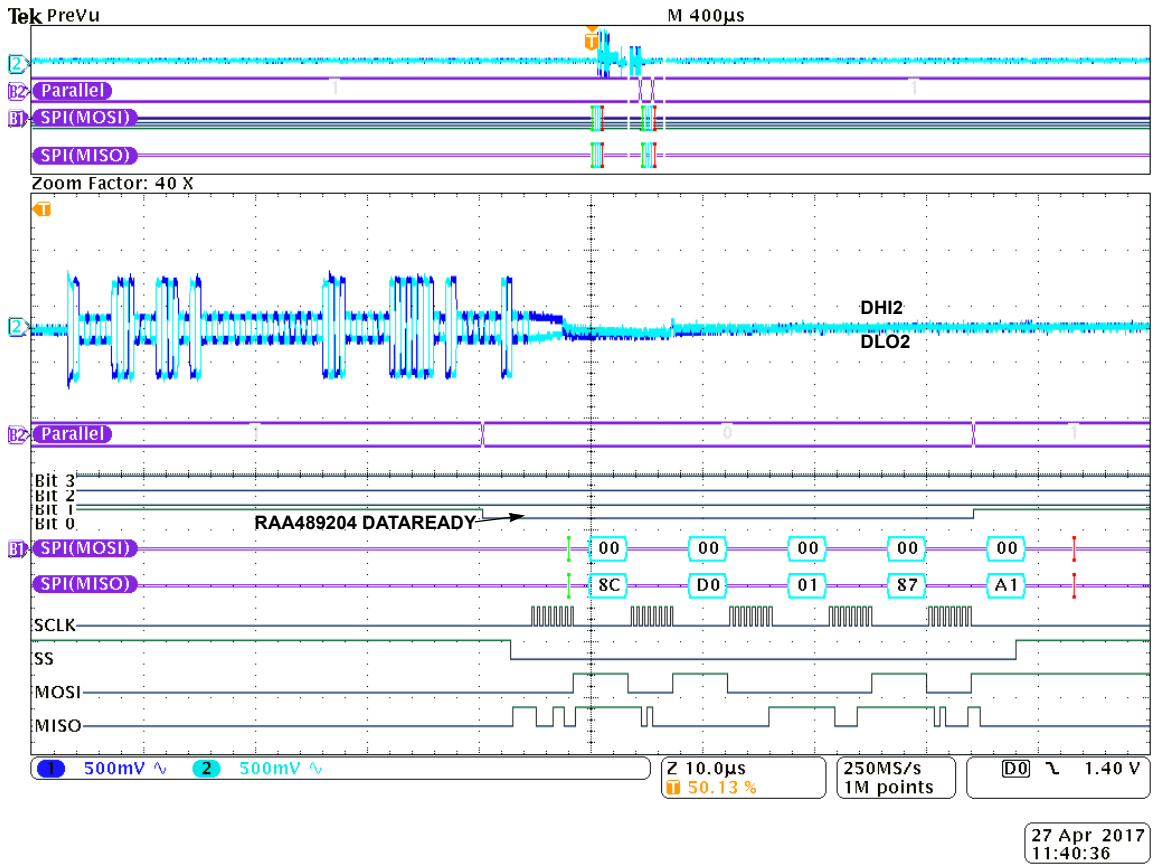
Figure 39. SPI/Daisy Chain Roll Call Response (3 Device Stack)
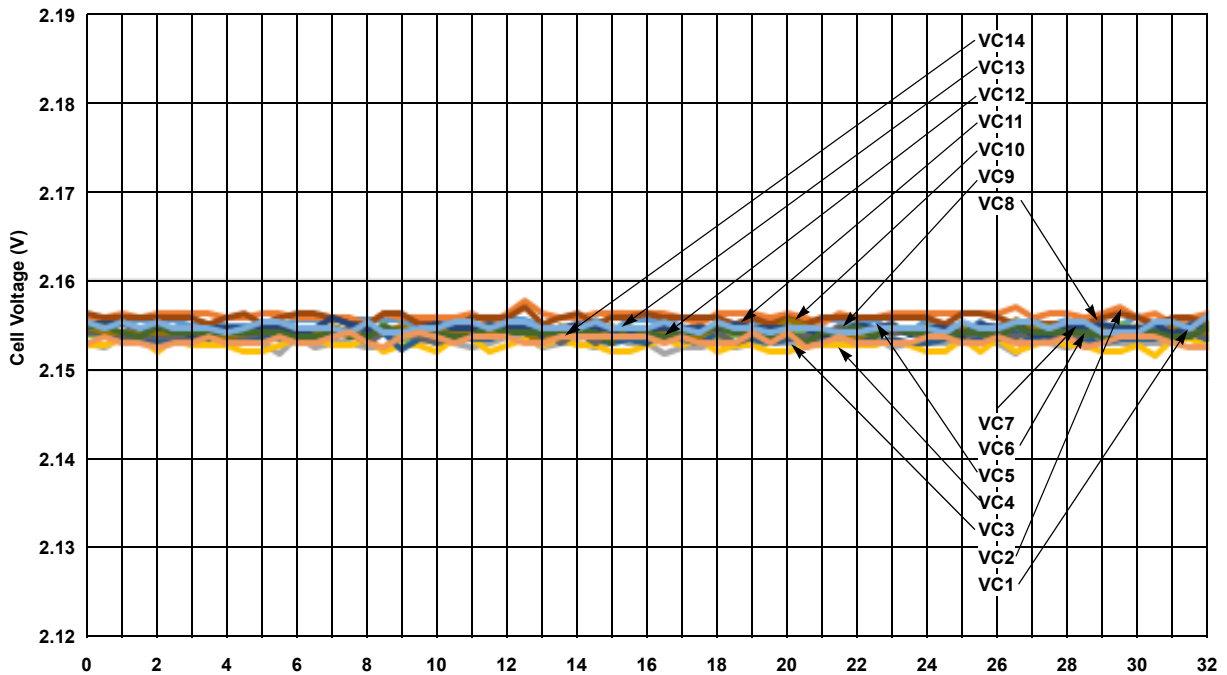
Figure 40. Evaluation Board Cell Voltage Scan - Board 1
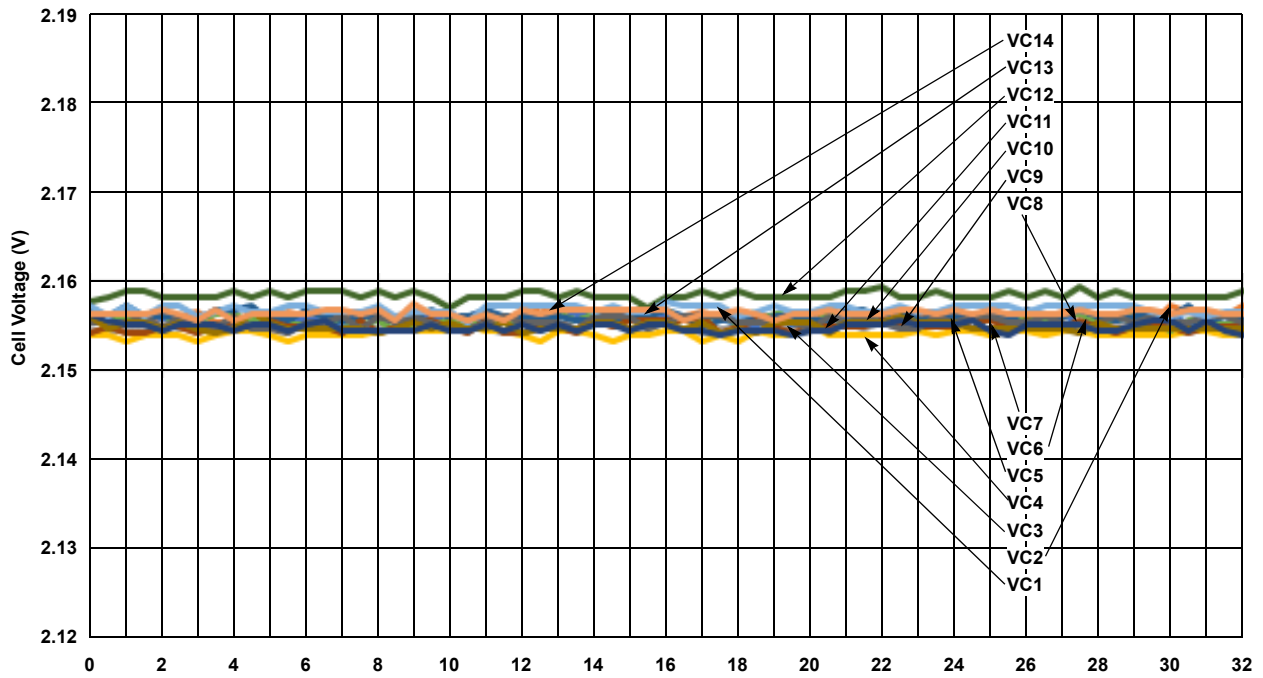
Figure 41. Evaluation Board Cell Voltage Scan - Board 2
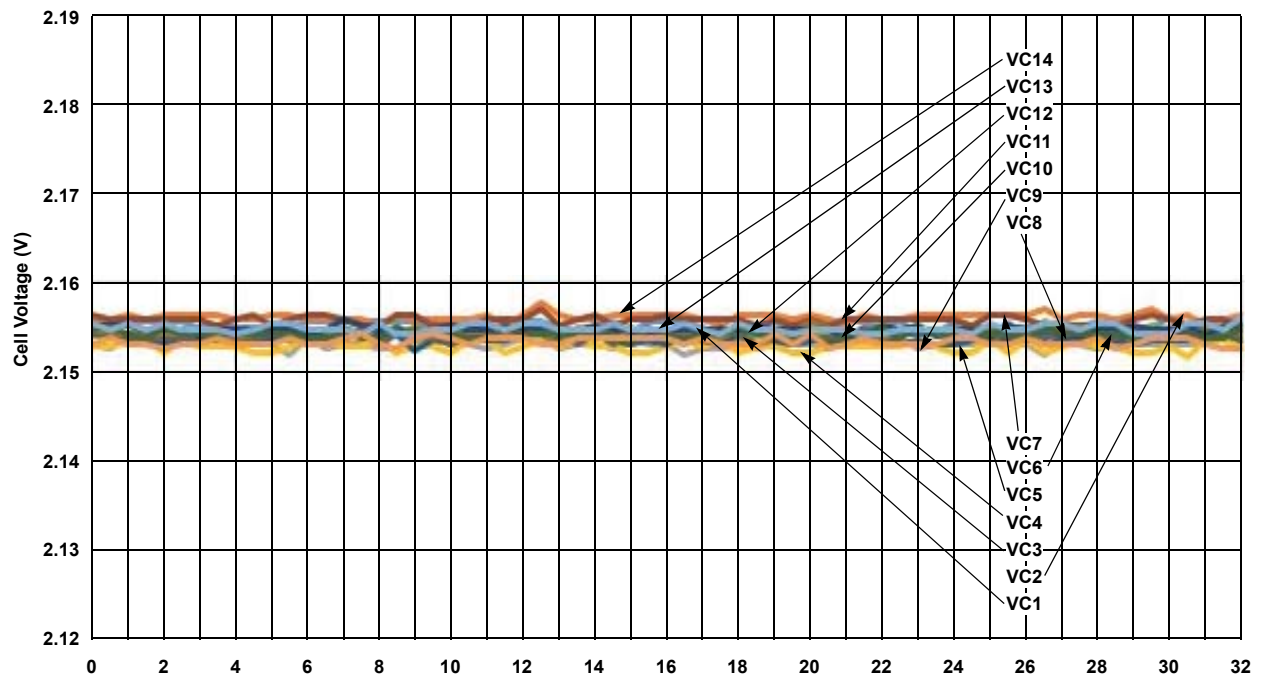
Figure 42. Evaluation Board Cell Voltage Scan - Board 3
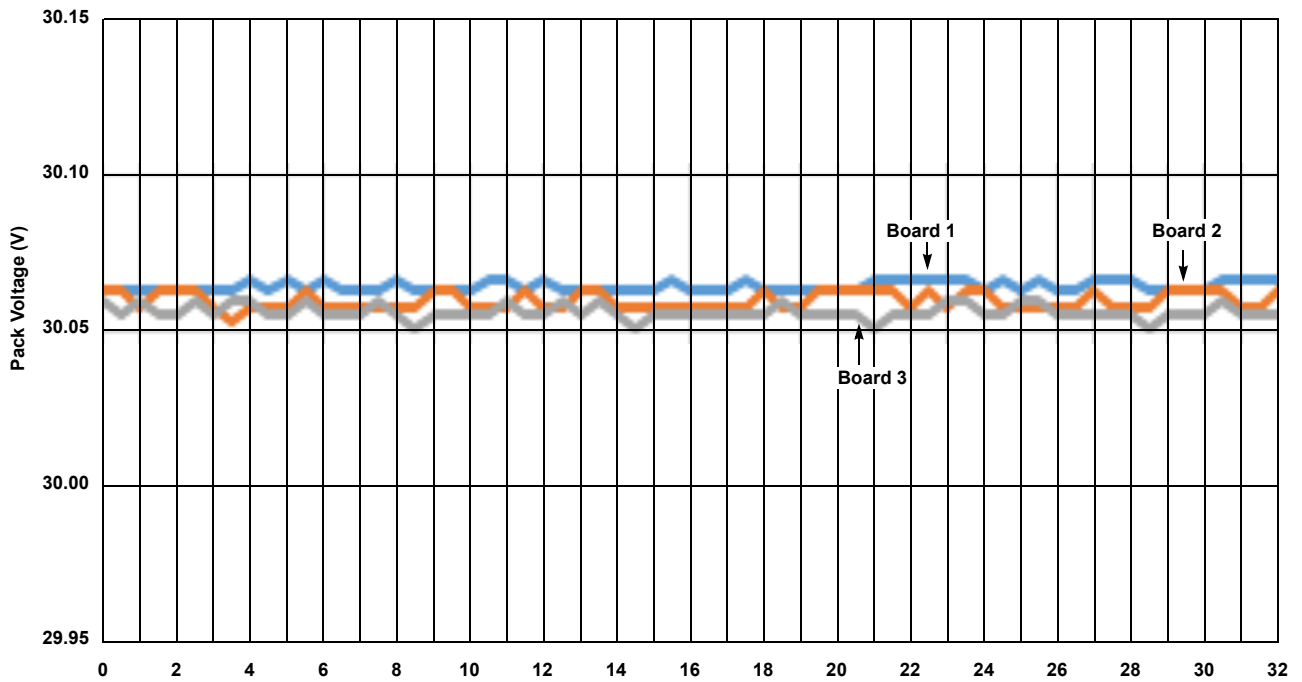
Figure 43. Evaluation Board Pack Voltage Scan
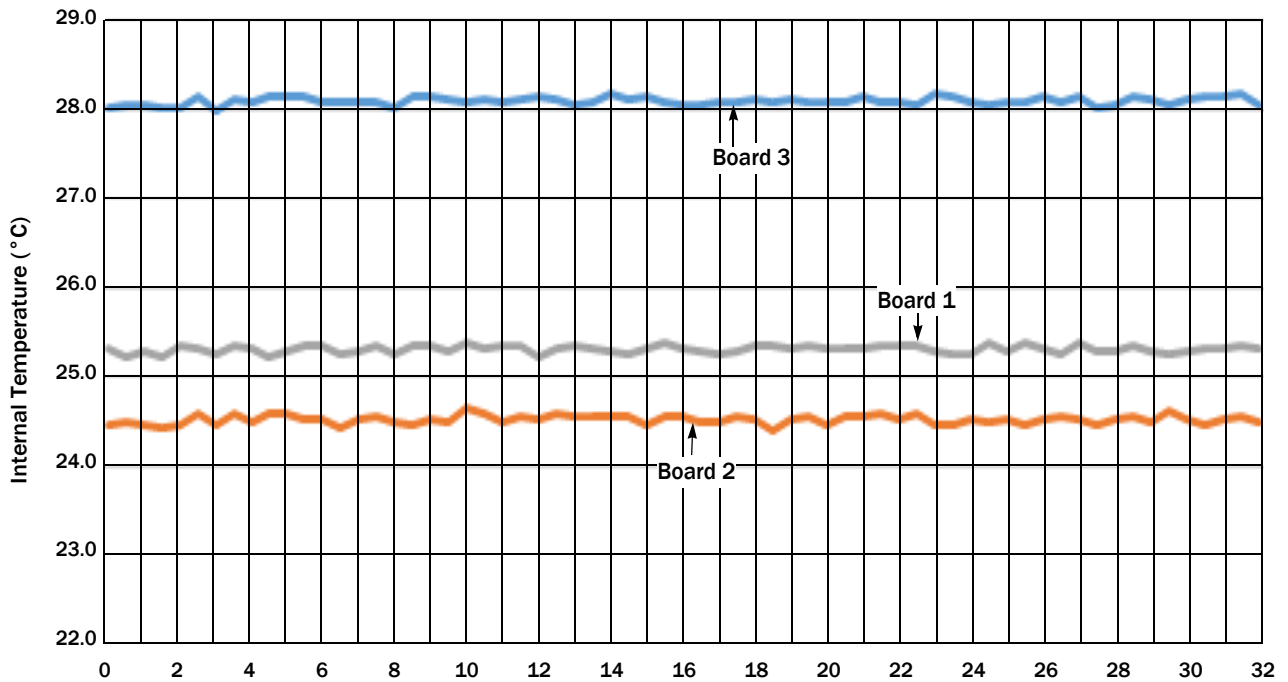
Figure 44. Evaluation Boards RAA489204 Internal Temperature

6. Ordering Information

Part Number	Description
RTKA489204DK0000BU	Evaluation Kit for the RAA489204

7. Revision History

Revision	Date	Description
1.00	Sep 23, 2021	Initial release

IMPORTANT NOTICE AND DISCLAIMER

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