LT80603EVKIT#

Evaluates: LT80603, LT80602 in 5V Output-Voltage Application

Description

The LT80603EVKIT# (EV kit) is a proven 5V design to evaluate the LT80603 synchronous step-down *Silent Switcher*®. The EV kit is designed for a 5V output. The wide input range up to 65V allows a variety of input sources, such as automotive batteries and industrial supplies. The LT80603 is a compact, ultralow electromagnetic interference (EMI) emission, high-efficiency, high-speed synchronous monolithic step-down switching regulator that consumes only 8µA of quiescent current when the output is regulated at 5V. The top and bottom power switches, compensation components, and other necessary circuits within the LT80603 minimize the need for external components and simplify the design. The EV kit can also evaluate the LT80602, LT80603A, LT80603HV, LT80602HV, and LT80603AHV. Refer to the IC datasheet guidelines when modifying the schematic to achieve optimal performance.

The application circuit demonstrated in the evaluation board is suitable for a wide range of automotive, telecom, industrial, and other applications.

The LT80603 data sheet provides a complete description of the part, its operation, and application information. Consult the data sheet in conjunction with this EV kit.

Design files for this circuit board are available at *https://www.analog.com/en/products/LT80603.html*.

Features and Benefits

- Silent Switcher Architecture, Ultralow EMI Emissions
- Input Voltage Range up to 65V
- 400kHz Switching Frequency
- High 92.6% Efficiency (V_{IN} = 24V, I_{OUT} = 3.5A)
- 8µA I_Q Regulating $24V_{IN}$ to $5V_{OUT}$
- On-the-Fly Mode Change Among Burst Mode, Pulse-Skipping Mode (PSM), and Forced Continuous Mode (FCM)
- 99% Duty-Cycle Operation
- 0.75µA Shutdown Current
- Bias Bootstrap Input for Improved Efficiency
- Burst and Pulse Skipping Modes to Enable Enhanced Light-Load Efficiency
- Programmable Soft-Start and Tracking
- Built-in Output-Voltage Monitoring and Die Temperature Monitoring with PG/T_J
- Overtemperature and Overcurrent Protection
- External Clock Synchronization
- Proven PCB Layout
- Fully Assembled and Tested
- Complies with CISPR 25 Class 5 Conducted and Radiated Emissions

***Ordering Information* appears at end of data sheet.**

Rev 0; 1/26

Quick Start

Required Equipment

- 65V, 3.5A DC power supply
- Digital multimeter (DMM)
- Load resistors capable of sinking up to 3.5A

Procedure

The EV kit is fully assembled and tested. See *Figure 1* for proper measurement equipment setup, use the following procedure.

1. Set an input power supply capable of 65V/3.5A. Then, turn off the supply.
2. Connect the input power supply to the input terminals V_{IN_EMI} and PGND to check the EMI performance of the EV kit. Connect the input power supply to the input terminals V_{IN} and PGND to operate without the EMI filter.
3. Place a voltmeter across the input voltage sense terminals V_{IN_SENSE} and PGND to get an accurate input voltage measurement.
4. Connect a variable load capable of sinking 3.5A at 5V to the output terminals V_{OUT} and PGND. Set the current to 0A.
5. Place a voltmeter across the output voltage sense terminals V_{OUT_SENSE} and PGND to get an accurate output voltage measurement.
6. Verify the shunts are not installed across pins on jumper JU1. See *Table 1* for more details.
7. Verify the shunts are installed properly across pins on jumper JU2. See *Table 2* for more details.
8. Verify the shunts are installed properly across pins on jumper JU3. See *Table 3* for more details.
9. Turn on the power at the input.

Note: Ensure that the input voltage never exceeds 65V.

10. Check for the proper output voltage of 5V.
11. Adjust the load and/or input within the operating range and observe the output voltage regulation, ripple voltage, efficiency, and other desired parameters.

Note: When measuring the input or output voltage ripple, take care to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip directly across the output capacitor. See *Figure 2* for the proper scope technique.

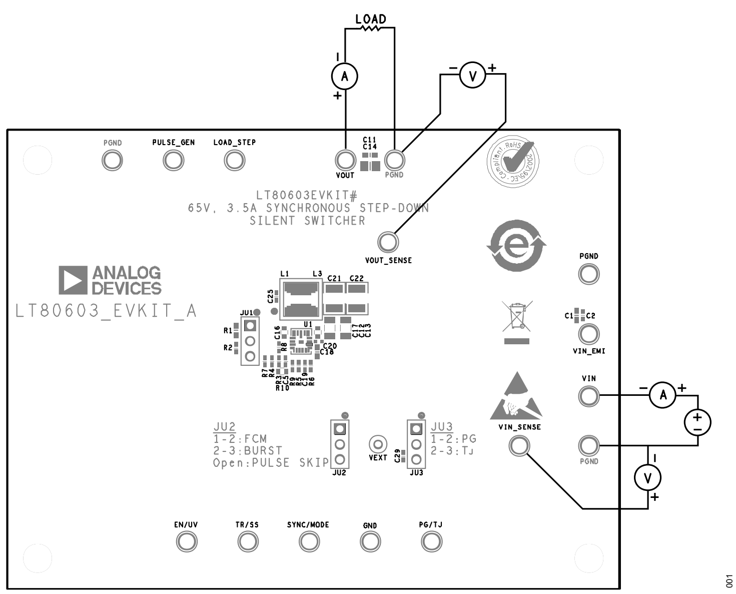


Figure 1. Proper Measurement Equipment Setup

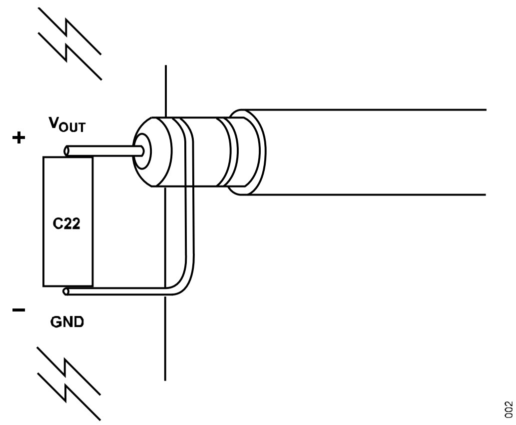


Figure 2. Measuring Output Ripple

Typical Performance Characteristics

(V_{IN} = $V_{EN/UV}$ = 24V, C_{INTVCC} = 2.2μF, V_{GND} = V_{GND1} = V_{GND2} = 0V, $V_{BIAS/VOUT}$ = V_{OUT}, C_{SS} = 8.2nF, T_A = +25°C, unless otherwise noted.)

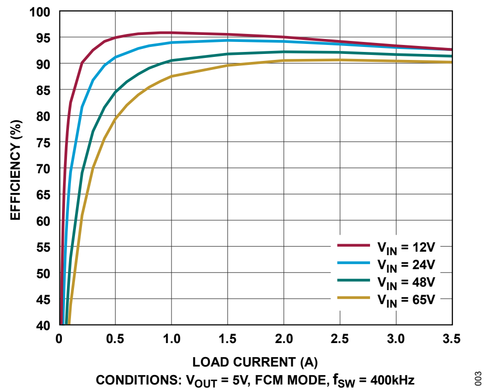


Figure 3. Efficiency vs. Load Current

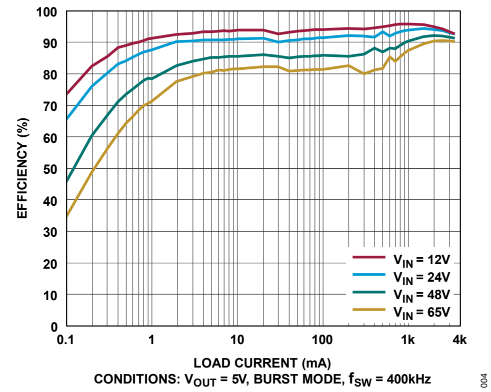


Figure 4. Efficiency vs. Load Current

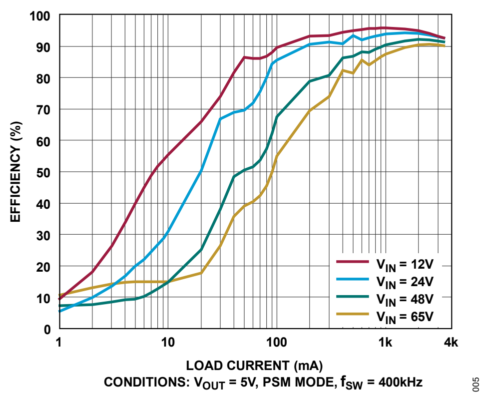


Figure 5. Efficiency vs. Load Current

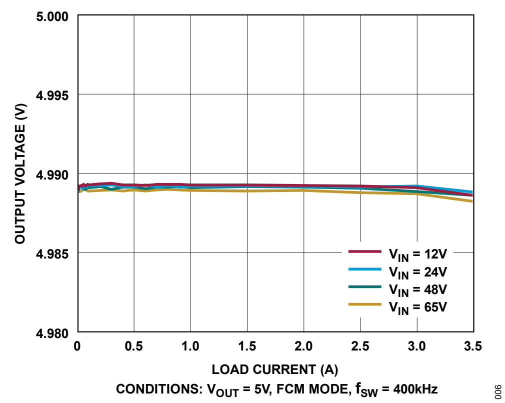


Figure 6. Output Voltage vs. Load Current

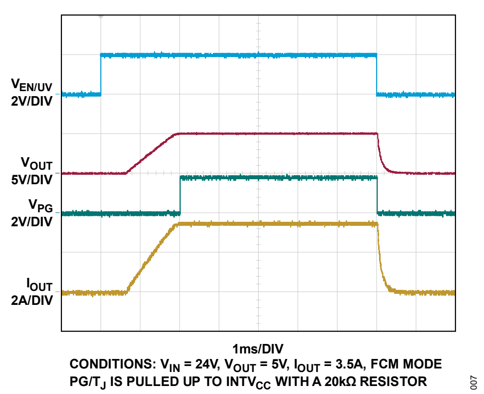


Figure 7. Startup/Shutdown through EN/UV

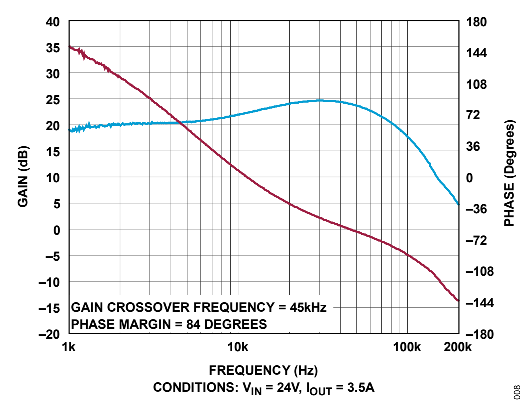


Figure 8. Gain/Phase vs Frequency

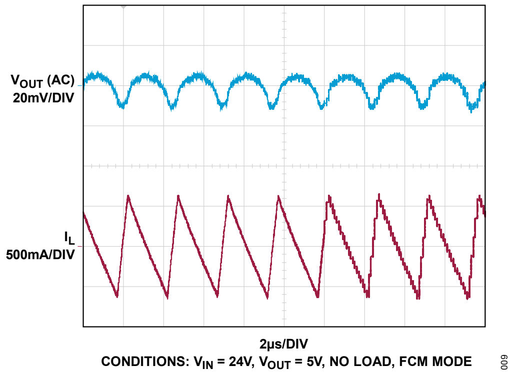


Figure 9. Steady State Switching Waveform

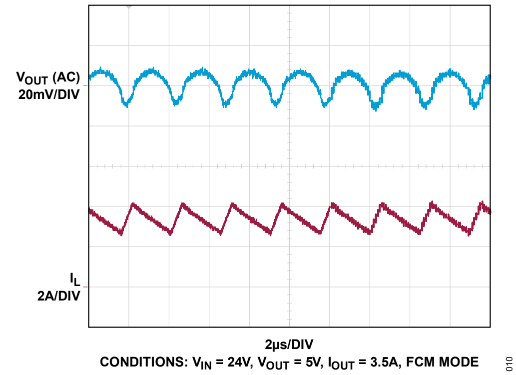


Figure 10. Steady State Switching Waveform

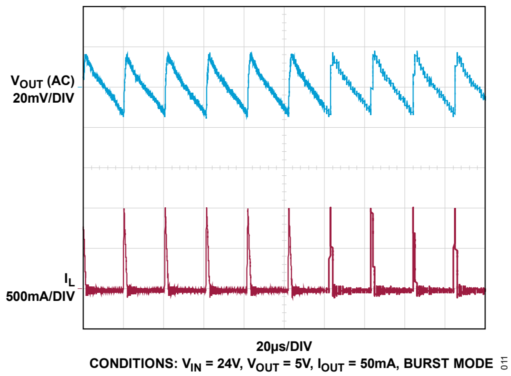


Figure 11. Steady State Switching Waveform

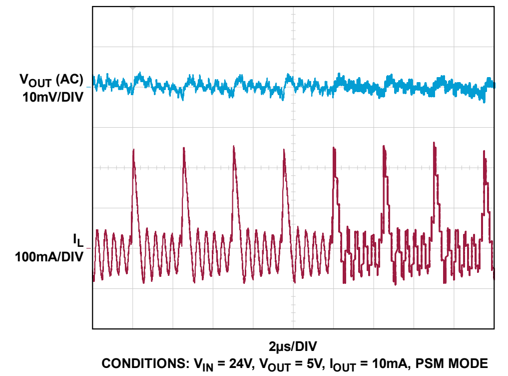


Figure 12. Steady State Switching Waveform

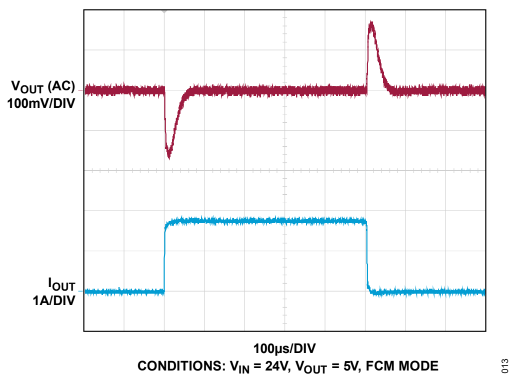


Figure 13. Load Current Stepped from 10mA to 1.75A

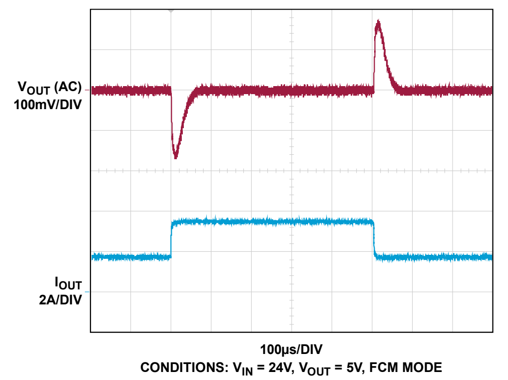


Figure 14. Load Current Stepped from 1.75A to 3.5A

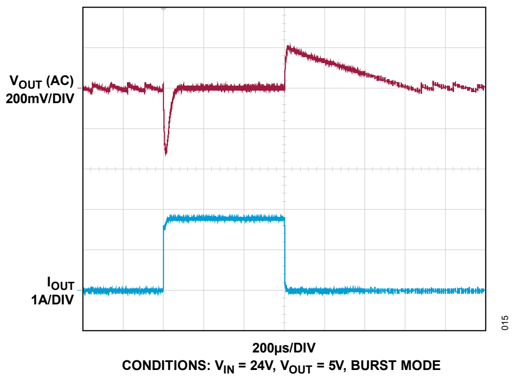


Figure 15. Load Current Stepped from 10mA to 1.75A

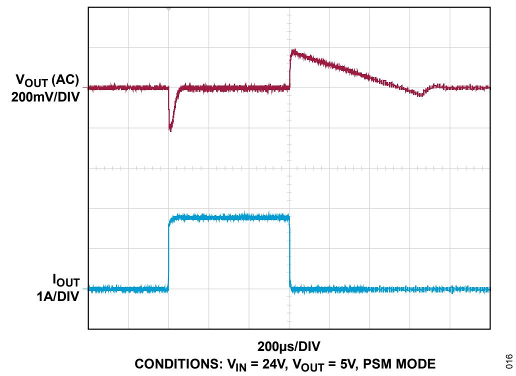


Figure 16. Load Current Stepped from 10mA to 1.75A

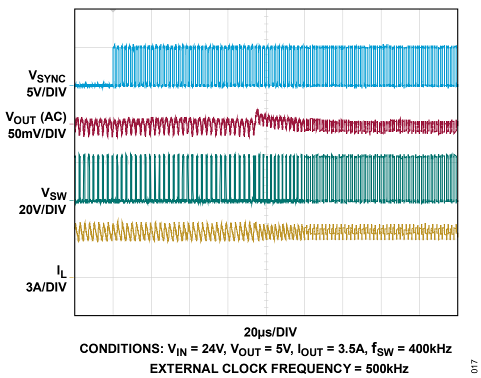


Figure 17. External Clock Synchronization

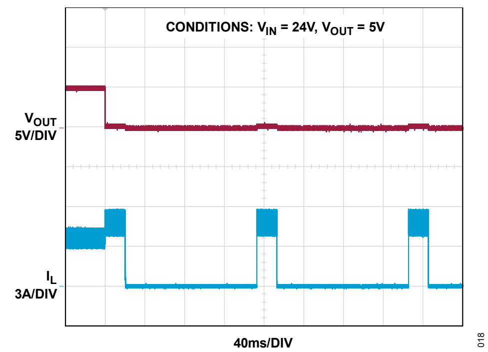


Figure 18. Output Short

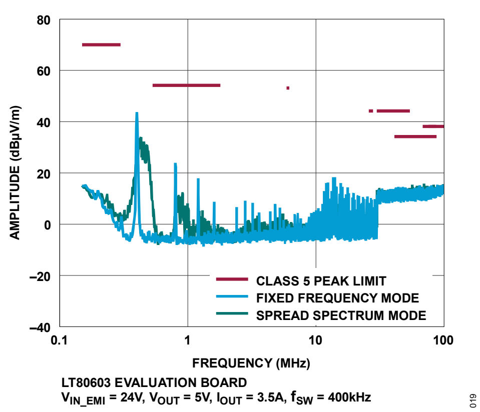


Figure 19. CISPR25 Conducted Emission Test with Class 5 Peak Limits

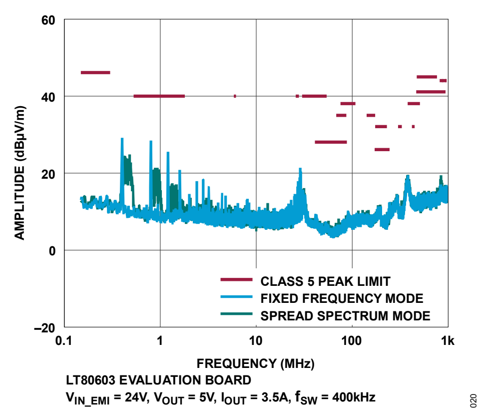
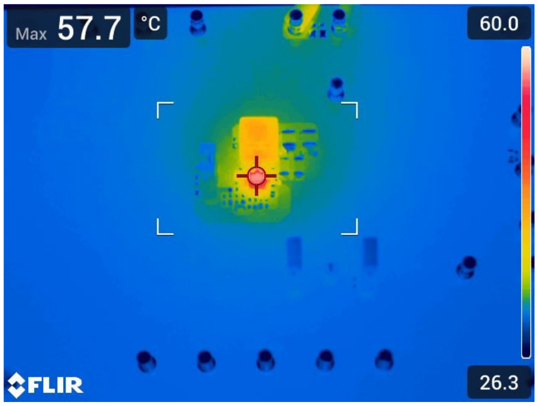


Figure 20. CISPR25 Radiated Emission Test with Class 5 Peak Limits



LT80603 EVALUATION BOARD
CONDITIONS: 5V OUTPUT, 3.5A, f_{SW} = 400kHz

021

Figure 21. Thermal Image with V_{IN} = 24V

Detailed Description

The LT80603EVKIT# is designed to demonstrate the salient features of the LT80603 synchronous step-down Silent Switcher®. The EV kit is preset for a 5V output and can handle input voltage up to 65V at load currents up to 3.5A. It also features a 400kHz switching frequency for optimum efficiency and component size.

Enable/UVLO (EN/UV) Programming

The LT80603 offers an adjustable input undervoltage lockout feature. When JU1 is left open, the LT80603 is enabled when the input voltage rises above 4.5V. If a shunt is installed across pins 1 to 2 on jumper JU1, the LT80603 is enabled when the input voltage rises above 2.8V (V_{IN} rising typical). To disable the LT80603, install a shunt across pins 2 to 3 on jumper JU1. See *Table 1* for JU1 settings. A potential divider formed by R1 and R2 sets the input voltage, above which the converter is enabled when JU1 is left open. Refer to the *Enable Pin* section of the *LT80603 data sheet* for more details.

The LT80603 supports external enable/disable control of the device. Leave JU1 open when external enable/disable control is desired.

Table 1. EN/UV Jumper (JU1) Settings

SHUNT POSITION	EN/UV PIN	OUTPUT
1 to 2	Connected to V_{IN}	Enabled
Not installed*	Connected to the center node of resistor-divider R1 and R2	Enabled, UVLO level is set by the resistor-divider between V_{IN} and GND
2 to 3	Connected to GND	Disabled

**Default position*

Mode Selection and External Clock Synchronization (SYNC/MODE)

The EV kit includes a jumper (JU2) that allows the LT80603 to operate in FCM, Burst mode, and Pulse-skipping modes. Refer to the LT80603 data sheet for more details on the modes of operation. *Table 2* shows the mode selection (JU2) settings used to configure the desired operating mode.

The internal oscillators of the converter can be synchronized to an external clock signal on the SYNC/MODE pin. The LT80603 also supports on-the-fly mode changes among FCM, Burst mode, and Pulse-skipping modes. Refer to the *Mode Selection and External Clock Synchronization (SYNC/MODE)* section of the *LT80603 data sheet* for more details.

Table 2. Mode Selection Jumper (JU2) Settings

SHUNT POSITION	MODE/SYNC PIN	OUTPUT
1 to 2*	Connected to GND	Force Continous Mode of Operation
Not installed	OPEN	Pulse-Skipping Mode of Operation
2 to 3	Connected to V_{CC}	Burst Mode of Operation

**Default position*

Setting the Switching Frequency

In the EV kit, a 400kHz switching frequency is chosen for the application circuit. Leaving R5 open programs the device to operate at a switching frequency of 400kHz. Refer to the *Setting the Switching Frequency* section of the *LT80603 data sheet* to choose different values of resistors for programming the required switching frequency.

BST Capacitor Selection

The BST capacitor must be selected appropriately so that it can hold sufficient charge and supply the BST to the SW rail in sleep mode. In the EV kit, the BST to SW capacitance C20 is chosen as 1µF. Refer to the *BST Capacitor Selection* section of the *LT80603 data sheet* to choose the appropriate BST capacitor value based on the programmed switching frequency and operating mode.

Output Voltage Tracking and Soft-Start

The EV kit offers an adjustable soft-start function to limit inrush current during start-up. The soft-start time is adjusted by changing the value of capacitor C19. In this EV kit, the default soft-start time is set to 1.3ms, which is programmed with an 8200pF soft-start capacitor. For output-tracking applications, TR/ SS can be externally driven by another voltage source. Refer to the *Output Voltage Tracking and Soft-Start* section of the *LT80603 data sheet* for more details.

FB Resistor Network

The output voltage is programmed using the resistor dividers R3 and R4. The EV kit is programmed to the adjustable 5V output by setting R3 = 1MΩ and R4 = 191kΩ. C5 is added to improve loop stability and transient performance. In the EV kit, for optimal bandwidth and transient performance, C5 is chosen as 5.6pF. Refer to the *FB Resistor Network* section of the *LT80603 data sheet* for more details on the selection of the feedback resistor and phase-lead capacitor.

The EV kit supports fixed 5V and 3.3V output voltage programming using the FB/V_{OS} pin. To program the EV kit to the 5V fixed output, connect a 0Ω resistor across R7 and open R10, R3, R4, and C5.

Input Capacitors

The input capacitors C6, C12, and C13 minimize EMI emissions, reduce current peaks drawn from the input-power supply, and reduce the switching frequency ripple at the input. Refer to the *Input Capacitors and Low EMI PCB Layout* section of the *LT80603 data sheet* for more details.

Output Capacitor and Output Ripple

The output capacitors C21 and C22 in the EV kit are both populated with 47µF and 22µF. Refer to the *Output Capacitor and Output Ripple* section of the *LT80603 data sheet* for adjusting the output capacitance.

Linear Regulator (INTV_{CC} and BIAS/V_{OUT})

Powering INTV_{CC} from BIAS/V_{OUT} increases the efficiency of the converter at higher input voltages. If the applied BIAS/V_{OUT} voltage exceeds 2.3V (typ), internal V_{CC} is powered from BIAS/V_{OUT}. If BIAS/V_{OUT} is lower than 2.2V (typ), internal V_{CC} is powered from V_{IN}. In this evaluation board, BIAS/V_{OUT} is connected to V_{OUT} by connecting a 0Ω resistor in R8.

Note: Connect the BIAS/V_{OUT} pin to the converter output voltage node only if the output voltage is programmed between 2.35V and 25V.

Output Power Good and Die Temperature Monitor

The LT80603 offers the PG/T_J pin to monitor either the status of the output voltage or the die temperature. Install a shunt across pins 1 to 2 on jumper JU3 for monitoring the converter output status. Install a shunt across pins 2 to 3 on jumper JU3 for monitoring the die temperature. See Table 3 for jumper settings. Refer to the *Output Power Good and Die Temperature Monitor* section of the *LT80603 data sheet* for more details.

Table 3. PG/T_J Jumper (JU3) Settings

SHUNT POSITION	PG/T_J PIN	OUTPUT
1 to 2*	Connected to V_{CC}	PG functionality
2 to 3	Connected to GND	Die temperature monitor

**Default position*

Hot Plugin and Long Input Cables

The LT80603 EV kit provides an optional electrolytic capacitor (C9, 33µF/100V) to dampen input voltage peaks and oscillations that can arise during hot-plugin and/or due to long input cables. These capacitors limit the peak voltage at the input of the DC-DC converters when the EV kit is powered directly from a precharged capacitive source or an industrial backplane printed circuit board (PCB). Long input cables between an input-power source and the EV kit circuit can cause input voltage oscillations due to the inductance of the cables. The equivalent series resistance (ESR) of the electrolytic capacitor helps damp out the oscillations caused by long input cables.

Electromagnetic Interference

Compliance with conducted emissions (CE) standards requires an EMI filter at the input of a switching power converter. The EMI filter attenuates high-frequency currents drawn by the switching power converter, and limits the noise injected back into the input power source. Power the converter from the V_{IN_EMI} terminal to evaluate the EMI performance.

Use of EMI filter components, as shown in the EV kits schematic, results in lower conducted emissions, below CISPR25 Class 5 limits. The manufacturer part numbers of the EMI filter components are listed in the bill of materials (BOM). The PCB layout is also designed to limit radiated emissions from switching nodes of the power converter, resulting in radiated emissions below CISPR25 Class 5 limits. Further, capacitors placed near the input of the board help in attenuating high-frequency noise.

Ordering Information

PART	TYPE
LT80603EVKIT#	EV kit

#Denotes RoHS-compliant.

LT80603EVKIT# Bill of Materials

ITEM	QTY	REFERENCE	DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C12, C13	Capacitor, 1206, 4.7µF, 100V, X7R, 10%	Murata, GRM31CZ72A475KE11
2	2	C16, C17	Capacitor, 0603, 0.1µF, 100V, X7R, 10%	Murata, GRM188R72A104KA35
3	1	C5	Capacitor, 0402, 5.6PF, 50V, C0G/NPO	Kemet, C0402C569C5GAC
4	1	C18	Capacitor, 0603, 2.2µF, 10V, X7R, 10%	Murata, GRM188R71A225KE15
5	1	C19	Capacitor, 0402, 8200PF, 50V, X7R, 10%	Venkel, C0402X7R500822KNP
6	1	C20	Capacitor, 0402, 1µF, 10V, X7R, 10%	Murata, GRM155Z71A105KE01
7	1	C26	Capacitor, 0402, 0.1µF, 16V, X7R, 10%	TDK, C1005X7R1C104K050BC
8	1	C21	Capacitor, 1210, 47µF, 10V, X7R, 10%	Murata, GRM32ER71A476KE15
9	1	C22	Capacitor, 1210, 22µF, 16V, X7R, 10%	Murata, GRM32ER71C226KEA8
10	1	L1	Inductor, 8.2µH, 20%	Coilcraft, XGL6060-822ME
11	1	R1	Resistor, 0603, 3.32MΩ, 1%, 1/10W	Vishay, CRCW06033M32FK
12	1	R2	Resistor, 0402, 953KΩ, 1%, 1/16W	Vishay, CRCW0402953KFKEDC
13	1	R3	Resistor, 0402, 1MΩ, 1%, 1/10W	Panasonic, ERJ-2RKF1004
14	1	R4	Resistor, 0402, 191KΩ, 1%, 1/16W	Vishay, CRCW0402191KFK
15	1	R6	Resistor, 0402, 20KΩ, 1%, 1/16W	Vishay, CRCW040220K0FK
16	1	R8	Resistor, 0402, 0, 1/10W	Panasonic, ERJ-2GE0R00
17	1	U1	IC, Regulator, FC2QFN17	Analog Devices, LT80603AFO+T
Additional Demo Board Circuit Components				
18	1	C1	Capacitor, 0603, 0.1µF, 100V, X7R, 10%	Murata, GRM188R72A104KA35
19	1	C2	Capacitor, 0402, 220pF, 100V, X7R, 10%	Murata, GRM155R72A221KA01
20	1	C9	Capacitor, Aluminium, 33µF, 100V, 20%	Panasonic, EEE-TG2A330P
21	1	C14	Capacitor, 0805	Open
22	1	L2	Inductor, 15µH, 20%	Coilcraft, XGL5050-153ME
23	1	R10	Resistor, 0603, 0, 5%, 1/10W	Samsung, RC1608J000CS
24	1	Q1	MOSFET, N-CH, 40V, 14A, DPAK	Vishay, SUD50N04-8M8P-4GE3
25	1	R12	Resistor, 2512; 0.1Ω, 1%, 3W	Bourns, CRA2512-FZ-R100ELF
26	1	R13	Resistor, 0805, 10KΩ, 0.1%, 1/10W	TE Connectivity, RN73C2A10KB
27	1	FB1	Ferrite Bead, 0805	Open

ITEM	QTY	REFERENCE	DESCRIPTION	MANUFACTURER/PART NUMBER
28	2	C3, C11	Capacitor, 0603	Open
29	3	C10, C25, C29	Capacitor, 0402	Open
30	1	C4	Capacitor, 1210	Open
31	1	C6	Capacitor, 1206, 4.7µF, 100V, X7R, 10%	Murata, GRM31CZ72A475KE11
32	2	C7,C8	Capacitor, 1206	Open
33	1	C30	Capacitor, 0805	Open
34	3	R5, R9, R7	Resistor, 0402	Open
Hardware: For Demo Board Only				
35	16	EN/UV, GND, LOAD_STEP, PG/TJ, PGND, PGND1–PGND3, PULSE_GEN, SYNC/MODE, TR/SS, VIN, VIN_EMI, VIN_SENSE, VOUT, VOUT_SENSE	Testpoint, Turret, 0.094"	Mill-Max, 2501-2-00-80-00-00-07-0
36	3	JU1, JU2, JU3	Connector, Male, 3 Pins	Sullins, PBC03SABN
37	2	SU1, SU2	Connector, Female, 2 Pins	Sullins, QPC02SXGN-RC
38	4	MH1 to MH4	Round-Thru Hole Spacer	Keystone, 9032
39	1	VEXT	Testpoint, Turret, 0.04"	Keystone, 5001

LT80603EVKIT# Schematic Diagram

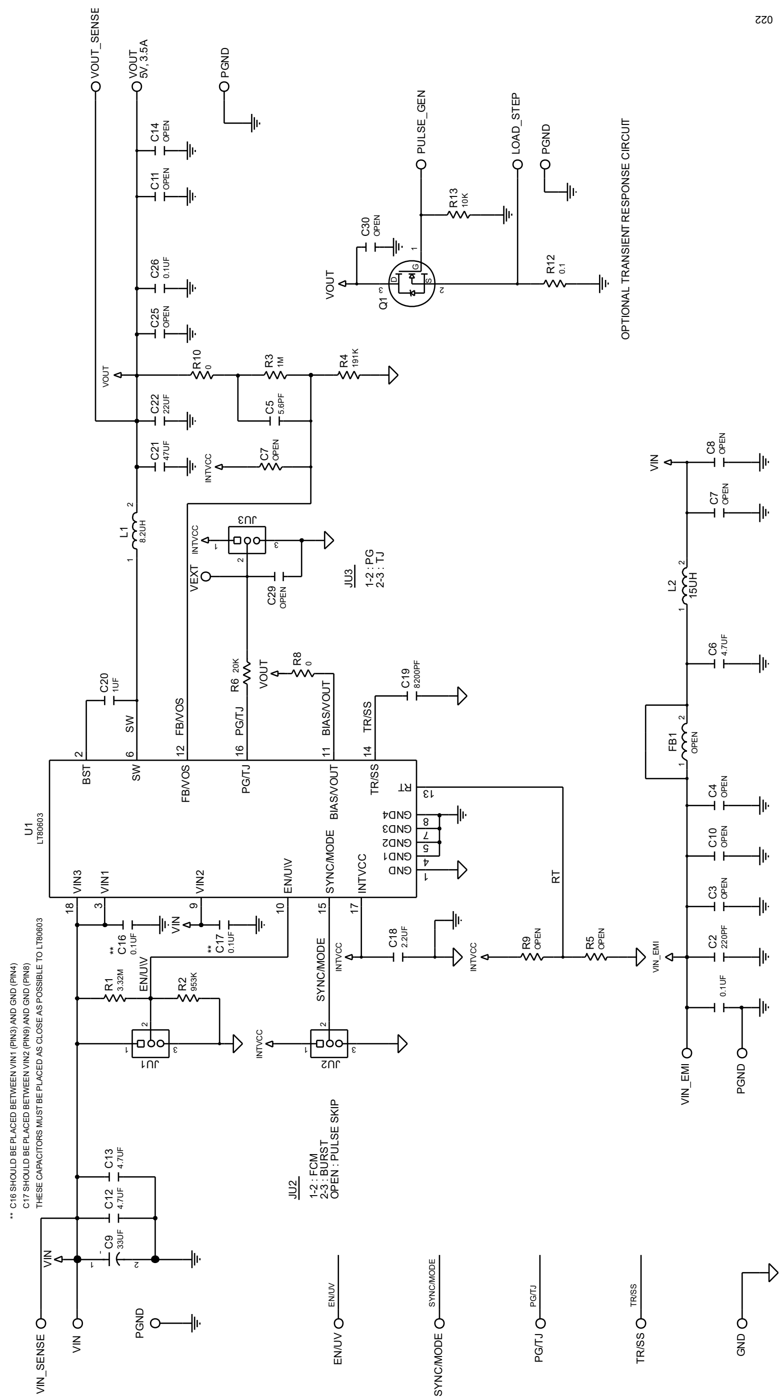


Figure 22. LT80603EVKIT# Schematic Diagram

LT80603EVKIT# PCB Layout Diagrams

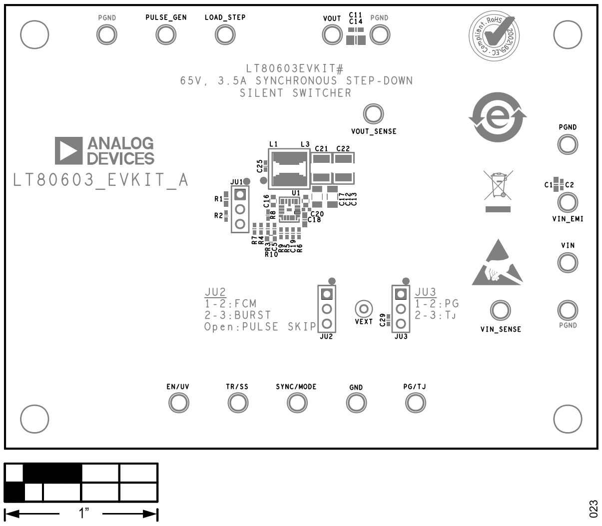


Figure 23. LT80603EVKIT# Component Placement Guide—Top Silkscreen

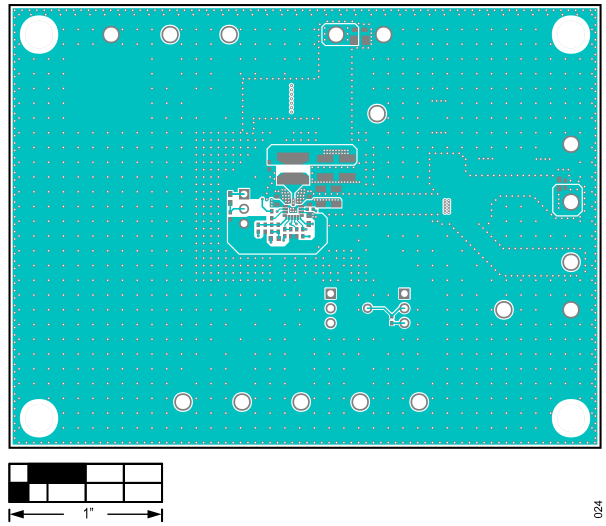


Figure 24. LT80603EVKIT# PCB Layout—Top View

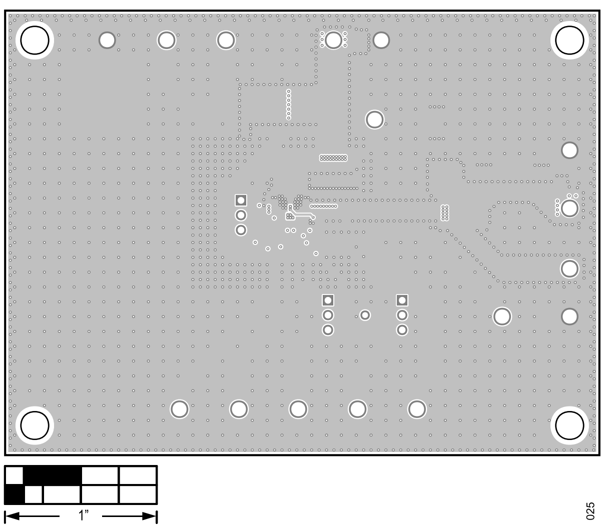


Figure 25. LT80603EVKIT# PCB Layout—Layer 2

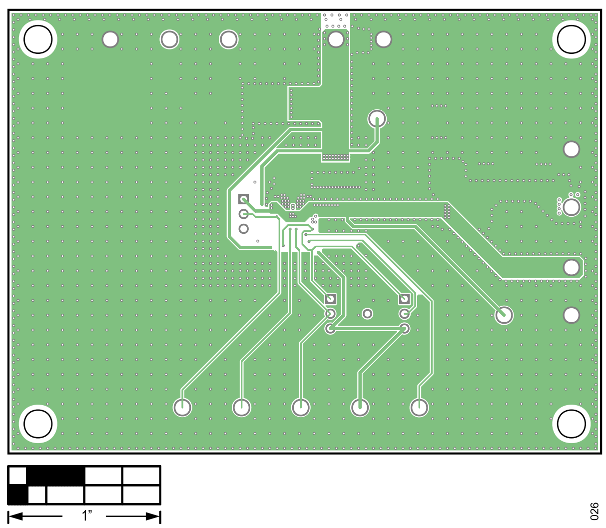


Figure 26. LT80603EVKIT# PCB Layout—Layer 3

PCB Layout (continued)

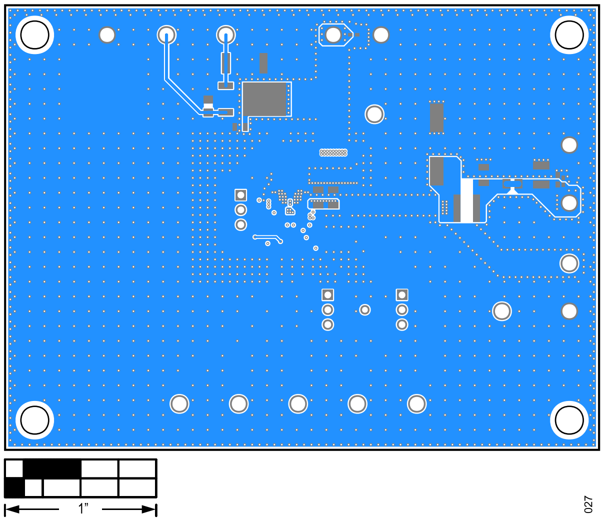


Figure 27. LT80603EVKIT# PCB Layout—Bottom View

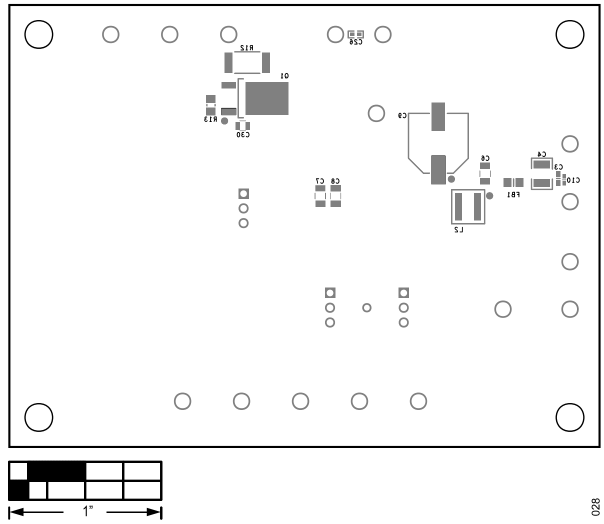


Figure 28. LT80603EVKIT# Component Placement Guide—Bottom Silkscreen

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	1/26	Initial release	—