

MAX20069 Evaluation Kit

Evaluates: MAX20069/MAX20069B

General Description

The MAX20069 evaluation kit (EV kit) demonstrates the MAX20069 IC, which is a highly integrated power supply plus LED backlight driver for automotive TFT-LCD applications. The EV kit is a fully assembled and tested surface-mount PCB that provides a complete power-management solution for small-size automotive displays. The EV kit demonstrates one buck-boost converter, one boost converter, two gate-voltage controllers, and a boost converter that powers a quad-string LED driver.

The EV kit can be configured to operate in stand-alone mode or in I²C mode.

The TFT bias portion of the EV kit operates from a 2.8V to 5.5V DC supply voltage. The step-up switching regulator (POS) is configured for a 4V to 18V output that provides up to 150mA. The inverting buck-boost converter (NEG) generates a negative output that tracks the positive output (down to a minimum of -7V) and provides up to 100mA. The gate-driver power supplies consist of regulated charge pumps that generate +28V (GVDD) and -21.5V (GVEE) and can deliver up to 3mA each.

The LED driver section demonstrates a step-up DC-DC pre-regulator followed by four channels of linear current sinks. The step-up pre-regulator switches at 2.2MHz or at 440kHz and operates as a current-mode-controlled regulator capable of providing up to 600mA for the linear circuits. Each channel can operate up to 48V and provides up to 150mA.

The LED driver portion of the EV kit operates from a DC supply voltage of 4.5V up to the HB LED string-forward voltage. The EV kit can withstand a 52V load-dump condition. The EV kit also demonstrates the IC's features, such as adaptive voltage optimization, Overvoltage and Undervoltage protection, cycle-by-cycle current limit, thermal shutdown, and digital PWM dimming operation using a digital PWM input signal to control the brightness of the HB LEDs.

The EV kit provides an I²C interface that can operate in conjunction with the MINIQUEB+ adapter board or a third-party I²C master. The EV kit also includes Windows®-compatible software that provides a simple graphical user interface (GUI) for exercising the features of the IC.

Benefits and Features

- Demonstrates Robustness of MAX20069
- 2.8V to 5.5V Input Range for TFT Power Section
- 4.5V to 42V Input Range for LED Driver Section
- 2.2MHz or 440kHz I²C programmable Boost and Inverted Buck-Boost Switching Frequency with Spread-Spectrum Option on TFT Power Section
- 2.2MHz or 440kHz I²C programmable Boost Frequency with Spread-Spectrum Option on LED Driver Section with four 150mA LED drivers
- TFT Section Default Output Voltages (Stand-alone Mode)
 - +6V Output at 150mA (Step-Up Switching Regulator)
 - -6V Output at 100mA (Inverting Buck-Boost Switching Regulator)
 - +16V Output at 3mA (Positive-Charge Pump)
 - -7V Output at 3mA (Negative-Charge Pump)
- HB LED String Output Currents Configurable for 20mA, 50mA, 100mA, 120mA or 150mA
- Demonstrates Cycle-by-Cycle Current-Limit and Thermal-Shutdown Features on Boost LED Driver
- Demonstrates Adaptive Voltage Optimization on LED Driver Section
- I²C Programmability
- Dedicated GUI
- Proven PCB Layout and Thermal Design
- Fully Assembled and Tested

Ordering Information appears at end of data sheet.

MAX20069 EV KIT FILES

FILE	DESCRIPTION
MAX20069GUISetupV01.exe	Windows GUI Installer

Quick Start

Required Equipment

- MAX20069 EV kit
- 2.8 to 5.5V, 2A DC power supply
- 5V to 36V, 4A DC power supply
- Two digital voltmeters (DVMs)
- Four series-connected HB LED strings (6 LEDs each) rated to no less than 150mA
- Current probe to measure the HB LED current
- MINIQUSB+ interface board with USB cable
- Windows-compatible PC with a spare USB port

Note: In the following sections, text that has been **bolded** refers to the MAX20069 GUI software. Text that is **bold and underlined** refers to the Windows operating system.

Procedure

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

Caution: Do not turn on the power supply until all connections are completed.

Stand-Alone Mode

- 1) Verify that jumper J1 is closed (DS1 green LED connected).
- 2) Verify that jumper J9 is closed (FAULT signaling enabled).
- 3) Verify that jumper J23 is open (device enabled).
- 4) Verify that jumper J19 is closed (buck-boost converter input connected to TFT_POWER_INPUT PCB pad).
- 5) Verify that jumpers J10, J11, J21 are open (FBP, FBPG, FBNG feedback Inputs enabled).
- 6) Verify that jumpers JMP1-JMP4 have shunts installed across pins 1-2 (bleed resistors connected, all current sinks enabled).
- 7) Verify that jumper I2C is open and that jumper J2 is closed (SEQ pin connected to GND through R1 = 10kΩ resistor).
- 8) Verify that a shunt is installed across pins 2-3 on jumper J12 (BATT pin connected to BATT PCB pad).
- 9) Verify that jumper 100mA is closed.
- 10) Connect the positive terminal of the 2.8V to 5.5V, 2A DC power supply to the TFT_POWER_INPUT PCB pad. Connect the negative terminal of the power supply to a PGND PCB pad.
- 11) Connect the positive terminal of the 5V to 36V, 4A DC power supply to the BATT PCB pad. Connect the negative terminal of the power supply to a PGND PCB pad.
- 12) Connect a DVM across the OUT1 and AGND PCB pads.
- 13) Connect a DVM across one of the TFT output PCB pads (POS, NEG, VGVDD, VGVEE) and the AGND PCB pad.
- 14) Connect the four LED strings from VBOOST to the OUT1, OUT2, OUT3 and OUT4 PCB pads.
- 15) Clip the current probe across the channel 1 HB LED+ wire to measure the LED current.
- 16) Turn on the 2.8V to 5.5V, 2A DC power supply and set it to 3.3V. The green LED (DS1) should be on at this point.
- 17) Turn on the 5V to 36V, 4A DC power supply and set it to 12V. The LED strings should be on at this point.
- 18) Verify the presence of the following default TFT voltages: POS = - NEG = 6V; VGVDD = 16V; VGVEE = -7V.
- 19) Measure the voltage from each of the OUT_ PCB pads to PGND and verify the lowest voltage is approximately 1V.
- 20) Measure the LED current using the current probe and verify all channels.

I²C Mode

- 1) Visit www.maximintegrated.com/evkitsoftware to download the latest version of the EV kit software, MAX20069GUISetupV01.exe.
- 2) Install the EV kit software (GUI) on your PC by running the MAX20069GUISetupV01.exe program. The EV kit software application will be installed together with the required MINIQUSB+ drivers.
- 3) Verify that jumper J1 is closed (DS1 green LED connected).
- 4) Verify that jumper J9 is closed (FLTB signaling enabled).
- 5) Verify that jumper J23 is closed (EN pin grounded, device to be enabled through I²C).
- 6) Verify that jumper J19 is closed (buck-boost converter input connected to TFPOWER_INPUT PCB pad).
- 7) Verify that jumpers J10, J11, J21 are closed (FBP, FBPG, FBNG feedback inputs grounded).
- 8) Verify that jumpers JMP1–JMP4 have shunts installed across pins 1-2 (bleed resistors connected, all current sinks enabled).
- 9) Verify that jumper I2C is closed and that jumpers J2–J8 are open (SEQ pin connected to TFT_POWER_INPUT PCB pad).
- 10) Verify that a shunt is installed across pins 2-3 on jumper J12 (BATT pin connected to BATT PCB pad).
- 11) Verify that a shunt is installed either on jumper ADD0 or on jumper ADD1.
- 12) Verify that jumper 100mA is closed.
- 13) Connect the MINIQUSB+ interface board's P3 header to the J24 header on the EV kit.
- 14) Connect the positive terminal of the 2.8V to 5.5V, 2A DC power supply to the TFT_POWER_INPUT PCB pad. Connect the negative terminal of the power supply to a PGND PCB pad.
- 15) Connect the positive terminal of the 5V to 36V, 4A DC power supply to the BATT PCB pad. Connect the negative terminal of the power supply to a PGND PCB pad.
- 16) Connect a DVM across the OUT1 and AGND PCB pads.
- 17) Connect a DVM across one of the TFT output PCB pads (POS, NEG, VGVDD, VGVEE) and the AGND PCB pad.
- 18) Connect the four LED strings from VBOOST to the OUT1, OUT2, OUT3 and OUT4 PCB pads.
- 19) Clip the current probe across the channel 1 HB LED+ wire to measure the LED current.
- 20) Turn on the 2.8V to 5.5V, 2A DC power supply and set it to 3.3V. The green LED (DS1) should be on at this point.
- 21) Turn on the 5V to 36V, 4A DC power supply and set it to 12V.
- 22) Launch the EV kit software application.
- 23) From the EV kit software toolbar, select **Device** → **Scan for Address**. The GUI scans the I²C bus for available slave addresses on the bus and selects the first one (in this case, the MAX20069 I²C address). Press **OK** once the MAX20069 I²C address has been found.
- 24) Verify that the status bar in the bottom-right corner of the GUI displays **EV Kit: Connected**, as shown in [Figure 1](#).
- 25) In the 0x02 **ENABLE** register group box, check ENBST, ENPOS, ENNEG, ENGVD, ENGVEE, ENBLIGHT to activate the TFT Power Section and LED Driver Section.
- 26) Verify the presence of the following default TFT voltages: POS = -NEG = 6V; VGVDD = 8V; VGVEE = -6V.
- 27) Measure the voltage from each of the OUT_ PCB pads to PGND and verify the lowest voltage is approximately 1V.
- 28) Measure the LED current using the current probe and verify all channels.
- 29) For more details on how to use the GUI and all the features available, click on the GUI Help menu item.

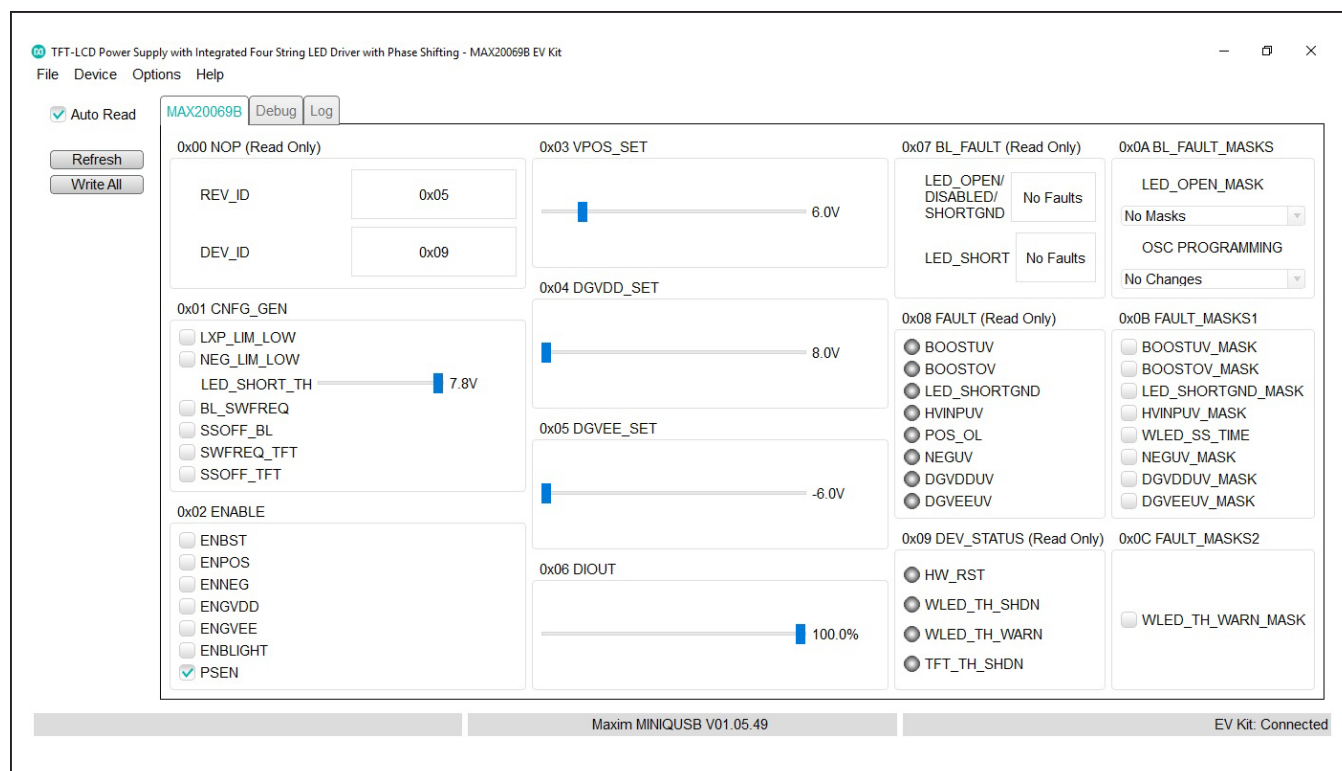


Figure 1. MAX20069 Evaluation Kit Software (GUI)

Detailed Description of Hardware

The MAX20069 EV kit consists of two sections with separate power supply inputs.

The TFT power section operates from a DC supply voltage of 2.8V up to 5.5V.

The HB LED driver section operates from a DC supply voltage of 4.5V up to the HB LED forward-string voltage and can handle load-dump conditions up to 52V.

TFT Power Section

The MAX20069 EV kit TFT power section features two source-driver power supplies (V_{POS} and V_{NEG} accessible through the POS and NEG PCB pads on the EV kit) and two gate-driver power supplies (DGVDD and DGVEE), accessible through the GVDD and VGVEE PCB pads on the EV kit).

The source-driver power supplies consist of a synchronous boost converter and an inverting buck-boost converter that switches at 2.2MHz (or 440kHz) and can gen-

erate voltages up to +18V and down to -7V. The positive source driver can deliver up to 150mA, while the negative source driver is capable of 100mA.

The gate-driver power supplies consist of regulated charge pumps that generate up to +28V and down to -21.5V and can deliver up to 3mA each.

Source-Driver Output-Voltage Selection

The EV kit's step-up switching-regulator output (POS) is set by feedback resistors R19 and R22 in stand-alone mode, with jumper J10 open. The default output voltage is set to 6V. To generate output voltages other than 6V, the user must select different external voltage-divider resistors for R19 and R22. The negative source-driver supply voltage (NEG) is automatically tightly regulated to -POS within $\pm 50\text{mV}$ when jumper J19 is closed. NEG cannot be adjusted independently of POS and is automatically shut down if POS is set to a value higher than 7V in stand-alone mode.

When jumper J10 is closed, the device should be operated in I²C mode. In I²C mode, POS and NEG voltages are enabled by checking **ENBST**, **ENPOS** and **ENNEG** in the **0x02 ENABLE** register group box. The POS voltage can then be regulated between 4V and 18V in 0.1V steps by acting on the 0x03 VPOS_SET slider bar while the NEG voltage is again regulated to -POS within $\pm 50\text{mV}$. See [Table 1](#) for J10 and J19 jumper settings.

Note: When POS is set to a voltage greater than 7V in I²C mode, the NEG converter should be disabled to avoid damage to the device.

Refer to the *Source Driver Power Supplies* section in the MAX20069 IC data sheet for more information.

Gate-Driver Output-Voltage Selection

The EV kit's positive gate-driver power supply (V_{GVDD}) is set to +16V by feedback resistors R23 and R20 in stand-alone mode, with jumper J21 open. To generate output voltages other than 16V, select different external voltage-divider resistors for R23 and R20. The negative gate-driver power supply (V_{GVEE}) is set to -7V in stand-alone mode by feedback resistors R21 and R24, with jumper J11 open. To generate output voltages other than -7V, select different external voltage-divider resistors for R21 and R24.

When jumpers J11 and J21 are closed, the device should be operated in I²C mode. In I²C mode, GVDD and GVEE voltages are enabled by checking **ENBST**, **ENPOS**, **ENGVD** and **ENGVEE** in the **0x02 ENABLE** register group box. The V_{GVDD} and V_{GVEE} voltages can then be regulated between 8V and 28V or between -6V and -21.5V, respectively, in 0.5V steps by acting on the **0x04 DGVDD_SET** and **0x05 DGVEE_SET** slider bars. See [Table 2](#) for J11 and J21 jumper settings.

Refer to the *Gate-Driver Power Supplies* section in the MAX20069 IC data sheet for more information.

TFT Output Sequencing Control (Stand-Alone Mode Only)

Source-driver and gate-driver outputs' power-up and power-off is controlled by the resistor value on the SEQ pin in stand-alone mode. When the EN pin is taken high (jumper J23 closed), the power-up sequence can be decided by connecting one of the R1–R3, R5–R7, or R18 resistors to ground through jumpers J2 to J8 (see [Table 3](#) for jumper settings).

Refer to the *Output Sequencing Control* section in the MAX20069 IC data sheet for more information.

Table 1. POS and NEG Voltage Setting (J10, J19)

SHUNT POSITION		FBP PIN	EV KIT OPERATION
J10	J19		
Open*	Closed*	Connected at mid-point between resistors R19 and R22	POS and -NEG voltages set to 6V in stand-alone mode
Closed	Closed	Connected to ground	POS and -NEG voltages set through I ² C registers

*Default Position

Table 2. GVDD and VGVEE voltage setting (J11, J21)

SHUNT POSITION		FBPG PIN	FBNG PIN	EVKIT OPERATION
J11	J21			
Open*	Open*	Connected at mid-point between resistors R23 and R20	Connected at mid-point between resistors R21 and R24	GVDD and GVEE voltages set to 16V and -7V, respectively, in stand-alone mode
Closed	Closed	Connected to ground	Connected to ground	GVDD and GVEE voltages set through I ² C registers

*Default Position

Table 3. TFT Output Sequencing Control (J2–J8)

SHUNT POSITION	POWER-ON SUPPLY SEQUENCING (FROM THE EXPIRATION OF SOFT-START PERIOD)				POWER-OFF SUPPLY SEQUENCING (FROM THE INSTANT WHEN EN IS DRIVEN LOW)			
	1st AFTER 15ms	2nd AFTER 30ms	3rd AFTER 45ms	4th AFTER 60ms	1st AFTER 15ms	2nd AFTER 30ms	3rd AFTER 45ms	4th AFTER 60ms
J2 closed*	POS	NEG	DGVEE	DGVDD	DGVDD	DGVEE	NEG	POS
J3 closed	POS	NEG	DGVDD	DGVEE	DGVEE	DGVDD	NEG	POS
J4 closed	NEG	POS	DGVEE	DGVDD	DGVDD	DGVEE	POS	NEG
J5 closed	POS	DGVEE	DGVDD	No NEG output	DGVDD	DGVEE	POS	No NEG output
J6 closed	POS	DGVDD	DGVEE	No NEG output	DGVEE	DGVDD	POS	No NEG output
J7 closed	POS NEG	—	—	DGVDD DGVEE	DGVDD DGVEE	—	—	POS NEG
J8 closed	DGVEE	DGVDD	NEG	POS	POS	NEG	DGVDD	DGVEE

*Default Position

HBLED Section

The MAX20069 EV kit LED driver section demonstrates the MAX20069 HB LED driver with an integrated step-up DC-DC pre-regulator followed by four channels of linear current sinks. The pre-regulator switches at 2.2MHz (or at 440kHz) and operates as a current-mode-controlled regulator, providing up to 600mA for the linear circuit while providing OVP. Cycle-by-cycle current limit is set by resistors R33 and R34, while resistors R31 and R32 set the OVP voltage to 29V. The pre-regulator power section consists of inductor L3, power-sense resistors R33 and R34, Q3 MOSFET and switching diode D7.

Each of the four linear channels (OUT1–OUT4) can operate up to 48V and sinks up to 150mA per channel. Each of the four channels' linear current sinks are configurable for 20mA, 50mA, 100mA, 120mA, or 150mA, or can be disabled independently by connecting the respective OUT_ channel to ground through a 12kΩ resistor before power-up, with the LED string connected to the corresponding OUT_ channel removed. Resistors R8–R12 and jumpers 50mA, 100mA, 120mA, and 150mA configure the linear current setting for the IC's ISET pin, which sets the HB LED string current.

The EV kit features PCB pads to facilitate connecting HB LED strings for evaluation. The VBOOST, VBOOST1, and VBOOST2 PCB pads provide connections for connecting each HB LED string's anode to the DC-DC preregulator

output. The OUT1–OUT4 PCB pads provide connections for connecting each HB LED string's cathode to the respective current sink. Capacitors C23 and C40–C42 are included on the design to prevent oscillations and provide stability when using long, untwisted HB LED connecting cables during lab evaluation. These capacitors are not required if the connection between the LED driver and the HB LEDs is a low-inductance connection.

A DIM PCB pad is provided for using a digital PWM signal to control the brightness of the HB LEDs.

HB LED Current

The EV kit features four jumpers (50mA, 100mA, 120mA, and 150mA) to configure the device's current sinks on all four channels. Place a shunt on one of the jumpers to configure the current-sink limits according to [Table 4](#). If no shunt is placed, the LED current will be set to 20mA. To reconfigure the circuit for another current-sink threshold, replace resistor R8, leave all the jumpers open, and use the following equation to calculate a new value for the desired current: $I_{LED} = 1500/R8$

where I_{LED} is the desired HB LED current per string in amperes and R8 is the new resistor value for obtaining the desired HB LED current. If the HB LED current is reconfigured for a different current, other components on the EV kit may need to be modified. Refer to the MAX20069 IC data sheet to calculate other component values.

Channel 1–Channel 4 Current-Sink Disabling

The EV kit features jumpers JMP1–JMP4 that are used to put each OUT_ current sink in one of three operating states:

- 1) Normal operation (i.e., OUT_ is connected to the corresponding ring on the board edge and LEDs are connected from there to the preregulator output (V_{OUT}).
- 2) OUT_ connected through a 12kΩ resistor to GND and thus disabled.
- 3) OUT_ shorted to GND, used to test fault detection.

To disable a channel, install a jumper in the channel's respective jumper across pins 1-3, connecting the OUT_ to ground through a 12kΩ resistor. The dimming algorithm in the IC requires that higher numbered OUT_ current sinks are disabled first (e.g., if only two strings are needed, OUT1–OUT2 should be used, with OUT3 and OUT4 disabled). See [Table 5](#) for jumper settings. The 100kΩ bleed resistors are installed to prevent the OUT_ leakage current from dimly turning on large LED strings, even when the DIM signal is low.

Table 4. LED Current Setting (20mA, 50mA, 100mA, 120mA and 150mA)

SHUNT POSITION	ISET RESISTOR SETTING (kΩ)	LED CURRENT SINK SETTING (mA)
Open	75	20
50mA	75 49.9 = 30	50
100mA*	75 18.7 = 15	100
120mA	75 15 = 12.5	120
150mA	75 11.5 = 10	150

*Default Position

Table 5. Selecting OUT_ Channels Operating State (JMP1–JMP4)

OUT_	JUMPER	SHUNT POSITION	CHANNEL OPERATION
OUT1	JMP4	1-2*	Channel 1 operational; connect an HB LED string** between V _{OUT} and OUT1. Bleed resistor connected.
		1-3	Channel 1 not used. OUT1 current sink disabled.
		1-4	Channel 1 shorted to GND to simulate a fault.
OUT2	JMP3	1-2*	Channel 2 operational; connect an HB LED string** between V _{OUT} and OUT2. Bleed resistor connected.
		1-3	Channel 2 not used. OUT2 current sink disabled.
		1-4	Channel 2 shorted to GND to simulate a fault.
OUT3	JMP2	1-2*	Channel 3 operational; connect an HB LED string** between V _{OUT} and OUT3. Bleed resistor connected.
		1-3	Channel 3 not used. OUT3 current sink disabled.
		1-4	Channel 3 shorted to GND to simulate a fault.
OUT4	JMP1	1-2*	Channel 4 operational; connect an HB LED string** between V _{OUT} and OUT4. Bleed resistor connected.
		1-3	Channel 4 not used. OUT4 current sink disabled.
		1-4	Channel 4 shorted to GND to simulate a fault.

*Default position.

**The series-connected HB LED string must be rated to no less than 150mA.

HB LED Digital Dimming Control

The EV kit features a DIM PCB input pad for connecting an external digital PWM signal. Apply a digital PWM signal with a 0.8V logic-low level (or less) and 2.1V logic-high level (or greater). The DIM signal frequency should be at least 100Hz. If the DIM frequency is changed during operation, the MAX20069 must be powered off and on again to register the change. To adjust the HB LED brightness, vary the signal duty cycle from 0% to 100% and maintain a minimum pulse width of 500ns. Apply the digital PWM signal to the DIM PCB pad. The DIM input of the IC is pulled up internally with a 5μA (typ) current source.

For additional information on the device's dimming feature, refer to the *PWM Dimming* section in the MAX20069 IC data sheet.

Phase-Shift Operation

The EV kit demonstrates the phase-shifting feature of the IC. Phase shift is enabled by default at each device's power-up, but it can be disabled when operating in I²C mode. To disable it, uncheck **PSEN** in the **0x02 ENABLE** register group box. This operation must be always performed before enabling any LED string.

When phase shifting is enabled, each current sink's turn-on is separated by 360°/n, where n is the number of enabled strings. When phase shifting is disabled, the dimming of each string is controlled directly by the DIM input and all current sinks turn on and off at the same time.

Overvoltage Detection and Protection

The resistors (R31 and R32) connected to OVP are configured for a V_{OUT_OVP} of 29V. This sets the maximum converter output (V_{BOOST}) voltage at 29V. During an open-LED string condition, the converter output ramps up to the output overvoltage threshold. Capacitor C33 can be added to provide noise filtering to the overvoltage signal. To reconfigure the circuit for a different voltage, replace resistor R31 with a different value using the following equation: $R31 = [(V_{OUT_OVP}/1.23) - 1] \times R32$

Where R32 is 10kΩ, V_{OUT_OVP} is the overvoltage-protection threshold desired, and R31 is the new resistor value for obtaining the desired overvoltage protection. Refer to the *Open-LED Management and Overvoltage Protection (OVP)* section in the MAX20069 IC data sheet for additional information.

SDA and SCL Voltages (SDA_PU, SCL_PU)

SDA and SCL voltage supplies can be selected between the TFT input voltage and the fixed 3.3V provided by the MINIQUSB+ (see [Table 6](#)).

Power LED Enable (J1)

A green LED (DS1) is used to indicate that the EV kit is powered on. The LED can be disconnected from the power supply, allowing precise current-consumption evaluation. See [Table 7](#) for shunt positions.

Enable (EN)

The EV kit features an enable input that can be used in stand-alone mode to enable/disable the device and place it in shutdown mode. To enable the EV kit whenever power is applied to the TFT_POWER_INPUT PCB pad, open jumper J23. Jumper J23 must be kept closed to disable the device in stand-alone mode, or to operate it in I²C mode. See [Table 8](#) for J23 jumper settings.

Table 6. SDA and SCL supply (SDA_PU, SCL_PU)

SHUNT POSITION		SDA AND SCL SUPPLY
SDA_PU	SCL_PU	
Open*	Open*	3.3V (with MINIQUSB+ connected)
Closed	Closed	TFT input voltage

*Default Position

Table 7. DS1 Enable Shunt Positions (J1)

SHUNT POSITION	DS1 POWER LED
Closed*	Connected
Open	Disconnected

*Default Position

Table 8. Enable Jumper Settings (J23)

SHUNT POSITION	EN PIN	EV KIT OPERATION
Open*	Connected to TFT_POWER_INPUT	Enabled when TFT_POWER_INPUT is powered
Closed	Connected to AGND	Disabled in stand-alone mode/operative in I ² C mode

*Default Position

TFT and LED Driver Sections Switching Frequency Selection (I²C Mode Only)

In I²C mode, the EV kit's step-up (POS) and buck-boost (NEG) switching-regulator frequencies are selectable between 440kHz and 2.2MHz by checking/unchecking **SWFREQ_TFT** in the **0x01 CNFG_GEN** register group box. Similarly, the EV kit's LED driver switching frequency is selectable between 440kHz and 2.2MHz by checking/unchecking **BL_SWFREQ** in the **0x01 CNFG_GEN** register group box.

Spread spectrum can be disabled/enabled in both sections by checking/unchecking **SSOFF_TFT** and **SSOFF_BL**, respectively in the **0x01 CNFG_GEN** register group box.

Note: Switching frequency is fixed at 2.2MHz and spread spectrum is always enabled for both sections in stand-alone mode.

Fault-Indicator Output (FLTB)

The EV kit features the IC's open-drain FLTB output. In I²C mode, FLTB goes low when an open-LED or shorted-LED string is detected, during thermal warning/shutdown, during boost undervoltage/overvoltage, or during TFT-rail undervoltage events. In stand-alone mode, the FLTB signal is continuously switching at 1kHz (typ) at different duty cycles depending on the type of fault detected.

Keep jumper J9 closed to allow the DS2 red LED enabling should FLTB go low. Refer to the *Fault Protection* section in the MAX20069 IC data sheet for additional information on the FLTB signal.

Ordering Information

PART	TYPE
MAX20069EVKIT#	EV Kit

#Denotes RoHS compliant.

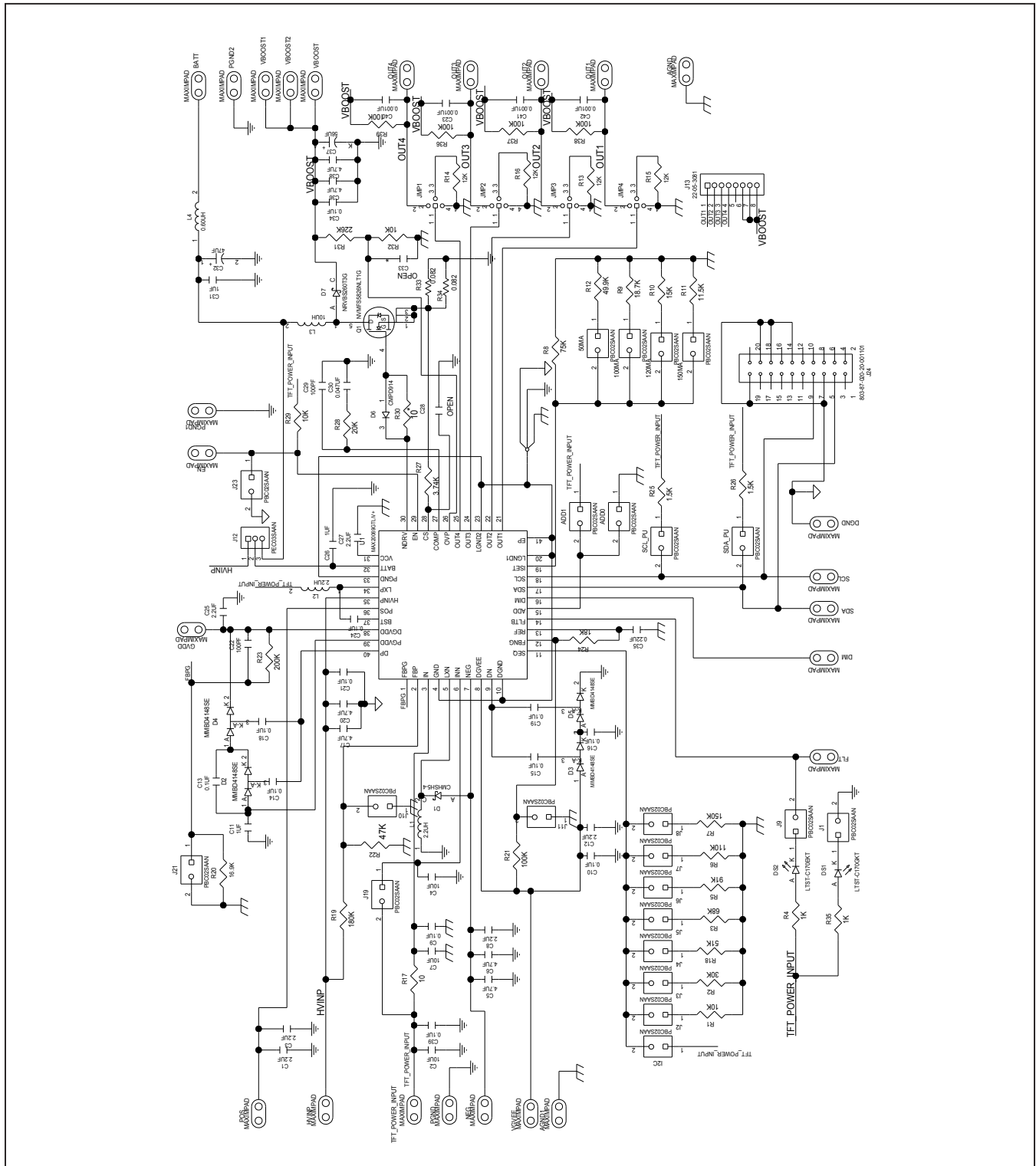
MAX20069 EV Kit Bill of Materials

REFERENCE DESIGNATOR	QTY	VALUE	DESCRIPTION	MFG PART #	MANUFACTURER
50MA, 100MA, 120MA, 150MA, ADD0, ADD1, I2C, J1-J11, J19, J21, J23, SCL_PU, SDA_PU	23	PBC02SAAN	EVKIT PART-CONNECTOR; MALE; THROUGH HOLE; BREAKAWAY; STRAIGHT; 2PINS; -65 DEGC TO +125 DEGC;	PBC02SAAN	SULLINS ELECTRONICS CORP.
AGND, AGND1, BATT, DGND, DIM, EN, FLT, GVDD, HVINP, NEG, OUT1-OUT4, PGND, PGND1, PGND2, POS, SCL, SDA, TFT_POWER_INPUT, VBOOST, VBOOST1, VBOOST2, VGVEE	25	MAXIMPAD	EVKIT PARTS: MAXIM PAD; WIRE; NATURAL; SOLID; WEICO WIRE; SOFT DRAWN BUS TYPE-S; 20AWG	9020 BUSS	WEICO WIRE
C1, C3, C8, C12, C25	5	2.2UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 2.2UF; 25V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7S	GRM188C71E225KE11	MURATA
C2, C4, C7	3	10UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 10UF; 6.3V; TOL=20%; MODEL=CL SERIES; TG=-55 DEGC TO +125 DEGC; TC=X7R	CL10B106MQ8NRN	SAMSUNG ELECTRONICS
C5, C6, C17, C20	4	4.7UF	CAPACITOR; SMT (0805); CERAMIC CHIP; 4.7UF; 25V; TOL=10%; MODEL=; TG=-55 DEGC TO +125 DEGC; TC=X7R	C2012X7R1E475K125AB	TDK
C9, C10, C15, C16, C19, C39	6	0.1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1UF; 100V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	CC0603KRX7R0BB104; GRM188R72A104KA35; GCJ188R72A104KA01	YAGEO;MURATA; MURATA
C11	1	1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 1UF; 25V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	GRM188R71E105KA12D; CGA3E1X7R1E105K; TMK107B7105KA; 06033C105KAT2A	MURATA;TDK;TAIYO YUDEN;AVX
C13, C18	2	0.1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1UF; 50V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R; AUTO	GCJ188R71H104KA12; GCM188R71H104K; CGA3E2X7R1H104K080AA	MURATA;MURATA;TDK
C14	1	0.1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1UF; 25V; TOL=10%; MODEL=C SERIES; TG=-55 DEGC TO +125 DEGC; TC=X7R	C1608X7R1E104K080AA	TDK
C21, C24	2	0.1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.1UF; 10V; TOL=10%; MODEL=C0603 SERIES; TG=-55 DEGC TO +125 DEGC; TC=X7R	C0603C104K8RAC	KEMET
C22, C29	2	100PF	CAPACITOR; SMT (0603); CERAMIC CHIP; 100PF; 50V; TOL=5%; TG=-55 DEGC TO +125 DEGC; TC=X7R	06035C101JAT	AVX
C23, C40-C42	4	0.001UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.001UF; 100V; TOL=10%; MODEL=; TG=-55 DEGC TO +125 DEGC; TC=X7R	GRM188R72A102KA01	MURATA
C26, C31	2	1UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 1UF; 50V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	UMK107AB7105KA	TAIYO YUDEN
C27	1	2.2UF	CAPACITOR; SMT (0603); CERAMIC; 2.2UF; 6.3V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R; AUTO	CGA3E1X7R0J225K080AC	TDK
C28, C33	0	OPEN	PACKAGE OUTLINE 0603 NON-POLAR CAPACITOR	DO NOT PROCURE: N/A	—
C30	1	0.047UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.047UF; 100V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	C0603C473K1RAC	KEMET
C32	1	47UF	CAPACITOR; SMT; CASE_F; ELECTROLYTIC-ALUMINUM; 47uF; 50V; 20%; SURFACE MOUNT ELECTROLYTIC CAPACITOR; -40degC to +105degC	MKA50VC47RMH10TP	UNITED CHEMI-CON
C34	1	0.1UF	CAPACITOR; SMT (0603); CERAMIC; 0.1UF; 50V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	CL10B104KB8NFN	SAMSUNG ELECTRONICS
C35	1	0.22UF	CAPACITOR; SMT (0603); CERAMIC CHIP; 0.22UF ; 10V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R	CC0603KRX7R6BB224	YAGEO
C36, C38	2	4.7UF	CAPACITOR; SMT (1206); CERAMIC CHIP; 4.7UF ; 50V; TOL=10%; TG=-55 DEGC TO +125 DEGC; TC=X7R; AUTO	CGA5L3X7R1H475K160AB	TDK
C37	1	56UF	CAPACITOR; SMT; ALUMINUM-ELECTROLYTIC; 56UF; 50V; TOL=20%; TG=-55 DEGC TO +125 DEGC; SUPER LOW ESR	50HVP56M	SUNCON
D1	1	CMHSH5-4	DIODE; SCH; SMT (SOD-123); PIV=40V; IF=0.5A; -65 DEGC TO +125 DEGC	CMHSH5-4	CENTRAL SEMICONDUCTOR CORP.
D2-D5	4	MMBD4148SE	DIODE; SS; SMT (SOT-23); PIV=100V; IF=0.2A	MMBD4148SE	FAIRCHILD SEMICONDUCTOR
D6	1	CMPD914	SMALL SIGNAL DIODE	CMPD914	CENTRAL SEMICONDUCTOR
D7	1	NRVBS260T3G	DIODE; SCH; SURFACE MOUNT SCHOTTKY POWER RECTIFIER; SMB; PIV=60V; IF=2A	NRVBS260T3G	ON SEMICONDUCTOR
DS1	1	LTST-C170GKT	DIODE; LED; STANDARD; GREEN; SMT (0805); PIV=2.1V; IF=0.01A	LTST-C170GKT	LITE-ON ELECTRONICS INC
DS2	1	LTST-C170EKT	DIODE; LED; STANDARD; RED; SMT (0805); PIV=2.0V; IF=0.02A	LTST-C170EKT	LITE-ON ELECTRONICS INC
J12	1	PEC03SAAN	EVKIT PART-CONNECTOR; MALE; THROUGH HOLE; BREAKAWAY; STRAIGHT; 3PINS; -65 DEGC TO +125 DEGC;	PEC03SAAN	SULLINS ELECTRONICS CORP.
J13	1	* 22-05-3081*	CONNECTOR; MALE; THROUGH HOLE; FRICTION LOCK HEADER; RIGHT ANGLE; 8PINS; 0 DEGC TO +75 DEGC	* 22-05-3081*	MOLEX

MAX20069 EV Kit Bill of Materials (continued)

REFERENCE DESIGNATOR	QTY	VALUE	DESCRIPTION	MFG PART #	MANUFACTURER
J24	1	803-87-020-20-001101	EVKIT PART-CONNECTOR; FEMALE; TH; DOUBLE ROW; 2.54MM; RIGHT ANGLE SOLDER TAIL; MATING PIN DIA 0.76MM; RIGHT ANGLE; 20PINS;	803-87-020-20-001101	PRECI-DIP SA
JMP1-JMP4	4	" 22-28-4043"	CONNECTOR; MALE; THROUGH HOLE; FLAT VERTICAL BREAKAWAY; STRAIGHT; 4PINS	" 22-28-4043"	MOLEX
L1, L2	2	2.2UH	INDUCTOR; SMT; FERRITE BOBBIN CORE; 2.2UH; TOL=+/-20%; 2A; -40 DEGC TO +85 DEGC	LPS4018-222MLC	COILCRAFT
L3	1	10UH	INDUCTOR; SMT; FERRITE BOBBIN CORE; 10UH; TOL=+/-20%; 4.2A; -40 DEGC TO +85 DEGC	MSS1246-103MLB	COILCRAFT
L4	1	0.60UH	INDUCTOR; SMT; CORE MATERIAL= COMPOSITE; 0.60UH; TOL=+/-20%; 11.7A	XAL4020-601ME	COILCRAFT
Q1	1	NVMFS5826NLT1G	TRAN; POWER MOSFET; SINGLE N-CHANNEL; NCH; SO-8FL; PD-(39W); I-(26A); V-(60V)	NVMFS5826NLT1G	ON SEMICONDUCTOR
R1, R29, R32	3	10K	RESISTOR; 0603; 10K OHM; 1%; 100PPM; 0.1W; THICK FILM	CRG0603F10K	TE CONNECTIVITY
R2	1	30K	RESISTOR; 0603; 30K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060330K0FK	VISHAY DALE
R3	1	68K	RESISTOR; 0603; 68K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060368K0FK	VISHAY DALE
R4, R35	2	1K	RESISTOR; 0603; 1K OHM; 1%; 100PPM; 0.10W; THICK FILM	CR0603-FX-1001ELF	BOURNS
R5	1	91K	RESISTOR; 0603; 91K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060391K0FK	VISHAY DALE
R6	1	110K	RESISTOR; 0603; 110K; 1%; 100PPM; 0.10W; THICK FILM	CRCW0603110KFK	VISHAY DALE
R7	1	150K	RESISTOR; 0603; 150K OHM; 0.1%; 25PPM; 0.1W; THIN FILM	ERA-3AEB154	PANASONIC
R8	1	75K	RESISTOR; 0603; 75K OHM; 1%; 100PPM; 0.10W; THICK FILM	ERJ-3EKF7502V	PANASONIC
R9	1	18.7K	RESISTOR; 0603; 18.7K OHM; 1%; 100PPM; 0.10W; THICK FILM	ERJ-3EKF1872V	PANASONIC
R10	1	15K	RESISTOR; 0603; 15K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060315K0FK	VISHAY DALE
R11	1	11.5K	RESISTOR; 0603; 11.5K OHM; 1%; 100PPM; 0.10W; THICK FILM	RC0603FR-0711K5L	YAGEO PHYCOMP
R12	1	49.9K	RESISTOR; 0603; 49.9K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060349K9FK;ERJ-3EKF4992V	VISHAY DALE; PANASONIC
R13-R16	4	12K	RESISTOR; 0603; 12K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060312K0FK	VISHAY DALE
R17, R30	2	10	RESISTOR; 0603; 10 OHM; 1%; 100PPM; 0.1W; THICK FILM	ERJ-3EKF10R0	PANASONIC
R18	1	51K	RESISTOR; 0603; 51K OHM; 1%; 100PPM; 0.1W; THICK FILM	ERJ-3EKF5102	PANASONIC
R19	1	180K	RESISTOR; 0603; 180K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW0603180KFK	VISHAY DALE
R20	1	16.9K	RESISTOR; 0603; 16.9K OHM; 1%; 100PPM; 0.10W; THICK FILM	ERJ-3EKF1692V;RC0603FR-0716K9	PANASONIC;YAGEO PHYCOMP
R21	1	100K	RESISTOR; 0603; 100K OHM; 1%; 100PPM; 0.1W; THICK FILM	ERJ-3EKF1003	PANASONIC
R22	1	47K	RESISTOR; 0603; 47K OHM; 1%; 100PPM; 0.25W; THICK FILM	CRCW060347K0FKEAHP	VISHAY DRALORIC
R23	1	200K	RESISTOR; 0603; 200K; 1%; 100PPM; 0.10W; THICK FILM	CRCW06032003FK	VISHAY DALE
R24	1	18K	RESISTOR; 0603; 18K OHM; 1%; 100PPM; 0.10W; THICK FILM	CRCW060318K0FK	VISHAY DALE
R25, R26	2	1.5K	RESISTOR; 0603; 1.5K; 1%; 100PPM; 0.10W; THICK FILM	CRCW06031K50FK	VISHAY DALE
R27	1	3.74K	RESISTOR; 0603; 3.74KOHMS; 1%; 100PPM; 0.1W; THICK FILM	CRCW06033K74FK	VISHAY DALE
R28	1	20K	RESISTOR; 0603; 20K OHM; 1%; 100PPM; 0.10W; THICK FILM	MCR03EZPF2002;ERJ-3EKF2002;CR0603-FX-2002ELF	ROHM;PANASONIC;BOURNS
R31	1	226K	RESISTOR; 0603; 226K OHM; 1%; 100PPM; 0.1W; THICK FILM	ERJ-3EKF2263	PANASONIC
R33, R34	2	0.082	RESISTOR; 1206; 0.082 OHM; 1%; 200PPM; 0.25W; THICK FILM	CRL1206FWR082ELF	BOURNS
R36-R39	4	100K	RESISTOR; 0603; 100K; 1%; 100PPM; 0.10W; THICK FILM	CRCW0603100KFK;RC0603FR-07100KL;RC0603FR-13100KL;ERJ-3EKF1003;AC0603FR-07100KL	VISHAY;YAGEO;YAGEO;PANASONIC;YAGEO
U1	1	MAX20069GTLV+	EVKIT PART - IC; MAX20069GTLV+; PACKAGE CODE: T4066-5C	MAX20069GTLV+	MAXIM
—	1	—	PCB:MAX20069 EVKIT	MAX20069EVKIT#	MAXIM

MAX20069 EV Kit Schematic



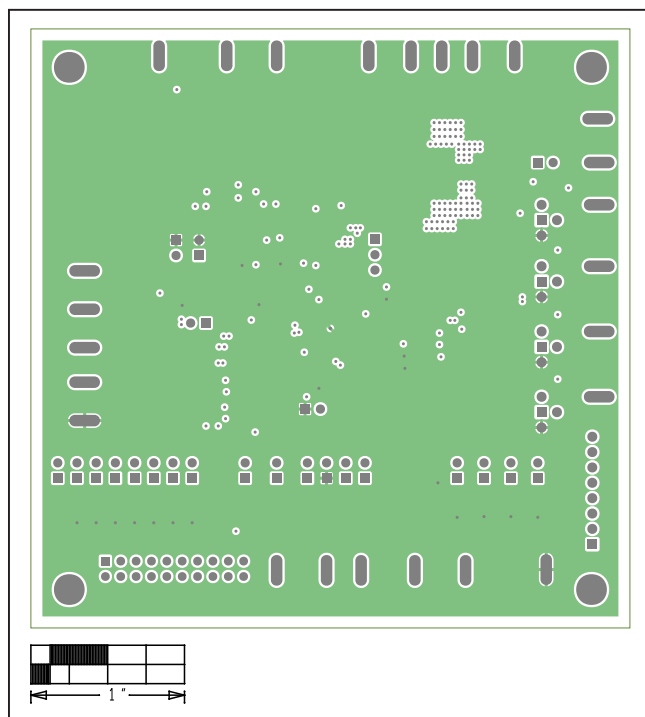
The diagram shows the MAX20069 EVKIT PCB layout. Key components and features include:

- Connectors:** MH2, MH3, MH4, MH1, EN, OUT4, OUT3, OUT2, OUT1, J23, J24, J19, J10, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25, J26, J27, J28, J29, J30, J31, J32, J33, J34, J35, J36, J37, J38, J39, J40, J41, J42, J43, J44, J45, J46, J47, J48, J49, J50, J51, J52, J53, J54, J55, J56, J57, J58, J59, J60, J61, J62, J63, J64, J65, J66, J67, J68, J69, J70, J71, J72, J73, J74, J75, J76, J77, J78, J79, J80, J81, J82, J83, J84, J85, J86, J87, J88, J89, J90, J91, J92, J93, J94, J95, J96, J97, J98, J99, J100, J101, J102, J103, J104, J105, J106, J107, J108, J109, J110, J111, J112, J113, J114, J115, J116, J117, J118, J119, J120, J121, J122, J123, J124, J125, J126, J127, J128, J129, J130, J131, J132, J133, J134, J135, J136, J137, J138, J139, J140, J141, J142, J143, J144, J145, J146, J147, J148, J149, J150, J151, J152, J153, J154, J155, J156, J157, J158, J159, J160, J161, J162, J163, J164, J165, J166, J167, J168, J169, J170, J171, J172, J173, J174, J175, J176, J177, J178, J179, J180, J181, J182, J183, J184, J185, J186, J187, J188, J189, J190, J191, J192, J193, J194, J195, J196, J197, J198, J199, J200, J201, J202, J203, J204, J205, J206, J207, J208, J209, J210, J211, J212, J213, J214, J215, J216, J217, J218, J219, J220, J221, J222, J223, J224, J225, J226, J227, J228, J229, J230, J231, J232, J233, J234, J235, J236, J237, J238, J239, J240, J241, J242, J243, J244, J245, J246, J247, J248, J249, J250, J251, J252, J253, J254, J255, J256, J257, J258, J259, J260, J261, J262, J263, J264, J265, J266, J267, J268, J269, J270, J271, J272, J273, J274, J275, J276, J277, J278, J279, J280, J281, J282, J283, J284, J285, J286, J287, J288, J289, J290, J291, J292, J293, J294, J295, J296, J297, J298, J299, J300, J301, J302, J303, J304, J305, J306, J307, J308, J309, J310, J311, J312, J313, J314, J315, J316, J317, J318, J319, J320, J321, J322, J323, J324, J325, J326, J327, J328, J329, J330, J331, J332, J333, J334, J335, J336, J337, J338, J339, J340, J341, J342, J343, J344, J345, J346, J347, J348, J349, J350, J351, J352, J353, J354, J355, J356, J357, J358, J359, J360, J361, J362, J363, J364, J365, J366, J367, J368, J369, J370, J371, J372, J373, J374, J375, J376, J377, J378, J379, J380, J381, J382, J383, J384, J385, J386, J387, J388, J389, J390, J391, J392, J393, J394, J395, J396, J397, J398, J399, J400, J401, J402, J403, J404, J405, J406, J407, J408, J409, J410, J411, J412, J413, J414, J415, J416, J417, J418, J419, J420, J421, J422, J423, J424, J425, J426, J427, J428, J429, J430, J431, J432, J433, J434, J435, J436, J437, J438, J439, J440, J441, J442, J443, J444, J445, J446, J447, J448, J449, J450, J451, J452, J453, J454, J455, J456, J457, J458, J459, J460, J461, J462, J463, J464, J465, J466, J467, J468, J469, J470, J471, J472, J473, J474, J475, J476, J477, J478, J479, J480, J481, J482, J483, J484, J485, J486, J487, J488, J489, J490, J491, J492, J493, J494, J495, J496, J497, J498, J499, J500, J501, J502, J503, J504, J505, J506, J507, J508, J509, J510, J511, J512, J513, J514, J515, J516, J517, J518, J519, J520, J521, J522, J523, J524, J525, J526, J527, J528, J529, J530, J531, J532, J533, J534, J535, J536, J537, J538, J539, J540, J541, J542, J543, J544, J545, J546, J547, J548, J549, J550, J551, J552, J553, J554, J555, J556, J557, J558, J559, J560, J561, J562, J563, J564, J565, J566, J567, J568, J569, J570, J571, J572, J573, J574, J575, J576, J577, J578, J579, J580, J581, J582, J583, J584, J585, J586, J587, J588, J589, J590, J591, J592, J593, J594, J595, J596, J597, J598, J599, J600, J601, J602, J603, J604, J605, J606, J607, J608, J609, J610, J611, J612, J613, J614, J615, J616, J617, J618, J619, J620, J621, J622, J623, J624, J625, J626, J627, J628, J629, J630, J631, J632, J633, J634, J635, J636, J637, J638, J639, J640, J641, J642, J643, J644, J645, J646, J647, J648, J649, J650, J651, J652, J653, J654, J655, J656, J657, J658, J659, J660, J661, J662, J663, J664, J665, J666, J667, J668, J669, J670, J671, J672, J673, J674, J675, J676, J677, J678, J679, J680, J681, J682, J683, J684, J685, J686, J687, J688, J689, J690, J691, J692, J693, J694, J695, J696, J697, J698, J699, J700, J701, J702, J703, J704, J705, J706, J707, J708, J709, J710, J711, J712, J713, J714, J715, J716, J717, J718, J719, J720, J721, J722, J723, J724, J725, J726, J727, J728, J729, J730, J731, J732, J733, J734, J735, J736, J737, J738, J739, J740, J741, J742, J743, J744, J745, J746, J747, J748, J749, J750, J751, J752, J753, J754, J755, J756, J757, J758, J759, J760, J761, J762, J763, J764, J765, J766, J767, J768, J769, J770, J771, J772, J773, J774, J775, J776, J777, J778, J779, J780, J781, J782, J783, J784, J785, J786, J787, J788, J789, J790, J791, J792, J793, J794, J795, J796, J797, J798, J799, J800, J801, J802, J803, J804, J805, J806, J807, J808, J809, J810, J811, J812, J813, J814, J815, J816, J817, J818, J819, J820, J821, J822, J823, J824, J825, J826, J827,

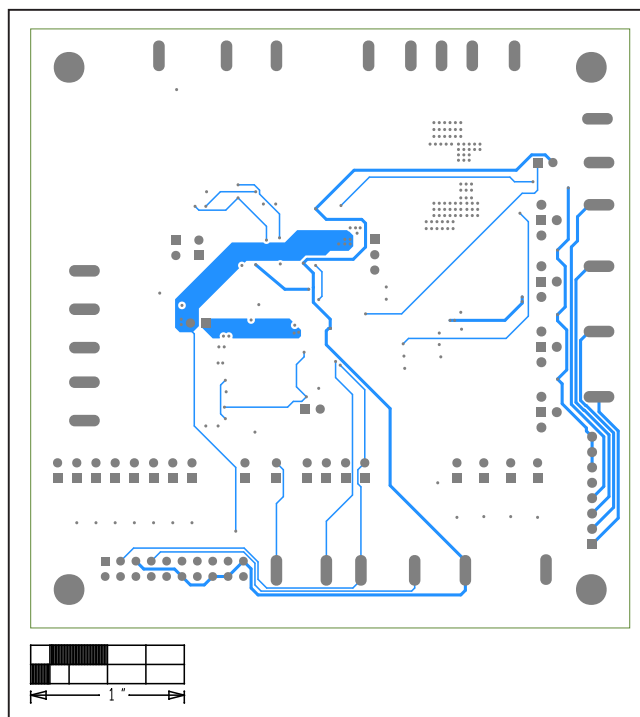
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MAX20069 EV Kit PCB Layout Diagrams (continued)



MAX20069 EV Kit PCB Layout—Internal Layer 3



MAX20069 EV Kit PCB Layout—Bottom Layer

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	8/18	Initial release	—
1	7/20	Added MAX20069B, updated GUI figure in <i>Quick Start</i> section	1–14

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