

Low Noise, Switched Capacitor-Regulated Voltage Inverters

January 1996

FEATURES

- Regulated Negative Voltage from Single Positive Supply
- Low Output Ripple: Less Than 1mV Typ
- High Charge Pump Frequency: 900kHz Typ
- Small Charge Pump Capacitors: 0.1 μ F
- Requires Only Four External Capacitors
- Fixed -4.1V Output
- Shutdown Mode Drops Supply Current to 1 μ A
- Output Current: Up to 20mA
- Output Regulation: 5%
- Available in SO-8

APPLICATIONS

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

DESCRIPTION

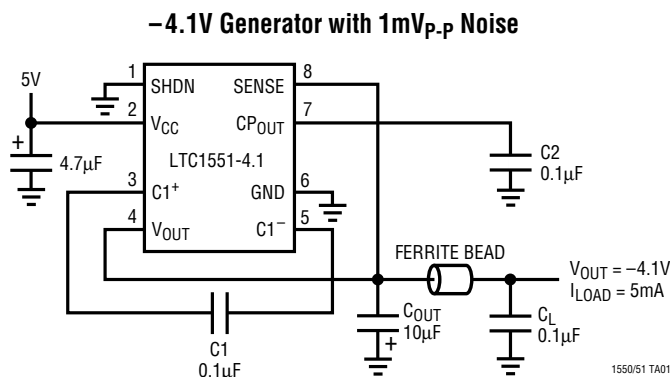
The LTC[®]1550/LTC1551 are switched-capacitor voltage inverters with internal linear post regulators. Each is available with a fixed -4.1V output. Typical output ripple is below 1mV. The LTC1550/LTC1551 are designed for use as bias voltage generators for GaAs transmitter FETs in portable RF and cellular telephone applications.

The LTC1550/LTC1551 operate from a single 4.5V to 6.5V supply, with a typical quiescent current of 4.25mA at $V_{CC} = 5V$. Both devices include a TTL compatible Shutdown pin which drops supply current to 0.2 μ A typically. The LTC1550 Shutdown pin is active low (\overline{SHDN}) while the LTC1551 Shutdown pin is active high (SHDN). Only four external components are required: an input bypass capacitor, two 0.1 μ F charge pump capacitors and a 10 μ F filter capacitor at the linear regulator output. The LTC1550/LTC1551 will supply up to 20mA output current with guaranteed output regulation of $\pm 5\%$.

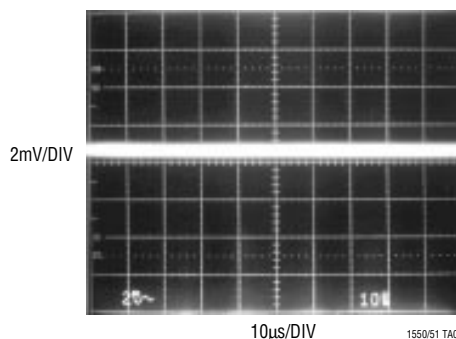
For applications with V_{CC} supplies as low as 3V, see the LTC1261. For applications requiring an external synchronization clock and V_{CC} as low as 3V, see the LTC1429.

 LTC and LT are registered trademarks of Linear Technology Corporation.

TYPICAL APPLICATION



V_{OUT} Output Noise and Ripple



ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage (Note 2)	7V
Output Voltage	0.3V to ($V_{CC} - 14V$)
Total Voltage, V_{CC} to CP_{OUT} (Note 2)	14V
Input Voltage (SHDN Pin)	-0.3V to ($V_{CC} + 0.3V$)
Output Short-Circuit Duration	30 sec
Operating Temperature Range	-30°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
	LTC1550CS8-4.1 LTC1551CS8-4.1
	S8 PART MARKING
	15504 15514

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS (Note 3)

$V_{CC} = 4.5V$ to $6.5V$, $C1 = C2 = 0.1\mu F$, $C_{OUT} = 10\mu F$, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V _{CC}	Supply Voltage	(Note 2)		4.5		6.5	V
V _{REF}	Reference Voltage				1.24		V
I _S	Supply Current (No Load)	V _{CC} = 5V, V _{SHDN} = GND (LTC1551) or V _{CC} (LTC1550)	●		4.25	7.0	mA
		V _{CC} = 5V, V _{SHDN} = 5V (LTC1551) or GND (LTC1550)	●		0.20	10.0	μA
f _{OSC}	Internal Oscillator Frequency				900		kHz
V _{IH}	SHDN Input High Voltage		●	2.0			V
V _{IL}	SHDN Input Low Voltage		●			0.8	V
I _{IN}	SHDN Input Current	V _{SHDN} = V _{CC}	●		0.1	1	μA
t _{ON}	Turn-On Time	I _{OUT} = 10mA			1		ms
V _{OUT}	Output Voltage (LTC1550-4.1, LTC1551-4.1)	V _{CC} = 4.5V, 0 ≤ I _{OUT} ≤ 5mA	●	−3.9	−4.1	−4.3	V
		V _{CC} = 5V, 0 ≤ I _{OUT} ≤ 10mA	●	−3.9	−4.1	−4.3	V
		V _{CC} = 6V, 0 ≤ I _{OUT} ≤ 20mA	●	−3.9	−4.1	−4.3	V
I _{SC}	Output Short-Circuit Current	V _{OUT} = 0V	●		80	200	mA
V _{RIPPLE}	Output Ripple Voltage				1		mV

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

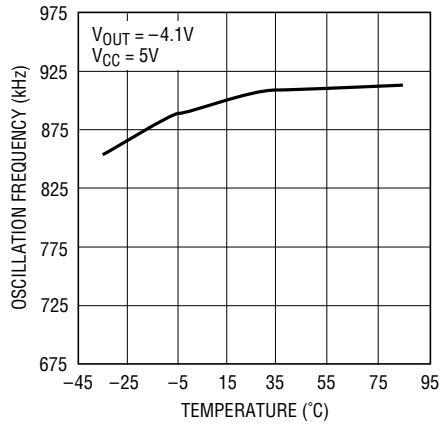
Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: The output should never be set to exceed $V_{CC} - 14V$.

Note 3: 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 $T_A = 25^\circ C$.

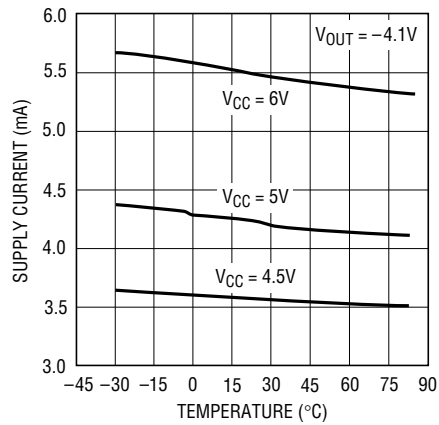
TYPICAL PERFORMANCE CHARACTERISTICS

**Oscillation Frequency
vs Temperature**



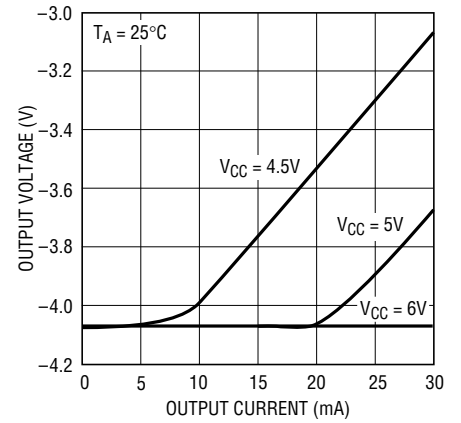
LTC1550/51 G01

Supply Current vs Temperature



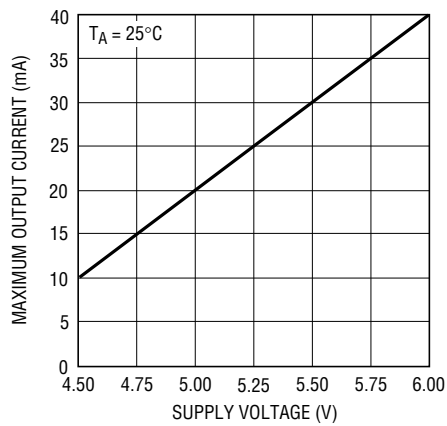
LTC1550/51 G02

Output Voltage vs Output Current



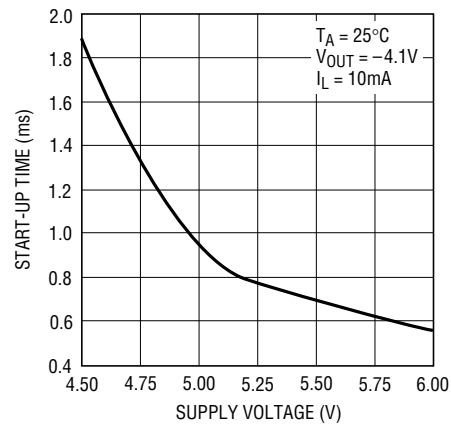
LTC1550/51 G03

**Maximum Output Current
vs Supply Voltage**



LTC1550/51 G04

Start-Up Time vs Supply Voltage



LTC1550/51 G05

PIN FUNCTIONS

SHDN: Shutdown (TTL Compatible). This pin is active low (SHDN) for the LTC1550 and active high (SHDN) for the LTC1551. When this pin is at V_{CC} (GND for LTC1551), the LTC1550 operates normally. When SHDN is pulled LOW (HIGH for LTC1551), the LTC1550 enters shutdown mode. In shutdown, the charge pump stops, the output collapses to 0V, and the quiescent current drops typically to 0.2 μ A.

V_{CC} : Power Supply. V_{CC} requires an input voltage between 4.5V and 6.5V. The difference between the input voltage and output should never be set to exceed 14V or damage to the chip may occur. V_{CC} must be bypassed to GND with at least a 1 μ F capacitor placed in close proximity to the chip. A 4.7 μ F or larger bypass capacitor is recommended to minimize noise and ripple at the output.

$C1^+$: C1 Positive Input. Connect a 0.1 μ F capacitor between $C1^+$ and $C1^-$.

V_{OUT} : Negative Voltage Output. This pin must be bypassed to ground with a 4.7 μ F or larger capacitor to ensure regulator loop stability. At least 10 μ F are recommended to provide specified output ripple. An additional low ESR 0.1 μ F capacitor is recommended to minimize high frequency spikes at the output.

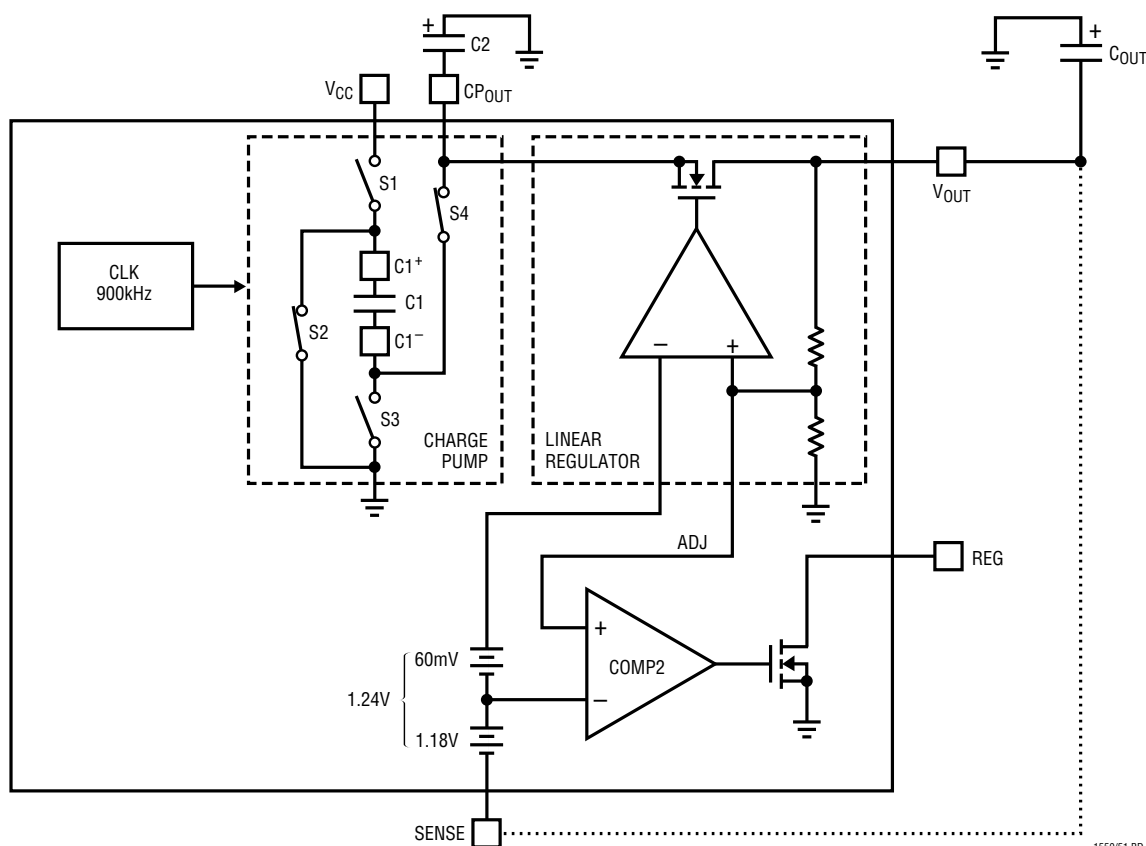
$C1^-$: C1 Negative Input. Connect a 0.1 μ F capacitor from $C1^+$ to $C1^-$.

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 0.1 μ F storage capacitor to ground.

SENSE: Connect to V_{OUT} . The LTC1550/LTC1551 internal regulator uses this pin to sense the output voltage. For optimum regulation, SENSE should be connected close to the output load.

BLOCK DIAGRAM



APPLICATIONS INFORMATION

THEORY OF OPERATION

The LTC1550/LTC1551 are switched-capacitor, inverting charge pumps with integral linear post regulators to provide a regulated, low ripple negative output voltage. The charge pump runs at a high 900kHz frequency to keep noise out of the 400kHz to 600kHz IF bands commonly used by portable radio frequency systems, and to minimize the size of the external capacitors required. The LTC1550/LTC1551 require only four external capacitors: an input bypass capacitor, two 0.1 μ F charge pump capacitors and a single output capacitor. At least 4.7 μ F is required at the output to maintain loop stability; for optimum output stability over temperature and minimum ripple, 10 μ F or greater is recommended.

The LTC1550 features an active-low shutdown pin which drops quiescent current to below 1 μ A. The LTC1551 is identical to the LTC1550 but the Shutdown pin is active high. Both the LTC1550/LTC1551 are available with fixed -4.1V output voltage. Both devices can be configured with other output voltages. Contact the Linear Technology marketing for more information.

Minimizing Output Noise and Ripple

Output ripple is largely eliminated by the internal linear regulator. It is typically below 1mV_{P-P} with output loads between zero and 10mA. Residual ripple is at the 900kHz switching frequency of the charge pump and is usually not a problem in most systems. This high frequency ripple can be minimized by using a low ESR capacitor at the output. An 0.1 μ F ceramic capacitor in parallel with a 10 μ F tantalum makes a good combination.

Figure 1a shows the test circuit used for spectrum analysis with test conditions $V_{CC} = 6V$, $I_{OUT} = 5mA$. Figures 1b and 1c are the V_{OUT} spectrum plots for the test circuit in Figure 1a, covering from 100Hz to 1MHz and to 10MHz respectively. The fundamental switching frequency appears at 900kHz.

Output ripple can be further reduced by increasing the size of the output capacitor, or by including a small external RC or LC filter at the output. A ferrite bead in series with the output capacitor will reduce the output ripple to negligible levels.

Output load and line transient response can be optimized by increasing the size of the output bypass capacitor.

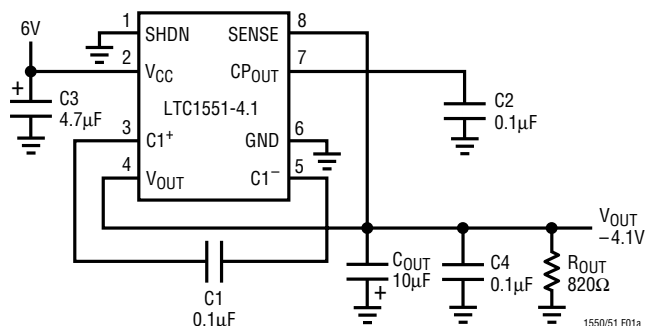


Figure 1a. Test Circuit Used for Spectrum Analysis

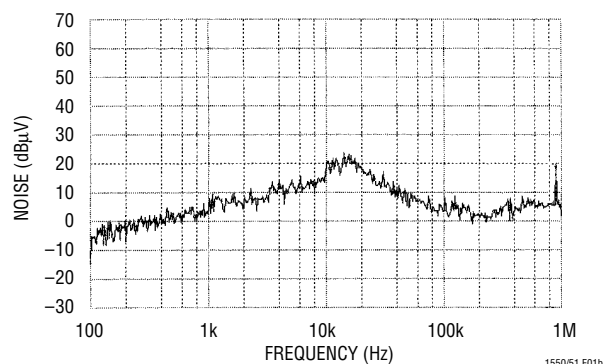


Figure 1b. Spectrum Plot of V_{OUT} from 100Hz to 1MHz

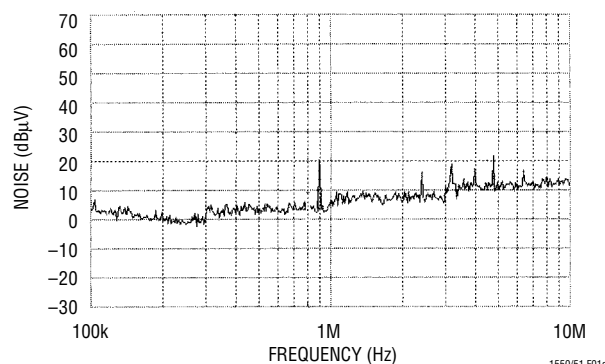
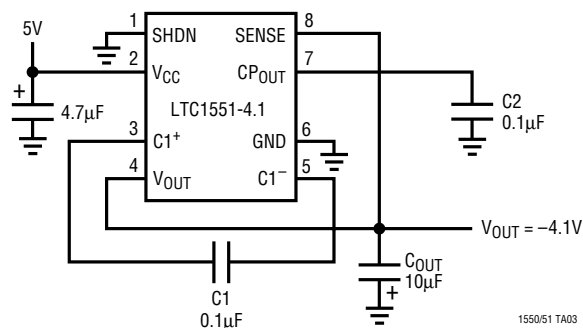


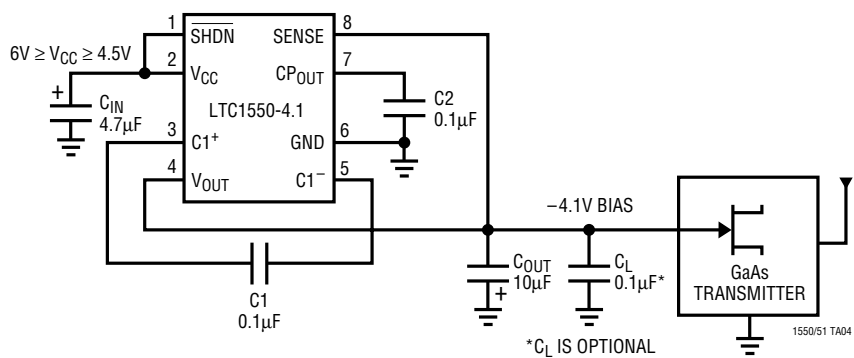
Figure 1c. Spectrum Plot of V_{OUT} from 100kHz to 10MHz

TYPICAL APPLICATIONS

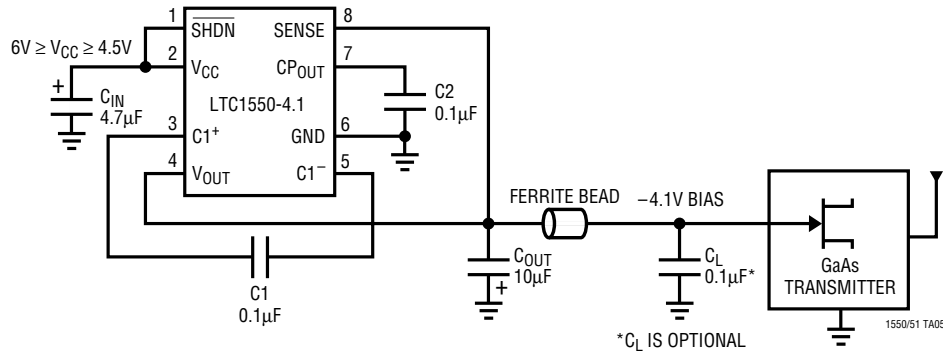
Minimum Part Count, Negative -4.1V Generator



-4.1V Output GaAs FET Bias Generator



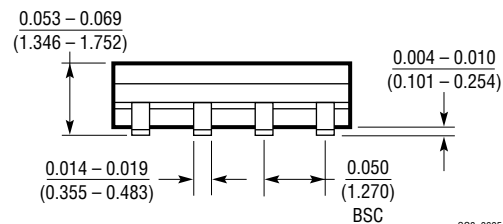
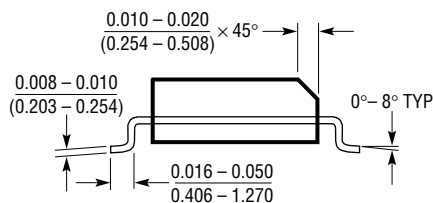
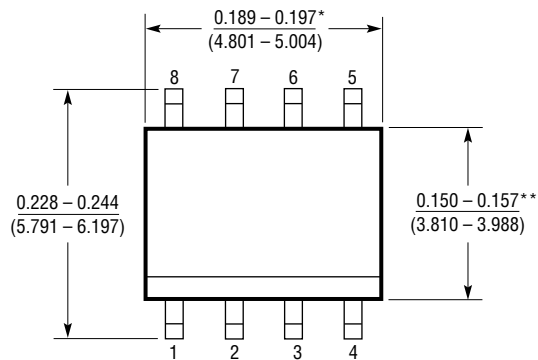
TYPICAL APPLICATIONS

1mV_{P-P} Ripple, -4.1V Output GaAs FET Bias Generator

PACKAGE DESCRIPTION

Dimension in inches (millimeters) unless otherwise noted.

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
 (LTC DWG # 05-08-1610)



*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

S08 0695

LTC1550/LTC1551

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