

# Information About the LM2650 Evaluation Board Rev. 1

National Semiconductor  
AN-1071  
Steven Hunt  
September 1997



Information About the LM2650 Evaluation Board Rev. 1

## INTRODUCTION

A printed circuit board (PCB) has been developed. This application note contains information about the board.

## GENERAL DESCRIPTION

The LM2650 evaluation board is provided as a tool for developing DC/DC converters based on the LM2650 IC. It is configured for single-output, step-down DC/DC converters. Figure 1 is a complete schematic of the board which can accommodate up to 28 components including the LM2650. Table 1 is a complete list of pads for placing components.

**Note:** Not all applications will require the placement of all 28 components. The number of components placed depends on the requirements of the application and the use of features like programmable soft-start. The LM2650 evaluation board is intended to be a reusable tool on which many different converters meeting the requirements of many different applications can be built. It is not intended to demonstrate only one application of the LM2650.

For convenience, a sample of the LM2650 and eight other components have been assembled: a 0.1  $\mu\text{F}$  capacitor at each of C1, C2, C6, and CB, a 0.2  $\mu\text{F}$  capacitor at CVDD, a 0.01  $\mu\text{F}$  capacitor at CSS, a 24.9 k $\Omega$  resistor at R2, and a 0 $\Omega$  resistor at R4. Of the eight, the first seven are common to many applications, and the last is simply a jumper grounding the SYNC input. When the synchronization feature is not being used, the SYNC input should be grounded.

## EXAMPLE CIRCUITS

The components contained in Tables 2, 3, and 4 can be used to build typical application circuits. As with the design of any DC/DC converter, the design of these involved tradeoffs between efficiency, size, and cost. The converters detailed in Table 2 were designed with efficiency as the number one criteria. Those detailed in Table 4 trade slightly higher switching losses for a much smaller inductor.

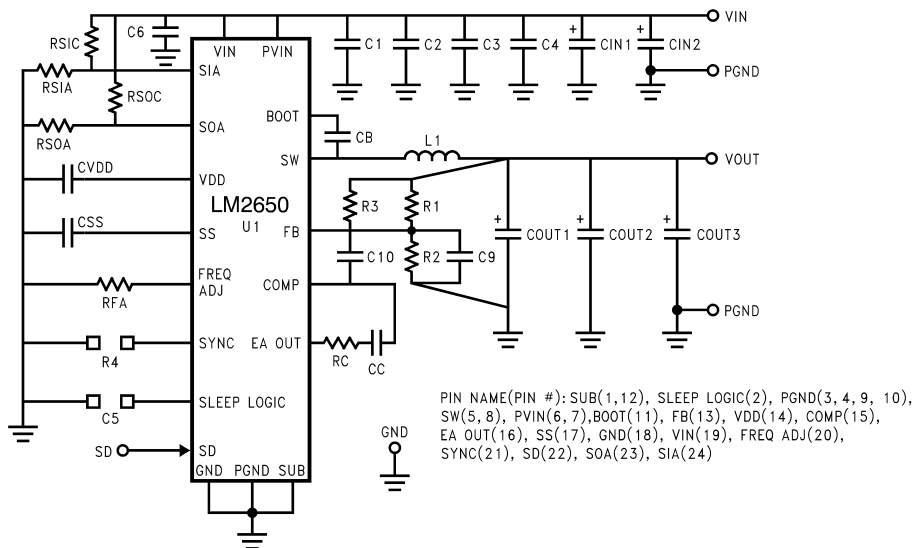


FIGURE 1. The LM2650 Evaluation Board Rev. 1 Schematic

## THERMAL PERFORMANCE

The 24-lead SO package is a molded plastic package with a solid copper lead frame. Most of the heat generated at the die flows through the lead frame into the 3-ounce copper planes on the board. The board then acts as a heat sink. The junction-to-ambient thermal resistance of the packaged IC mounted on the board has been measured to be 38 $^{\circ}\text{C}/\text{W}$ , 37 $^{\circ}\text{C}/\text{W}$ , and 35 $^{\circ}\text{C}/\text{W}$  for the dissipation of 1.0W, 1.5W, and

2.0W respectively. These measurements were made in still air. The junction-to-ambient thermal resistance of the packaged IC alone in still air is 78 $^{\circ}\text{C}/\text{W}$ . The board is 0.063" thick FR-4 material.

## ART

Figure 2 through Figure 4 show the PCB art work.

AN-1071

**TABLE 1. A Complete List of Pads for Placing Components**

Label	#	Notes
U1	1	For placing the LM2650.
C1, C2, C3, and C4	4	Capacitors placed here filter high-frequency switching noise from the input power rail.
C5	0	These pads should not be labeled with a C. No component is placed here. They can be used to ground the SLEEP LOGIC input. The pad connected to the SLEEP LOGIC pin can be used to pull the input up.
C6	1	A capacitor placed here also filters high-frequency switching noise from the input power rail but at the VIN rail, the rail used by the signal-level circuits inside the IC.
C9	1	Usually no component is placed here. A capacitor might be placed here for loop compensation purposes, but most applications don't use it.
C10	1	A capacitor is placed here for loop compensation purposes.
CB	1	The bootstrap capacitor is placed here.
CC	1	A capacitor is placed here for loop compensation purposes. This capacitor and an internal 6.5 kΩ resistor create an integrator pole.
CIN1 and CIN2	2	The bulk input capacitors are placed here.
COUT1, COUT2, and COUT3	3	The output filter capacitors are placed here.
CSS	1	A capacitor placed here programs the soft-start interval.
CVDD	1	A capacitor placed here bypasses the output of the VDD regulator.
L1	1	The inductor is placed here.
R1	1	One of the feedback resistors is placed here.
R2	1	The other feedback resistor is placed here.
R3	1	A resistor is placed here for loop compensation purposes.
R4	1	These pads can be used to ground the SYNC input when the synchronization feature is not being used. The pad connected to the SYNC input can be used to connect the synchronization signal. The evaluation board has a 0Ω jumper placed here to ground the SYNC input.
RC	1	A resistor is also placed here for loop compensation purposes. This resistor and the capacitor placed at CC create an integrator zero.
RFA	1	A resistor placed here adjusts the switching frequency up from the nominal 90 kHz. No component is placed here for applications switching at 90 kHz.
RSIA and RSIC	2	Resistors placed here program the sleep-in threshold.
RSOA and RSOC	2	Resistors placed here program the sleep-out threshold.

**TABLE 2. Components for Two Typical 90 kHz Application Circuits**

Input Voltage	7 to 18V IN	
Applicable Cell Stacks	8- to 12-Cell NiCd or NiMH, 3- to 4-Cell Li Ion, 8- to 11-Cell Alkaline, 6-Cell Lead Acid	
Output	5V, 3A Out	3.3V, 3A Out
Input Filter Capacitors C1, C2, and C6	0.1 μF ceramic chip capacitor	0.1 μF ceramic chip capacitor
Bootstrap Capacitor CB	0.1 μF ceramic chip capacitor	0.1 μF ceramic chip capacitor
Soft-start Capacitor CSS	0.01 μF ceramic chip capacitor	0.01 μF ceramic chip capacitor
VDD Bypass Capacitor CVDD	0.2 μF ceramic chip capacitor	0.2 μF ceramic chip capacitor
Input Bulk Capacitors CIN1 and CIN2	22 μF, 35V AVX TPS Series or Sprague 593D Series tantalum chip capacitor	22 μF, 35V AVX TPS Series or Sprague 593D Series tantalum chip capacitor
Inductor L1	40 μH (See Table 3.)	33 μH (See Table 3.)
Output Capacitors COUT1, COUT2, and COUT3	220 μF, 10V AVX TPS Series or Sprague 593D Series tantalum chip capacitor	220 μF, 10V AVX TPS Series or Sprague 593D Series tantalum chip capacitor
Feedback Resistors R1 and R2	R1 = 75 kΩ, 1%, R2 = 24.9 kΩ, 1%	R1 = 41.2 kΩ, 1%, R2 = 24.9 kΩ, 1%

**TABLE 2. Components for Two Typical 90 kHz Application Circuits (Continued)**

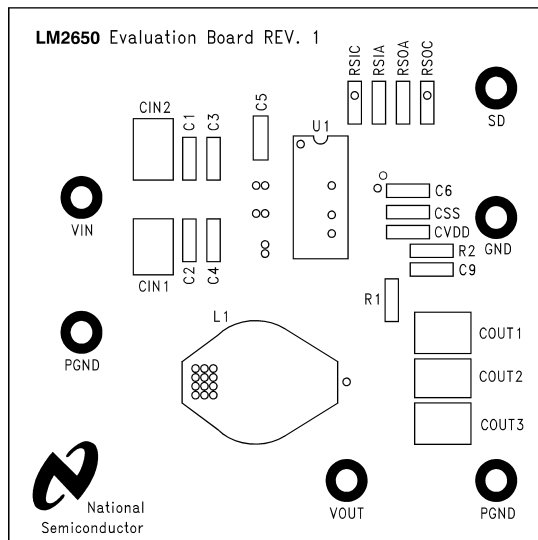
Compensation Components RC, CC, R3, and C10	RC = 37.4 kΩ, CC = 4.7 nF, R3= 3.57 kΩ, C10 = 5.6 nF	RC = 23.2 kΩ, CC= 8.2 nF, R3 = 2.0 kΩ, C10 = 10 nF
Sleep Resistors RSIA and RSOA	RSIA = 33 kΩ, RSOA = 200 kΩ	RSIA = 39 kΩ, RSOA = 130 kΩ

**TABLE 3. Toroidal Inductors Using Cores from MICROMETALS, INC.**

	Core #	Core Material	Wire Gauge	# of Strands	# of Turns
15 μH	T38	-52	AWG #23	1	21
20 μH	T38	-52	AWG #23	1	25
33 μH	T50	-52	AWG #21	1	41
40 μH	T50(B)	-18	AWG #21	1	41

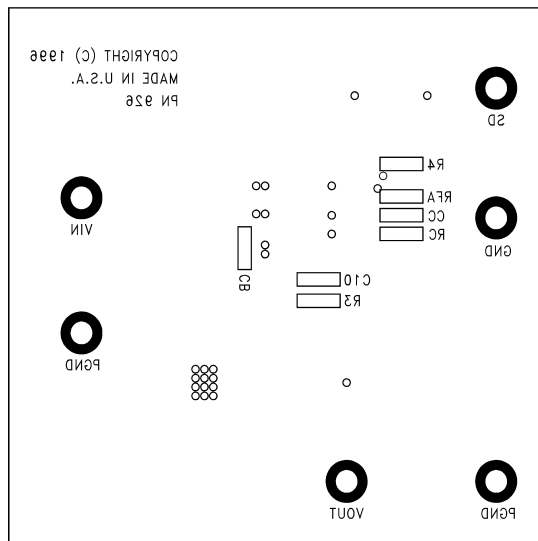
**TABLE 4. Components for Two Typical 200 kHz Application Circuits**

Input Voltage	7 to 18V IN	
Applicable Cell Stacks	8- to 12-Cell NiCd or NiMH, 3- to 4-Cell Li Ion, 8- to 11-Cell Alkaline, 6-Cell Lead Acid	
Output	5V, 3A Out	3.3V, 3A Out
Input Filter Capacitors C1, C2, and C6	0.1 μF ceramic chip capacitor	0.1 μF ceramic chip capacitor
Bootstrap Capacitor CB	0.1 μF ceramic chip capacitor	0.1 μF ceramic chip capacitor
Soft-start Capacitor CSS	0.01 μF ceramic chip capacitor	0.01 μF ceramic chip capacitor
VDD Bypass Capacitor CVDD	0.2 μF ceramic chip capacitor	0.2 μF ceramic chip capacitor
Input Bulk Capacitors CIN1 and CIN2	22 μF, 35V AVX TPS Series or Sprague 593D Series tantalum chip capacitor	22 μF, 35V AVX TPS Series or Sprague 593D Series tantalum chip capacitor
Inductor L1	20 μH (See Table 3.)	15 μH (See Table 3.)
Output Capacitors COUT1, COUT2, and COUT3	220 μF, 10V AVX TPS Series or Sprague 593D Series tantalum chip capacitor	220 μF, 10V AVX TPS Series or Sprague 593D Series tantalum chip capacitor
Feedback Resistors R1 and R2	R1 = 75 kΩ, 1%, R2 = 24.9 kΩ, 1%	R1 = 41.2 kΩ, 1%, R2 = 24.9 kΩ, 1%
Compensation Components RC, CC, R3, and C10	RC = 53.6 kΩ, CC = 2.7 nF, R3= 4.02 kΩ, C10 = 4.7 nF	RC = 33.2 kΩ, CC= 3.9 nF, R3 = 3.01 kΩ, C10 = 6.8 nF
Sleep Resistors RSIA and RSOA	RSIA = 47 kΩ, RSOA = 200 kΩ	RSIA = 47 kΩ, RSOA = 91 kΩ
Frequency Adjusting Resistor RFA	RFA = 24.9 kΩ	RFA = 24.9 kΩ



AN100011-1

FIGURE 2. LM2650 Evaluation Board Top Silk Screen (Scale 1:1)



AN100011-2

FIGURE 3. LM2650 Evaluation Board Bottom Silk Screen (Scale 1:1)

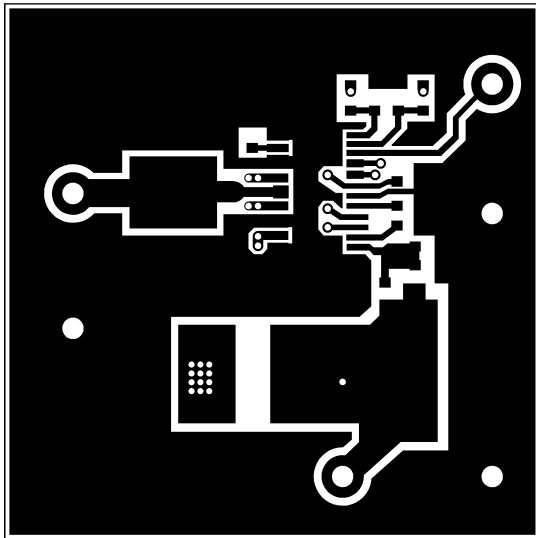


FIGURE 4. LM2650 Evaluation Board Component Side (Scale 1:1)

AN100011-3

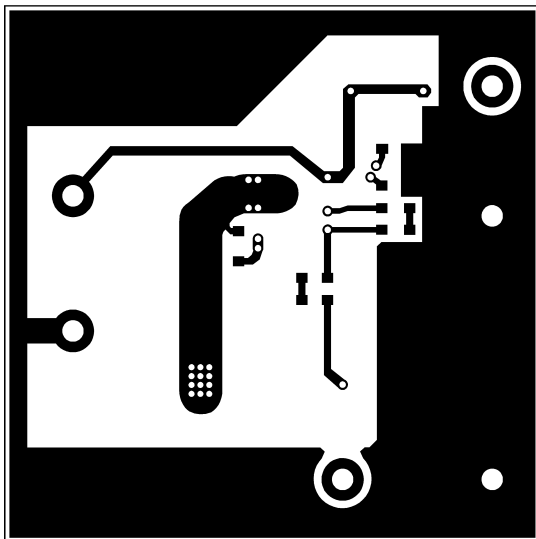


FIGURE 5. LM2650 Evaluation Board Solder Side (Scale 1:1)

AN100011-4

**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 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 in 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](http://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 Hong Kong Ltd.**  
13th Floor, Straight Block,  
Ocean Centre, 5 Canton Rd.  
Tsimshatsui, Kowloon  
Hong Kong  
Tel: (852) 2737-1600  
Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5620-6175  
Fax: 81-3-5620-6179