MAX20461 Evaluation Kit

Evaluates: MAX20461

General Description

The MAX20461 evaluation kit (EV kit) demonstrates the MAX20461 automotive high-current, high-efficiency, step-down DC-DC converter with integrated USB Type-C DFP controller and 1GHz bandwidth USB 2.0 D+/D- protection switches, which provide ESD and short-to-battery protection for low-voltage transceivers.

The MAX20461 features integrated host-charger port-detection circuitry that adheres to the USB Type-C specification, the USB-IF BC1.2 battery-charging specification, Apple iPod/iPhone/iPad® and Samsung® charge-detection termination resistors, and Chinese Telecommunication Industry Standard YD/T 1591-2009.

The MAX20461 integrates high-side current sensing and voltage adjustment circuitry, which provides automatic USB voltage adjustment to compensate for voltage drops in captive cables associated with automotive applications.

The MAX20461 step-down, synchronous, DC-DC converter operates from a voltage of up to 28V continuous and protects against load-dump transients up to 40V. The converter is programmable for frequencies from 275kHz to 2.2MHz and can deliver 3A continuously.

The EV kit contains an I^2C-enabled MAX20461. The I^2C interface allows for flexible configuration, detailed fault diagnostics, and access to the on-chip ADC that reports die temperature, output voltage, and output current. The I^2C features are easily accessed using the Maxim MINIQUSB module and the provided example GUI.

The EV kit is configured for 2.2MHz operation. The data switches of the MAX20461 generally do not require far-eye tuning; the EVKIT is populated with shorts.

Features and Benefits

- Configurable Charge-Detection Modes
  - USB-C 3.0A, 1.5A, 0.5A
  - USB-IF BC1.2 CDP, DCP
  - Apple 2.4A, 1.0A
  - China YD/T1591-2009 Charging Specification
- Automatic USB Voltage Adjustment by Integrated DC-DC Converter (275kHz to 2.2MHz)
- Proven PCB Layout
- Fully Assembled and Tested

***Ordering Information** appears at end of data sheet.*

319-100329; Rev 0; 3/19

Quick Start

The following procedure demonstrates the MAX20461's high-speed data switches, voltage adjustment capability, and I2C interface.

Required Equipment

- MAX20461 EV Kit
- USB Type-C to Type-A Adapter
- 2m USB-A Extension Cable
- 3A Electronic Load (Preferred) or Two 3.5Ω 10W Resistors in Parallel (Included), Connected to a USB Type-A Plug (Included)
- 14V/2A DC Power Supply or Car Battery (V_{BAT})
- Digital Voltmeter (DVM) or Oscilloscope
- MINIQUSB and MAX20461 GUI
- Two Jumpers
- Four DuPont Jumper Wires, Female-Female: GND, SDA, SCL, 3V3

Note: In the following sections, software-related items are identified by bolding. Text in **bold** refers to items directly from the EV kit software. Text in **bold and underlined** refers to items from the Windows operating system.

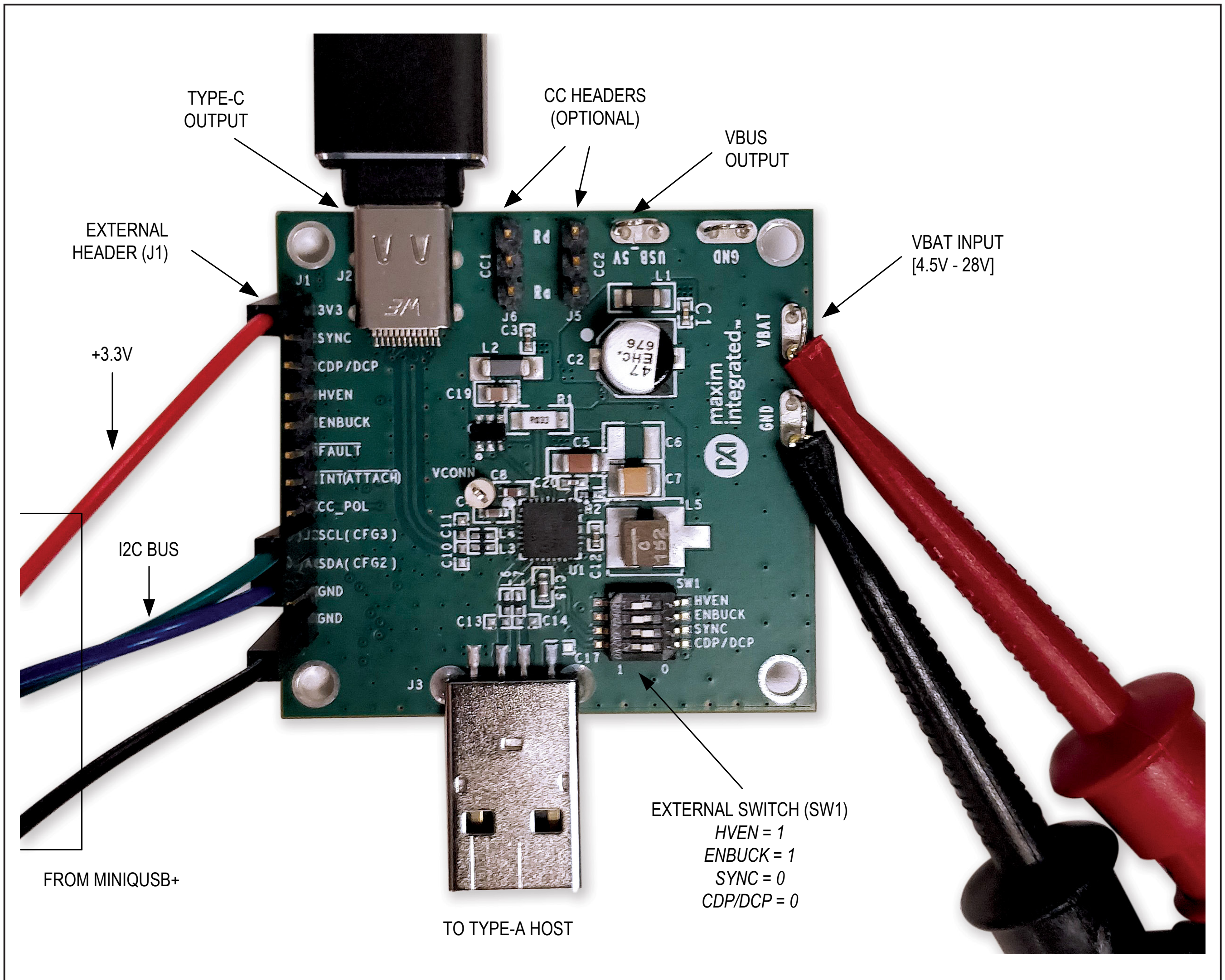


Figure 1. EV Kit Interface

Initial Setup

The EV kit is fully assembled and tested. Follow the steps below to set up the board for evaluation.

1) MAX20461 GUI is installed.
2) Verify SW1 switch is set to HVEN = 1, ENBUCK = 1, SYNC = 0, CDP/DCP = 0.
3) Using the jumper wires, connect the MINIQUSB to the EVKIT as follows:
   - V_{DD} to 3V3
   - SCL to SCL
   - SDA to SDA
   - GND to GND
4) Connect the MINIQUSB+ to the computer.
5) Verify that the MINIQUSB+ is recognized in the **Windows Device Manager** as USB Serial Converter.

6) Set the V_{BAT} power supply to 14V output, 2A current limit. Turn the output off. Connect the negative lead to the GND test loop on the EVKIT. Connect the positive lead to the V_{BAT} test loop on the EVKIT.
7) Turn the V_{BAT} power supply output on.
8) Plug the USB-C to USB-A adapter to the EVKIT.
9) Plug a USB flash drive to the USB-C adapter.

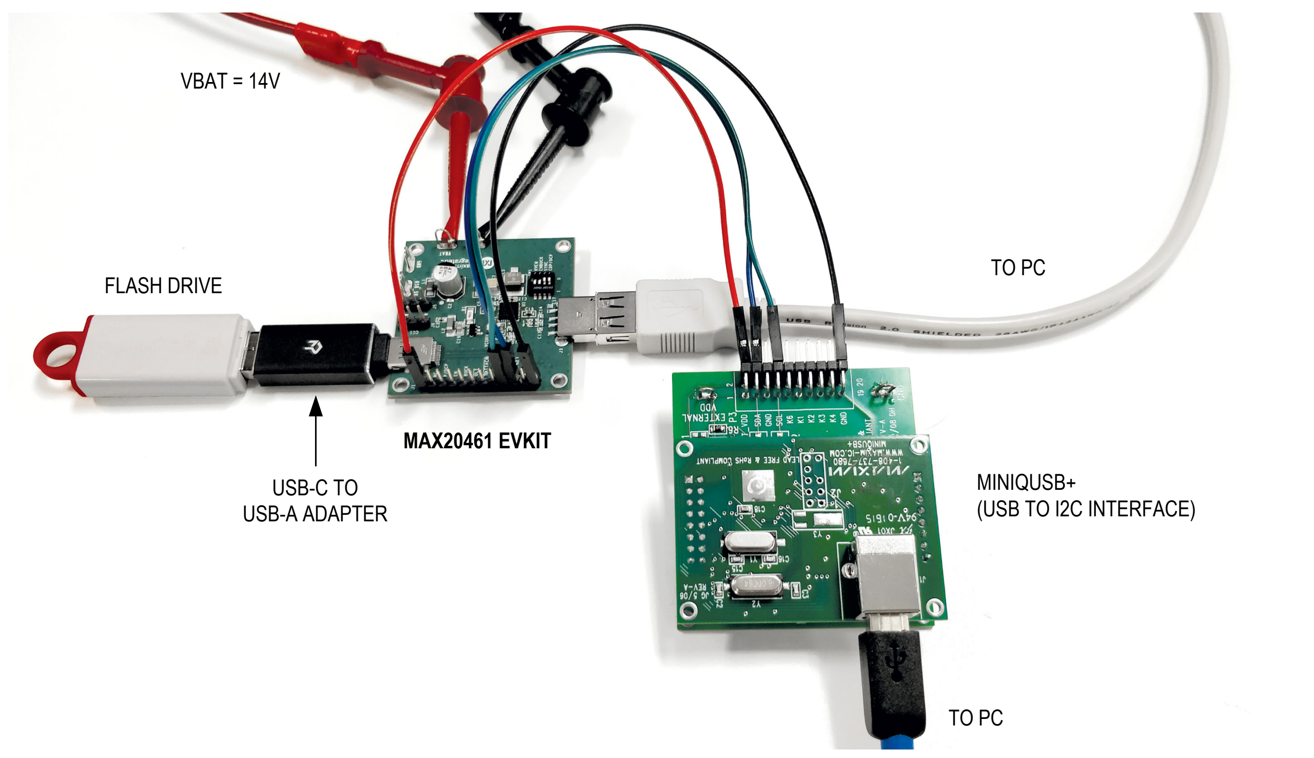


Figure 2. EV Kit Setup

10) Start the MAX20461 GUI. Look at the message bar at the bottom of the GUI to verify that both the MINIQUSB and the EV kit are detected. See Figure 3 for GUI startup configuration.
11) Click **Auto Read**. Click **Configuration Complete**. ***Note:*** *Every time the MAX20461 is polled by the GUI (either by clicking the* ***Refresh*** *button or by selecting* ***Auto Read****) the SENSN output voltage, USB output current, and die temperature will continuously update in the corresponding windows of the GUI. See the ADC Timing Diagram in the MAX20461 IC datasheet for the ADC polling procedure.*

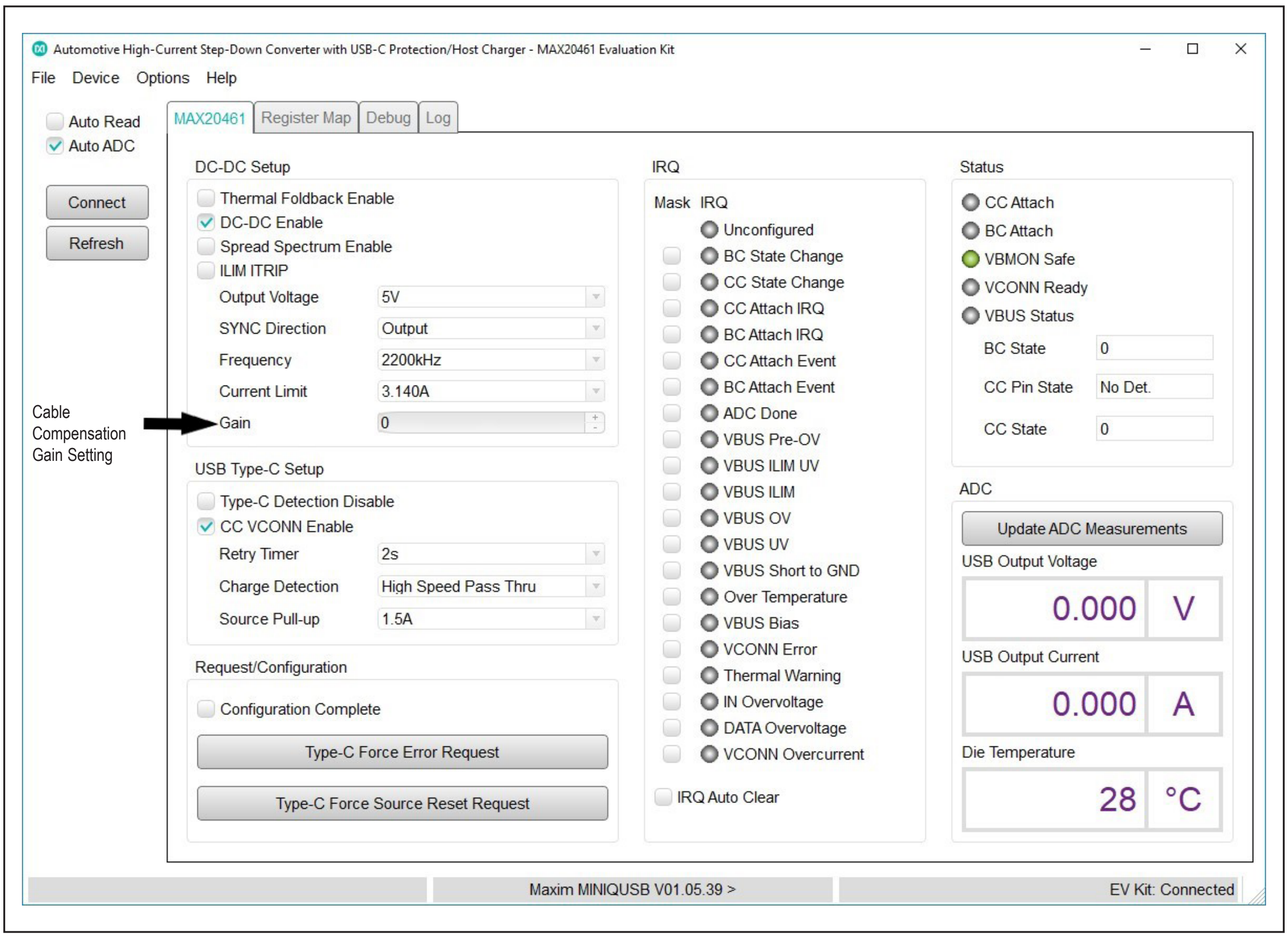


Figure 3. MAX20461 GUI Startup

12) The USB output voltage should display approximately 5.15V, as seen in Figure 4.

High-Speed Data Switches

1) Connect the EVKIT to the computer USB port using a USB-A extension cable.
2) Check that the USB flash drive is recognized on the computer and that it can be opened. This verifies that the high-speed data switches are operating correctly.
3) Unplug the flash drive from the USB-C adapter.

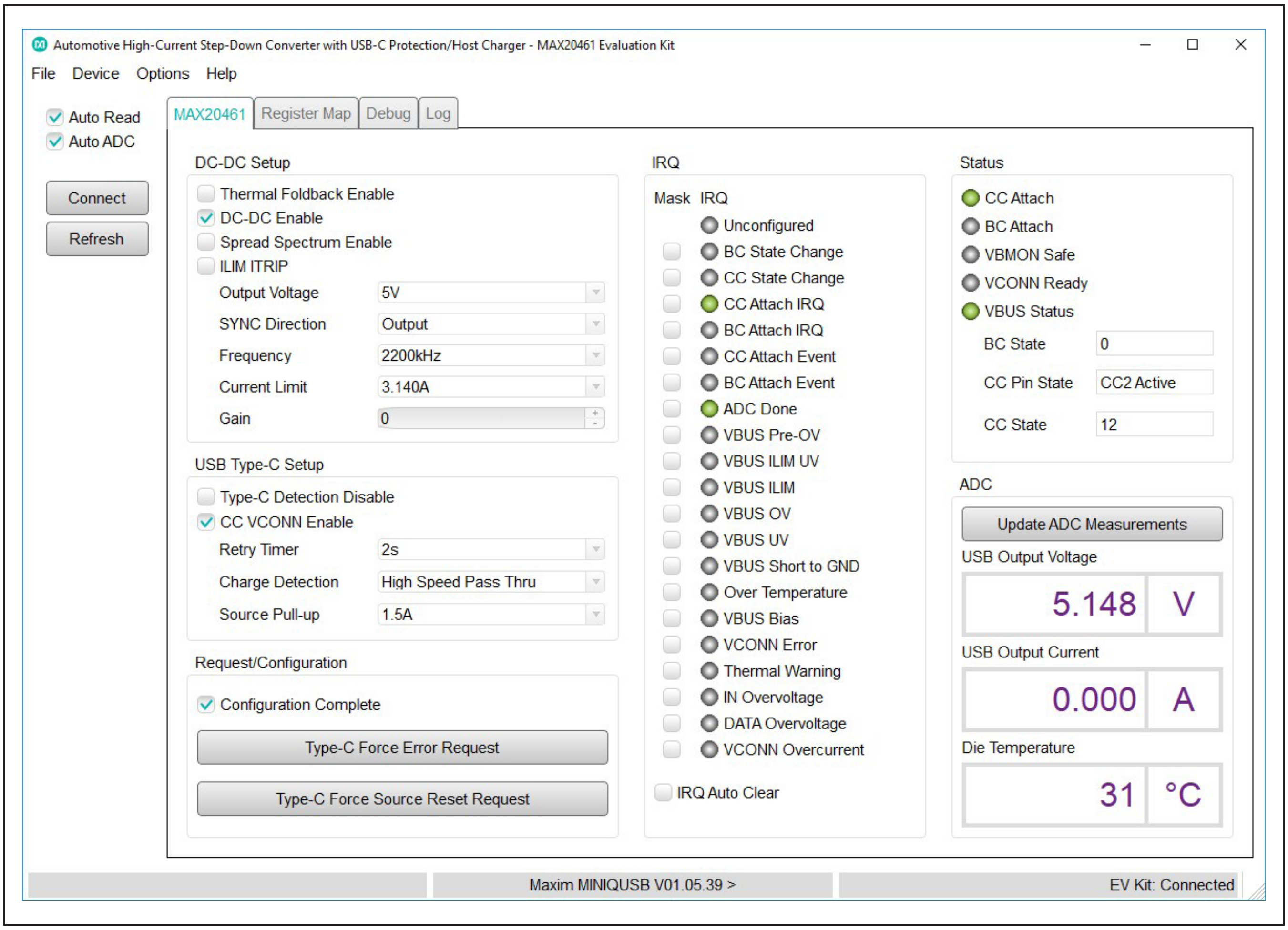


Figure 4. MAX20461 GUI Configured

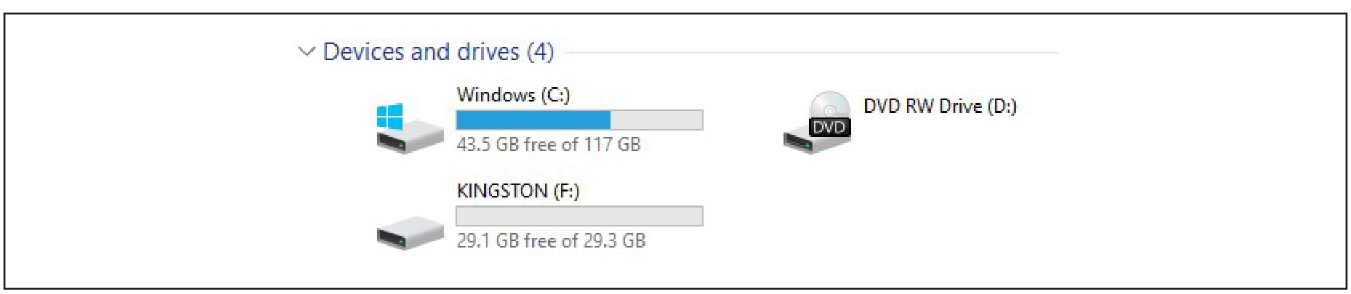


Figure 5. USB Flash Drive Recognized

Cable Compensation

See Figure 6 for illustration of the setup

1) Connect the 2m USB-A Extension Cable to the USB-C adapter as shown in Figure 6.
2) Connect the Type-A Plug to the other end of the cable. ***Note:*** *this is the voltage that a portable device will see.*
3) Check that the V_{BUS} voltage at the end of cable is approximately 5.15V.
4) Connect the E-load to the plug's ground and V_{BUS} pins. Enable the 3A load. Use a voltmeter to find V_{BUS} and GND on the plug's leads.
5) With the voltage adjustment disabled (GAIN = 0; default setting) the V_{BUS} voltage on the GUI should still be near 5.15V. Since this is the output of the DC/DC converter, there will be a slight drop due to load regulation and the current through the SENSE resistor, output filter, and PCB trace.
6) The voltage at the far end of the USB cable, however, will be significantly below 5V and will depend on the load current and cable resistance.
7) Set the voltage adjustment to step 28 by typing it directly into the **Gain** box of the example GUI.
8) The buck output voltage will increase and the voltage at the far end of the USB adapter and 2m cable will now be approximately 5.15V, regardless of the load current.

Optional - Powering E-Marked Cables

For ports that support USB SuperSpeed Signals, the USB Type-C Specification requires V_{CONN} to power E-Marked Cables. By default, the MAX20461 V_{CONN} switch can be quickly evaluated using the low-power V_{DD} rail from MINIQUSB+ or a dedicated 3V3/0.3A supply. In order to provide higher power (up to 1.5W), a separate 5V supply for V_{CONN} must be used, as follows:

1) Remove R23 (located at the back of the PCB) to disconnect the 3V3 rail from V_{CONN}.
2) Follow the same procedure as before to bring the board up and configure the GUI.
3) Connect a 5V/0.3A DC power supply to the V_{CONN} test point.
4) Verify that the GUI displays the green **V_{CONN} Ready** status indicator.
5) Place a jumper on the EVKIT on pins 1-2 of J6 (Ra) and a jumper on pins 2-3 of J5 (Rd).
6) Verify that the GUI displays the green **V_{BUS} Status** indicator.
7) Remove J6 jumper to expose the V_{CONN} output. ***Note:*** *To save power, an E-marked cable can remove Ra once V_{CONN} has been supplied.*
8) Connect the E-load to pin 2 of J6. Set the load to 300mA and turn the E-load on.
9) Observe the current being supplied from the 5V supply. Measure the voltage at pin 2 of J6 and verify that it is within the required V_{CONN} range of 3.0V to 5.5V.

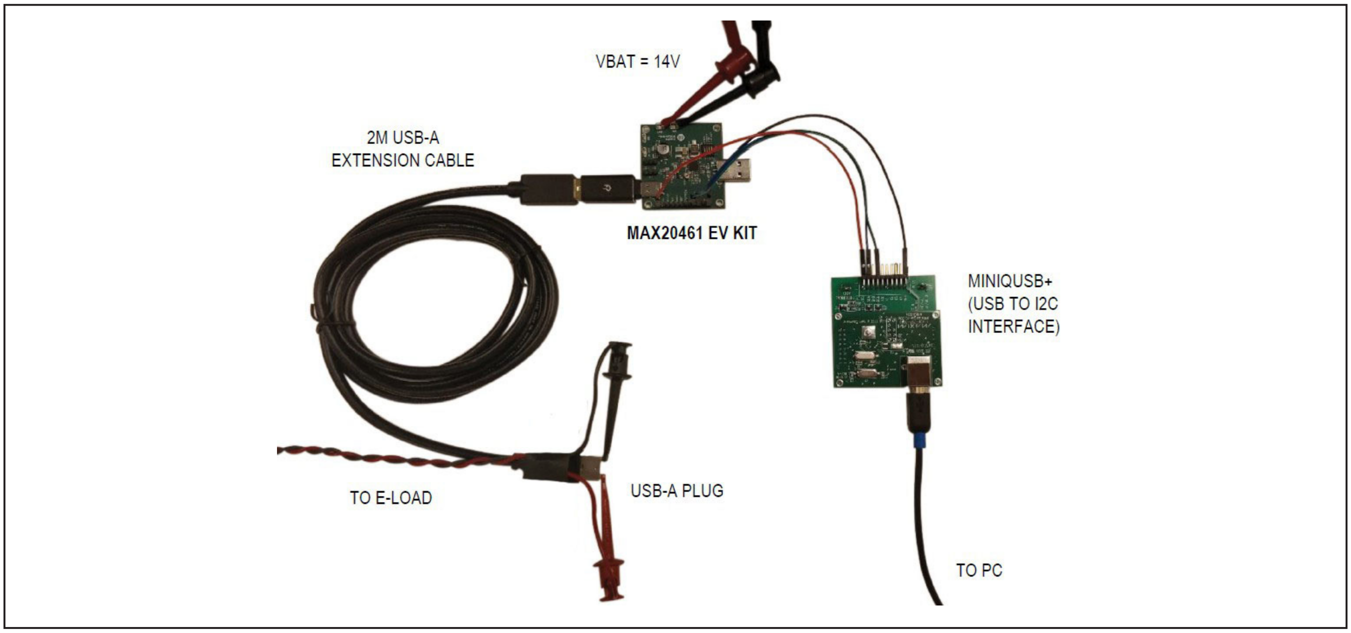


Figure 6. Cable Compensation Setup

Detailed Description

The MAX20461 EV kit comes fully assembled, tested, and installed with MAX20461ATJA/V+. The stand-alone variant can also be used on this EV kit by changing the IC and configuration resistors (R2, R3, R4). See Table 1 for an example of stand-alone configuration. Refer to the MAX20461 data sheet for further details on configuration resistors.

EV Kit Interface

The header J1 includes input and output test points for controlling the IC and evaluating its functionality. Table 2 lists the individual pins and their functions.

Switch SW1 allows the user to set the voltage on the HVEN, ENBUCK, SYNC, and CDP/DCP pins. Setting the switch to the ON/1 position ties the connected pin to the 3.3V supply, and setting the switch to the OFF/0 position ties the pin to ground through a 100kΩ pulldown resistor. To externally control these pins through the header J1, set the switch to the OFF/0 position. This leaves the pin connected to the header with a pulldown resistor. Table 3 describes the switch and its functionality.

Basic Functionality

Connect a battery voltage supply between V_{BAT} and GND test loops, and connect a 3.3V supply to the 3V3 pin on J1. Setting the HVEN switch to 1 pulls the HVEN pin to 3V3 and enables the device. The ENBUCK pin must also be high for the DC-DC converter to turn on. The charge mode can be configured through I^2C or using the CDP/DCP switch or pin. If the CDP/DCP pin is high, it will override the current I^2C register setting.

Table 1. Stand-Alone Configuration Example

PIN NAME	RESISTOR	VALUE	DESCRIPTION
CONFIG1	R2	0Ω	Spread Spectrum: ON; SYNC as Input; f_{SW} = 2.2MHz *Note: If Sync is an Input, tie SYNC to GND if no external clock is used*
CONFIG2	R3	15kΩ	GAIN[3:0] = 1100
CONFIG3	R4	3.9kΩ	GAIN[4] = 1; ILIM = 3.04A (min); CC Pullup Mode = 3.0A *Note: Gain programmed with this configuration is 28*

Table 2. External Header

J1 PIN	NAME	DESCRIPTION
1	3V3	3.3V Supply (Input)
2	SYNC	Buck Regulator Synchronization Pin (Input/Output)
3	CDP/DCP	Charge Detection Configuration Pin (Input)
4	HVEN	IC Enable (Active High, Input)
5	ENBUCK	DC-DC Enable (Active High, Input)
6	$\overline{\text{FAULT}}$	FAULT indicator (Active Low, Open Drain, Output)
7	$\overline{\text{INT}}$($\overline{\text{ATTACH}}$)	I^2C interrupt (Active Low, Open Drain, Output)
8	CC_POL(SHIELD)	CC Polarity Output Pin (Open Drain, Output) Logic-low for Rd on CC2, logic-high for Rd on CC1
9	SCL	I^2C Clock
10	SDA	I^2C Data
11	GND	EV Kit Ground
12	GND	EV Kit Ground

Table 3. External Switch

SW1 PIN	POSITION	DESCRIPTION
HVEN	0	Device Disabled
	1	Device Enabled
ENBUCK	0	Buck Output Disabled
	1	Buck Output Enabled
SYNC	0	SYNC Pin Functions: 1) The primary function is synchronization with another DC/DC converter. In this case, leave SYNC in the 0 position (100kΩ to GND) and connect the SYNC signal to another DC/DC converter synchronization signal, if needed. For instance, another MAX20461 EVKIT can be used. 2) The second function on the SYNC pin is to configure MAX20461 when operating as a Type-A source only (Type-A mode only is achieved by setting CC_ENB = 1 through I^2C, which disables Type-C detection). This option is rarely used because MAX20461 targets Type-C ports; however, it can be used for debugging. Leave in this position when SYNC is an output (default). When SYNC is an input and set to logic-low with CC_ENB = 1, SKIP mode operation of the DC/DC converter in light-load/no-load conditions is enabled.
	1	When SYNC is an input and is in this position with CC_ENB = 1, forced-PWM operation is enabled
CDP/DCP	0	Preload CD[1:0] = b00 (SDP mode) on startup
	1	Override CD[1:0] to auto-CDP mode

Type-C Functionality

The headers J5 and J6 provide CC1 and CC2 with pull-down resistors (Ra and Rd) used for Type-C device/charger detection. These resistors are included for validation purposes; they would typically come from a connected Type-C device or Type-C to Type-A legacy adapter. With Type-C enabled (default), the buck converter will not turn on until Rd is detected on either CC1 or CC2. For V_{CONN} power, connect Ra to the CC pin that will provide V_{CONN} power, then connect Rd to the other CC pin.

V_{CONN} can be used to supply electronically marked cables and other V_{CONN}-powered devices. By default, the V_{CONN} pin of the IC is tied to the 3.3V supply on the EV Kit. The application may require a higher V_{CONN} supply voltage to ensure ohmic losses do not droop the V_{CONN} voltage below the required 3V. V_{CONN} can be reconfigured to connect to an external supply by removing R23 and connecting a supply to the white V_{CONN} test point.

The CC_POL pin is an open-drain output that asserts high when Rd is detected on CC1. This output can be used to control a MUX in a USB 3.x application.

Table 4. J5 Jumper Positions

JUMPER POSITION	DESCRIPTION
1-2	CC2 pulled to ground through a 1.2kΩ resistor (Ra)
2-3	CC2 pulled to ground through a 5.1kΩ resistor (Rd)

Table 5. J6 Jumper Positions

JUMPER POSITION	DESCRIPTION
1-2	CC1 pulled to ground through a 1.2kΩ resistor (Ra)
2-3	CC1 pulled to ground through a 5.1kΩ resistor (Rd)

Fault Diagnostics

The $\overline{\text{FAULT}}$ pin is designed to be software-compatible with Maxim Type-A automotive USB solutions. More advanced diagnostics are available using the I^2C bus and the $\overline{\text{INT}}$ pin. The IRQ bits have an associated IRQ_MASK bit. When the IRQ_MASK bit is set to 1, the $\overline{\text{INT}}$ pin asserts and de-asserts following the IRQ bit. All IRQ bits clear on read. IRQ bit de-assertion is controlled by the IRQ_AUTOCLR bit. When IRQ_AUTOCLR = 0 (default), the error bit remains asserted until the register is read, even if the fault condition is no longer present. When IRQ_AUTOCLR = 1, the IRQ bit de-asserts without a read as soon as the fault criteria are no longer met.

The EV kit GUI does not connect to the $\overline{\text{FAULT}}$ or $\overline{\text{INT}}$ pins. It uses a polling mechanism to read all of the MAX20461 registers. A read is initiated when the **Refresh** button is clicked, or periodically if auto read is enabled. Because of the polling mechanism, when IRQ_AUTOCLR = 1, it is possible that IRQ bit assertions will not be detected by the GUI because of quick de-assertions after a fault.

PCB Layout Guidelines

A good PCB layout is critical to proper system performance. The loop area of the DC/DC conversion circuitry must be minimized as much as possible. Place the input capacitor, power inductor, and output capacitor very close to the IC. Shorter traces should be prioritized over wider traces.

A low-impedance ground connection between the input and output capacitors is necessary (route through the ground pour on the exposed pad). Connect the exposed pad to ground. Place multiple vias in the pad to connect to all other ground layers for proper heat dissipation. (Failure to do this may result in the IC repeatedly reaching thermal shutdown.) Use a single common ground with GND vias directly adjacent to all components that via down to an adjacent ground plane. High-frequency return currents will flow directly under their corresponding traces.

USB traces must be routed as a 90Ω differential pair with an appropriate keep-out area. Avoid routing USB traces near high-frequency switching nodes or other sources of noise, such as clocks. The length of the routing should be minimized and avoid 90-degree turns, excessive vias, and RF stubs. MAX20461 has high-bandwidth data switches. See the IC datasheet for details on tuning recommendations.

Ordering Information

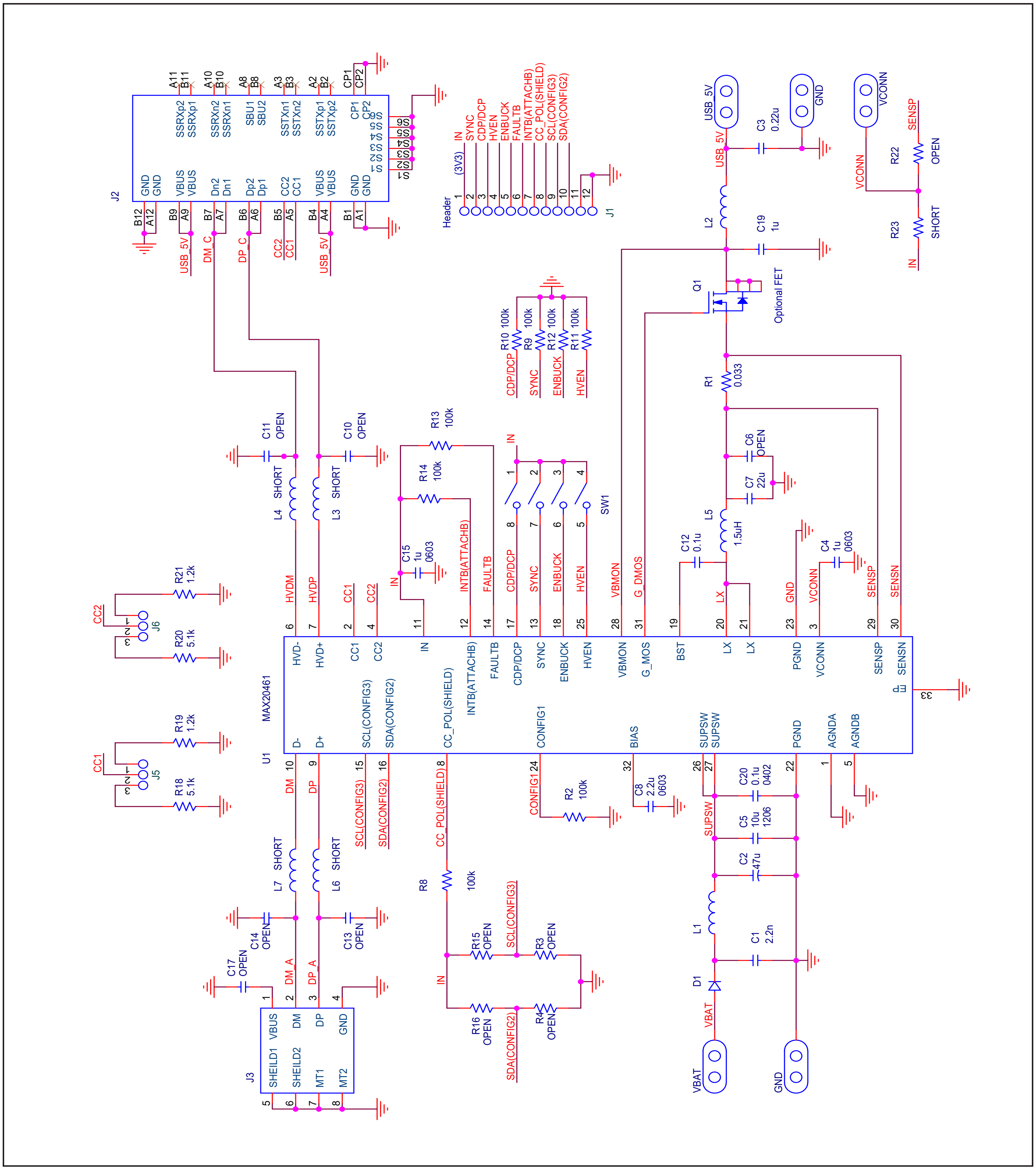
PART	TYPE
MAX20461EVKIT#	EVKIT

#denotes RoHS-compliant.

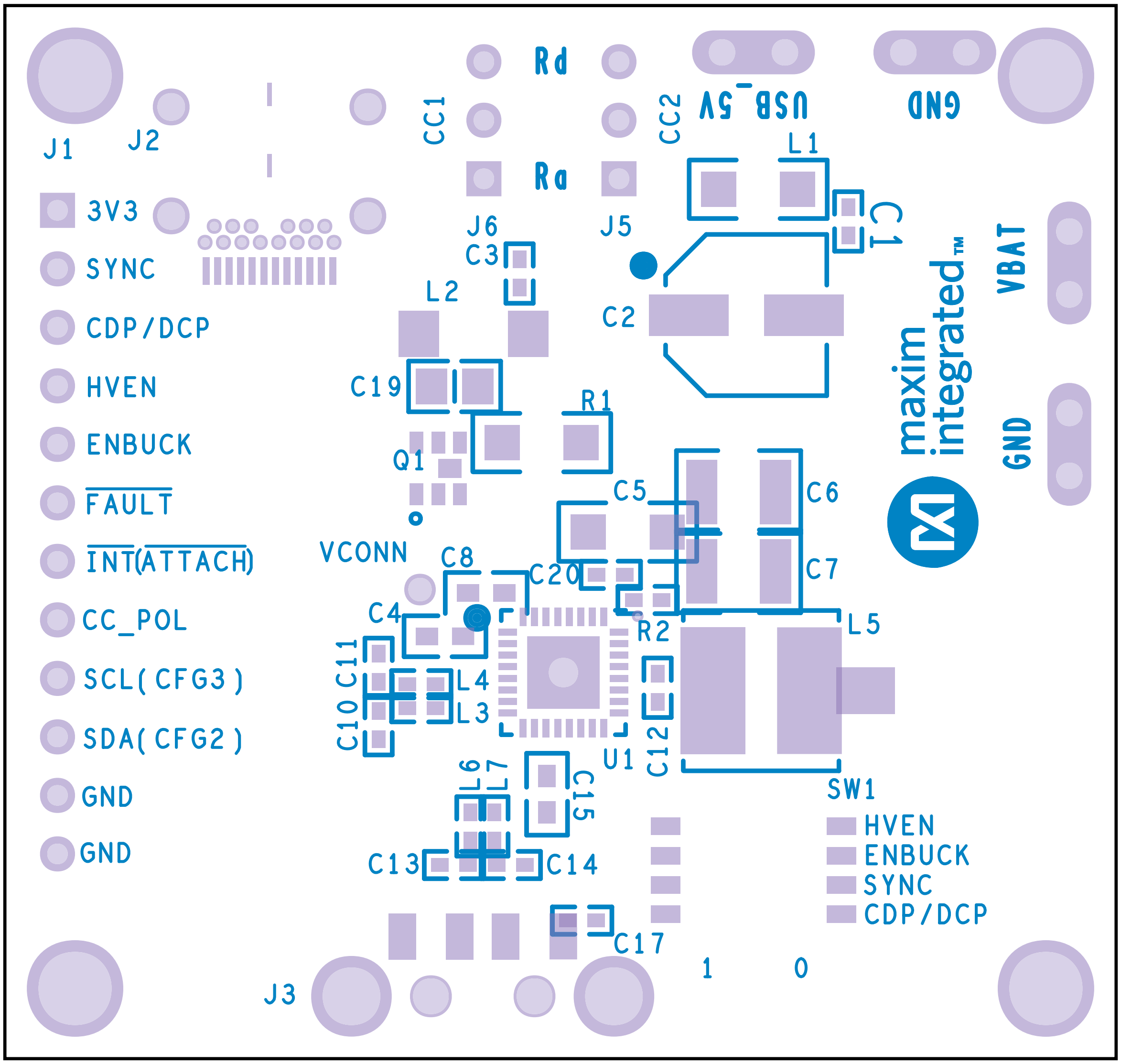
MAX20461 EV Kit Bill of Materials

REFERENCE	QTY	DESCRIPTION	MANUFACTURER NUMBER	MANUFACTURER
C1	1	Ceramic Capacitor (0402) 2200PF 50V X7R 0402	Murata	GCM155R71H222KA37D
C2	1	Electrolytic Capacitor (SMD) 47uF 25V 20%	Panasonic	EEE-HC1E470XP
C3	1	Ceramic Capacitor (0402) 0.22uF 35V 10% X7R	TDK	CGA2B1X7R1V224KC
C4, C15	2	Ceramic Capacitor (0603) 1uF 16V 10% X7R	TDK	CGA3E1X7R1C105K080AC
C5	1	Ceramic Capacitor (1206)10uF 50V 10% X7R	TDK	CGA5L1X7R1H106K
C6	1	DNI	DNI	DNI
C7	1	Ceramic Capacitor (1210) 22uF 25V 10% X7R	Murata	GRM32ER71E226KE5L
C8	1	Ceramic Capacitor (0603) 2.2uF 16V 10% X7S	TDK	CGA3E1X7S1C225K080AC
C10-11	2	DNI	DNI	DNI
C12, C20	2	Ceramic Capacitor (0402) 0.1uF 50V 10% X7R	TDK	CGA2B3X7R1H104K050BB
C13-14	2	DNI	DNI	DNI
C17	4	DNI	DNI	DNI
C19	1	Ceramic Capacitor (0805) 1uF 25V 10% X7R	Murata	GCM21BR71E105KA56L
D1	1	Schottky Diode (SMB) 3A 60V	Diodes Inc	B360B-13-F
USB_5V, GND, VBAT, GND	4	Loop Testpoints	Keystone	5024
VCONN	1	Mini Test Point	Keystone	5002
J1	1	1 row, 12 pos, .100" Gold Header	TE Connectivity	5-146858-1
J2	1	USB Type C Receptical	Wurth	632723x00011
J3	1	USB-A Plug	Kycon	KUSBX-SMT2AP5S-B
J5, J6	2	1 row, 3 pos, .100" Gold Header	TE Connectivity	5-146858-1
L1	1	Ferrite Bead (1206) 3A	Wurth	742792121
L2	1	Ferrite Bead (1806) 6A	Murata	BLM41P600S
L3-4, L6-L7	4	Resistor (0402) SHORT	Panasonic	ERJ-2GE0R00X
L5	1	Inductor, 1.5uH, 8.5A Isat	Coilcraft	XEL4030-152MEB
R1	1	Resistor (1206) .033Ω 1%, 0.75W, 50ppm	Susumu	KRL1632E-M-R033-F-T5
R2, R8-14	8	Resistor (0402) 100k Ohm 5%	Vishay Dale	CRCW0402100KJNED
R3-4, R15-16	5	DNI	DNI	DNI
R18, R20	2	Resistor (0402) 5.1k Ohm 1% 1/16W	Vishay Dale	CRCW04025K10FKED
R19, R21	2	Resistor (0402) 1.2k Ohm 1% 1/16W	Vishay Dale	CRCW04021K20FKED
R22	1	DNI	DNI	DNI
R23	1	Resistor (1206) SHORT 1/4W	Vishay Dale	CRCW12060000Z0EC
SW1	1	1.27mm Pitch DIP Switch	C&K Components	TDA04H0SB1R
Q1	1	30V, 3.5A NMOS	ON Semi	NTGS4141NT1G
U1	1	USB Type-C DFP Controller and Buck Converter	Maxim Integrated	MAX20461ATJA/V+
PACK-OUT	1	USB Type-C to Type-A adapter	Tripp Lite	U428-000-F
PACK-OUT	1	2m USB-A Extension Cable	Qualtek	3021057-02M
PACK-OUT	1	USB-A Plug	Kycon	KUSBX-SMT2AP5S-B
PACK-OUT	2	3.5Ω 10W 1% Resistor	Vishay Dale	RS0103R500FE12
PACK-OUT	1	USB to I2C Interface	Maxim Integrated	MINIQUSB+
PACK-OUT	2	Shunt Jumper 0.1"	3M	969102-0000-DA
PACK-OUT	1	Jumper Wires F-F 15cm 10PK	MikroElektronika	MIKROE-511

MAX20461 EV Kit Schematics

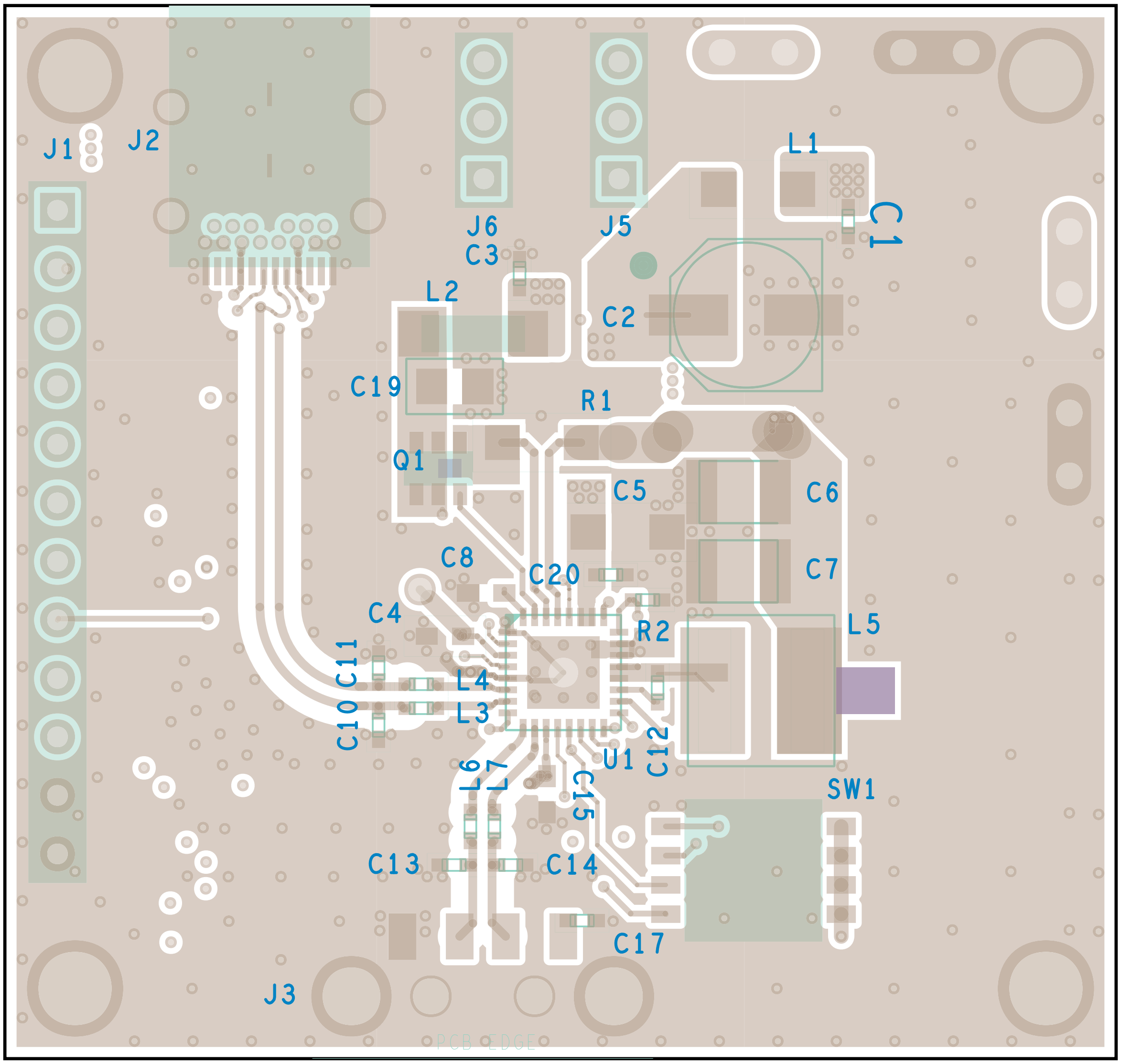


MAX20461 EV Kit PCB Layout Diagrams



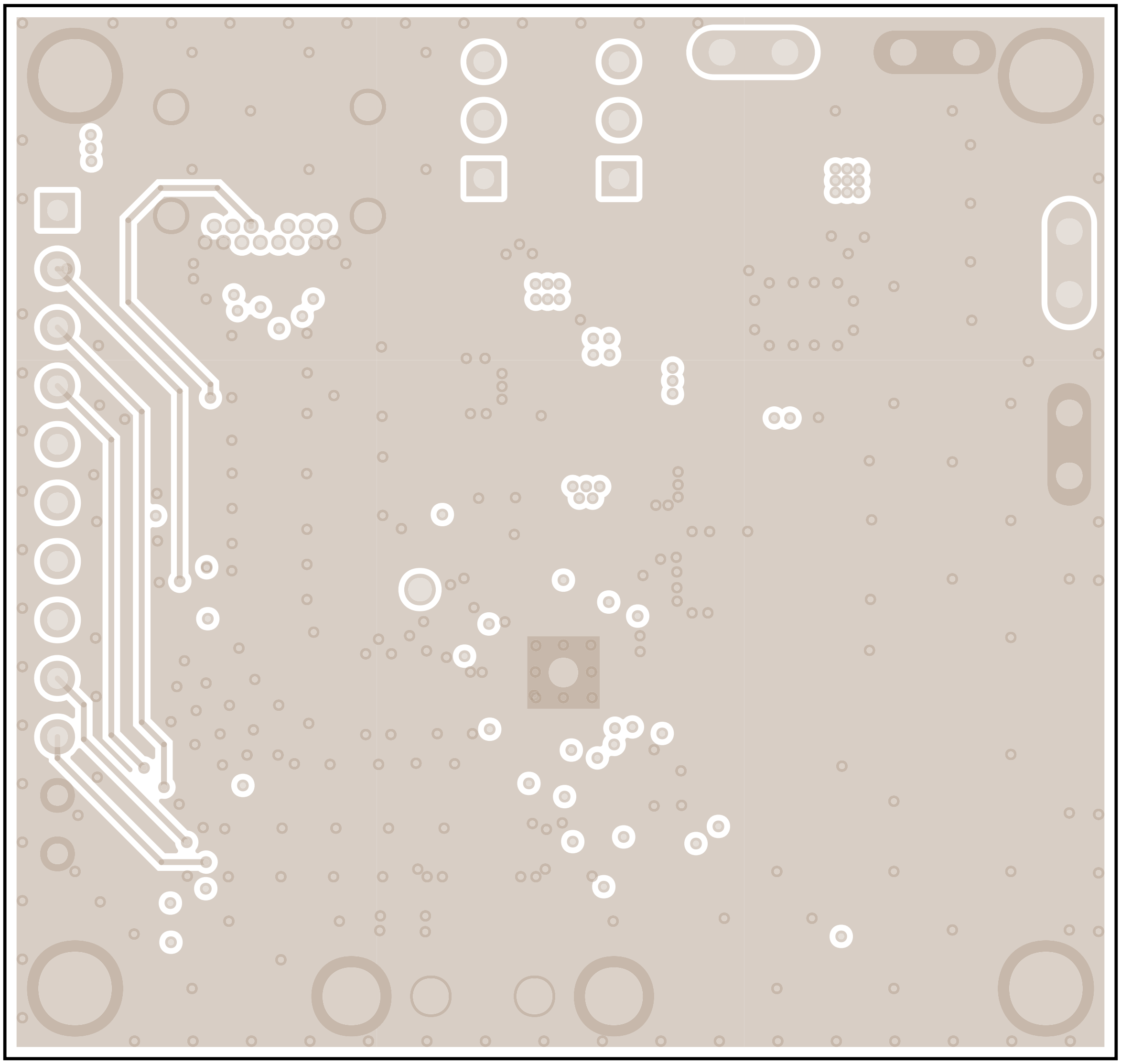
MAX20461 EV Kit Component Placement Guide—Top Silkscreen

MAX20461 EV Kit PCB Layout Diagrams (continued)



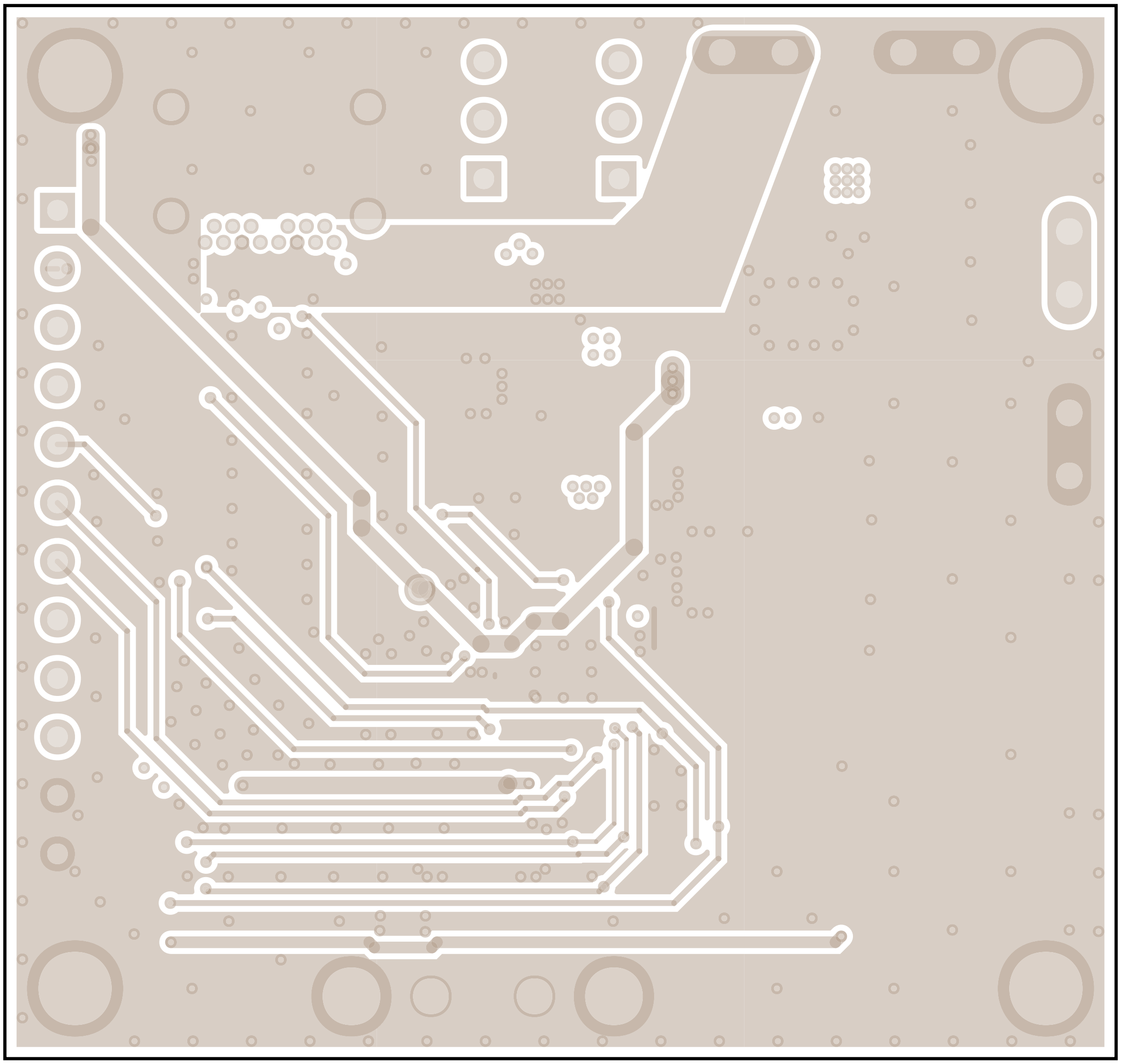
MAX20461 EV Kit PCB Layout—Top View

MAX20461 EV Kit PCB Layout Diagrams (continued)



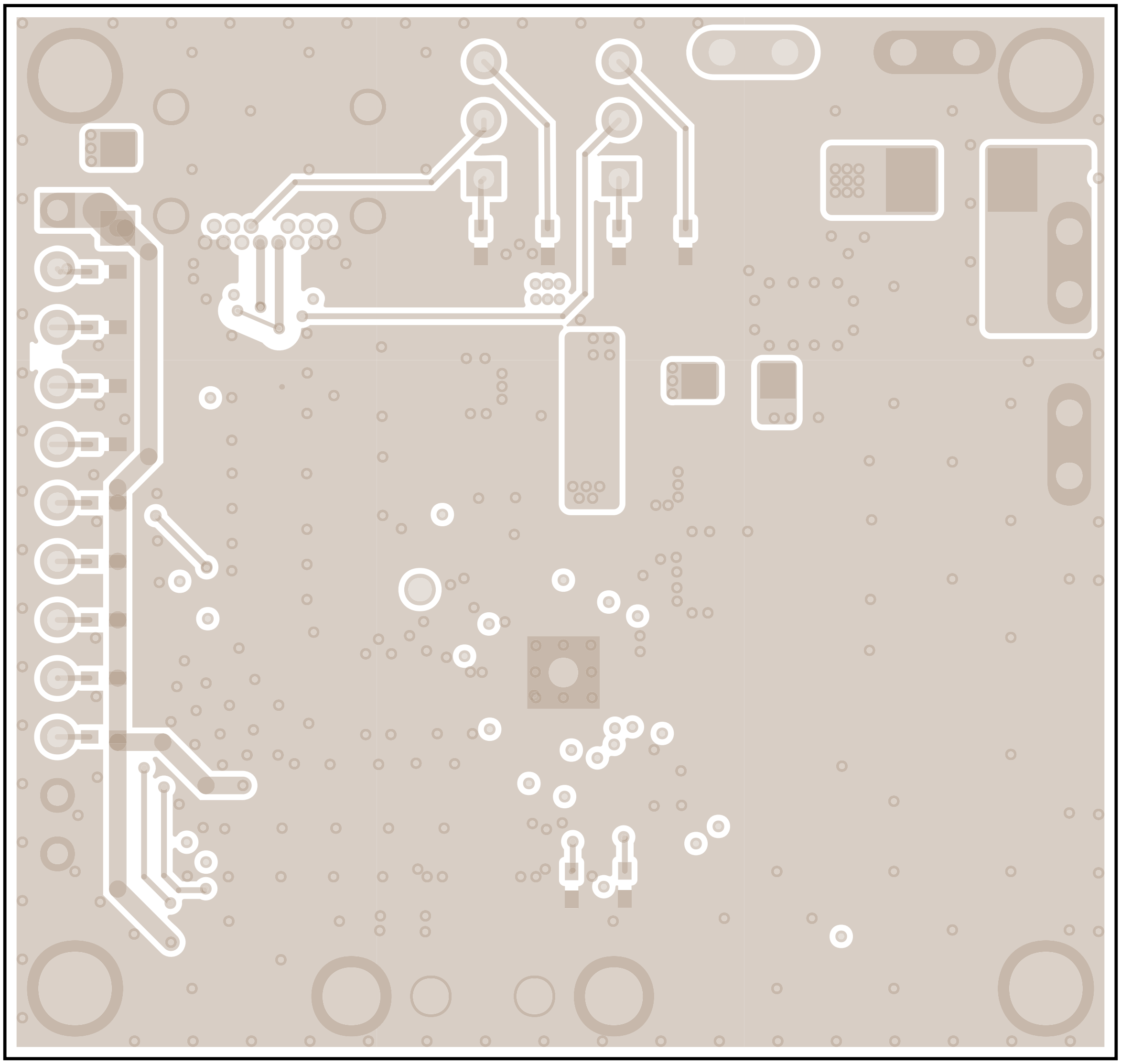
MAX20461 EV Kit PCB Layout—Layer 2

MAX20461 EV Kit PCB Layout Diagrams (continued)



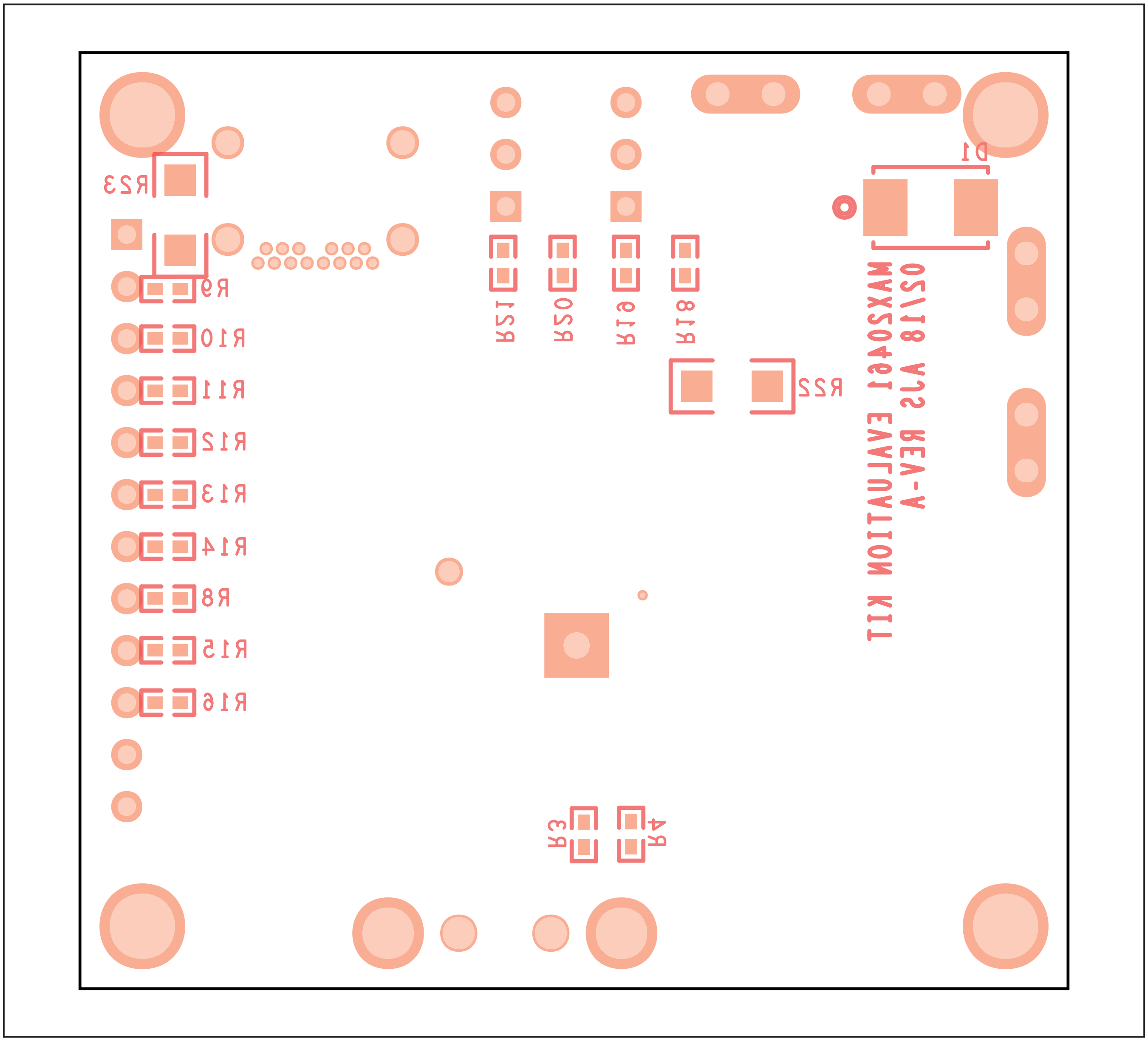
MAX20461 EV Kit PCB Layout—Layer 3

MAX20461 EV Kit PCB Layout Diagrams (continued)



MAX20461 EV Kit PCB Layout—Bottom View

MAX20461 EV Kit PCB Layout Diagrams (continued)



MAX20461 EV Kit Component Placement Guide—Bottom Silkscreen

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	3/19	Initial release	—

