TPS60120EVM-174

Battery-Powered, Dual-Output Power Supply EVM For DSP's

User's Guide

September 2000

Power Management Products

SLVU035

Preface

About This Manual

This user's guide describes the TPS60120EVM-174 battery-powered, dual-output evaluation module (SLVP174). The SLVP174 provides a convenient method for evaluating the performance of a dual-output linear regulator.

How to Use This Manual

- Chapter 1 – Introduction
- Chapter 2 – EVM Test Setup
- Chapter 3 – Test Results

Information About Cautions and Warnings

This book may contain cautions and warnings.

CAUTION

This is an example of a caution statement.

A caution statement describes a situation that could potentially damage your software or equipment.

WARNING

This is an example of a warning statement.

A warning statement describes a situation that could potentially cause harm to you.

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

Related Documentation From Texas Instruments

- TPS70751 data sheet (literature number SLVS291)
- TPS60120 data sheet (literature number SLVS257B)
- TPS60120EVM-142 user’s guide (literature number SLVU022)

Trademarks

PowerPAD is a trademark of Texas Instruments.

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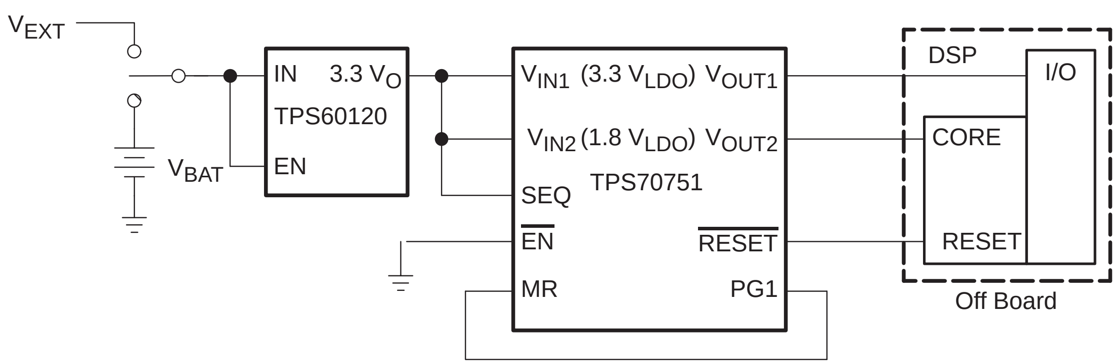
Chapter 1

Introduction

This user's guide describes the TPS60120EVM-174 battery-powered, dual-output power supply evaluation module (SLVP174). This power supply solution is comprised of a TPS60120 low-power dc/dc converter and a TPS70751 dual LDO regulator with integrated supervisory and power-up sequencing circuitry. Figure 1-1 shows a block diagram of the EVM. The DSP is not part of the EVM.

Figure 1–1. TPS60120EVM-174 Configuration



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The EVM allows the user to select either two AA batteries in series or an external power supply as the input supply for the dc/dc converter. As shown in the block diagram in Figure 1–1, the TPS60120 converter generates a 3.3-V output voltage and can provide up to 200 mA of output current. The 3.3-V converter output voltage is the input for both of the regulators on the TPS70751. Using its power-up sequencing circuitry, the TPS70751 powers up its 1.8-V output before its 3.3-V output. The supervisory circuitry reset signal is low until both voltages are within a certain threshold of regulation. This configuration is designed to provide a complete power management solution for battery powered DSP, ASIC, and other low-power applications where two independent supply voltages are required.

1.1 Low-Power DC/DC Converter

Low-power dc/dc converters with internal charge pumps use a capacitor instead of an inductor or transformer for energy storage. The Texas Instruments TPS60120 is one of these low-power dc/dc converters and performs as a regulated voltage multiplier. Some of the key features of the TPS60120 include:

- Up to 200-mA output current from 1.8-V to 3.6-V input voltage range
- Regulated 3.3-V ±4% output
- Only four external capacitors are required
- Up to 90% efficiency
- Only 55-µA quiescent supply current
- 0.055-µA current in shutdown mode
- Low-battery indicator
- Available in thermally enhanced TSSOP package (PowerPAD™)

For a complete functional description, refer to the TPS60120 data sheet, SLVS257, and the Charge Pump application note, SLVA070.

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1.2 LDO Regulator

LDO regulators use a series pass element, feedback network, including an error amplifier and voltage reference to provide a regulated output voltage from a slightly larger and variable input voltage. Specific features of the TPS707xx family of dual LDO regulators include:

- Fixed and adjustable dual-output voltages optimized for low power DSPs and processor power supplies
- Logic selectable power-up sequencing
- Output currents of 250 mA (regulator 1) and 125 mA (regulator 2)
- Fast response to line and load transient allows use of small, low cost capacitors
- Integrated supervisory circuit (SVS) with 120-ms delayed open-drain $\overline{\text{RESET}}$
- Low quiescent current (approximately 190 μA), and low dropout to reduce power and prolong battery operating life
- Output noise only 65 μV_{RMS}
- Small PowerPAD™ TSSOP packaging

See the TPS707xx family data sheet (SLVS291) for further explanation.

1.3 Design Strategy

The demand for smaller electronic devices is driving the need for innovative battery powered solutions including smaller batteries because smaller batteries provide smaller voltages. Since the battery supply voltages vary over the life of the battery, it is necessary to have a dc/dc converter capable of providing a regulated output over a wide range of input voltages. For example, AA alkaline batteries have a rated output voltage of 1.5 V but typically provide 1.2 – 1.5 V over most of their life and finally fall to 0.9 V near the end of their life. NiHM and NiCd rechargeable batteries have a rated output voltage of 1.2 V but typically provide 1.4 V over most of their life and also fall to 1 V near the end of their life. With its 1.5x or 2x voltage multiplication modes, the TPS60120 converter is an ideal solution for efficiently providing a regulated 3.3 V from batteries whose end of life voltage falls well below the required 3.3 V. With a minimum input of 1.8 V, the TPS60120 continues to supply power over the entire usable life of alkaline, NiCd, and NiMH batteries. The TPS60120 also provides an input voltage monitoring feature and an open drain output pin which is pulled high when the input voltage falls below a user determined threshold. In this application, the threshold is resistor-divider selected as 1.8 V, and the open-drain output activates a red LED in the event of a low-battery condition.

Today’s advanced DSPs and microprocessors are designed with the processor’s core operating at a lower voltage than the input/output (I/O) cells that communicate with the peripherals in the external system. Without proper power-up sequencing, the long term reliability of many DSP systems can be compromised when one rail is powered and the other rail is left inactive for extended periods of time. In addition, bus contention, a condition when the processor and another device both attempt to control a bidirectional bus during power up, can affect I/O hardware reliability without proper power-up sequencing. To provide proper power-up sequencing of the separate 1.8-V core and the 3.3-V I/O voltage, the TPS70751 dual regulator was chosen. With the sequence pin tied high, regulator 2 of the TPS70751 is enabled first and provides the regulated 1.8-V core output. When the core output reaches approximately 95% of its regulated voltage, regulator 1 is enabled and provides the 3.3-V core voltage. Had sequencing not been a concern, a single LDO regulator could have provided a 1.8-V core output and the TPS60120 dc/dc converter could have provided the 3.3-V I/O output directly. In this configuration, regulator 1 of the TPS70751 operates as a switch to ensure that the I/O voltage powers up after the core voltage. In addition, the output capacitors of regulator 1 provide some filtering to reduce some of the ripple on the dc/dc converter’s output. Also included in this implementation is a Schottky diode with cathode connected to the 1.8-V core voltage and anode connected to the 3.3-V I/O voltage. The diode provides additional protection for long-term reliability and against bus contention issues by ensuring that the rails are never more than 0.3 V apart during power up.

As with any power solution, the output voltages should be monitored to ensure that the electronics are properly notified and shut down if the voltages fall below a predetermined threshold. The TPS70751 monitors both 3.3-V and 1.8-V outputs and provides an open drain, active low, 120-ms delayed $\overline{\text{RESET}}$ output. Therefore, the application on this EVM is designed to provide a complete power management solution for battery powered DSP, ASIC, and other digital applications where two independent supply voltages are required.

The TPS60120EVM174 from TI provides a convenient method for evaluating this dual power supply solution as well as the individual operation of the TPS60120 dc/dc converter and the TPS70751 dual LDO regulator.

1.4 Adjustment by Switch and Jumpers

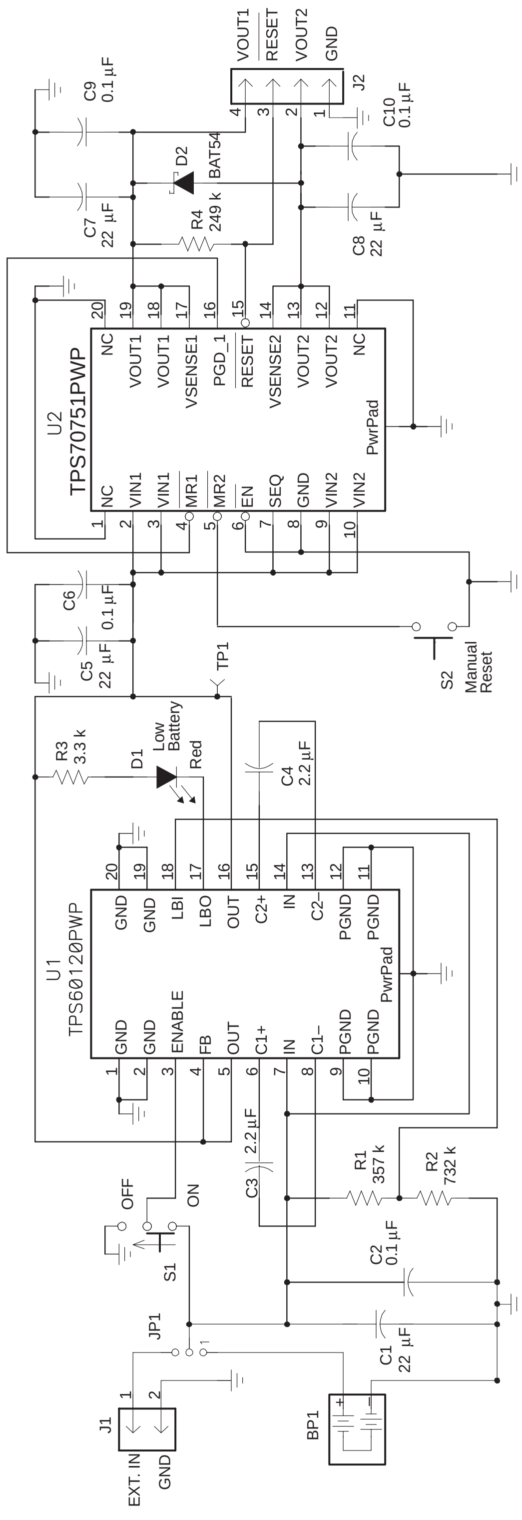
The schematic for the EVM is provided in Figure 1-2.

- S1 – Toggleswitch S1 is used to enable or disable the TPS60120.
- S2 – Push button switch S2 is connected to the manual reset input of the TPS70751. Depressing the button will cause the RESET output of the dual regulator to toggle.
- JP1 – Jumper JP1 is used to select the input voltage for the charge pump as either the external power supply or the battery pack as labeled on the board.
- TP1 – Test point TP1 can be used to measure the output voltage of the charge pump.

1.5 Schematic

Figure1–2 shows the TPS60120EVM-174 schematic diagram.

Figure 1–2. TPS60120EVM-174 Schematic Diagram



1.6 Bill of Materials

Table 1–2 lists materials required for the TPS60120EVM-174.

Table 1–1. TPS60120EVM-174 Bill of Materials

Ref Des	Qty	Part Number	Description	MFG	Size
BP1	1	BH2AA–PC	Battery holder, 2 AA cells, PC mount	MPD	
C2, 6, 9, 10	4	GRM39X7R104K016	Capacitor, ceramic, 0.1 µF, 16 V, X7R	muRata	603
C3, 4	2	GMK316F225ZG	Capacitor, ceramic, 2.2 µF, 35 V, Y5V+80/–20%	Taiyo-Yuden	1206
C1, 5, 7, 8	4	GRM235Y5V226Z010	Capacitor, ceramic, 22 µF, 10 V, Y5V, +80/–20%	muRata	1210
D1	1	CMD28–21SRC/TR8	Diode, LED, red, 20 mA, 11.0	Chicago Mini	CMD28
D2	1	BAT54	Diode, Schottky, 200 mA, 30 V	Vishay-Liteon	SOT23
J1	1	ED1660	Header, 2-pin, 5 mm spacing	OST	
J2	1	ED1662	Header, 4-pin, 5 mm spacing	OST	
JP1	1	PTC36SAAN	Header, 3-pin, 100 mil spacing, (36 pin strip)	Sullins	
R1	1	Std	Resistor, chip, 375 kΩ, 1/10 W, 1%		805
R2	1	Std	Resistor, chip, 732 kΩ, 1/10 W, 1%		805
R3	1	Std	Resistor, chip, 3.3 kΩ, 1/10 W, 5%		805
R4	1	Std	Resistor, chip, 250 kΩ, 1/10 W, 1%		805
S1	1	EG1218	Switch, 1P2T, slide, PC mount, 200 mA	E_Switch	
S2	1	EVQ–PJA04Q	Switch, 1P1T, PB momentary, 50 mA	Panasonic	
U1	1	TPS60120PWP	IC, charge pump, regulated 3.3 V, 200 mA	TI	PWP20
U2	1	TPS70751PWP	IC, dual-output LDO regulators w/sequencing for DSP systems	TI	PWP20
TP1	1	240-345	Test point, red, 1 mm	Farnell	

1.7 Board Layout

Figures 1–3 and 1-4 show the board layout for the TPS60120EVM-174.

Figure 1–3. Top Layer

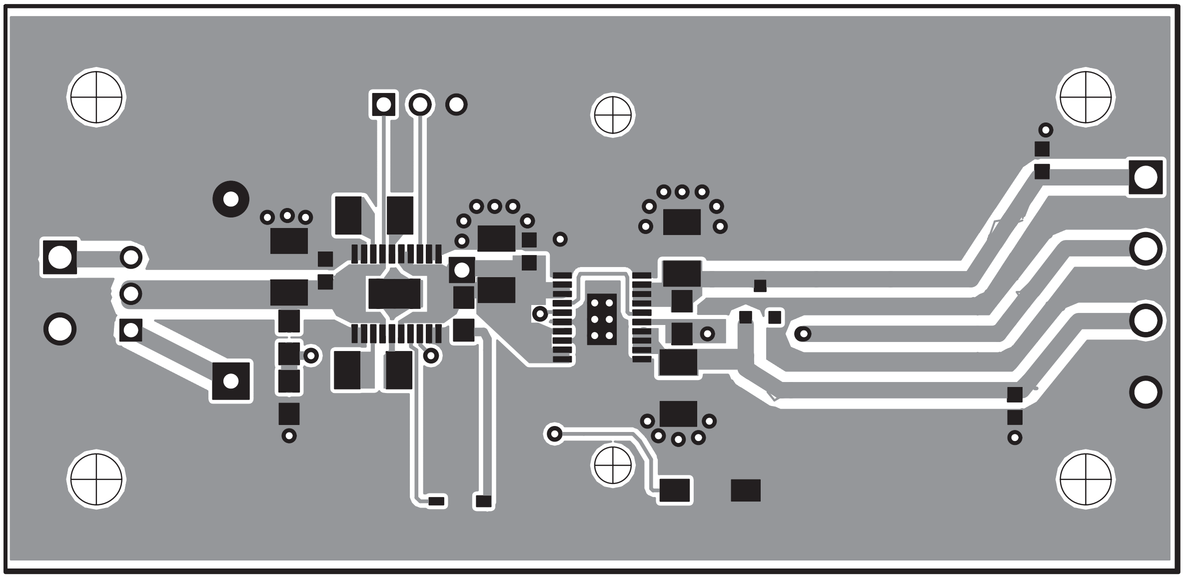


Figure 1–4. Bottom Layer (top view)

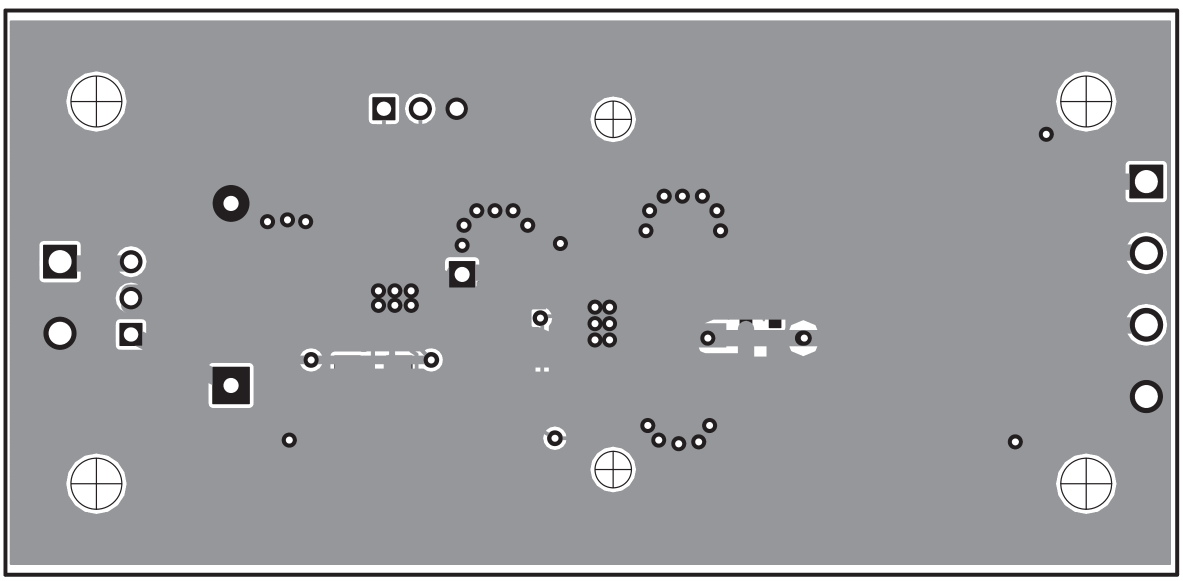
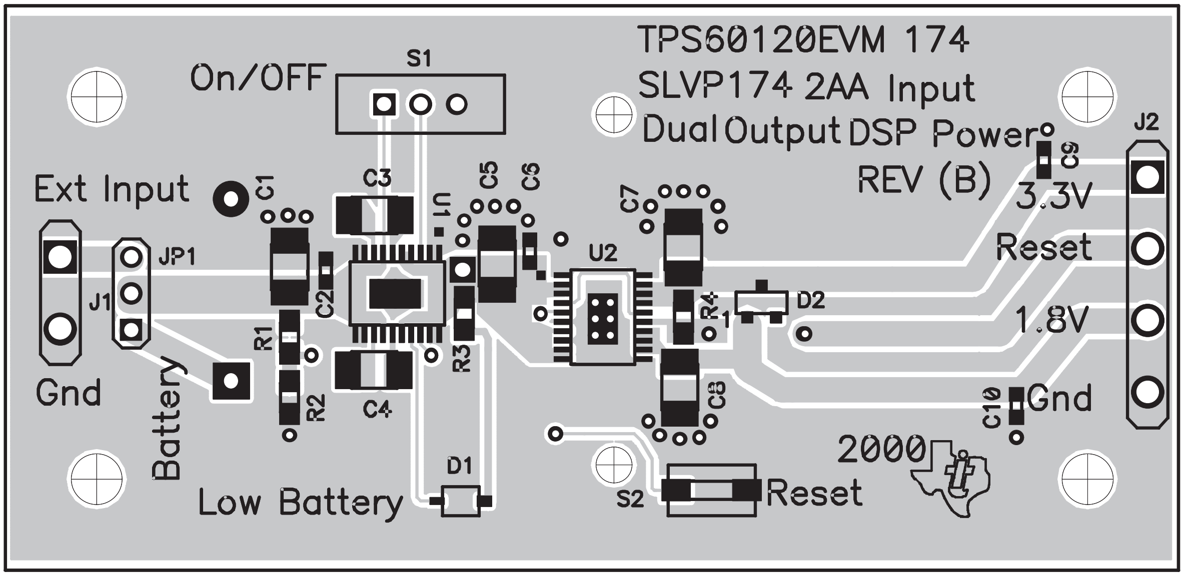


Figure 1–5. Assembly



EVM Test Setup

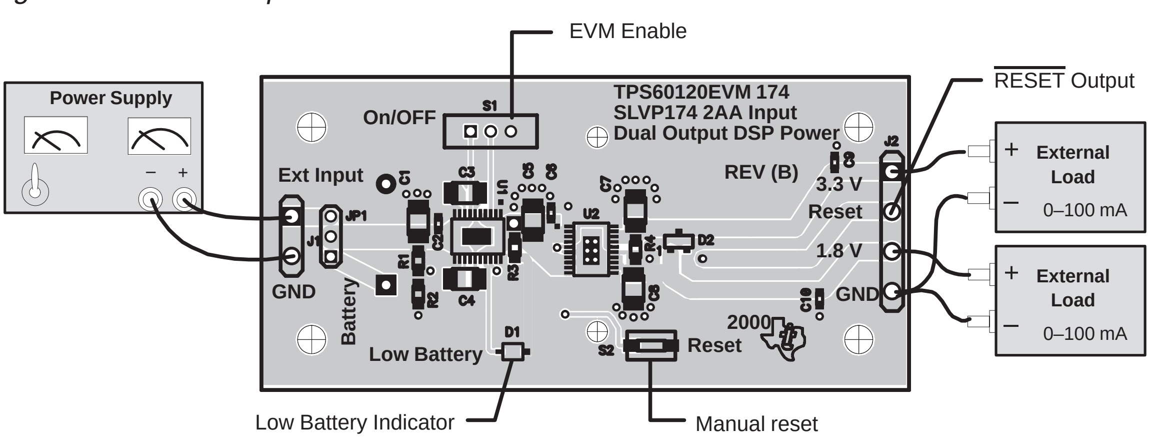
This chapter provides a recommended test setup. Figure 2–1 shows the test setup. Follow these steps for initial power up of the SLVP174:

1) Adjust the settings of the jumpers to fit test requirements. If the battery pack is selected as the input, install two AA alkaline batteries into the battery pack on the back of the board. If an external supply is selected as the input, connect another voltage source (e.g. power supply or external batteries) to the EXT INPUT and GND input pins of the board. The external voltage source should supply no more than 3.6 V, the maximum recommended input voltage for the TPS60120.

2) If desired, connect an external load to either or both outputs. The load should not exceed 200 mA on the 3.3-V charge pump output if it is the only loaded output. The load should not exceed 100 mA on either the 3.3-V or the 1.8-V output if both devices are loaded. Use of short leads on the external load will prevent loss of performance due to capacitive loading and/or inductive effects.

3) Connect measurement devices to the test points and output pins as desired. For a more precise measurement of noise and/or ripple at the output of the charge pump, use an ac-coupled oscilloscope with either a differential probe placed directly across the output capacitor (C5), or connect a regular scope probe with as short of a ground lead as possible across the output capacitor of the charge pump.

Figure 2–1. Test Setup



Chapter 3

Test Results

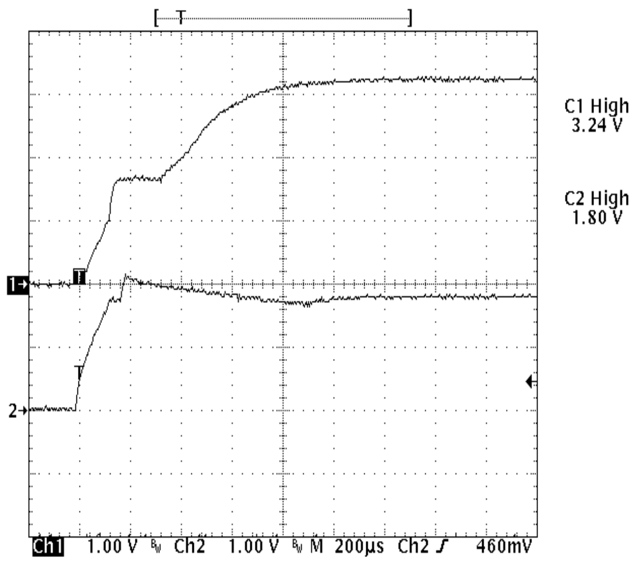
This chapter presents laboratory test results for the TPS60120EVM-174.

3.1 Test Results

Figures 3–1 through 3–6 show the results of various test conditions using the TPS60120EVM-174.

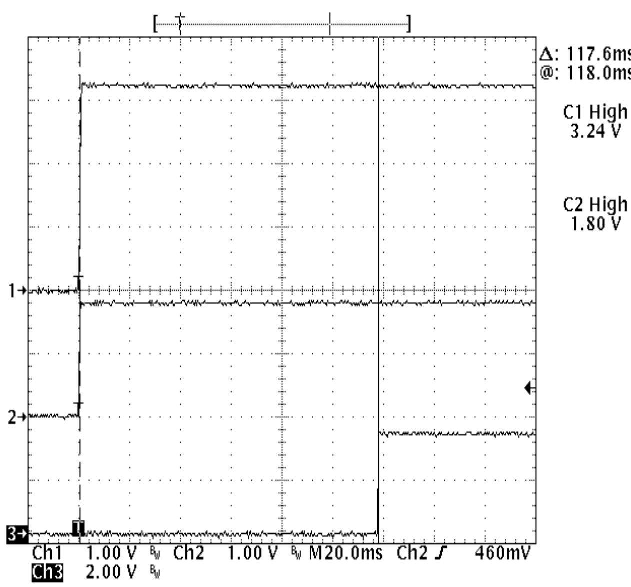
Figures 3–1 shows the startup curves of the 3.3-V output (CH1) and 1.8-V output (CH2) of the EVM. Each at no load using switch SW1 to manually trigger start up.

Figure 3–1. Start-Up Curves (TPS70751)



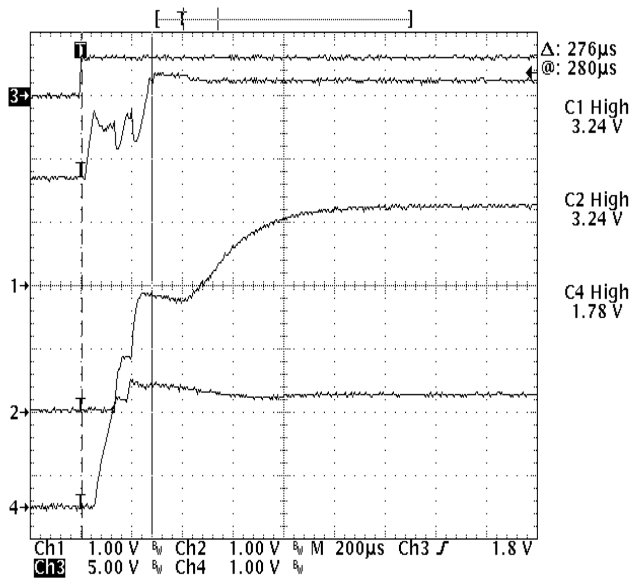
Figures 3–2 shows the same measurement as in Figure 3–1 except for a longer time period. It demonstrates the operation of the TPS70751 supervisory circuit $\overline{\text{RESET}}$ output (CH3).

Figure 3–2. Start-Up Curves (TPS70751) Over an Extended Period



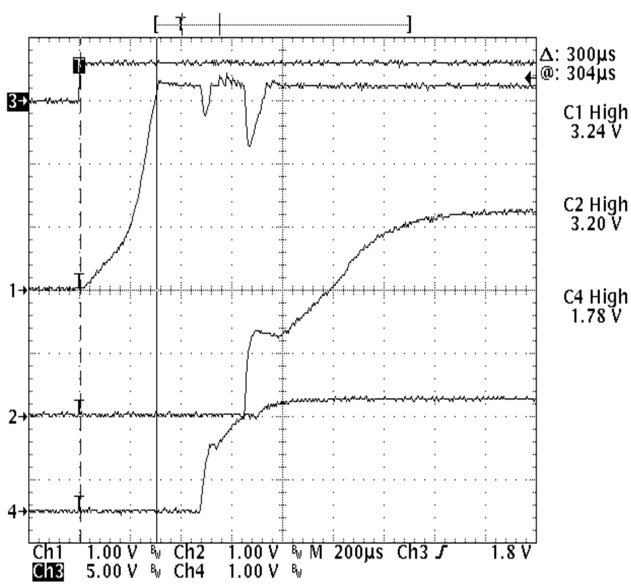
Figures 3–3 shows the startup curves of the TPS60120, 3.3-V output(CH1), and the TPS70751, 3.3-V output (CH1) and 1.8-V output (CH2). Switch SW1 was disconnected and the TPS60120 ENABLE (CH3) pin was enabled using a pulse generator. Both TPS70751 outputs have 1 mA loads. The TPS60120 output is distorted due to the load on the charge pump from the charging of the TPS70751 output capacitors and the 1 mA loads.

Figure 3–3. Start-Up Curves (TPS60120 and TPS70751)



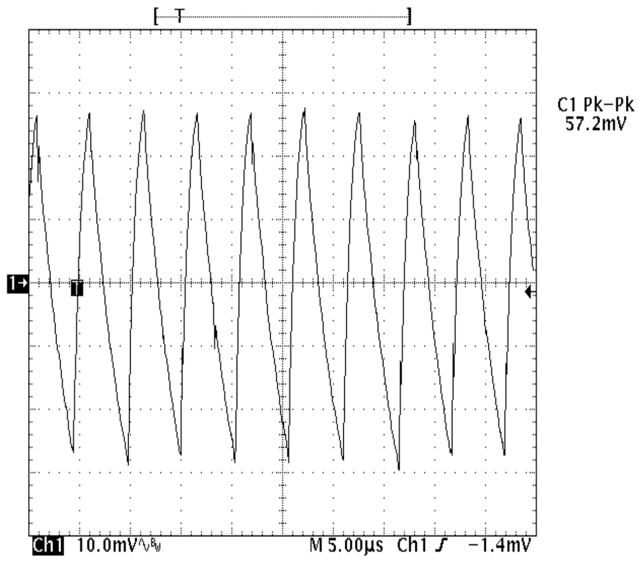
Figures 3–4 is the same as Figure 3–3 except that the TPS60120 (CH1) now has a 1 mA load and the Schottky diode between the TPS70751 has been removed. This figure shows the startup curves if no Schottky diode is used.

Figure 3–4. Start-Up Curves(TPS60120 With a 1 mA Load and TPS70751)



Figures 3–5 shows an ac measurement of the TPS60120, 3.3-V output, with each TPS70751 output loaded with 100 mA.

Figure 3–5. AC Measurements (TPS60120)



Figures 3–6 shows an ac measurement of the TPS70751, 3.3-V output (CH1) and 1.8-V output (CH2), each loaded with 100 mA. The TPS70751 3.3-V output capacitors provide some filtering of the TPS60120 3.3-V output waveform shown in Figure 3–5.

Figure 3–6. AC Measurements (TPS70751)