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12A, 22V, Step Down Power Module

Description

The LX9610 is a 22V, 12A Power Module designed for step down point of load applications. This device includes a synchronous controller with compensation built-in, internal power MOSFETs, and the output inductor all in a 15mm x 15mm QFN package. It will operate with an input voltage from 8V to 22V, while the output voltage is adjustable from 0.8V to 5V, using a single external resistor. Included is an internal 5V regulator, and the only other components needed to make a complete 12A DC to DC converter are a 4.7µF decoupling capacitor for the 5V regulator, and the bulk input and output capacitors.

Other features of this device are internal digital soft start, thermal shutdown and hiccup mode current limit. The device can be enabled or shut down through the COMP/EN pin. Over current sensing is accomplished by measuring the voltage across the Rds-on of the low-side MOSFET.

Current of the OCP pin of the IC multiplied by resistance of the OCP resistor (residing on the PCB inside the module) sets the OCP threshold. An external resistor can be used to reduce the OCP threshold.

The LX9610 is package in a thermal enhanced, compact over-molded module with a length, width and height of the power module are 15mm, 15mm and 4mm, respectively. This package is suitable for assembly by standard automated surface mount equipment.

Features

- Fully integrated 12A Power Module Requiring Only Input/output Caps and Few External Components
- Operational Input Supply Voltage Range: 8V to 22V
- Adjustable Output from 0.8V to 5V Using One External Resistor
- Integrated Upper and Lower N-Channel MOSFET's
- Maximum 1MHz Switching Frequency (Preset frequency is 600kHz)
- Can be Enabled or Shut Down Through the COMP/EN pin
- Internal Digital Soft Start
- Cycle-by-cycle Over Current Monitoring with Hiccup mode protection
- Available in QFN 15mm x 15mm x 4mm
- RoHS Compliant & Halogen Free

Applications

- Set-top Box
- Servers
- Industrial Equipments
- Telecom and Datacom Applications
- Point of Load Regulator Applications
- Gaming

Product Highlight

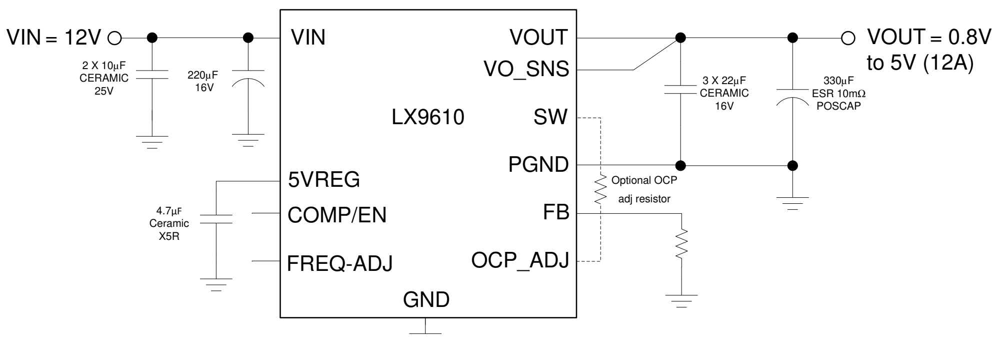


Figure 1 · Product Highlight

Pin Configuration

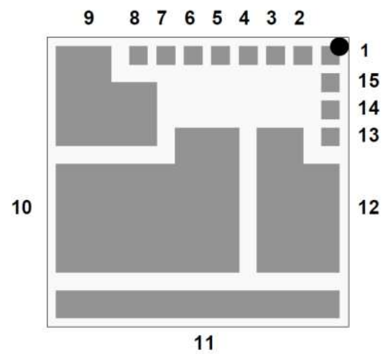


Figure 2 · Pinout (Top View)

Top mark

- MSC
- LX9610

YYWWA = Year/Week/Lot Identifier

Ordering Information

Ambient Temperature	Type	Package	Part Number	Packaging Type
-40°C to 85°C	RoHS2 compliant, Pb-free Matte Sn lead finish MSL 3	QFN 15 x 15 x 3.75 15L	LX9610ILQ	Tube
			LX9610ILQ -TR	Tape and Reel

Pin Description

Pin Number	Pin Designator	Description
1, 2, 3, 4	GND	These pins are connected to the GND pin of the controller IC. Connect the external controller components to these pins for ground connection.
5	5VREG	The output of the internal 5V regulator. A 4.7µF ceramic cap must be connected from this pin to GND.
6	VO_SNS	This pin is connected to the VOUT at the regulation point of the load.
7	Unused	NC, this pin is not used.
8	OCP_ADJ	A resistor between this pin and SW pin adjusts the OCP threshold down.
9	VIN	Power input pin of the module. Connect a low ESR bulk capacitor from this pin to GND to have low ripple voltage at this pin.

Pin Number	Pin Designator	Description
10	SW	Switch node pin. The high-side and low-side MOSFET's and the inductor are connected to this pin. If needed, connect an R-C snubber network from this pin to GND to limit the voltage spike at this to 30V (max).
11	PGND	Power ground pin. Connect the input and output bulk caps to this pin for ground connection. This pin needs to be connected to GND pins on the application PCB.
12	VOUT	Output terminal of the power module. Connect a 330µF POSCAP in parallel with three 22µF ceramic caps from this pin to PGND pin.
13	COMP/EN	This is the output of the transconductance error amplifier. Pulling this pin to ground shuts down the power module. Floating this pin enables the power module.
14	FB	Feedback pin. A resistor connected from this pin to GND sets the output voltage. Use the formula: $V_{OUT} = V_{FB} * (1 + 49.9k / R_{FB})$
15	FREQ-ADJ	Switching frequency adjustment pin. With this pin floating, the module will have a switching frequency of 600kHz. By connecting an external resistor from this pin to GND, the switching frequency can be increased. Maximum frequency allowed is 1MHz.

Absolute Maximum Ratings

Parameter	Value	Units
Supply Input Voltage (VIN)	-0.3 to 25	V
Switch Node Voltage (SW)	-0.3 to 30	V
All Other Pins	-0.3 to 6.5	V
Operational Ambient Temperature	-55 to +125	°C
Storage Temperature Range	-65 to +150	°C
Peak Package Solder Reflow Temperature (40 seconds maximum exposure)	245	°C

Exceeding these ratings could cause damage to the device. All voltages are with respect to GND. Currents are positive into, negative out of specified terminal. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" are not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

Thermal Properties

Thermal Resistance	Typ	Units
θ_{JP} Junction to Pads	1.5	°C/W
θ_{JA} Junction to Ambient	8	

Note: Note: The θJx numbers assume no forced airflow. Junction Temperature is calculated using $T_J = T_A + (PD \times \theta J_A)$. In particular, θJ_A is a function of the PCB construction. The stated number above is for a four-layer board in accordance with JESD-51 (JEDEC) with thermal vias on VIN, SW, VOUT, and PGND pins. See PCB layout Guidelines, figure 21.

Electrical Characteristics

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
Unless otherwise specified, the following specifications apply over the operating ambient temperature of -40°C ≤ T_A ≤ 85°C except where otherwise noted with the following test conditions: VIN = 12V, VOUT = 1.2V, C_{IN} = 220µF + 2x10µF(ceramic), C_{OUT}=330 µF, ESR =10miliohm + 3 x 22µF ceramic capacitors. Typical parameter refers to T_J = 25°C						
Operating Current						
IQ	Quiescent Current	I_{VOUT} = 0A, VOUT = 5V, VIN = 12V		75		mA
I_{SHDN}	Shutdown Supply Current	$V_{COMP/EN}$ = 0V	3.7	4.8	11	mA
VIN UVLO						
V_{UVLO}	Under Voltage Lockout	VIN Rising	6	6.5	7.5	V
V_{HYS}	UVLO Hysteresis			0.6		V
FD						
V_{FB}	Feedback Voltage		0.784	0.8	0.816	V
Oscillator						
F_{OSC}	Internal Oscillator Frequency	FREQ-ADJ pin = floating, open		600		kHz
		FREQ-ADJ pin = 20kΩ to GND		930		
D_{MAX}	Maximum Duty Cycle	V_{FB} = 0.7V, FREQ-ADJ pin = floating, open	80	83	86	%
TON_{MIN}	Minimum On Time	V_{FB} = 1V			150	ns
COMP/EN						
G_{EA}	Error Amplifier Transconductance	1V ≤VCOMP/EN ≤ 4V; GBD	1.35	1.85	2.35	mA/V
	COMP/EN Shut Down Threshold	GBD	0.14	0.2	0.26	V
Output						
$\Delta VOUT_{LINE}$	Line Regulation	I_{VOUT} = 0.5A, 8V < VIN < 22V		0.1		%
$\Delta VOUT_{LOAD}$	Load Regulation	VIN = 12V, 0A < I_{VOUT} < 12A, GBD		0.013		%/A
RDS_{ONL}	Low-side Switch On Resistance	I_{SW} = 1A (current coming out of SW)		7	9	mΩ
$I_{LEAK-SW}$	SW Pin Leakage Current	V_{O_SNS} Open		1.14		mA
Soft Start						
T_{SS}	Soft Start Time			1.7		ms
T_{HICCUP}	Hiccup Time	VIN=12V, GBD		7.3		ms
Protection						
V_{FBUV}	Output Under Voltage Protection Threshold	OCP_ADJ pin floating	0.54	0.6	0.66	V
	OCP Threshold for Output Current	GBD	13.6	23.6	28.5	A
T_{OTSD}	Thermal Shutdown Threshold			155		°C
T_{HYS}	Thermal Shutdown Hysteresis			21		
5VREG						
	5VREG Voltage Range	I_{5VREG} = 5mA	4.875	5.125	5.325	V
	5VREG UVLO	5VREG voltage rising, GBD		4.04		V
	5VREG UVLO Hysteresis	GDB		0.28		V
	5VREG Max Current	8V ≤ VIN ≤ 22V	20	50		mA
GBD = Guaranteed by design, characterization, not production tested.						

Simplified Schematic

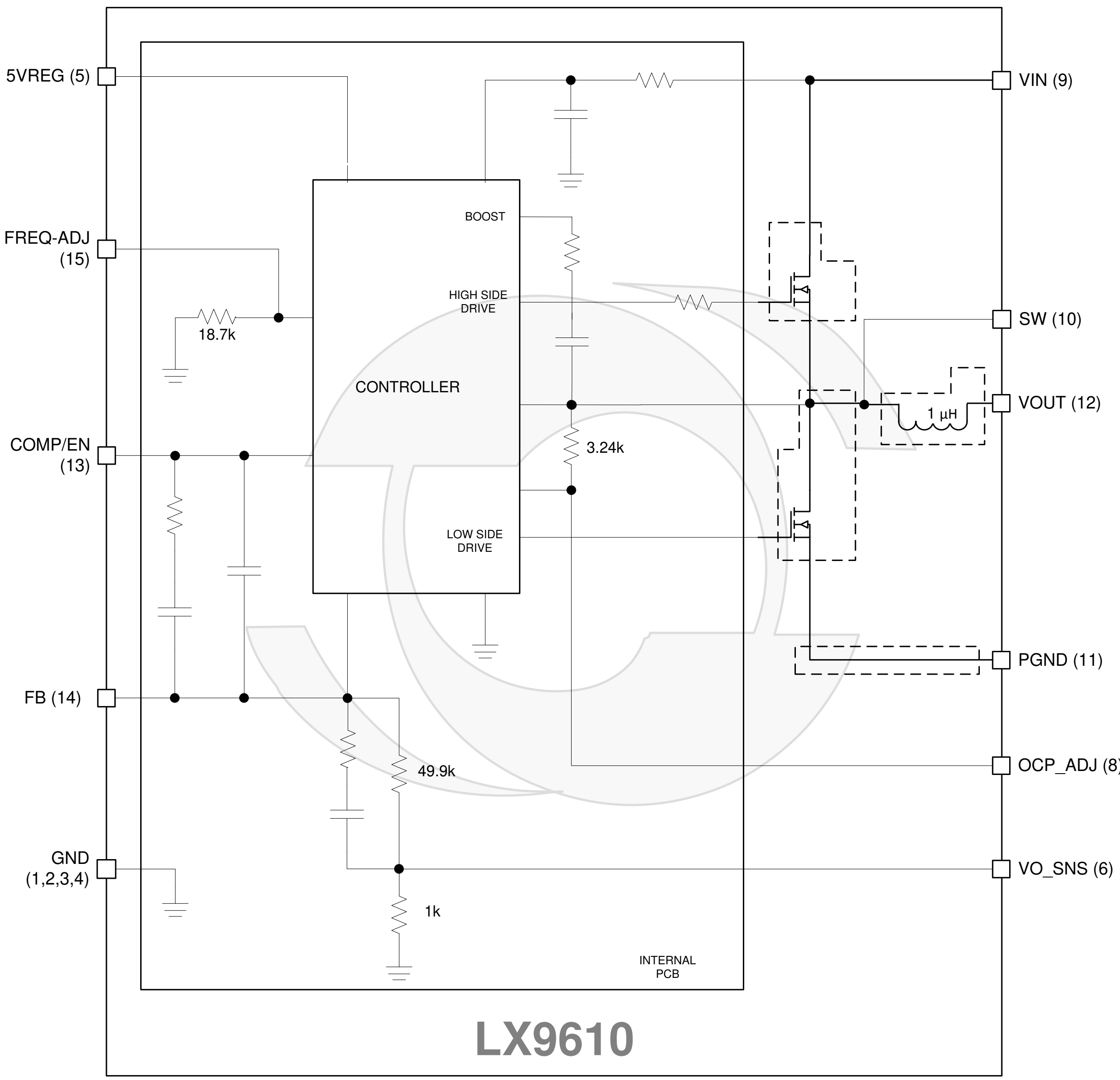


Figure 3 · LX9610 Simplified Schematic

Characteristic Curves – VIN = 12V, VOUT = 1.2V

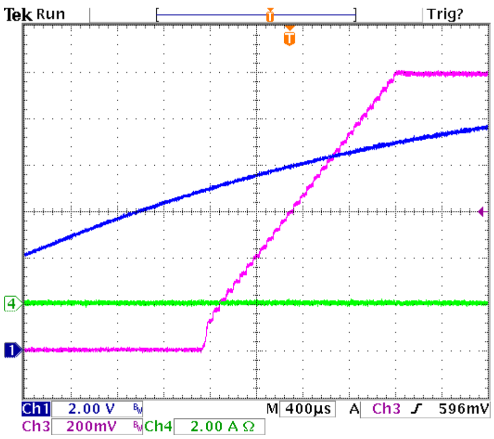


Figure 4 · Startup No Load
CH1 VIN, CH3 VOUT, R_{FB} = 100kΩ, CH4 Load Current

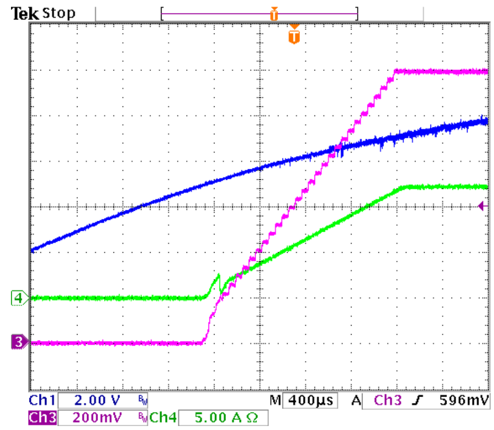


Figure 5 · Startup 12A (Constant Current)
CH1 VIN, CH3 VOUT, R_{FB} = 100kΩ CH4 Load Current

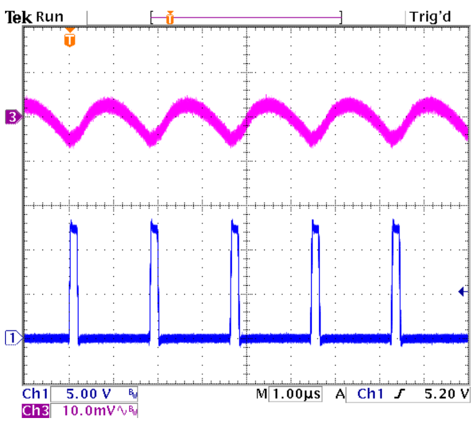


Figure 6 · Output Ripple , No Load
CH1 Switch Node Voltage, CH3 VOUT (AC coupled across Ceramic Output Capacitors)

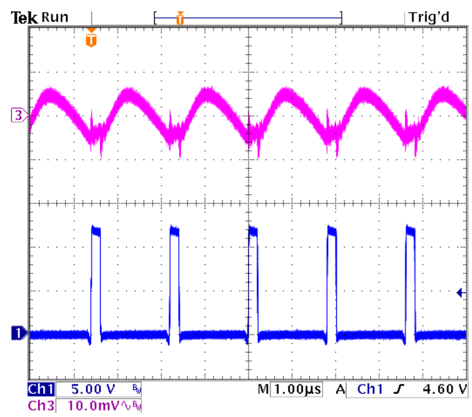


Figure 7 · Output Ripple, 12A Load
CH1 Switch Node Voltage, CH3 VOUT (AC coupled across Ceramic Output Capacitors)

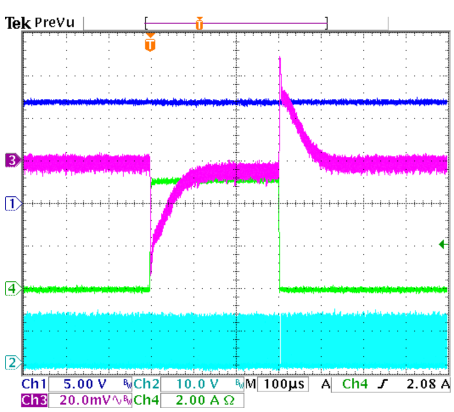


Figure 8 · Transient Response 0A to 5A (5A/µs)
CH1 VIN, CH2 Switch Node Voltage, CH3 VOUT (AC coupled across Ceramic Output Capacitors), CH4 Load Current

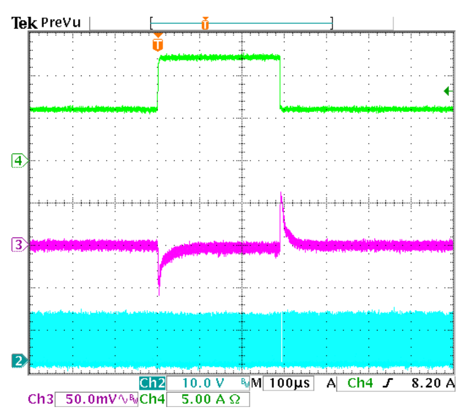


Figure 9 · Transient Response 6A to 12A (5A/µs)
CH2 Switch Node Voltage, CH3 VOUT (AC coupled across Ceramic Output Capacitors), CH4 Load Current

Characteristic Curves – VIN = 12V, VOUT = 5V

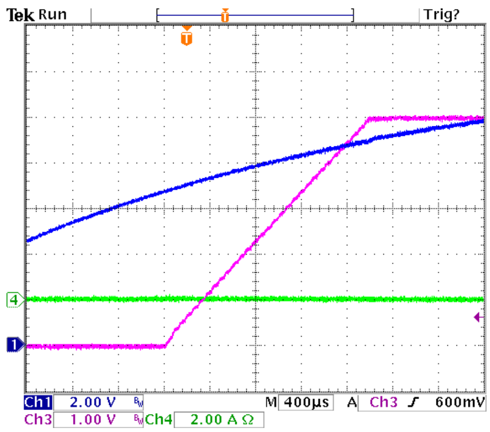


Figure 10 · Startup No Load
CH1 VIN, CH3 VOUT, R_{FB} = 9.53kΩ, CH4 Load Current

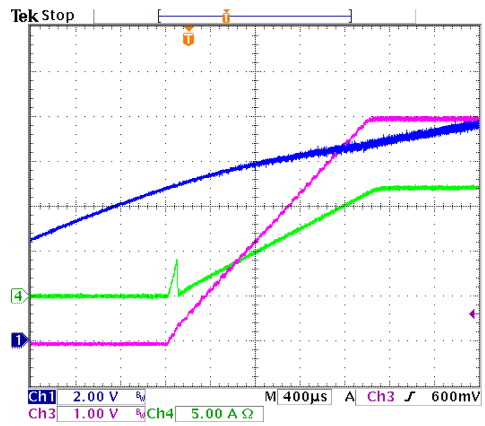


Figure 11 · Startup 12A (Constant Current)
CH1 VIN, CH3 VOUT, R_{FB} = 9.53kΩ, CH4 Load Current

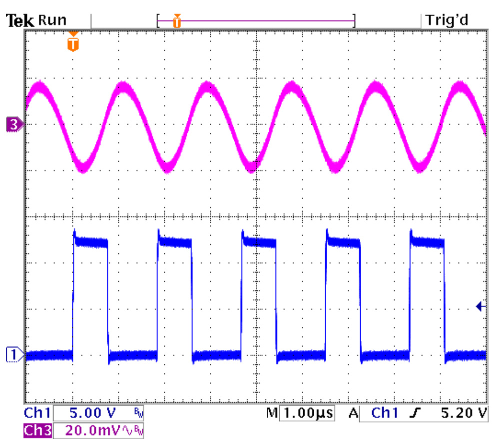


Figure 12 · Output Ripple , No Load
CH1 Switch Node Voltage, CH2 VOUT (AC coupled across ceramic output capacitors)

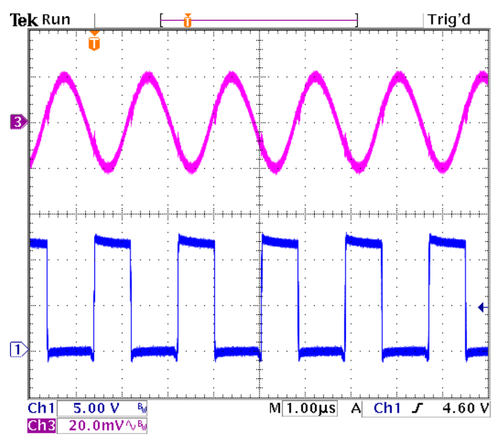


Figure 13 · Output Ripple, 12A Load
CH1 Switch Node Voltage, CH2 VOUT (AC coupled across ceramic output capacitors)

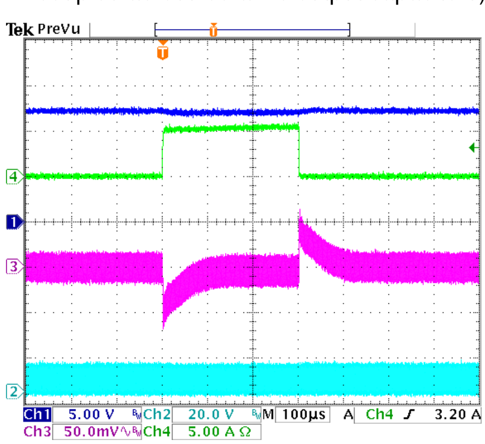


Figure 14 · Transient Response 0A to 5A (5A/µs)
CH1 VIN, CH2 Switch Node Voltage, CH3 VOUT (AC coupled across ceramic output capacitors), CH4 Load Current

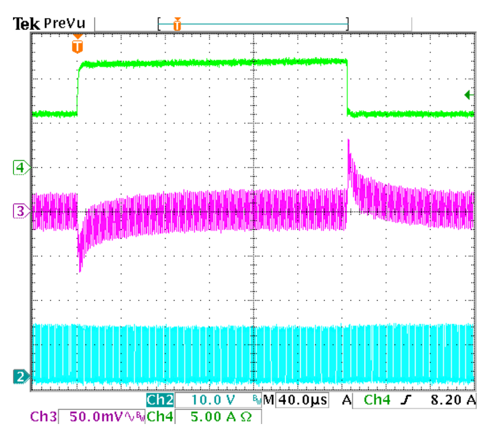


Figure 15 · Transient Response 6A to 12A (5A/µs)
CH2 Switch Node Voltage, CH3 VOUT (AC coupled across ceramic output capacitors), CH4 Load Current

Characteristic Curves

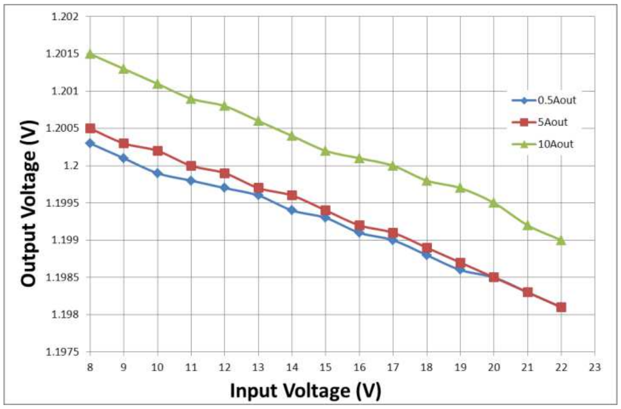


Figure 16 · Line Regulation
VOUT = 1.2V, IOUT = 5A

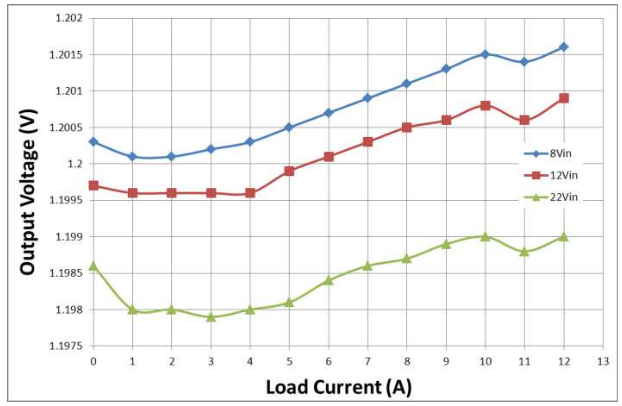


Figure 17 · Load Regulation
VOUT = 12V, VIN = 8V, 12V, 22V

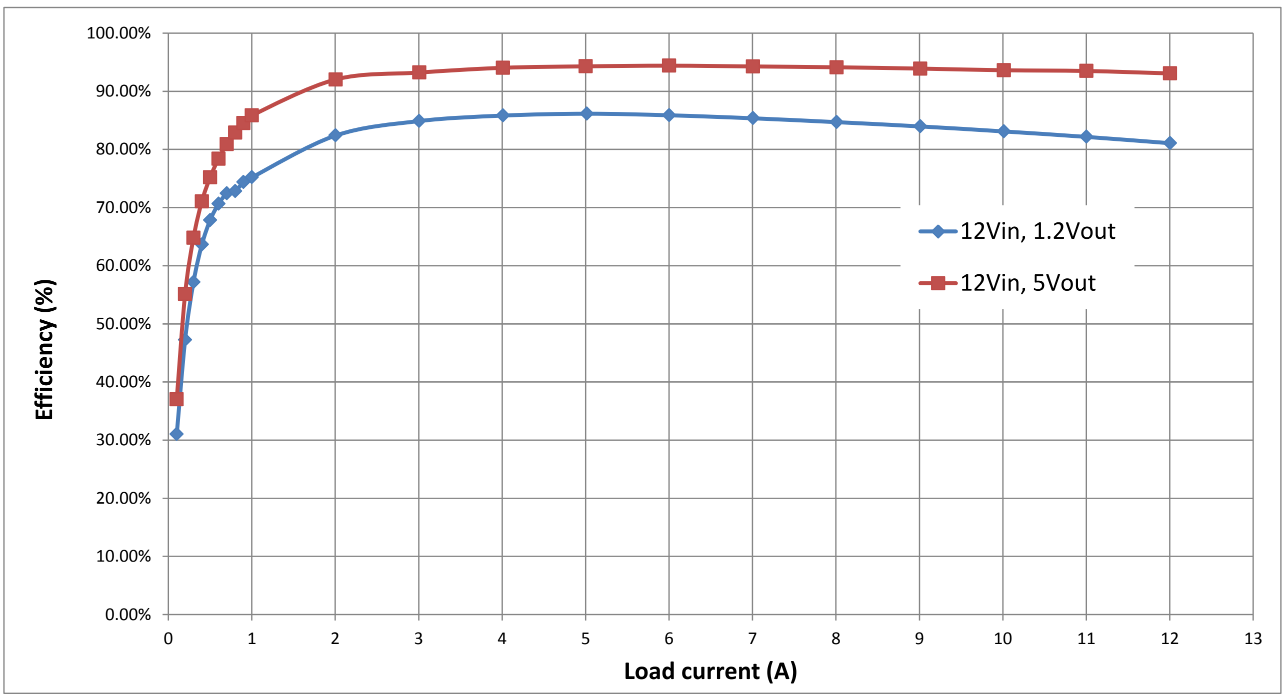


Figure 18 · Efficiency Measurements
VIN = 12V, VOUT = 1.2V and 5V

Characteristic Curves

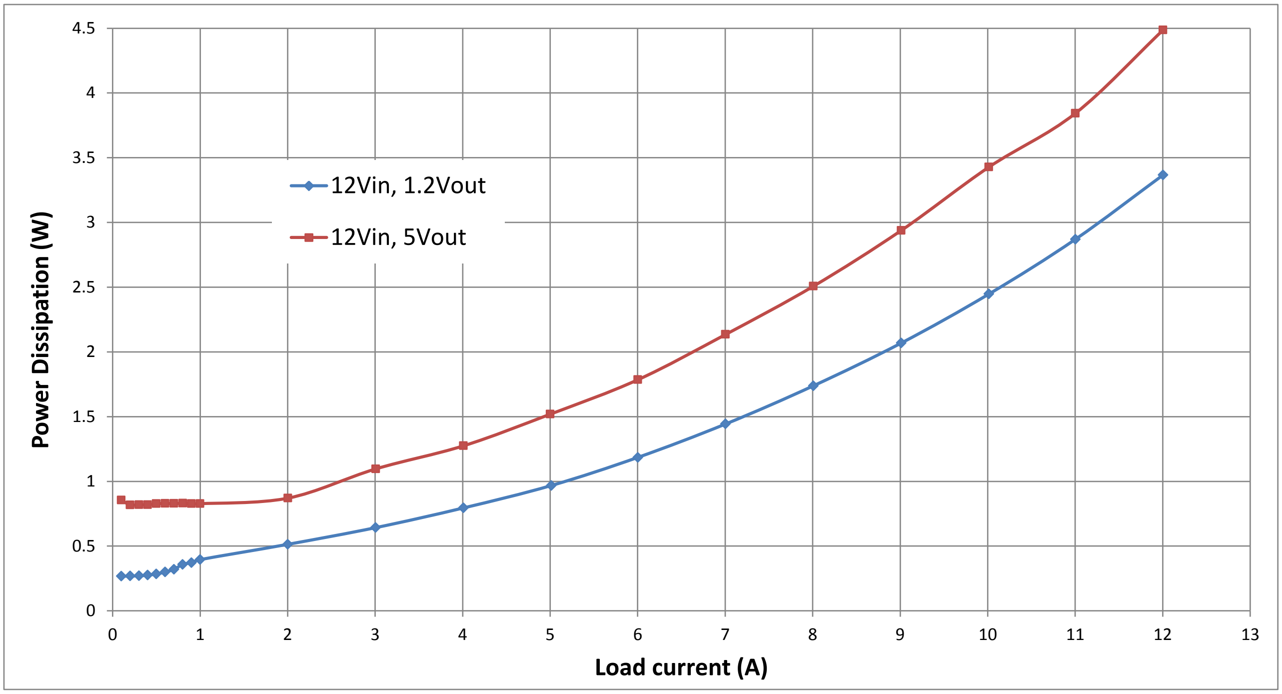


Figure 19 · Power Dissipation Measurements
VIN = 12V, VOUT = 1.2V and 5V

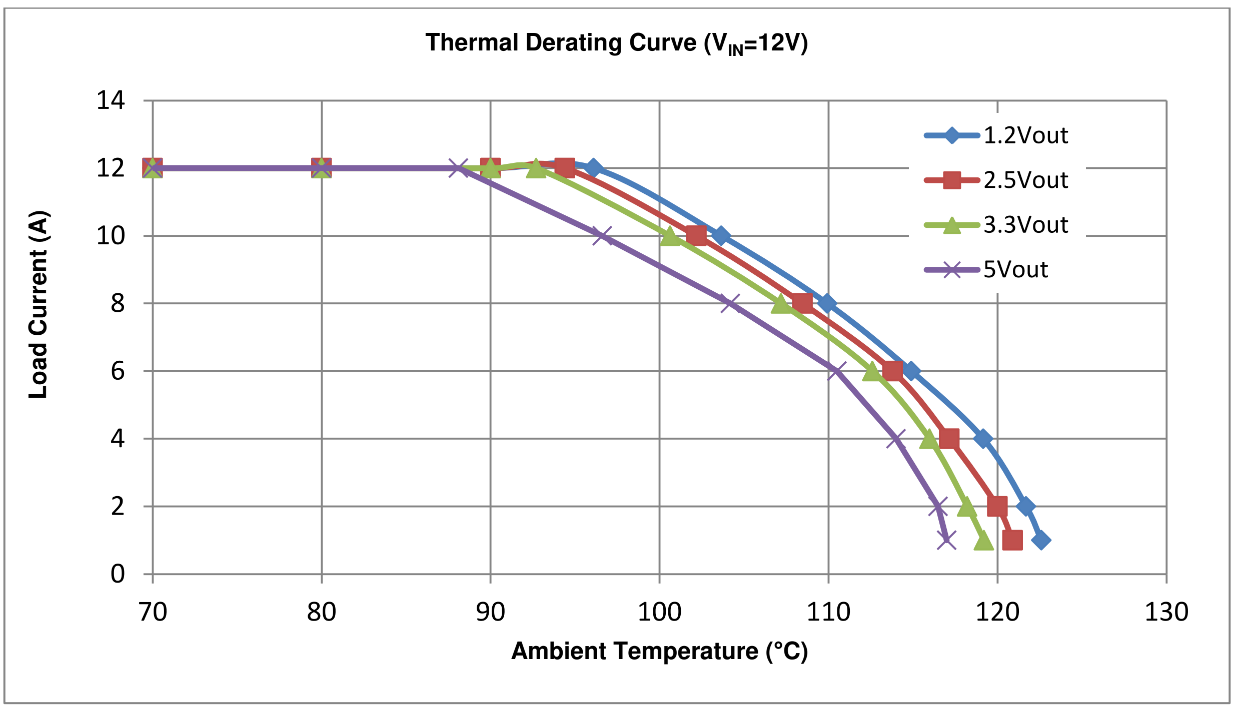


Figure 20 · Thermal Derating Curve (VIN = 12V)
Thermal performance shown requires use of thermal vias on all power components and large copper planes.

PCB Layout Guidelines

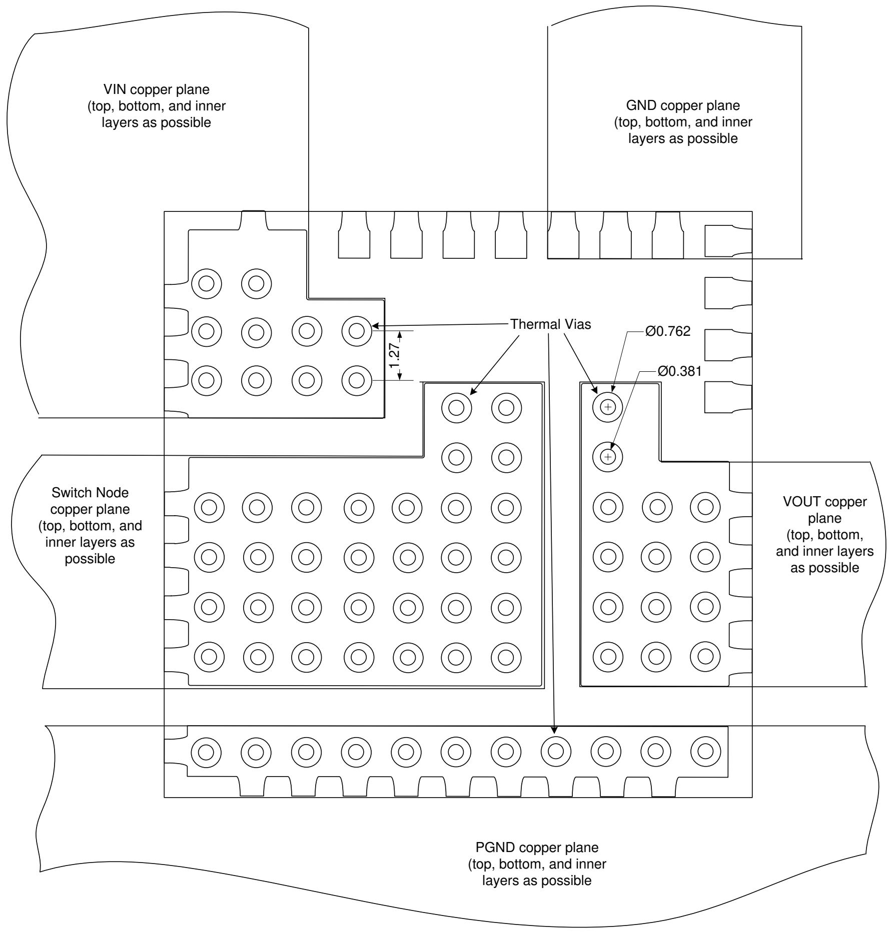


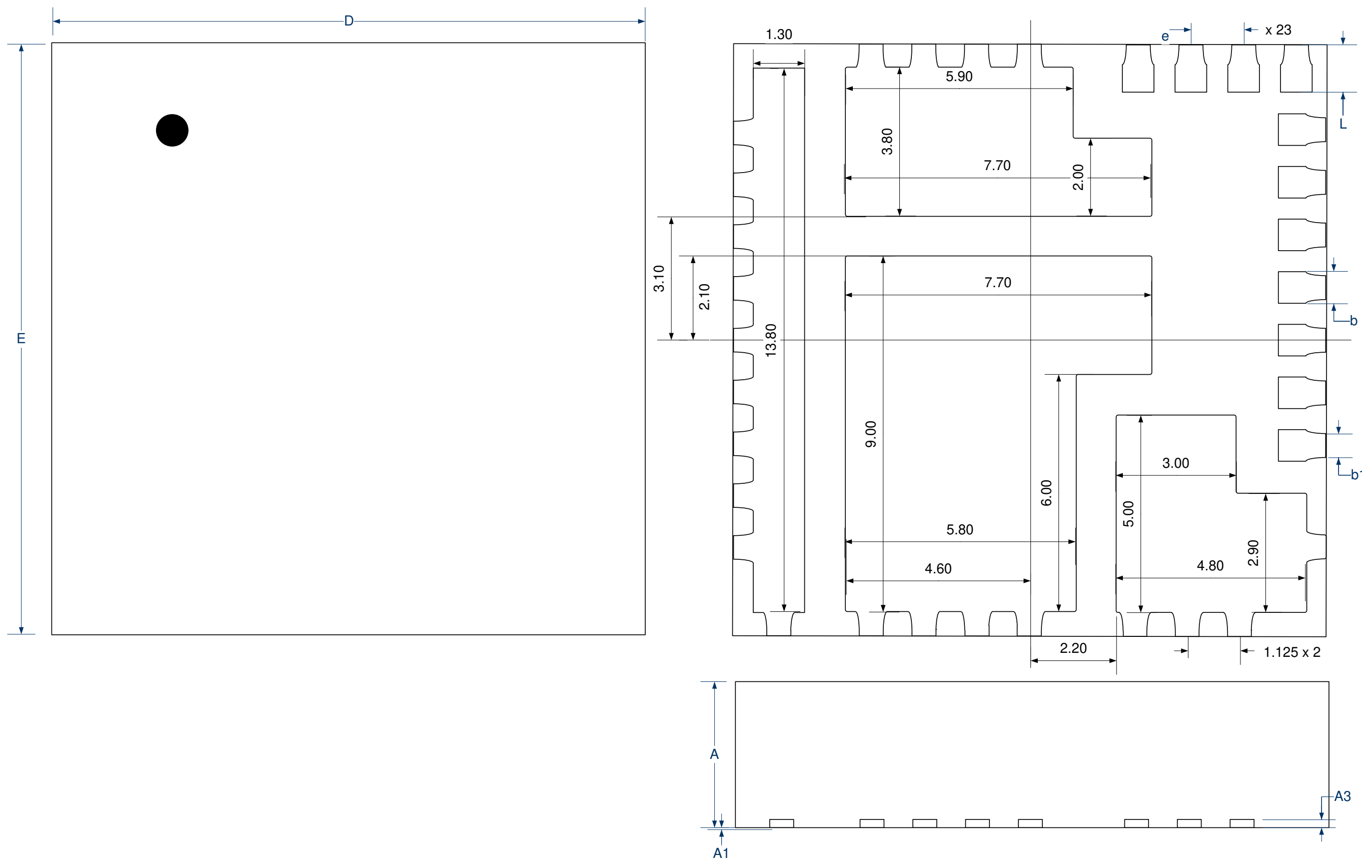
Figure 21 · PCB Footprint with Thermal Vias

Notes:

1.Thermal vias diameter 0.762 mm, hole diameter 0.381, spacing is 1.27mm
2. Recommended tented thermal vias as shown with vias filled with solder.
3. Aperture design for thermal pads using multiple openings with 60 to 80% solder paste coverage.
4. For best thermal performance maximize plane size and include copper planes on inner layers.
5. For additional layout details see the LX9610 Evaluation Board User Guide.

Package Outline Dimensions

The package is halogen free and meets RoHS2 and REACH standards.



Dim	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.85	4.00	0.151	0.158
A1	0	0.05	0	0.002
A3	0.203 REF		0.008 REF	
b	0.75	0.85	0.030	0.033
D	15.00 BSC		0.591 BSC	
E	15.00 BSC		0.591 BSC	
b1	0.45	0.55	0.018	0.022
e	1.30 BSC		0.051 BSC	
L	1.15	1.25	0.045	0.049

Note:

Dimensions do not include mold flash or protrusions; these shall not exceed 0.155mm (.006") on any side. Lead dimension shall not include solder coverage.
All dimensions are ± 0.50mm unless otherwise noted.

Figure 22 · Package Dimensions

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