LTC1757-1/LTC1757-2

Single/Dual Band RF Power Controllers

August 1999

FEATURES

- **Dual Band RF Power Amplifier Control (LTC1757-2)**
- **Internal Schottky Diode Detector**
- **Wide Input Frequency Range: 850MHz to 2GHz**
- **Autozero Loop Cancels Offset Errors**
- **Wide V_{IN} Range: 2.7V to 6V**
- RF Output Power Set by External DAC (0V to 2V Range)
- High Slew Rate: 4V/µs
- Fast Acquire After Transmit Enable
- 1MHz Control Loop Bandwidth
- Internal Frequency Compensation
- Rail-to-Rail Power Control Outputs
- RF PA Supply Current Limiting
- Battery Overvoltage Protection
- Power Control Signal Overvoltage Protection
- Low Operating Current: 850µA
- Very Low Shutdown Current: <1µA
- Available in a 8-Pin MSOP Package (LTC1757-1) and 10-Pin MSOP (LTC1757-2)

APPLICATIONS

- Dual Band Cellular Telephones
- PCS Devices
- Wireless Data Modems

DESCRIPTION

The LTC®1757-2 is a dual band RF power controller for RF power amplifiers operating in the 850MHz to 2GHz range. The input voltage range is optimized for operation from a single lithium-ion cell or 3× NiMH. Several functions required for RF power control and protection are integrated in one small 10-pin MSOP package, thereby minimizing PCB area.

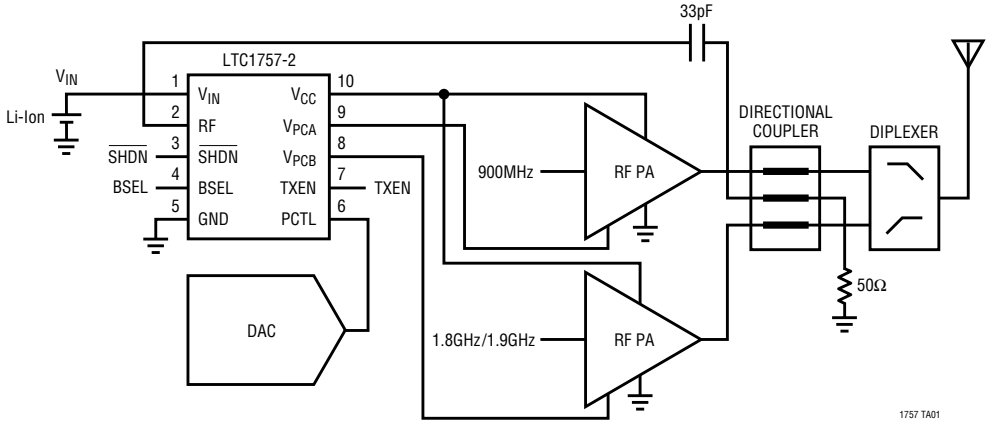
The LTC1757-1 is a single output RF power controller that is identical in performance to the LTC1757-2 except that only one output (V_{PCA}) is provided. This part is available in an 8-pin MSOP package.

RF output power is controlled by driving the RF amplifier power control pins and sensing the resultant RF output power via a directional coupler. The RF sense voltage is peak detected using an internally terminated Schottky diode that is capable of detecting frequencies in the 850MHz to 2GHz range. This detected voltage is compared to the DAC voltage at the PCTL pin to control the output power. The RF power amplifier is protected against high supply current, excessive supply voltage and high power control pin voltages.

Internal and external offsets are cancelled by an autozero control loop, allowing accurate low power programming. The shutdown feature disables the part and reduces the supply current to <1µA.

TYPICAL APPLICATION

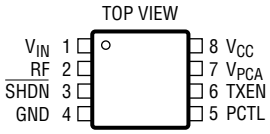
LTC1757-2 Dual Band Cellular Telephone Transmitter



ABSOLUTE MAXIMUM RATINGS (Note 1)

V_{IN} to GND ..... –0.3V to 6.5V
V_{PCA}, V_{PCB} Voltage ..... –0.3V to 3V
PCTL Voltage ..... –0.3V to (V_{IN} + 0.3V)
RF Voltage ..... (V_{IN} – 2.2V) to (V_{IN} + 2.2V)
I_{VCC}, Continuous 1A
I_{VCC}, 1/8 Duty Cycle 2.4A
$\overline{SHDN}$, TXEN, BSEL
Voltage to GND ..... –0.3V to (V_{IN} + 0.3V)
$I_{VPCA/B}$ 20mA
Operating Temperature Range ..... 0°C to 70°C
Extended Commercial Range (Note 2) ... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Maximum Junction Temperature ..... 125°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

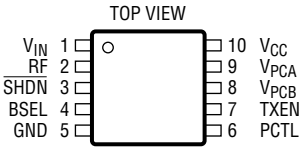
PACKAGE/ORDER INFORMATION



MS8 PACKAGE
8-LEAD PLASTIC MSOP

T_{JMAX} = 150°C, θ_{JA} = 250°C/W

ORDER PART NUMBER
LTC1757-1CMS8
MS8 PART MARKING
LTIH



MS10 PACKAGE
10-LEAD PLASTIC MSOP

T_{JMAX} = 125°C, θ_{JA} = 250°C/W

ORDER PART NUMBER
LTC1757-2CMS
MS10 PART MARKING
LTIG

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 3.6V, $\overline{SHDN}$ = TXEN = V_{IN}, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IN} Operating Voltage		●	2.7		6	V
I_{VIN} Shutdown Current	$\overline{SHDN}$ = 0V	●			1	µA
I_{VIN} Standby Current	$\overline{SHDN}$ = V_{IN}, TXEN = 0V	●	500	660	950	µA
I_{VIN} Operating Current	$\overline{SHDN}$ = V_{IN}, TXEN = V_{IN}, I_{VPCA} = I_{VPCB} = 0mA, $V_{PCA/B}$ = 2.7V			850		µA
I_{VCC} Current Limit	RF PA Supply	●	2.1	2.25	2.4	A
V_{IN} to V_{CC} Resistance				90	110	mΩ
$V_{PCA/B}$ V_{OL}	R_{LOAD} = 400Ω, Enabled	●	0		0.1	V
$V_{PCA/B}$ Dropout Voltage	I_{LOAD} = 6mA, V_{IN} = 2.7V to 4.8V	●			V_{IN} – 0.25	V
$V_{PCA/B}$ Voltage Clamp		●	2.7	2.85	3.0	V
$V_{PCA/B}$ Output Current	$V_{PCA/B}$ = 2.4V, V_{IN} = 2.7V	●	7	10		mA
$V_{PCA/B}$ Enable Time	V_{PCTL} = 2V Step (Note 5)			200		ns
$V_{PCA/B}$ Bandwidth	C_{LOAD} = 100pF, R_{LOAD} = 1K			1		MHz
$V_{PCA/B}$ Load Capacitance		●			100	pF
$V_{PCA/B}$ Slew Rate	V_{PCTL} = 2V Step, C_{LOAD} = 100pF, R_{LOAD} = 400Ω (Note 3)		2	4		V/µs
$V_{PCA/B}$ Droop	Unity Gain, V_{PCTL} = 2V, $T_A \leq$ 85°C			±1		mV/ms
$V_{PCA/B}$ TXEN Glitch	Unity Gain, TXEN Low to High			100	150	mV

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 3.6V, $\overline{SHDN}$ = TXEN = V_{IN}, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
$\overline{SHDN}$, TXEN, BSEL Input Threshold	V_{IN} = 2.7V to 6V	●	0.35		1.2	V
$\overline{SHDN}$, TXEN, BSEL Input Current	$\overline{SHDN}$, TXEN or BSEL = V_{IN} = 3.6V	●	16	28	40	µA
PCTL Input Voltage Range		●	0		2	V
PCTL Input Resistance		●	50	100	150	kΩ
PCTL Input Time Constant				100		ns
Autozero Range	(Note 4)	●			200	mV
Autozero Settling Time (t_S)	Shutdown to Enable (Standby)	●			50	µs
RF Input Frequency Range	(Note 6)	●	850		2000	MHz
RF Input Power Range	(Note 6)	●	–15		15	dBm
RF DC Input Resistance	Referenced to V_{IN}	●	30	50	65	Ω
V_{IN} Overvoltage Range	Onset of $V_{PCA/B}$ Voltage Reduction $V_{PCA/B}$ < 2.5V	● ●	4.80 4.85	5.0	5.20 5.25	V V

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

Note 2: C grade device specifications are guaranteed over the 0°C to 70°C temperature range. In addition, C grade device specifications are assured over the –40°C to 85°C temperature range by design or correlation, but are not production tested.

Note 3: Slew rate is measured open loop. The rise time at V_{PCA} or V_{PCB} is measured between 0.5V and 1.5V.

Note 4: Maximum DAC zero-scale offset voltage that can be applied to PCTL.

Note 5: This is the time from TXEN rising edge to $V_{PCA/B}$.

Note 6: Guaranteed by design. This parameter is not production tested.

PIN FUNCTIONS (LTC1757-2/LTC1757-1)

V_{IN} (Pin 1): Input Supply Voltage, 2.7V to 6V. V_{IN} should be bypassed with 0.1µF and 100pF ceramic capacitors. Used as return for RF 50Ω termination.

RF (Pin 2): RF Feedback Voltage from the Directional Coupler. Referenced to V_{IN}. A coupling capacitor of 33pF must be used to connect to the ground referenced directional coupler. The frequency range is 850MHz to 2000MHz. This pin has an internal 50Ω termination, an internal Schottky diode detector and peak detector capacitor.

SHDN (Pin 3): Shutdown Input. A logic low on the $\overline{SHDN}$ pin places the part in shutdown mode. A logic high places the part in standby when TXEN is low. $\overline{SHDN}$ has an internal 150k pull-down resistor to ensure that the part is in shutdown when the drivers are in a three-state condition.

BSEL (Pin 4): (LTC1757-2 Only) Selects V_{PCA} when low and V_{PCB} when high. This input has an internal 150k resistor to ground.

GND (Pin 5/Pin 4): System Ground.

PCTL (Pin 6/Pin 5): Analog Input. The external power control DAC drives this input. The amplifier servos the RF power until the RF detected signal equals the DAC signal full-scale range.

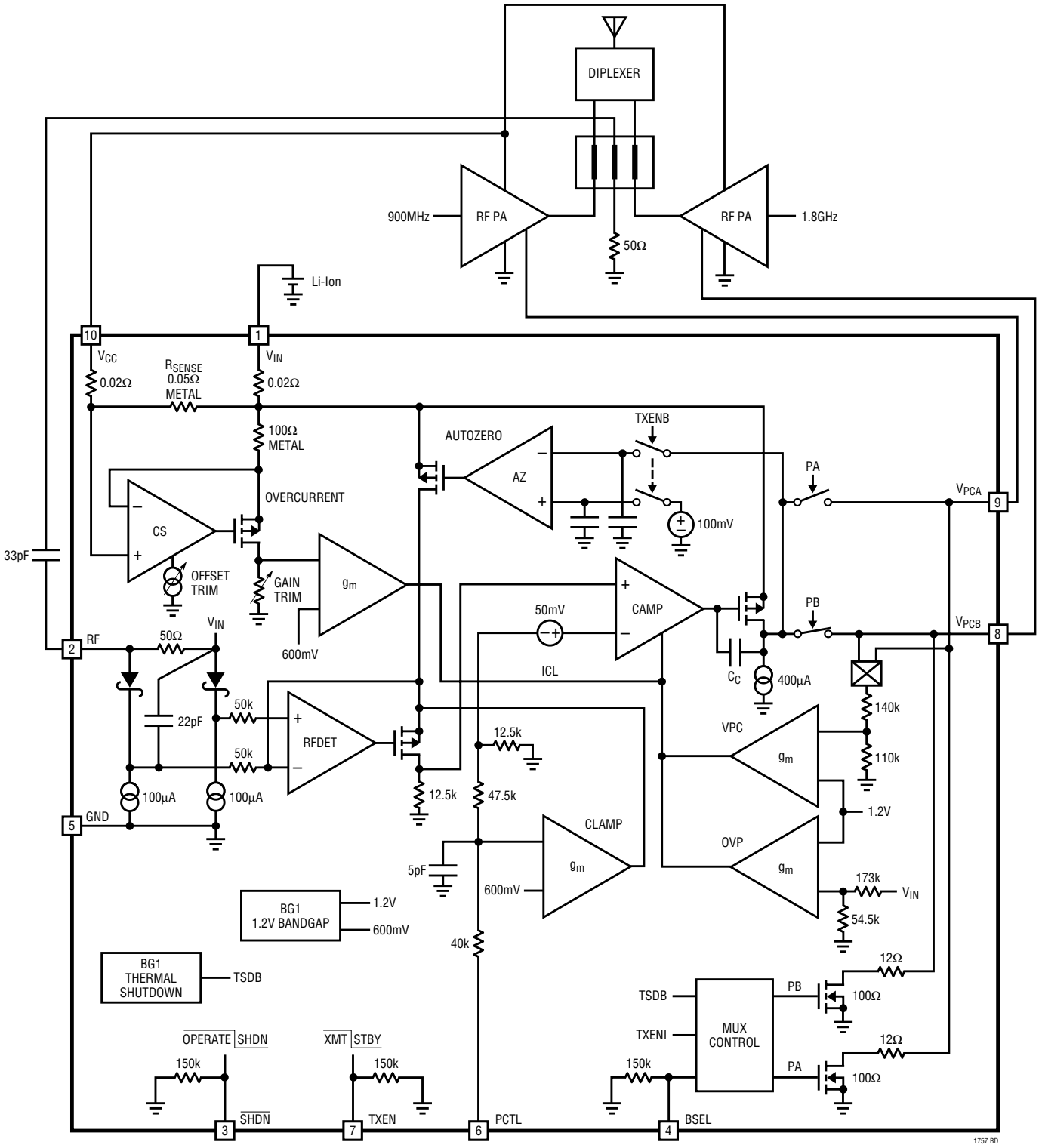
TXEN (Pin 7/Pin 6): Transmit Enable Input. A logic high enables the control amplifier. When TXEN is low and $\overline{SHDN}$ is high the part is in the autozero mode. This input has an internal 150k resistor to ground.

V_{PCB} (Pin 8): (LTC1757-2 Only) Power Control Voltage Output. This pin drives an external RF power amplifier power control pin. The maximum load capacitance is 100pF. The output is capable of rail-to-rail swings at low load currents. Selected when BSEL is high.

V_{PCA} (Pin 9/Pin 7): Power Control Voltage Output. This pin drives an external RF power amplifier power control pin. The maximum load capacitance is 100pF. The output is capable of rail-to-rail swings at low load currents. Selected when BSEL is low (LTC1757-2 only).

V_{CC} (Pin 10/Pin 8): RF Power Amplifier Supply. This pin has an internal 0.090Ω sense resistor between V_{IN} and V_{CC} that senses the RF power amplifier supply current to detect overcurrent conditions.

BLOCK DIAGRAM (LTC1757-2)



APPLICATIONS INFORMATION

Operation

The LTC1757-2 dual band RF power control amplifier integrates several functions to provide RF power control over two frequencies ranging from 850MHz to 2GHz. The device also prevents damage to the RF power amplifier due to overvoltage or overcurrent conditions. These functions include an internally compensated power control, amplifier to control the RF output power, an autozero section to cancel internal and external voltage offsets, a sense amplifier with an internal sense resistor to limit the maximum RF power amplifier current, an RF Schottky diode peak detector and amplifier to convert the RF feedback signal to DC, a $V_{PCA/B}$ overvoltage clamp, a V_{IN} overvoltage detector, a bandgap reference, a thermal shutdown circuit and a multiplexer to switch the control amplifier output to either V_{PCA} or V_{PCB}.

Band Selection

The LTC1757-2 is designed for dual band operation. The BSEL pin will select output V_{PCA} when low and output V_{PCB} when high. For example, V_{PCA} could be used to drive a 900MHz channel and V_{PCB} a 1.8GHz/1.9GHz channel. BSEL should be established before the part is enabled.

Control Amplifier

The control amplifier supplies the power control voltage to the RF power amplifier. A portion (typically –20dB for low frequencies and –15dB for high frequencies) of the RF output signal is sampled, via a directional coupler, to close the gain control loop. When a DAC signal is applied to PCTL, the amplifier quickly servos V_{PCA} or V_{PCB} positive until the detected feedback signal applied to the RF pin matches the signal at PCTL. This feedback loop provides accurate RF power control. V_{PCA} or V_{PCB} are capable of driving a 10mA load current and 100pF load capacitor.

RF Detector

The internal RF Schottky diode peak detector and amplifier converts the RF feedback signal from the directional coupler to a low frequency signal. This signal is compared to the DAC signal at the PCTL pin by the control amplifier to close the RF power control loop. The RF pin input impedance is typically 50Ω and the frequency range of this pin is 850MHz to 2000MHz. The detector demonstrates excellent efficiency and linearity over a wide range of input power. The Schottky detector is biased at about 100μA and drives an on-chip peak detector capacitor of 22pF.

Autozero

An autozero system is included to improve power programming accuracy. This section cancels internal offsets associated with the Schottky diode detector and control amplifier. External offsets associated with the DAC driving the PCTL pin are also cancelled. The maximum offset allowed at the DAC output is limited to 200mV. Autozeroing is performed when the part is in standby mode ($\overline{SHDN}$ = high, TXEN = low). When the part is enabled (TXEN = high, $\overline{SHDN}$ = high) the autozero capacitors are held and the V_{PCA} or V_{PCB} pin is connected to the control amplifier output. The hold droop voltage of typically 1mV/ms provides for accurate offset cancellation over the normal 1/8 duty cycle associated with the GSM protocol. The part must be in standby for at least 50μs for autozero to settle to the correct value.

Protection Features

The RF power amplifier is overcurrent protected by an internal sense amplifier. The sense amplifier measures the voltage across an internal 0.090Ω resistor to determine the RF power amplifier current. V_{PCA} or V_{PCB} is lowered as this supply current exceeds 2.2A, thereby regulating the current to about 2.25A. The regulated current limit is temperature compensated and remains accurate over the entire operating temperature range. The 0.090Ω resistor and the current limit feature can be removed by shorting V_{CC} to V_{IN}.

The RF power amplifier control voltage pins are overvoltage protected. The V_{PC} overvoltage clamp regulates V_{PCA} or V_{PCB} to 2.85V when the gain and PCTL input combination attempts to exceed this voltage.

The RF power amplifier is protected against excessive input supply voltages. The V_{IN} overvoltage detector starts to reduce V_{PCA} or V_{PCB} when V_{IN} exceeds 5V. V_{PCA} or V_{PCB}

APPLICATIONS INFORMATION

will be reduced to 0V as V_{IN} continues to increase by about 200mV. This gain control voltage reduction lowers the RF output power eventually reducing it to zero.

The internal thermal shutdown circuit will disable the LTC1757-2 if the junction temperature exceeds approximately 150°C. The part will be enabled when the temperature falls below 140°C.

Modes of Operation

The LTC1757-2 supports three operating modes: shutdown, standby and enable.

In shutdown mode ($\overline{SHDN}$ = 0V) the part is disabled and supply currents will be reduced to <1µA. V_{PCA} and V_{PCB} will be connected to ground via 100Ω switches.

In standby mode ($\overline{SHDN}$ = High, TXEN = 0V) V_{PCA} and V_{PCB} will remain connected to ground and the part will be in the autozero mode. The part must remain in standby for at least 50µs to allow for the autozero circuit to settle.

In enable mode ($\overline{SHDN}$ = High, TXEN = High) the control loop and protection functions will be operational. When TXEN is switched high, acquisition will begin. The control amplifier will quickly start to ramp the control voltage to the RF power amplifier. The RF amplifier will then start to turn on. The feedback signal from the directional coupler and the output power will be detected by the LTC1757-2 at the RF pin. The loop closes and the amplifier output tracks the DAC voltage ramping at PCTL. The RF power output will then follow the programmed power profile from the DAC.

MODE	$\overline{SHDN}$	TXEN	OPERATION
Shutdown	0V	0V	Disabled
Standby	High	0V	Autozero
Enable	High	High	Power Control

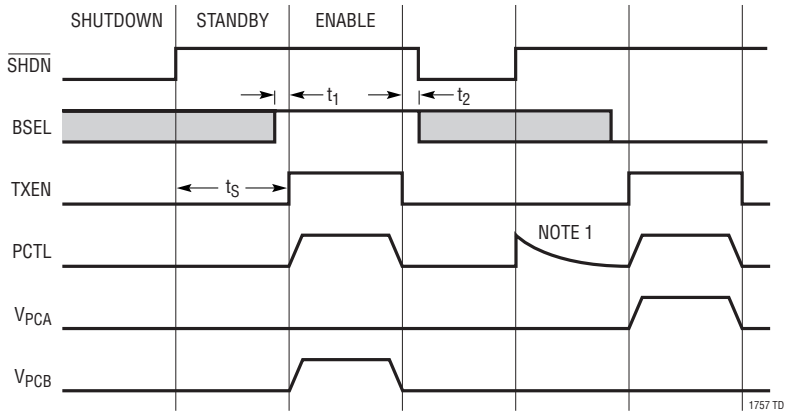
LTC1757-1 Description

The LTC1757-1 is identical in performance to the LTC1757-2 except that only one control output (V_{PCA}) is available. The user can implement an external MUX to select dual RF channels or drive a single RF channel in the 850MHz to 2GHz range.

General Layout Considerations

The LTC1757-1/LTC1757-2 should be placed near the directional coupler. The feedback signal line to the RF pin should be a 50Ω transmission line. Bypass capacitors are required at V_{IN} and V_{CC}.

LTC1757-2 Timing Diagram



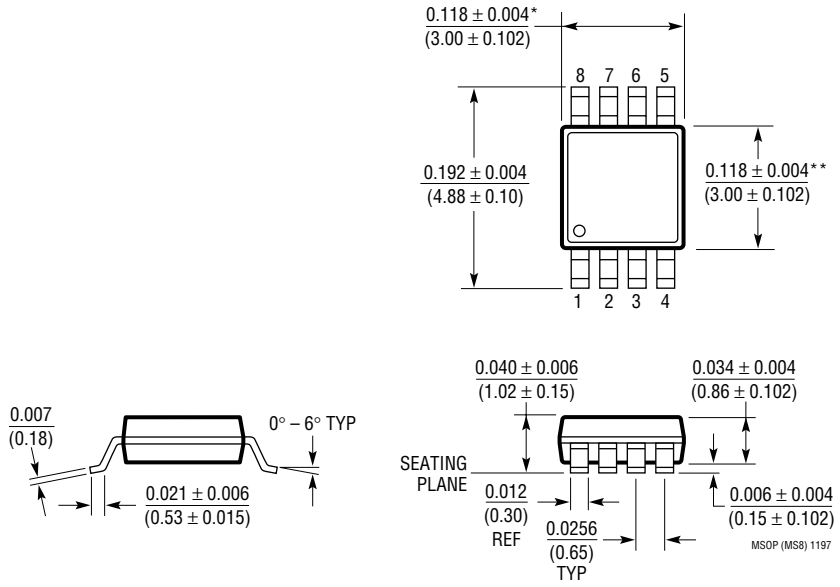
t_S: AUTOZERO SETTLING TIME, 50µs MINIMUM
t_1: BSEL CHANGE PRIOR TO TXEN, 100ns MINIMUM
t_2: BSEL CHANGE AFTER TXEN, 100ns MINIMUM

NOTE 1: THE EXTERNAL DAC DRIVING THE PCTL PIN CAN BE ENABLED DURING STANDBY. THE AUTOZERO SYSTEM WILL CANCEL THE DAC TRANSIENT. THE DAC MUST BE SETTLED TO AN OFFSET ≤200mV BEFORE TXEN IS ASSERTED HIGH.

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

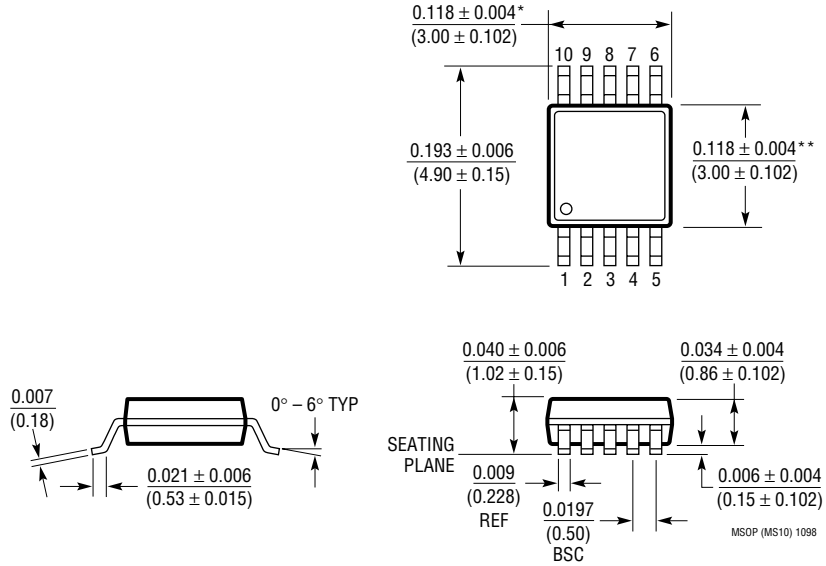
MS8 Package
8-Lead Plastic MSOP
(LTC DWG # 05-08-1660)



* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

MS10 Package
10-Lead Plastic MSOP
(LTC DWG # 05-08-1661)



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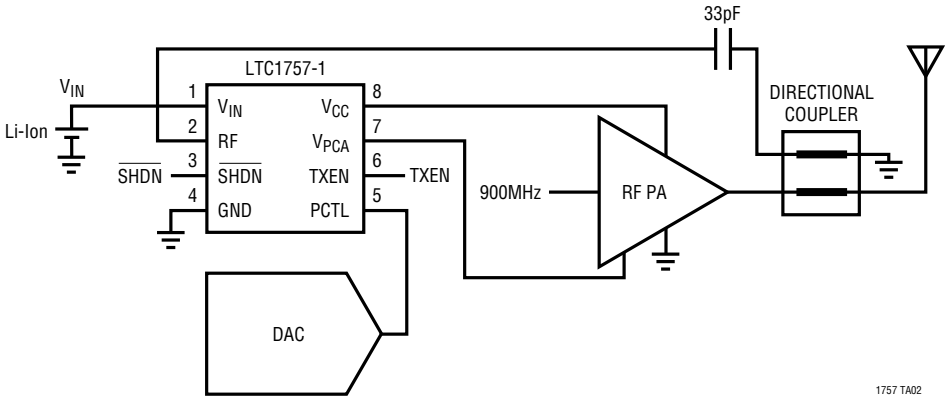
TYPICAL APPLICATION

Single Band Cellular Telephone Transmitter



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1261	Regulated Inductorless Voltage Inverter	Regulated –5V from 3V, REG Pin Indicates Regulation, Up to 15mA, Micropower
LTC1550/LTC1551	Low Noise Inductorless Voltage Inverter	Regulated Output, <1mV$_{P-P}$ Ripple, 900kHz

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