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Evaluation Board for the ADP2384/ADP2386, 20 V, 4 A/6 A Synchronous Step-Down DC-to-DC Regulators

FEATURES

- Input voltage: 4.5 V to 20 V
- ±1% output voltage accuracy
- Integrated MOSFET
  - 44 mΩ/11 mΩ
- Continuous output current
  - 4 A for ADP2384
  - 6 A for ADP2386
- Programmable switching frequency: 200 kHz to 1.4 MHz
- Synchronizes to external clock: 200 kHz to 1.4 MHz
- 180° out-of-phase synchronization
- Precision enable and power good
- External compensation
- Internal soft start with external adjustable option
- Startup into precharged output

GENERAL DESCRIPTION

The ADP2384/ADP2386 evaluation board is a complete, 4 A/6 A, 20 V, step-down regulator solution that allows users to evaluate the performance of the ADP2384/ADP2386 with a near ideal printed circuit board (PCB) layout.

The switching frequency can be programmed between 200 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 ADP2384/ADP2386 evaluation board is preset to 3.3 V and the switching frequency is set to 600 kHz. Different output voltage settings can be achieved by changing appropriate passive components. The ambient temperature operating range is −40°C to +85°C.

Full details on the ADP2384 and ADP2386 regulators are provided in the ADP2384 and ADP2386 data sheets, available from Analog Devices, Inc., which should be consulted in conjunction with this user guide.

DEMO BOARD

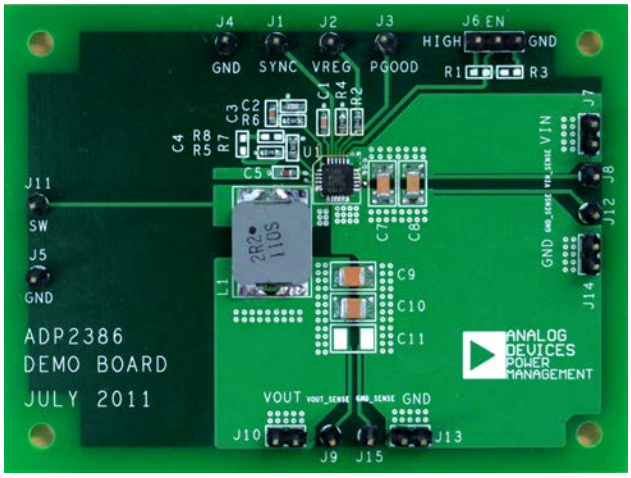


Figure 1.

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REVISION HISTORY

11/12—Revision 0: Initial Version

USING THE EVALUATION BOARD

POWERING UP

The ADP2384/ADP2386 evaluation board is supplied fully assembled and tested. Before applying power to the evaluation board, follow the procedures in this section.

Jumper J6 (Enable)

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

- To enable the regulator, short the middle pin of J6, EN, to HIGH.
- To disable the regulator, short the middle pin of J6, EN, to GND.

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 J7 (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 J7 (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 J10 (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. Make sure that the voltmeters are connected to the appropriate terminals of 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 J8 (VIN_SENSE) and the negative terminal to J12 (GND_SENSE). Likewise, to measure the output voltage, connect the positive terminal of the voltmeter to J9 (VOUT_SENSE) and the negative terminal to J15 (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 EN is high and monitor the output voltage.
3. Turn on the load, check 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 J11 (SW) with the probe ground at J5 (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.

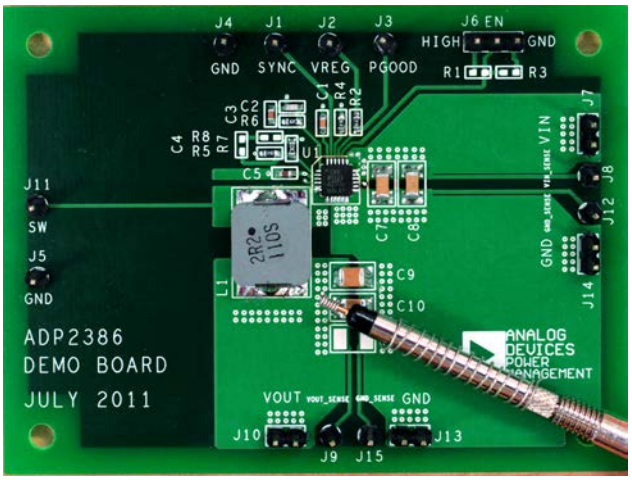


Figure 2. Measuring Output Voltage Ripple

MODIFYING THE BOARD

To modify the ADP2384/ADP2386 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 ADP2384/ADP2386 can be changed by replacing the R7 and R5 resistors with the resistor values shown in Table 1.

Table 1. Resistive Divider for Various Output Voltages

V_{OUT} (V)	R7, ±1% (kΩ)	R5, ±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, R5, is less than 30 kΩ.

The top resistor, R7, value is calculated using the following equations:

$$R7 = R5 \times \left(\frac{V_{OUT} - 0.6\ \text{V}}{0.6\ \text{V}} \right)$$

When the output voltage is changed, the values of the inductor (L1), the output capacitors (C9, C10, and C11), and the compensation components (R6, C2, and C3) must be recalculated and changed to ensure stable operation (see the ADP2384 and ADP2386 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 R4 resistor with a different value, as shown in the following equation:

$$f_{SW}\ [\text{kHz}] = 69,120 / (R4\ [\text{k}\Omega] + 15)$$

A 215 kΩ resistor sets the frequency to 300 kHz, and a 100 kΩ resistor sets the frequency to 600 kHz.

When the switching frequency is changed, the values of the inductor (L1), the output capacitors (C9, C10, C11), the compensation networks (R6, C2, C3) must be recalculated and changed for stable operation (see the ADP2384 and ADP2386 data sheets for details on external component selection).

Changing the Soft Start Time

The soft start time of the ADP2384/ADP2386 on the evaluation board is programmed to 4 ms.

To change the soft start time, t_{SS}, replace the C1 capacitor value using the following equation:

$$C1\ [\text{nF}] = 5.33 \times t_{SS}\ [\text{ms}]$$

External Synchronization

To synchronize the regulator to an external clock signal, apply an external clock signal to J1 (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 below 0.4 V. Set the external clock pulse width to more than 100 ns and the frequency range between 200 kHz and 1.4 MHz.

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

For reliable synchronization, connect a resistor from the RT pin to GND (R4) to program the internal oscillator to run at 90% to 110% of the external synchronization clock signal.

EVALUATION BOARD SCHEMATIC AND ARTWORK

ADP2384 SCHEMATIC

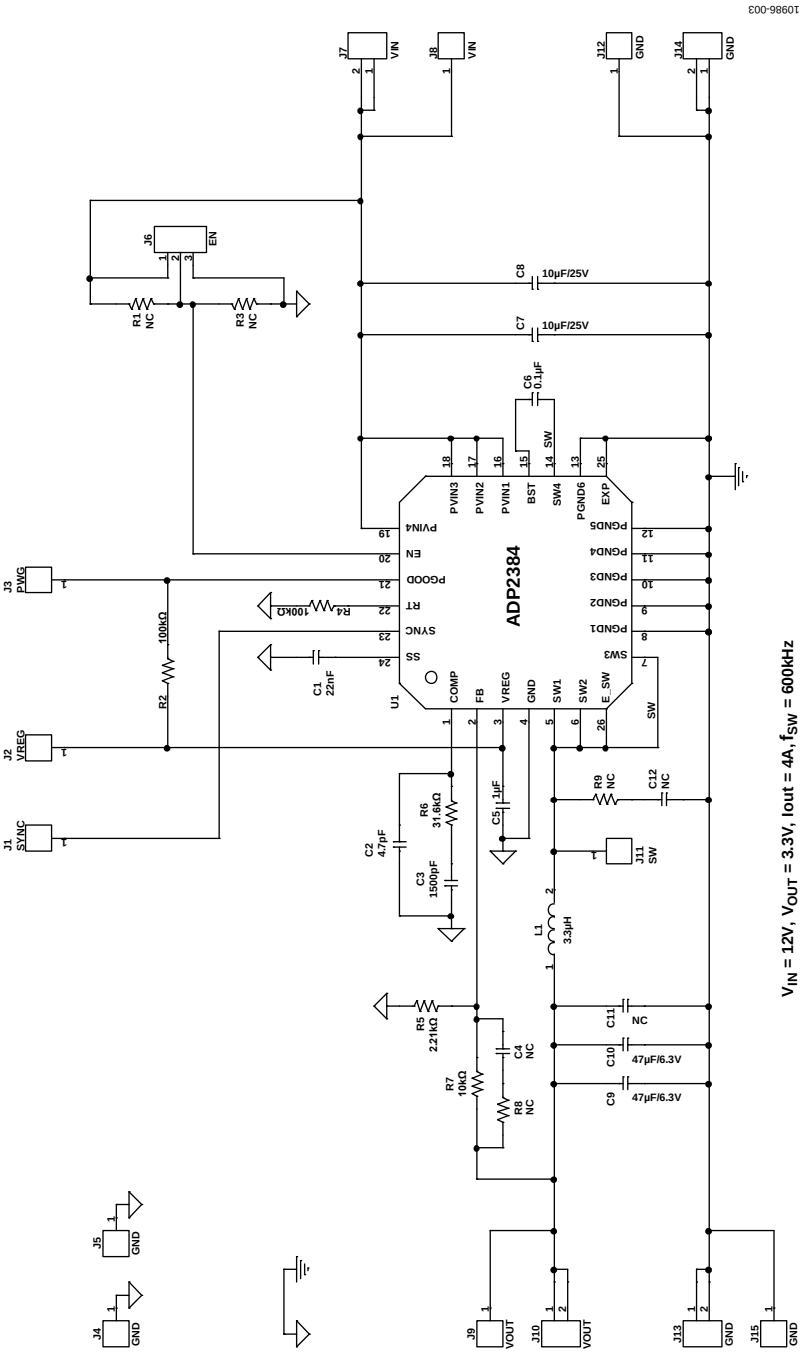


Figure 3. Evaluation Board Schematic for ADP2384

ADP2386 SCHEMATIC

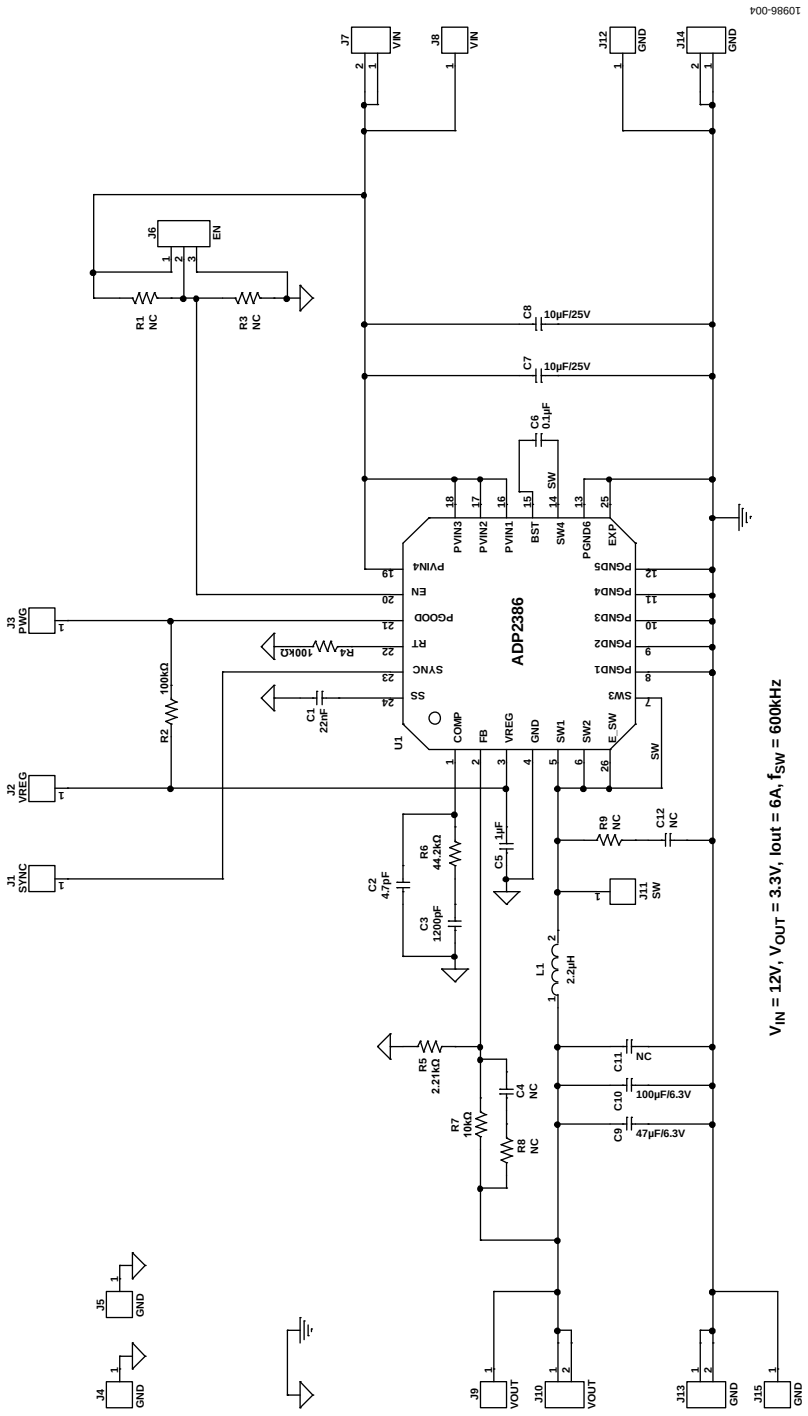


Figure 4. Evaluation Board Schematic for ADP2386

PCB LAYOUT

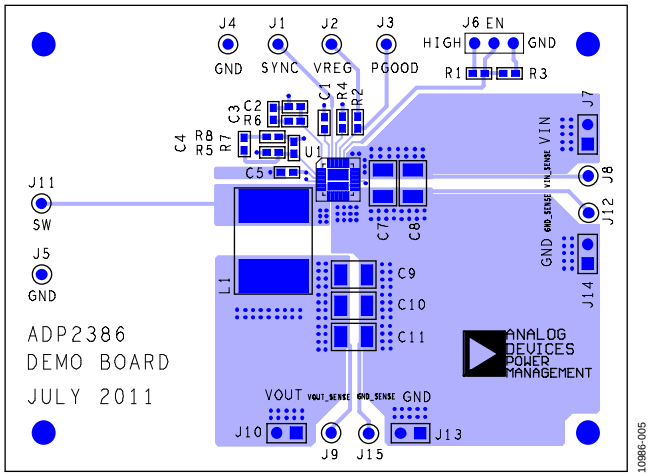


Figure 5. Layer 1, Component Side

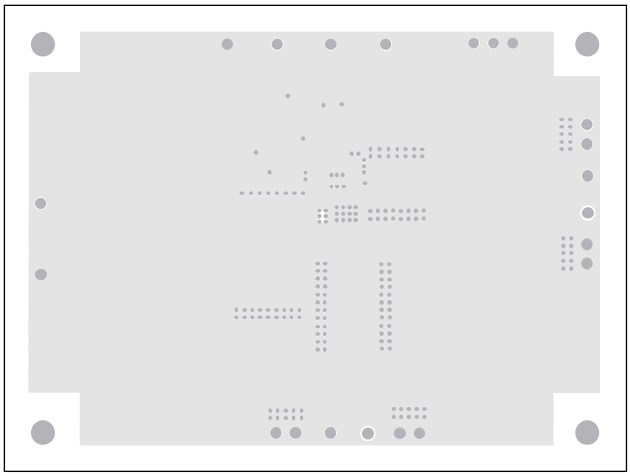


Figure 7. Layer 2, Ground Plane

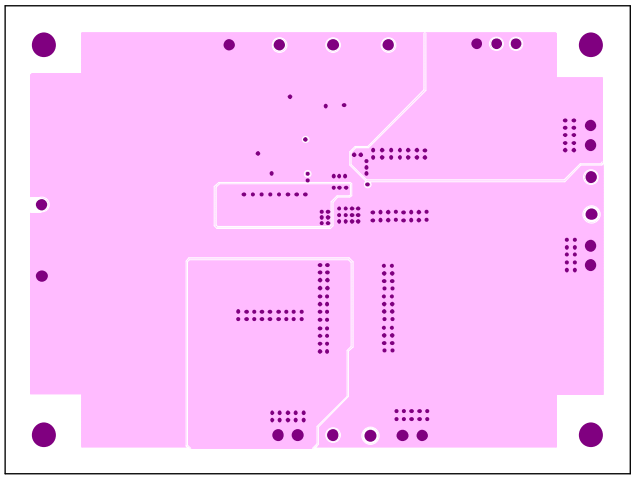


Figure 6. Layer 3, Power Plane

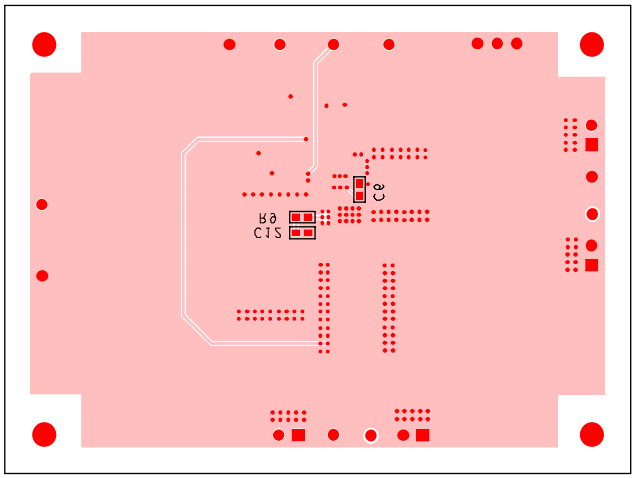


Figure 8. Layer 4, Bottom Side

ORDERING INFORMATION

BILL OF MATERIALS

Table 2. ADP2384

Qty	Reference Designator	Description	Part Number/Vendor
1	C1	22 nF, 16 V, capacitor, 0603	GRM188R71C223KA01D/Murata
1	C2	4.7 pF, 50 V, capacitor, 0603	GRM1885C1H4R7CZ01D/Murata
1	C3	1500 pF, 50 V, capacitor, 0603	GRM188R71H152KA01D/Murata
2	C4, C12	Optional, capacitor, 0603	Optional/Murata
1	C5	1 µF, 16 V, capacitor, 0603	GRM188R61C105KA93D/Murata
1	C6	0.1 µF, 16 V, capacitor, 0603	GRM188R71C104KA01D/Murata
2	C7, C8	10 µF, 25 V, capacitor, 1206	GRM31CR61E106MA12L/Murata
2	C9, C10	47 µF, 6.3 V, capacitor, 1210	GRM32ER70J476KE19L/Murata
1	C11	Optional, capacitor, 1210	Optional/Murata
1	L1	Inductor, FDVE1040, L = 3.3 µH, I_{RAT} = 9.8 A, DCR = 9.2 mΩ	FDVE1040-3R3M/Toko
4	R1, R3, R8, R9	Optional, resistor, 0603	Optional/Vishay Dale
2	R2, R4	100 kΩ, 1%, resistor, 0603	CRCW0603100KFKEA/Vishay Dale
1	R5	2.21 kΩ, 1%, resistor, 0603	CRCW06032K21FKEA/Vishay Dale
1	R6	31.6 kΩ, 1%, resistor, 0603	CRCW060331K6FKEA /Vishay Dale
1	R7	10 kΩ, 1%, resistor, 0603	CRCW060310K0FKEA/Vishay Dale
1	U1	20 V, 4 A, synchronous, step-down regulator, 24-lead, LFCSP_WQ, with exposed paddles	ADP2384/Analog Devices, Inc.
10	J1, J2, J3, J4, J5, J8, J9, J11, J12, J15	Test point, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, SIP1	M20-9990245/Harwin
4	J7, J10, 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
1	J6	Jumper, 0.1-inch header, 3-way, SIP3	M20-9990346/Harwin

Table 3. ADP2386

Qty	Reference Designator	Description	Part Number/Vendor
1	C1	22 nF, 16 V, capacitor, 0603	GRM188R71C223KA01D/Murata
1	C2	4.7 pF, 50 V, capacitor, 0603	GRM1885C1H4R7CZ01D/Murata
1	C3	1200 pF, 50 V, capacitor, 0603	GRM188R71H122KA01D/Murata
2	C4, C12	Optional, capacitor, 0603	Optional/Murata
1	C5	1 µF, 16 V, capacitor, 0603	GRM188R61C105KA93D/Murata
1	C6	0.1 µF, 16 V, capacitor, 0603	GRM188R71C104KA01D/Murata
2	C7, C8	10 µF, 25 V, capacitor, 1206	GRM31CR61E106MA12L/Murata
1	C9	47 µF, 6.3 V, capacitor, 1210	GRM32ER70J476KE19L/Murata
1	C10	100 µF, 6.3 V, capacitor, 1210	GRM32ER60J107ME20L /Murata
1	C11	Optional, capacitor, 1210	Optional/Murata
1	L1	Inductor, FDVE1040, L = 2.2 µH, I_{RAT} = 11.4 A, DCR = 6.1 mΩ	FDVE1040-2R2M/Toko
4	R1, R3, R8, R9	Optional, resistor, 0603	Optional/Vishay Dale
2	R2, R4	100 kΩ, 1%, resistor, 0603	CRCW0603100KFKEA/Vishay Dale
1	R5	2.21 kΩ, 1%, resistor, 0603	CRCW06032K21FKEA/Vishay Dale
1	R6	44.2 kΩ, 1%, resistor, 0603	CRCW060344K2FKEA /Vishay Dale
1	R7	10 kΩ, 1%, resistor, 0603	CRCW060310K0FKEA/Vishay Dale
1	U1	20 V, 6 A, synchronous, step-down regulator, 24-lead, LFCSP_WQ, with exposed paddles	ADP2386/Analog Devices, Inc.
10	J1, J2, J3, J4, J5, J8, J9, J11, J12, J15	Test point, 2.54 mm pitch SIL vertical PC tail pin header, 6.1 mm mating pin height, tin, SIP1	M20-9990245/Harwin
4	J7, J10, 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
1	J6	Jumper, 0.1-inch header, 3-way, SIP3	M20-9990346/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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