MAX20056B Evaluation Kit

Evaluates: MAX20056B

General Description

The MAX20056B evaluation kit (EV kit) demonstrates the MAX20056B, an integrated, 6-channel high-brightness LED driver with very wide PWM dimming ratio and phase shifting for automotive displays.

The EV kit operates from a DC supply voltage from 4.5V to 36V and the switching frequency is set at 400kHz. Spread-spectrum mode (SSM) is enabled for EMI improvement. The EV kit demonstrates direct dim and phase-shifted pulse-width modulation (PWM) dimming. The EV kit also demonstrates short-LED, open-LED, and overtemperature-fault protection.

For operation at switching frequencies other than 400kHz, the external components should be chosen according to the calculations in the MAX20056B IC data sheet.

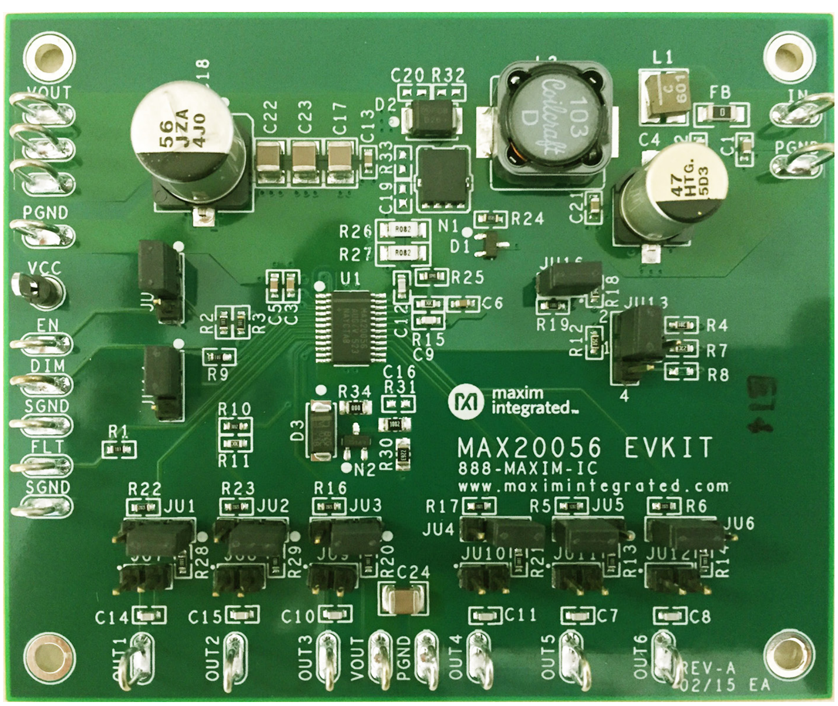
Note: *The MAX20056B EV kit is identical to the MAX20056 EV kit, except for the U1 component. The photos and figures indicate MAX20056, but there are no differences between this version and the standard version.*

Features

- Input Voltage: 4.5V to 36V (Up to 50V Load Dump)
- Drives Six Strings of HB LEDs
- LED Current: 20mA to 120mA
- Demonstrates Both Phase-Shifted and Direct PWM Dimming
- Demonstrates Undervoltage Lockout and Output Short Protection
- Demonstrates Cycle-by-Cycle Current Limit and Thermal-Shutdown Feature
- Demonstrates 5V, 30mA LDO Output Capability
- Proven PCB and Thermal Design
- Fully Assembled and Tested

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

MAX20056B EV Kit Photo



319-100310; Rev 0; 2/19

Quick Start

Required Equipment

- MAX20056B EV kit
- 5V to 36V, 4A DC power supply
- Two digital voltmeters (DVMs)
- Six series-connected HB LED strings rated to no less than 120mA
- Current probe to measure the HB LED current

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.**

1) Verify that a shunt is installed across pins 1-2 on jumper JU15 (device enabled).
2) Verify that a shunt is installed across pins 1-2 on jumper JU16 (400kHz switching frequency).
3) Verify that a shunt is installed across pins 1-4 on jumper JU13 (80mA LED current per string).
4) Verify that a shunt is installed across pins 1-2 on jumper JU14 (phase-shift operation enabled).
5) Verify that a shunt is installed across pins 1-2 on jumpers JU1–JU6 (bleed resistors connected, all current sinks enabled).
6) Verify that jumpers JU7–JU12 are open (LED strings not shorted).
7) Connect the power supply to the IN PCB pad and the power-supply ground to the PGND PCB pad.
8) Connect a DVM across the OUT1 and PGND PCB pads.
9) Connect each HB LED string as follows:
   - Channel 1: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT1 PCB pad
   - Channel 2: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT2 PCB pad
   - Channel 3: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT3 PCB pad
   - Channel 4: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT4 PCB pad
   - Channel 5: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT5 PCB pad
   - Channel 6: Connect HB LED string anode to the VOUT PCB pad and cathode to the OUT6 PCB pad
10) Clip the current probe across the channel 1 HB LED+ wire to measure the HB LED current.
11) Turn on the power supply and set to 12V.
12) Measure the voltage from each of the OUT_ PCB pads to PGND and verify the lowest voltage is approximately 1.1V.
13) Measure the HB LED current using the current probe and verify all channels.

Detailed Description of Hardware

The MAX20056B EV kit demonstrates the MAX20056B HB LED driver with an integrated step-up DC-DC preregulator followed by six linear current sinks for driving up to six strings of LEDs. The preregulator switches at 400kHz and operates as a current-mode-controlled regulator, providing up to 720mA for the linear circuit as well as overvoltage protection. The cycle-by-cycle current limit is set by resistors R26 and R27, while resistors R30 and R31 set the OVP voltage to 29V. The preregulator power section consists of inductor L2, MOSFET N1, power-sense resistors R26 and R27, and switching diode D2. The EV kit circuit operates from a 4.5V DC supply voltage up to the HB LED forward string voltage. The circuit handles load-dump conditions up to 50V.

The EV kit circuit demonstrates ultra-low shutdown current when the EN pin of the device is pulled to ground by shorting the EN PCB pad to ground. Each of the six linear current sinks (OUT1–OUT6) is capable of operating up to 48V, sinking up to 120mA per channel. Each of the six channel's linear current sinks is configurable for 120mA, 100mA, 80mA, or 20mA, or can be disabled independently. Jumpers JU1–JU6 provide the disable feature when the HB LED string is not connected. See the *Channel 1–Channel 6 Current-Sink Disabling* section. Resistors R4, R7, R8, R12, and jumper JU13 configure the linear current setting for the device'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 VOUT PCB pads provide connections for connecting each HB LED string's anode to the DC-DC preregulator output. The OUT1–OUT6 PCB pads provide connections for connecting each HB LED string's cathode to the respective linear channel's current sink. Additionally, 2-pin headers (JU7–JU12) provide convenient access to the VOUT and respective OUT_ connections when using a twisted-pair wiring connection scheme. On each header, pin 1 provides access to the respective OUT_ connection and pin 2 provides access to the VOUT connection. Capacitors C7, C8, C10, C11, C14, and C15 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. The EV kit features both phase-shifted PWM dimming and direct PWM dimming, configurable by jumper JU14. Test points are also provided for easy access to the device's V_{CC}.

Enable (EN)

The EV kit features an enable input that can be used to enable/disable the device and place it in shutdown mode. To enable the EV kit whenever power is applied to IN, place the jumper across pins 1-2 on jumper JU15. To enable the EV kit from an external enable signal, place the jumper across pins 2-3 on JU15. In this configuration, apply a logic signal on the EN PCB input pad on the EV kit. A 1MΩ pulldown resistor on the EV kit pulls the EN input to ground in the event that JU15 is left open or the EN signal is high impedance. Refer to the *Enable (EN)* section in the MAX20056B IC data sheet for additional information. See Table 1 for JU15 jumper settings.

HB LED Current

The EV kit features jumper JU13 to reconfigure the device's current sinks on all six channels. Place a shunt on JU13 to configure the current-sink limits according to Table 2. To reconfigure the circuit for another current-sink threshold, replace resistor R12 and use the following equation to calculate a new value for the desired current:

$$R12 = \frac{1500}{I_{LED}}$$

where I_{LED} is the desired HB LED current in amps and R12 is the new resistor value for obtaining the desired HB LED current. Remove JU13 when configuring for another current-sink threshold. 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 MAX20056B IC data sheet to calculate other component values.

Channel 1–Channel 6 Current-Sink Disabling

The EV kit features jumpers JU1–JU6 to disable each channel's OUT_ current sink. To disable a channel, install a jumper in the channel's respective OUT_ jumper across pins 2-3, connecting the OUT_ to ground through a 12kΩ resistor. Remove the shunt or connect the shunt across pins 1-2 of the jumper to use the channel's OUT_ sink capability. The dimming algorithm inside the IC requires that higher numbered OUT_ current sinks be disabled first. For example, if only four strings are needed, OUT1–OUT4 should be used, with OUT5 and OUT6 disabled. See Table 3 for JU1–JU6 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. Refer to the *V_{OUT} to OUT_ Bleed Resistors* section in the MAX20056B IC data sheet for more information.

Table 1. Enable (JU15)

SHUNT POSITION	EN PIN	EV KIT OPERATION
1-2	Connected to IN	Enabled when IN is powered
2-3	Connected to EN PCB pad	Enabled by signal on EN PCB pad

Table 2. HB LED Current (JU13)

SHUNT POSITION	ISET RESISTOR SETTING (kΩ)	HB LED CURRENT-SINK SETTING (mA)
Open	75	20
1-4	75 || 25 = 18.75	80
1-3	75 || 18.7 = 15	100
1-2	75 || 15 = 12.5	120

Table 3. Disabling Channel 1–Channel 6 (JU1–JU6)

OUT_	JUMPER	SHUNT POSITION	CHANNEL OPERATION
OUT1	JU1	1-2	Channel 1 operational; connect an HB LED string* between VOUT and OUT1. Bleed resistor connected.
		2-3	Channel 1 not used. OUT1 current sink disabled.
		Open	Channel 1 operational; connect an HB LED string* between VOUT and OUT1. Bleed resistor not connected.
OUT2	JU2	1-2	Channel 2 operational, connect an HB LED string* between VOUT and OUT2. Bleed resistor connected.
		2-3	Channel 2 not used. OUT2 current sink disabled.
		Open	Channel 2 operational; connect an HB LED string* between VOUT and OUT2. Bleed resistor not connected.
OUT3	JU3	1-2	Channel 3 operational; connect an HB LED string* between VOUT and OUT3. Bleed resistor connected.
		2-3	Channel 3 not used. OUT3 current sink disabled.
		Open	Channel 3 operational; connect an HB LED string* between VOUT and OUT3. Bleed resistor not connected.
OUT4	JU4	1-2	Channel 4 operational; connect an HB LED string* between VOUT and OUT4. Bleed resistor connected.
		2-3	Channel 4 not used. OUT4 current sink disabled.
		Open	Channel 4 operational; connect an HB LED string* between VOUT and OUT4. Bleed resistor not connected.
OUT5	JU5	1-2	Channel 5 operational; connect an HB LED string* between VOUT and OUT5. Bleed resistor connected.
		2-3	Channel 5 not used. OUT5 current sink disabled.
		Open	Channel 5 operational; connect an HB LED string* between VOUT and OUT5. Bleed resistor not connected.
OUT6	JU6	1-2	Channel 6 operational; connect an HB LED string* between VOUT and OUT6. Bleed resistor connected.
		2-3	Channel 6 not used. OUT6 current sink disabled.
		Open	Channel 6 operational; connect an HB LED string* between VOUT and OUT6. Bleed resistor not connected.

**The series-connected HB LED string must be rated to no less than 120mA.*

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. 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 MAX20056B IC data sheet.

Phase-Shift Operation

The EV kit demonstrates the phase-shifting feature of the IC. Install a shunt across pins 1-2 on jumper JU14 to enable phase shifting of the LED strings. Install a shunt across pins 2-3 on JU14 to enable direct dimming of the LED strings (see Table 4). When phase shifting is enabled, each current sink's turn-on is separated by 360º/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. The PSEN input should not be left unconnected. Refer to the *Phase Shifting* section in the MAX20056B IC data sheet for more information.

Switching Frequency

The EV kit is optimized for 400kHz switching operation by default. Install jumper JU16 so the total RT resistance is approximately 20kΩ. If another switching frequency is desired, the relevant external components should be replaced according to the calculations in the MAX20056B IC data sheet. Refer to the *Oscillator Frequency* section in the MAX20056B IC data sheet for more information.

Fault-Indicator Output ($\overline{FLT}$)

The EV kit features the device's $\overline{FLT}$ output. The $\overline{FLT}$ signal is pulled up to V_{CC} by resistor R1. An open-drain fault-flag output ($\overline{FLT}$) goes low when an open-LED or shorted-LED string is detected, or during thermal shutdown. Refer to the *Fault Protections* section in the MAX20056B IC data sheet for additional information on the $\overline{FLT}$ signal.

Table 4. Phase-Shift Enable (JU14)

SHUNT POSITION	PSEN PIN	EV KIT OPERATION
1-2	Connected to VCC	Phase-shift operation enabled
2-3	Connected to SGND	Direct dimming operation enabled

Shorted-LED Detection and Protection

The short-LED threshold is programmed through the RSDT input. R10 and R11 form a resistor-divider from V_{CC} to RSDT to SGND. A shorted LED is detected when the following condition is satisfied:

$$V_{OUT} > 4 \times V_{RSDT}$$

When the short-LED threshold is reached, that current sink is disabled to reduce excess power dissipation and the $\overline{FLT}$ indicator asserts low.

Overvoltage Detection and Protection

The device's OVP resistors (R30 and R31) are configured for a V_{OUT_OVP} of 29V. This sets the maximum converter output (V_{OUT}) voltage at 29V. During an open-LED string condition, the converter output ramps up to the output overvoltage threshold. Capacitor C16 provides noise filtering to the OVP signal. To reconfigure the circuit for a different OVP voltage, replace resistor R30 with a different value using the following equation:

$$R30 = \left(\frac{V_{OUT\_OVP}}{1.23V} - 1\right) \times R31$$

Where R31 is 10kΩ, V_{OUT_OVP} is the overvoltage-protection threshold desired, and R30 is the new resistor value for obtaining the desired overvoltage protection. MOSFET N2 is an optional OVP resistor-divider disconnect switch for ultra-low shutdown current. Refer to the *Open-LED Management and Overvoltage Protection* section in the MAX20056B IC data sheet for additional information.

Ordering Information

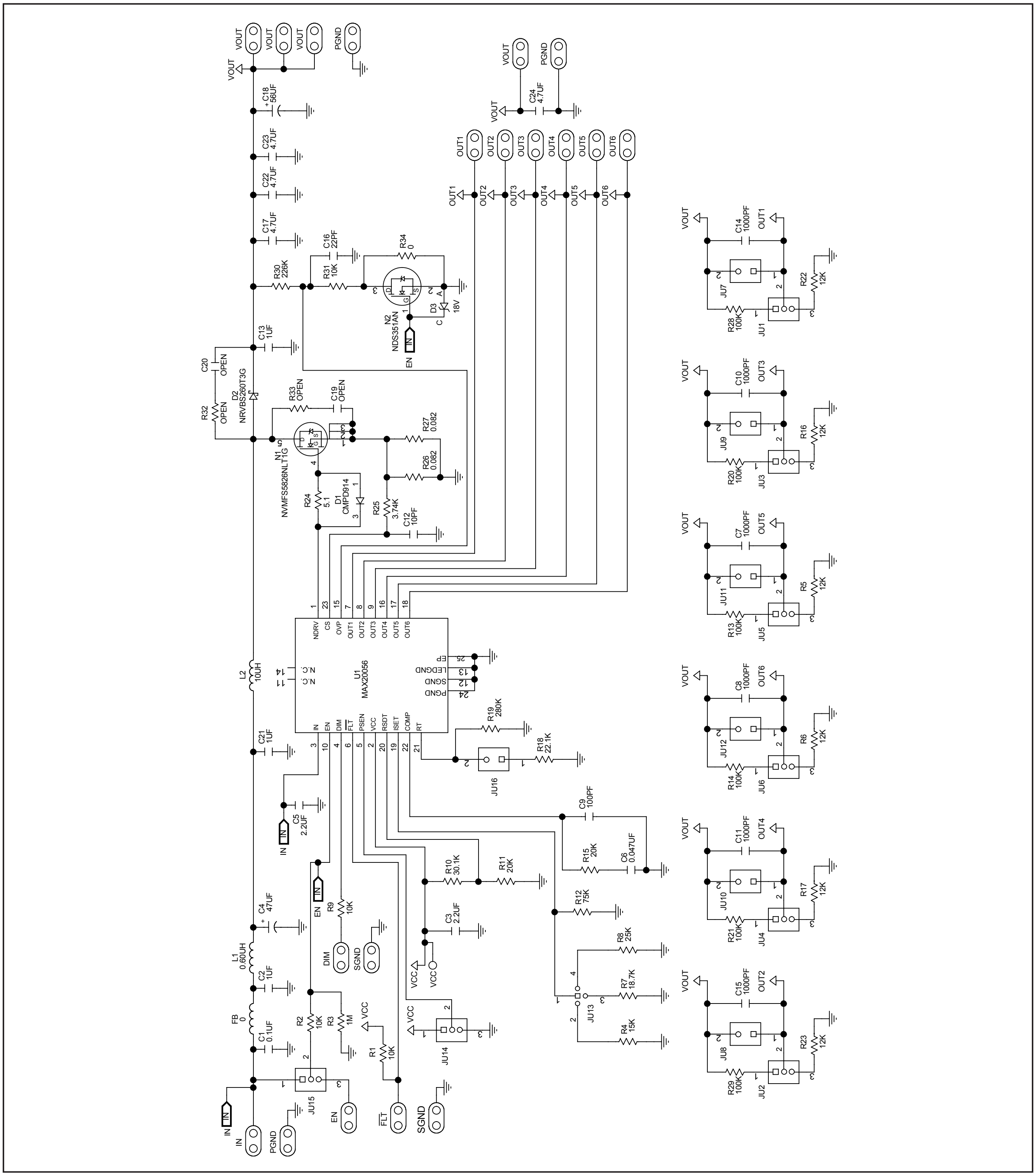
PART	TYPE
MAX20056BEVKIT#	EV kit

#Denotes RoHS compliant.

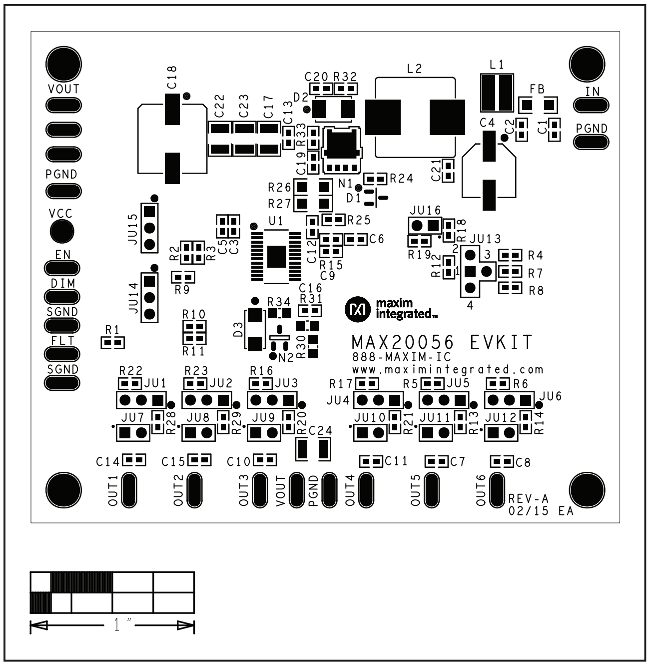
MAX20056B EV Kit Bill of Materials

QTY	REF_DES	VALUE	MFG PART #	MANUFACTURER
1	C1	0.1UF	ECJ-1VB1H104K;GRM188R71H104KA93;CGJ3E2X7R1H104K080AA; C1608X7R1H104K080AA;CL10B104KB8NNN	PANASONIC;MURATA;TDK;TDK; SAMSUNG ELECTRO-MECHANICS
3	C2, C13, C21	1UF	UMK107AB7105KA;CC0603KRX7R9BB105	TAIYO YUDEN;YAGEO
1	C3	2.2UF	GRM188R71A225KE15;CL10B225KP8NNN; C1608X7R1A225K080AC	MURATA;SAMSUNG;TDK
1	C4	47UF	EEE-TG1H470UP	PANASONIC
1	C5	2.2UF	C0603C225K5RAC	KEMET
1	C6	0.047UF	C0603C473K5RAC;GRM188R71H473KA61; GCM188R71H473KA55;CGA3E2X7R1H473K080AA	KEMET;MURATA;MURATA;TDK
6	C7, C8, C10, C11, C14, C15	1000PF	GRM1885C1H102JA01;C1608C0G1H102J080AA; GCM1885C1H102JA16	MURATA;TDK;MURATA
1	C9	100PF	C0603H101J5GAC	KEMET
1	C12	10PF	ECJ-1VC1H100D	PANASONIC
0	C16	22PF	GRM39C0G220J50V; GRM1885C1H220J; C1608C0G1H220J080AA	MURATA;MURATA;TDK
4	C17, C22-C24	4.7UF	C1210C475K5RAC;GRM32ER71H475KA88;GRM32ER71H475KA88; GCM32ER71H475KA55;CGA6P3X7R1H475K250AB	KEMET;MURATA;MURATA; MURATA;TDK
1	C18	56UF	50HVP56M	SUNCON
0	C19, C20	OPEN	N/A	N/A
1	D1	CMPD914	CMPD914	CENTRAL SEMICONDUCTOR
1	D2	NRVBS260T3G	NRVBS260T3G	ON SEMICONDUCTOR
1	D3	18V	BZG03C18	VISHAY SEMICONDUCTORS
19	DIM, EN, FLT, IN, OUT1-OUT6, PGND, PGND_PAD1, PGND_PAD2, SGND, SGND_PAD1, VOUT, VOUT_PAD1-VOUT_PAD3	MAXIMPAD	9020 BUSS	WEICO WIRE
1	FB	0	RC3216J000CS	SAMSUNG ELECTRONICS
1	JU13	JUMPER_3WAY	ANY	ANY
8	JU1-JU6, JU14, JU15	PEC03SAAN	PEC03SAAN	SULLINS
7	JU7-JU12, JU16	PEC02SAAN	PEC02SAAN	SULLINS
1	L1	0.60UH	XAL4020-601ME	COILCRAFT
1	L2	10UH	MSS1246T-103ML	COILCRAFT
1	N1	NVMFS5826NLT1G	NVMFS5826NLT1G	ON SEMICONDUCTOR
1	N2	NDS351AN	NDS351AN	FAIRCHILD SEMICONDUCTOR
1	PCB	PCB	MAX20056	MAXIM
3	R1, R2, R9	10K	301-10K-RC	XICON
1	R3	1M	CRCW06031M00JN	VISHAY DALE
1	R10	30.1K	CRCW06033012FK	VISHAY DALE
1	R11	20K	CRCW060320K0JN	VISHAY DALE
1	R12	75K	ERJ-3EKF7502	PANASONIC
6	R13, R14, R20, R21, R28, R29	100K	CRCW0603100KFK;RC0603FR-07100KL;RC0603FR-13100KL; ERJ-3EKF1003;AC0603FR-07100KL	VISHAY DALE;YAGEO;YAGEO; PANASONIC
1	R15	20K	MCR03EZPFX2002;ERJ-3EKF2002;CR0603-FX-2002ELF; CRCW060320K0FK	ROHM;PANASONIC;BOURNS; VISHAY DALE
1	R18	22.1K	CRCW060322K1FK	VISHAY DALE
1	R19	280K	CRCW0603280KFK	VISHAY DALE
1	R24	5.1	CRCW06035R10FN	VISHAY DALE
1	R25	3.74K	CRCW06033K74FK	VISHAY DALE
2	R26, R27	0.082	TL2BR082F; 1-1625826-2	TE CONNECTIVITY; TE CONNECTIVITY
1	R30	226K	CRCW0805226KFK	VISHAY DALE
1	R31	10K	CRCW080510K0FK;MCR10EZHF1002;ERJ-6ENF1002; RC0805FR-0710KL	CRCW080510K0FK; MCR10EZHF1002; ERJ-
0	R32, R33	OPEN	N/A	N/A
1	R34	0	RC0805JR-070RL	YAGEO PHYCOMP
1	R4	15K	CRCW060315K0FK	VISHAY DALE
6	R5, R6, R16, R17, R22, R23	12K	CRCW060312K0FK	VISHAY DALE
1	R7	18.7K	ERJ-3EKF1872;CRCW060318K7FK	PANASONIC;VISHAY
1	R8	25K	PNM0603E2502BS	VISHAY DALE
4	SU1-SU4	STC02SYAN	STC02SYAN	SULLINS ELECTRONICS CORP.
1	U1	MAX20056BAUGA/V+	MAX20056BAUGA/V+	MAXIM
1	VCC	N/A	5011	KEYSTONE

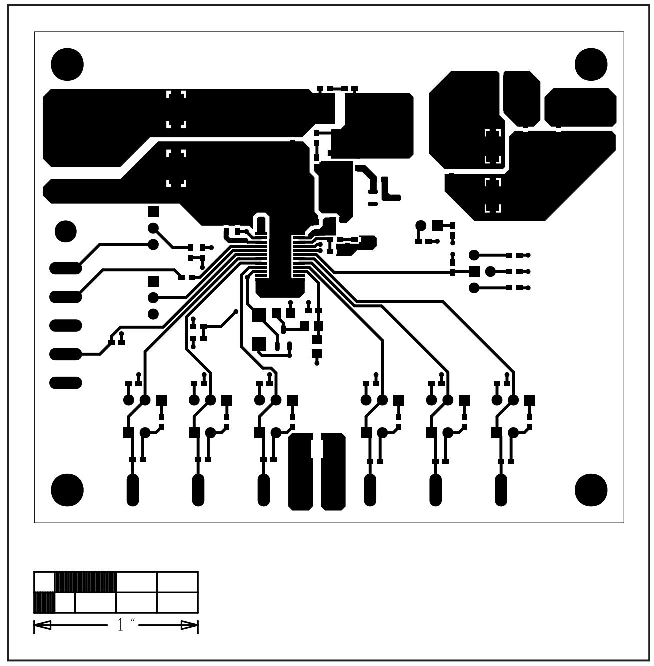
MAX20056B EV Kit Schematic



MAX20056B EV Kit PCB layout diagrams



Silk_Top



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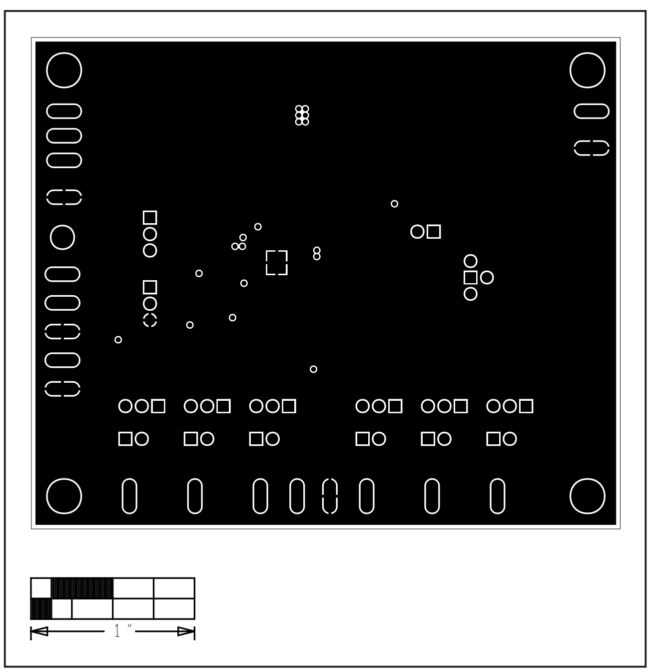
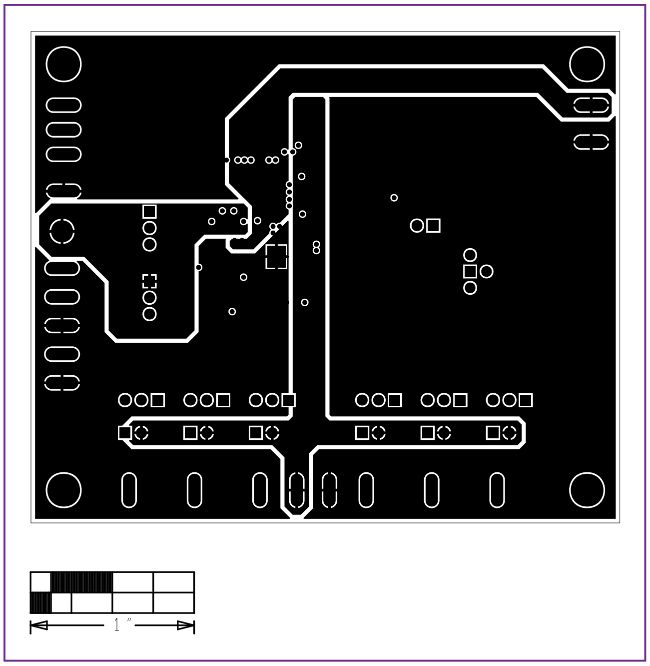
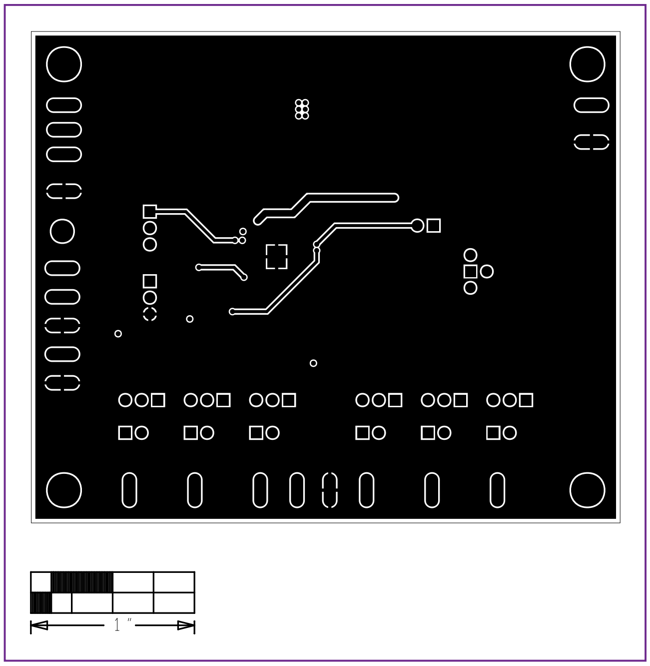


Internal2

MAX20056B EV Kit PCB layout diagrams (continued)



Internal3



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Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/19	Initial release	—

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