LMZ1050x Evaluation Board

National Semiconductor
Application Note 2022
Ricardo Capetillo
January 21, 2010

Introduction

The LMZ1050x SIMPLE SWITCHER® power module is a complete, easy-to-use DC-DC solution capable of driving up to 3A, 4A, or 5A load with exceptional power conversion efficiency, output voltage accuracy, line and load regulation. The LMZ1050x is available in an innovative package that enhances thermal performance and allows for hand or machine soldering.

The LMZ1050x can accept an input voltage rail between 2.95V and 5.5V and deliver an adjustable and highly accurate output voltage as low as 0.8V. One megahertz fixed frequency PWM switching provides a predictable EMI characteristic. Two external compensation components can be adjusted to set the fastest response time, while allowing the option to use ceramic and/or electrolytic output capacitors. Externally programmable soft-start capacitor facilitates controlled startup. The LMZ1050x is a reliable and robust solution with the following features: lossless cycle-by-cycle peak current limit to protect for over current or short-circuit fault, thermal shutdown, input under-voltage lock-out, and pre-biased startup.

Board Specifications

- V_{IN} = 2.95V to 5.5V
- V_{OUT} = 2.5V (default output voltage setting, refer to *Table 2* for other output settings)
- ±2.5% feedback voltage accuracy at 2.5V output (Including line and load regulation from T_J = -40°C to 125° C)
- ±1.63% feedback voltage accuracy over temperature
- I_{OUT} = 0A to 3A, 4A, and 5A
- θ_{JA} = 20°C / W, θ_{JC} = 1.9°C / W
- Designed on four layers, the top and bottom layers are 1oz. copper and the two inner layers are 1/2 oz. copper weight
- Measures 2.25 in. x 2.25 in. (5.8 cm x 5.8 cm) and is 62mil (.062") thick on a FR4 laminate

Evaluation Board Design Concept

The evaluation board is designed to demonstrate low conducted noise on the input and output lines, as seen in *Figure 7*and *Figure 10*. Four input capacitors (C_{in1} - C_{in4}) and three output capacitors (C_{o1} - C_{o3}) are populated for this purpose. All the input and output filter capacitors are not necessary to comply with radiation standards. For a circuit example that passes radiated emissions standards (EN55022, class B) please refer to *Figure 12*. Additionally, C_{in5} is present to reduce the resonance of the input line produced by the inductance and resistance in the cables connecting the bench power supply to the evaluation board and the input capacitors.

Additional Component Footprints

When the tracking feature of the LMZ1050x is used, remove the soft-start capacitor C_{SS} and use a resistor divider on designators R_{trkb} and R_{trkt}. The ground and V_{trk} post have been provided for easy connection.

The LMZ1050x eval board incorporates a precision enable circuit which is pulled high by a 100 kΩ pull up resistor to VIN. This allows the user to pull low on the enable pin to ground. The top enable resistor is R_{ent} and the bottom enable resistor is R_{enb}. Refer to the Design Guideline and Operating Description section of the LMZ1050x data sheet for detailed design implementation.

Select FPGAs specify input inrush currents for particular power-up sequences and others require sequencing rails to avoid start-up or latch-up problems. To prevent early turn-on of the LMZ1050x in systems with multiple power rails, precision enable and tracking are useful as the main input voltage rail rises at power-up.

Component Circuit Schematic

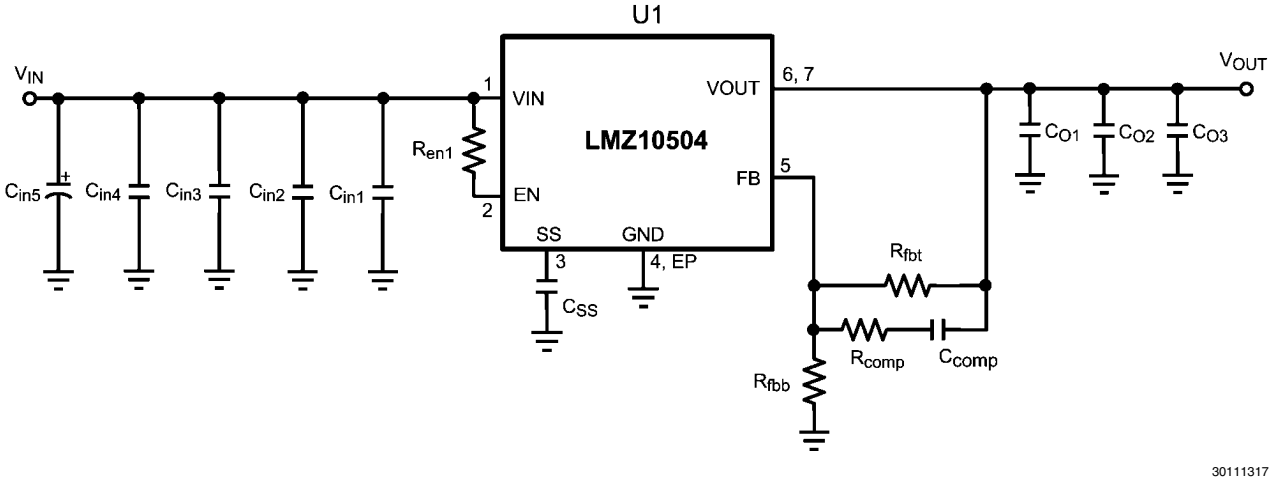


FIGURE 1. Component Schematic for Evaluation Board

TABLE 1. Bill of Materials for Evaluation Board, V_{IN} = 3.3V to 5V, V_{OUT} = 2.5V

Designator	Description	Case Size	Manufacturer	Manufacturer P/N	Quantity
U1	SIMPLE SWITCHER®	TO-PMOD-7	National Semiconductor	LMZ10504TZ-ADJ	1
C_{in1}	1 µF, X7R, 16V	0805	TDK	C2012X7R1C105K	1
C_{in2}, C_{O1}	4.7 µF, X5R, 6.3V	0805	TDK	C2012X5R0J475K	2
C_{in3}, C_{O2}	22 µF, X5R, 16V	1210	TDK	C3225X5R1C226M	2
C_{in4}	47 µF, X5R, 6.3V	1210	TDK	C3225X5R0J476M	1
C_{in5}	220 µF, 10V, AL-Elec	E	Panasonic	EEE1AA221AP	1
C_{O3}	100 µF, X5R, 6.3V	1812	TDK	C4532X5R0J107M	1
R_{fbt}	75 kΩ	0805	Vishay Dale	CRCW080575K0FKEA	1
R_{fbb}	34.8 kΩ	0805	Vishay Dale	CRCW080534K8FKEA	1
R_{comp}	1.1 kΩ	0805	Vishay Dale	CRCW08051K10FKEA	1
C_{comp}	180 pF, ±5%, C0G, 50V	0603	TDK	C1608C0G1H181J	1
R_{en1}	100 kΩ	0805	Vishay Dale	CRCW0805100KFKEA	1
C_{SS}	10 nF, ±5%, C0G, 50V	0805	TDK	C2012C0G1H103J	1

TABLE 2. Output Voltage Setting (R_{fbt} = 75 kΩ)

V_{OUT}	R_{fbb}
3.3 V	23.7 kΩ
2.5 V	34.8 kΩ
1.8 V	59 kΩ
1.5 V	84.5 kΩ
1.2 V	150 kΩ
0.9 V	590 kΩ

Complete Circuit Schematic

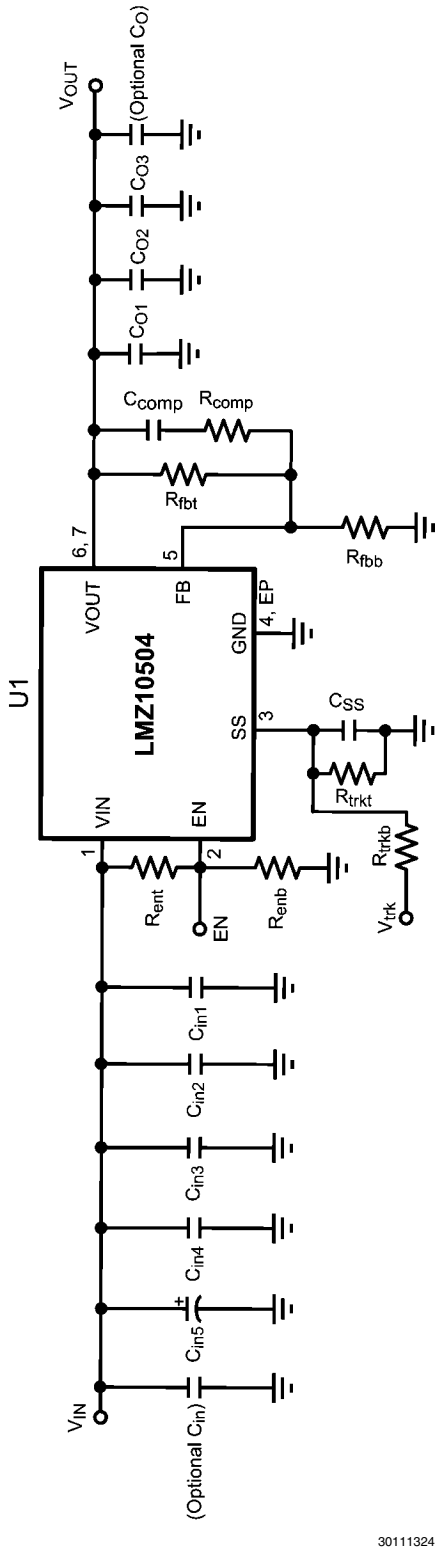


FIGURE 2. Complete Evaluation Board Schematic

Connection Diagram

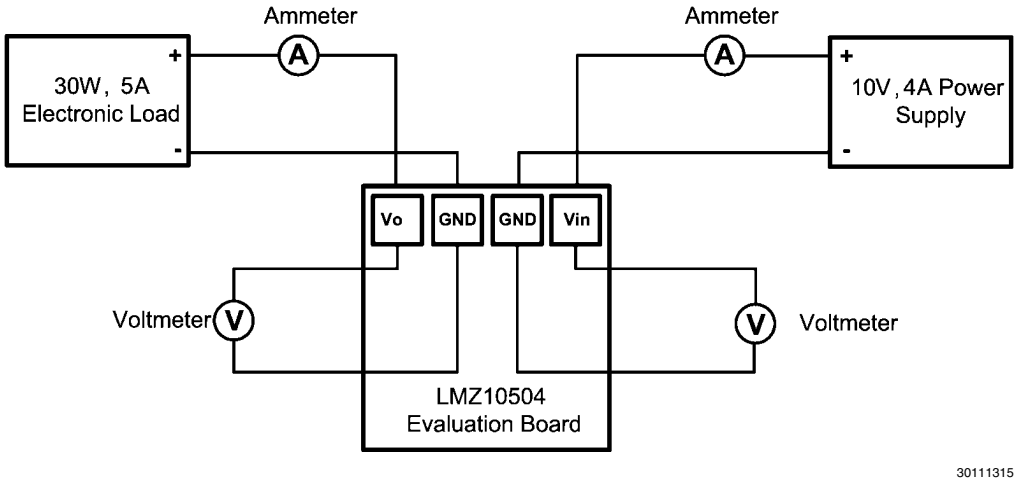


FIGURE 3. Efficiency Measurement Setup

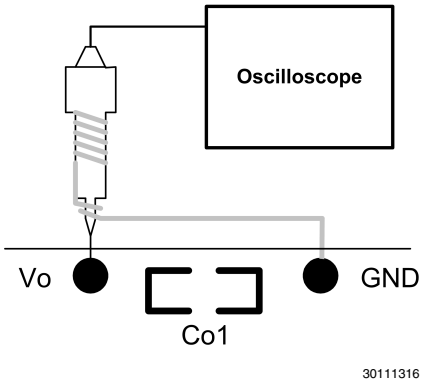


FIGURE 4. Output Voltage Ripple Measurement Setup

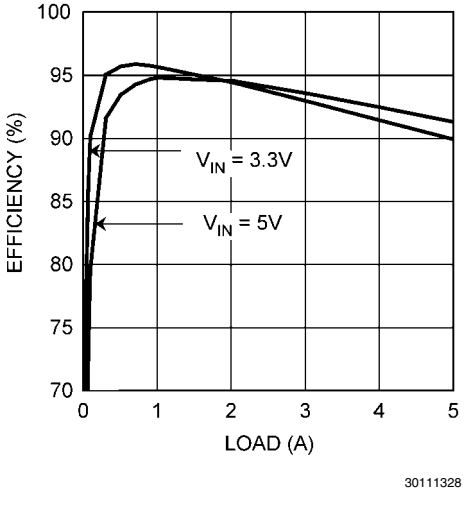


FIGURE 5. Efficiency vs. Load Current
LMZ10504 & LMZ10505, V_{OUT} = 2.5V, T_{AMB} = 25°C

Performance Characteristics

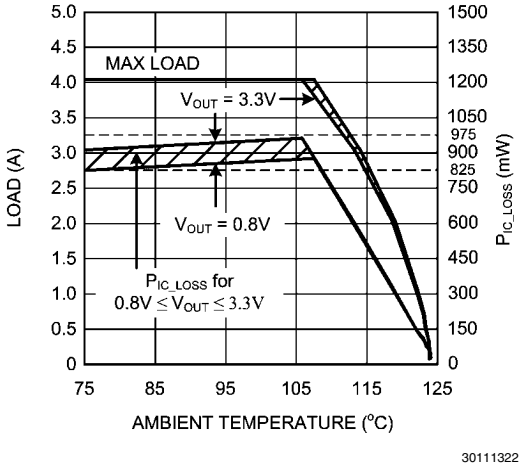


FIGURE 6. Current Derating vs. Ambient Temperature
V_{IN} = 5.0V, θ_{JA} = 20°C/W

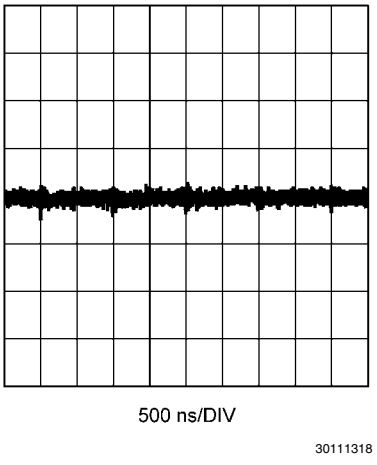


FIGURE 7. Output Voltage Ripple
V_{IN} = 5V, V_{OUT} = 2.5V, I_{OUT} = 4A

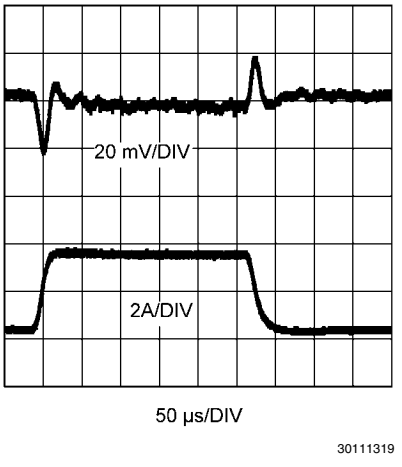


FIGURE 8. Load Transient Response
V_{IN} = 5V, V_{OUT} = 2.5V
I_{OUT} = 400 mA to 3.6A, 20 MHz Bandwidth Limit

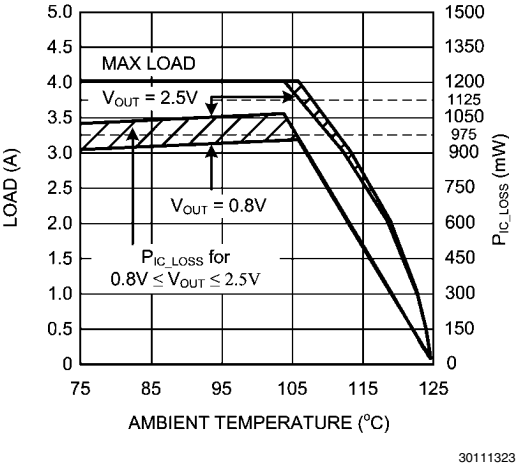


FIGURE 9. Current Derating vs. Ambient Temperature
V_{IN} = 3.3V, θ_{JA} = 20°C/W

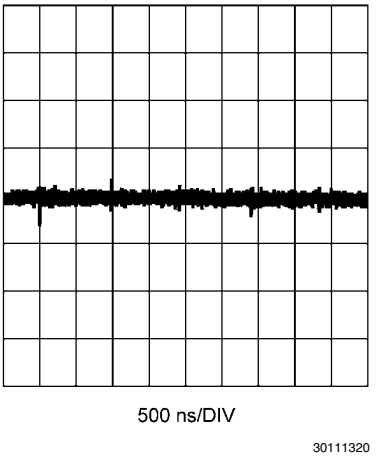


FIGURE 10. Output Voltage Ripple
V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{OUT} = 4A

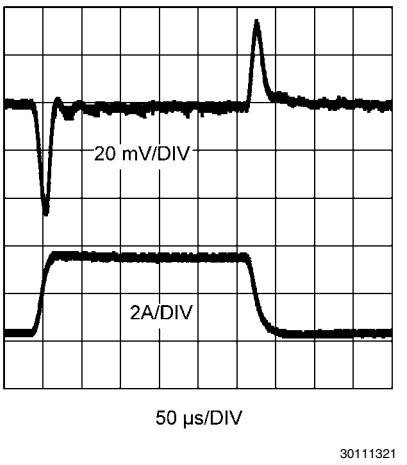


FIGURE 11. Load Transient Response
V_{IN} = 3.3V, V_{OUT} = 2.5V
I_{OUT} = 400 mA to 3.6A, 20 MHz Bandwidth Limit

Circuit Example: Complies with EN55022 Class B Radiated Emissions

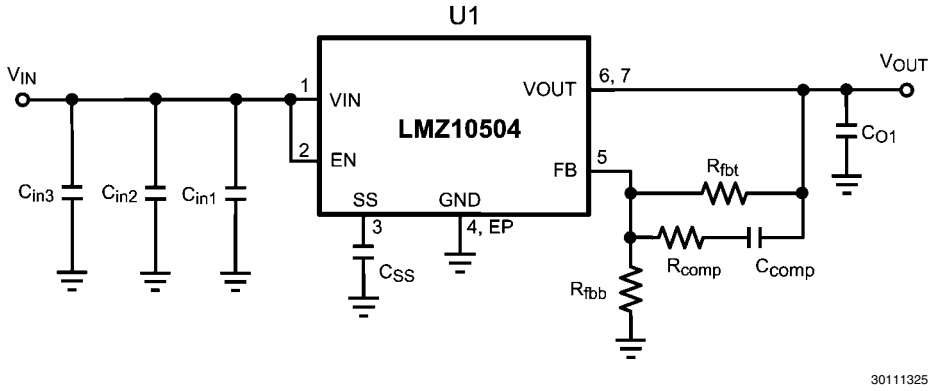


FIGURE 12. Component Schematic, V_{IN} = 5V, V_{OUT} = 2.5V, $I_{OUT\ (MAX)}$ = 4A, Complies with EN55022 Class B Radiated Emissions

TABLE 3. Bill of Materials

Designator	Description	Case Size	Manufacturer	Manufacturer P/N	Quantity
U1	SIMPLE SWITCHER®	TO-PMOD-7	National Semiconductor	LMZ10504TZ-ADJ	1
C_{in1}	1 µF, X7R, 16V	0805	TDK	C2012X7R1C105K	1
C_{in2}	4.7 µF, X5R, 6.3V	0805	TDK	C2012X5R0J475K	1
C_{in3}	47 µF, X5R, 6.3V	1210	TDK	C3225X5R0J476M	1
C_{O1}	100 µF, X5R, 6.3V	1812	TDK	C4532X5R0J107M	1
R_{fbt}	75 kΩ	0805	Vishay Dale	CRCW080575K0FKEA	1
R_{fbb}	34.8 kΩ	0805	Vishay Dale	CRCW080534K8FKEA	1
R_{comp}	1.1 kΩ	0805	Vishay Dale	CRCW08051K10FKEA	1
C_{comp}	180 pF, ±5%, C0G, 50V	0603	TDK	C1608C0G1H181J	1
C_{SS}	10 nF, ±5%, C0G, 50V	0805	TDK	C2012C0G1H103J	1

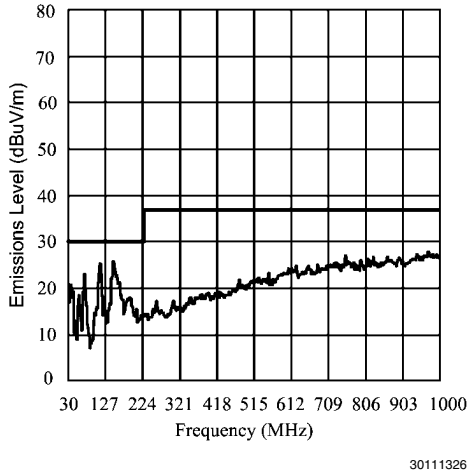


FIGURE 13. Radiated Emissions (EN55022, Class B)
V_{IN} = 5V, V_{OUT} = 2.5V, I_{OUT} = 4A
Tested on Evaluation Board

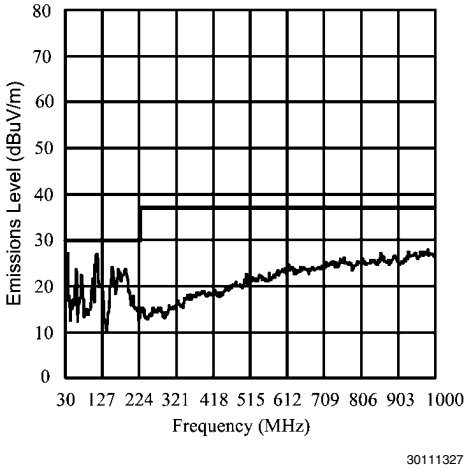
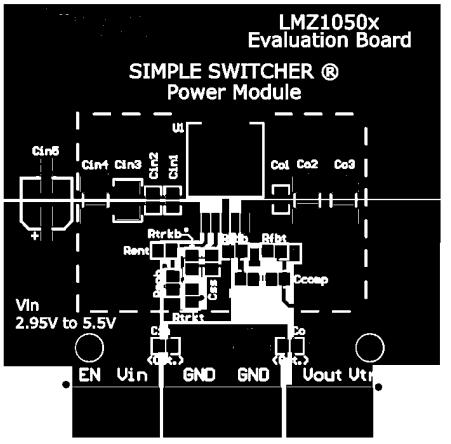


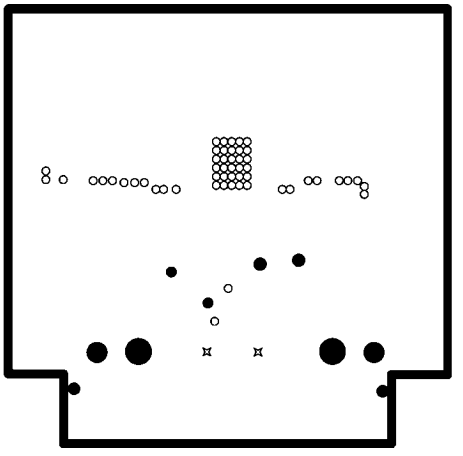
FIGURE 14. Radiated Emissions (EN55022, Class B)
V_{IN} = 5V, V_{OUT} = 2.5V, I_{OUT} = 5A
Tested on Evaluation Board

PCB Layout Diagram



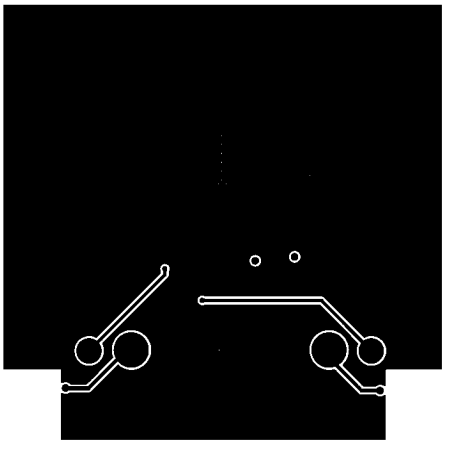
30111307

FIGURE 15. Top Layer



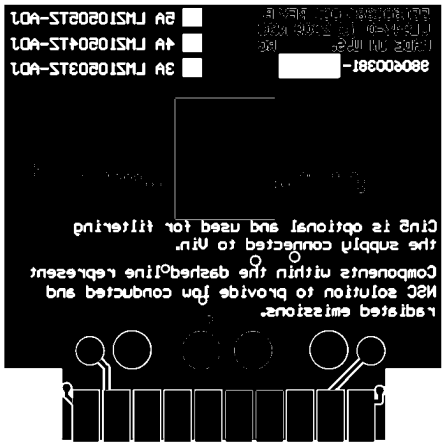
30111309

FIGURE 16. Internal Layer I (Ground)



30111311

FIGURE 17. Internal Layer II (Ground)



30111313

FIGURE 18. Bottom Layer

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at: www.national.com

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adc	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempsensors	SolarMagic™	www.national.com/solarmagic
PLL/VCO	www.national.com/wireless	PowerWise® Design University	www.national.com/training

National Semiconductor Americas Technical Support Center
Email: support@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Technical Support Center
Email: europe.support@nsc.com

National Semiconductor Asia Pacific Technical Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Technical Support Center
Email: jpn.feedback@nsc.com