General Description

The MAX16972A evaluation kit (EV kit) demonstrates the MAX16972 and MAX16972A automotive USB 2.0 protector ICs. The ICs support Hi-Speed, full-speed, and low-speed operation. In addition, the ICs also include integrated circuitry to enable fast charging for consumer devices adhering to the Apple® 1A dedicated charging mode, the USB-IF host-charger port-detection protocol, and the China YD/T 1591-2009 standard. Dedicated charging modes feature autodetection, which automatically selects the correct dedicated charging protocol for the connected portable device (PD). The IC part numbers with GEEB and GTEB suffixes also support independent control of the +5V bus per the USB-IF OTG specification, and add Apple 2.1A dedicated charging support.

Two EV kits are available: MAX16972AGTEVKIT# (TQFN version) and MAX16972AGEEVKIT# (QSOP version), which come with the MAX16972AGTEB/V+ and MAX16972AGEEB/V+ installed, respectively. These user-friendly EV kits can be connected directly to a USB host port, thanks to the on-board MAX15007A automotive regulator that provides the IN logic power supply. Contact the factory for free samples of the pin-compatible variants of the MAX16972/MAX16972A ICs, which offer additional dedicated charging-mode functionality and active-low enable logic.

Features

- 900MHz Bandwidth USB 2.0 Data Switches
- Integrated Dedicated-Charging and Host-Charger Port-Detection Circuitry
- Supports Charging Current from 500mA to 3A
- USB 2.0-Compliant LS/FS and HS Operation
- Short-to-Battery, Short-to-Ground, and Overcurrent Protection on Protected HVBUS Output
- Short-to-Battery and Short-to-HVBUS Protection on Protected HVD+ and HVD- Outputs
- USB-Powered or User-Supplied Power Supplies
- Proven PCB Layout
- Fully Assembled and Tested

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

Quick Start

Required Equipment

- MAX16972A EV kit
- 5V, 3A DC power supply (Supply A)
- 18V, 2A DC power supply (Supply B)
- 10Ω, 5W resistor (Load A) and 10Ω, 40W adjustable resistor (Load B)
- Voltmeter or oscilloscope

Procedure

The EV kit is fully assembled and tested. Follow the steps below to verify board operation. **Caution: Do not turn on the power supplies until all connections are completed.**

1) Set the SW1-EN switch to the 1 position and the SW1-CHEN switch to the 0 position. Verify that the shunt on jumper JU7 is installed across pins 1-2.
2) Connect Load A between the red HVBUS test point and the GND1 test point on the EV kit.
3) Set the Supply A output to 5V and disable the output.
4) Connect the positive terminal of Supply A to the red VBUS test point on the EV kit.
5) Connect Supply A to the black GND2 test point on the EV kit.
6) Set the Supply B output to 18V and the current limit to 2A. Disable the output.
7) Connect the Supply B ground to the GND1 test point. Connect the positive terminal of Supply B to a test lead (18V test lead) for later use.
8) Connect the voltmeter or the oscilloscope ground reference to the GND1 test point.
9) Enable the Supply A 5V power supply.
10) Enable the Supply B 18V power supply.
11) Use the voltmeter or oscilloscope to probe the HVBUS test point. Verify that voltage is 5V.
12) Verify that the Supply A output current from the power supply is approximately 500mA.

The following steps generate the overvoltage event on the protected HVD- and HVD+ pins (high-voltage side):

13) Connect the 18V test lead to the D- or D+ data lines on the J1 USB connector. Observe that the Supply A output current decreases to approximately 0mA. At the same time, observe with the voltmeter that the voltage on the $\overline{\text{FAULT}}$ PCB pad changes to 0V, indicating a fault condition.
14) Remove the 18V test lead from the data lines. Observe that the Supply A output current recovers to 500mA and the voltage on the $\overline{\text{FAULT}}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

The following steps generate the overvoltage event on the protected HVBUS pin (high-voltage side):

15) Connect the 18V test lead to the HVBUS test point. Observe that the Supply A output current decreases to approximately 0mA. At the same time, observe that the voltage on the $\overline{\text{FAULT}}$ PCB pad changes to 0V, indicating a fault condition.
16) Remove the 18V test lead from the HVBUS test point. Observe that the Supply A output current recovers to 500mA and the voltage on the $\overline{\text{FAULT}}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

The following steps generate the short-to-ground event on the protected HVBUS pin (high-voltage side):

17) Connect the HVBUS test point to the GND1 test point with a test lead. Observe that the Supply A output current decreases to approximately 30mA. At the same time, observe that the voltage on the $\overline{\text{FAULT}}$ PCB pad changes to 0V, indicating a fault condition.
18) Remove the test lead between the HVBUS and GND1 test points. Disconnect and then reconnect Load A. Observe that the Supply A output current recovers to 500mA and the voltage on the $\overline{\text{FAULT}}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

The following steps generate the undervoltage event on the protected HVBUS pin (high-voltage side):

19) Set the adjustable Load B to its maximum value of approximately 10Ω.
20) Replace Load A with Load B and verify that the Supply A output current is approximately 500mA.
21) Decrease the Load B value until the Supply A output current approaches 2.9A (approximately 20% above forward-current limit) and suddenly changes to approximately 30mA. Observe that the voltage on the $\overline{FAULT}$ PCB pad changes to 0V, indicating a fault condition.
22) Increase Load B back to its maximum value. Disconnect and then reconnect Load B. Observe that the Supply A output current recovers to 500mA and the voltage on the $\overline{FAULT}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

The following steps generate the undervoltage event on the BUS pin:

23) Decrease Supply A to approximately 4.3V and observe that the output current decreases to approximately 0mA. At the same time, observe that the voltage on the $\overline{FAULT}$ PCB pad changes to 0V, indicating a fault condition.
24) Increase Supply A back to 5V and observe that the output current recovers to 500mA and the voltage on the $\overline{FAULT}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

The following steps generate the low R_{ISET} event on the ISET pin:

25) Connect the ISET test point to the GND2 test point with a test lead. Observe that the Supply A output current decreases to approximately 0mA. At the same time, observe that the voltage on the $\overline{FAULT}$ PCB pad changes to 0V, indicating a fault condition.
26) Remove the test lead between the ISET and GND2 test points. Observe that the Supply A output current recovers to 500mA and the voltage on the $\overline{FAULT}$ PCB pad changes back to 3.3V, indicating the removal of the fault condition.

Additional Evaluation (Charging a Device in DCP Mode)

27) To test the dedicated charging functionality, a portable device (PD) is needed that supports USB-IF BC1.2 DCP, China YD/T1591-2009, or Apple dedicated charging.
28) To place the MAX16972AGEEB/V+ in Apple 1A/DCP autodetect mode, set the SW1-EN switch to the 0 position and the SW1-CHEN switch to the 1 position. To place the MAX16972GEEA/V+ in Apple 2.1A/DCP autodetect mode, set both the SW1-EN and the SW1-CHEN switch to the 1 position.
29) The ISET resistor setting should allow a charging current that is equal to or greater than the PD's maximum charging current. The EV kit comes with a 15.4kΩ resistor installed in position R1 for a 2.37A (typ) current limit.
30) Use the device's manufacturer-supplied USB cable to connect the PD to the EV kit. If the device charges with a current expected for fast-charge operation, the test is successful. Note that most PDs that support fast charge only charge at the maximum-rated charge current under very specific conditions relating to device temperature, battery level, and internal activity.

Detailed Description of Hardware

The MAX16972A EV kit demonstrates the MAX16972 and MAX16972A family of automotive USB protection ICs. This product family features integrated fast-charge circuitry, USB-IF host-charger port detection, and offers overvoltage and high-ESD protection on the 5V bus and USB data lines. The 5V bus is also protected from overcurrent and short-to-ground conditions, and the current limit can be set from 500mA to 1A.

The USB data-line protection consists of both ESD and overvoltage protection (OVP) for all modes of operation, when used with or without a USB transceiver.

The HVBUS short-to-battery protection is implemented with an external power FET. An internal charge pump drives the gate of this FET, which generates a 7V (min) gate-source voltage. If HVBUS short-to-battery protection is not required, remove the external FET and connect the HVBUS pin directly to the S_DMOS pin.

Short-to-ground and overcurrent protection are also provided on the protected HVBUS output, protecting the internal BUS power rail from overcurrent faults.

The ICs support USB Hi-Speed, full-speed, and low-speed operation, with all USB signal traces designed for 90Ω differential impedance.

Forward Current Limit

The ICs enable the forward-current limit of the power switch to be set by a resistor connected on the ISET pin. The EV kit PCB ships with a 15.4kΩ resistor installed.

Device Enable

Depending on the device under evaluation, the device's enable pin can be either active-high or active-low. Set the SW1-EN switch to the 1 position to set the enable pin high and to the 0 position to set the enable pin low. See Table 1 for SW1 settings.

Charger-Detect Enable (CHEN)

Use CHEN to enable the IC's host-charging port-detection circuit. See Table 1 for SW1-CHEN settings.

Power Supplies

The USB transceiver power supply is set through the J2 USB connector or the VBUS and GND2 test points. The protected USB HVBUS is connected to the J1 USB connector and the HVBUS test point.

By deault, the logic power supply (IN) is provided by the on-board MAX15007A 3.3V regulator. The user can also apply an external logic power supply through the EXT_VIN and GND2 test points and place a shunt on jumper JU7 in the 2-3 position. See Table 1 for jumper JU7 settings.

Fault Conditions

The fault-condition pin ($\overline{\text{FAULT}}$) is active-low. A pullup resistor (R5) is connected to the IN power supply on the EV kit board.

Table 1. Jumper/Switch Descriptions (SW1-EN, SW1-CHEN, JU7)

JUMPER	SHUNT POSITION	DESCRIPTION
SW1-EN	0*	EN or $\overline{\text{EN}}$ is set to logic-low
	1	EN or $\overline{\text{EN}}$ is set to logic-high
SW1-CHEN	0*	CHEN is set to logic-low
	1	CHEN is set to logic-high
JU7	1-2*	IN pin 3.3V input is connected to the on-board 3.3V regulator output
	2-3	IN pin 3.3V input is connected to the EXT_VIN test point

**Default position.*

Ordering Information

PART	TYPE
MAX16972AGTEVKIT#	EV Kit - TQFN Version
MAX16972AGEEVKIT#	EV Kit - QSOP Version

#Denotes RoHS compliant.

MAX16972A EV Kit Bill of Materials

DESGINATION	QTY	DESCRIPTION
C1	1	10μF ±10%, 25V X5R ceramic capacitor (1206) Murata GRM31CR61E106KE83L
C2, C11	2	0.1μF ±10%, 25V X7R ceramic capacitors (0603) Kemet C0603C104K3RALTU
C4	1	100μF ±20%, 6.3V X6S ceramic capacitor (1210) Taiyo Yuden JMK325AC6107MM-T
C6	1	1μF ±10%, 16V X7R ceramic capacitor (0805) Taiyo Yuden EMK107B7105KA-T
C8,C9	2	3.3μF ±10%, 25V X5R ceramic capacitor (0805) TDK CGA4J3X5R1E335M125AB
C12	1	Not installed, ceramic capacitor (0603)
C14, C15	2	Not installed, ceramic capacitor (0402)
C16, C17	2	Not installed, ceramic capacitor (0402)
D2	1	Not installed, zener diode (SOD123)
D_DMOS, G_DMOS, S_DMOS	3	Orange Miniature Test Points
EXT_VIN, HVBUS, VBUS	3	Red Multipurpose PCB Test Points
GND1, GND2	2	Black Multipurpose PCB Test Points
J1	1	USB type-A right-angle receptacle
J2	1	USB type-A right-angle plug
JU7	1	3-pin header
L1, L2	2	0Ω 0402 resistors
L3, L4	2	0Ω 0402 resistors
Q1	1	n-channel powermosfet 6TSOP
R1	1	15.4kΩ ±1% 0603 resistor
R2, R3, R5	3	100kΩ ±1% 0603 resistor
R4	1	1Ω ±5% 0603 resistor
R6	1	1kΩ ±5% 0603 resistor
R7	1	0Ω 0603 resistor
SW1	1	2-position miniature DIP Switch
U1	1	Automotive USB Protector 16 TQFN: Maxim MAX16972AGTEB/V+ 16 QSOP: Maxim MAX16972AGTEB/V+
U2	1	Automotive 3.3V Regulator (8-SO-EP*) Maxim MAX15007AASA+
FAULT, EN, CHEN, GND	4	Thru-hole mount test point
—	1	Shunt
—	1	PCB: MAX16972 EVALUATION KIT+

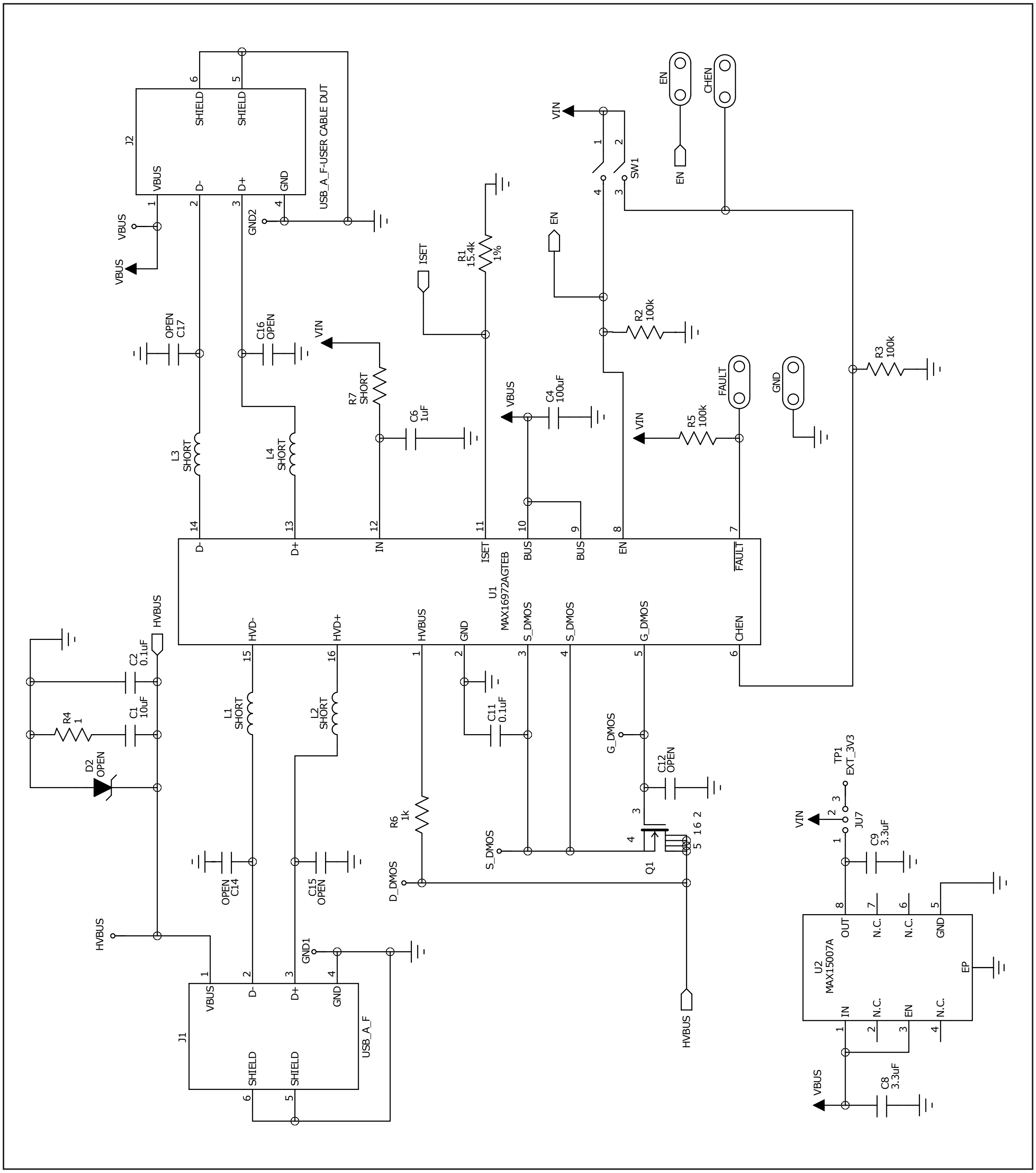
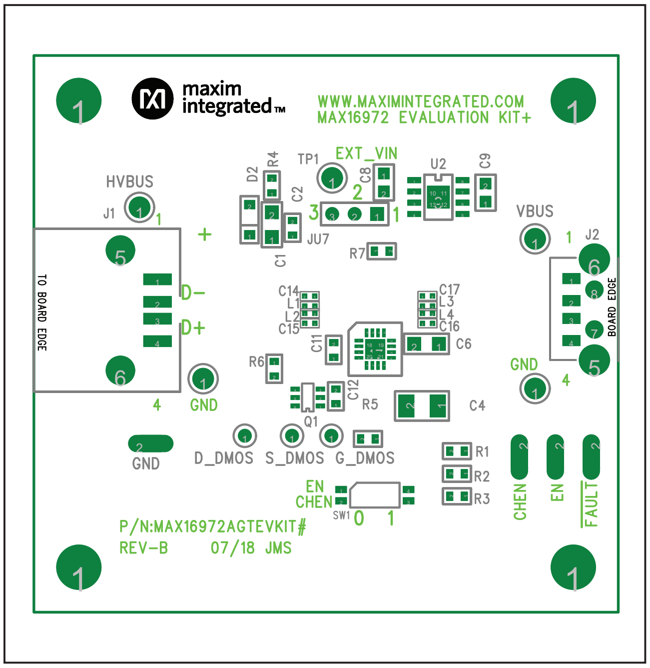
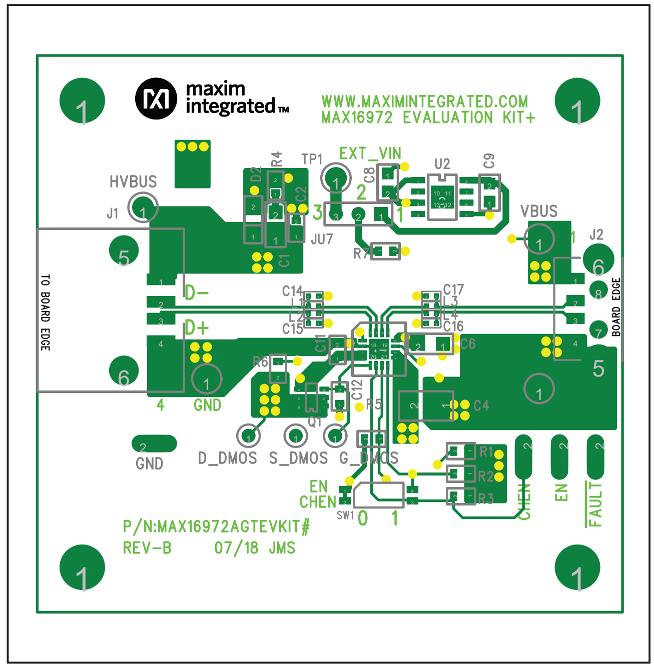


Figure 1. MAX16972A EV Kit Schematic (TQFN)

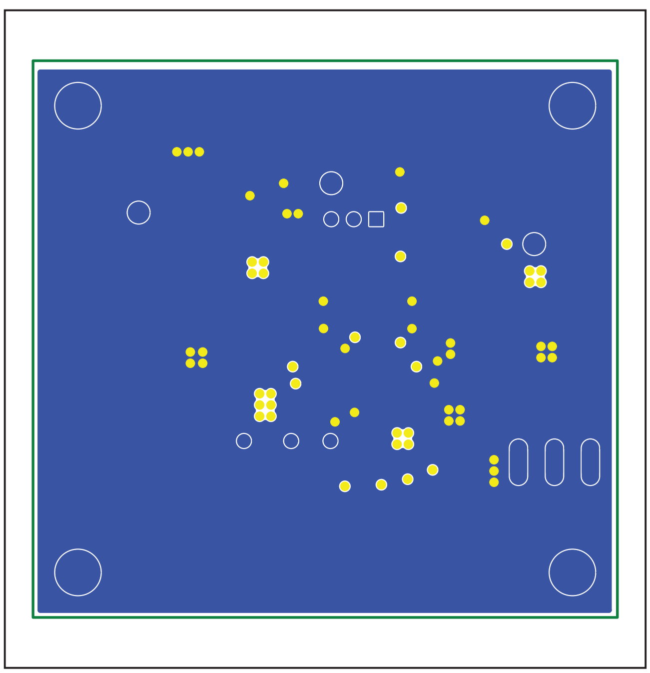
MAX16972A EV Kit PCB Layout - TQFN Version



MAX16972A EV Kit Component Placement Guide (TQFN)—Component Side

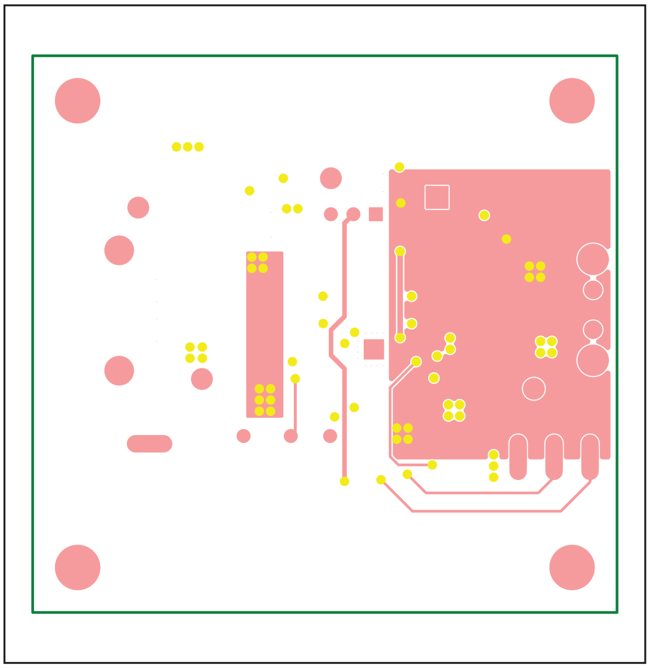


MAX16972A EV Kit PCB Layout (TQFN)—Component Side

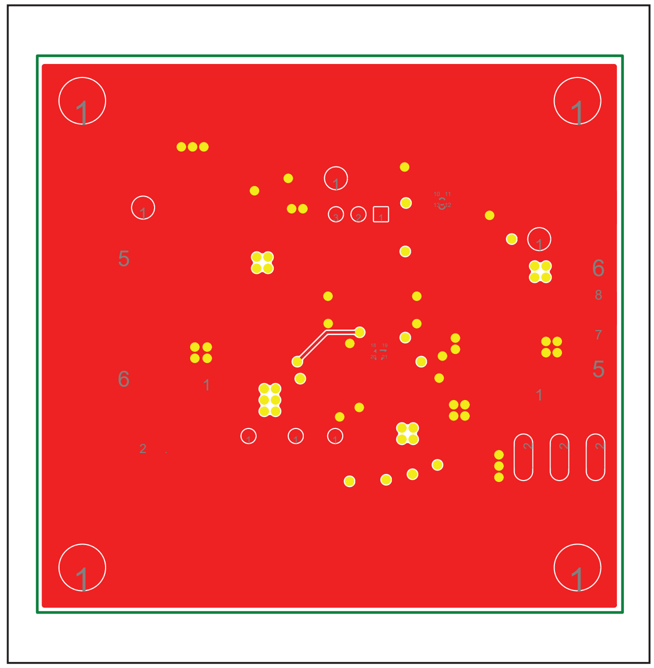


MAX16972A EV Kit PCB Layout (TQFN)—Inner Layer 2

MAX16972A EV Kit PCB Layout - TQFN Version (continued)

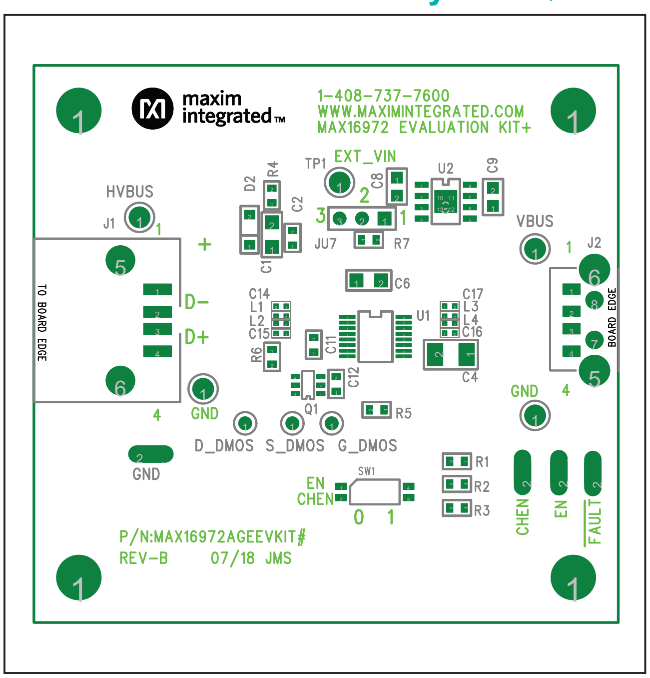


MAX16972A EV Kit PCB Layout (TQFN)—Inner Layer 3

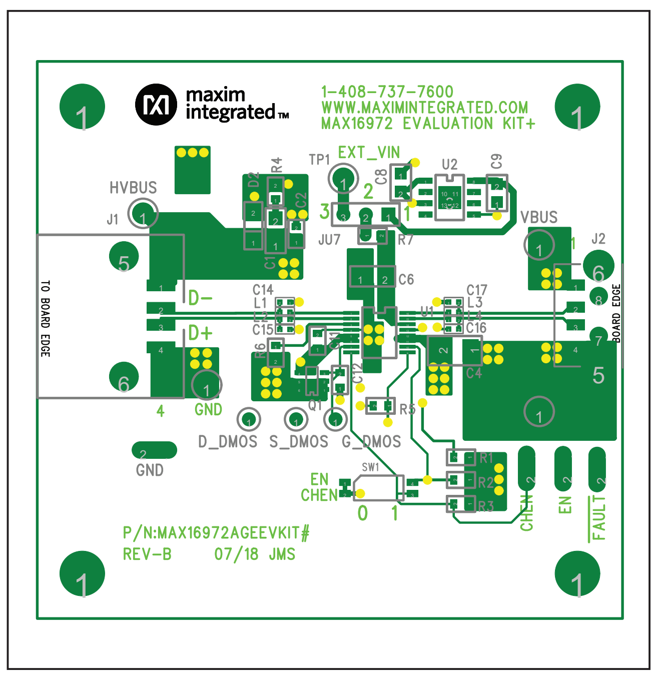


MAX16972A EV Kit PCB Layout (TQFN)—Solder Side

MAX16972A EV Kit PCB Layout - QSOP Version

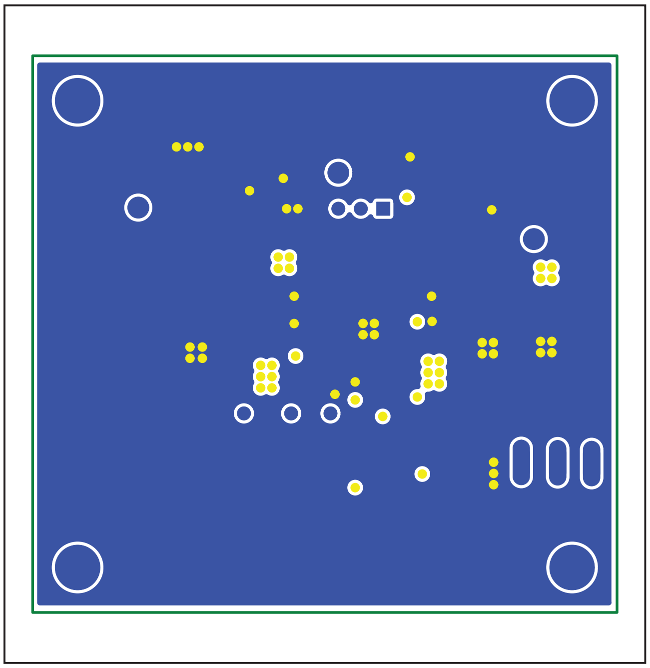


MAX16972A EV Kit Component Placement Guide (QSOP)—Component Side

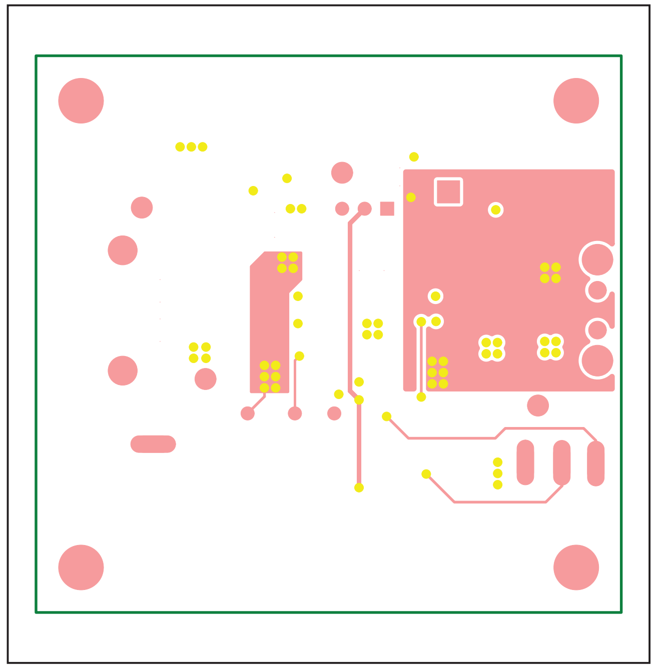


MAX16972A EV Kit PCB Layout (QSOP)—Component Side

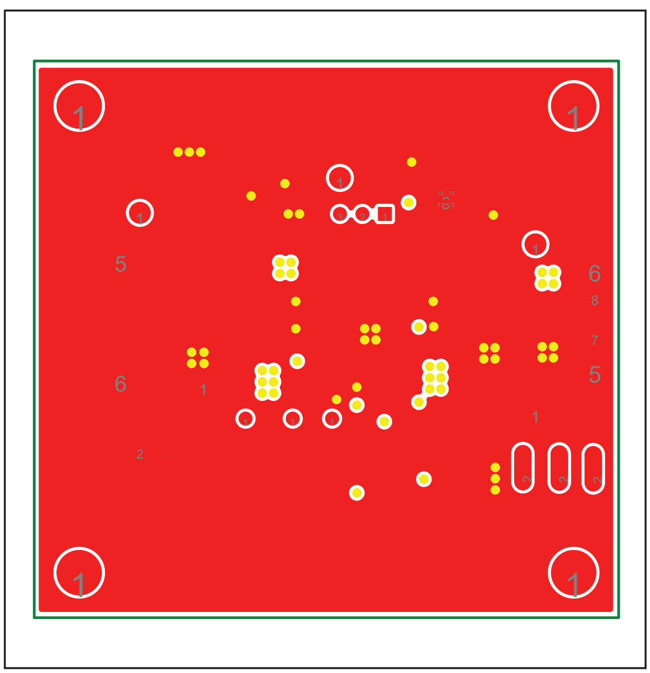
MAX16972A EV Kit PCB Layout - QSOP Version (continued)



MAX16972A EV Kit PCB Layout (QSOP)—Inner Layer 2



MAX16972A EV Kit PCB Layout (QSOP)—Inner Layer 3



MAX16972A EV Kit PCB Layout (QSOP)—Solder Side

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/18	Initial release	—

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at https://www.maximintegrated.com/en/storefront/storefront.html.

