

**ABSTRACT**

The [LM38020QEVN](#) is a 80-V DC/DC buck regulator that employs synchronous rectification to achieve high conversion efficiency in a small footprint. The EVM operates over a wide input voltage range of 6 V to 80 V to provide a regulated 5-V output at 400-kHz switching frequency. The output voltage has better than 1.5% setpoint accuracy and is adjustable using an external resistor divider. The module design uses the LMR38020S-Q1 synchronous buck converter with the following:

- Wide input voltage (wide  $V_{IN}$ ) range
- Wide duty-cycle range
- Integrated high-side and low-side power MOSFETs
- Cycle-by-cycle overcurrent protection
- Spread spectrum

The LMR38020S-Q1 converter is available in an 8-pin SO PowerPAD™ package to enable high-density, low-component count DC/DC solutions. The LMR38020QEVN evaluation module is qualified for the LMR38020-Q1 as well as the LMR38020 buck converter. See [Table 1-1](#) for package information.

**Table 1-1. Device and Package Configurations**

CONVERTER	IC	PACKAGE
U1	LMR38020-Q1	8-pin SO package with PowerPAD (4.89 mm × 3.90 mm)
	LMR38020	

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# 1 General TI High Voltage Evaluation User Safety Guidelines



Always follow TI's setup and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure the user's personal safety and the safety of those working around the user. Contact TI's Product Information Center [TI's Product Information Center](#) for further information.

**Save all warnings and instructions for future reference.**

**Failure to follow warnings and instructions can result in personal injury, property damage, or death due to electrical shock, burn hazards, or both.**

The term TI HV EVM refers to an electronic device typically provided as an open-framed, unenclosed printed-circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users that have training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use, application, or both, are strictly prohibited by Texas Instruments. If the user is not suitably qualified, the user should immediately stop from further use of the HV EVM.

- **Work Area Safety:**

- Maintain a clean and orderly work area.
- Qualified observer or observers must be present any time circuits are energized.
- Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
- All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50- $V_{RMS}$ /75-VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
- Use a stable and non-conductive work surface.
- Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

- **Electrical Safety:**

As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.

- De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
- With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- When EVM readiness is complete, energize the EVM as intended.

**WARNING**

**WARNING: While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.**

- **Personal Safety:**
  - Wear personal protective equipment, for example, latex gloves, safety glasses with side shields, or both, or protect the EVM in an adequate lucent plastic box with interlocks from accidental touch.
- **Limitation for Safe Use:**
  - EVMs are not to be used as all or part of a production unit.

### Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training, and is designed to operate from an AC power supply or a high-voltage DC supply. Please read this user's guide and the safety-related documents that come with the EVM package before operating this EVM.

#### CAUTION



Do not leave the EVM powered when unattended.

#### WARNING



Hot surface! Contact may cause burns. Do not touch!

#### WARNING



High Voltage! Electric shock is possible when connecting board to live wire. Board should be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

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## 2 LMR38020-Q1 Evaluation Module

The LMR38020QEVM is configured to deliver 5 V and 2 A at a switching frequency of 400 kHz.

- Tightly regulated output voltage of 5 V with 1.5% setpoint accuracy
- Wide input voltage operating range of 4.2 V to 80 V
- 98% maximum duty cycle
- PFM operation to improve efficiency at light load
- Spread spectrum option for reduced EMI
- PWRGD signal indicates output regulation
- Supports start-up with pre-biased output
- Programmable system UVLO through precision enable
- Fully assembled, tested, and proven PCB layout

### 2.1 Quick Start Procedure

1. Connect the voltage supply between VIN and GND connectors using short wires.
2. Connect the load of the converter between VOUT and GND connectors using short wires.
3. Set the supply voltage ( $V_{IN}$ ) at an appropriate level between 6 V to 80 V. Set the current limit of the supply to an appropriate level as well.
4. Turn on the power supply. The EVM powers up and provides  $V_{OUT} = 5$  V.
5. Monitor the output voltage while increasing the load current to 2-A maximum.

See [Figure 2-1](#) for the location of the connectors.

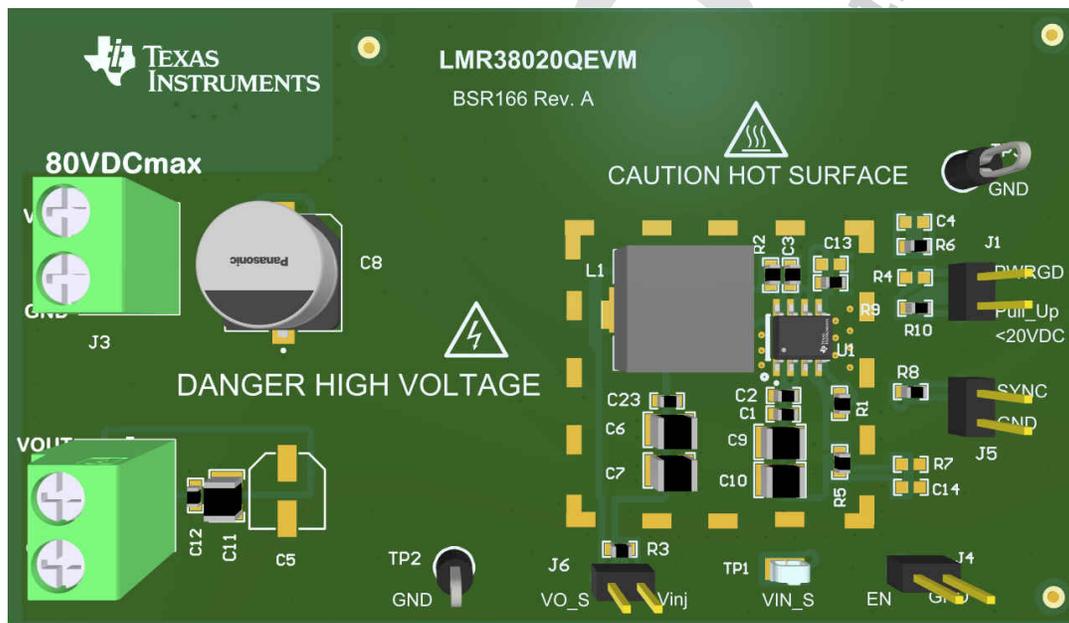


Figure 2-1. LMR38020QEVM Top View



## 2.2 Detailed Descriptions

This section describes the connectors and the test points on the EVM and how to properly connect, set up, and use the LMR38020QEVM. See [Figure 2-1](#) for a top view of the EVM.

### **VOUT (J2)** Output voltage of the converter

VOUT connector and test point connected to the power inductor and the output capacitors. Connect the loading device between VOUT and GND connectors to provide loading to the regulator. Connect the loading device to the board with short wires to handle the DC output current.

### **GND** Ground of the converter

It is connected to the LMR38020-Q1 GND as well as the return terminals of the input and output capacitors. GND is the current return path for both supply voltage and load. Connect to supply and load grounds with short wires.

### **VIN (J3)** Input voltage to the converter

VIN connector and test point connects to the input capacitors and the VIN pin of the LMR38020-Q1. Connect the supply voltage from a power supply or a battery between the VIN and GND connectors. The voltage range should be higher than 4.2 V for the device to be active.  $V_{VIN}$  higher than 6 V provides a regulated 5-V output voltage. To avoid damaging the device,  $V_{VIN}$  should be no greater than 80 V. The current limit on the supply should be high enough to provide the needed supply current when the output is fully loaded. The supply voltage should be connected to the board with short wires.

### **VIN\_EMI** Input voltage to input filter of the converter

If an input filter is desired between the supply voltage and the LMR38020-Q1, connect the supply voltage between VIN\_EMI and GND on the bottom layer. The supply voltage should be connected to the board with short wires.

The EMI filter components were not assembled on this evaluation board.

### **EMI GND** Ground connection near the input EMI filter

This is the current return path for the supply connected to VIN\_EMI. It provides a direct connection to the input filter capacitors to filter conducted noise generated by the converter. Use VIN\_EMI and GND connections at the input filter to minimize EMI.

### **SYNC (J5)** SYNC clock injection

J5 is used to synchronize the switching frequency to external clock. Refer to the [LMR38020-Q1 SIMPLE SWITCHER® 4.2-V to 80-V, 2-A Synchronous Buck Converter Data Sheet](#) for detail application information.

Do *not* short J5 SYNC pin to ground.

### **EN (J4)** Set EN pin options

Use this jumper to enable/disable the LMR38020-Q1. PIN-1 is connected to GND and PIN-2 is connected to EN.

1. Connect PIN-1 to PIN-2 to disable the device.
2. Leave PIN-1 and PIN-2 open for EN to be connected to VIN through a resistor divider.

The system UVLO voltage can be programmed by resistor divider on EN pin. The lower UVLO resistor,  $R_7$ , was not assembled on this board, so the EN/UVLO voltage pulls up to the input voltage.

Calculate the lower UVLO resistor,  $R_7$ , based on the desired turn-on voltage and the upper UVLO resistor,  $R_5$ , of 115 K $\Omega$ . Refer to the External UVLO section of the [LMR38020-Q1 SIMPLE SWITCHER® 4.2-V to 80-V, 2-A Synchronous Buck Converter Data Sheet](#) for more detailed application information.

### **PWRGD (J1)** Power-good indication

PWRGD jumper with PIN-1 connected to PGOOD and PIN-2 connected to the pullup voltage. PIN-1 can be used as a test point to monitor the power-good indicator. This flag indicates whether the output voltage has reached its regulation level. The LMR38020-Q1 PGOOD is an open-drain output that is tied to voltage below 20 V through pullup resistor R<sub>10</sub>.

**Header  
(J6)**

Measure  $V_{OUT}$  and loop response

J6 PIN-2 (VO\_S) is connected to the output for output voltage sensing and efficiency measurement. PIN-1 (V<sub>INJ</sub>) is connected to the noise injection resistor R3. The loop response can be measured on J6.

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### 3 Schematic

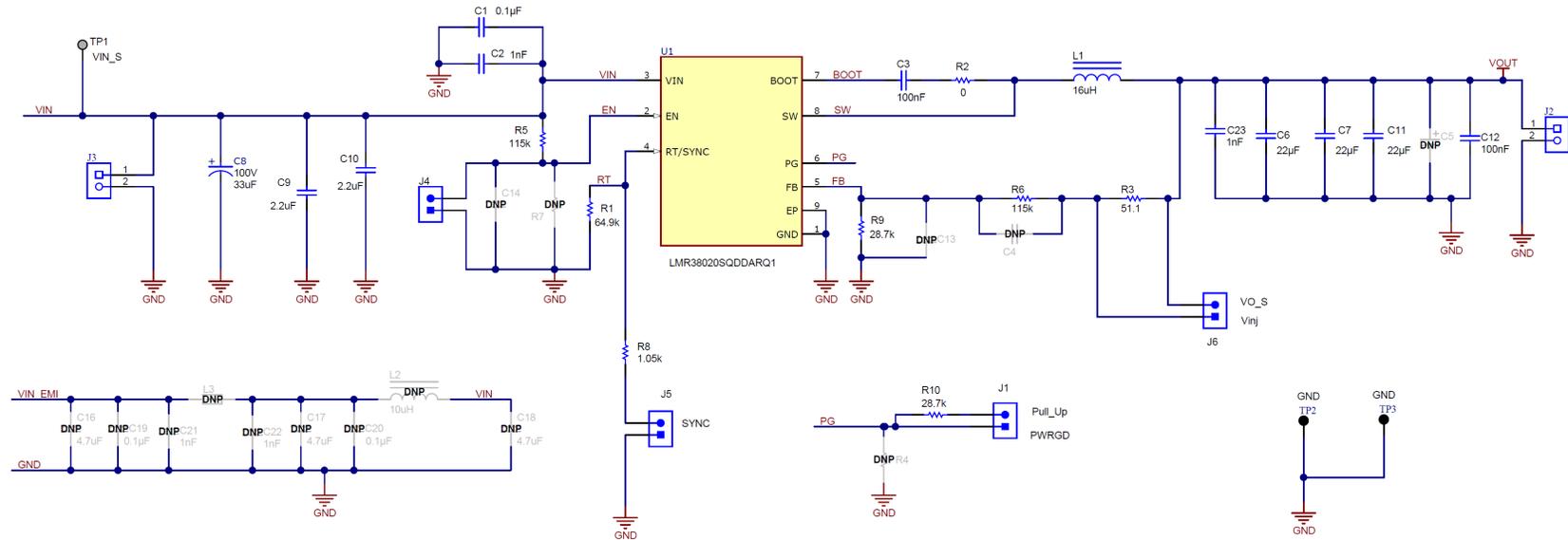


Figure 3-1. LMR38020QEVM Schematic

## 4 PCB Layout

Figure 4-1 through Figure 4-4 show the board layout for the LMR38020QEV. The EVM offers resistors, capacitors, and test points to configure the output voltage, precision enable, and switching frequency.

The 8-pin SO PowerPAD™ package offers an exposed thermal pad, which must be soldered to the copper landing on the PCB for optimal thermal performance. The PCB consists of a 4-layer design. There are 2-oz copper planes on the top and bottom and 1-oz copper mid-layer planes to dissipate heat with an array of thermal vias under the thermal pad to connect to all four layers.

Test points have been provided for ease of use to connect the power supply, required load, and to monitor critical signals.

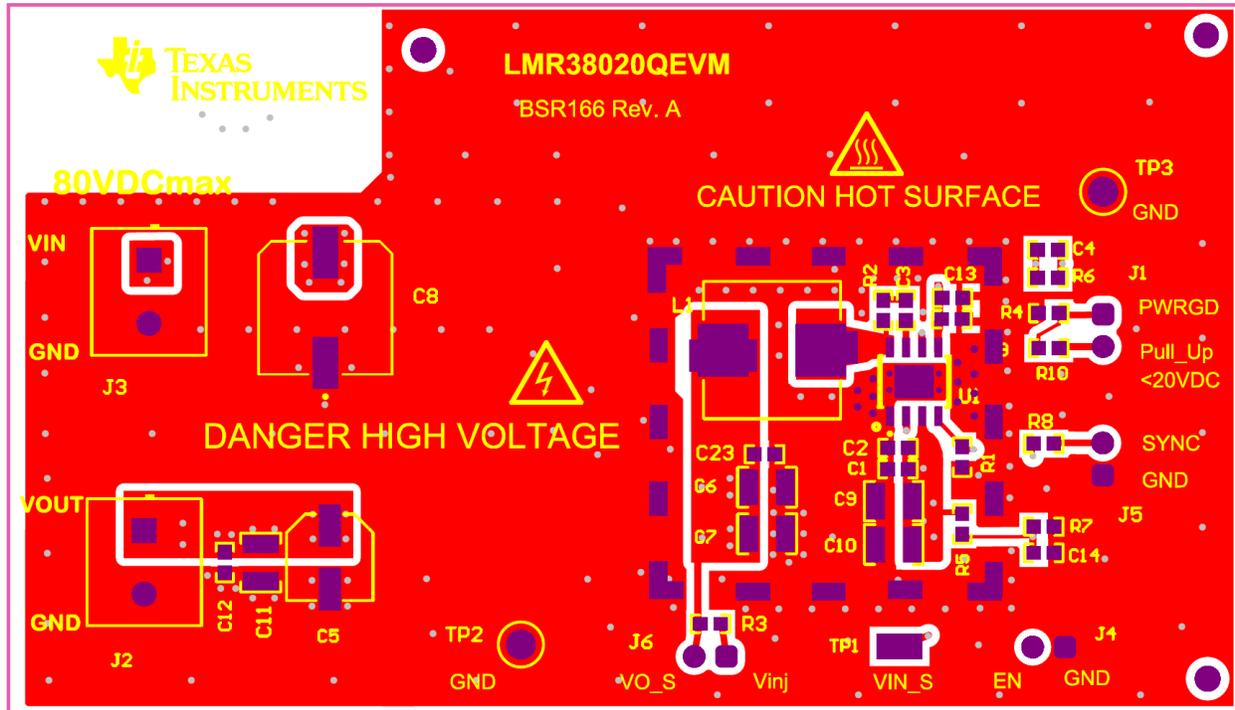


Figure 4-1. Top Layer and Silkscreen Layer

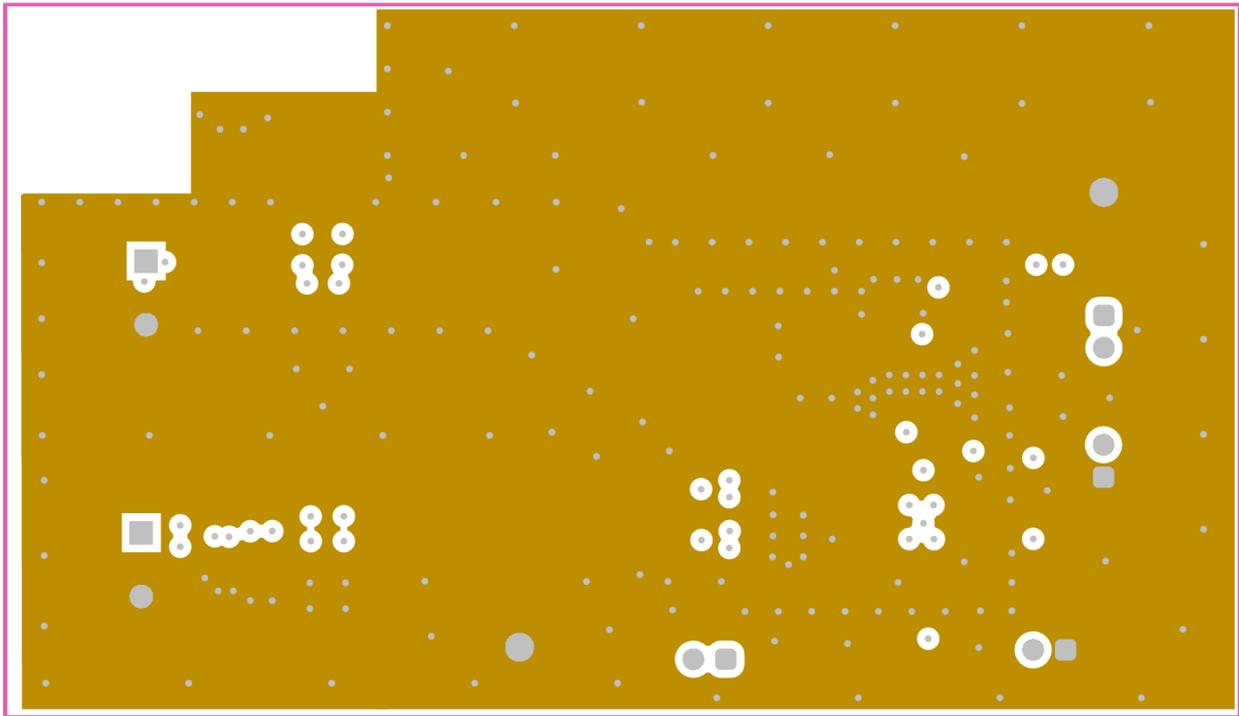


Figure 4-2. Mid-Layer 1 Ground Plane

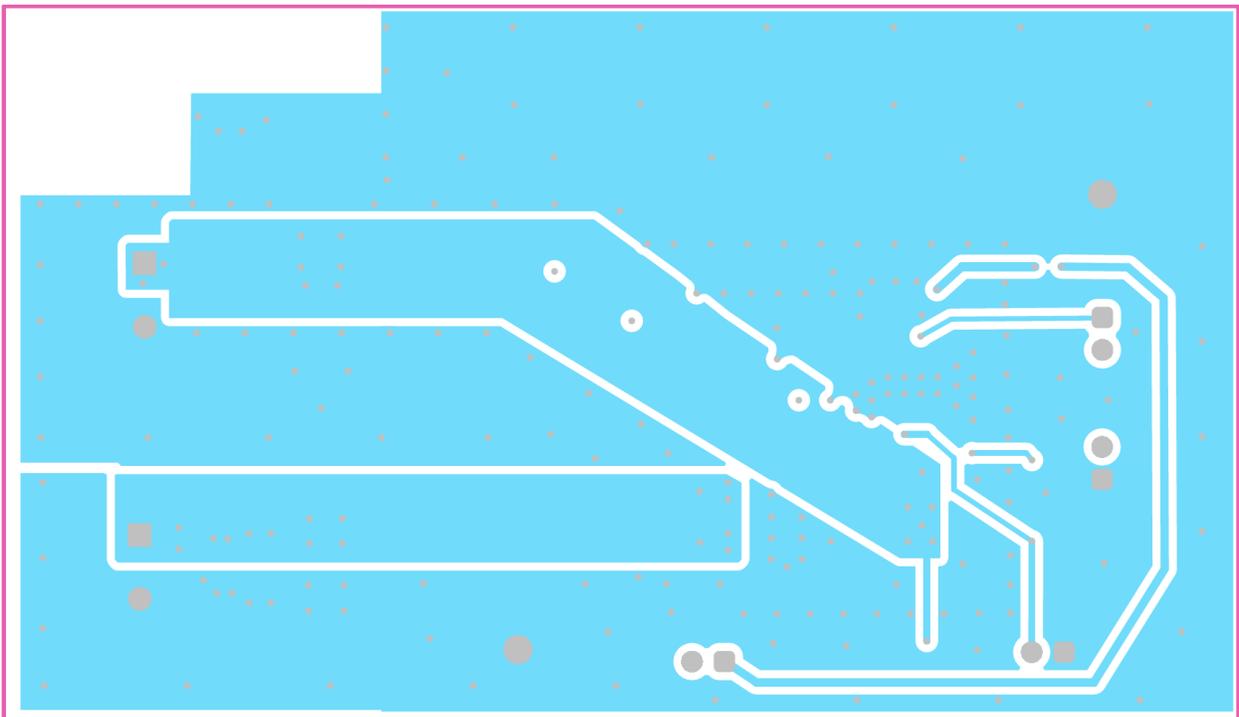


Figure 4-3. Mid-Layer 2 Routing



## 5 Bill of Materials

**Table 5-1. LMR38020QEV M Bill of Materials**

REF DES	DESCRIPTION	PART NUMBER	VENDOR	QTY
PCB	Printed Circuit Board	BSR166A		1
C1	CAP, CERM, 0.1 $\mu$ F, 100 V, $\pm$ 10%, X7R, AEC-Q200 Grade 1, 0603	HMK107B7104KAHT	Taiyo Yuden	1
C2, C23	CAP, CERM, 1000 pF, 100 V, $\pm$ 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A102K080AA	TDK	2
C3, C12	CAP, CERM, 0.1 $\mu$ F, 50 V, $\pm$ 10%, X7R, AEC-Q200 Grade 1, 0603	C0603C104K5RACAUTO	Kemet	2
C6, C7, C11	CAP, CERM, 22 $\mu$ F, 25 V, $\pm$ 10%, X7R, 1210	CL32B226KAJNFNE	Samsung	3
C8	CAP, AL, 33 $\mu$ F, 100 V, $\pm$ 20%, 0.7 $\Omega$ , AEC-Q200 Grade 2, SMD	EEE-FK2A330P	Panasonic	1
C9, C10	CAP, CERM, 2.2 $\mu$ F, 100 V, $\pm$ 10%, X7R	HMK325B7225KN-T	Taiyo Yuden	2
J2, J3	TERM BLK, 2POS, SIDE ENTRY, 5MM	1935776	Phoenix Contact	2
J1, J4, J5, J6	Header, 100 mil, 2 $\times$ 1, Gold, TH	TSW-102-07-G-S	Samtec	4
L1	FIXED IND, 16 $\mu$ H, 5 A, SMD	7443251600	Wurth	1
	Fixed Inductors IND MP, 15 $\mu$ H, 4.6 A	HCM1A0805V2-150-R	Coiltronics	
R2	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0	CRCW06030000Z0EA	Vishay	1
R5, R6	RES, 115 k, 1%, 0.1 W, 0603	CRCW0603115KFKEA	Vishay	2
R8	RES, 1.05 k, 1%, 0.1 W, 0603	RC0603FR-07226KL	Vishay	1
R9, R10	RES, 28.7 k, 1%, 0.1 W, 0603	CRCW060328K7FKEAv	Vishay	2
R3	RES, 51.1, 1%, 0.1 W, 0603	CRCW060351R1FKEA	Vishay	1
R1	RES, 64.9 k, 1%, 0.1 W, 0603	CRCW060364K9FKEA	Vishay	1
SH-J4	Shunt, 100 mil, Gold plated, Black	SNT-100-BK-G	Samtec	1
TP1	Test Lead clips and hooks, SMT	S1751-46	Harwin	1
TP2, TP3	Test Point, Multipurpose, Black, TH	5011	Keystone	2
U1	80-V, Low I <sub>Q</sub> Synchronous Buck Converter	LMR38020SQDDARQ1	TI	1

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