## General Description

The MAX31865 evaluation kit (EV kit) provides the hardware and software (graphical user interface) necessary to evaluate the MAX31865 RTD-to-digital Converter. The EV kit includes a MAX31865ATP+ installed as well as a USB-to-SPI interface.

The USB-to-SPI master section of the EV kit can be used to interact with the MAX31865 EV kit software and exercise the device's functionality.

## EV Kit Contents

- Assembled circuit board including MAX31865ATP+ and USB-to-SPI circuitry
- Mini-USB cable
- Two 0.2in jumper wires
- 1kΩ resistor

## Features

- Easy Evaluation of the MAX31865
- Fully Assembled and Tested
- USB HID Interface
- EV Kit Hardware is USB Powered (USB Cable Included)
- Windows XP®-, Windows Vista®-, and Windows® 7-Compatible Software
- RoHS Compliant
- Proven PCB Layout

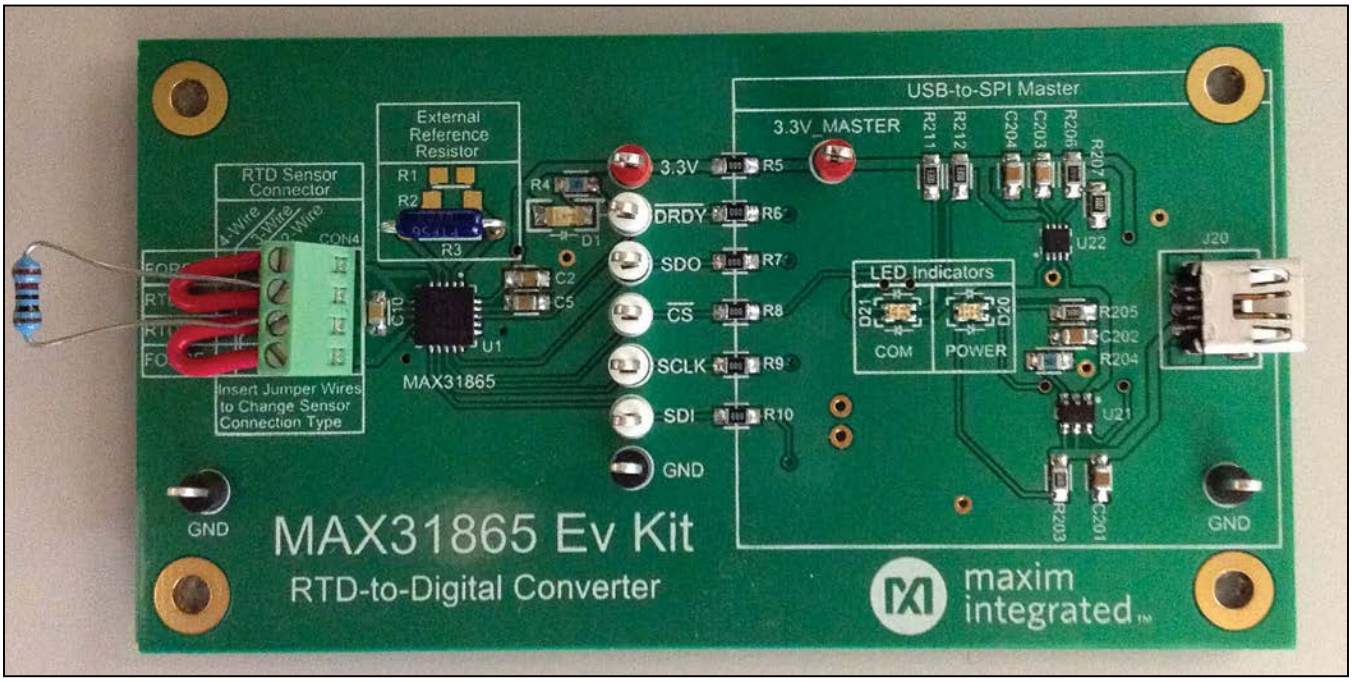
## MAX31865 EV Kit Files

| FILE | DESCRIPTION |
|---|---|
| MAX31865EVKitSoftwareInstall.EXE | Application program |

***Note:*** *The .EXE file is downloaded as a .ZIP file.*

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

## EV Kit Photo

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*19-6500; Rev 0; 11/12*

maxim integrated™

## Component List

| DESIGNATION | QTY | DESCRIPTION |
|---|---|---|
| C2, C5, C10, C212 | 4 | 0.1µF X7R ceramic capacitors (0805) TDK C2012X7R1H104K |
| C4, C215 | 2 | Ceramic capacitors (0805), do not populate |
| C201, C202, C204 | 3 | 10µF X7R ceramic capacitors (0805) TDK C2012X7R1A106K |
| C203, C214 | 2 | 10nF ceramic capacitors (0805) TDK C2012C0G1H103J |
| C211 | 1 | 1.0µF ceramic capacitor (0805) TDK C2012X7R1H105K |
| C213 | 1 | 220nF ceramic capacitor (0805) TDK C2012X7R1H224K |
| CON4 | 1 | 4-position screw terminal, 2.54mm pitch Phoenix Contact 1725672 |
| D1 | 1 | Red LED (1206) Kingbright APTR3216EC |
| D20, D21 | 2 | Red/green dual LEDs Kingbright APHB M2012SURKCGKC |
| D22 | 1 | Schottky diode ROHM Semi RB060M-30TR |
| J20 | 1 | 5-pin mini USB, female Molex 54819-0519 |
| J21 | 1 | 2-pin header, do not populate |
| R1 | 1 | Resistor (0805), do not populate |
| R2 | 2 | Resistor (1206), do not populate |
| R3 | 1 | 4kΩ ±0.1% resistor (1/8W, through hole) Vishay PTF564K0000BYEB |
| R4 | 1 | 1.2kΩ ±1% resistor (0805) Vishay CRCW08051K20FKEA |
| R5–R10, R201, R202, R214 | 9 | 0Ω ±1% resistors (0805) Vishay CRCW08050000Z0EA |
| R11 | 1 | 10MΩ ±1% resistor (0805) Vishay CRCW251210M0FKEG |
| R203, R205 | 2 | 560Ω ±1% resistors (0805) Vishay CRCW0805560RFKEA |
| R204 | 1 | 56kΩ ±1% resistor (0805) Vishay CRCW0805056KFKTA |
| R206 | 1 | 45.3kΩ ±1% resistor (0805) Vishay CRCW080545K3FKEA |
| R207 | 1 | 10kΩ ±1% resistor (0805) Vishay CRCW0805010KFKTA |
| R210 | 1 | 4.7kΩ ±1% resistor (0805) Vishay CRCW08054K70FKEA |
| R211, R212 | 2 | 330kΩ ±1% resistors (0805) Vishay CRCW0805330KFKTA |
| R213 | 1 | 2.2kΩ ±1% resistor (0805) Vishay CRCW08052K20FKEA |
| TP1, TP10 | 2 | Red test points Keystone 5010 |
| TP2–TP6 | 5 | White test points Keystone 5012 |
| TP7, TP9, TP11 | 3 | Black test points Keystone 5011 |
| U1 | 1 | RTD-to-digital converter (20 TQFN-EP*) Maxim MAX31865ATP+ |
| U20 | 1 | Microcontroller (28 SO) Microchip PIC18LF2550-I/SO |
| U21 | 1 | 50mA to 600mA current-limit switch (6 SOT23) Maxim MAX4995AAUT+ |
| U22 | 1 | 500mA LDO regulator (8 TDFN-EP*) Maxim MAX8902BATA+ |
| X1 | 1 | 48MHz, 3.3V oscillator (SMD) AVX KC3225A48.0000C30E00 |
| — | 2 | 0.2in jumper wires |
| — | 1 | 1.0kΩ ±1% resistor (0805) Vishay CRCW08051K00FKEA |
| — | 1 | Mini-USB cable |
| — | 1 | PCB: MAX31865 EV kit |

**Exposed pad.*

## Component Suppliers

| SUPPLIER | PHONE | WEBSITE |
|---|---|---|
| AVX Corporation | 843-946-0238 | www.avx.com |
| Keystone Electronics Corp. | 209-796-2032 | www.keyelco.com |
| Kingbright Corporation | 909-468-0500 | www.kingbrightusa.com |
| Molex | 800-786-6539 | www.molex.com |
| Phoenix Contact | 800-808-7177 | www.phoenixcontact.com |
| ROHM Co., Ltd. | 858-625-3630 | www.rohm.com |
| TDK Corp. | 847-803-6100 | www.component.tdk.com |
| Vishay | 402-563-6866 | www.vishay.com |

***Note:*** *Indicate that you are using the MAX31865 when contacting these component suppliers.*

## Quick Start

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

### Required Equipment

- Windows XP, Windows Vista, or Windows 7 PC
- USB port
- Mini-USB cable (included)
- EV kit hardware (included)
- Micro screwdriver, bladed, size 0.4mm x 2.0mm x 60mm
- Jumper wire and a resistor (included) or an RTD (NOT included)

### Procedure

The EV kit is fully assembled and tested. Follow the steps below to verify board operation:

1) Verify the two jumper wires (included) are properly secured in the terminal block in accordance with the 2-wire RTD Sensor Connector diagram on the PCB's silkscreen (Figure 6).
2) Verify the 1kΩ resistor is properly secured in the terminal block connecting the RTDIN+ terminal to the RTDIN- terminal.
3) Set the EV kit hardware on a nonconductive surface that ensures that nothing on the PCB gets shorted to the workspace.
4) Prior to starting the GUI, connect the EV kit hardware to a PC using the supplied mini-USB cable, or equivalent. The POWER LED (D20) should be green and the COM LED (D21) should be red and slowly flash orange.
5) Windows should automatically begin installing the necessary device driver. The USB interface of the EV kit hardware is configured as a HID device and therefore does not require a unique/custom device driver. Once the driver installation is complete, a Windows message appears near the **System Icon** menu indicating that the hardware is ready to use. Do not attempt to run the GUI prior to this message. If you try to run the GUI prior to this message, close the application and restart it once the driver installation is complete. On some versions of Windows, administrator privileges may be required to install the USB device.
6) Once the device driver installation is complete, visit **www.maximintegrated.com/MAX31865evkit** to download the latest version of the EV kit software, MAX31865EVKitSoftwareInstall.ZIP. Save the EV kit software to a temporary folder.
7) Open the .ZIP file and double click the .EXE file to run the installer. A message box stating "The publisher could not be verified. Are you sure you want to run this software?" may appear. If so, click **Yes**.
8) The installer GUI appears. Click **Next** and then **Install**. Once complete, click **Close**.
9) Go to **Start** >> **All Programs**. Look for the **MAX31865EVKitSoftware** folder and click on MAX31865EVKitSoftware.EXE inside the folder.
10) When the GUI appears, the text below the Maxim Integrated logo should indicate that the EV kit hardware is connected. The COM LED (D21) turns off and flashes red when communication occurs.

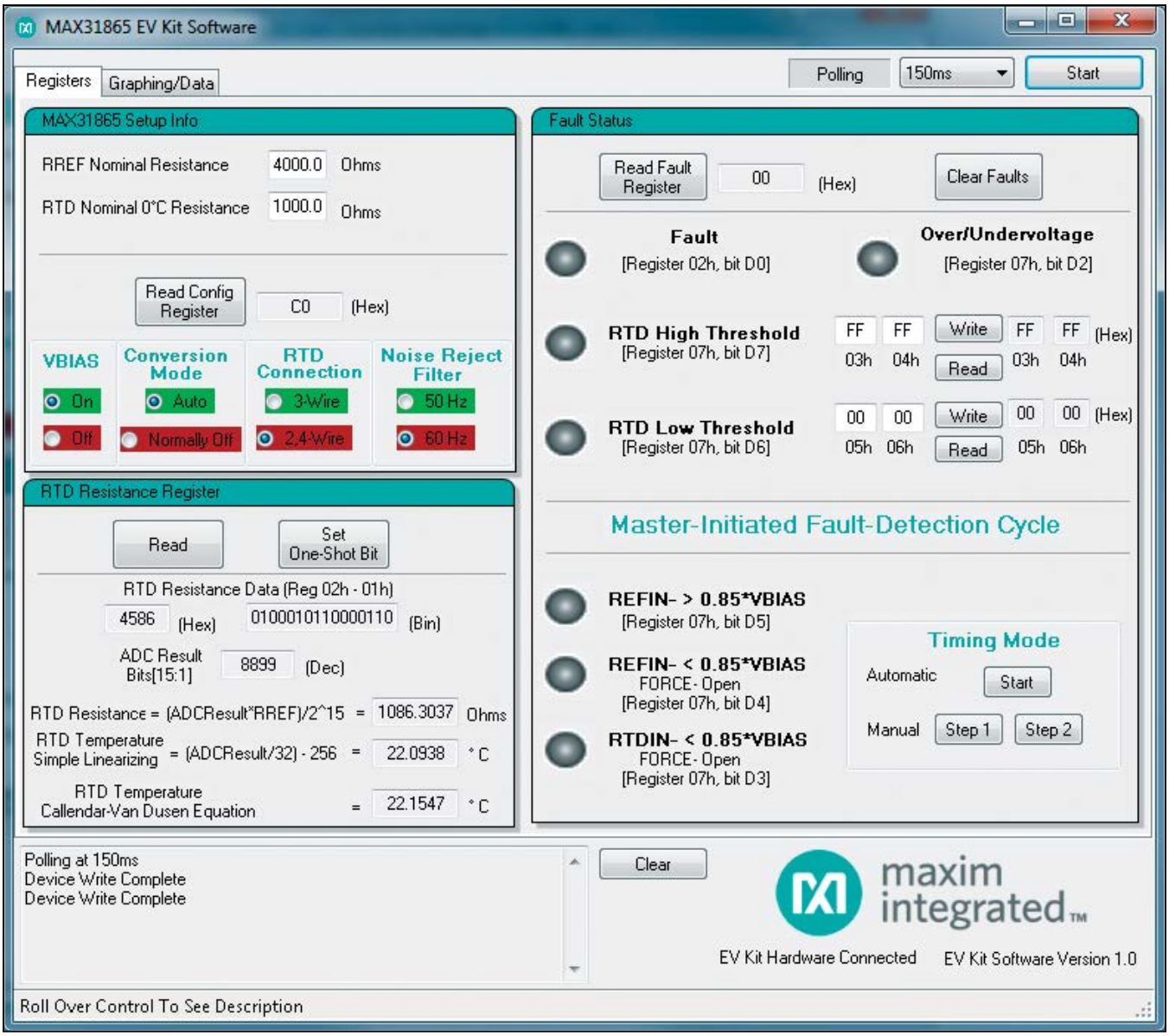


*Figure 1. MAX31865 EV Kit GUI (Registers Tab)*

## Detailed Description of Software

### Device Configuration

Upon successful completion of the setup procedure, the user is ready to begin evaluation of the device. The device powers up in “normally off” conversion mode. To begin conversions, first enable the **VBIAS** output by clicking the **On** radio button located in the **MAX31865 Setup Info** group box in the **Registers** tab (Figure 1). Next, enable conversions by changing the **Conversion Mode** to **Auto** by clicking the **Auto** radio button. It is now time to read the results. This is accomplished by clicking the **Read** button in the **RTD Resistance Register** group box. The conversion results are displayed below the button in hex and binary format. Also note that the ADC result is displayed in decimal format. The RTD resistance is then calculated from the ADC result and the value entered in the **RREF Nominal Resistance** edit box located in the **MAX31865 Setup Info** group box. With the supplied 1kΩ resistor, the calculated RTD resistance should be 1kΩ ±6% due to the tolerance of the provided resistors. **Note:** Since there is not an RTD connected at this time, the RTD temperature equations are not valid registers.

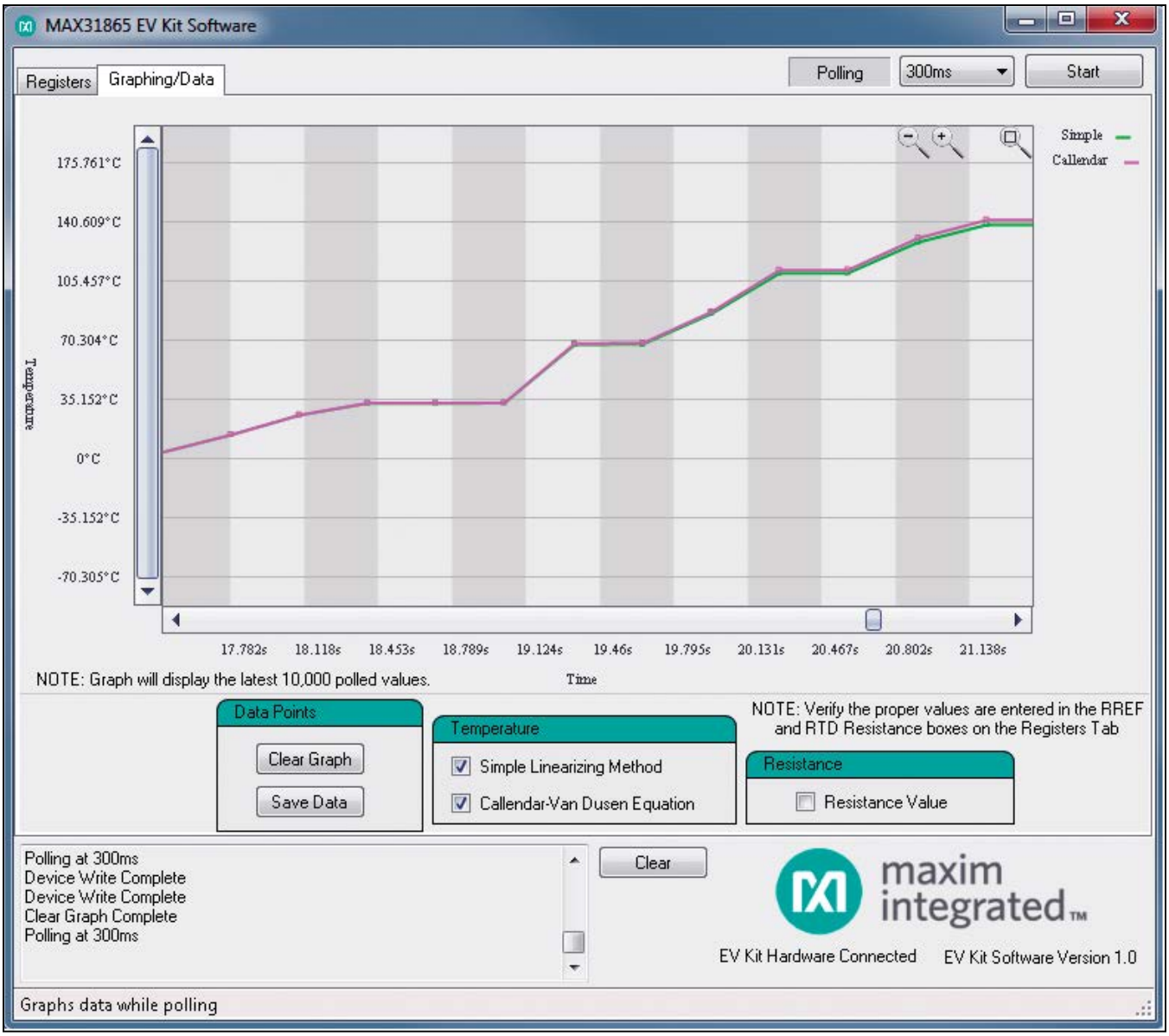


*Figure 2. MAX31865 EV Kit GUI (Graphing/Data Tab)*

## Reads

Each register of the device can be read from the **Registers** tab of the GUI. Clicking a read button does a single read of the register and updates the associated data fields. There is also an option to do continuous reads of the device. This **Polling** feature is located in the top right section of the GUI. To start polling, select the delay between reads: **150ms**, **300ms**, **500ms**, or **1000ms** and click **Start**. Each poll reads all eight registers of the device and updates their associated data fields on the **Registers** tab and collects data for the **Graphing/Data** tab. Once the continuous read starts, the button text changes to **Stop** for the user to stop the reads.

## Writes

Writes to the device are accomplished from the **Registers** tab. Clicking on any of the radio buttons in the **MAX31865 Setup Info** group box automatically writes that bit to the configuration register, followed by a read to update the associated data fields. The high- and low-threshold

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Graph data | | | | |
| 2 | | | | | |
| 3 | Time(s) | Raw RTD Conversion Data( Hex ) | Simple Linearize(°C) | Callendar Equation(°C) | Resistance ( Ohm ) |
| 4 | 0.305 | 0x4679 | 25.875 | 25.96101603 | 1101.074219 |
| 5 | 0.623 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 6 | 0.934 | 0x4679 | 25.875 | 25.96101603 | 1101.074219 |
| 7 | 1.243 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 8 | 1.554 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 9 | 1.863 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 10 | 2.183 | 0x4679 | 25.875 | 25.96101603 | 1101.074219 |
| 11 | 2.494 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 12 | 2.804 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 13 | 3.113 | 0x4679 | 25.875 | 25.96101603 | 1101.074219 |
| 14 | 3.423 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 15 | 3.743 | 0x467B | 25.90625 | 25.99249126 | 1101.196289 |
| 16 | 4.054 | 0x4675 | 25.8125 | 25.89806644 | 1100.830078 |
| 17 | 4.364 | 0x4687 | 26.09375 | 26.18134888 | 1101.928711 |
| 18 | 4.673 | 0x471D | 28.4375 | 28.54296603 | 1111.083984 |
| 19 | 4.986 | 0x4815 | 32.3125 | 32.45115662 | 1126.220703 |
| 20 | 5.303 | 0x48EF | 35.71875 | 35.89034999 | 1139.526367 |
| 21 | 5.615 | 0x49F5 | 39.8125 | 40.0283728 | 1155.517578 |
| 22 | 5.923 | 0x4A6F | 41.71875 | 41.95698685 | 1162.963867 |
| 23 | 6.233 | 0x4BF5 | 47.8125 | 48.12970828 | 1186.767578 |
| 24 | 6.544 | 0x4D45 | 53.0625 | 53.45691964 | 1207.275391 |
| 25 | 6.864 | 0x4EE9 | 59.625 | 60.12794105 | 1232.910156 |
| 26 | 7.173 | 0x4F8B | 62.15625 | 62.70463037 | 1242.797852 |
| 27 | 7.484 | 0x5075 | 65.8125 | 66.43004823 | 1257.080078 |

*Figure 3. MAX31865 Data Table*

registers can be set in the **Fault Status** group box with the associated input boxes and **Write** buttons. This data is input in hexadecimal format only. The master-initiated fault-detection cycle can be run from the **Fault Status** group box by selecting the corresponding button. Note that if using the **Manual Timing Mode** that once Step 1 has been selected it must be followed by selecting **Step 2**.

### Graphing

This GUI comes complete with a very simple graphing tool located in the **Graphing/Data** tab (Figure 2). The **Graphing/Data** tab plots the polled values in a graph. Polled values are collected any time the **Polling** feature is active. Three data options can be displayed; the calculated **Resistance Value**, the temperature calculated using the **Simple Linearizing Method**, or the temperature calculated using **Callendar-Van Dusen Equation** with IEC 751 coefficients and the user-supplied RTD nominal 0°C resistance. The **Simple Linearizing Method** is the straight-line approximation, as defined by the equation shown on the **Registers** tab in the **RTD Resistance Register** group box. Click the desired checkbox to plot the collected data. The graph displays the latest 10,000 polled values and when the polled count reaches 10,000, the graph deletes the oldest polled values and adds a new polled value. To reset and clear all collected data, select the **Clear Graph** button. To save all the data graphed to a comma-separated value (.CSV) file, press the **Save Data** button and provide a folder and filename.

## Detailed Description of Hardware

### User-Supplied SPI Interface

The USB-to-SPI master section of the EV kit is not necessary for the proper operation of the device. If the user wants to supply the SPI interface, the USB-to-SPI master section of the EV kit can be disconnected by removing resistors R7–R10. Connect test points SDO, $\overline{CS}$, SCLK, SDI, and GND. The $\overline{DRDY}$ output signal from the device can also be routed to a different master by removing resistor R6 and connecting to the $\overline{DRDY}$ and GND test points.

### User-Supplied Power Supply

To disconnect the device from the USB-powered supply and apply an outside power source, remove resistor R5 and connect to the 3.3V and GND test points.

### User-Supplied RTD

The EV kit comes with a 1kΩ resistor and two jumper wires installed to the CON4 terminal block. This is to allow for an out-of-the-box functioning system, but does not provide real-world temperatures. To evaluate temperature, an RTD must be connected. Connect a PT1000 RTD to make the **RTD temperature Simple Linearizing** equation and the **RTD temperature Calendar-Van Duesen Equation** in the **RTD Resistance Register** group box valid. To connect a user-supplied RTD, loosen the terminal block with a screwdriver and remove the preinstalled resistor and jumper wires. Insert the RTD and tighten the terminals. Note that for a 2-wire RTD, the two jumper wires also need to be inserted in accordance with the 2-wire RTD Sensor Connector diagram on the PCB's silkscreen. Also, for a 3-wire RTD, one jumper wire needs to be inserted in accordance with the 3-wire RTD Sensor Connector diagram on the PCB's silkscreen. The 4-wire RTD does not need any jumper wires.

### User-Supplied Reference Resistor

The EV kit comes equipped with a 4kΩ, 10ppm/°C temperature coefficient, ±0.1% tolerance reference resistor. User-supplied reference resistors can also be used by removing R3 and populating one of the following: R1 (0805 footprint), R2 (1206 footprint), or R3 (0.3in axial footprint). Properly clean the PCB after any soldering rework.

## Table 1. Hardware Configurations

| HARDWARE ACTION | COMPONENTS | DESCRIPTION |
|---|---|---|
| Connect User-Supplied Reference Resistor | R3 | Remove factory-installed reference resistor R3 and populate R1–R3 with user-supplied reference. |
| Connect User-Supplied RTD | CON4 | Remove factory-installed resistor and jumpers from the terminal block CON4 and insert user-supplied RTD. |
| Connect $\overline{DRDY}$ Pin to User-Supplied Input | R6 | Remove resistor R6 and connect to the $\overline{DRDY}$ test point. |
| Connect User-Supplied Power Supply | R5 | Remove resistor R5 and connect the user supply to the 3.3V and GND test points. |
| Connect User-Supplied SPI Interface | R7–R10 | Remove resistors R7–R10 and connect the user SPI interface to test points. |

## Table 2. Description of LEDs

| LED | COLOR | DESCRIPTION |
|---|---|---|
| D1 | Red | **$\overline{DRDY}$:** LED connected to the active-low/DRDY data-ready output. The LED is red when a new conversion result is available in the RTD Data registers. |
| D20 (POWER) | Red | **USB Power Fault:** A fault occurred due to overvoltage limit, current limit, or thermal limit. |
| | Green | **USB Power:** USB power supply is on. |
| D21 (COM) | Red | **Communication:** After the software has initialized the hardware, the LED flashes red when a command from the PC is received. |
| | Off | **Initialized:** Hardware has been initialized by software. |
| | Red and Flashing Orange | **Waiting:** Hardware is powered on and waiting for the software to be opened. |

## Troubleshooting

All efforts were made to ensure that each kit works on the first try, right out of the box. In the rare occasion that a problem is suspected, refer to the table below to help troubleshoot the issue.

| SYMPTOM | CHECK | SOLUTION |
|---|---|---|
| GUI says hardware not found. | Is the D20 LED red? | If yes, then the electronic fuse (U20) is in a fault state. Inspect for electrical shorts on the PCB and ensure that the PCB is not sitting on a conductive surface. |
| | Does the D21 LED turn off when the GUI is running? | If not, then exit the GUI and try running it again. If D21 still does not turn off, then exit the GUI and try connecting the USB cable to a different USB port on the PC and wait for a Windows message that states the hardware is ready to use. Run the GUI again. If D21 still does not turn off, unplug the USB cable and reboot the PC. Connect the USB cable and open the GUI. |
| | Are any of the LEDs illuminated? | If not, then the PCB may not be getting power from the USB. Try a different USB cable or a different USB port. |
| RTD Data register reports all 00s or all FFs | Are all terminal block connections secure and making good contact? | Unscrew all terminals in the terminal block. Remove and reinsert the RTD resistor, paying special attention to the connector diagram on the PCB silkscreen and jumper wires. |

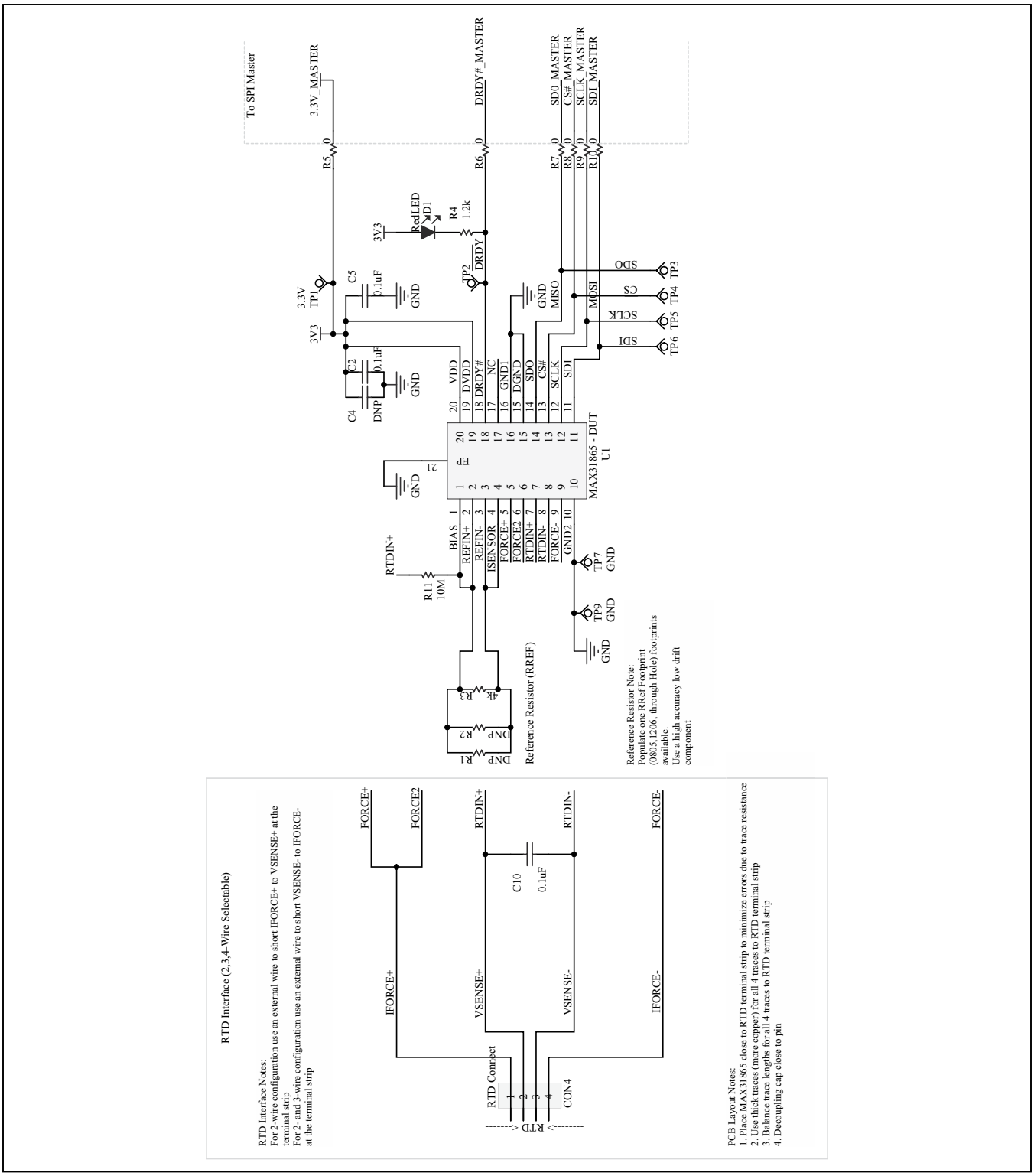


*Figure 4. MAX31865 EV Kit Schematic (Sheet 1 of 2)*

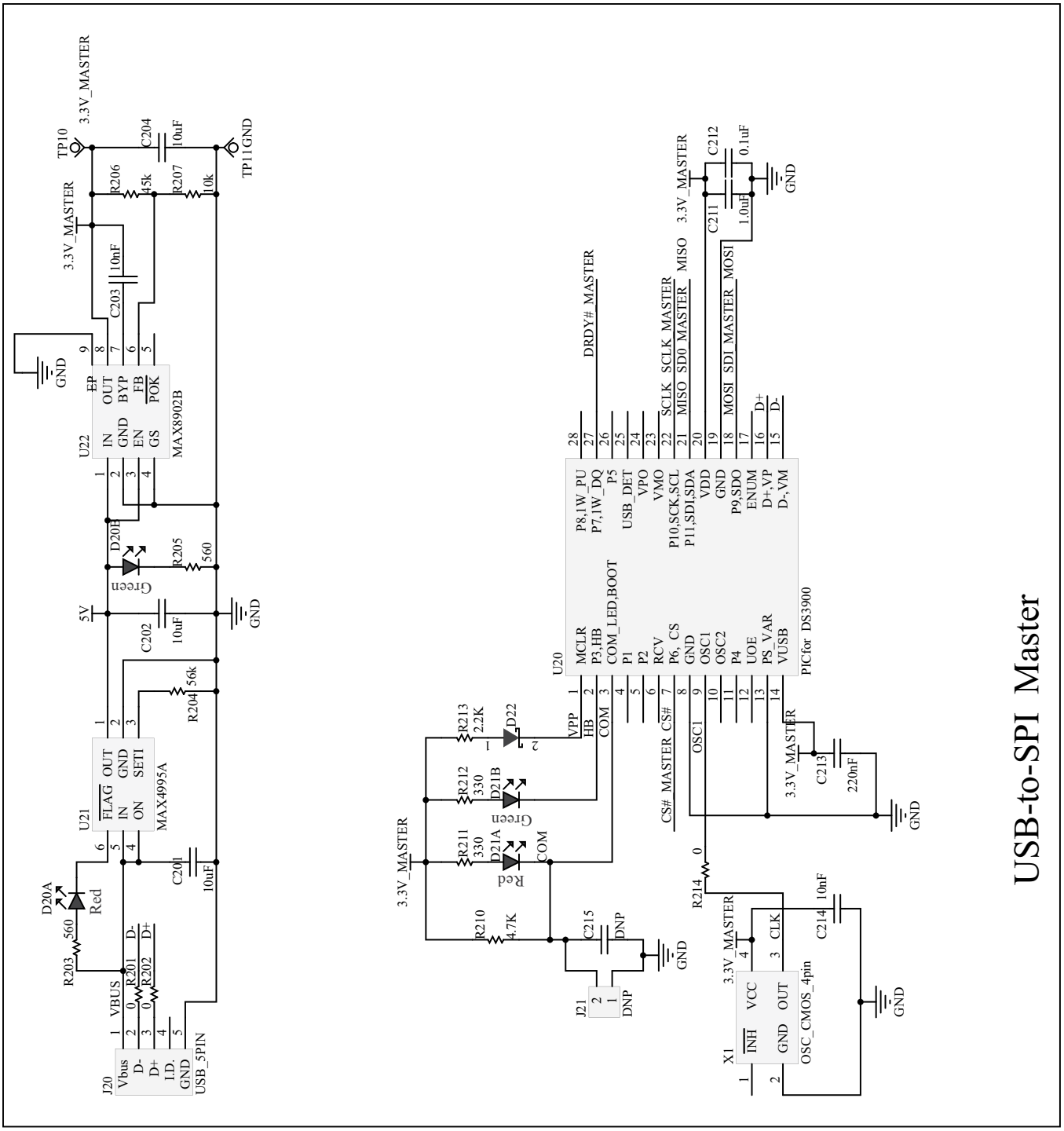


*Figure 5. MAX31865 EV Kit Schematic (Sheet 2 of 2)*

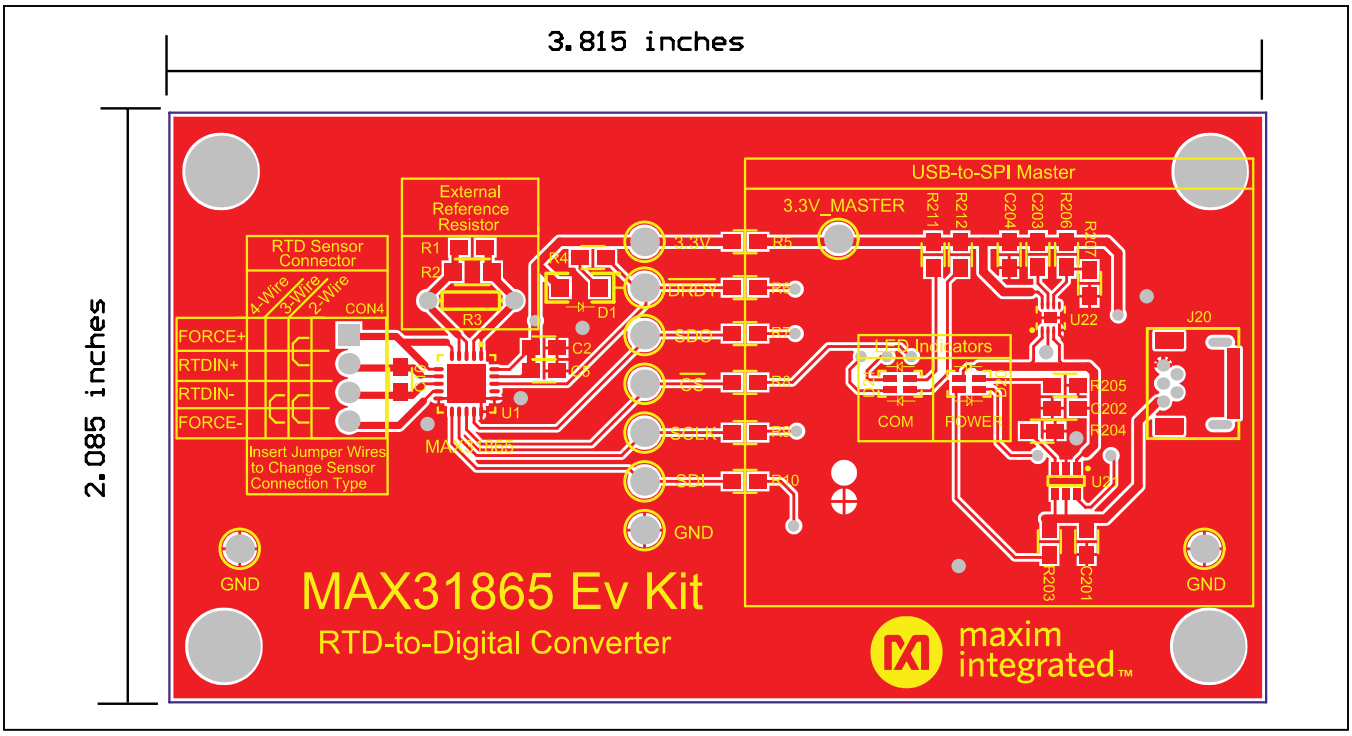


*Figure 6. MAX31865 EV Kit PCB Layout—Top*

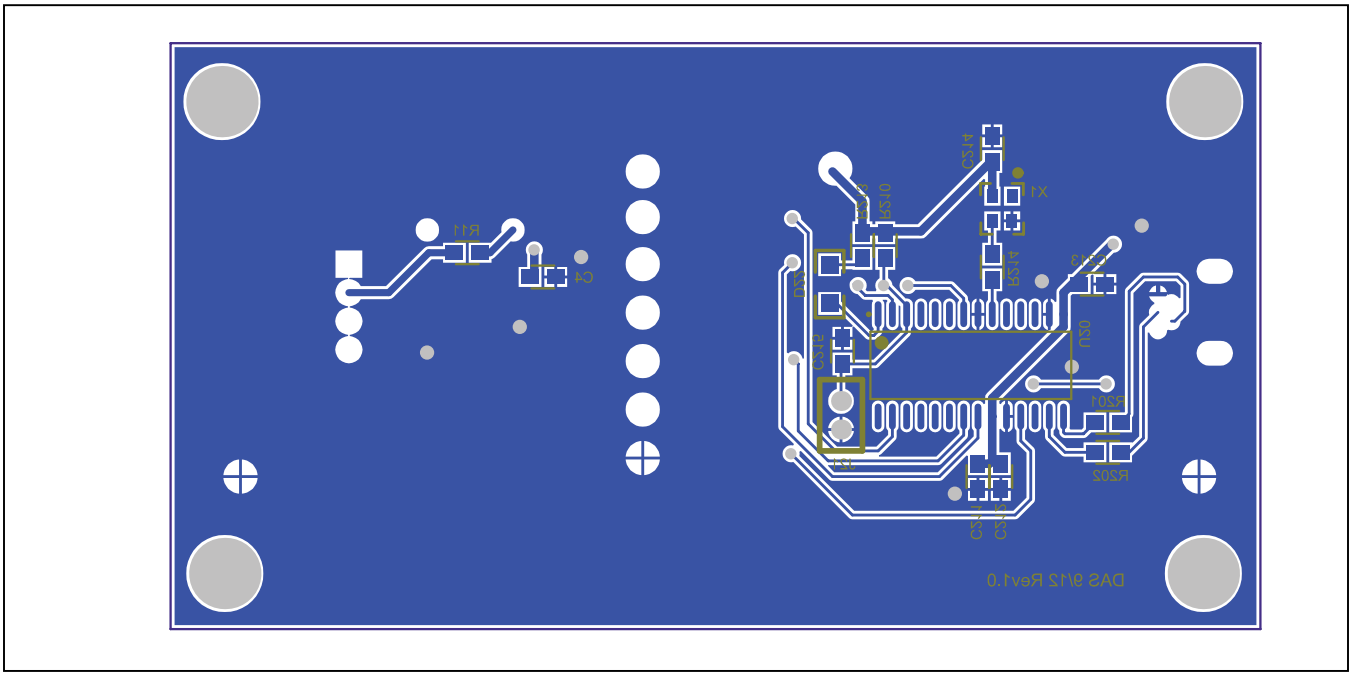

*Figure 7. MAX31865 EV Kit PCB Layout—Bottom*

## Ordering Information

| PART | TYPE |
|---|---|
| MAX31865EVKIT# | EV Kit |

*#Denotes an RoHS-compliant device that may include lead(Pb) that is exempt under the RoHS requirements.*