

LM267X 3A, 5A Evaluation Boards

National Semiconductor
Application Note 1135
Ifeanyi Nwachukwu
July 1999



AN-1135 LM267X 3A, 5A Evaluation Boards

INTRODUCTION

The LM267X evaluation board was developed for the evaluation of LM267X SIMPLE SWITCHER® series of 3 Amp and 5 Amp high efficiency step-down (Buck) switching voltage regulators. This application note describes the printed circuit board, and provides example circuits and directions on setup and operation of the LM2673S-5_EVAL and LM2679S-5_EVAL evaluation boards.

GENERAL DESCRIPTION

Many of our boards are intended to provide the user with device characterization and layout optimization data. The LM267x evaluation board was intended to allow the user to experiment with a variety of circuit topologies and components, and therefore not optimized for size. Please refer to the discussions of layout optimization in the PCB Layout Optimization section.

This board was designed such that both through-hole and surface-mount components can be used for construction. The regulator IC can be placed on the board as a surface-mount component only. The ground plane serves as a heatsink.

Table 1 shows an overview of the family of devices with special features of each indicated. Consult the device data sheet, or use the special power supply design software called **LM267X Made Simple Version 2.0** (available for free download from National Semiconductor's Internet page, www.national.com) to determine all necessary component values for the particular device being used to accomplish a specific design and board layout considerations.

The printed circuit board, PCB, is labeled to indicate the location of all of the needed components for all possible design options. Table 2 shows a complete list of the component labels and their functions.

Figure 1 identifies all components, but not all are necessary in every design.

Figure 2, Figure 3 and Figure 4 show the top, bottom and silk screen of the printed circuit board respectively.

TABLE 1. LM267X Family of High-Current Regulators supported by the Evaluation Board

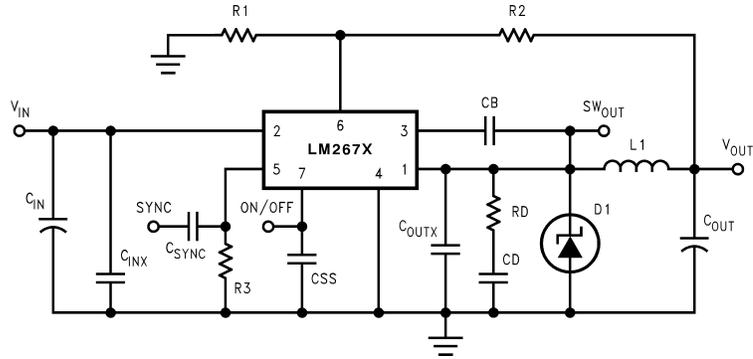
DEVICE	Maximum Load Current (A)	SPECIAL FEATURES
LM2670	3	ON/OFF, External Frequency Sync Capability
LM2673	3	Adjustable Current Limit, Softstart
LM2676	3	ON/OFF
LM2678	5	ON/OFF
LM2679	5	Adjustable Current Limit, Softstart

TABLE 2. List of Component Labels and Functionality

LABEL	FUNCTION
U1	LM267X Switching Regulator IC
CIN	Input Capacitor(s); All devices.
CINX	0.47µF, optional high frequency input bypass capacitor, recommended in all designs; All devices.
CB	Boost capacitor; All devices.
D1	Output clamp diode; All devices.
R1	Feedback resistor (1kΩ) for adjustable output devices and shorted, replaced by a jumper wire, with fixed output voltage devices.
R2	Feedback resistor for adjustable output devices and shorted, replaced by a jumper wire, with fixed output voltage devices.
R3*	Current limit resistor for LM2673, LM2679; Sync input resistor (1KΩ) for LM2670; Not inserted for LM2676 and LM2678.
L1	Inductor; All devices.
CSYNC	Sync input capacitor (100pF); LM2670 only. Not inserted with other devices.
CSS	Soft start capacitor; LM2673 and LM2679 only. Not inserted with other devices.
COUTX	0.47µF, optional high frequency output bypass capacitor; All devices.
COUT	Output capacitor(s); All devices.

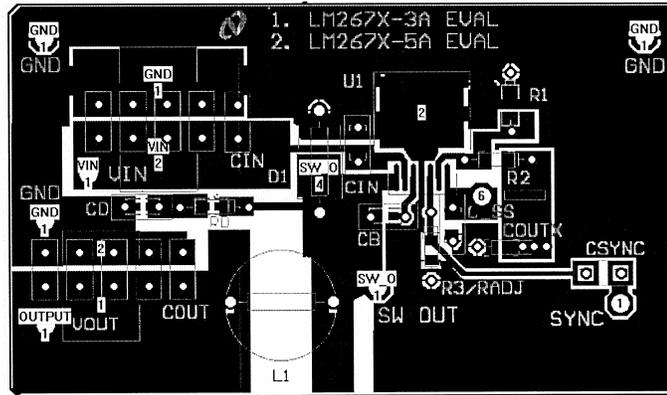
AN-1135

*All devices have internally preset current limits, but those with adjustable current limit capability can be used to set the current limit to any value up to the maximum preset value.



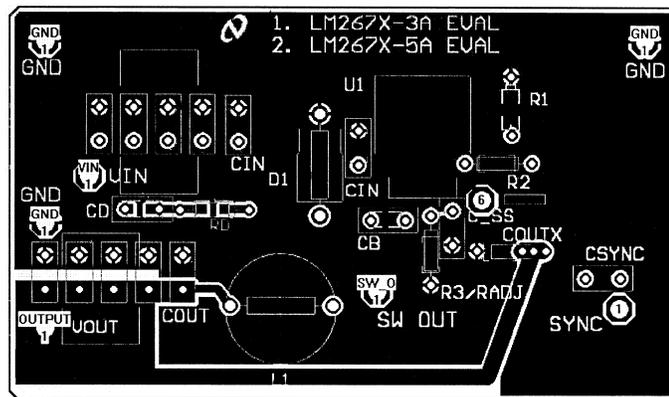
AN101145-1

FIGURE 1. Example Schematic Showing Connection for all Components.



AN101145-2

FIGURE 2. Top Layer Foil Pattern of Printed Circuit Board (1X size)



AN101145-3

FIGURE 3. Bottom Layer Foil Pattern of Printed Circuit Board (1X size)

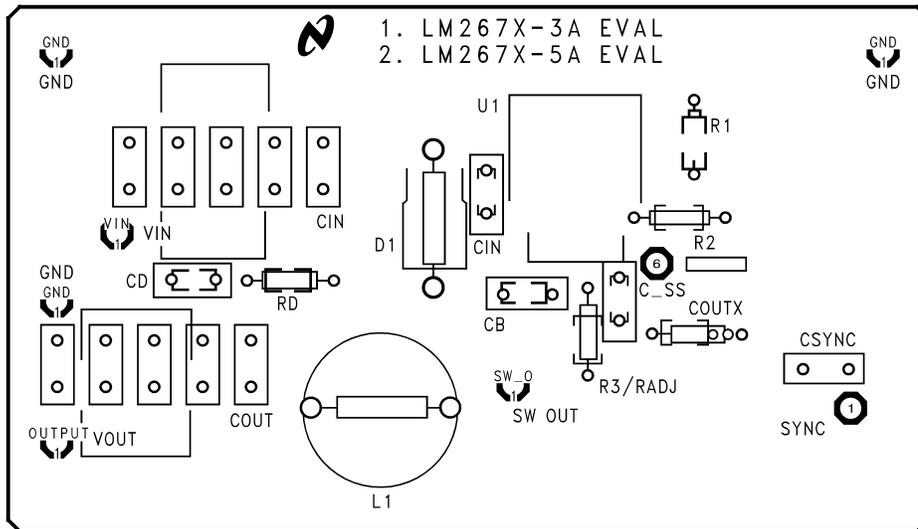


FIGURE 4. Silkscreen Image Of Printed Circuit Board

AN101145-4

Special Notes

The evaluation board was designed primarily for circuit implementation using all surface-mount components. The small series "trace inductance", particularly from the Switch Output pin, can create a high frequency (10's of MHz) ringing signal at the switch output. If problematic, this ringing can be reduced or eliminated by the use of a series RC damper or snubber network from the switch output to ground. The addition of these components is made at the locations labeled CD and RD. Values of 0.01 μ F and 10 Ω are good starting values that may need to be varied depending on the magnitude of parasitic factors in a given design. In an actual end application, these components are normally not required if proper care to minimize trace lengths is taken in the PCB design.

EXAMPLE CIRCUIT DESIGNS

Example 1: 5V/3A Converter with Surface Mount Components.

In this example, it is desired to convert a voltage range of between 8V and 12V, to 5VDC with load current of 3A. It is also

desired to implement the design with surface mount components only. Softstart duration will be set to between 1 and 1.5 ms.

Target Design Specifications

V_{IN} min.	8V
V_{IN} max.	16V
V_{OUT}	5V
I_{LOAD}	3A
I_{CL}	5.0A (approx.)
T_{SS}	1 to 1.5ms

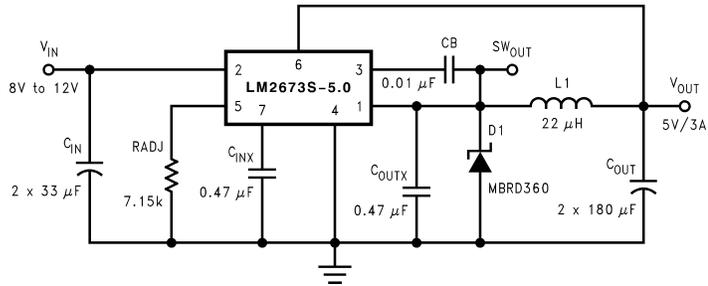
The **LM267X Made Simple** power supply design software was used for the design and the following components and their values are recommended:

TABLE 3. Component Values for an 8-12V in, 5V/3A Out LM2673S-5.0 Buck Converter

Component	Value	Suggested Part Number
U1		National LM2673S-5.0
CIN	2 x 33 μ F/35V	Sprague 594D336X0035R2T
CINX	0.47 μ F	NOVACAP 1812B472101NT
CB	0.01 μ F/50V	AVX 08055C103KAT
D1	3A/60V Schottky (450mV at 3A)	Motorola MBRD360
R3*	7.15 k Ω (5.19A current limit)	
L1	22 μ H (L41)	SUMIDA ELECTRIC CO. CDRH127-220
CSS	3.3nF/100V softstart)	100V AVX 08051C332KAT
COUTX	0.47 μ F	NOVACAP 1812B472101NT
COUT	2 x 180 μ F/16V	Sprague 594D187X0016R2T

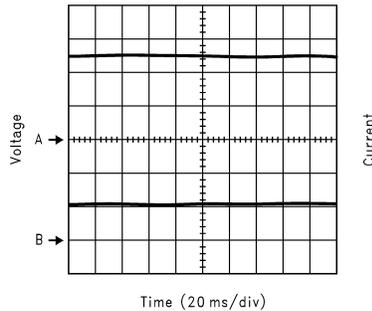
Figure 5 below shows the 5V/3A design circuit. This solution is available as evaluation board **LM2673S-5_EVAL**.
 Figure 6, Figure 7, Figure 8 and Figure 9 show the output waveforms for output voltage with 500 mA load, output voltage with 1A load, output ripple with 1A load, output voltage with 3A load, output ripple with 3A load, output response to 1A transient load and output response to 3A transient load respectively.

age with 1A load, output ripple with 1A load, output voltage with 3A load, output ripple with 3A load, output response to 1A transient load and output response to 3A transient load respectively.



AN101145-13

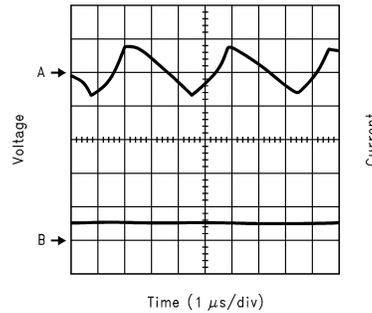
FIGURE 5. 5V/3A Design Circuit



AN101145-5

A: OUTPUT VOLTAGE: V_{OUT} ; 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 500\text{mA}$; 500mA/DIV

Output Voltage with 500mA Load

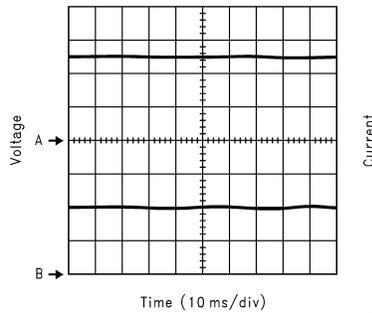


AN101145-6

A: OUTPUT RIPPLE; 10mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 0.5\text{A}$; 1A/DIV

Output Ripple with 500mA Load

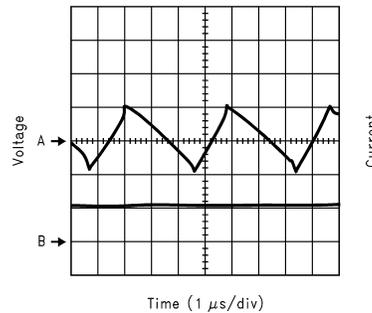
FIGURE 6. Output Voltage Waveforms with 500mA Load



AN101145-7

A: OUTPUT VOLTAGE: V_{OUT} ; 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 1\text{A}$; 500mA/DIV

Output Voltage with 1A Load

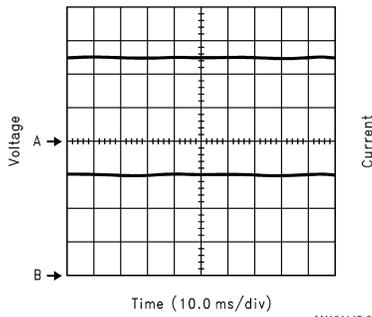


AN101145-8

A: OUTPUT RIPPLE; 10mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 1\text{A}$; 1A/DIV

Output Ripple with 1 Amp Load

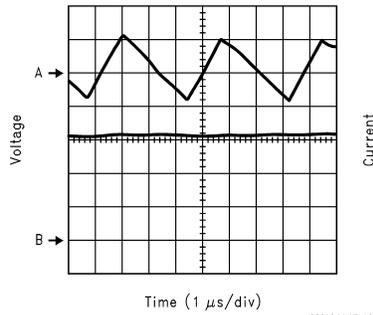
FIGURE 7. Output Voltage Waveforms with 1A Load



AN101145-9

A: OUTPUT VOLTAGE: V_{OUT} : 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 3A$; 1A/DIV

Output Voltage with 3A Load

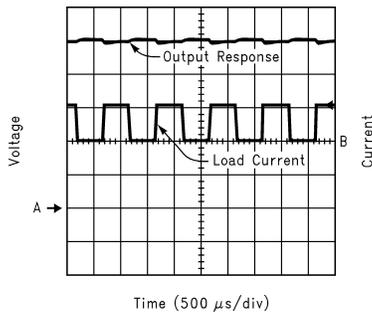


AN101145-10

A: OUTPUT RIPPLE: 10mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 3A$; 1A/DIV

Output Ripple with 3 Amp Load

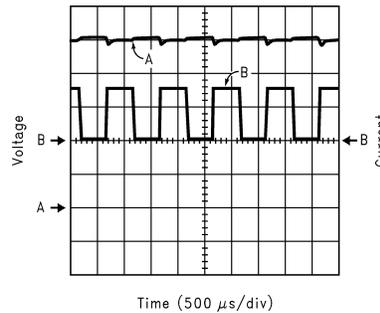
FIGURE 8. Output Voltage Waveforms with 3 Amp Load



AN101145-11

A: OUTPUT RESPONSE; 1V/DIV
 B: TRANSIENT LOAD CURRENT: 1A/DIV

Output Response to 0-1A Transient Load



AN101145-12

A: OUTPUT RESPONSE; 1V/DIV
 B: TRANSIENT LOAD CURRENT: 2A/DIV

Output Response to 0-3A Load Transient

FIGURE 9. Output Response To Load Transient

Example 2: 5V/5A Design with Surface Mount Components

For this example, it is desired to design a power supply to convert an input voltage within the range of 14V and 28V to an output voltage of 5V with a maximum load current of 5A using only surface mount components. In addition, the current limit of the regulator will be set to approximately 7.0A, and the softstart time will be set to approximately 1.0ms to limit the startup surge current.

Target Design Specifications:

$V_{IN \text{ min.}}$	14V
$V_{IN \text{ max.}}$	28V
V_{OUT}	5V
I_{LOAD}	5A
I_{CL}	7.0A (approx.)
T_{SS}	1.0ms (approx.)

The **LM267X Made Simple** power supply design software was used for the design and the following components and their values are recommended:

TABLE 4. Component Values for an 14V-28V in, 5V/5A Out LM2679S-5.0 Buck Converter

Component	Value	Suggested Part Number
U1		National LM2679S-5.0
CIN	3 x 15 μ F/50V	Sprague 594D336X0035R2T
CINX	0.47 μ F	NOVACAP 1812B472101NT
CB	0.01 μ F/50V	AVX CORPORATION 08055C103KAT
D1	8A/35V Schottky (500mV at 5A)	Motorola MBRD835L
R3*	4.99 k Ω (7.19A current limit)	
L1	15 μ H (L50)	Pulse Engineering P0850 or Coilcraft D05022P-153
CSS	4.7nF/100V (1.0ms softstart)	AVX 08051C272KAT
COUTX	0.47 μ F	NOVACAP 1812B472101NT
COUT	2 x 180 μ F/16V	Sprague 594D187X0016R2T

Figure 10 below shows the circuit for the 5V/5A design. This solution is available as evaluation board **LM2679S-5_EVAL**. Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15 show the output waveforms for output voltage with 500 mA load, output voltage with 2.5A load, output ripple with 2.5A

load, output voltage with 5A load, output ripple with 5A load, output response to 500mA transient load, output response to 2.5A transient load and output response to 5A transient load respectively.

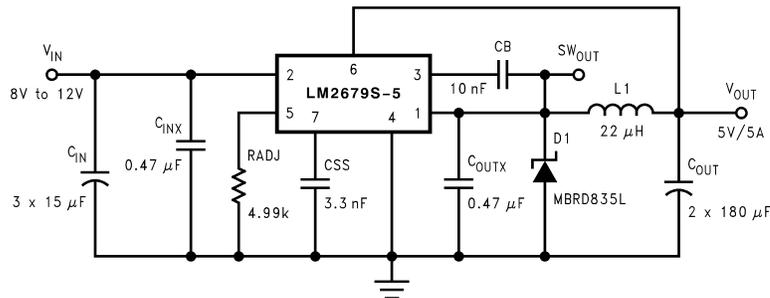
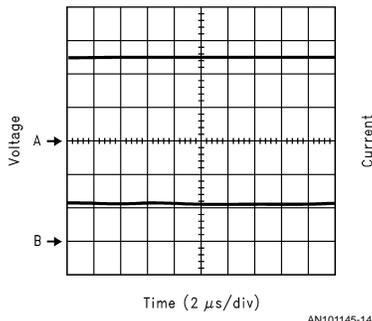


FIGURE 10. 5V/5A Design Circuit

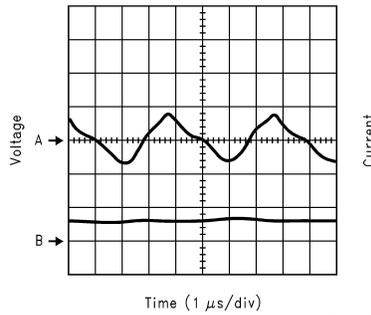
AN101145-23



AN101145-14

A: OUTPUT VOLTAGE: V_{OUT} ; 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 500\text{mA}$; 500mA/DIV

Output Voltage with 500mA Load

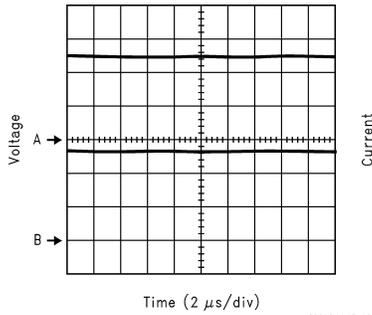


AN101145-15

A: OUTPUT RIPPLE; 100mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 500\text{mA}$; 1A/DIV

Output Ripple with 500mA Load

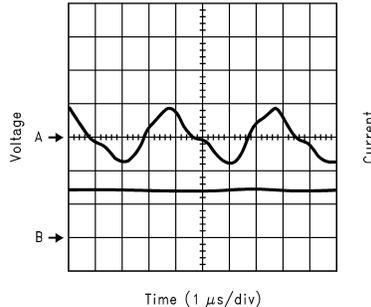
FIGURE 11. Output Voltage Waveforms with 500mA Load



AN101145-16

A: OUTPUT VOLTAGE: V_{OUT} ; 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 2.5\text{A}$; 1A/DIV

Output Voltage with 2.5A Load

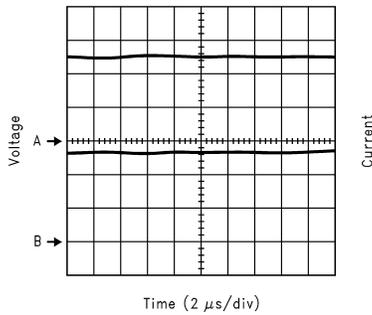


AN101145-17

A: OUTPUT RIPPLE; 100mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 2.5\text{A}$; 2A/DIV

Output Ripple with 2.5A Load

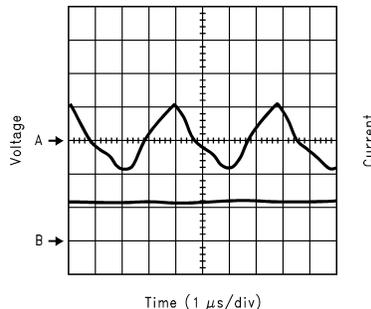
FIGURE 12. Output Voltage Waveforms with 2.5A Load



AN101145-18

A: OUTPUT VOLTAGE: V_{OUT} ; 2V/DIV
 B: LOAD CURRENT: $I_{LOAD} = 5\text{A}$; 2A/DIV

Output Voltage with 5A Load

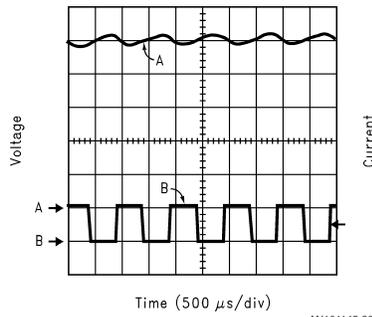


AN101145-19

A: OUTPUT RIPPLE; 100mV/DIV
 B: LOAD CURRENT: $I_{LOAD} = 5\text{A}$; 5A/DIV

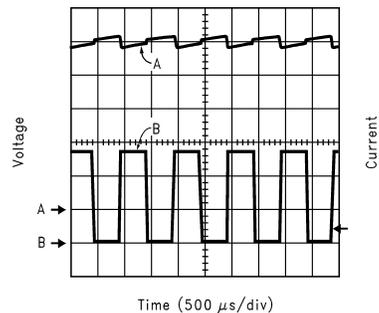
Output Ripple with 5A Load

FIGURE 13. Output Voltage Waveforms with 5A Load



A: OUTPUT RESPONSE; 1V/DIV
 B: TRANSIENT LOAD CURRENT; 500mA/DIV

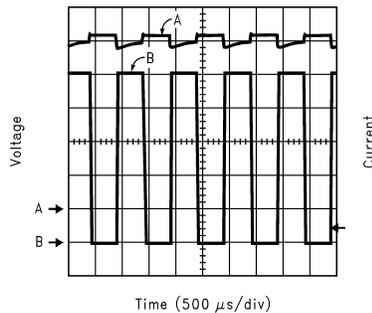
Output Response to 0-0.5A Transient Load



A: OUTPUT RESPONSE; 1V/DIV
 B: TRANSIENT LOAD CURRENT; 1A/DIV

Output Response to 0-2.5A Load Transient

FIGURE 14. Output Response To Load Transient



A: OUTPUT RESPONSE; 1V/DIV
 B: LOAD CURRENT; $I_{LOAD} = 1A/DIV$

FIGURE 15. Output Response to 0-5A Transient Load

OPERATING THE EVALUATION BOARDS

Setup

The **LM2673S-5_EVAL** and **LM2679S-5_EVAL** evaluation boards come ready to be tested. The only setup needed is connecting the input voltage to the VIN and GND posts. The output can be taken from the VOUT post. The other signals of interest, switch output (SW out) and softstart (C_SS) posts, are clearly marked for use in checking the signal integrity. The softstart post has an ON/OFF input when this feature is being used.

Operating Conditions

The input source for the LM267x family of regulators must be 8V or greater for proper setup and operation. The input voltage range for **LM2673S-5_EVAL** evaluation board is from 8V to 12V and the range for **LM2679S-5_EVAL** is from 14V to 28V. The maximum voltage rating of the LM267x family of regulators is 40V.

Load can be applied from 0A to the maximum for the design. Higher current above the design current limit will result in activation of the design current limit circuit. It is advisable to have a minimal load of (at least 10mA) during startup when the input to output differential voltage is greater than 10V to prevent output ramping beyond desired value.

PCB Layout Optimization

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the printed circuit traces should be as wide and short as possible on the PCB. For best results, external components should be located as close to the switcher IC as possible using ground plane construction or single point grounding.

If **open core inductors are used**, special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC groundpath and C_{OUT} wiring can cause problems.

When using the adjustable version, special care must be taken as to the location of the feedback resistors and associated wiring. Physically locate both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor.

Notes

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



National Semiconductor Corporation
Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 1 80-530 85 85
English Tel: +49 (0) 1 80-532 78 32
Français Tel: +49 (0) 1 80-532 93 58
Italiano Tel: +49 (0) 1 80-534 16 80

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: sea.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507