EQCO5X31 USB Type-C™ Evaluation Board User Guides

EV40G35A

EV23B43A

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1.0 INTRODUCTION

This document describes the EQCO5X31 USB Type-C™ Evaluation Boards , EV40G35A and EV23B43A, and how to use these boards to extend USB3 data networks. The Microchip EQCO5X31 IC used on these boards is a device intended for USB 3.2 Gen 1 networks to extend cable distances and improve signal quality. Microchip has called this device a USB Reclocker/Redriver. It includes three functions:

1. An auto-adaptive equalizer at the receiver which automatically adjusts for frequency dependent losses in the cable.
2. A Reclocker which includes a bit-level CDR that re-times the signal to reset accumulated jitter.
3. A Redriver that drives the now cleaned up signal onto a cable or PCB trace.

The result is a device that simply passes through the signal at the Physical layer, equalizing the cable losses at its input, then Reclocking/Redriving the signal back out. It does this for both USB data directions.

FIGURE 1-1: EQCO5X31 USB TYPE-C™ EXTENDER BOARD - EV40G35A

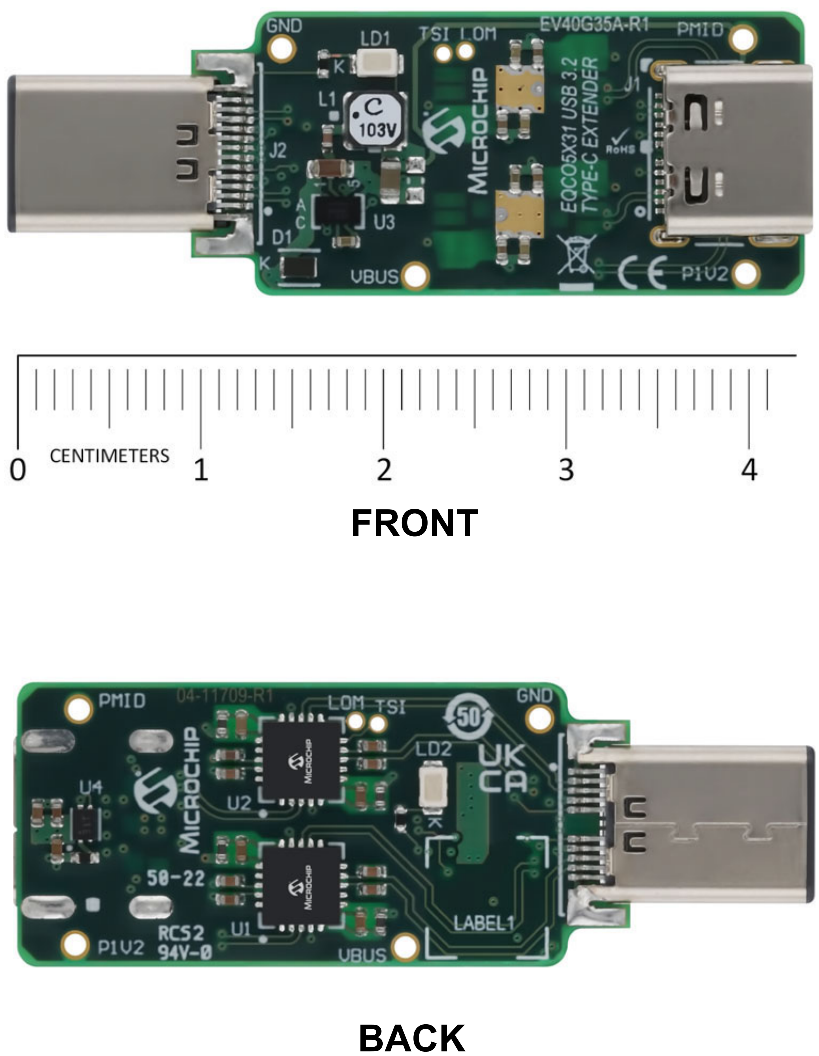
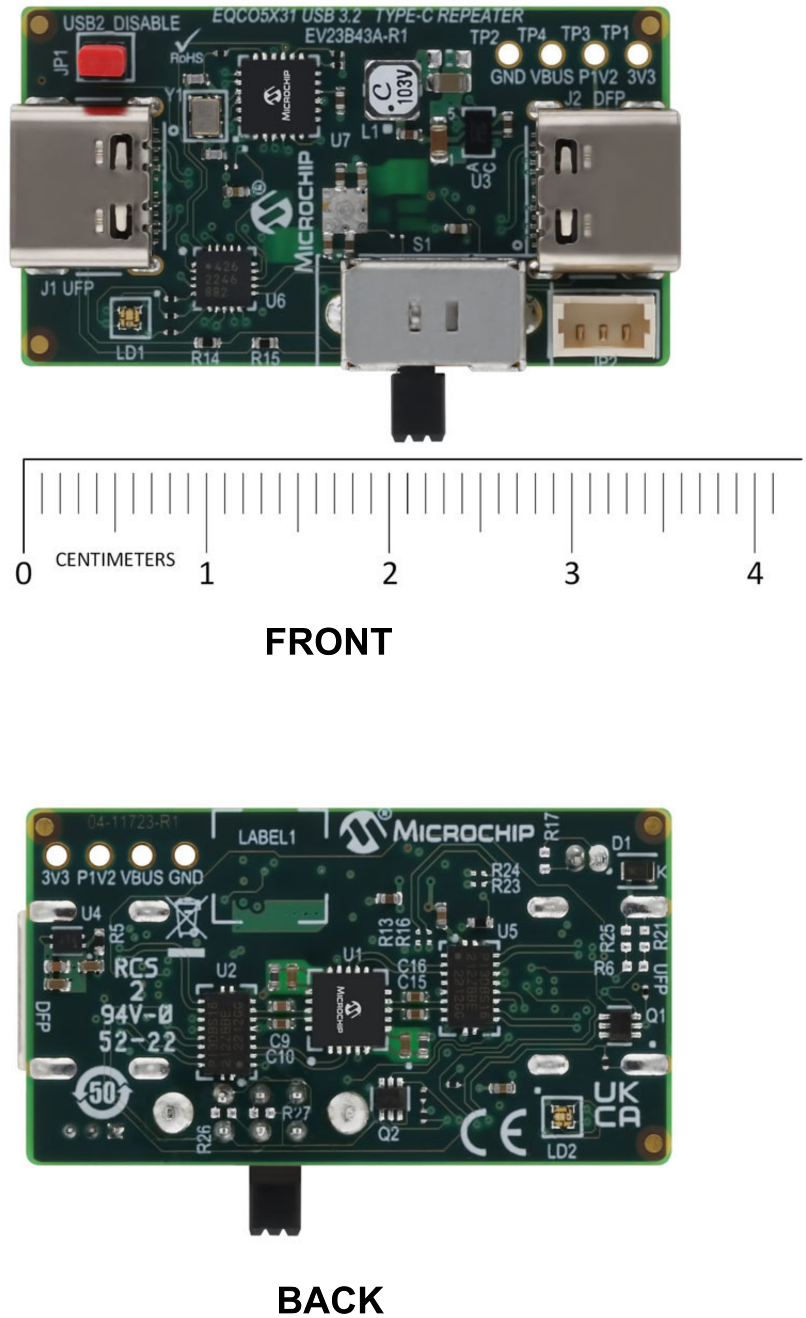


FIGURE 1-2: EQCO5X31 USB TYPE-C™ REPEATER BOARD - EV23B43A

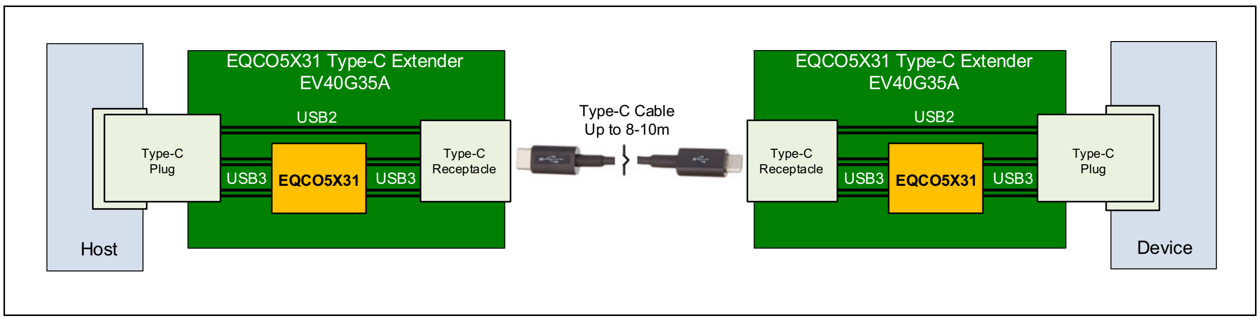


2.0 USAGE DIAGRAMS

The EQCO5X31 USB Type-C™ Evaluation Boards are used to increase USB3 Type-C cable length. The EV40G35A is a Type-C Extender that would be located at the Host and Device side. The EV23B43A is a Type-C Repeater that would be used to couple and extend two cables. Below are some example diagrams showing how these boards could be used. Other configurations scenarios beyond these examples are also possible.

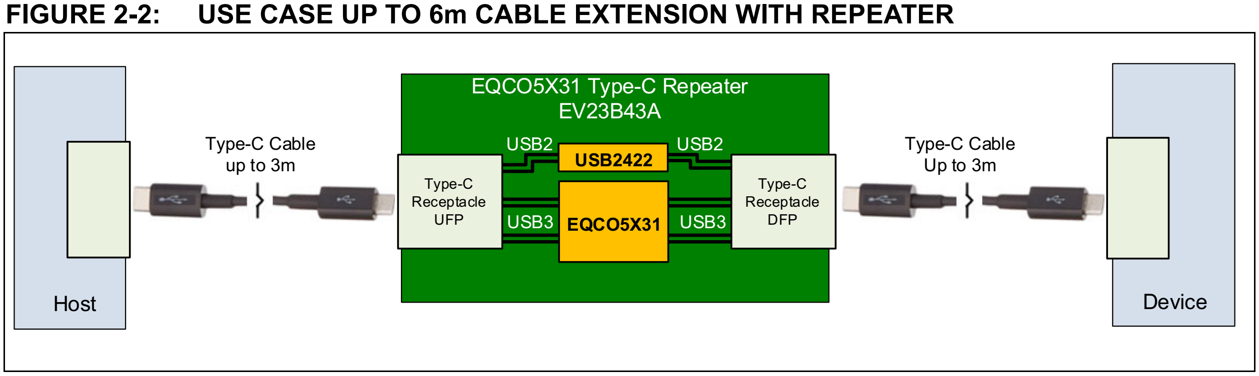
The first example usage scenario below (Figure 2-1) shows how two EV40G35A Extenders can be used to extend a cable between a Host and Device beyond the standard 3m Type-C limit. The male side of the Extender plugs directly into the Host or Device, with a cable used between the Extenders. The same board design supports being placed at both the Host and Device side. The cable used should be wired as a "USB Full-Featured Type-C Standard Cable Assembly" as defined in the USB Type-C™ Cable and Connector Specification [1]. Depending on the cable insertion loss and crosstalk specifications for the USB3.x signaling wires, it is estimated that up to 8-10m cables can be supported. See Section 5.2 of the EQCO5X31 Product Data Sheet [2] for more information on determining maximum cable length.

FIGURE 2-1: USE CASE UP TO 8-10m CABLE EXTENSION WITH EXTENDERS



The second example usage scenario below (Figure 2-2) shows how a EV23B43A Repeater would be used to extend two cables up to 3m in length to form a network up to 6m. The cables used should be off-the-shelf "USB Full-Featured Type-C Standard Cable Assembly" as defined in the USB Type-C™ Cable and Connector Specification [1]. The Repeater has an UFP (Upward Facing Port) which must be connected to the Host side cable, and a DFP (Downward Facing Port) which must be connected to the Device side cable.

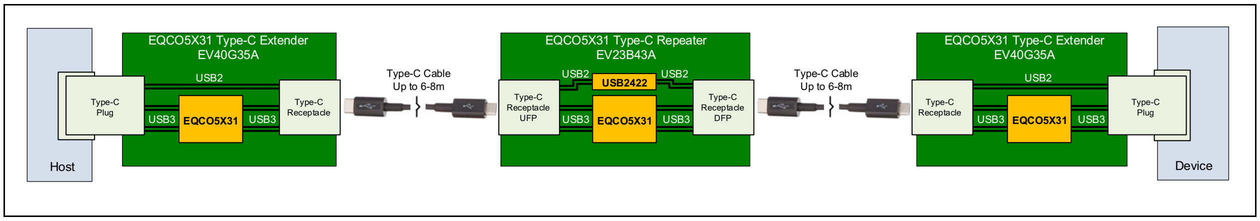
FIGURE 2-2: USE CASE UP TO 6m CABLE EXTENSION WITH REPEATER



> **Note:** The UFP/DFP directionality on the Repeater is only required if USB2 is used. If only USB3 is used, these ports become agnostic, either can be pointed to UFP or DFP.

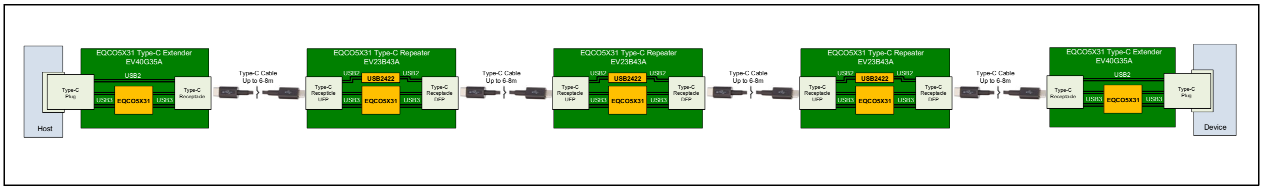
The third example usage scenario below (Figure 2-3) shows how Extenders and a Repeaters can be used together. The cable lengths supported are not quite as long as the Extender only case shown in Figure 2-1, because the Repeater includes data muxes (see Section 5.0) that add additional loss.

FIGURE 2-3: USE CASE UP TO 16m CABLE EXTENSION WITH REPEATER AND EXTENDERS



The fourth example usage scenario below (Figure 2-4) shows how Extenders and multiple Repeaters can be used together.

FIGURE 2-4: USE CASE UP TO 32m CABLE EXTENSION WITH REPEATERS AND EXTENDERS



> **Note:** For USB2 signaling, the Extender simply passes USB2 directly through, while the Repeater uses a USB2 hub IC which can be enabled/disabled with a jumper. If USB2 is required for operation, the lengths of the cables will be limited to standard USB2 lengths

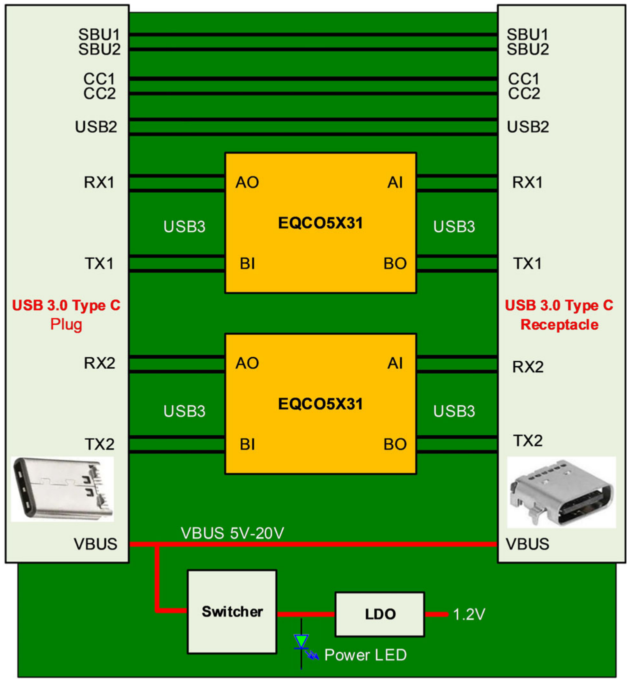
3.0 ACTIVE CABLES

The functions performed by the EQCO5X31 IC on these boards could also be integrated into a cable assembly to create an active cable. This has several advantages over using external boards: 1) There would be fewer physical connectors, and so less signal loss and crosstalk and 2) If the cable is Type-C, there would be less need for duplication of components and multiplexers to support Type-C reversibility, this because the cable manufacturer would have better control of the wire connections.

4.0 BLOCK DIAGRAM - EV40G35A TYPE-C EXTENDER

Figure 4-1 shows a block diagram of the EV40G35A Type-C EXTENDER.

FIGURE 4-1: EV40G35ATYPE-C EXTENDER BLOCK DIAGRAM



4.1 USB Connectors

There are two USB connectors on the board, a Type-C plug (J2), and a Type-C receptacle (J1). The plug would be inserted directly into a Host/Device side receptacle, (for example a laptop). The receptacle would accept a USB Type-C™ cable.

4.2 USB3 Signaling

The USB3 signals pass through the EQCO5X31 where they are re-clocked and re-driven. There are two EQCO5X31 parts on the board to handle two lanes supported by the USB Type-C™ Cable and Connector Specification [1]. Normally only one lane would be active at a time (USB 3.2 Gen1X1), however the Extender board also supports both lanes active at the same time (USB 3.2 Gen1X2).

4.3 Power

Power comes from the VBUS lines of the Plug connector. It gets passed directly onto the receptacle connector. The board also takes some power from VBUS. The voltage range can be 5V to 20V (Nominal), depending on the Source and Sync power negotiations. To accommodate this wide voltage range, a switching power supply is used on the board to provide local power. There is also a LDO on the board to provide 1.2V power for the EQCO5X31's.

4.4 USB2 Signaling

USB2 signals are passively connected through the board between connectors.

4.5 CC Lines

The USB Type-C™ CC lines are passively connected through the board between connectors. This allows the Source and Sync to connect and negotiate power levels normally as if the Extender were not present.

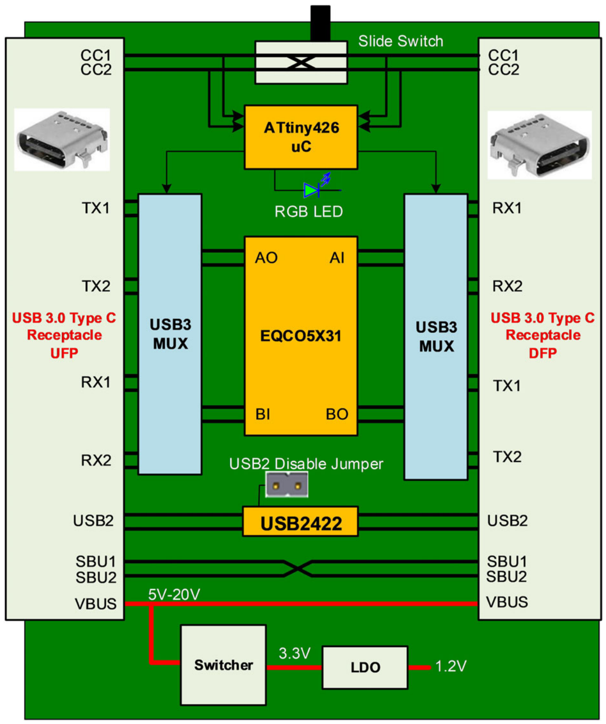
4.6 SBU Lines

The USB Type-C™ SBU lines are passively connected through the board between connectors.

5.0 BLOCK DIAGRAM - EV23B43A TYPE-C REPEATER

Figure 5-1 shows a block diagram of the EV23B43A TYPE-C REPEATER.

FIGURE 5-1: EV23B43ATYPE-C REPEATER BLOCK DIAGRAM



5.1 USB Connectors

There are two USB connectors on the board, both are Type-C receptacles, J1 and J2 to allow for a cable to accepted. J1 is the UFP (Upward Facing Port) that would attach to the Host side, and J2 is DFP (Downward Facing Port) that would attach to the Device side. Note that if USB2 is disabled or not used, these ports become agnostic, either can be pointed to UFP or DFP.

5.2 USB3 Signaling

The USB3 signals pass through the EQCO5X31 where they are re-clocked and re-driven. There is one EQCO5X31 on the board, and along with muxes, can handle two lanes supported by the USB Type-C™ Cable and Connector Specification [1]. There can be only one lane active at a time (USB 3.2 Gen1X1). The Repeater board does not support both lanes active at the same time (USB 3.2 Gen1X2).

5.3 Power

Power comes from the VBUS line of the Source connector (typically at the UFP). It gets passed directly onto the other receptacle connector. The board also takes some power from VBUS. The voltage range can be 5V to 20V (Nominal), depending on the Source and Sync power negotiations. To accommodate this wide voltage range, a switching power supply is used on the board to provide local power. There is also a LDO on the board to provide 1.2V power for the EQCO5X31.

5.4 USB2 Signaling

USB2 signals from each USB connector go to a USB2 HUB chip (USB2422), in this way, USB2 is also repeated. USB2 can be disabled by connecting a jumper plug on JP1, or zero-ohm resistor at R17. If USB2 is required, the UFP connector (J1) must be attached to the UFP (Host) side and the DFP connector (J2) must attach to the DFP (Device) side.

5.5 CC Lines

The USB Type-C™ CC lines are passively connected through the board between connectors, either straight through or swapped, controlled by mechanical slide switch S1. The reason S1 is required is because if they were simply passed through straight, then only half of the configurations would work. For more information, please see Section 8.0 “Theory of Operation EV23B43A TYPE-C REPEATER”. Because the CC lines are passively connected, this allows the Source and Sync to connect and negotiate PD power levels and protocols normally as if the Repeater were not present.

5.6 SBU Lines

The USB Type-C™ SBU lines are passively connected through the board and swapped between connectors. The reason for the swap is because the Repeater is essentially like a short cable segment, and like a cable, these are swapped per the USB Type-C™ Cable and Connector Specification [1].

5.7 Microcontroller

There is a ATtiny426 microcontroller on the boards that performs the following functions:

1. Determines the CC line configuration by measuring the voltages with its integrated ADC
2. Controls the USB data muxes according to the CC line configuration
3. Controls a RGB LED and sets the color according to the CC line configuration, see Section 8.6 “LED Indication” for LED definition.
4. Controls the USB2 HUB reset pin

5.7.1 MICROCONTROLLER PROGRAMMING

Connector JP2 (1x3 header) is used to program the microcontroller through a standard AVR programming tool. JP2 is a Molex connector PN 0530470360. The mating connector always comes as a cable assembly, an example of which is Molex PN 0151340303. See Section 6.2.1 “Microcontroller Connector JP2” for pinout and programming tool information.

6.0 CONNECTOR AND JUMPER INFORMATION

6.1 EV40G35ATYPE-C EXTENDER Connectors

The EV40G35A TYPE-C EXTENDER board contains two connectors.

1. A Type-C plug connector J2. This connector plugs directly into a Host or Device. Please see Section B.1 “EV40G35A Schematics” for more information on the pinouts of this connector.
2. A Type-C Receptacle connector J1. A Type-C cable would be plugged into this connector. Please see Section B.1 “EV40G35A Schematics” for more information on the pinouts of this connector.

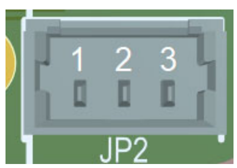
6.2 EV23B43A TYPE-C REPEATER Connectors and Jumpers

1. A Type-C Receptacle connector J1. A Type-C cable would be plugged into this connector. This is the UFP connector so it must point towards the UFP (Host). Please see Section C.1 “EV23B43A Schematics” for more information on the pinouts of this connector.
2. A Type-C Receptacle connector J2. A Type-C cable would be plugged into this connector. This is the DFP connector so it must point towards the DFP (Device). Please see Section C.1 “EV23B43A Schematics” for more information on the pinouts of this connector.
3. A USB2 enable/disable jumper JP1. Remove jumper plug to enable USB2 and connect jumper plug to disable USB2
4. A Microcontroller programming connector JP2. The pinout is defined in Figure 6-1.

6.2.1 MICROCONTROLLER CONNECTOR JP2

This connector is used to program the microcontroller. The pinout is defined in Figure 6-1.

FIGURE 6-1: MICROCONTROLLER PROGRAMMER HEADER PINOUT

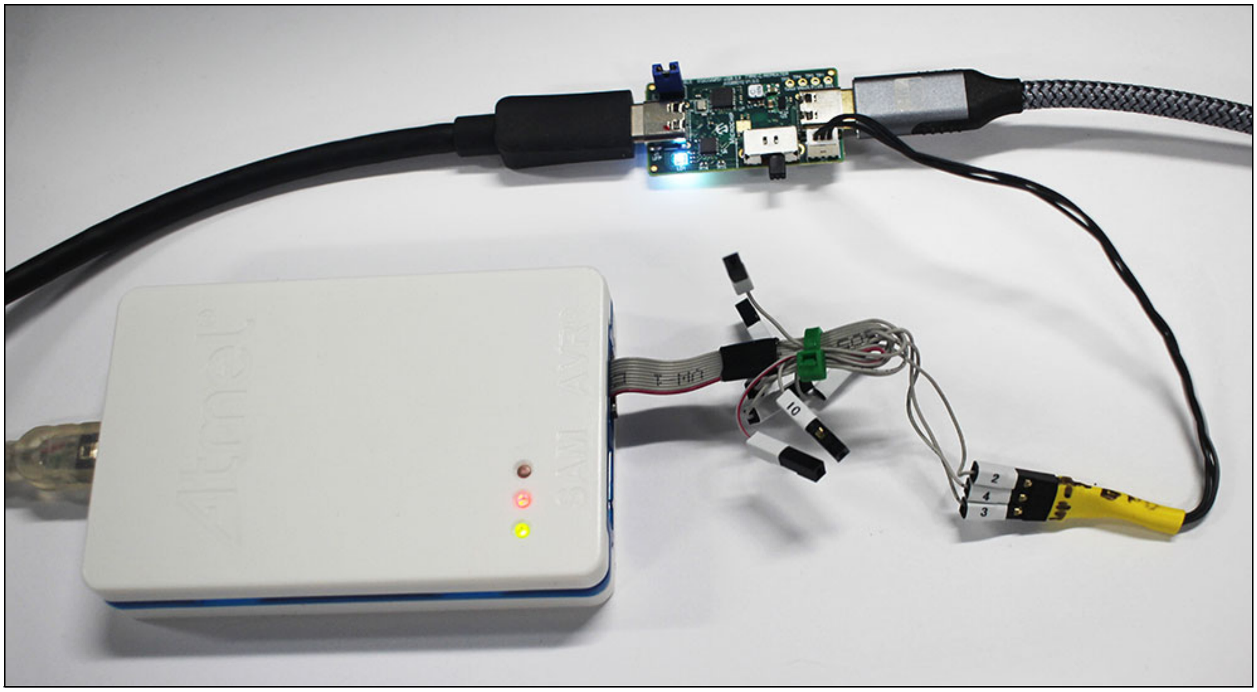


PIN 1: Board GND
PIN 2: Board 3.3V
PIN 3: UPDI (to programmer)

To connect to a programmer, it is suggested to:

1. Obtain a Molex cable assembly, such as PN 0151340303.
2. This cable includes two connectors, only one is needed so cut off one end
3. Wire the bare end wires to a 3-pin male header. Using a flywire adapter for the programmer, connect the appropriate signals to the header. Figure 6-2 shows an example connection to an Atmel-ICE tool.

FIGURE 6-2: MICROCONTROLLER PROGRAMMER HEADER EXAMPLE



7.0 THEORY OF OPERATION EV40G35ATYPE-C EXTENDER

Please refer to Figure 4-1. The TYPE-C EXTENDER is very simple in operation. Imagine a board that simply passively converts a Type-C plug to Type-C Receptacle. This board would simply connect all the signals between connectors straight through. The EV40G35A TYPE-C EXTENDER is just that, except for the USB3 signals, which are re-clocked and re-driven in each direction by the EQCO5X31. Because there are two USB3 lanes on a Type-C connector, two EQCO5X31 parts are used. Normally only one EQCO5X31 would be on at a time (USB 3.2 Gen 1X2), with the other going to sleep once it sees no activity, however the EV40G35A TYPE-C EXTENDER will also support both lanes operating at the same time (USB 3.2 Gen 1X2).

Power for the EV40G35ATYPE-C EXTENDER is tapped off the VBUS line. Because Type-C supports voltages between 5V and 20V nominal, a switching regulator is used to convert VBUS voltage to a lower voltage. This then is further converted to 1.2V for the EQCO5X31 Vcc supply by Microchip LDO, PN MIC94310/1.2V. This LDO is a special low noise LDO that has an excellent PSRR at the input switching frequency. This will provide a clean 1.2V supply to the EQCO5X31, which is very important for best CDR operation.

8.0 THEORY OF OPERATION EV23B43A TYPE-C REPEATER

Please refer to Figure 5-1. EV23B43A TYPE-C REPEATER is also a simple Device, but not as simple as the EV40G35A TYPE-C EXTENDER. This is primarily due to the complications of connecting the CC1 and CC2 lines and data multiplexing.

8.1 CC1/CC2 Connections

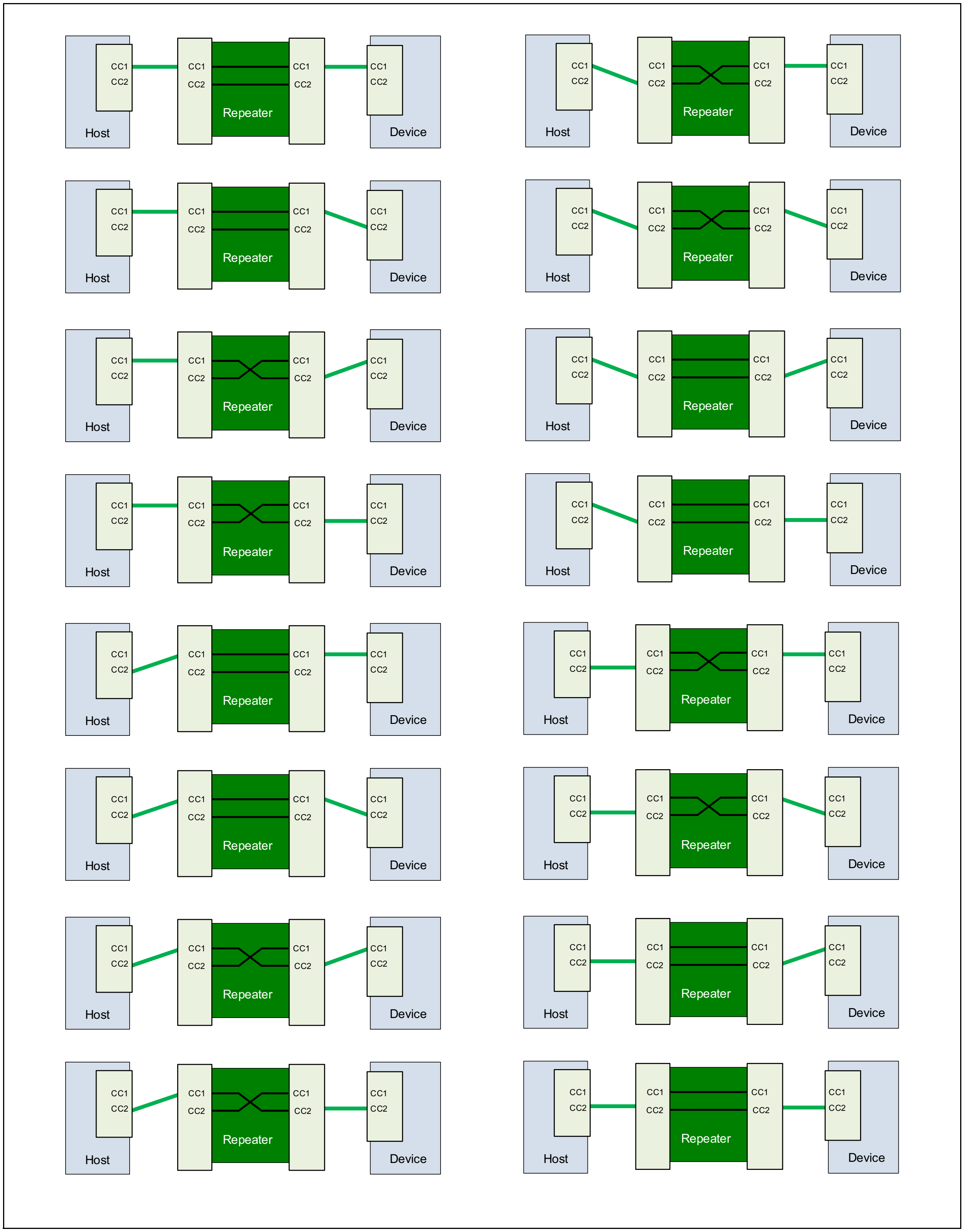
As the Type-C cable is allowed to plug into the receptacle in either orientation, the CC1 and CC2 connections indicate how the cable is actually oriented. Please reference the CC PINS section of the AN1953 Introduction to USB Type-C™ Application Note [3], which explains how the CC lines work.

For a Repeater, the question is how to make sure that the CC lines are always connected between Host and Device. The problem being that power will not be applied until there is a CC connection. Some ideas:

1. Spoof the Host/Device into thinking the Repeater is a Host/Device. This would imply having Rd resistors on the UFP (Host connection side) and Rp resistors on the DFP (Device connection side) of the Repeater. This would work but has the drawback that The PD power level would be fixed, as the real Host and Device CC lines are not connected through, so they cannot perform Power Delivery negotiation.
2. Connect the CC lines straight through. This is a better option as it allows the Host and Device to perform Power Delivery negotiation. However only half of the sixteen possible configurations work, see Figure 8-1.
3. Connect the CC lines crossed. This, like the straight through option allows the other half of the configurations to work.
4. Use a mechanical switch to either connect the CC lines straight through or crossed. This allows all 16 combinations to work. The drawback to this is it requires some user intervention, if after connecting everything, the power does not come on, then toggle the switch, the power will then come on. This is the method used on the EV23B43A Type-C REPEATER board, with the switch being a two-position slide switch.

Because there are four possible CC configurations on each side of the Repeater, there are then a total of sixteen possible configurations as shown in Figure 8-1. Since there is only one CC wire in the cable (green line), to connect through, the slide switch will need to either be in straight through mode, or crossed mode.

FIGURE 8-1: CC LINE CONFIGURATIONS, SIXTEEN TOTAL



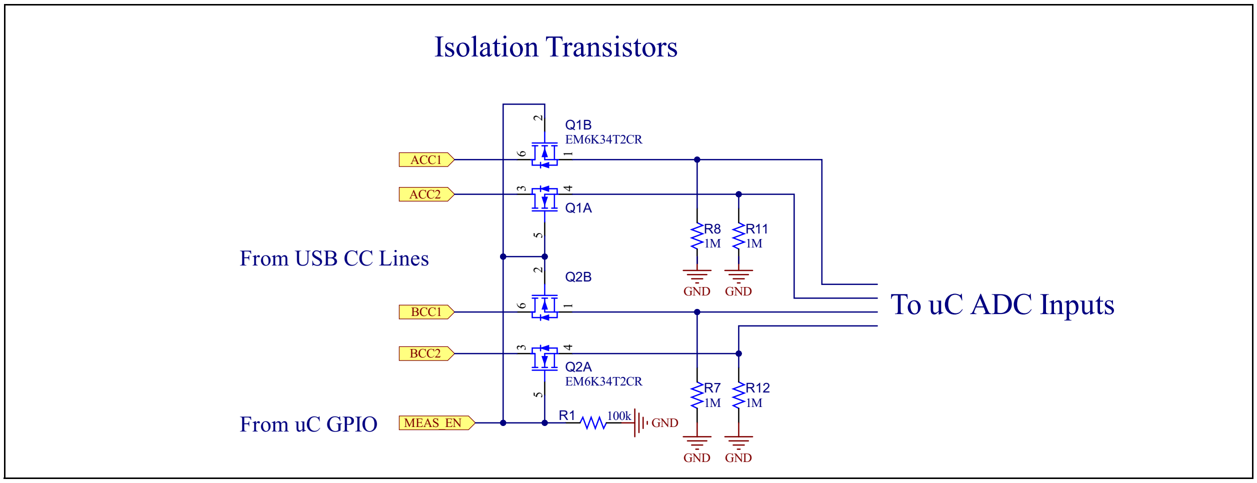
8.2 CC1/CC2 Voltage Detection

Once power come on (indicating that the CC line connection has been made), the voltage on the CC lines on each side of the Repeater can be measured to determine the cable orientation on each side. This is done with a microcontroller (see Section 5.7) via its ADC. Each of the four CC lines (two on each side) are inputs to the microcontroller ADC, allowing the microcontroller to read these voltages and set up the data muxes properly. The voltage range that could be measured is defined by the Rp and Rd resistors as shown in the *Termination Parameters* section of USB Type-C™ Cable and Connector Specification [1].

8.3 CC1/CC2 Isolation

It is necessary to isolate the CC lines to the ADC inputs in certain cases. FET transistors are used to provide this isolation, as shown in Figure 8-2.

FIGURE 8-2: CC1/CC2 ISOLATION TRANSITORS



The purpose of the isolation is:

1. With Repeater board power off, if there were no isolation, up to 5.5V could be connected (if Rp pullup present, but not Rd pulldown) to an unpowered microcontroller input. The input protection diodes of the microcontroller would likely conduct, causing a possible false CC detection.
2. With Repeater board power on, if there were no isolation, it is also possible that 5.5V could be present on the microcontroller inputs, violating the ViH max parameter. This situation would occur if the Device were unplugged, taking away the Rd pulldown, leaving only Rp pullup, before the Host removes power.
3. When the microcontroller does not need to make ADC measurements, it is good design practice to isolate these inputs from the external world.

8.3.1 TRANSISTOR OPERATION

For case 1, with power off, Vgs = 0V (due to pull down resistors on gate and source), the FETs will be off.

For case 2, once the CC source/sync negotiation succeeds (because the CC's are attached through), VBUS comes on and the Repeater is now powered. The CC lines that are connected through will be at a voltage determined by the voltage divider of Rp and Rd. The CC lines that are not connected will be floating, so ~0V. The "MEAS_EN" signal from the microcontroller is initially 0V, so again the FETs are off. When the microcontroller wants to measure the CC voltage, it will turn on "MEAS_EN" = 3.3V, and the FET will come on because Vgs = (3.3-0). When the FET turns on, Vgs will change to (3.3-2.18) = ~1.1V (note 2.18V is the maximum voltage that can be present on a CC line if Rp and Rd are connected). The FETs used must have a very low Vth to stay on, and this is met by the EM6K34T2CR transistor.

For case 3, when Rd gets disconnected (Device unplugged) and "MEAS_EN" happens to be on (3.3V), 5.5V will appear on the CC line because the pull down is taken away. This high voltage will get passed to the microcontroller, but only for a very short time because the FET will turn off immediately, Vgs = (3.3 -5.5). The FET will immediately turn on again though, Vgs = (3.3-0). In reality, the FET will not oscillate, but settle to a semi on state, causing a voltage drop across it, and so the worst-case voltage on the microcontroller can't be greater than the gate voltage. There could be a very short (ns) pulse of 5.5V that gets to the microcontroller, but that will be ok, it has protection diodes, plus there cannot be much current flow because the source impedance (Rp) is relatively high.

8.4 Data Multiplexing

As shown in Figure 5-1, there is one EQCO5X31 only, whose data connections must be muxed to the appropriate USB lane. High speed 2:1 multiplexors on the board handle this. The microcontroller sets the mux position after determining the CC lines connected. Note, the data muxes, being in the USB3 data path will add some loss to the signals.

8.5 Slide Switch

As mentioned, there is a mechanical slide switch that must be set correctly for power to come on. If multiple Repeaters are used in the chain, it gets more complicated to get all the slide switches in the proper positions. In that case it is suggested to set all switches to the same initial position and using a binary progression, go through all possible combinations until the power comes on. For example, if three Repeaters are used, there would 8 combinations, as shown in Table 8-1.

TABLE 8-1: EXAMPLE REPEATER SLIDE SWITCH COMBINATIONS FOR THREE REPEATERS.

Switch Positions - Left or Right, try each combination until power comes on		
Left	Left	Left
Left	Left	Right
Left	Right	Left
Left	Right	Right
Right	Left	Left
Right	Left	Right
Right	Right	Left
Right	Right	Right

8.6 LED Indication

There is one RGB LED on the board that is used to indicate 1) power and 2) CC line configuration. The LED will turn on if there is power to the board (meaning the slide switch is set correctly). And, as there are four possible CC line configurations, each configuration is indicated by a different color as defined in Table 8-2.

TABLE 8-2: LED COLOR DEFINITION

UFP CC Data Lane	DFP CC Data Lane	LED Color
1	1	Blue
1	2	White
2	1	Yellow
2	2	Green

> **Note:** The microcontroller must be programmed for the LED to function. The LED will not turn on if there is no program loaded, even if there is power to the board.

APPENDIX A: OPERATING SPECIFICATIONS

TABLE A-1: ELECTRICAL SPECIFICATIONS

Description	Min	Typ	Max	Units	Comments
EV40G35A Extender					
VBUS Voltage	3.5	5	22	Volts	
VBUS Power (5.25V)		0.2	0.5	Watts	
VBUS Power (22V)		0.25	0.6	Watts	
EV23B43A Repeater					
VBUS Voltage	3.5	5	22	Volts	
VBUS Power (5.25V)		0.25	0.6	Watts	
VBUS Power (22V)		0.3	0.7	Watts	

APPENDIX B: EV40G35ADESIGN DOCUMENTS

FIGURE B-1: EV40G35A Schematic - USB Connections
FIGURE B-2: EV40G35A Schematic - Power
FIGURE B-3: EV40G35A Assembly Drawing (Top)
FIGURE B-4: EV40G35A Assembly Drawing (Bottom)

B.1 EV40G35A Schematics

Note: Schematics are provided “as is” without any warranty as an example implementation, and are not guaranteed to be suitable for any particular application. Any design using this information should be tested over the full environmental stress conditions of the intended application.

Note: This schematic is for reference only and could be out of date with actual built boards. The latest information is available by obtaining our reference design files. Please contact Microchip support via the Microchip support portal.

FIGURE B-1: EV40G35A SCHEMATIC - USB CONNECTIONS

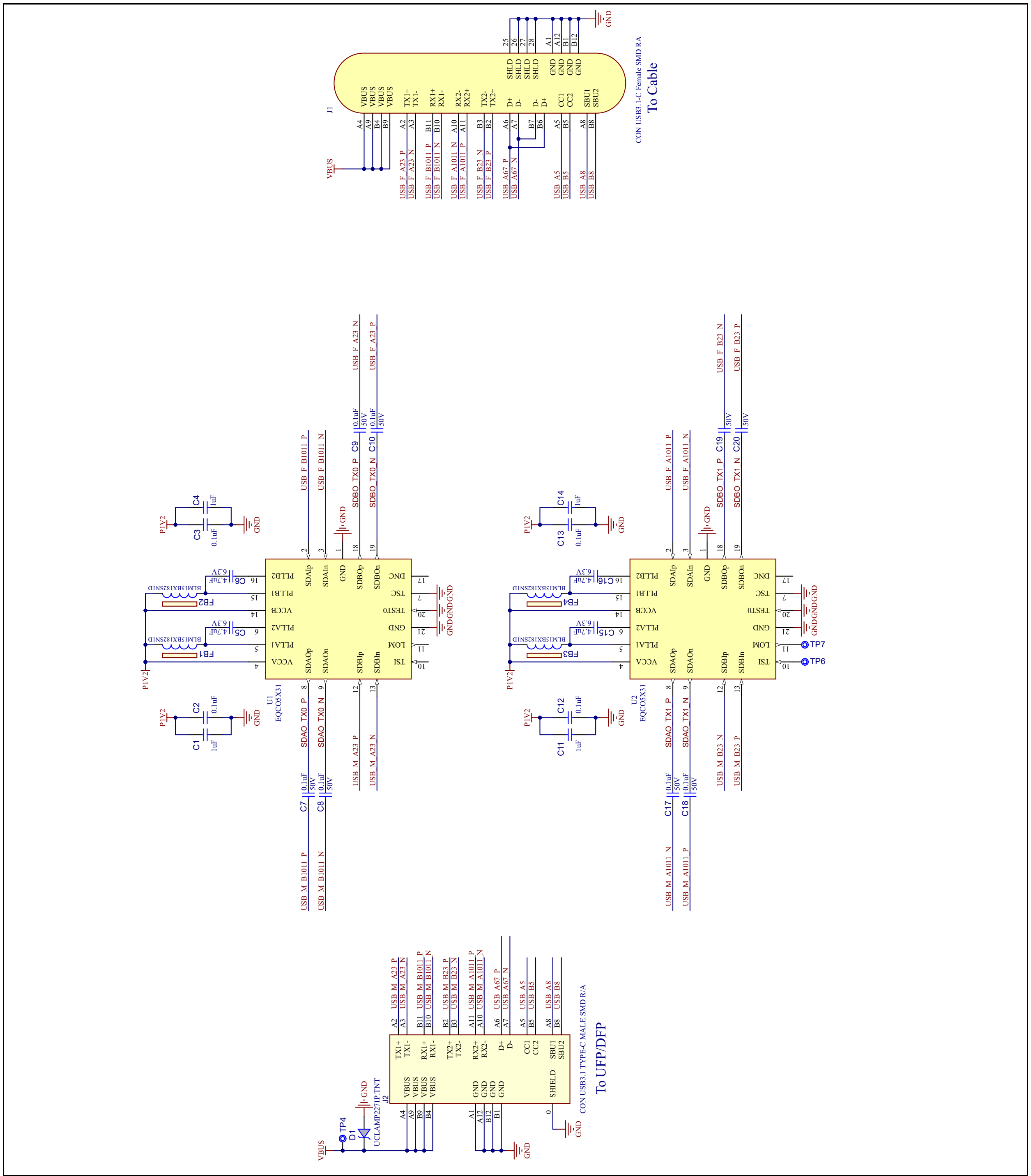
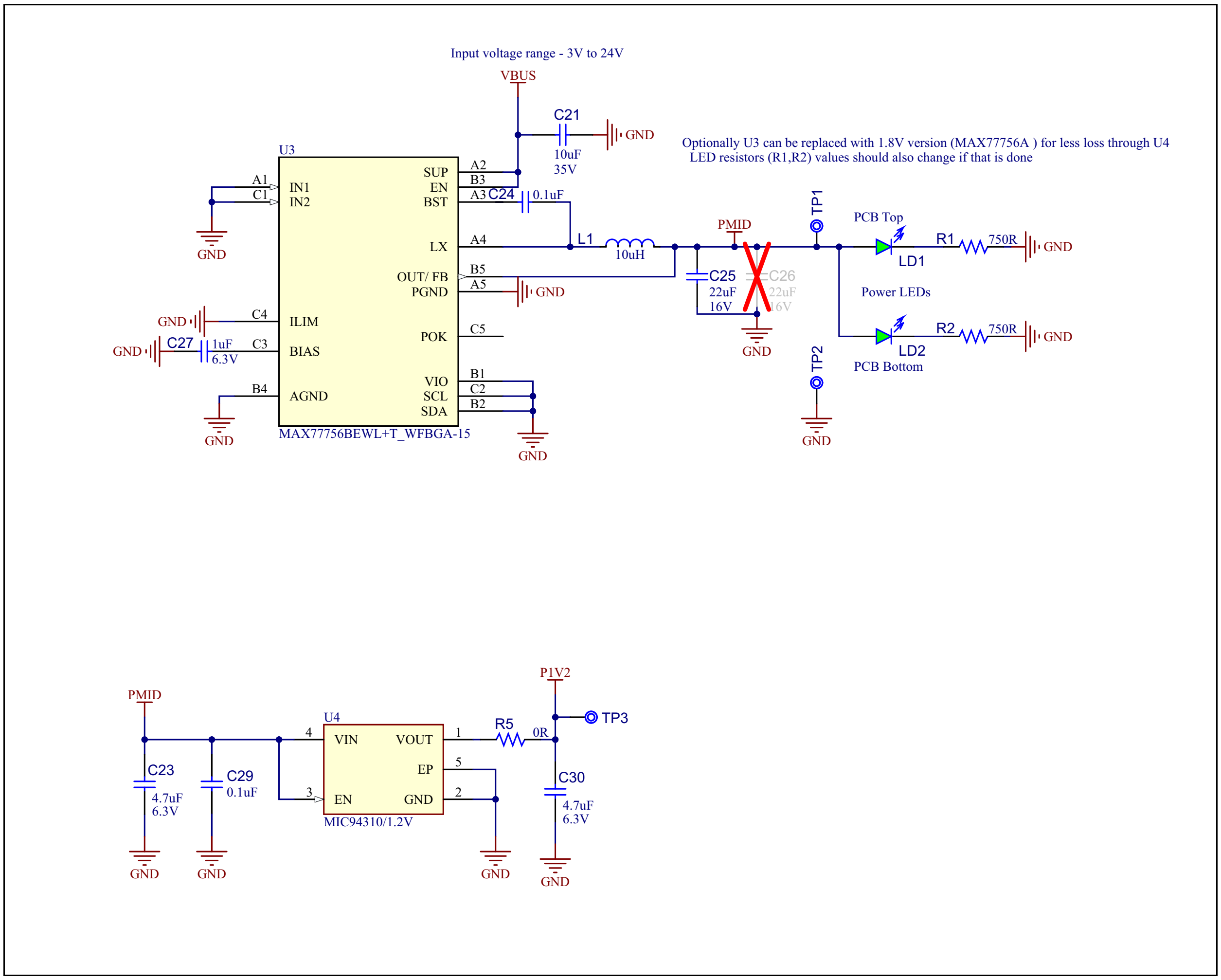


FIGURE B-2: EV40G35A SCHEMATIC - POWER



B.2 EV40G35A Assembly Drawings

FIGURE B-3: EV40G35A ASSEMBLY DRAWING (TOP)

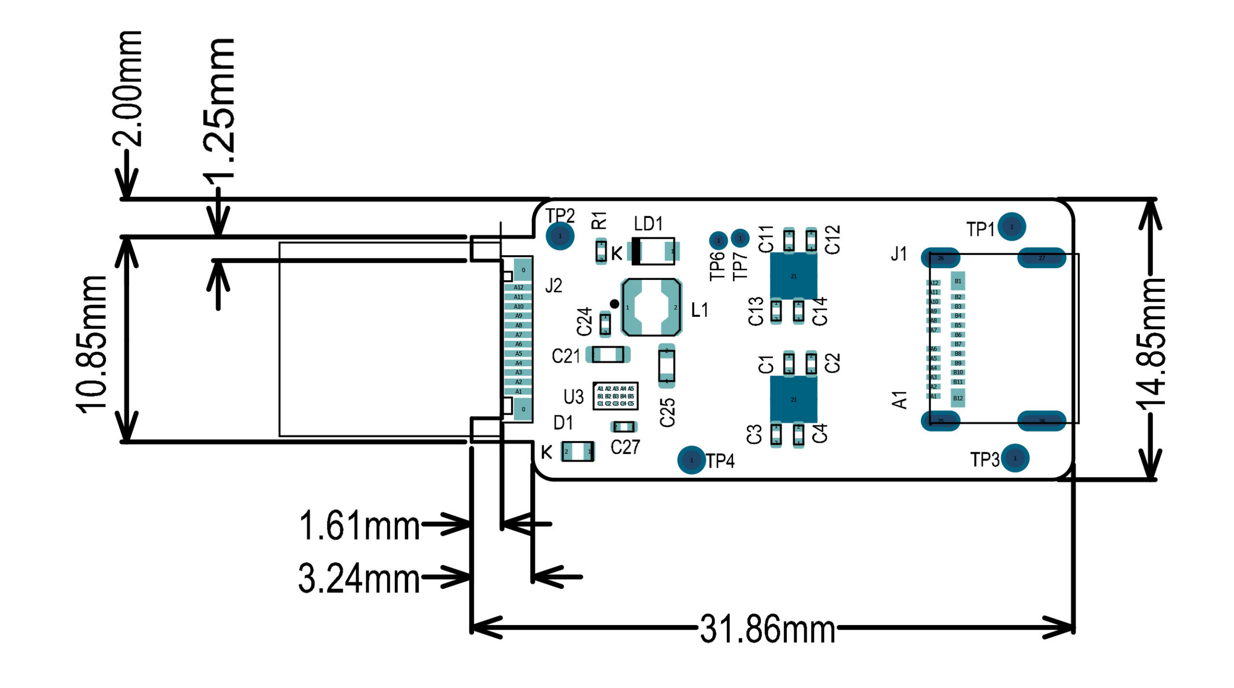
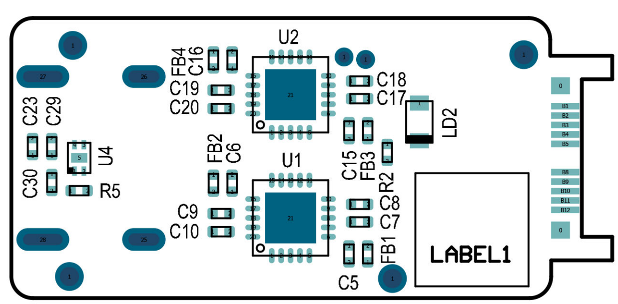


FIGURE B-4: EV40G35A ASSEMBLY DRAWING (BOTTOM)



APPENDIX C: EV23B43A DESIGN DOCUMENTS

FIGURE C-1: EV23B43A Schematic - USB Connection
FIGURE C-2: EV23B43A Schematic - Power
FIGURE C-3: EV23B43A Schematic - Micro
FIGURE C-4: EV23B43A Schematic - USB Hub
FIGURE C-5: EV23B43A Assembly Drawing (Top)
FIGURE C-6: EV23B43A Assembly Drawing (Bottom)

C.1 EV23B43A Schematics

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Note: This schematic is for reference only and could be out of date with actual built boards. The latest information is available by obtaining our reference design files. Please contact Microchip support via the Microchip support portal.

FIGURE C-1: EV23B43A SCHEMATIC - USB CONNECTION

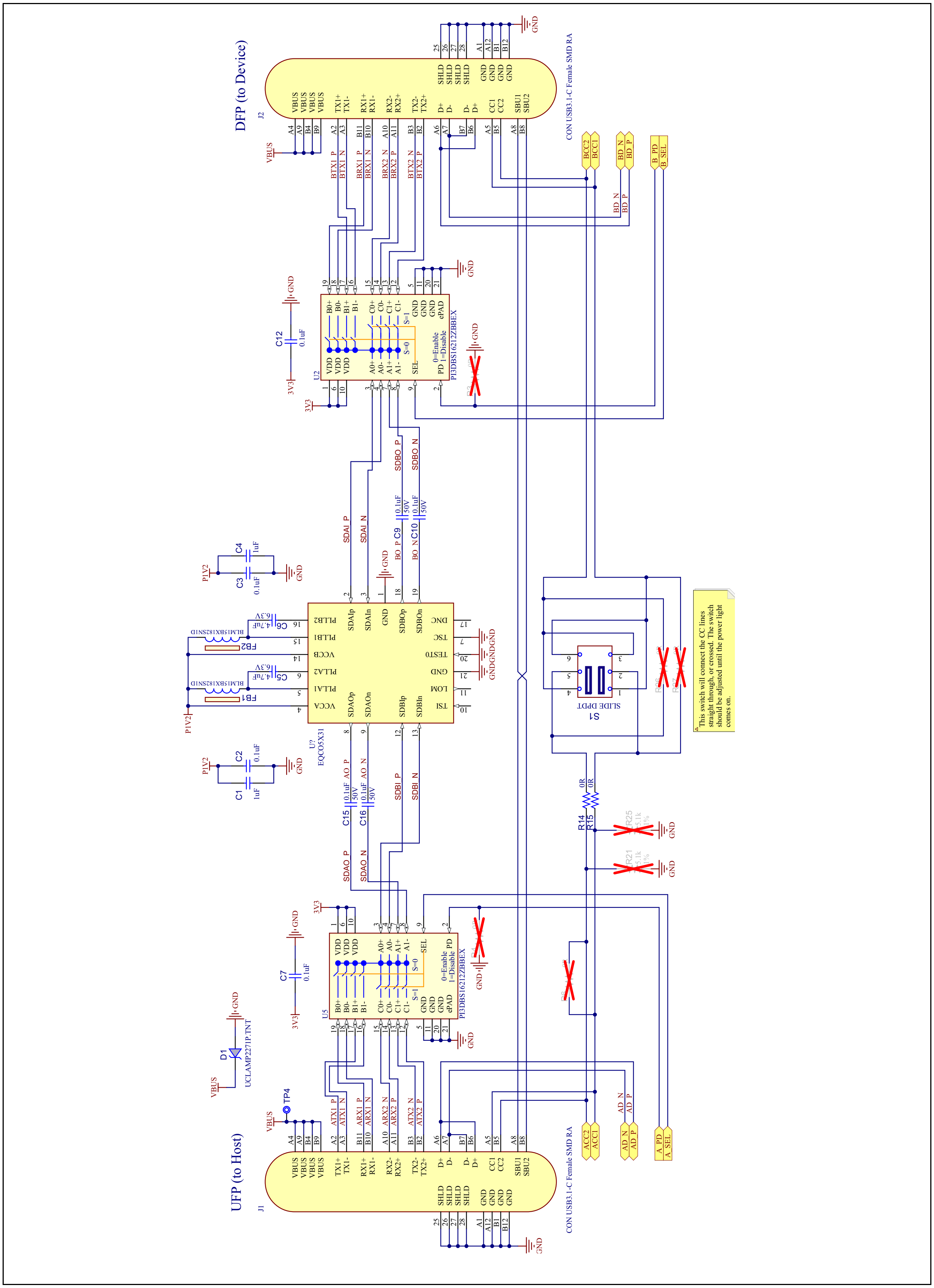


FIGURE C-2: EV23B43A SCHEMATIC - POWER

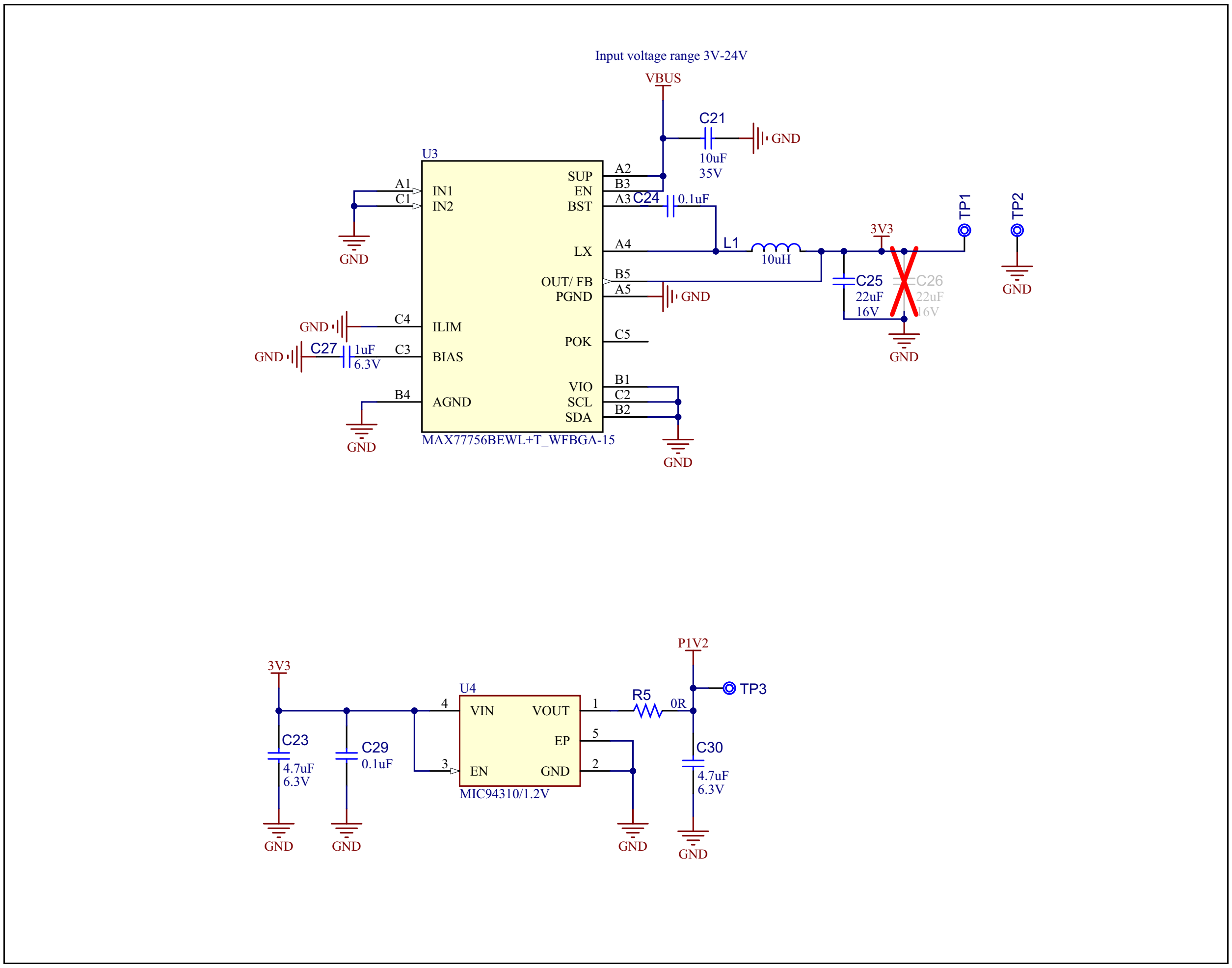


FIGURE C-3: EV23B43A SCHEMATIC - MICRO

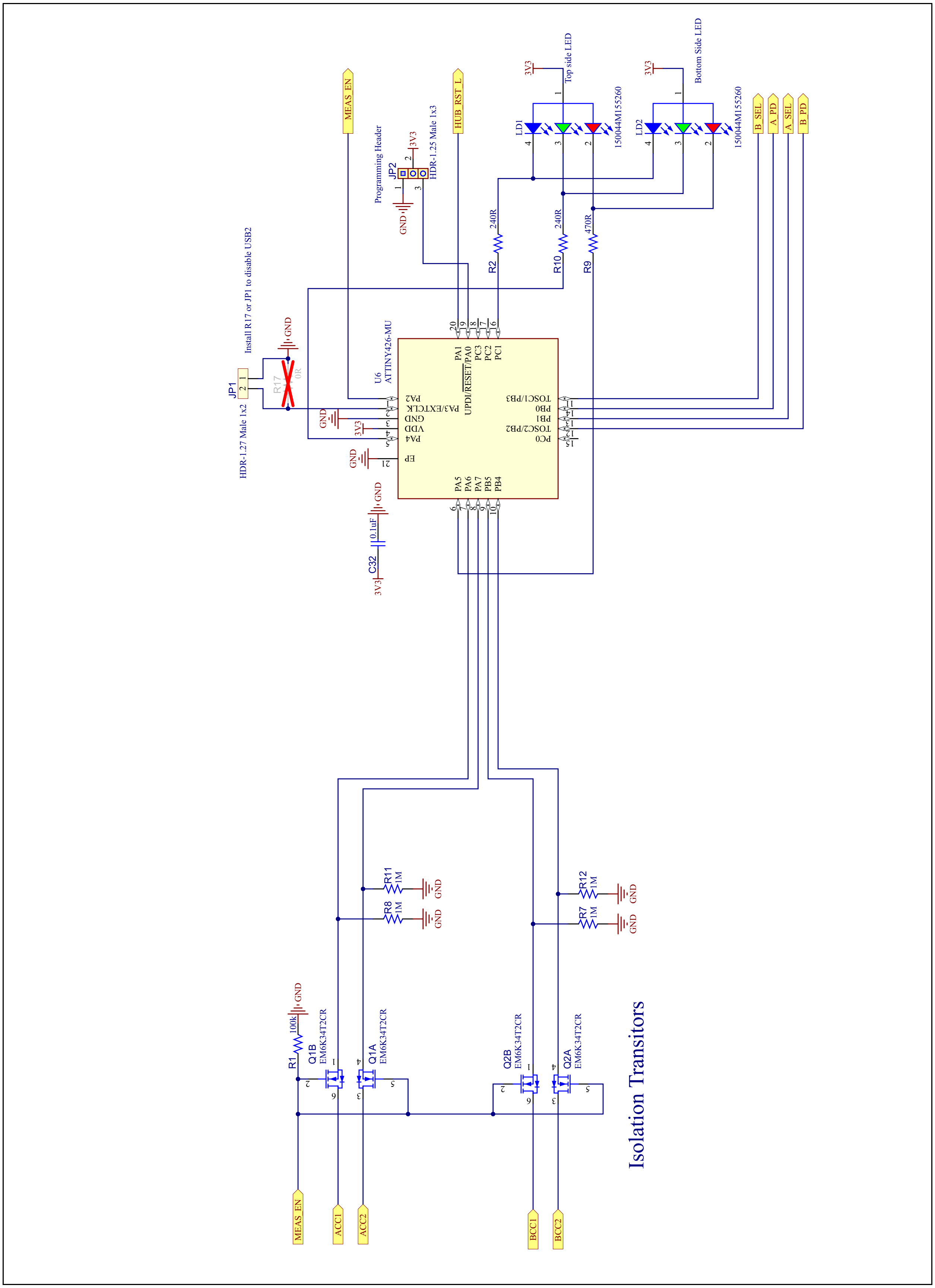
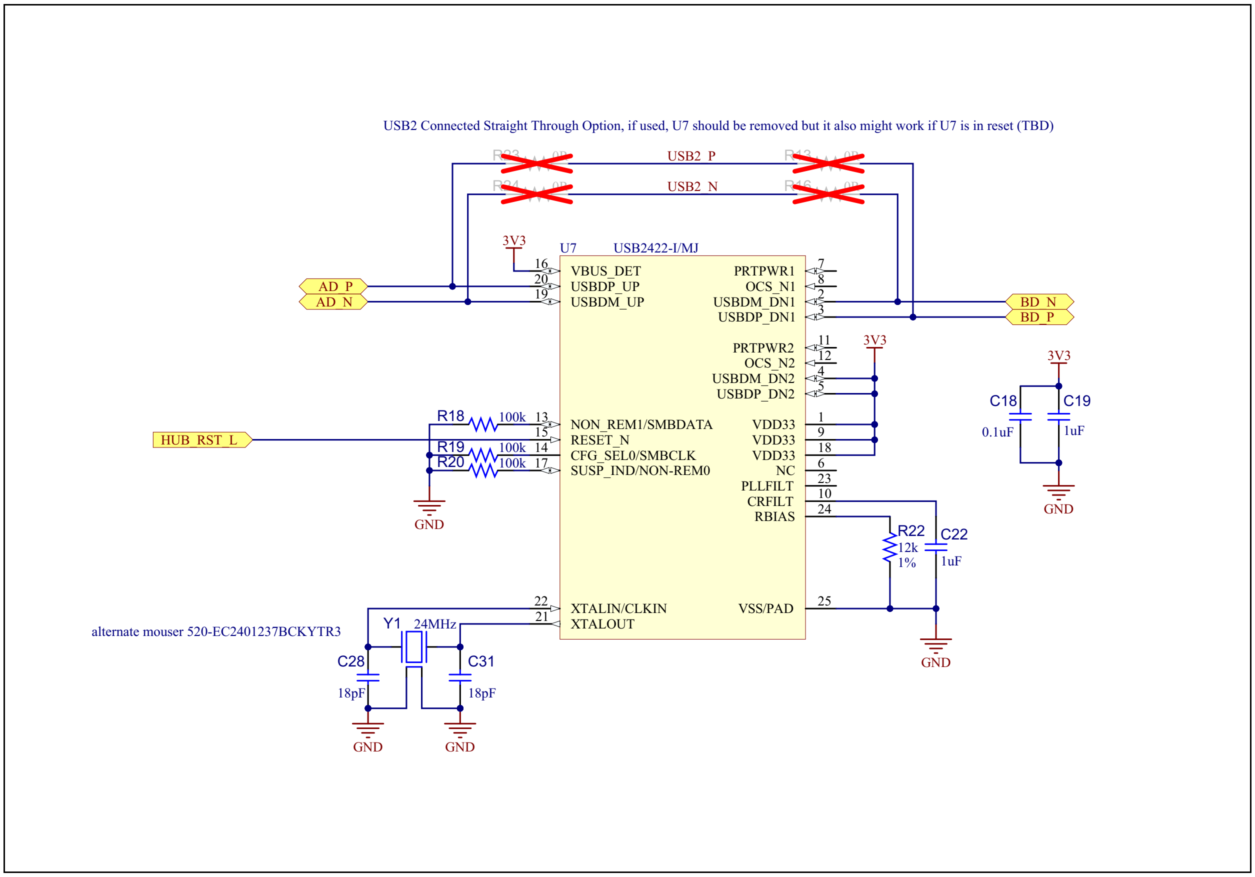


FIGURE C-4: EV23B43A SCHEMATIC - USB HUB



C.2 EV23B43A Assembly Drawings

FIGURE C-5: EV23B43A ASSEMBLY DRAWING (TOP)

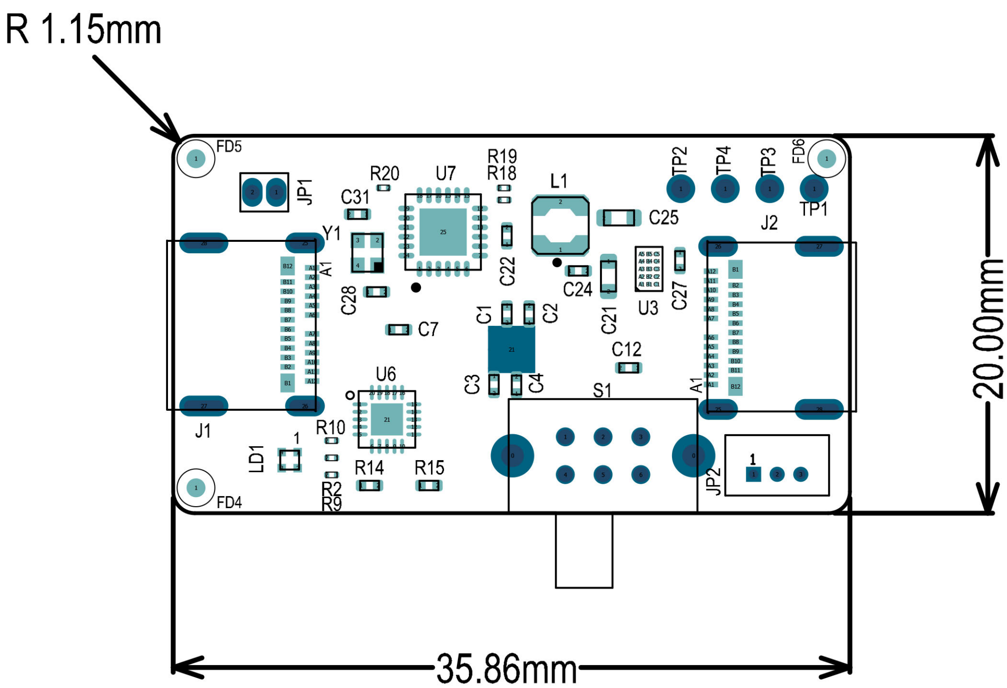
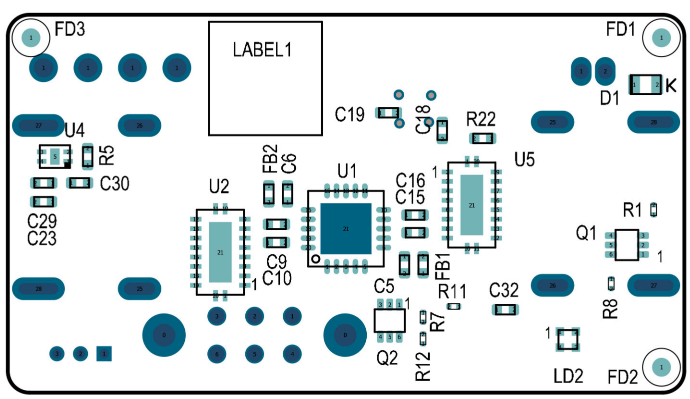


FIGURE C-6: EV23B43A ASSEMBLY DRAWING (BOTTOM)



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Documents listed below and referenced within this publication are current as of the release of this publication and may have been reissued with more current information. To obtain the latest releases of Microchip documentation please visit the Microchip website. Please note, some Microchip documentation may require approval. Contact information can be found at www.microchip.com.

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Because the Internet is a constantly changing environment, all Internet links mentioned below and throughout this document are subject to change without notice.

[1] USB Type-C™ Cable and Connector Specification
USB 3.0 Promoter Group. www.usb.org.

[2] EQCO5X31 Product Data Sheet
60001668. Microchip. www.microchip.com.

[3] AN1953 Introduction to USB Type-C™ Application Note
00001953. Microchip. www.microchip.com.

APPENDIX E: USER'S GUIDE REVISION HISTORY

E.1 Current Document Revision

Revision A (DS60001794A - April 2023)

- Initial Release

NOTES:

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