

# ***TPS61040EVM-001*** ***Evaluation Module***

## *User's Guide*

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It is important to operate this EVM within the supply voltage range of 1.8 V to 6 V.

Exceeding the specified supply range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the supply range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 125°C. The EVM is designed to operate properly with certain components above 125°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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# Preface

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## ***About This Manual***

This users guide describes the characteristics, operation, and use of the TPS61040EVM LCD bias supply evaluation module (EVM). This EVM is a Texas Instruments high-efficiency boost converter that is configured to generate 18 V at 20 mA, for LCD bias supply, from a single cell Li-Ion battery. The users guide includes a schematic diagram, bill of materials (BOM), and test data.

## ***How to Use This Manual***

This document contains the following chapters:

- ☐ Chapter 1—Introduction
- ☐ Chapter 2—Setup and Test Results
- ☐ Chapter 3—Board Layout
- ☐ Chapter 4—Schematic and Bill of Materials

## ***Related Documentation From Texas Instruments***

- ☐ **TPS601040/41** data sheet (literature number SLVS413).

## ***FCC Warning***

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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# Introduction

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This chapter contains background information for the TPS61040 and support documentation for the TPS61040EVM-001 evaluation module.

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## 1.1 Background

This TPS61040EVM uses the TPS61040 boost converter to generate an 18-V output from a single cell Li-Ion battery (3 V to 4.2 V). This EVM operates over an input voltage range of 1.8 V to 6 V, but has been optimized over the 3-V to 5-V input range. Operation with an input voltage down to 1.8 V is possible, depending on the output current and voltage settings. The EVM includes an adjust pin that allows the user to adjust the LCD bias with either a variable resistance or an analog voltage.

The output voltage of the TPS61040EVM can be adjusted up to 28 V by modifying the resistor values used in resistor divider R1 & R2. The EVM can also be configured for higher or lower output currents. For lower currents, the TPS61040 may be replaced by the pin for pin compatible TPS61041. More information about output voltage adjustment and current ratings of TPS61040/41 devices can be found in the data sheet *Literature Number SLVS413*.

## 1.2 Performance Specification Summary

Table 1–1 provides a summary of the TPS61040EVM–001 performance specifications. All specifications are given for an ambient temperature of 25°C. The EVM may be modified to operate over different input and output currents and voltages, per the TPS61040 data sheet specifications.

*Table 1–1. TPS61040 Performance Specification Summary*

| Specification         | Test Conditions       | Min | Typ   | Max | Unit |
|-----------------------|-----------------------|-----|-------|-----|------|
| Input voltage range   | $I_O = 20 \text{ mA}$ | 3   |       | 5   | V    |
| Output voltage        |                       |     | 18    |     | V    |
| Output current        |                       | 5   |       | 20  | mA   |
| Output voltage ripple |                       |     | 100   |     | mV   |
| Efficiency            |                       |     | 88.5% |     |      |

# Setup and Test Results

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This chapter describes how to properly connect, setup, and use the TPS61040EVM-001. This chapter also presents the test results for this EVM.

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## 2.1 Input/Output Connections

The TPS61040EVM-001 PWB has several connections, which are described in Table 2-1.

Table 2-1. Input/Output Connections

| Reference Designator | Name   | Description                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| J1                   | Vin    | This is the positive connection to the input power supply. The leads to the input supply should be twisted and kept as short as possible.                                                                                                                                                                                                                                                                                         |
| J2                   | GND    | This is the return connection to the input power supply.                                                                                                                                                                                                                                                                                                                                                                          |
| J3                   | Adjust | A variable resistor may be connected between J3-1 and J3-2 to vary the output voltage of the EVM. J3-1 has a square pad and is connected directly to the FB pin of the TPS61040. J3-2 has a round pad and is connected directly to ground. The output voltage may also be adjusted by connecting an analog voltage through a resistor to J3-1.                                                                                    |
| J4                   | GND    | This is the return pin for the load.                                                                                                                                                                                                                                                                                                                                                                                              |
| J5                   | Vout   | This is the positive connection for the load.                                                                                                                                                                                                                                                                                                                                                                                     |
| JP1                  | Enable | Use this connector to enable and disable the power supply. Connect a jumper between the <b>On</b> pin and the center pin to enable the supply, and connect a jumper between the <b>Off</b> pin and the center pin to disable the supply. When the EN pin of the TPS61040 is left open, its state is undetermined. The jumper must either be connected to <b>On</b> (Vin) or to <b>Off</b> (GND) for the EVM to operate correctly. |

## 2.2 EVM Operation

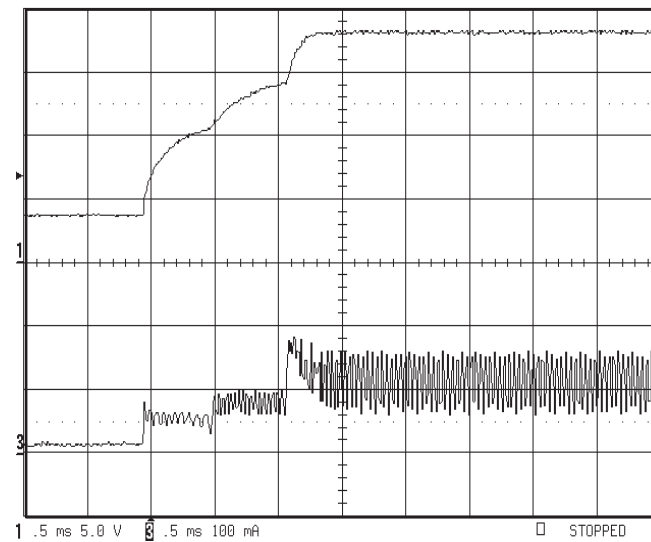
Connect an input supply and a load to the appropriate connectors provided on the EVM. The absolute maximum input voltage is 7 V. The TPS61040 is designed to operate with a maximum 6-V input voltage. Move the *adjust* jumper from the **Off** position to the **On** position to enable the supply.

Placing a variable resistor across the adjust pins of the EVM allows the user to vary the output voltage. Specific design equations may be found in the TPS61040 data sheet.

## 2.3 Start-Up

Figure 2-1 shows the startup voltage and current waveforms of the EVM. When the EVM is enabled, the TPS61040 goes through its programmed three-stage soft-start sequence to reduce inrush current at turn on.

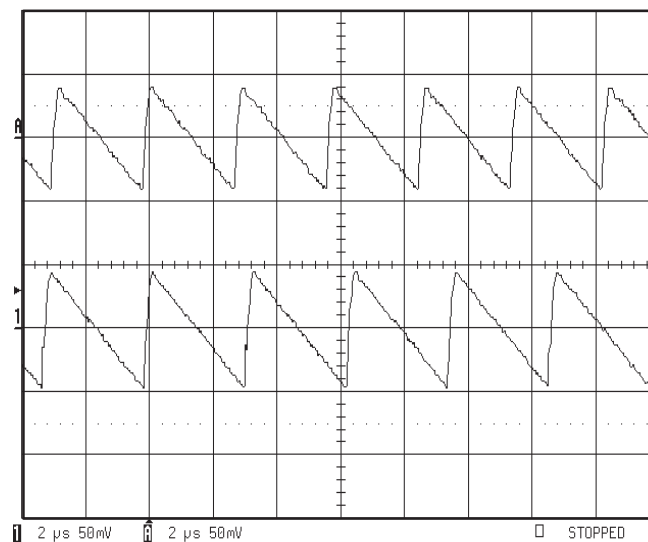
Figure 2–1. Start-Up Waveforms



## 2.4 Output Voltage Ripple

Figure 2–2 shows the output voltage ripple with  $I_O = 20$  mA. The top trace shows the ripple with 3.6-V input, and the bottom trace shows the ripple with a 4.2-V input. The difference in switching frequency between the two traces is expected and is explained in the data sheet.

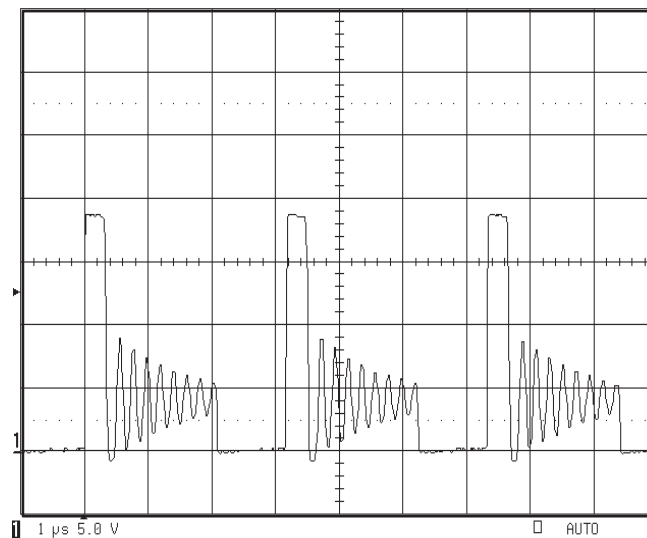
Figure 2–2. Output Ripple



## 2.5 Switching Waveforms

Figure 2–3 shows the switching waveform at the SW pin of the TPS61040. When the internal FET turns on, the voltage at the SW pin is pulled to ground until the inductor current reaches 450 mA. When the inductor current reaches 450 mA, the FET turns off and the voltage at the SW pin rises to the output voltage plus the forward voltage drop of the diode. During this time, the inductor transfers its stored energy to the load and the output capacitor. When the inductor current decays to zero, the SW node rings at a frequency determined by the output inductor and the drain capacitance of the internal FET. This ringing is indicative of a discontinuous boost power supply topology.

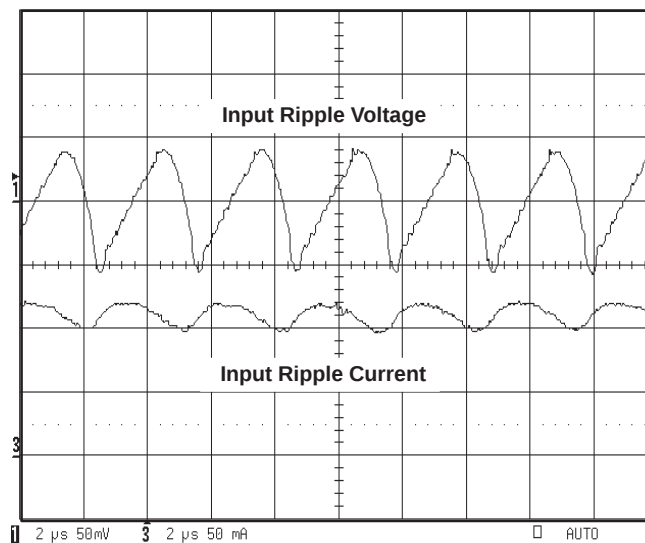
Figure 2–3. SW Waveform



## 2.6 Input Voltage Ripple

Figure 2–4 shows the input voltage and current ripple of the supply with  $V_{in} = 3.6$  V and  $I_O = 20$  mA. The input capacitance of the TPS61040 and the impedance of the input voltage supply largely determine the input voltage and current ripple. Increasing the input capacitance or lowering the source impedance reduces the input voltage and current ripple.

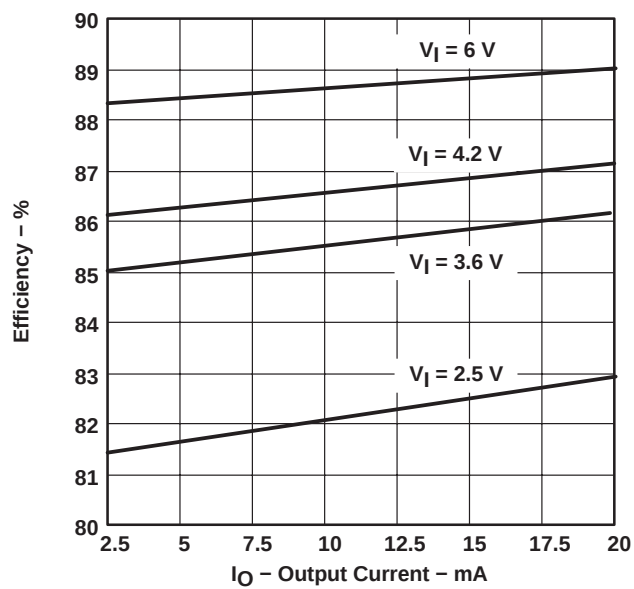
Figure 2–4. Input Ripple Voltage



## 2.7 Efficiency

Figure 2–5 shows the measured efficiency of the TPS61040.

Figure 2–5. Typical Efficiency



## 2.8 Output Adjust

The TPS61040EMV-001 provides two methods of output voltage adjustment for LCD contrast control. The first method of output voltage adjustment is accomplished with a variable resistor, while the second method is accomplished using a variable control voltage.

### 2.8.1 Variable Resistor Output Voltage Adjust

This method is accomplished by removing R2 on the EVM and then placing a variable resistor between J3-1 and ground. The equations provided below calculate the range of the variable resistor where:

- $R_{\text{adjust,min}}$  = minimum value for R2
- $R_{\text{adjust,max}}$  = maximum value for R2
- $R1$  = value for R1
- $V_{O,\text{max}}$  = maximum desired output voltage
- $V_{O,\text{min}}$  = minimum desired output voltage

$$R_{\text{adjust,min}} = 1.233 \text{ V} \times \frac{R1}{(V_{O,\text{max}} - 1.233 \text{ V})} \quad (1)$$

$$R_{\text{adjust,max}} = 1.233 \text{ V} \times \frac{R1}{(V_{O,\text{min}} - 1.233 \text{ V})} \quad (2)$$

For example, if  $V_{O,\text{max}} = 19 \text{ V}$ ,  $V_{O,\text{min}} = 17 \text{ V}$ , and  $R1 = 2.21 \text{ M}\Omega$ , then  $R_{\text{adjust,min}} = 153.4 \text{ k}\Omega$ , and  $R_{\text{adjust,max}} = 172.8 \text{ k}\Omega$ . This scenario is best implemented using a 154-k $\Omega$  resistor in series with a 20-k $\Omega$  potentiometer.

### 2.8.2 Variable Control Voltage Output Voltage Adjust

This method is accomplished by connecting a variable control voltage through a resistor,  $R_{\text{adjust}}$ , to J3-1. The equations provided below calculate R2 and  $R_{\text{adjust}}$  where:

$$R2 = 1.233 \text{ V} \times R1 \times \frac{(V_{\text{adjust,max}} - V_{\text{adjust,min}})}{\left[ 1.233 \text{ V}(V_{O,\text{min}} - V_{O,\text{max}} + V_{\text{adjust,min}} - V_{\text{adjust,max}}) - V_{\text{adjust,min}} \times V_{O,\text{min}} + V_{\text{adjust,max}} \times V_{O,\text{max}} \right]} \quad (3)$$

$$R_{\text{adjust}} = R2 \times R1 \times \frac{(V_{\text{adjust,max}} - 1.233 \text{ V})}{\left[ 1.233 \text{ V}(R2 + R1) - V_{O,\text{min}} \times R2 \right]} \quad (4)$$

For example, if  $V_{O,\text{max}} = 19 \text{ V}$ ,  $V_{O,\text{min}} = 17 \text{ V}$ ,  $V_{\text{adjust,min}} = 0 \text{ V}$ ,  $V_{\text{adjust,max}} = 3.3 \text{ V}$ , and  $R1 = 1 \text{ M}\Omega$ , then  $R2 = 72.4 \text{ k}\Omega$ , and  $R_{\text{adjust}} = 1.65 \text{ M}\Omega$ . When  $V_{\text{adjust}} = 0 \text{ V}$  then  $V_O = 19 \text{ V}$ . When  $V_{\text{adjust}} = 3.3 \text{ V}$  then  $V_O = 17 \text{ V}$ .

# Board Layout

This chapter provides the TPS61040EVM-001 board layout and illustrations.

| Topic            | Page |
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| 3.1 Layout ..... | 3-1  |

## 3.1 Layout

Board layout is critical for all switch mode power supplies. Figures 3-1, 3-2 and 3-3 show the board layout for the TPS61040EVM-001 PWB. The nodes with high-switching frequency are short and isolated from the noise-sensitive feedback circuitry. Careful attention has been given to the routing of high-frequency current loops. Refer to the data sheet for specific layout guidelines.

Figure 3-1. Assembly Layer

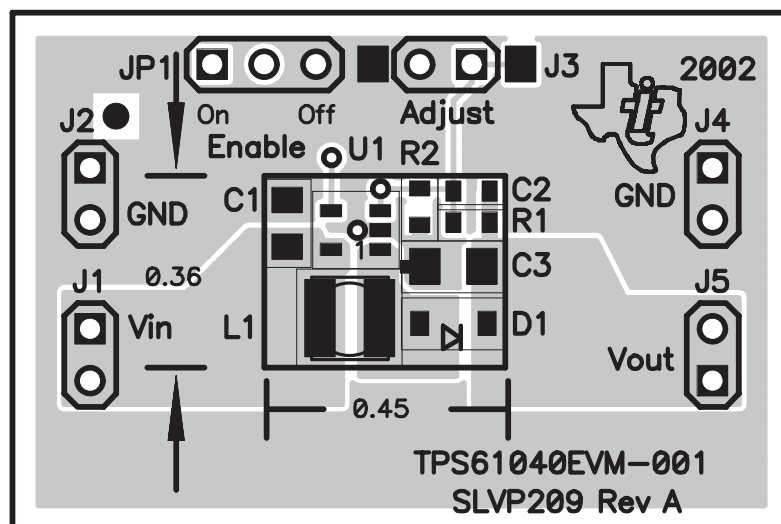


Figure 3–2. Top Layer Routing

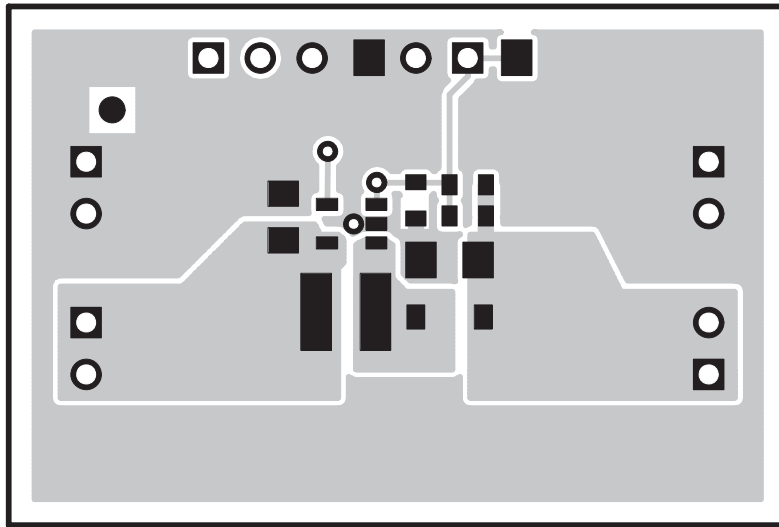
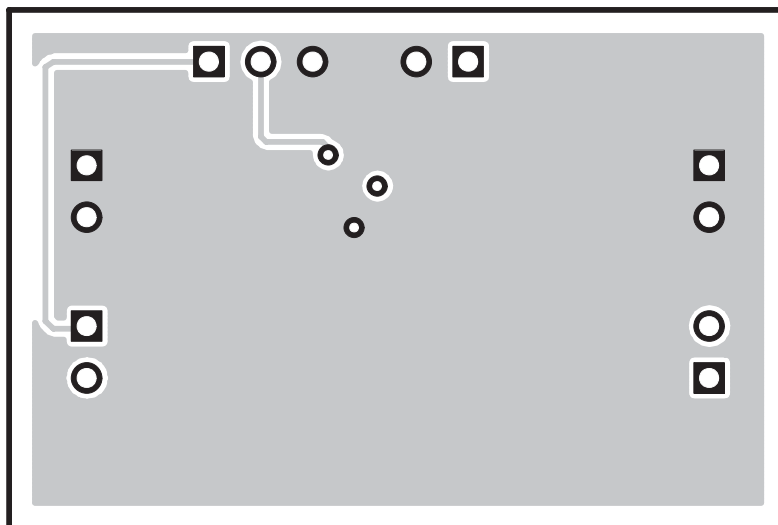


Figure 3–3. Bottom Layer Routing



# Schematic and Bill of Materials

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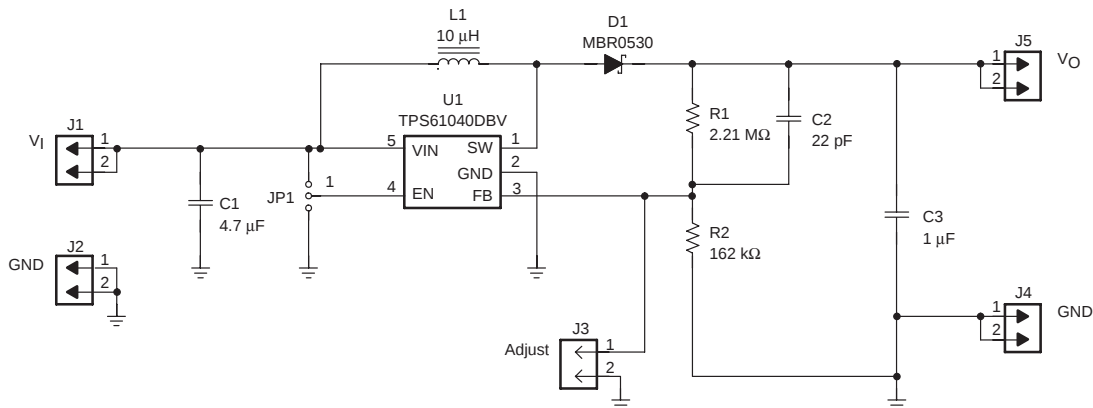
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This chapter provides the TPS61040EVM-001 schematic and bill of materials.

| Topic                      | Page |
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| 4.1 Schematic .....        | 4-2  |
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## 4.1 Schematic

Figure 4–1. TPS61040EVM–001 Schematic



## 4.2 Bill of Materials

Table 4–1. TPS61040EVM–001 Bill of Materials

| Reference | Description                                   | Size          | Qty. | MFG      | Part #            |
|-----------|-----------------------------------------------|---------------|------|----------|-------------------|
| C1        | Capacitor, ceramic, 4.7 µF, 6.3 V, X5R, 15%   | 0805          | 1    | Murata   | GRM21B60J475KA11  |
| C2        | Capacitor, ceramic, 22 pF, 50 V, C0G, 5%      | 0603          | 1    | Murata   | GRM1885C1H220JZ01 |
| C3        | Capacitor, ceramic, 1 µF, 25 V, X7R, 10%      | 1206          | 1    | Murata   | GRM31MR7E105KC01  |
| D1        | Diode, Schottky 0.5 A 30 V                    | SOD–123       | 1    | On Semi  | MBR0530T1         |
| J1 – J5   | Header, 2-pin, 100-mil spacing (36-pin strip) | 0.1 x 2"      | 5    | Sullins  | PTC36SAAN         |
| JP1       | Header, 3-pin, 100-mil spacing (36-pin strip) | 0.1 x 3"      | 1    | Sullins  | PTC36SAAN         |
| L1        | Inductor, SMT, 10 µH, 0.76 A, 0.23 Ω          | 0.15 x 0.162  | 1    | Sumida   | CR32–100          |
| R1        | Resistor, chip, 2.21 MΩ, 1/16 W, 1%           | 0603          | 1    | Standard | Standard          |
| R2        | Resistor, chip, 162 kΩ, 1/16 W, 1%            | 0603          | 1    | Standard | Standard          |
| U1        | IC, high efficiency boost converter           | SOT23–5 (DBV) | 1    | TI       | TPS61040DBV       |
|           | PCB, 1.5' x 1" x 0.062"                       |               | 1    | Any      | SLVP209           |
|           | Shunts, 100-mil, black                        | 0.1 mm        | 1    | 3M       | 929950-00         |

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