INITIAL RELEASE

Final Electrical Specifications

LTC1649

3.3V Input High Power Step-Down Switching Regulator Controller

May 1998

FEATURES

- **High Power 3.3V to 1.XV-2.XV Switching Regulator Controller: Up to 20A Output**
- **All N-Channel External MOSFETs**
- **Provides 5V MOSFET Gate Drive with 3.3V Input**
- Constant Frequency Operation Minimizes Inductor Size
- **Excellent Output Regulation: ±1% Over Line, Load and Temperature Variations**
- High Efficiency: Over 90% Possible
- No Low-Value Sense Resistor Needed
- Available in 16-Lead SO Package

APPLICATIONS

- 3.3V Input Power Supply for Low Voltage Microprocessors and Logic
- Low Input Voltage Power Supplies
- High Power, Low Voltage Regulators
- Local Regulation for Multiple Voltage Distributed Power Systems

DESCRIPTION

The LTC®1649 is a high power, high efficiency switching regulator controller optimized for use with very low supply voltages. It operates from 2.7V to 5V input, and provides a regulated output voltage from 1.26V to 2.5V at up to 20A load current. A typical 3.3V to 2.5V application features efficiency above 90% from 1A to 10A load. The LTC1649 uses a pair of standard 5V logic-level N-channel external MOSFETs, eliminating the need for expensive P-channel or super-low-threshold devices.

The LTC1649 shares its internal switching architecture with the LTC1430, and features the same ±1% line, load and temperature regulation characteristics. Current limit is user-adjustable without requiring an external low-value sense resistor. The LTC1649 uses a 200kHz switching frequency and voltage mode control, minimizing external component count and size. Shutdown mode drops the quiescent current to below 10µA.

The LTC1649 is available in the 16-pin narrow SO package.

TYPICAL APPLICATION

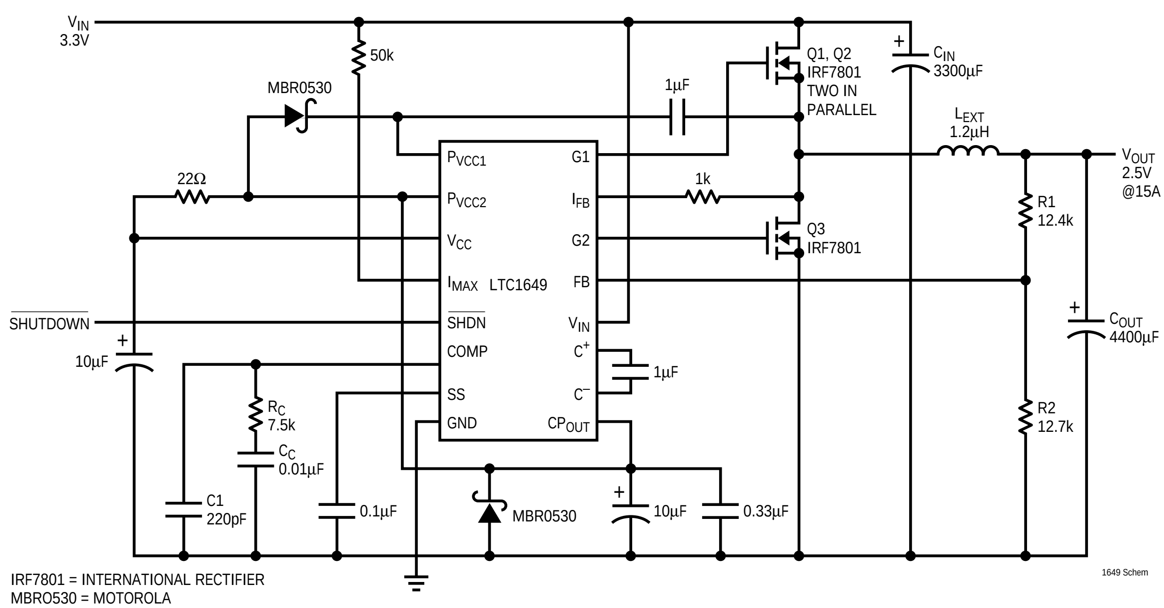


Figure 1. 3.3V to 2.5V, 15A Converter

ABSOLUTE MAXIMUM RATINGS

(Note 1)

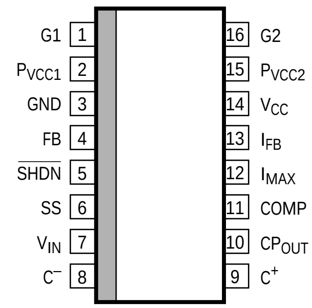
Supply Voltage
- V_{IN} 6V
- V_{CC} 9V
- $P_{VCC1, 2}$ 13V

Input Voltage
- I_{FB} .... –0.3V to 18V
- C^+, C^- .... –0.3V to (V_{IN} + 0.3V)
- All Other Inputs .... –0.3V to (V_{CC} + 0.3V)

Operating Temperature Range .... 0°C to 70°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW



S PACKAGE
16-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 110°C/ W

ORDER PART NUMBER
LTC1649CS

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

V_{IN} = 3.3V, T_A = 25°C unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IN}	Minimum Supply Voltage	Figure 1 (Note 3)	●	2.7			V
V_{FB}	Feedback Voltage	Figure 1	●	1.25	1.265	1.28	V
V_{CPOUT}	Charge Pump Output Voltage	Figure 1	●	4.8	5	5.2	V
I_{IN}	Supply Current (V_{IN})	$V_{\overline{SHDN}}$ = V_{CC}, I_{LOAD} = 0 $V_{\overline{SHDN}}$ = 0V	●		3 10	5 25	mA µA
$I_{PVCC1, 2}$	Supply Current ($P_{VCC1, 2}$)	P_{VCC} = 5V, $V_{\overline{SHDN}}$ = V_{CC} (Note 4) $V_{\overline{SHDN}}$ = 0V			1.5 0.1		mA µA
f_{CP}	Internal Charge Pump Frequency	I_{CPOUT} = 20mA (Note 5)			700		kHz
f_{OSC}	Internal PWM Oscillator Frequency		●	140	200	260	kHz
V_{IH}	$\overline{SHDN}$ Input High Voltage		●	2.4			V
V_{IL}	$\overline{SHDN}$ Input Low Voltage		●			0.8	V
I_{IN}	$\overline{SHDN}$ Input Current		●		±0.01	±1	µA
gm_V	Error Amplifier Transconductance				650		µMho
gm_I	I_{LIM} Amplifier Transconductance	(Note 6)			1300		µMho
I_{IMAX}	I_{MAX} Sink Current	V_{IMAX} = VCC	●	8	12	16	µA
I_{SS}	Soft Start Source Current	V_{SS} = 0V	●	–8	–12	–16	µA
t_r, t_f	Driver Rise/Fall Time	P_{VCC1} = P_{VCC2} = 5V			80	250	ns
t_{NOV}	Driver Non-Overlap Time	P_{VCC1} = P_{VCC2} = 5V		25	130	250	ns
DC_{MAX}	Maximum Duty Cycle	V_{COMP} = V_{CC}			95		%

The ● denotes specifications which apply over the full operating temperature range.

Note 1: Absolute Maximum Ratings are those values beyond which the life of a part may be impaired.

Note 2: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to ground unless otherwise specified.

Note 3: Maximum Duty Cycle limitations will limit the output voltage obtainable at very low supply voltages.

Note 4: Supply current at P_{VCC1} and P_{VCC2} is dominated by the current needed to charge and discharge the external MOSFET gates. This current will vary with the operating voltage and the external MOSFETs used.

Note 5: Under normal operating conditions, the charge pump will skip cycles to maintain regulation and the apparent frequency will be lower than 700kHz.

Note 6: The I_{LIM} amplifier can sink but not source current. Under normal (not current limited) operation, the I_{LIM} output current will be zero.

PIN FUNCTIONS

G1 (Pin 1): Driver Output 1. Connect this pin to the gate of the upper N-channel MOSFET, Q1. This output will swing from P_{VCC1} to GND. G1 will always be low when G2 is high. In shutdown, G1 and G2 go low.

P_{VCC1} (Pin 2): Power V_{CC} for Driver 1. This is the power supply input for G1. G1 will swing from P_{VCC1} to GND. P_{VCC1} must be connected to a potential of at least V_{IN} + $V_{GS(ON)}$(Q1). This potential can be generated using a simple charge pump connected to the switching node between the two external MOSFETs as shown in Figure 1.

GND (Pin 3): System Ground. Connect to a low impedance ground in close proximity to the source of Q2. The system signal and power grounds should meet at only one point, at the GND pin of the LTC1649.

FB (Pin 4): Feedback. The FB pin is connected to the output through a resistor divider to set the output voltage. $V_{OUT} = V_{REF} [1 + (R1/R2)]$.

$\overline{SHDN}$ (Pin 5): Shutdown, Active Low. A TTL compatible LOW level at $\overline{SHDN}$ for more than 50µs puts the LTC1649 into shutdown mode. In shutdown, G1, G2, COMP and SS go low, and the quiescent current drops to 25µA max. CP_{OUT} remains at 5V in shutdown mode. A TTL compatible HIGH level at $\overline{SHDN}$ allows the LTC1649 to operate normally.

SS (Pin 6): Soft Start. An external capacitor from SS to GND controls the startup time and also compensates the current limit loop, allowing the LTC1649 to enter and exit current limit cleanly.

V_{IN} (Pin 7): Charge Pump Input. This is the main low voltage power supply input. V_{IN} requires an input voltage between 3V and 5V. Bypass V_{IN} to ground with a 1µF ceramic capacitor located close to the LTC1649.

C^- (Pin 8): Flying Capacitor, Negative Terminal. Connect a 1µF ceramic capacitor from C^- to C^+.

C^+ (Pin 9): Flying Capacitor, Positive Terminal.

CP_{OUT} (Pin 10): Charge Pump Output. CP_{OUT} provides a regulated 5V output to provide power for the internal switching circuitry and gate drive for the external MOSFETs. CP_{OUT} should be connected directly to P_{VCC2} in most applications. At least 10µF of reservoir capacitance to ground is required at CP_{OUT}. This requirement can usually be met by the bypass capacitor at P_{VCC2}.

COMP (Pin 11): External Compensation. The COMP pin is connected directly to the output of the internal error amplifier and the input of the PWM generator. An RC network is used at this node to compensate the feedback loop to provide optimum transient response.

I_{MAX} (Pin 12): Current Limit Set. I_{MAX} sets the threshold for the internal current limit comparator. If I_{FB} drops below I_{MAX} with G1 on, the LTC1649 will go into current limit. I_{MAX} has an internal 12µA pull-down to GND. The voltage at I_{MAX} can be set with an external resistor to the drain of Q1 or with an external voltage source.

I_{FB} (Pin 13): Current Limit Sense. Connect to the switched node at the source of Q1 and the drain of Q2 through a 1kΩ resistor. The resistor is required to prevent voltage transients at the switched node from damaging the I_{FB} pin. I_{FB} can be taken up to 18V above GND without damage.

V_{CC} (Pin 14): Internal Power Supply. V_{CC} provides power to the feedback amplifier and switching control circuits. V_{CC} is designed to run from the 5V supply provided by CP_{OUT}. V_{CC} requires a 10µF bypass capacitor to GND.

P_{VCC2} (Pin 15): Power V_{CC} for Driver 2. This is the power supply input for G2. G2 will swing from P_{VCC2} to GND. P_{VCC2} must be connected to a potential of at least $V_{GS(ON)}$(Q2). This voltage is usually supplied by the CP_{OUT} pin. P_{VCC2} requires a bypass capacitor to GND; this capacitor also provides the reservoir capacitance required by the CP_{OUT} pin.

G2 (Pin 16): Driver Output 2. Connect this pin to the gate of the lower N-channel MOSFET, Q2. This output will swing from P_{VCC2} to GND. G2 will always be low when G1 is high. In shutdown, G1 and G2 go low.

APPLICATIONS INFORMATION

The LTC1649 shares the bulk of its circuitry with the LTC1430, and many of the applications shown in the LTC1430 datasheet apply equally to the LTC1649. The significant difference is the LTC1649 includes an onboard charge pump to boost a 3.3V input supply to a level adequate to fully enhance 5V logic-level external MOSFETs. In exchange, the LTC1649 gives up the adjustable frequency control and the fixed 3.3V output options of the LTC1430. The LTC1649 runs at an internally fixed 200kHz clock frequency, and requires an external resistor divider at the FB pin to set the output voltage.

The LTC1649 features an internal charge pump that provides a regulated 5V output at the CP_{OUT} pin with supply voltages at the V_{IN} pin as low as 2.7V. This output is used to power the LTC1649 output drivers to provide 5V drive to the external MOSFETs. A typical application has the CP_{OUT} pin connected directly to the P_{VCC2} pin, to the V_{CC} pin through an RC filter, and to the P_{VCC1} pin via a simple charge pump at the SW pin, as shown in Figure 1 on the first page of this data sheet. The CP_{OUT} pin can typically provide 5V at 50mA with a 3.3V supply at V_{IN}, enough to drive multiple external MOSFETs in parallel. Input voltages below 3.3V reduce the current capacity at CP_{OUT}, reducing the total gate capacitance the LTC1649 can drive. The circuit shown in Figure 1 on the first page of this data sheet will continue to adequately drive typical external MOSFETs with as little as 2.7V at V_{IN}.

The LTC1649 features a shutdown mode that reduces supply current below 25µA when the $\overline{SHDN}$ pin is taken low. In shutdown, the external MOSFET drivers both go low, keeping the external MOSFETs off and isolating the output from the input supply. The CP_{OUT} pin remains regulated at 5V in shutdown, and can be used as a keep-alive supply if desired. Note that any current drawn from the CP_{OUT} pin adds to the quiescent current in shutdown, and subtracts from the current available to drive the external MOSFETs if the load remains connected while the LTC1649 is active.

As with any switching regulator controller, the LTC1649 is sensitive to layout and external component parasitics, and requires a carefully designed PCB layout to provide optimum performance. External component selection is also critical to proper operation. Switching regulators are notorious for unusual modes of operation and erratic regulation when built with poorly chosen components. The LTC1430 datasheet provides extensive advice on proper switching regulator controller layout and design, and the LTC Applications Department is always ready to help at (408) 432-1900. Recommended component lists and sample layouts are available to aid in PCB design.

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1430	High Power Step-Down Switching Regulator Controller	5V to 1.X – 3.X @10A
LTC1553	High Power Switching Regulator with Digital Output Voltage Control	1.8V to 3.5V Supply for Pentium®II
LTC1517-5	Micropower, Regulated 5V Charge Pump in a 5-Pin SOT-23 Package	Low Power 3.3V to 5V Step-Up Converter

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