

Low Noise, Switched Capacitor Regulated Voltage Inverters

September 1998

FEATURES

- Regulated Negative Voltage from a Single Positive Supply
- Low Output Ripple: Less Than 1mV_{P-P}
- High Charge Pump Frequency: 900kHz Typ
- Small Charge Pump Capacitors: 0.1 μF
- Requires Only Four External Capacitors
- Fixed -4.1V, -2.5V, -2V or Adjustable Output
- Shutdown Mode Drops Supply Current to <1 μA
- High Output Current: Up to 20mA (Depending on V_{CC} to V_{OUT} Range)
- Output Regulation: 2.5% Over Line, Load and Temperature
- Available in 8-Lead MSOP, 8-Lead Narrow SO and 16-Lead Narrow SSOP

APPLICATIONS

- GaAs FET Bias Generators
- Negative Supply Generators
- Battery-Powered Systems
- Single Supply Applications

DESCRIPTION

The LTC[®]1550L/LTC1551L are switched capacitor charge pump voltage inverters which include internal linear post-regulators to minimize output ripple. The LTC1550L output voltages include -4.1V, -2.5V and -2V with ripple voltages typically below 1mV_{P-P}. The LTC1550L is also available in an adjustable output voltage version. The LTC1550L/LTC1551L are ideal for use as bias voltage generators for GaAs transmitter FETs in portable RF and cellular telephone applications.

The LTC1550L/LTC1551L operate from single 2.7V to 5.5V supplies and draw typical quiescent currents of 3.5mA with a 5V supply. Each device includes a TTL compatible Shutdown pin which drops supply current to 0.2μA typically. The LTC1550L Shutdown pin is active low (SHDN), while the LTC1551L Shutdown pin is active high (SHDN). Only four external components are required: an input bypass capacitor, two 0.1μF charge pump capacitors and a filter capacitor at the linear regulator output. The adjustable LTC1550L/LTC1551L require two additional resistors to set the output voltage. The LTC1550L/LTC1551L will supply up to 20mA (depending on V_{CC} to V_{OUT} range), while maintaining guaranteed output regulation of ±2.5%.

Both fixed voltage and adjustable LTC1550L/LTC1551L are available in 8-lead MSOP and SO plastic packages: the adjustable LTC1550L is also available in a 16-pin SSOP with the REG pin.

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TYPICAL APPLICATION

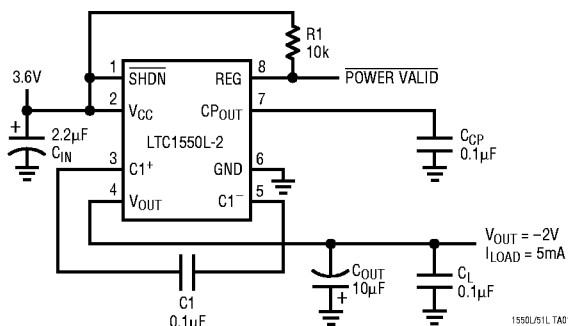
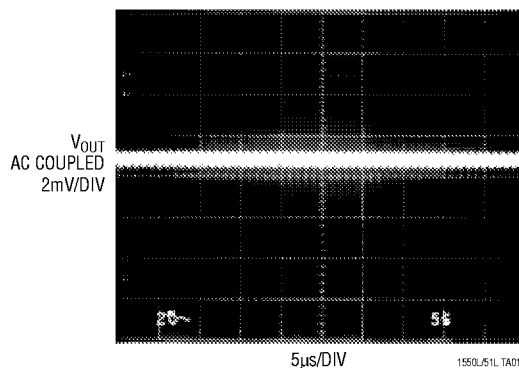


Figure 1. -2V Generator with 1mV_{P-P} Noise

V_{OUT} Output Noise and Ripple

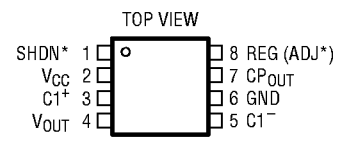
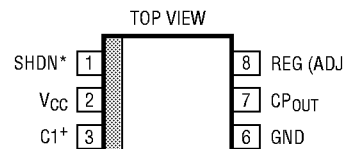
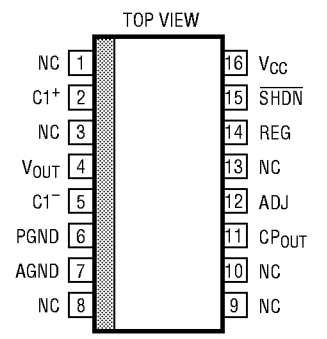


LTC1550L/LTC1551L

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage	5.5V	Commercial Temperature Range	0°C to 70°C
Output Voltage	0.3V to ($V_{CC} - 10.5V$)	Extended Commercial Operating	
Total Voltage, V_{CC} to CP_{OUT}	10.8V	Temperature Range (Note 3)	-40°C to 85°C
Input Voltage (SHDN Pin)	-0.3V to ($V_{CC} + 0.3V$)	Industrial Temperature Range	-40°C to 85°C
Input Voltage (REG Pin)	-0.3V to 6V	Storage Temperature Range	-65°C to 150°C
Output Short-Circuit Duration	30 sec	Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

 <p>TOP VIEW</p> <p>SHDN* 1, V_{CC} 2, C1+ 3, VOUT 4, 8 REG (ADJ)*, 7 CP_{OUT}, 6 GND, 5 C1-</p> <p>MS8 PACKAGE 8-LEAD PLASTIC MSOP</p> <p>*SHDN FOR LTC1550L, SHDN FOR LTC1551L *FOR ADJUSTABLE VERSION</p> <p>$T_{JMAX} = 150^{\circ}C, \theta_{JA} = 200^{\circ}C/W$</p>	 <p>TOP VIEW</p> <p>SHDN* 1, V_{CC} 2, C1+ 3, VOUT 4, 8 REG (ADJ)*, 7 CP_{OUT}, 6 GND, 5 C1-</p> <p>S8 PACKAGE 8-LEAD PLASTIC SO</p> <p>*SHDN FOR LTC1550L, SHDN FOR LTC1551L *FOR ADJUSTABLE VERSION</p> <p>$T_{JMAX} = 150^{\circ}C, \theta_{JA} = 135^{\circ}C/W$</p>	 <p>TOP VIEW</p> <p>NC 1, C1+ 2, NC 3, VOUT 4, C1- 5, PGND 6, AGND 7, NC 8, 16 V_{CC}, 15 SHDN, 14 REG, 13 NC, 12 ADJ, 11 CP_{OUT}, 10 NC, 9 NC</p> <p>GN PACKAGE 16-LEAD PLASTIC SSOP</p> <p>$T_{JMAX} = 150^{\circ}C, \theta_{JA} = 150^{\circ}C/W$</p>
ORDER PART NUMBER		ORDER PART NUMBER
LTC1550LCMS8 LTC1551LCMS8 LTC1550LCMS8-2 LTC1551LCMS8-4.1 LTC1550LCMS8-2.5 LTC1550LCMS8-4.1	ORDER PART NUMBER	ORDER PART NUMBER
MS8 PART MARKING		GN PART MARKING
LTEG LTFQ LTGR LTFT LTFV LTEH	LTC1550LCS8 LTC1550LCS8-2 LTC1550LCS8-2.5 LTC1550LCS8-4.1 LTC1551LCS8 LTC1551LCS8-4.1	LTC1550LCGN LTC1550LIGN
		1550L 1550LI

Consult factory for Military grade parts and additional voltage options.

ELECTRICAL CHARACTERISTICS

$V_{CC} = 2.7V$ to $5.25V$, $C1 = C2 = 0.1\mu F$, $C_{OUT} = 10\mu F$, $T_A = 25^{\circ}C$ unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Supply Voltage (Adjustable, Fixed -2V) (Fixed -2.5V) (Fixed -4.1V)		●	2.7	5.25	V
			●	3.05	5.25	V
			●	4.5	5.25	V
V_{REF}	Reference Voltage	$V_{CC} = 5V, ADJ = GND, V_{REF} = -V_{OUT}$		1.225		V
$\frac{\Delta V_{REF}}{\Delta(V_{CC} - V_{OUT})}$	Reference Voltage Line Regulation	$I_{OUT} = 0mA, 2.7V \leq V_{CC} \leq 5.25V$		2.5		mV/V
I_S	Supply Current	$V_{CC} = 5V, V_{SHDN} = V_{CC}$ (LTC1550L) or GND (LTC1551L)	●	3.65	7	mA
		$V_{CC} = 5V, V_{SHDN} = GND$ (LTC1550L) or V_{CC} (LTC1551L)	●	0.2	10	μA

ELECTRICAL CHARACTERISTICS

$V_{CC} = 2.7V$ to $5.25V$, $C_1 = C_2 = 0.1\mu F$, $C_{OUT} = 10\mu F$, $T_A = 25^\circ C$ unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
f_{OSC}	Internal Oscillator Frequency			900		kHz	
V_{OL}	REG Output Low Voltage	$I_{REG} = 1mA$, $V_{CC} = 5V$	●	0.1	0.8	V	
I_{REG}	REG Sink Current	$V_{REG} = 0.8V$, $V_{CC} = 5V$	●	4	10	mA	
V_{IH}	SHDN Input High Voltage	$V_{CC} = 5V$	●	2		V	
V_{IL}	SHDN Input Low Voltage	$V_{CC} = 5V$	●		0.8	V	
I_{IN}	SHDN Input Current	$V_{SHDN} = V_{CC}$ (All LTC1550L Versions) $V_{SHDN} = V_{CC}$ (All LTC1551L Versions)	●	0.1	1	μA	
			●	5	20	μA	
t_{ON}	Turn-On Time	$I_{OUT} = 10mA$		1		ms	
V_{OUT}	Output Regulation (LTC1550L/LTC1551L)	$2.7V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $2.8V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$ $3.5V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 20mA$	●	-1.537	-1.5	-1.463	V
			●	-1.537	-1.5	-1.463	V
			●	-1.537	-1.5	-1.463	V
V_{OUT}	Output Regulation (LTC1550L/LTC1550L-2/ LTC1551L)	$2.7V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $3.1V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$ $3.75V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 20mA$	●	-2.05	-2.0	-1.95	V
			●	-2.05	-2.0	-1.95	V
			●	-2.05	-2.0	-1.95	V
V_{OUT}	Output Regulation (LTC1550L/LTC1550L-2.5/ LTC1551L)	$3.05V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $3.45V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$ $4.1V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 20mA$	●	-2.562	-2.5	-2.438	V
			●	-2.562	-2.5	-2.438	V
			●	-2.562	-2.5	-2.438	V
V_{OUT}	Output Regulation (LTC1550L/LTC1551L)	$3.45V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $3.85V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$ $4.5V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 20mA$	●	-3.075	-3.0	-2.925	V
			●	-3.075	-3.0	-2.925	V
			●	-3.075	-3.0	-2.925	V
V_{OUT}	Output Regulation (LTC1550L/LTC1551L)	$3.9V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $4.2V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$ $4.85V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 20mA$	●	-3.587	-3.5	-3.413	V
			●	-3.587	-3.5	-3.413	V
			●	-3.587	-3.5	-3.413	V
V_{OUT}	Output Regulation (LTC1550L/LTC1550L-4.1) (LTC1551L/LTC1551L-4.1)	$4.5V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $4.75V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$	●	-4.203	-4.1	-3.998	V
			●	-4.203	-4.1	-3.998	V
V_{OUT}	Output Regulation (LTC1550L/LTC1551L))	$4.8V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 5mA$ $5.1V \leq V_{CC} \leq 5.25V$, $0 \leq I_{OUT} \leq 10mA$	●	-4.613	-4.5	-4.388	V
			●	-4.613	-4.5	-4.388	V
I_{SC}	Output Short-Circuit Current	$V_{OUT} = 0V$, $V_{CC} = 5.25V$	●	80	200	mA	
V_{RIPPLE}	Output Ripple Voltage			1		mV	

The ● denotes specifications which apply over the specified temperature range.

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device 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. All typicals are given at $T_A = 25^\circ C$.

Note 3: The LTC1550L/LTC1551L are guaranteed to meet specified performance from $0^\circ C$ to $70^\circ C$ and are designed, characterized and expected to meet these extended temperature limits, but are not tested at $-40^\circ C$ and $85^\circ C$. The LTC1550LI is guaranteed to meet the extended temperature limits.

PIN FUNCTIONS

SHDN: Shutdown (TTL Compatible). This pin is active low (\overline{SHDN}) for the LTC1550L and active high (SHDN) for the LTC1551L. When this pin is at V_{CC} (GND for LTC1551L), the LTC1550L operates normally. When SHDN is pulled low (high for LTC1551L), the LTC1550L enters shutdown mode. In shutdown, the charge pump stops, the output collapses to 0V, and the quiescent current drops typically

to $0.2\mu A$. The \overline{SHDN} pin for the LTC1550L is a high impedance input and has no internal pull-up. The user must supply a resistor or current source pull-up to default the LTC1550L into normal operation. The SHDN pin for the LTC1551L has an internal $5\mu A$ typical pull-down that defaults the LTC1551L into normal operation.

PIN FUNCTIONS

V_{CC}: Power Supply. V_{CC} requires an input voltage between 2.7V and 5.25V. Certain combinations of output voltage and output load current may place additional restrictions on the required input voltage. Consult the Electrical Characteristics table and Typical Performance Characteristics for guaranteed test points. The difference between the input voltage and output should not exceed 10.5V or damage to the chip may occur. V_{CC} must be bypassed directly to PGND (GND for 8-pin packages) with at least a 0.1μF capacitor placed in close proximity to the chip. A 1μF or larger low ESR bypass capacitor is recommended to minimize noise and ripple at the output. A surface mount ceramic capacitor is recommended.

C1⁺: C1 Positive Input. Connect a 0.1μF capacitor between C1⁺ and C1⁻.

V_{OUT}: Negative Voltage Output. This pin must be bypassed with a 4.7μF or larger capacitor to ensure regulator loop stability. LTC recommends at least 10μF to achieve the specified output ripple. The output capacitor should be a moderate ESR capacitor, and not a very low ESR capacitor, as the zero in the feedback loop (formed by the ESR and the output capacitor) provides phase lead to the linear regulator feedback loop. Using very low ESR output capacitors will result in the output oscillating. A low ESR 0.1μF capacitor is recommended in parallel with the main output capacitor to minimize high frequency spikes at the output. The ground connection for the output capacitor should connect directly to the V_{CC} and CP_{OUT} bypass capacitors, as well as to the GND of the LTC1550L/LTC1551L. LTC recommends a separate trace for the V_{OUT} capacitor ground connection to minimize noise.

C1⁻: C1 Negative Input. Connect a 0.1μF capacitor from C1⁺ to C1⁻.

GND: Ground. Connect to a low impedance ground. A ground plane will help minimize regulation errors.

CP_{OUT}: Negative Charge Pump Output. This pin requires a 0.1μF storage capacitor to ground. In order to achieve ripple on the output voltage of less than 1mV, the ground connection for the CP_{OUT} capacitor must tie directly to the bottom of the V_{CC} bypass capacitor and at the GND pin of the LTC1550L/LTC1551L. This minimizes the AC current path for the charge pump.

REG: This is an open-drain output that pulls low when the output voltage is within 5% of the set value. It will sink 4mA to ground with a 5V supply. The external circuitry must provide a pull-up or REG will not swing high. The voltage at REG may exceed V_{CC} and can be pulled up to 6V above ground without damage. For the LTC1550L adjustable voltage version, the REG pin is only available in the 16-lead GN package.

ADJ (for adjustable versions): This is the feedback point for the external resistor divider string. Connect a divider string from GND to V_{OUT} with the divided tap connected to ADJ. Note that the resistor string needs to be connected “upside-down” from a negative regulator. See the Applications Information section for hook-up details.

GN PACKAGE ONLY

PGND: Power Ground. Connect to a low impedance ground. PGND should be connected to the same potential as AGND.

AGND: Analog Ground. Connect to a low impedance ground. AGND should be connected to a ground plane to minimize regulation errors.

NC: No Internal Connection.

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT [®] 1054	Switched-Capacitor Voltage Converter with Regulator	100mA Switched-Capacitor Converter
LTC1261	Switched-Capacitor Regulated Voltage Inverter	Selectable Fixed Output Voltages
LTC1429	Clock-Synchronized Switched-Capacitor Voltage Inverter	Synchronizable Up to 2MHz System Clock
LTC1550/LTC1551	Low Noise, Switched-Capacitor Regulated Voltage Inverters	900kHz Charge Pump, 1mV _{P-P} Ripple