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Evaluation Board for the ADP2380 and ADP2381, 20 V, 4 A/6 A Synchronous Step-Down Regulators with Low-Side Driver

FEATURES

Input voltage: 4.5 V to 20 V
±1% output voltage accuracy
Integrated 44 mΩ high-side MOSFET
Continuous output current
  4 A for the ADP2380
  6 A for the ADP2381
Programmable switching frequency: 250 kHz to 1.4 MHz
Synchronizes to external clock: 250 kHz to 1.4 MHz
180° out-of-phase synchronization
Programmable UVLO
Power-good output
External compensation
Internal soft start with external adjustable option
Startup into a precharged output

GENERAL DESCRIPTION

The ADP2380/ADP2381 evaluation board is a complete, 4 A/6 A, 20 V, step-down regulator solution that allows users to evaluate the performance of the ADP2380 and the ADP2381 with a nearly ideal printed circuit board (PCB) layout.

The switching frequency can be programmed between 250 kHz and 1.4 MHz, or it can be synchronized to an external clock with a 180° phase shift, which provides the possibility for a stackable, multiphase power solution.

The output of the ADP2380/ADP2381 evaluation board is preset to 3.3 V, and the switching frequency is set to 500 kHz. Different output voltage settings can be achieved by changing the appropriate passive components. The ambient temperature operating range is −40°C to +85°C.

Full details about the ADP2380 and ADP2381 regulators are provided in the ADP2380 and ADP2381 data sheets, which are available from Analog Devices, Inc. The data sheets should be consulted in conjunction with this user guide.

DEMO BOARD

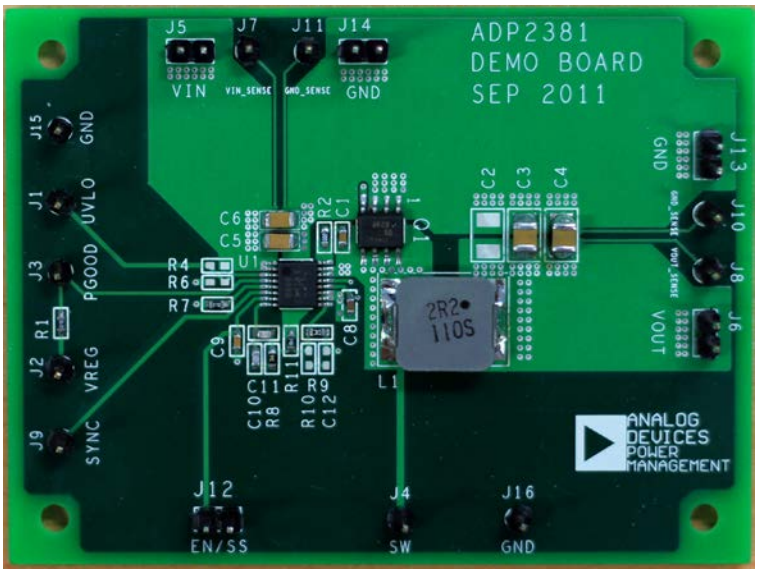

Figure 1.

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REVISION HISTORY

12/12—Revision 0: Initial Version

USING THE EVALUATION BOARD

POWERING UP

The ADP2380/ADP2381 evaluation board is supplied fully assembled and tested. Before applying power to the evaluation board, follow the procedures in this section.

Jumper J12 (EN/SS)

Use one of the following methods to enable or disable the regulator:

- To enable the regulator, leave Jumper J12 open.
- To disable the regulator, short Jumper J12.

Input Power Source

If the input power source includes a current meter, use that meter to monitor the input current. Connect the positive terminal of the power source to J5 (VIN) of the evaluation board, and the negative terminal of the power source to J14 (GND) of the evaluation board.

If the power source does not include a current meter, connect a current meter in series with the input source voltage. Connect the positive lead (+) of the power source to the positive (+) ammeter terminal, the negative lead (−) of the power source to J14 (GND), and the negative lead (−) of the ammeter to J5 (VIN).

Output Load

Before connecting the load, ensure that the board is turned off. Connect an electronic load or resistor to set the load current.

Connect the positive terminal of the load to J6 (VOUT) of the evaluation board and connect the negative terminal of the load to J13 (GND).

Input and Output Voltmeter

Measure the input and output voltages using voltmeters. Ensure that the voltmeters are connected to the appropriate terminals of the evaluation board and not to the load or power source. If the voltmeters are not connected directly to the evaluation board, the measured voltages are incorrect, due to the voltage drop across the leads and/or connections between the evaluation board, the power source, and/or the load.

To measure the input voltage, connect the positive terminal of the voltmeter to J7 (VIN_SENSE) and the negative terminal to J11 (GND_SENSE). Likewise, to measure the output voltage, connect the positive terminal of the voltmeter to J8 (VOUT_SENSE) and the negative terminal to J10 (GND_SENSE).

Turning On the Evaluation Board

When the power source and load are connected to the evaluation board, it can be powered for operation.

Perform the following steps to turn on the board:

1. Ensure that the power source voltage is >4.5 V and <20 V.
2. Ensure that J12 (EN/SS) is open.
3. Turn on the load, ensure that it is drawing the proper load current, and verify that the output voltage maintains its regulation.

MEASURING EVALUATION BOARD PERFORMANCE

Measuring the Switching Waveform

To observe the switching waveform with an oscilloscope, place the oscilloscope probe tip at Test Point J4 (SW) with the probe ground at J16 (GND). Set the scope to dc with the appropriate voltage and time divisions. The switching waveform limits should alternate approximately between 0 V and the input voltage.

Measuring Load Regulation

Load regulation can be tested by observing the change in the output voltage with increasing output load current. To minimize the voltage drop, use short, low resistance wires.

Measuring Line Regulation

Vary the input voltage and examine the change in the output voltage with a fixed output current.

Line Transient Response

Generate a step input voltage change and observe the behavior of the output voltage using an oscilloscope.

Load Transient Response

Generate a load current transient at the output and observe the output voltage response using an oscilloscope. Attach the current probe to the wire between the output and the load to capture the current transient waveform.

Measuring Efficiency

The efficiency, η, is measured by comparing the input power with the output power.

$$\eta = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}}$$

Measure the input and output voltages as close as possible to the input and output capacitors to reduce the effect of voltage drop.

Measuring Inductor Current

The inductor current can be measured by removing one end of the inductor from its pad and connecting a current loop in series. A current probe can be connected onto this wire.

Measuring Output Voltage Ripple

To observe the output voltage ripple, place the oscilloscope probe across the output capacitor with the probe ground lead connected to the negative (−) capacitor terminal and the probe tip placed at the positive (+) capacitor terminal. Set the oscilloscope to ac, 10 mV/division, 2 µs/division time base, and 20 MHz bandwidth.

A standard oscilloscope probe has a long wire ground clip. For high frequency measurements, this ground clip picks up high frequency noise and injects it into the measured output ripple. Figure 2 shows an easy way to measure the output ripple properly. It requires removing the oscilloscope probe sheath and wrapping an unshielded wire around the oscilloscope probe. By keeping the ground length of the oscilloscope probe as short as possible, the true ripple can be measured.

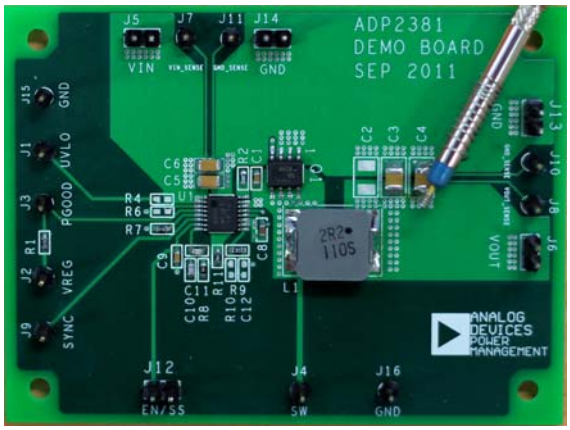

Figure 2. Measuring Output Voltage Ripple

MODIFYING THE BOARD

To modify the ADP2380/ADP2381 evaluation board configuration, unsolder and/or replace/remove the appropriate passive components or jumpers on the board.

Changing the Output Voltages

The output voltage setpoints of the ADP2380 and the ADP2381 can be changed by replacing the R9 and R11 resistors with the resistor values shown in Table 1.

Table 1. Resistive Divider for Various Output Voltages

V_{OUT} (V)	R9, ±1% (kΩ)	R11, ±1% (kΩ)
1.0	10	15
1.2	10	10
1.5	15	10
1.8	20	10
2.5	47.5	15
3.3	10	2.21
5.0	22	3

To limit output voltage accuracy degradation due to the FB pin bias current (0.1 µA maximum) to less than 0.5% (maximum), ensure that the bottom divider string resistor, R11, is less than 30 kΩ.

The value of the top resistor, R9, is calculated using the following equation:

$$R9 = R11 \times \left(\frac{V_{OUT} - 0.6\ \text{V}}{0.6\ \text{V}} \right)$$

When the output voltage is changed, the values of the inductor (L1), the output capacitors (C2, C3, and C4), and the compensation components (R8, C10, and C11) must be recalculated and changed to ensure stable operation (see the ADP2380 and ADP2381 data sheets for details on external component selection).

Changing the Switching Frequency

The switching frequency (f_{SW}) set point can be changed by replacing the R7 resistor with a different value, as shown in the following equation:

$$f_{SW}\ [\text{kHz}] = 57,600/(R7\ [\text{k}\Omega] + 15)$$

A 215 kΩ resistor sets the frequency to 250 kHz, and a 100 kΩ resistor sets the frequency to 500 kHz.

When the switching frequency is changed, the values of the inductor (L1), the output capacitors (C2, C3, C4), and the compensation networks (R8, C10, C11) must be recalculated and changed for stable operation (see the ADP2380 and ADP2381 data sheets for details on external component selection).

Changing the Soft Start Time

The soft start time of the ADP2380/ADP2381 on the evaluation board is programmed to 4 ms.

To change the soft start time, t_{SS}, replace the C9 capacitor value, using the following equation:

$$C9\ [\text{nF}] = 5.5 \times t_{SS}\ [\text{ms}]$$

Changing the Input Voltage UVLO

The default values of PVIN UVLO rising/falling threshold are 4.2 V/3.9 V, and these default values can be replaced by placing an external voltage divider (R4 and R6) to achieve more accurate, externally adjustable UVLO. Lower values of the external resistors are recommended to get high accuracy of the UVLO threshold.

Setting R6 to 1 kΩ is a proper choice, and the value of R4 for a chosen input voltage rising threshold is as follows:

$$R4 = \frac{(V_{IN\_RISING} - 1.2\ \text{V}) \times R6}{1.2\ \text{V}}$$

where:
V_{IN_RISING} is the input voltage rising threshold. The input voltage falling threshold can be determined by the following equation:

$$V_{IN\_FALLING} = \frac{1.1\ \text{V} \times R4}{R6} + 1.1\ \text{V}$$

External Synchronization

To synchronize the regulator to an external clock signal, apply an external clock signal to J9 (SYNC) of the evaluation board.

The clock signal must have a logic high level from 1.3 V to 5 V and a logic low level that is below 0.4 V. Set the external clock pulse width to greater than 100 ns and the frequency range to between 250 kHz and 1.4 MHz.

During synchronization, the regulator operates in CCM mode, and the rising edge of the switching waveform runs 180° out of phase to the external clock rising edge.

For reliable synchronization, connect a resistor from the RT pin to GND (R7) to program the internal oscillator to run at 90% to 110% of the external synchronization clock signal.

EVALUATION BOARD SCHEMATICS AND ARTWORK

ADP2380 SCHEMATIC

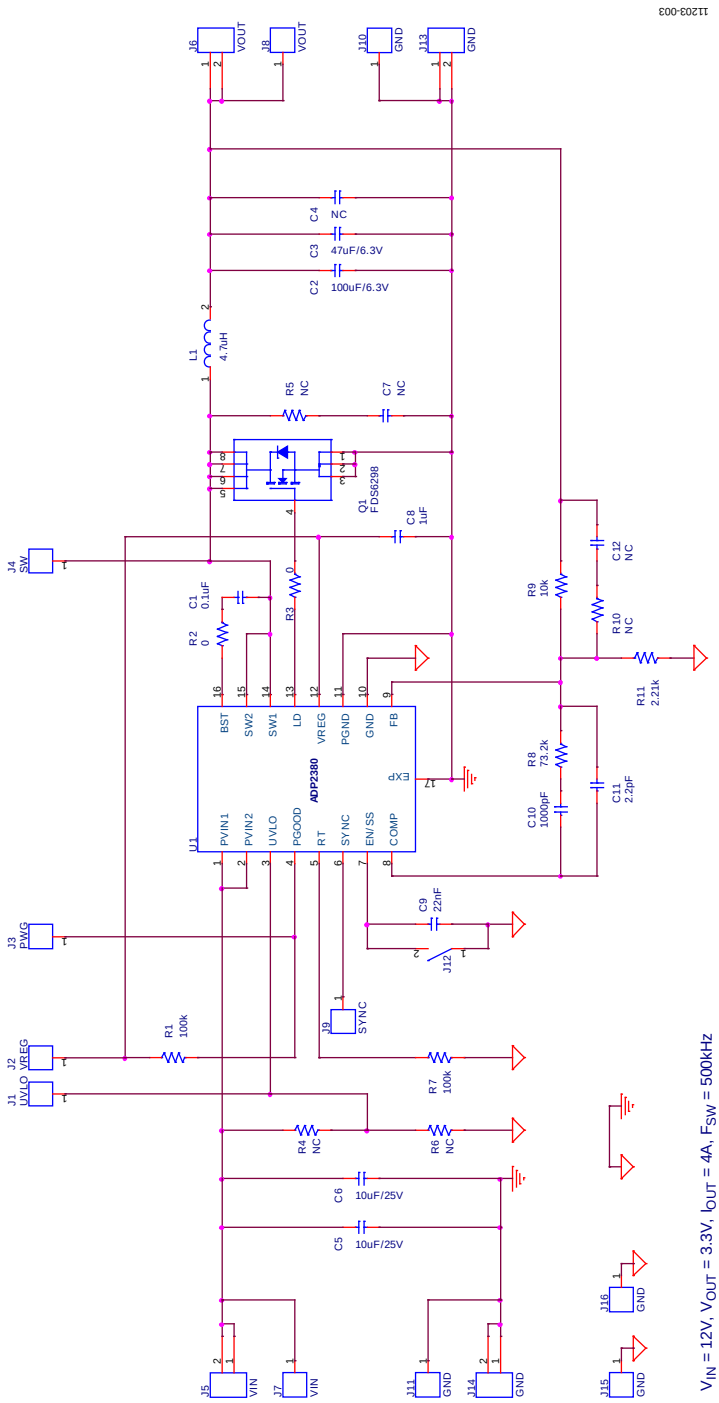

Figure 3. Evaluation Board Schematic for the ADP2380

ADP2381 SCHEMATIC

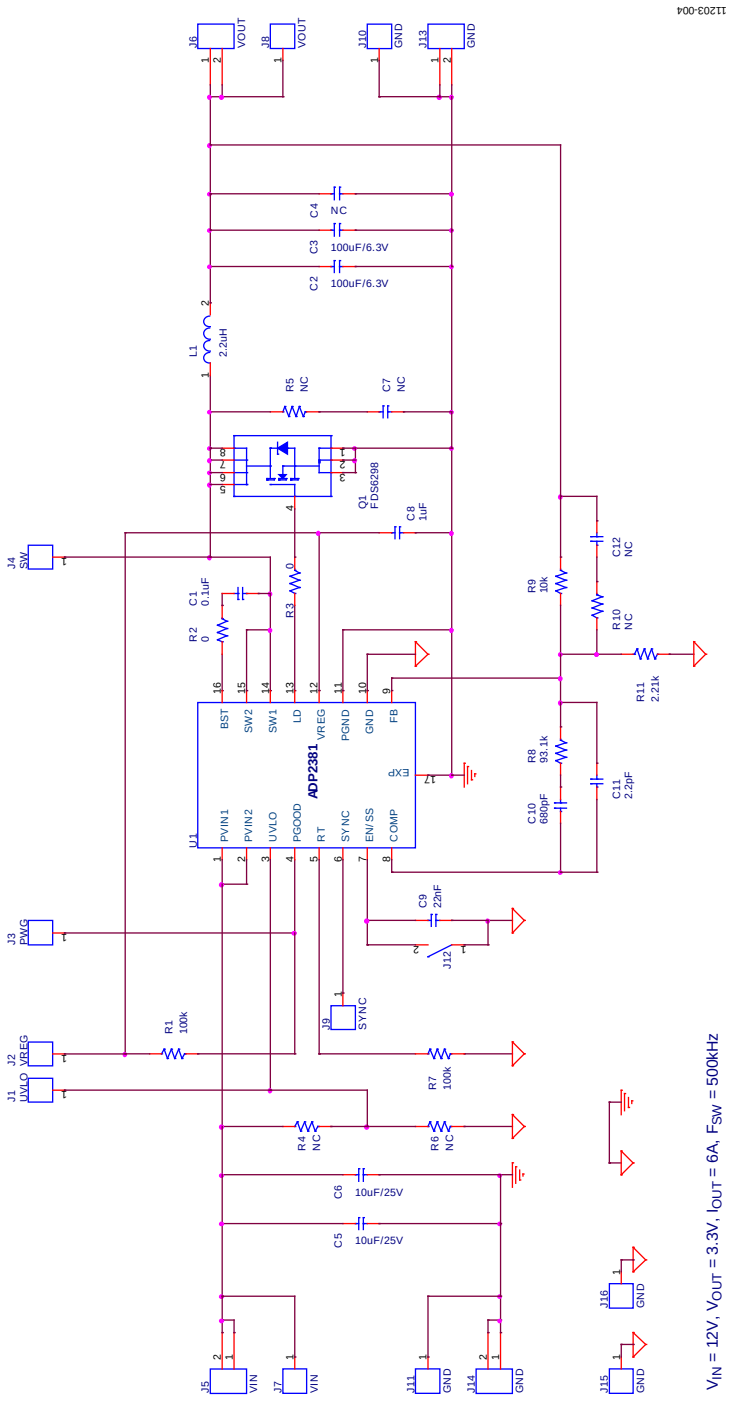

Figure 4. Evaluation Board Schematic for the ADP2381

PCB LAYOUT

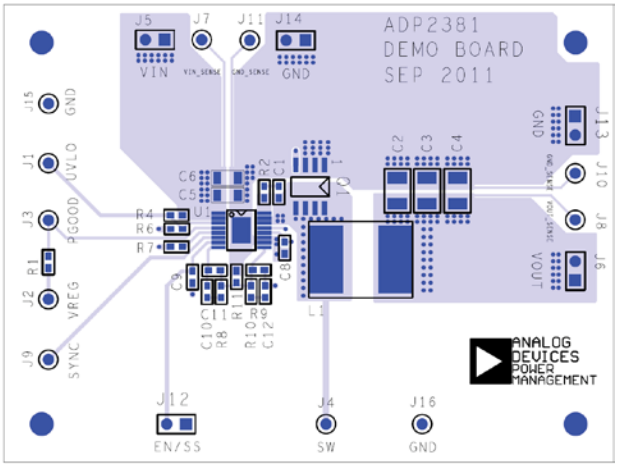

Figure 5. Layer 1, Component Side

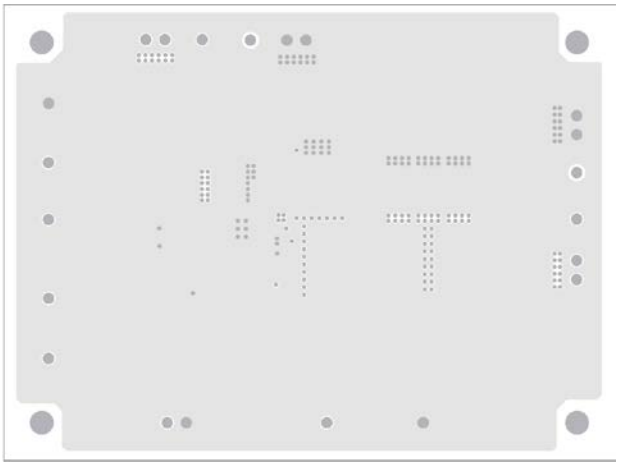

Figure 7. Layer 2, Ground Plane

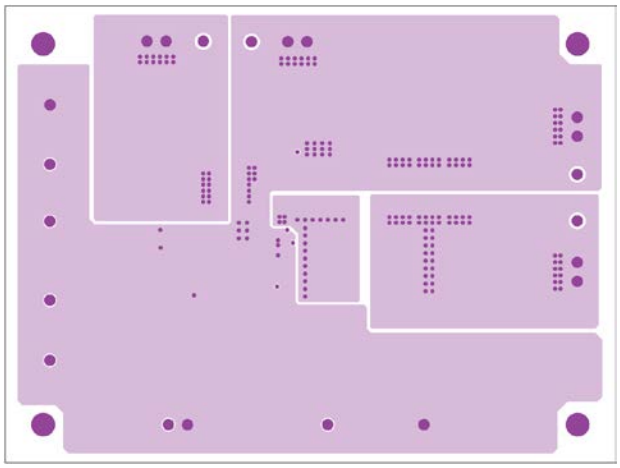

Figure 6. Layer 3, Power Plane

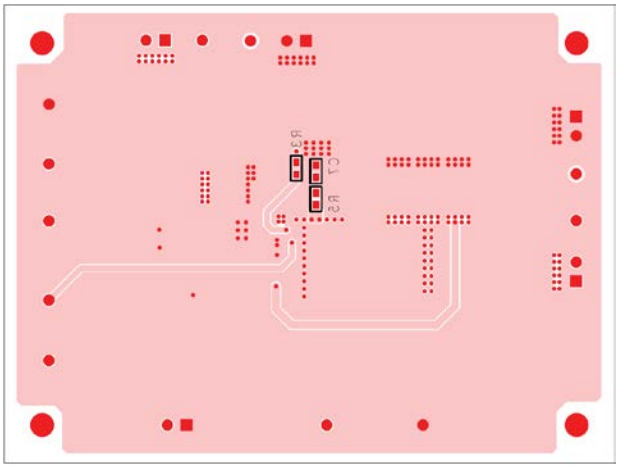

Figure 8. Layer 4, Bottom Side

ORDERING INFORMATION

BILL OF MATERIALS

Table 2. ADP2380 Bill of Materials

Qty	Reference Designator	Description	Part Number/Vendor
1	C1	Capacitor, 0.1 µF, 16 V, 0603	GRM188R71C104KA01D/Murata
1	C2	Capacitor, 100 µF, 6.3 V, 1210	GRM32ER60J107ME20L /Murata
1	C3	Capacitor, 47 µF, 6.3 V, 1210	GRM32ER70J476KE19L/Murata
1	C4	Capacitor, optional, 1210	Optional/Murata
2	C5, C6	Capacitor, 10 µF, 25 V, 1206	GRM31CR61E106MA12L /Murata
2	C7, C12	Capacitor, optional, 0603	Optional/Murata
1	C8	Capacitor, 1 µF, 16 V, 0603	GRM188R61C105KA93D/Murata
1	C9	Capacitor, 22 nF, 16 V, 0603	GRM188R71C223KA01D/Murata
1	C10	Capacitor, 1000 pF, 50 V, 0603	GRM188R61H102KA01D/Murata
1	C11	Capacitor, 2.2 pF, 50 V, 0603	GRM1885C1H2R2BZ01D/Murata
1	L1	Inductor, FDVE1040, L = 4.7 µH, I_{RAT} = 8.2 A, DCR = 12.5 mΩ	FDVE1040-4R7M/Toko
1	Q1	N-channel MOSFET, V_{DS} = 30 V, $R_{DS(ON)}$ = 9.4 mΩ, I_D = 13 A, SO8	FDS6298/Fairchild
2	R1, R7	Resistor, 100 kΩ, 1%, 0603	CRCW0603100KFKEA/Vishay Dale
2	R2, R3	Resistor, 0 Ω, 1%, 0603	CRCW06030000Z0EA/Vishay Dale
4	R4, R5, R6, R10	Resistor, optional, 0603	Optional/Vishay Dale
1	R8	Resistor, 73.2 kΩ, 1%, 0603	CRCW060373K2FKEA/Vishay Dale
1	R9	Resistor, 10 kΩ, 1%, 0603	CRCW060310K0FKEA/Vishay Dale
1	R11	Resistor, 2.21 kΩ, 1%, 0603	CRCW06032K21FKEA/Vishay Dale
1	U1	Regulator, 20 V, 4 A, synchronous step-down with low-side driver, 16-lead, TSSOP_EP	ADP2380/Analog Devices, Inc.
11	J1, J2, J3, J4, J7, J8, J9, J10, J11, J15, J16	Test point, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, SIP1	M20-9990245/Harwin
5	J5, J6, J12, J13, J14	Connector, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, 2-way, SIP2	M20-9990245/Harwin

Table 3. ADP2381 Bill of Materials

Qty	Reference Designator	Description	Part Number/Vendor
1	C1	Capacitor, 0.1 µF, 16 V, 0603	GRM188R71C104KA01D/Murata
2	C2, C3	Capacitor, 100 µF, 6.3 V, 1210	GRM32ER60J107ME20L/Murata
1	C4	Capacitor, optional, 1210	Optional/Murata
2	C5, C6	Capacitor, 10 µF, 25 V, 1206	GRM31CR61E106MA12L/Murata
2	C7, C12	Capacitor, optional, 0603	Optional/Murata
1	C8	Capacitor, 1 µF, 16 V, 0603	GRM188R61C105KA93D/Murata
1	C9	Capacitor, 22 nF, 16 V, 0603	GRM188R71C223KA01D/Murata
1	C10	Capacitor, 680 pF, 50 V, 0603	GRM188R71H681KA01D/Murata
1	C11	Capacitor, 2.2 pF, 50 V, 0603	GRM1885C1H2R2BZ01D/Murata
1	L1	Inductor, FDVE1040, L = 2.2 µH, I_{RAT} = 11.4 A, DCR = 6.1 mΩ	FDVE1040-2R2M/Toko
1	Q1	N-channel MOSFET, V_{DS} = 30 V, $R_{DS(ON)}$ = 9.4 mΩ, I_D = 13 A, SO8	FDS6298/Fairchild
2	R1, R7	Resistor, 100 kΩ, 1%, 0603	CRCW0603100KFKEA/Vishay Dale
2	R2, R3	Resistor, 0 Ω, 1%, 0603	CRCW06030000Z0EA/Vishay Dale
4	R4, R5, R6, R10	Resistor, optional, 0603	Optional/Vishay Dale
1	R8	Resistor, 93.1 kΩ, 1%, 0603	CRCW060393K1FKEA/Vishay Dale
1	R9	Resistor, 10 kΩ, 1%, 0603	CRCW060310K0FKEA/Vishay Dale
1	R11	Resistor, 2.21 kΩ, 1%, 0603	CRCW06032K21FKEA/Vishay Dale
1	U1	Regulator, 20 V, 6 A, synchronous step-down with low-side driver, 16-lead, TSSOP_EP	ADP2381/Analog Devices, Inc.
11	J1, J2, J3, J4, J7, J8, J9, J10, J11, J15, J16	Test point, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, SIP1	M20-9990245/Harwin
5	J5, J6, J12, J13, J14	Connector, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, 2-way, SIP2	M20-9990245/Harwin

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ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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