MIC2310 Evaluation Board

Single-FET, Constant Power-Limit Hot Swap Controller

General Description

The MIC2310 is a single-channel, positive voltage, constant power-limit hot swap controller designed to provide for the safe insertion and removal of pc boards into fixed, rack, and pedestal mid- or back-planes using few external components. In addition, the MIC2310 employs a patent-pending, output load power-limiting technique where the current limit is inversely proportional to the output load voltage, such that the power product will not exceed the programmed power limit any longer than the externally programmed primary overcurrent period. The MIC2310 is ideally suited to address the power-limiting and timing requirements per the UL60950 specification for 240-VA applications. The MIC2310 incorporates high-side controller circuitry for an external N-channel MOSFET for which the MOSFET drain current rate of change is user-programmable via an external capacitor. The MIC2310 employs a dual-speed, dual-level overcurrent fault protection where the secondary overcurrent detection level is 2-bit user-programmable. The primary overcurrent detector response time is programmable and the secondary overcurrent detector exhibits a very fast (default) response to faults to ensure that the system power supplies are protected against catastrophic load current and short-circuit faults. Additionally, an analog output (voltage) signal is provided that is proportional to the steady-state load current to allow monitoring of the system's power. A PWRGD signal is provided to indicate a valid output voltage and PWRGD can also be used to enable a DC-DC power module.

Ordering Information

Part Number	Description
MIC2310-1ZTS EV	Evaluation board with the MIC2310-1 device.

Evaluation Board General Description

The MIC2310 evaluation board demonstrates the operation and features of the MIC2310, a Single-FET, constant Power-Limit Hot Swap Controller. The MIC2310 evaluation board is capable of drawing up to 600W and operates over a voltage range of 10.8V to 13.2V. The current-limit configuration for the board is set by the external sense resistor, R5. The standard board is programmed for 20A to demonstrate a 240-VA application utilizing the MIC2310-1ZTS option. The external LED driver circuits are configured for the active-HIGH outputs (PWRGD and I_FLT) of the MIC2310-1ZTS.

The board comes equipped with input/output power connectors that are capable of passing up to 50A. Additionally, 6-gauge power cables are recommended for higher current (>25A) applications.

The MIC2310 has three digital output indicators to alert users of fault (HW_FLT and I_FLT) and "Power-is-good" status conditions. These outputs can be connected to external LED drive circuits via shorting 2-terminal jumpers.

The schematic is shown in Figure 1 below and the top and bottom side assembly diagrams, along with the rest of the PCB layout files, are illustrated in Figures 2 and 3.

Powering the Board

The MIC2310 can be powered either by the high-current cable lugs at the input (TS1, TS2) using 6-gauge copper wire, or if evaluating at much lower current levels, the evaluation board can be powered by the input terminal pins for VCC and GND, TP9 and TP7, respectively. The input voltage range for proper operation of the MIC2310 is 10.8V to 13.2V. Additionally, a second power rail is generated (from the VCC supply) to power the LED drive circuits for the output logic signals (HW_FLT, I_FLT, and PWRGD). This power rail is labeled VLOGIC in the circuit schematic.

Output Turn-On and GATE Control (dI_D/dt or dV_{GATE}/dt)

With the input supply voltage applied, the MIC2310 is enabled by applying a logic HIGH input voltage signal on the ENABLE control pin. Upon the application of an ENABLE LOW-to-HIGH transition after the Power-on Reset delay (t_{POR}), or at the end of t_{POR} if ENABLE is already HIGH, a nominal start-up commences where the dI_D/dt-controlled inrush current (by $dI_D/dt = 17.6x10^{-3} \times I_{SLEW} / (R_{SENSE} \times C_{SLEW})$) is permitted to exceed the I_{POC} threshold for t_{POC}, until there is sufficient charge stored on the load capacitor as evidenced by the output load voltage profile. Note that the secondary overcurrent detection threshold (I_{SOC}) is set externally at the controller's S[1:0] pins. Once the inrush current exceeds the I_{SOC} threshold, the circuit breaker trips without delay and the MIC2310 controller shuts down the output. If the inrush current profile does not cause either of the OC detection circuits to trip the circuit breaker and assert the I_FLT digital output, the controller will assert the PWRGD digital output when the output load voltage is higher than the controller's V_{PGH} threshold voltage and the V_{GS} of the external MOSFET is higher than the controller's V_{GSPGH} threshold voltage. Due to the low $R_{DS(ON)}$ of the external MOSFET, the output load voltage rises with the GATE voltage as the V_{GS} of the MOSFET reaches its threshold voltage. Once the output load voltage stabilizes near the V_{CC} supply voltage, the V_{GS} of the external MOSFET increases above its threshold voltage and eventually exceeds V_{GSPGH}. The PWRGD output asserts to signal that the external MOSFET is fully enhanced and ready for the application of the full load.

An alternate mode for the output load charging can be achieved by use of the dV_{GATE}/dt controlled profile. This mode is realized by leaving the CSLEW pin OPEN (floating JP8) and connecting a capacitor from GATE to AGND.

Circuit Breaker Function

The MIC2310 employs a dual-level circuit breaker function to protect against excessive load currents. The dual-level circuit breaker "trips" when either

1) the load current remains above the primary overcurrent threshold (V_{CBP}) yet below the secondary, or fast-trip, threshold current limit for a programmed fault time, t_{POC}, where $t_{POC} = t_{POCSENSE} + C_{PRIMARY} * (V_{PRIL}/I_{PRI})$, or
2) the voltage monitored across the sense resistor exceeds the 2-bit user-programmed secondary overcurrent threshold, V_{CBS}. In the latter case, the GATE output is immediately disabled to shut down the output. The value for the $C_{PRIMARY}$ capacitor (C5) can be chosen to set the duration of t_{POC}

MIC2310 Highlighted Features

Fast Load Discharge Circuit (Optional)

The MIC2310 features a DISCH output pin that provides a signal to drive an external transistor to quickly discharge the bulk capacitance at the output. In general, these transistors are used either as a solitary switch with other passive components or in tandem with an SCR and external passive components for an extremely fast output load discharge. For the MIC2310 EVB, jumper JP5 provides an option for a very fast load discharge through the external crowbar circuit consisting of two transistors, an SCR, and several passive components. Shorting JP5 to ground will disable the discharge circuitry and allows the load to discharge much slower, but the HW_FLT will normally assert in this case due to the ΔV between the SOURCE and GATE exceeding the V_{GSPGH} threshold.

Adaptable Current Limit Threshold

The MIC2310 will maintain a constant power product (V·A) over the entire operating voltage range of 10.8V-13.2V. This is achieved by dynamically adjusting the current-limit threshold based on the voltage level monitored by the LOADSENSE and GNDSENSE pins and fed back to the MIC2310 current limit threshold control circuitry. For example, in a 240-VA (240W) application, when the voltage level falls to 11.0V, the MIC2310 controller would allow for close to 22A of current to flow before tripping the circuit breaker. Conversely, if the voltage level rises to 13.0V, the MIC2310 controller allows approximately 18.5A of current to flow before tripping the circuit breaker.

Auto-Retry or Latch Off Fault Modes

The MIC2310 has an optional configuration for overcurrent fault responses, either employing an output auto-retry or latch off mode. With jumper JP6 left open, the MIC2310 is configured for auto-retry of the output upon an overcurrent fault event. Capacitor C6 sets the auto-retry period and is determined by

$$t_{RETRY} = C_{RETRY} * (V_{RETRYH}/I_{RETRYUP})$$

With JP6 shorted to ground, the MIC2310 will latch the output upon an overcurrent fault event and remains latched OFF unless the ENABLE input is toggled HIGH-to-LOW-to-HIGH as defined by t_{ENLPW} (from the AC Electrical Characteristics Table in the MIC2310 datasheet) or the V_{CC} supply voltage is turned OFF then ON.

Digital Signal Output Indicators

There are three MIC2310 digital outputs that are used to drive LEDs to indicate several occurrences:

1) The "Power-is Good" (PWRGD or /PWRGD) will be asserted when the output voltage level is higher than the controller's V_{PGH} threshold.
2) The overcurrent fault signal (I_FLT or /I_FLT) will assert when there is a primary overcurrent

condition lasting longer than the programmed t_{POC} or immediately for an overcurrent that exceeds the secondary overcurrent threshold.

3) The HW_FLT signal will assert when a shorted R_{SENSE} is detected or a damaged power MOSFET is detected by either a D-S short or D-G short during startup.

Jumper Options

Jumper	Label	Position	Function	Factory Setting
JP1	VISS	Shorted Open	Provides an analog output level that is proportional to the steady-state load current. This output is often fed through an ADC for data conversion back to the system controller to manage the power allocated for the downstream modules.	Shorted
JP2	ENABLE	Shorted Open	ON/OFF control pin used to turn on the GATE output.	Shorted (Ground)
JP3	S0_SEL	Shorted Open	Secondary Overcurrent Threshold Set (Input)	Shorted (High)
JP4	S1_SEL	Shorted Open	Secondary Overcurrent Threshold Set (Input)	Open (Pull-Down to Ground)
JP5	SCR_SEL (DISCH)	Enabled Ground	Control for enabling a fast-responding (crowbar) circuit for the output bulk capacitance to quickly discharge to ground.	Enabled
JP6	RETRY_SH (CRETRY)	Shorted Open	Output auto-retry or latch-off configuration upon an overcurrent fault occurrence.	Shorted (Latch-off)
JP7	LDO_SEL	Shorted Open	Power supply input to an LDO that powers the logic output signal circuitry.	Shorted
JP8	SLEW (CSLEW)	Shorted Open	Output slew control that is used to adjust the inrush current profile via dI_{DRAIN}/dt if enabled (shorted) or via dV_{GATE}/dt	Shorted (dV_{GATE}/dt)
JP9	HWF_DRV	Shorted Open	Drive circuit to an LED for HW_FLT indication	Shorted
JP10	PG_DRV	Shorted Open	Drive circuit to an LED for “Power-is Good” indication	Shorted
JP11	IFLT_DRV	Shorted Open	Drive circuit to an LED for an overcurrent fault indication	Shorted

Evaluation Board Schematic

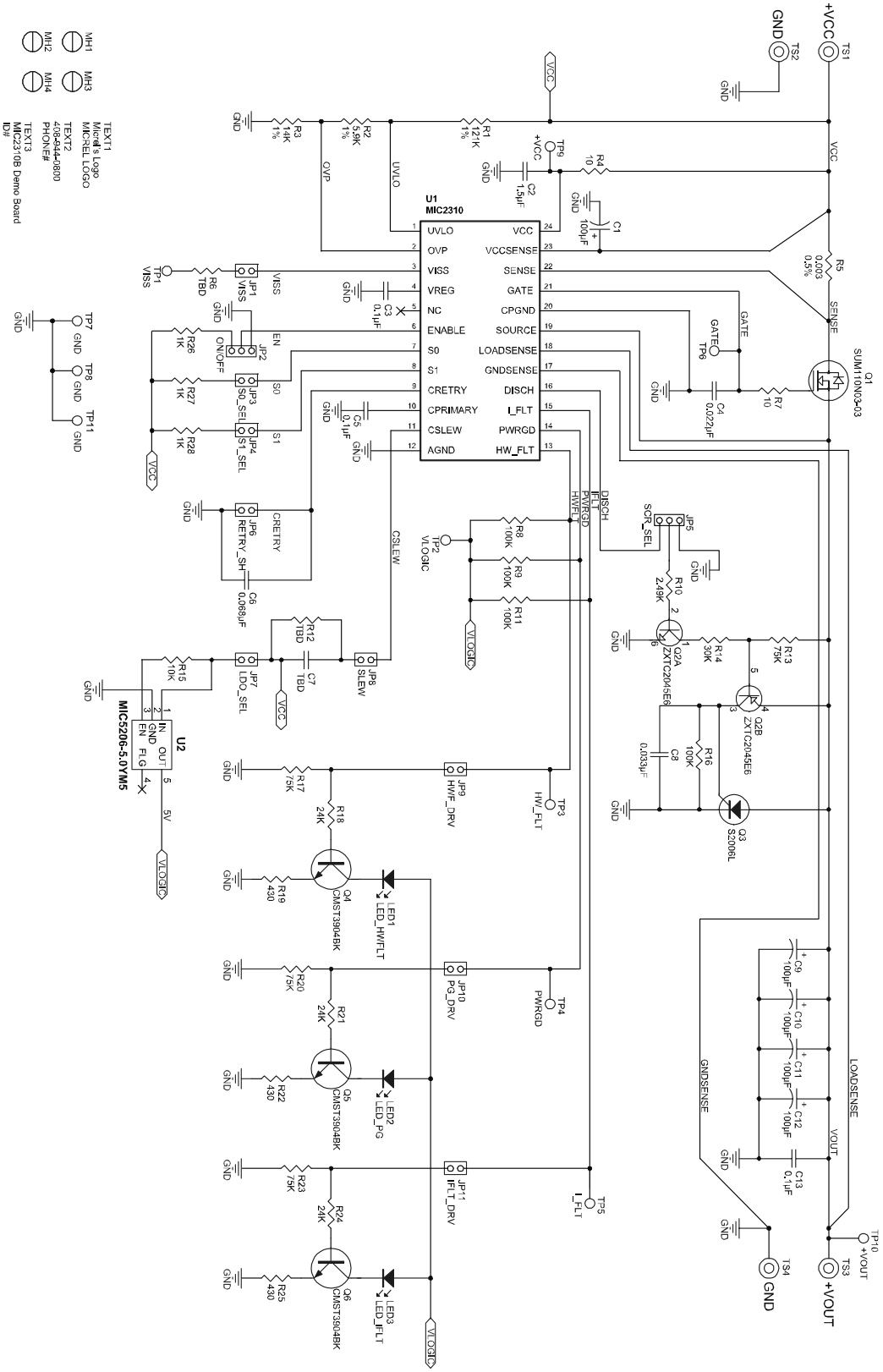

Figure 1. MIC2310 Schematic

Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1, C9, C10, C11	ECE-V1EA101XP	Panasonic[1]	Capacitor, Electroytic, 100µF, 25V, Size D8 Case	4
C2	C1206C155K3RACTU	Kemet[2]	Capacitor, Ceramic, 1.5µF, 25V, Size 1206	1
C3, C5, C13	VJ0603Y104KXXA	Vishay[3]	Capacitor, Ceramic, 0.1µF, 25V, X7R, Size 0603	3
C4	VJ0603Y223KXAA	Vishay[3]	Capacitor, Ceramic, 0.022µF, 50V, X7R, Size 0603	1
C6	VJ0603Y683KXXA	Vishay[3]	Capacitor, Ceramic, 0.068µF, 25V, X7R, Size 0603	1
C7			TBD	1
C8	VJ0603Y333KXAC	Vishay[3]	Capacitor, Ceramic, 0.033µF, 50V, X7R, Size 0603	1
C12	2222 136 31102	Vishay[3]	Capacitor, Electroytic, 1000µF, 50V, Size Radial	1
JP1, JP3, JP4, JP6-JP11	22-03-2021	Molex[4]	Connector, Jumper, Header, 2 Pin – 0.1” Center, 2 Pin sq. post	9
JP2, JP5	22-03-2031	Molex[4]	Connector, Jumper, Header, 3 Pin – 0.1” Center, 3 Pin sq. post	2
LED_HWFLT, LED_IFLT	TLMS2000	Vishay[3]	LED, 1.8V, 15mA, 4.5MCD Red, Size 0805	2
LED_PG	TLMS2100	Vishay[3]	LED, 1.8V, 15mA, 4.5MCD Green, Size 0805	1
MH1-MH4	9904	Keystone[5]	Screw, Machine Screw, Philips Head, Size 6-32 x 3/8	4
MH1-MH4	2211	Keystone[5]	Stand-off, Aluminum, HEX, 6-32, Size 0.750”	4
Q1	SUM110N03-03	Vishay[3]	Mosfet, N-CH 30V, 110A, 2.5mΩ, Size TO-263	1
Q2	ZXTC2045E6TA	Zetex[6]	Transistor, Dual 40V, Complementary 1.5A, Size SOT23-6	1
Q3	S2006L	Littelfuse[7]	SCR, 6A, 200V, Size TO-220	1
Q4, Q5, Q6	CMST3904 BK	Central[8]	Transistor, NPN, 40V, 200mA, Size SOT-323	3
R1	CRCW06031213F	Vishay[3]	Resistor, 121k, 1%, Size 0603	1
R2	CRCW06035901F	Vishay[3]	Resistor, 5.9k, 1%, Size 0603	1
R3	CRCW06031402F	Vishay[3]	Resistor, 1k, 1%, Size 0603	1
R4	CRCW080510R0F	Vishay[3]	Resistor, 10Ω, 1%, Size 0805	1
R5	WSR23L000FEA	Vishay[3]	Resistor, 0.003Ω, 1%, 2W, Size 4527	1
R6			TBD	1
R7	CRCW060310R0F	Vishay[3]	Resistor, 10Ω, 1%, Size 0603	1
R8, R9, R11, R16	CRCW06031003F	Vishay[3]	Resistor, 100k, 1%, Size 0603	4
R10	CRCW06032491F	Vishay[3]	Resistor, 2.49k, 1%, Size 0603	1
R12			TBD	1
R13, R17, R20, R23	CRCW06037502F	Vishay[3]	Resistor, 75k, 1%, Size 0603	4
R14	CRCW06033002F	Vishay[3]	Resistor, 30k, 1%, Size 0603	1
R15	CRCW06031002F	Vishay[3]	Resistor, 10k, 1%, Size 0603	1
R18, R21, R24	CRCW06032402F	Vishay[3]	Resistor, 24k, 1%, Size 0603	3
R19, R22, R25	CRCW06034300F	Vishay[3]	Resistor, 430Ω, 1%, Size 0603	3
R26, R27, R28	CRCW06031001F	Vishay[3]	Resistor, 1k, 1%, Size 0603	3
TP1-TP11	1593-2	Keystone[5]	Test Point, Turret Terminal, 0.062” diam.	11
U1	**MIC2310-1ZTS**	**Micrel, Inc.[8]**	**Constant Power-Limiting Hot Swap Controller, 12V**	**1**
U2	**MIC5206-5.0YM5**	**Micrel, Inc.[8]**	**LDO Regulator, 5V Low-Noise 150mA**	**1**

Notes:

1. Panasonic: www.panasonic.com/industrial/components/components.html
2. Kemet: www.kemet.com
3. Vishay: www.vishay.com
4. Molex: www.molex.com
5. Keystone: www.keyelco.com
6. Zetex: www.zetex.com
7. Littlefuse: www.fusecoinc.com
8. **Micrel, Inc.: www.micrel.com**

PCB Layout Recommendations

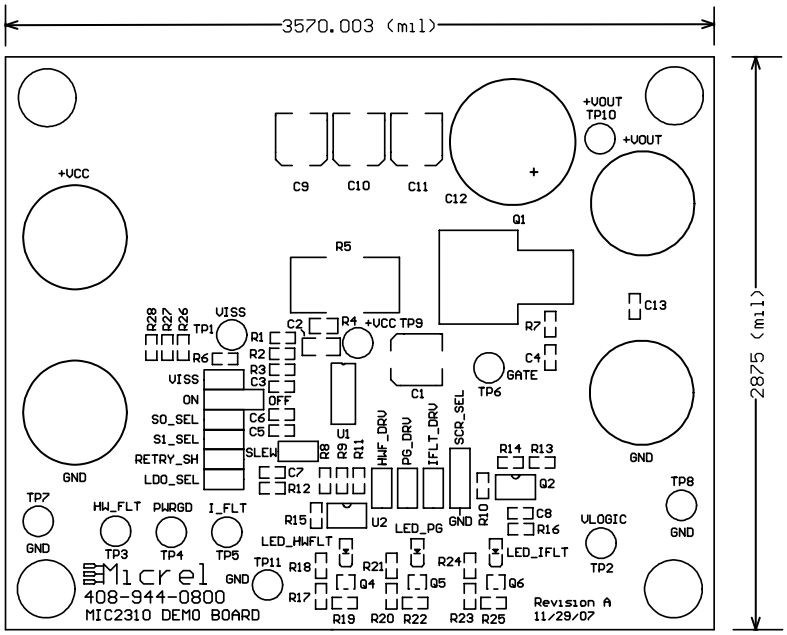

Figure 2. Top Layer Overlay

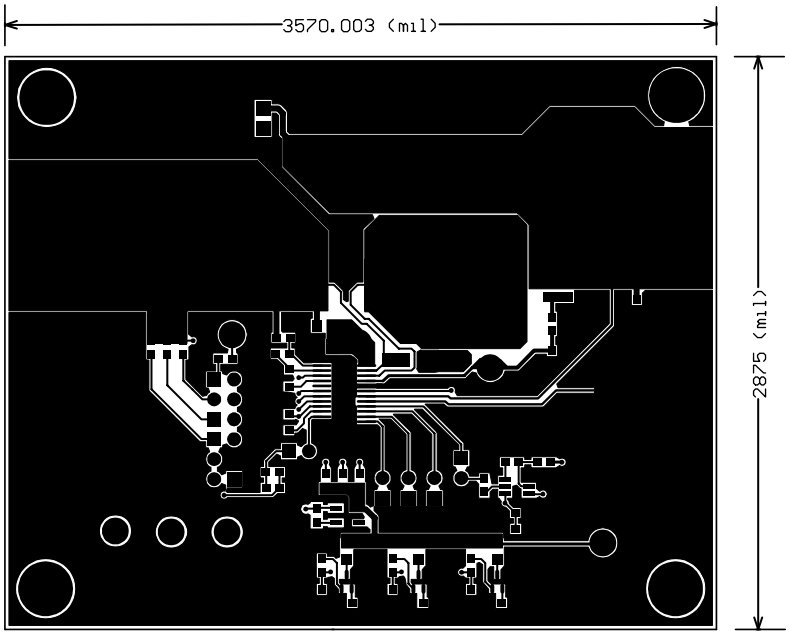

Figure 3. Top Layer

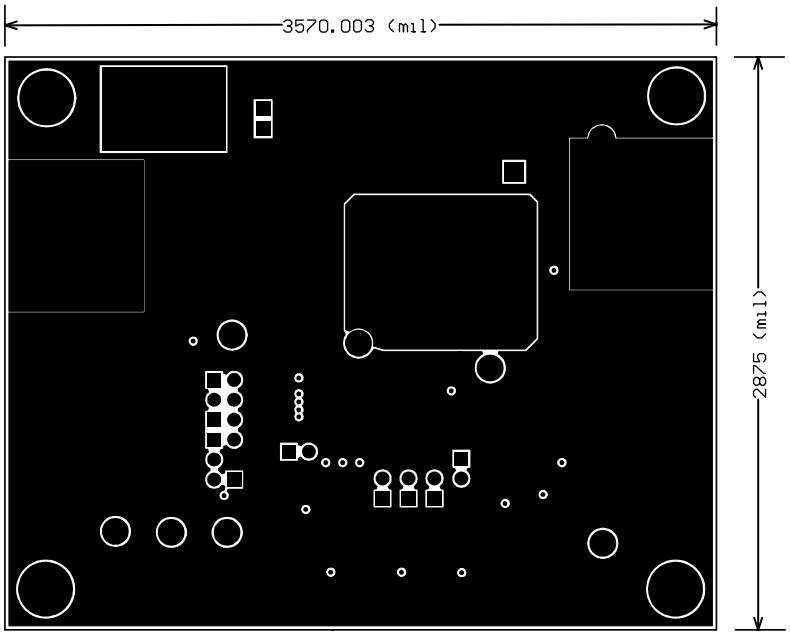

Figure 4. Bottom Layer

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