

KIT33771TPLEVB evaluation board

Featuring the MC33771 battery cell controller IC



Figure 1. KIT33771TPLEVB

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1 Important notice

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This evaluation kit is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This evaluation board may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. This evaluation board is not a Reference Design and is not intended to represent a final design recommendation for any particular application. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

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2 Getting started

2.1 Kit contents/packing list

The **KIT33771TPLEVB** contents include:

- Assembled and tested evaluation board/module in anti-static bag
- Quick start guide

2.2 Jump start

NXP's analog product development boards serve as an easy-to-use platform for evaluating NXP products. They support a range of analog, mixed-signal and power solutions. The boards incorporate monolithic ICs and system-in-package devices that use proven high-volume SMARTMOS technology. NXP products enable longer battery life, smaller form factor, component count reduction, ease of design, lower system cost and improved performance in powering state of the art systems.

- Go to www.nxp.com/KIT33771TPLEVB
- Review your Tool Summary Page
- Look for



Jump Start Your Design

- Download the documents, software, and other information

Once the files are downloaded, review the user guide in the bundle. The user guide includes setup instructions, BOM and schematics. Jump start bundles are available on each tool summary page with the most relevant and current information. The information includes everything needed for design.

2.3 Required equipment and software

To use this kit, you need:

- Power supply with a range of 10 V to 70 V and a current limit set initially to 1.0 A
- Oscilloscope (preferably four-channel)
- KIT33664AEVB isolated network high speed transceiver (optional)

3 Getting to know the hardware

3.1 Board overview

The KIT33771TPLEVB evaluation board serves as a hardware evaluation tool in support of NXP's MC33771 device. The MC33771 is a battery cells controller that accommodates up to fourteen lithium-Ion batteries. It is designed for use in both automotive and industrial applications. The device performs ADC conversion on the differential cell voltage and currents. It is also capable of battery charge coulomb counting and battery temperature measurements. The KIT33771TPLEVB evaluation board is an ideal platform for rapid prototyping of MC33771-based applications that involve current, voltage, and temperature sensing.

The KIT33771TPLEVB includes a transformer enabling communication in a high speed isolated communication network. The information is digitally transmitted to a microcontroller for processing. The evaluation board can be used in conjunction with a transceiver physical layer transformer driver (MC33664) to convert MCU SPI data bits to pulse bit information for the MC33771.

3.2 Board features

This KIT33771TPLEVB evaluation board's main features are as follows:

- Daisy chain device connection
- LED indicator for operation mode
- Cell-balancing resistor
- Transformer isolation
- Cell sense input with RC filter
- GPIO: digital I/O, wake-up inputs, convert trigger inputs, ratiometric analog inputs, analog inputs with absolute measurements
- Interface I²C link to an external local EEPROM to store user-defined calibration parameters
- Fault detection pin report

3.3 Block diagram

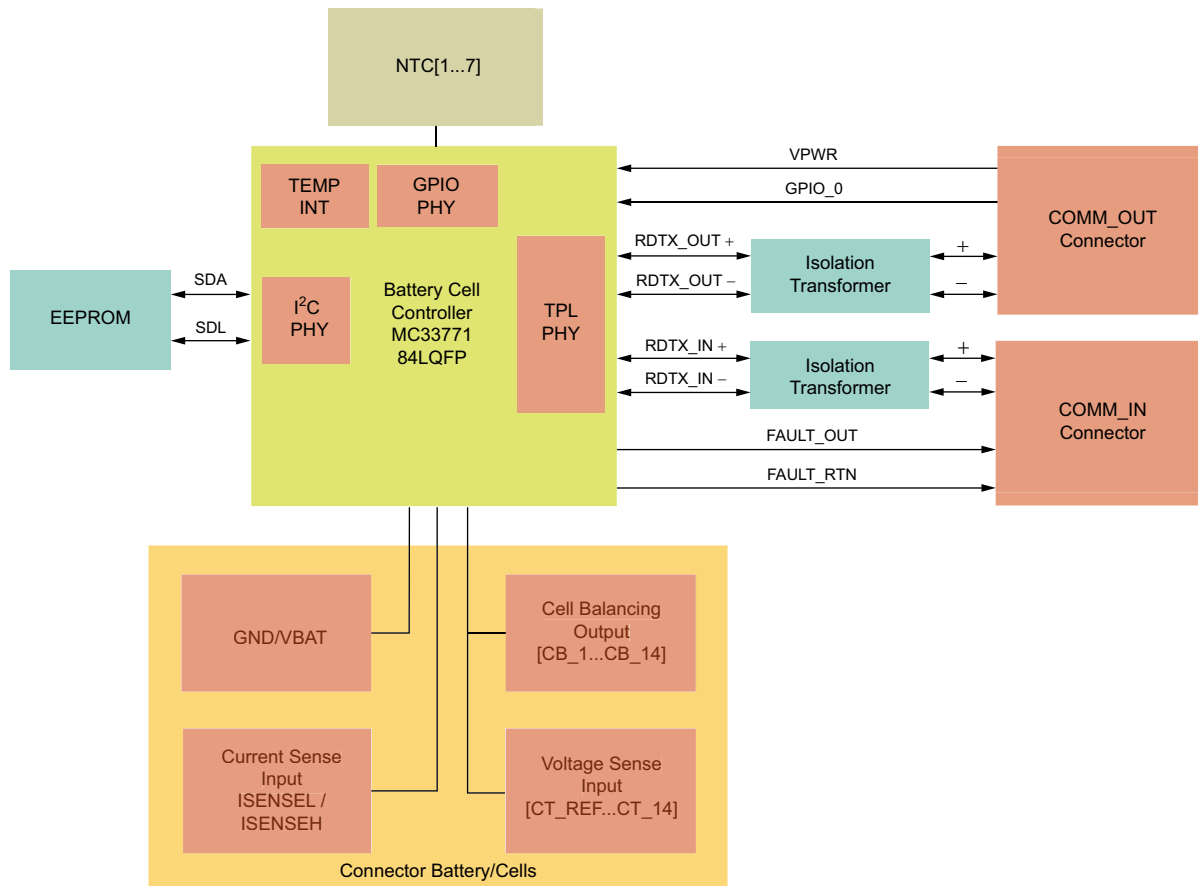


Figure 2. Block diagram

3.4 Device features

The MC33771 is a battery cell controller IC designed to monitor battery characteristics, such as voltage, current and temperature. The MC33771 contains all the circuit blocks necessary to perform synchronous battery voltage/current measurement, coulomb counting, cell temperature measurement and integrated cell balancing. The device supports the following functions:

Table 1. MC33771 device features

| Device | Description | Features |
|---------|-------------------------|---|
| MC33771 | Battery cell controller | <ul style="list-style-type: none"> • 9.6 V VPWR, 61.6 V operation, 70 V transient • SPI or isolated 2.0 MHz differential communication • Synchronized cell voltage/current measurement with coulomb count • Total stack voltage measurement • Seven ADC/GPIO/temperature sensor inputs • Addressable on initialization • 5.0 V at 5.0 mA reference supply output • Integrated sleep mode over/undervoltage and temperature monitoring • Over/undervoltage, over/undertemperature fault verification • Onboard 300 mA passive cell balancing with diagnostics • Open cell pin detection • Internal diagnostics • Hot plug capable • Operational low-power mode |

3.5 Board overview

The KIT33771TPLEVB circuit board allows the user to exercise all the functions of the MC33771 battery controller cell.

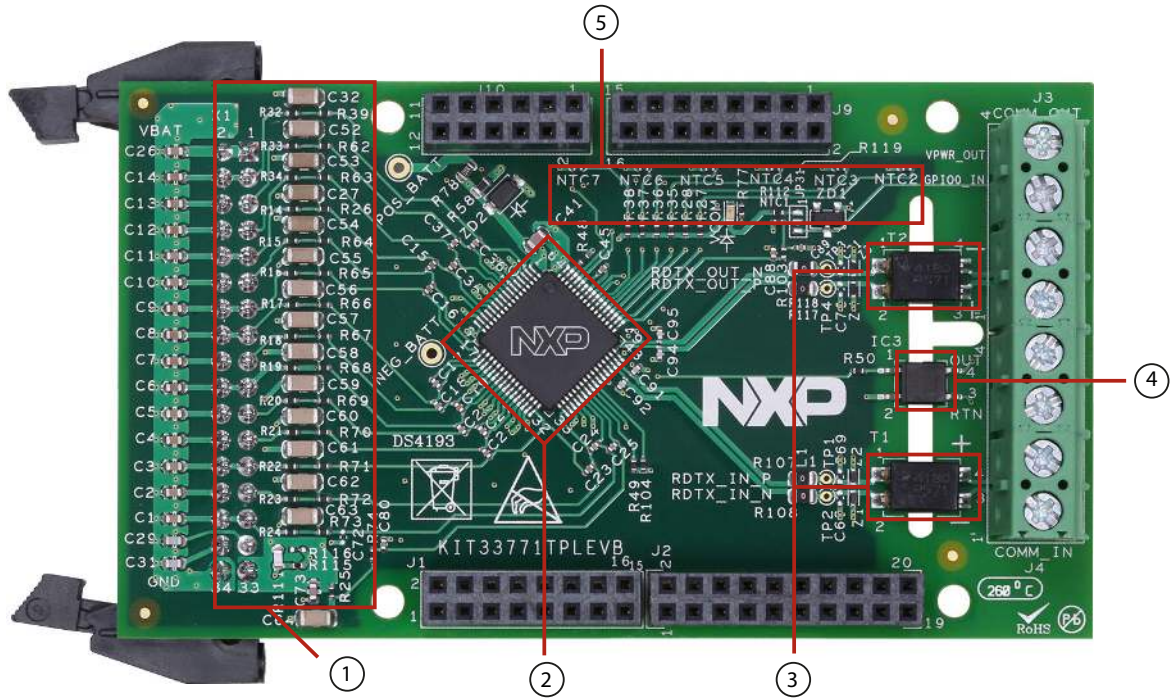


Figure 3. Board description

Table 2. Board description

| Number | Description |
|--------|---|
| 1 | Cells terminal filters — Connection to battery cells through low pass filters |
| 2 | MC33771 — Battery cell controller IC |
| 3 | Transformer isolated communication |
| 4 | Fault detection |
| 5 | GPIO:NYC[1...7] |

3.6 VCOM LED

The VCOM LED is located on the board as shown in [Figure 4](#).



Figure 4. VCOM LED

The VCOM LED indicates when the device is in normal mode. Upon reset, the MC33771 enters into normal mode (VCOM lights). If there is no activity on the bus after a timeout period of 60 seconds, the device enters low-power idle mode (VCOM turns off). Once the device is initialized, if no communication occurs on the TPL bus after 1 second, the device switches to sleep mode and the LED turns off (VCOM off). Depending on the device settings, the VCOM LED may flash every second during cyclic acquisition.

3.7 Test point definitions

Figure 5 shows the location of the test points on the board.

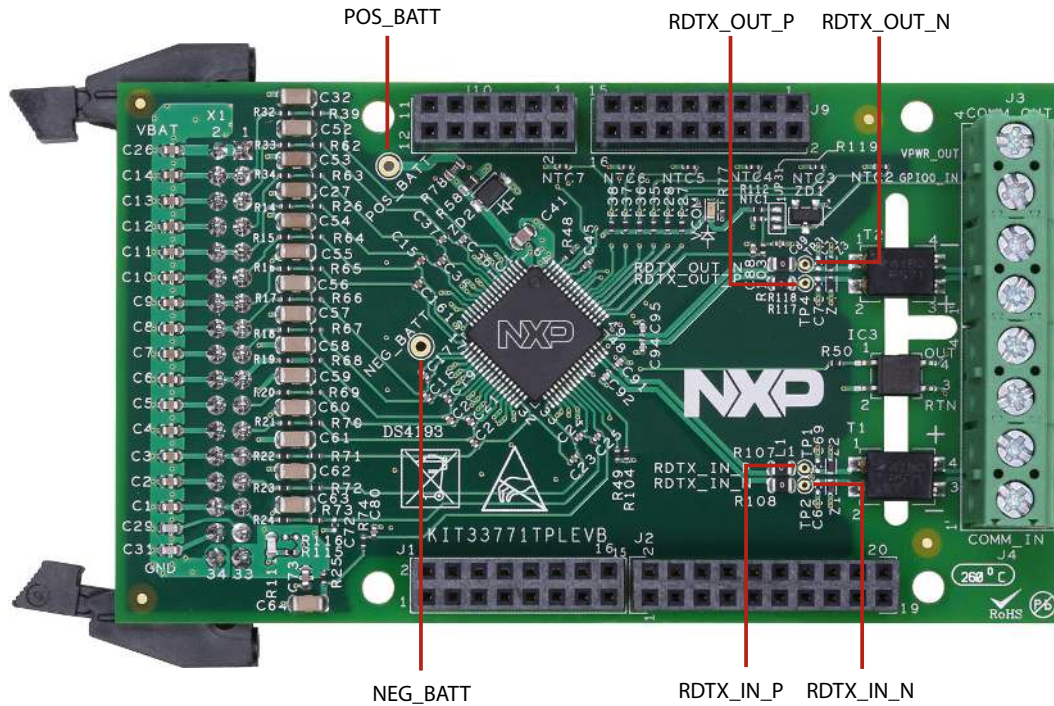


Figure 5. Test points

The following test points provide access to various signals to and from the board.

Table 3. Test points

| Test point name | Signal name | Description |
|-----------------|------------------|--|
| RTDX_IN_N | SI/RTDX_IN- | Measures the isolated pulse communication sent to the device |
| RTDX_IN_P | SCLK/RTDX_IN+ | |
| RTDX_OUT_N | RTDX_OUT- | |
| RTDX_OUT_P | RTDX_OUT+ | |
| NEG_BATT | GNDREF | Ground reference of the device |
| POS_BATT | V _{BAT} | Positive V _{BAT} |

3.8 Connectors

Figure 6 shows the location of connectors on the board. Table 4, Table 5, and Table 6 list the pinouts for each connector.

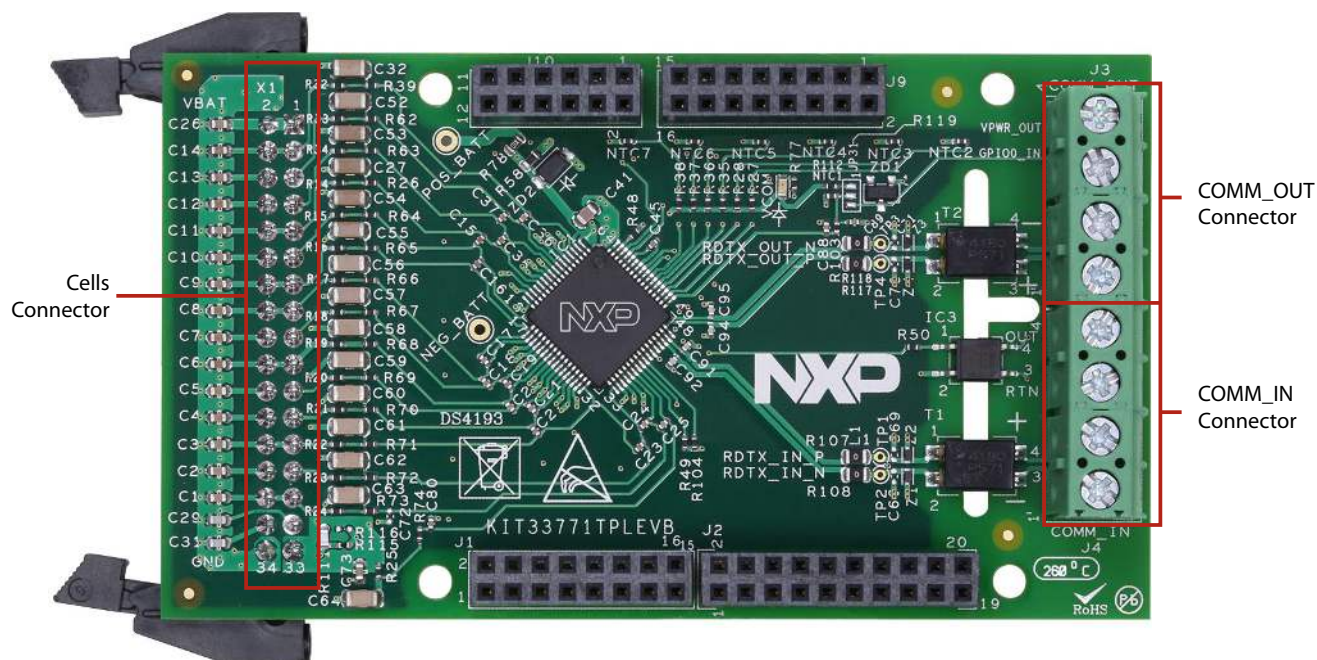


Figure 6. Connectors

Table 4. COMM_IN connector (J4)

| Pin # | Name | Description |
|-------|-----------|---------------------------------|
| 1 | COMM_IN- | Receive/transmit input negative |
| 2 | COMM_IN+ | Receive/transmit input positive |
| 3 | FAULT_RTN | Fault return |
| 4 | FAULT_OUT | Fault output |

Table 5. COMM_OUT connector (J3)

| Pin # | Name | Description |
|-------|-----------|--|
| 1 | COMM_OUT+ | Receive/transmit output positive |
| 2 | COMM_OUT- | Receive/transmit output negative |
| 3 | GPIO_0 | General purpose analog input or GPIO or wake-up or fault daisy chain |
| 4 | VPWR_PU | External device supply |

Table 6. Cells connector

| Pin # | Connection | Description |
|--------------|---------------------|---|
| X1-1 X1-2 | VBAT | MC33771 Power supply |
| X1-3 X1-4 | CT_14 CB_14 | Cell pin 14 input with external LPF resistor. Cell balance driver. Terminate to cell 14 cell balance load resistor |
| X1-5 X1-6 | CT_13 CB_14:13_C | Cell pin 13 input with external LPF resistor. Cell balance 14:13 common. Terminate to cell 14 and 13 common pin |

Table 6. Cells connector (continued)

| Pin # | Connection | Description |
|----------------|------------------------|--|
| X1-7 X1-8 | CT_12 CB_13 / CB_12 | Cell pin 12 input with external LPF resistor. Cell balance driver. Terminate to cell 13 and 12 cell balance load resistor |
| X1-9 X1-10 | CT_11 CB_12:11_C | Cell pin 11 input with external LPF resistor. Cell balance 12:11 common. Terminate to cell 12 and 11 common pin |
| X1-11 X1-12 | CT_10 CB_11 / CB_10 | Cell pin 10 input with external LPF resistor. Cell balance driver. Terminate to cell 11 and 10 cell balance load resistor |
| X1-13 X1-14 | CT_9 CB_10:9_C | Cell pin 9 input with external LPF resistor. Cell balance 10:9 common. Terminate to cell 10 and 9 common pin |
| X1-15 X1-16 | CT_8 CB_9 / CB_8 | Cell pin 8 input with external LPF resistor. Cell balance driver. Terminate to cell 9 and 8 cell balance load resistor |
| X1-17 X1-18 | CT_7 CB_8:7_C | Cell pin 7 input with external LPF resistor. Cell balance 8:7 common. Terminate to cell 8 and 7 common pin |
| X1-19 X1-20 | CT_6 CB_7 / CB_6 | Cell pin 6 input with external LPF resistor. Cell balance driver. Terminate to cell 7 and 6 cell balance load resistor |
| X1-21 X1-22 | CT_5 CB_6:5_C | Cell pin 5 input with external LPF resistor. Cell balance 6:5 common. Terminate to cell 6 and 5 common pin |
| X1-23 X1-24 | CT_4 CB_5 / CB_4 | Cell pin 4 input with external LPF resistor. Cell balance driver. Terminate to cell 5 and 4 cell balance load resistor |
| X1-25 X1-26 | CT_3 CB_4:3_C | Cell pin 3 input with external LPF resistor. Cell balance 4:3 common. Terminate to cell 4 and 3 common pin |
| X1-27 X1-28 | CT_2 CB_3 / CB_2 | Cell pin 2 input with external LPF resistor. Cell balance driver. Terminate to cell 3 and 2 cell balance load resistor |
| X1-29 X1-30 | CT_1 CB_2:1_C | Cell pin 1 input with external LPF resistor. Cell balance 2:1 common. Terminate to cell 2 and 1 common pin |
| X1-31 | ISENSE_+ | Current measurement input+ with external filter RC |
| X1-32 | ISENSE_-- | Current measurement input- with external filter RC |
| X1-33 | CT_REF | Cell pin REF input with external LPF resistor. |
| X1-34 | GND CB_1 | Negative_Battery Cell balance driver. Terminate to cell 1 cell balance load resistor |

3.9 External EEPROM

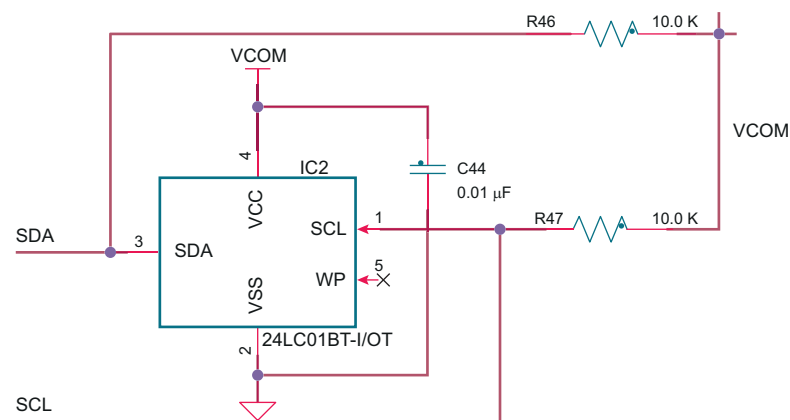


Figure 7. External EEPROM

The KIT33771TPLEVB has an integrated gateway communication link to an external local EEPROM. In high-voltage isolated applications, the MC33771's I²C Communication Interface manages communication with the EEPROM.

After a reset, the device automatically loads the EEPROM calibration parameters into the MC33771 registers.

3.10 GPIO configuration

The KIT33771TPLEVB offers seven customizable GPIOs [GPIO_0...GPIO_6] for measuring external temperature with a bridge divisor. [GPIO_0] can be used as the input for wake-up or fault daisy chain.

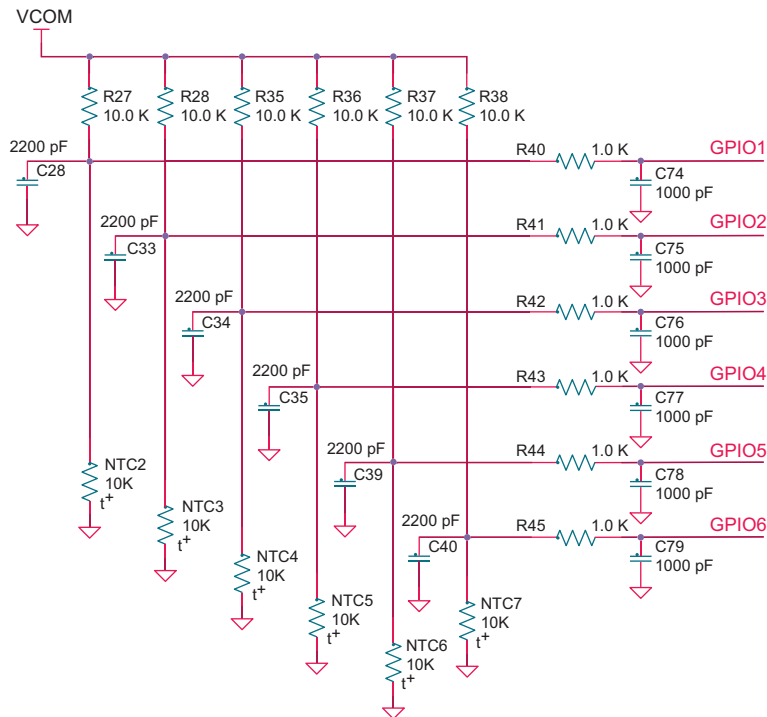


Figure 8. External temperature sensing

3.11 Cell terminal voltage measurement

The differential measurement of each cell terminal input is designed to function in conjunction with an external anti-aliasing filter with a corner frequency.

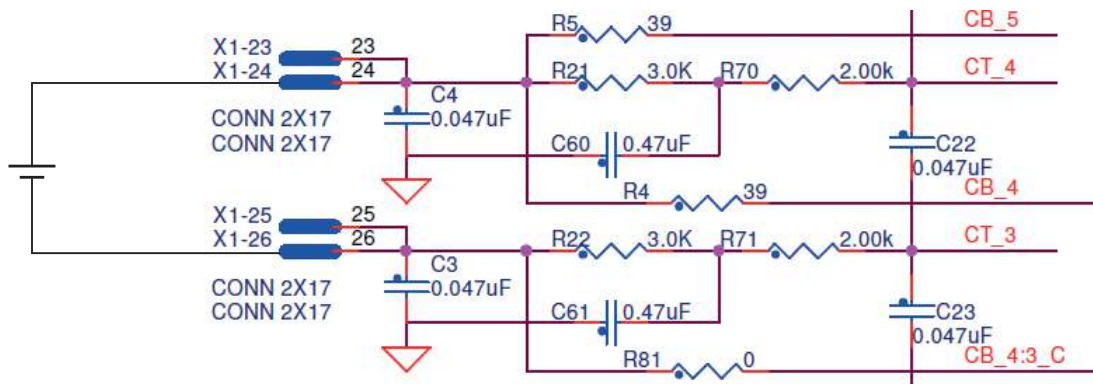


Figure 9. Cell sensing filter

3.12 Fault detection

The KIT33771PTLEVB uses an optocoupler to detect a fault that is dependent on user defined internal or external faults. The Fault signal can be chained between EVBs and can be made available on the controller inputs. With two KIT33771TPLEVB boards, the fault is chained as shown below.

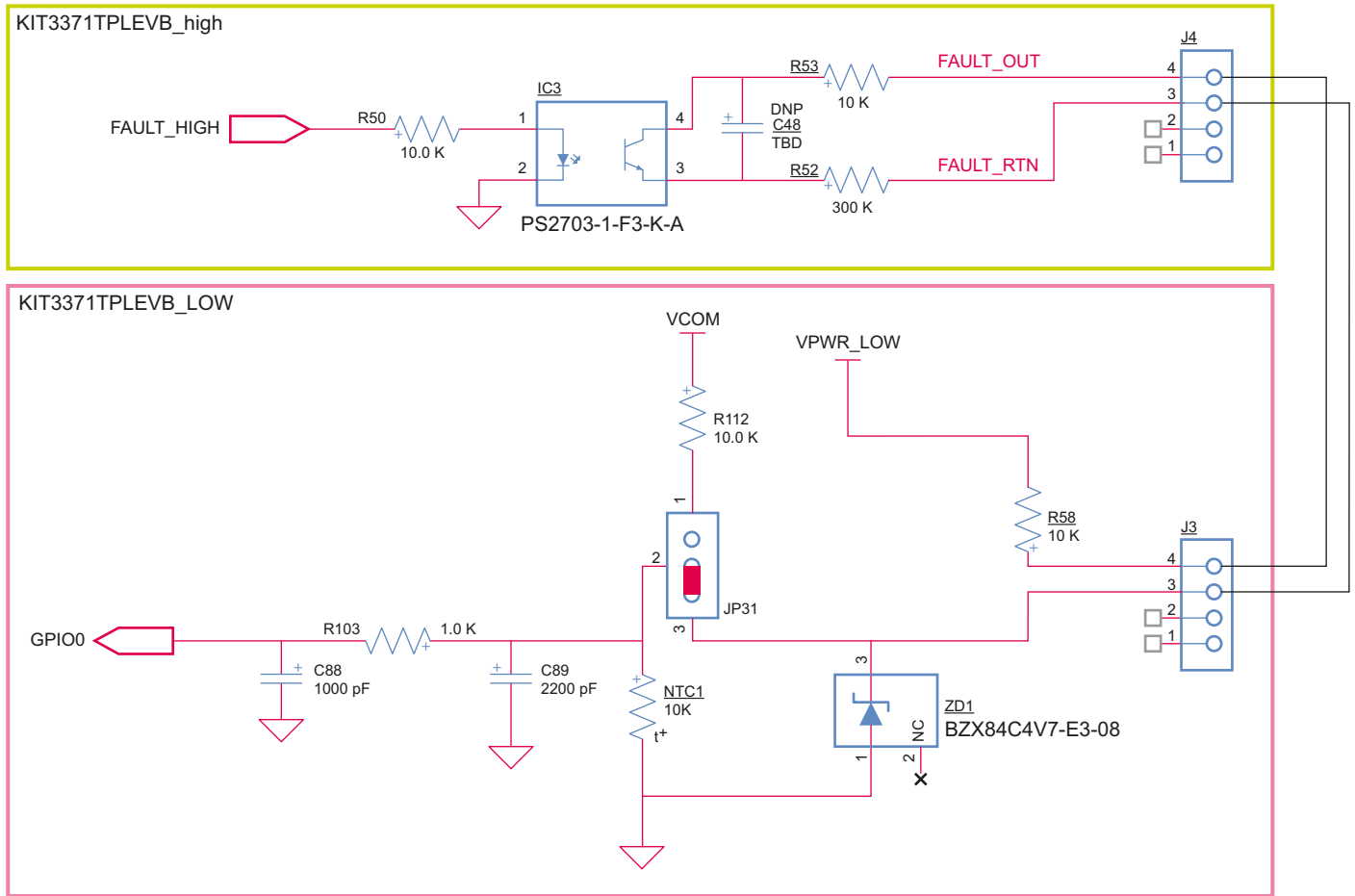


Figure 10. Fault detection

3.13 Bus terminal communication

The transformers isolate communication between the MC33771 and the pack controller and between each MC33771. They are protected against ESD (Z1, Z2, Z3, Z4). There are significant advantages to using transformers for isolation and communication:

- High degree of voltage isolation
- Communication rates of 2.0 MHz with very low radiated emissions
- Ability to force the secondary signals to be true differential reducing radiated emissions
- Ability to loop the network back to the pack controller

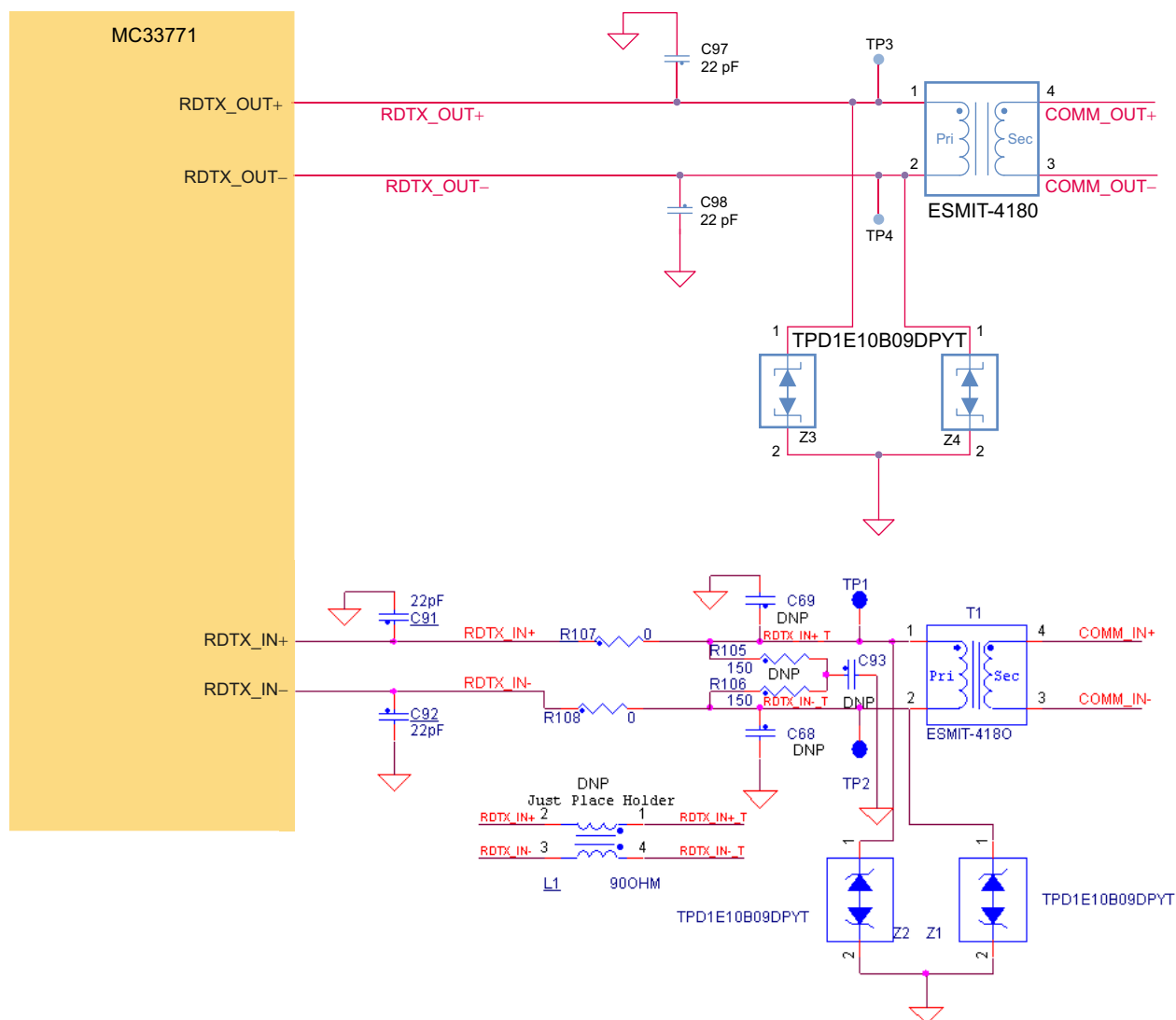


Figure 11. Bus terminal communication

Some component values may be placed and adjusted for EMC purpose: C91 (default 22 pF), C92 (default 22 pF), R107, R108, C68, C69, and the pi filter made of R105, R106 and C93. By default, all other components (except C91 and C92) are not populated.

4 Accessory transceiver board

The KIT33771TPLEVB kit is designed for use with the KIT33664AEVB in high-voltage isolated applications which provide a SPI to high speed isolated communication interface. The KIT33664AEVB includes a MC33664 isolated network high speed transceiver. MCU SPI data bits are directly converted to pulse bit information.

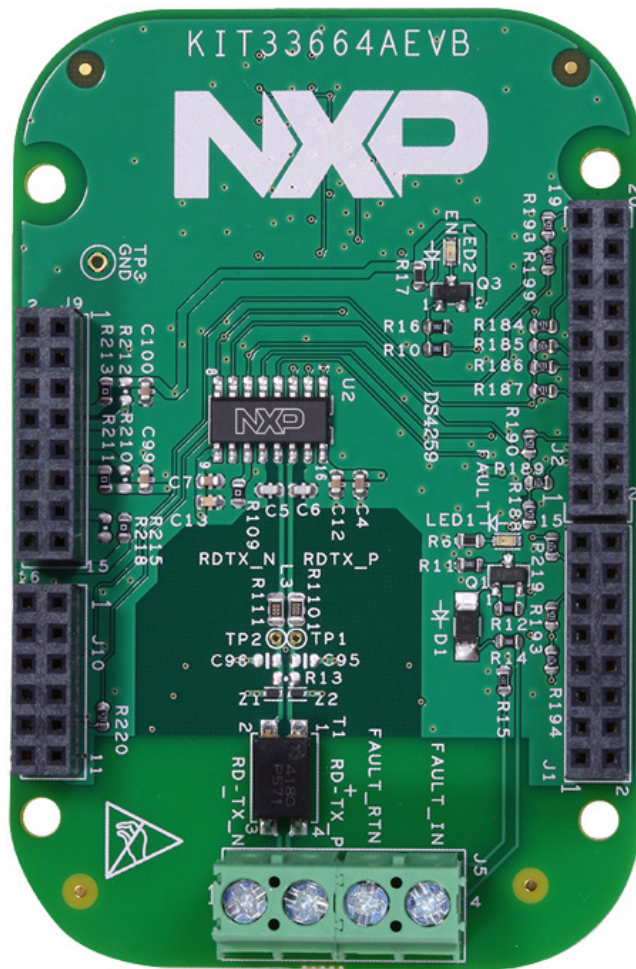


Figure 12. KIT33664AEVB

5 Configuring the hardware

5.1 Battery stack connection

A minimum of eight cells and a maximum of 14 cells can be monitored.

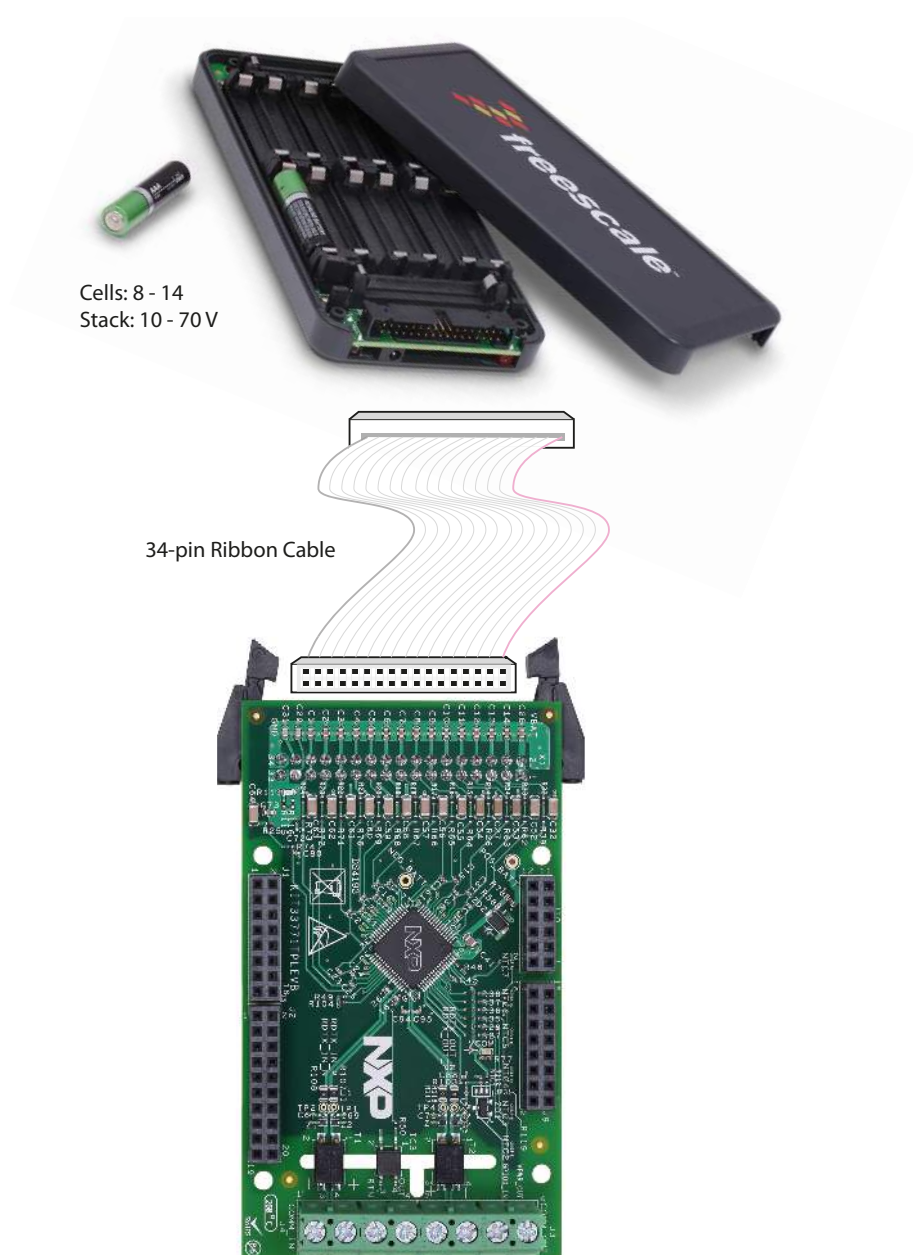


Figure 13. Battery stack connection

5.2 Isense connection

A 0.1 Ω shunt resistor is available on the KIT33771TPLEVB for current measure during demonstrations. It is also possible to use an external shunt for current measure by disconnecting the embedded one.

5.2.1 Using the embedded 0.1 Ω shunt (default configuration)

The current should be limited to ± 500 mA to avoid any damage of the EVB.

5.2.1.1 Configuration 1: measuring external load and KIT33771TPLEVB currents (default configuration)

To measure both currents:

1. Make sure that R109, R110, R111 (0.1 Ω shunt) and R115 are populated and R116 is not placed (see [Figure 14](#)).
2. Connect the battery stack to the X1-1 to X1-4 connector pins (positive) and the X1-33 connector pins (negative). The current is considered as negative.
3. For optional external loads, connect the negative side of the external load should be to the X1-34 connector pins. In this case, both currents are added.

5.2.1.2 Configuration 2: measuring an external load current only

To measure the external load current only:

1. Make sure that R109, R110, R111, and R116 are populated and R115 is not placed.
2. Connect the battery stack should be connected to the X1-1 to X1-4 connector pins (positive) and the X1-33 connector pin (negative).
3. Connect the load negative side to the X1-32 connector pin.

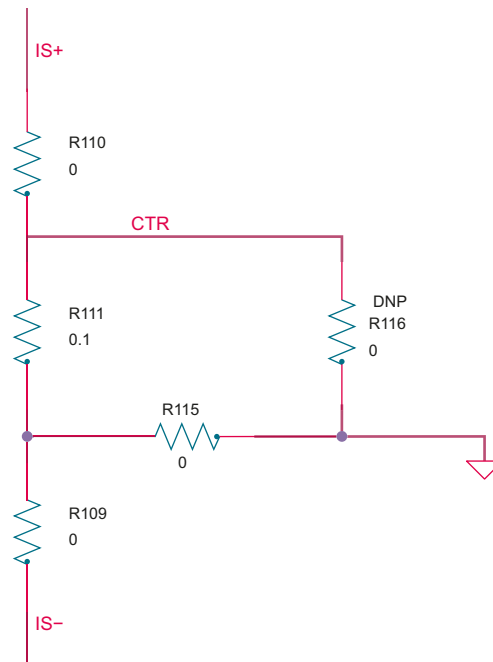


Figure 14. Resistor configuration

5.2.2 Connecting an external shunt (disconnecting the embedded shunt)

To connect an external shunt, disconnect the embedded shunt by removing resistors R109, R110, R111, R115, R116.

5.2.2.1 Configuration 1: measuring external loads and KIT33771TPLEVB currents

Figure 15 illustrates the connections required to measure both external load currents and KIT33771TPLEVB loads.

1. Connect the battery stack to the X1-1 to X1-4 pins (positive) and X1-33, X1-31 pins (negative).
2. Connect one side of the external shunt to the X1-33 and X1-31 pins. Connect the other side to X1-34 and X1-32 pins.

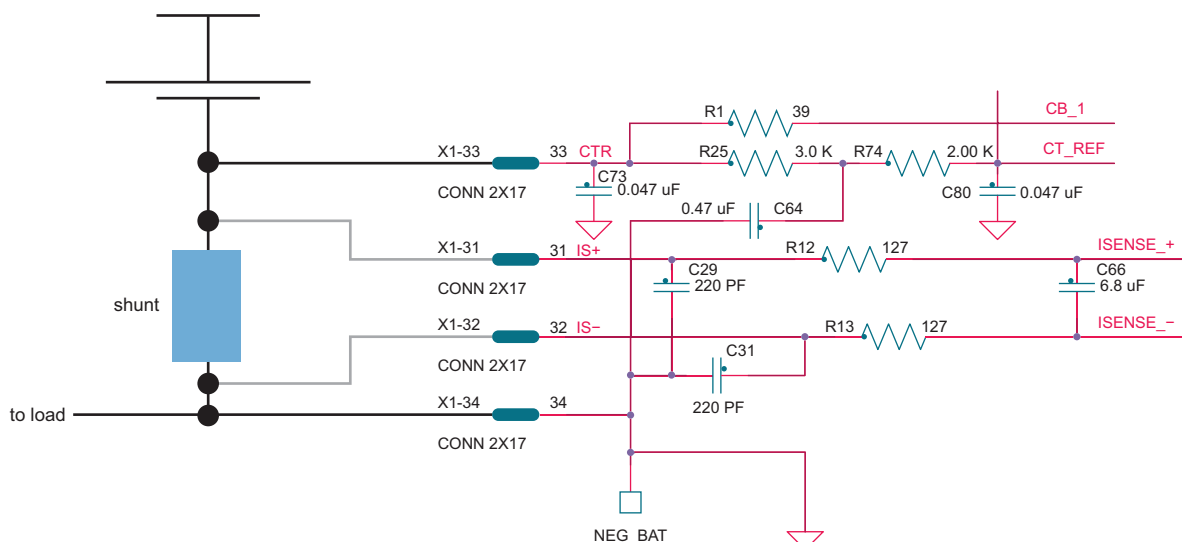


Figure 15. ISENSE connection

5.2.2.2 Configuration 2: measuring an external load current only

Figure 16 illustrates the connections required to measure an external load current only.

1. Connect the positive side of the battery stack to the X1-1 to X1-4 pins. Connect the negative side of the battery stack to the X1-33 and the X1-34 pins.
2. Connect one side of the external shunt to the load and to X1-31 (Isense+). Connect the other side of the external shunt to X1-34 (EVB neg) and X1-32 (Isense-).

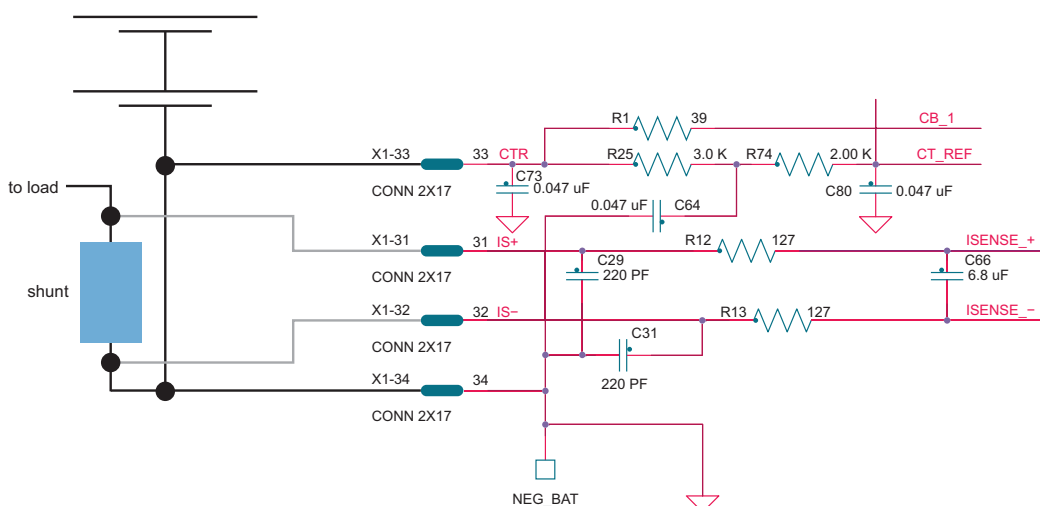


Figure 16. ISENSE connection for an external load

5.3 JUMPER connection

One hand-soldered jumper (JP31) on the EVB is used to set the GPIO0 pin input. In position 1-2 (default), the NTC (NTC1) is connected to GPIO0 pin of the MC33771. This input can be used as analog input. If the jumper is placed in position 2-3, the GPIO0 can be used as fault input for fault daisy chain function.

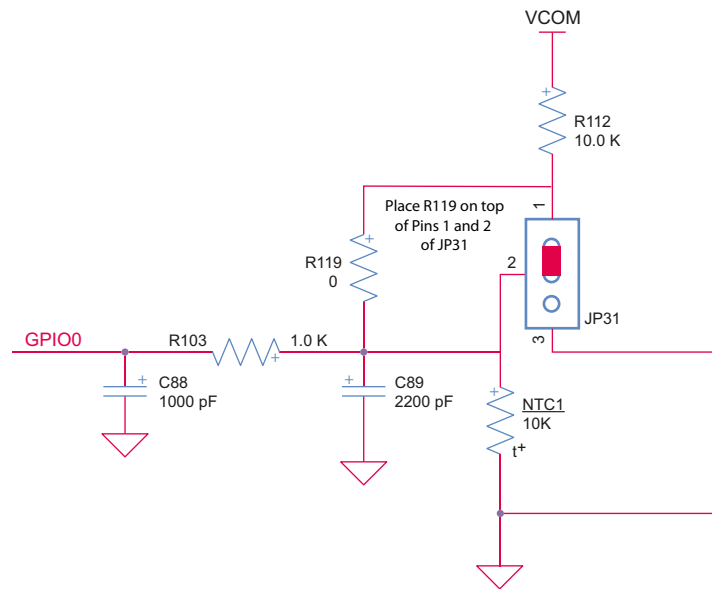


Figure 17. Jumper JP31 connection

5.5 Fault Chain Connection

The FAULT chain connection is optional. When used, it connects through connectors COMM_IN (J4) and COMM_OUT (J3)

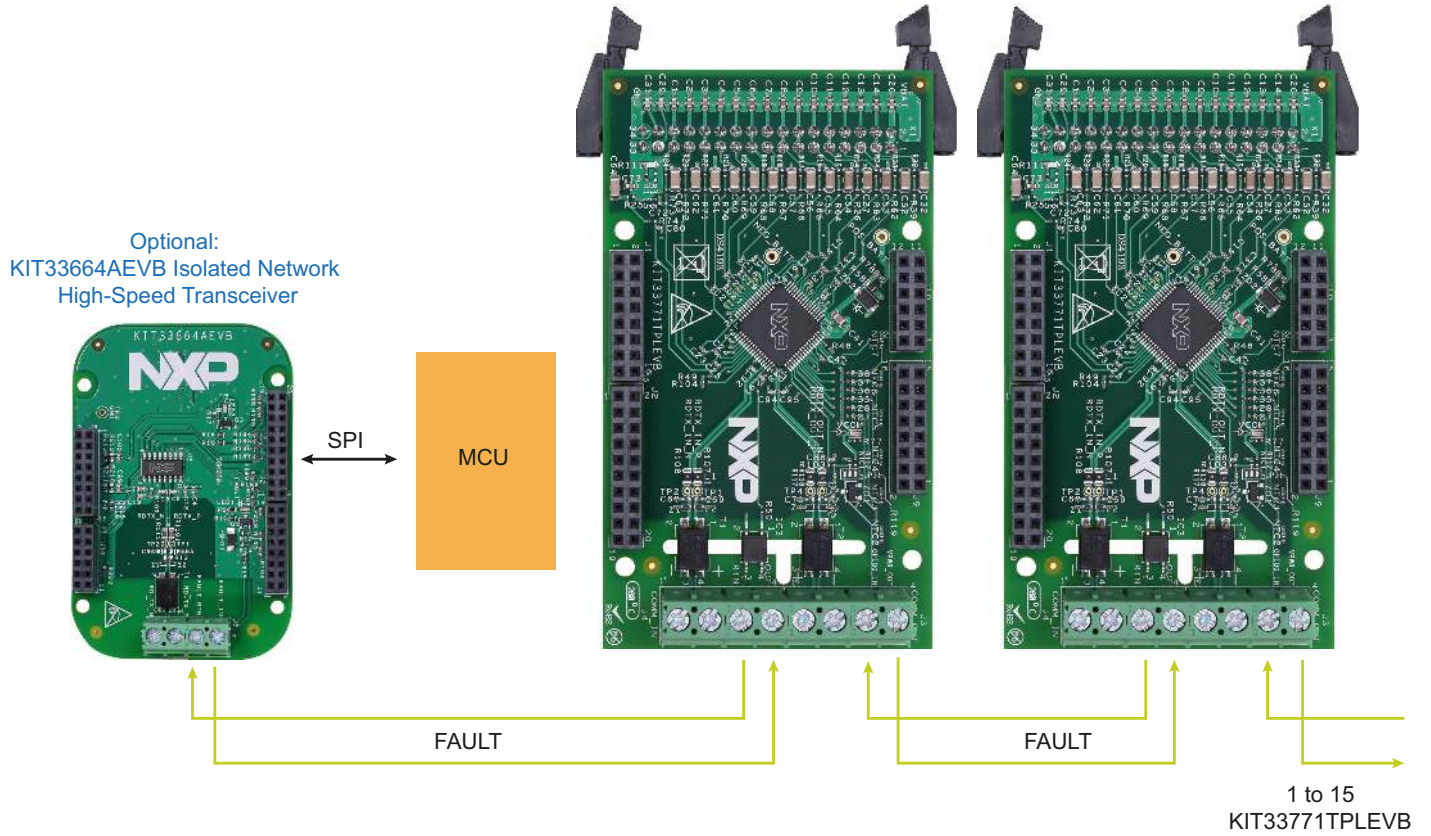
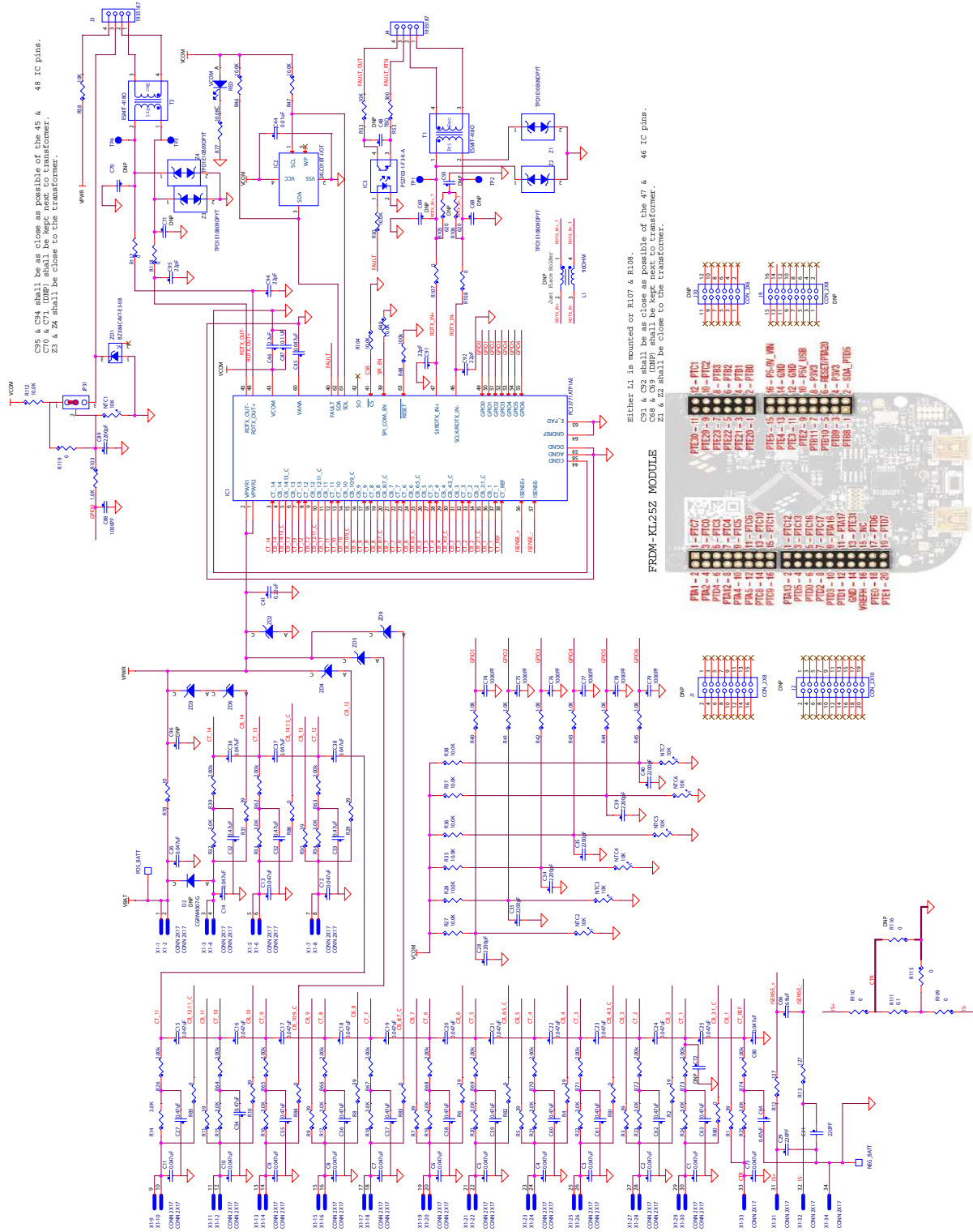


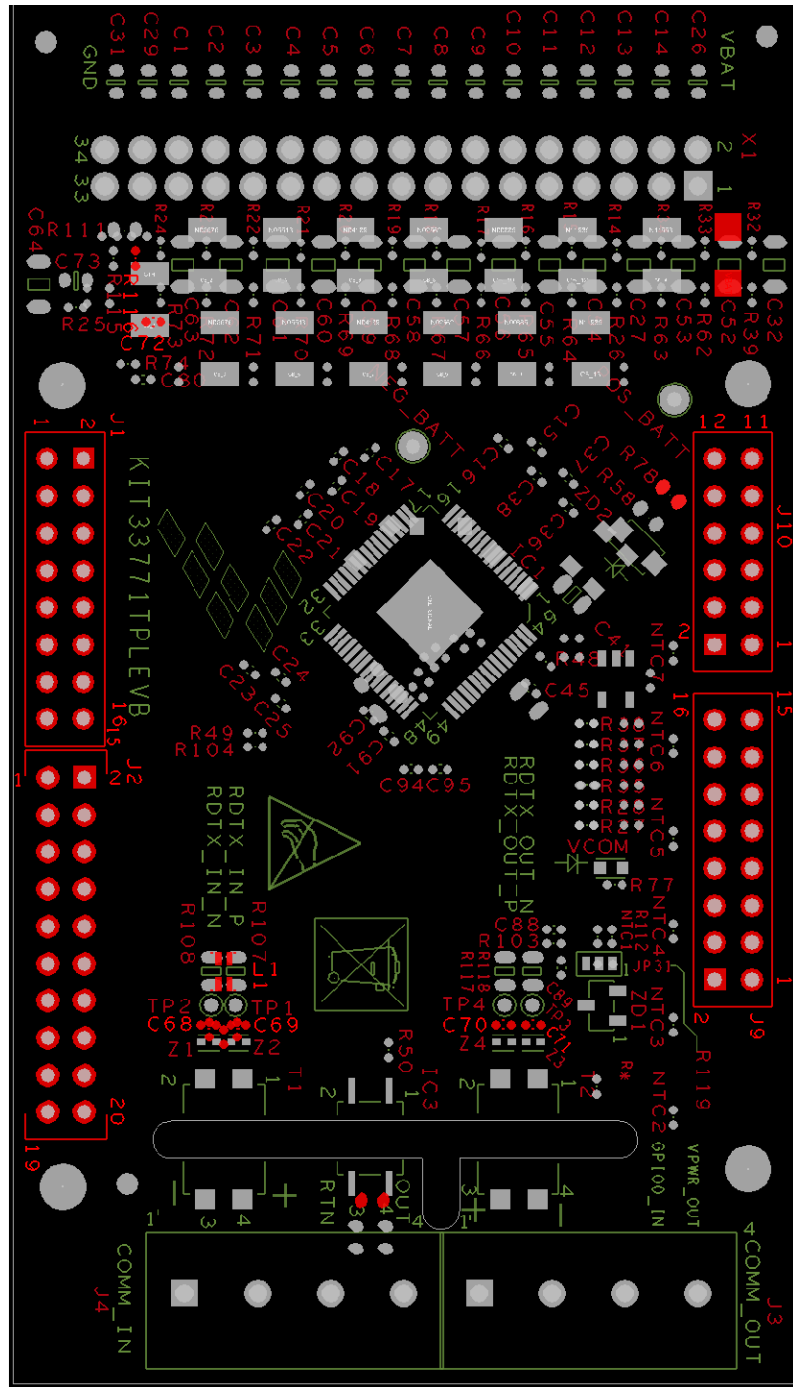
Figure 19. Fault chain connection

6 Schematic

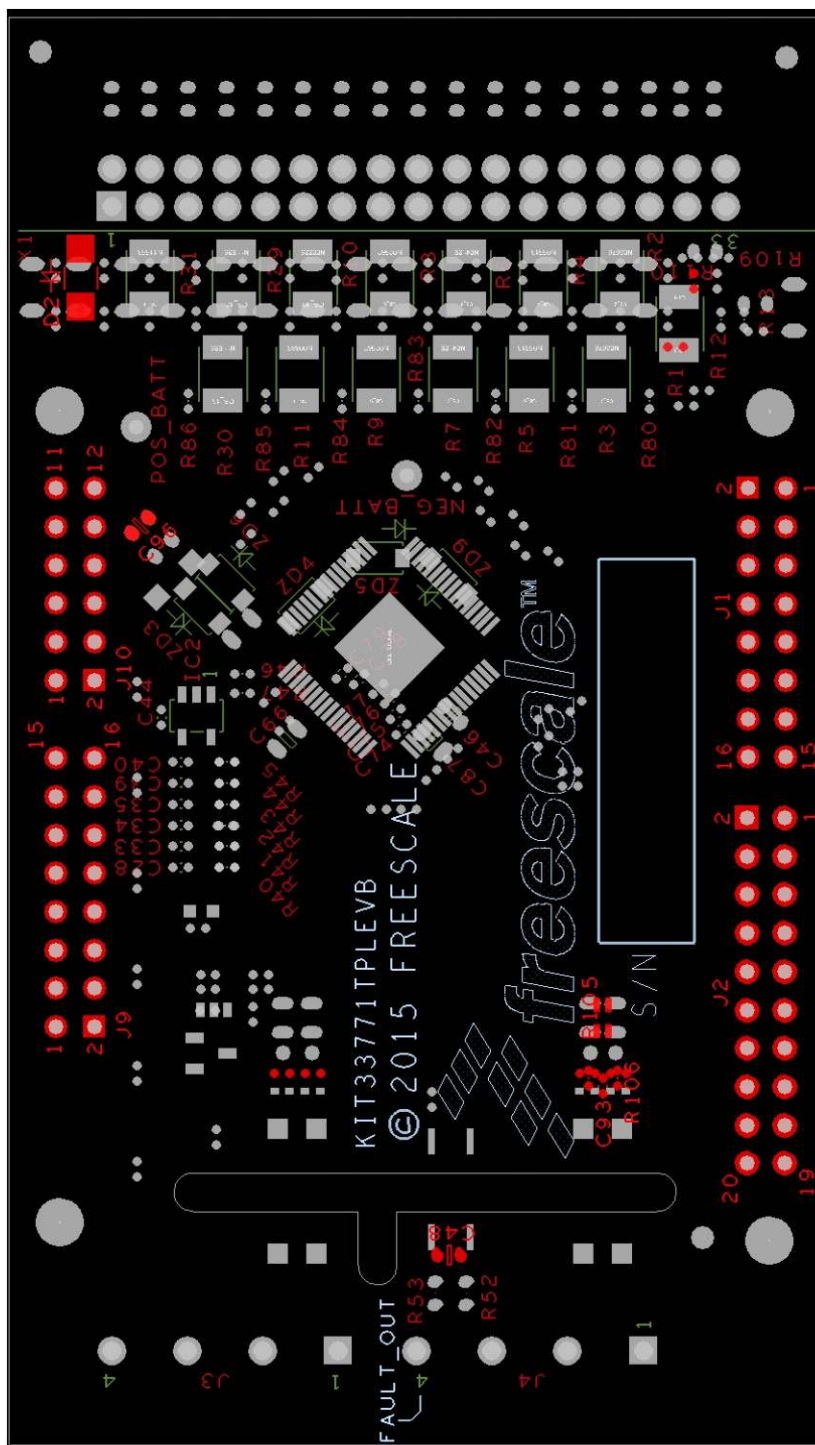


7 Board Layout

7.1 Assembly Layer Top



7.2 Assembly Layer Bottom



KIT33771TPLEVB evaluation board, Rev. 2.0

8 Board bill of materials

Table 7. Bill of materials ⁽¹⁾

| Item | Qty | Schematic label | Value | Description | Part Number | Assy opt |
|----------------------------|-----|--|----------|---------------------------------------|-----------------|----------|
| Integrated circuits | | | | | | |
| 1 | 1 | IC1 | | Battery Cell Controller 64 LQFP | MC33771ATP1AE | |
| 2 | 1 | IC2 | | Serial EEPROM SOT23-5L | 24LC01BT-I/OT | |
| 3 | 1 | IC3 | | Optoisolator 3.75 kV DIL4-SMD | PS2703-1-F3-K-A | |
| Diodes | | | | | | |
| 4 | 1 | D2 | 1000 V | Diode General purpose 1 kV 1 A SOD123 | CGRM4007-G | (2) |
| 5 | 1 | ZD1 | 4.7 V | Zener Diode 4.7 V SOT23 | BZX84C4V7-E3-08 | |
| 6 | 1 | ZD2 | 75 V | Zener Diode 75 V SOD123 | MMSZ5267BT1G | |
| 7 | 2 | ZD3, ZD6 | 8.2 V | Zener Diode 8.2 V SOD123 | MMSZ5237BT1G | |
| 8 | 1 | ZD4 | 20 V | Zener Diode 20 V SOD123 | MMSZ5250BT1G | |
| 9 | 1 | ZD5 | 33 V | Zener Diode 33 V SOD123 | MMSZ5257BT1G | |
| 10 | 1 | ZD9 | 43 V | Zener Diode 43 V SOD123 | MMSZ5260BT1G | |
| 11 | 4 | Z1, Z2, Z3, Z4 | 10 V TVS | IC ESD Protection 0402 | TPD1E10B09DPYT | |
| LEDs | | | | | | |
| 12 | 1 | VCOM LED | | LED 630 nm Red LED0603 | SML-311UTT86 | |
| Capacitors | | | | | | |
| 13 | 15 | C27, C32, C52, C53, C54, C55, C56, C57, C58, C59, C60, C61, C62, C63, C64 | 470 nF | 100 V Capacitor C1206 | | |
| 14 | 16 | C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C26, C73 | 47 nF | 100V Capacitor C0603 | | |
| 15 | 16 | C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C36, C37, C38, C45, C80 | 47 nF | 50 V Capacitor C0402 | | |
| 16 | 7 | C28, C33, C34, C35, C39, C40, C89 | 2.2 nF | 50 V capacitor C0402 | | |
| 17 | 2 | C29, C31 | 220 pF | 50 V capacitor C0603 | | |
| 18 | 1 | C41 | 220 nF | 100 V Capacitor C0805 | | |
| 19 | 1 | C44 | 10 nF | 50 V capacitor C0402 | | |
| 20 | 1 | C46 | 2.2 μF | 6.3 V capacitor C0603 | | |
| 21 | 1 | C66 | 6.8 μF | 16 V capacitor C0805 | | |
| 22 | 4 | C68, C69, C70, C71 | 22 pF | 50 V capacitor C0402 | | (2) |
| 23 | 2 | C72, C93 | 47 nF | 50 V capacitor C0402 | | (2) |
| 24 | 7 | C74, C75, C76, C77, C78, C79, C88 | 1 nF | 50 V capacitor C0402 | | |
| 25 | 1 | C87 | 100 nF | 50 V capacitor C0805 | | |
| 26 | 4 | C91, C92, C94, C95 | 22 pF | 50 V capacitor C0402 | | |
| 27 | 1 | C96 | 47 nF | 100 V Capacitor C0603 | | (2) |
| Inductors | | | | | | |
| 28 | 2 | T1, T2 | 120 μH | Transformer CBM5D33 | ESMIT-4180/A | |
| 29 | 1 | L1 | 90 Ω | Chock_0805 | DLW21SN900SQ2B | (2) |

Table 7. Bill of materials (continued) ⁽¹⁾

| Item | Qty | Schematic label | Value | Description | Part Number | Assy opt |
|---|-----|---|----------------|----------------------------------|---------------|----------|
| Resistors | | | | | | |
| 30 | 14 | R1, R2, R3, R4, R5, R6, R7, R8,R9, R10, R11, R29, R30, R31 | 39 Ω | Resistor 3/4 W R1210 | | |
| 31 | 2 | R12,R13 | 127 Ω | Resistor 1/16 W R0402 | | |
| 32 | 15 | R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R32, R33, R34 | 3.0 k Ω | Resistor 1/16 W R0402 | | |
| 33 | 15 | R26, R39, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74 | 2.0 k Ω | Resistor 1/16 W R0402 | | |
| 34 | 13 | R27, R28, R35, R36, R37, R38, R46, R47, R49, R50, R77, R104, R112 | 10 k Ω | Resistor 1/16 W R0402 | | |
| 35 | 7 | R40, R41, R42, R43, R44, R45, R103 | 1.0 k Ω | Resistor 1/16 W R0402 | | |
| 36 | 1 | R48 | 100 k Ω | Resistor 1/16 W R0402 | | |
| 37 | 1 | R52 | 300 Ω | Resistor 1/10 W R0603 | | |
| 38 | 2 | R53, R58 | 10 k Ω | Resistor 1/10 W R0603 | | |
| 39 | 1 | R78 | 10 Ω | Resistor 1/10 W R0603 | | |
| 40 | 11 | R80, R81, R82, R83, R84, R85, R86, R109, R110, R115, R119 | 0 Ω | Resistor 1/16 W R0402 | | |
| 41 | 2 | R105,R106 | 620 Ω | Resistor 1/16 W R0402 | | (2) |
| 42 | 4 | R107, R108, R117, R118 | 0 Ω | Resistor 1/8 W R0805 | | |
| 43 | 1 | R111 | 0.1 Ω | Resistor 1/5 W R0603 | | |
| 44 | 1 | R116 | 0 Ω | Resistor 1/16 W R0402 | | (2) |
| 45 | 7 | NTC1, NTC2, NTC3, NTC4, NTC5, NTC6, NTC7 | 10 k Ω | Thermistor R0402 | 490-6940-6-ND | |
| Switches, connectors, jumpers, and test points | | | | | | |
| 46 | 1 | X1 | | CONN 2x17 | N3431-5202RB | |
| 47 | 2 | J3, J4 | | CONN term block 4POS 5.08 MM PCB | 1935187 | |
| 48 | 4 | J1, J2, J9, J10 | | | | (2) |

Notes

1. NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP offers component recommendations in this configuration, it is the customer's responsibility to validate their application.
2. Do not populate

9 Accessory item bill of materials

Table 8. Bill of materials ⁽³⁾

| Item | Qty | Part number | Description |
|------|-----|--------------|---|
| 1 | 1 | KIT33664AEVB | NXP MC33664 isolated network high speed transceiver |
| 2 | 1 | M50-9101742 | 34-Pin ribbon cable |

Notes

3. NXP does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While NXP offers component recommendations in this configuration, it is the customer's responsibility to validate their application.

10 References

| NXP.com Support Pages | Description | URL |
|-----------------------|----------------------|---|
| KIT33771TPLEVB | Tool summary page | http://www.nxp.com/KIT33771TPLEVB |
| MC33771 | Product summary page | http://www.nxp.com/MC33771 |
| KIT33771SP1EVB | Tool summary page | http://www.nxp.com/KIT33771SPIEVB |
| KIT33664AEVB | | http://www.nxp.com/KIT33664AEVB |

10.1 Support

Visit www.nxp.com/support for a list of phone numbers within your region.

10.2 Warranty

Visit www.nxp.com/warranty to submit a request for tool warranty.

11 Revision history

| Revision | Date | Description of changes |
|----------|---------|---|
| 1.0 | 5/2016 | <ul style="list-style-type: none">Initial release |
| 2.0 | 10/2016 | <ul style="list-style-type: none">Updated part number for schematic label IC1 in Table 7 |

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