

Micropower Op Amp and Comparator

April 1998

FEATURES

- **Quiescent Current: 5 μ A Typ**
- **Outputs Swing Rail-to-Rail**
- **Low Op Amp Offset Voltage: 700 μ V Max**
- **Low Input Bias Current: 1nA Max**
- **Internal \pm 3mV Comparator Hysteresis**
- **Comparator and Op Amp Input Range Includes Ground**
- **Op Amp Capable of Driving Up to 1000pF Load**
- **Unity-Gain Stable with 12kHz Bandwidth**
- **2.5V to 12.6V Supply Voltage Range**
- **Pin Compatible Upgrade for MAX953**

APPLICATIONS

- Battery- or Solar-Powered Systems
- Automotive Keyless Entry
- Low Frequency, Local Area Alarms/Detectors
- Infrared Receivers for Remote Controls
- Smoke Detectors and Safety Sensors
- GSM Portable Phones

DESCRIPTION

The LTC[®] 1542 combines a micropower amplifier and comparator in an 8-pin package. The part operates from a single 2.5V to 12.6V or dual $\pm 1.25\text{V}$ to $\pm 6.3\text{V}$ supply with a typical supply current of $5\mu\text{A}$. Both the op amp and comparator feature a common mode input voltage range that extends from the negative supply to within 1.3V of the positive supply. The op amp output stage swings from rail to rail. The input current is 10pA typical for both op amp and comparator.

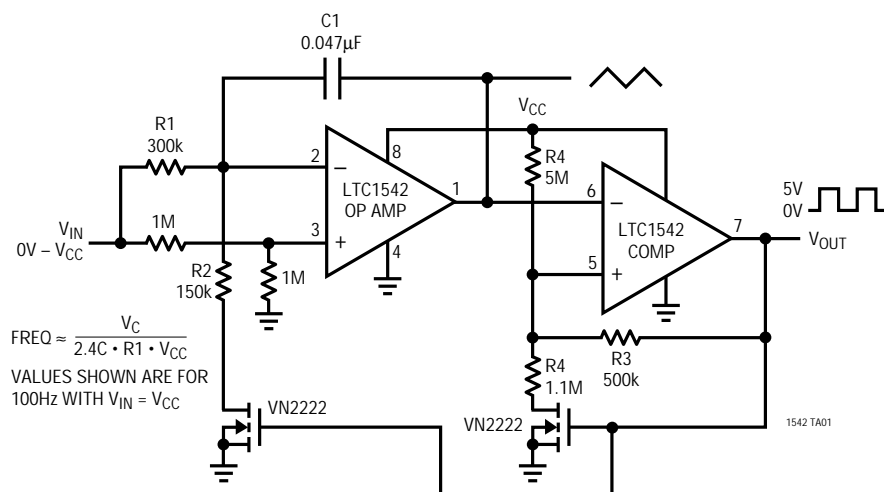
The op amp is internally compensated to be unity-gain stable with typical GBW at 12kHz and slew rate of 8V/ms. The comparator has $\pm 3\text{mV}$ of internal hysteresis to ensure clean output switching, even with slow moving input signals.

The LTC1542 is available in MSOP and SO-8 packages.

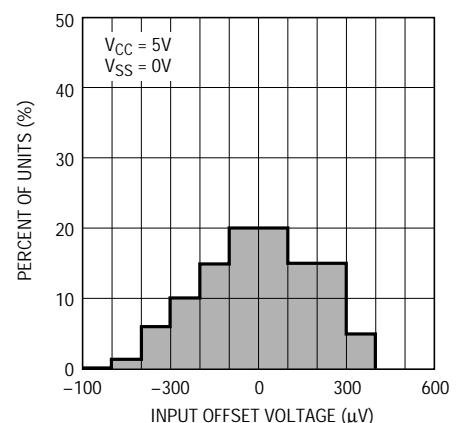
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TYPICAL APPLICATION

Voltage Control Oscillator



Op Amp V_{OS} Distribution,
 $V_{CM} = 2.5V$, SO-8 Package
Total of 839 Units



1542 TA02

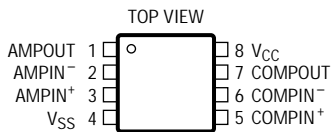
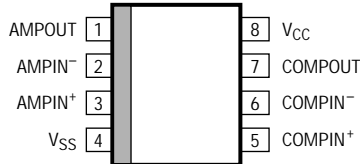
LTC1542

ABSOLUTE MAXIMUM RATINGS

Supply Voltage 13V
 Input Voltage -0.3V to 13V
 Output Voltage -0.3V to 13V
 Output Short-Circuit Duration Indefinite
 Storage Temperature Range -65°C to 150°C

Operating Temperature Range
 Commercial 0°C to 70°C
 Industrial -40°C to 85°C
 Lead Temperature (Soldering, 10 sec) 300°C

PACKAGE/ORDER INFORMATION

| | | | |
|--|-------------------|--|--------------------------|
|  <p>MS8 PACKAGE 8-LEAD PLASTIC MSOP $T_{JMAX} = 125^{\circ}\text{C}$, $\theta_{JA} = 250^{\circ}\text{C/W}$</p> | ORDER PART NUMBER |  <p>S8 PACKAGE 8-LEAD PLASTIC SO $T_{JMAX} = 125^{\circ}\text{C}$, $\theta_{JA} = 150^{\circ}\text{C/W}$</p> | ORDER PART NUMBER |
| | LTC1542CMS8 | | LTC1542CS8 LTC1542IS8 |
| | MS8 PART MARKING | | S8 PART MARKING |
| | LTDE | | 1542 1542I |

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS $V_{CC} = 5V$, $V_{SS} = 0V$, $T_A = 25^{\circ}\text{C}$, unless otherwise noted.

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------|-------------------------------|--------------------------------------|-----|----------|-----------------|---------------|
| Power Supply | | | | | | |
| V_{CC} | Supply Voltage Range | | ● | 2.5 | 12.6 | V |
| I_{CC} | Supply Current (Note 1) | Commercial Grade | ● | 5 | 7.5 | μA |
| | | Industrial Grade | ● | | 13 | μA |
| | | | ● | | 14 | μA |
| Comparator | | | | | | |
| V_{OS} | Input Offset Voltage (Note 2) | (SO-8) | ● | | 1 | mV |
| | | Commercial Grade (SO-8) | ● | | 1.5 | mV |
| | | Industrial Grade (SO-8) | ● | | 2.0 | mV |
| | | (MSOP) | ● | | 1.2 | mV |
| | | | ● | | 2.0 | mV |
| V_{TRIP} | Trip Point (Note 3) | $V_{CM} = 1/2V_{CC}$ | ● | 1.7 1 | 2.25 3.8 | mV mV |
| I_{IN} | Input Leakage Current | $V_{COMPIN+} = V_{COMPIN-} = 2.5V$ | ● | 0.01 | 1 | nA |
| V_{CM} | Input Common Mode Range | | ● | V_{SS} | $V_{CC} - 1.3V$ | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = V_{SS}$ to $V_{CC} - 1.3V$ | ● | | 0.25 | mV/V |
| | | Commercial Grade | ● | | 0.30 | mV/V |
| | | Industrial Grade | ● | | 0.35 | mV/V |
| PSRR | Power Supply Rejection Ratio | $V_{CC} = 3V$ to 12V | ● | | 0.25 | mV/V |
| | | Commercial Grade | ● | | 0.30 | mV/V |
| | | Industrial Grade | ● | | 0.35 | mV/V |
| t_{PD} | Propagation Delay | Overdrive = 10mV | | 20 | | μs |
| | | Overdrive = 100mV | | 8 | | μs |

ELECTRICAL CHARACTERISTICS $V_{CC} = 5V$, $V_{SS} = 0V$, $T_A = 25^\circ C$, unless otherwise noted.

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---------------|------------------------------|--|---|-----------------|------|-----------------|---------------|
| V_{OH} | Output High Voltage | $I_{OUT} = -2mA$ | ● | $V_{CC} - 0.2V$ | | | V |
| V_{OL} | Output Low Voltage | $I_{OUT} = 1.8mA$ | ● | | | $V_{SS} + 0.3V$ | V |
| Op Amp | | | | | | | |
| V_{OS} | Input Offset Voltage | $V_{CM} = 2.5V$ (SO-8) | ● | | | 0.7 | mV |
| | | Commercial Grade (SO-8) | ● | | | 1.25 | mV |
| | | Industrial Grade (SO-8) | ● | | | 1.5 | mV |
| | | $V_{CM} = 2.5V$ (MSOP) | ● | | | 1.00 | mV |
| | | | | | | 1.75 | mV |
| I_B | Input Bias Current | $V_{CM} = 2.5V$ | ● | | 0.01 | 1 | nA |
| A_{VOL} | Large-Signal Gain | AMPOUT = 0.5V to 4.5V, No Load | | 80 | 1000 | | V/mV |
| | | AMPOUT = 0.5V to 4.5V, $R_{LOAD} = 100k$ | | 60 | 500 | | V/mV |
| | | Commercial Grade | ● | 38 | | | V/mV |
| | | Industrial Grade | ● | 35 | | | V/mV |
| GBW | Gain Bandwidth | $A_V = 1V/V$ | | | 12 | | kHz |
| SR | Slew Rate | $A_V = 1V/V$ | | | 8 | | V/ms |
| V_{CM} | Input Common Mode Range | | ● | V_{SS} | | $V_{CC} - 1.3V$ | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = V_{SS}$ to $V_{CC} - 1.3V$ | | | | 0.28 | mV/V |
| | | Commercial Grade | ● | | | 0.33 | mV/V |
| | | Industrial Grade | ● | | | 0.38 | mV/V |
| PSRR | Power Supply Rejection Ratio | $V_{CC} = 3V$ to 12V | | | | 0.19 | mV/V |
| | | Commercial Grade | ● | | | 0.21 | mV/V |
| | | Industrial Grade | ● | | | 0.23 | mV/V |
| V_{OH} | Output High Voltage | $R_{LOAD} = 100k$ to V_{SS} | | $V_{CC} - 0.07$ | | | V |
| | | Commercial Grade | ● | $V_{CC} - 0.10$ | | | V |
| | | Industrial Grade | ● | $V_{CC} - 0.12$ | | | V |
| V_{OL} | Output Low Voltage | $R_{LOAD} = 100k$ to V_{SS} | | | | $V_{SS} + 0.05$ | V |
| | | Commercial Grade | ● | | | $V_{SS} + 0.10$ | V |
| | | Industrial Grade | ● | | | $V_{SS} + 0.12$ | V |
| I_{SOURCE} | Output Source Current | | | 0.9 | 1.8 | | mA |
| | | | ● | 0.7 | | | mA |
| I_{SINK} | Output Sink Current | | | 1.3 | 1.8 | | mA |
| | | | ● | 0.9 | | | mA |
| e_n | Input Noise Voltage | $f_0 = 0.1Hz$ to 10Hz | | | 3 | | μV_{P-P} |

$V_{CC} = 3V$, $V_{SS} = 0V$, $T_A = 25^\circ C$, unless otherwise noted.

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---------------------|-------------------------|------------------|---|-----|-----|------|---------|
| Power Supply | | | | | | | |
| V_{CC} | Supply Voltage Range | | ● | 2.5 | | 12.6 | V |
| I_{CC} | Supply Current (Note 1) | | | | 4.5 | 7.0 | μA |
| | | Commercial Grade | ● | | | 12 | μA |
| | | Industrial Grade | ● | | | 13 | μA |

ELECTRICAL CHARACTERISTICS

$V_{CC} = 3V$, $V_{SS} = 0V$, $T_A = 25^\circ C$, unless otherwise noted.

| SYMBOL | PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|-------------------|-------------------------------|--|---|-----------------|------|-----------------|---------|
| Comparator | | | | | | | |
| V_{OS} | Input Offset Voltage (Note 2) | (SO-8) | | | | 1.0 | mV |
| | | Commercial Grade (SO-8) | ● | | | 1.5 | mV |
| | | Industrial Grade (SO-8) | ● | | | 2.0 | mV |
| | | (MSOP) | ● | | | 1.2 | mV |
| V_{TRIP} | Trip Point (Note 3) | $V_{CM} = 1/2V_{CC}$ | | | | | |
| | | | ● | 1.8 | 2.35 | 2.9 | mV |
| I_{IN} | Input Leakage Current | $V_{COMPIN}^+ = V_{COMPIN}^- = 1.5V$ | ● | | 0.01 | 1 | nA |
| V_{CM} | Input Common Mode Range | | ● | V_{SS} | | $V_{CC} - 1.3$ | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = V_{SS}$ to $V_{CC} - 1.3V$ | | | | 0.35 | mV/V |
| | | Commercial Grade | ● | | | 0.40 | mV/V |
| | | Industrial Grade | ● | | | 0.45 | mV/V |
| PSRR | Power Supply Rejection Ratio | $V_{CC} = 3V$ to $12V$ | | | | 0.25 | mV/V |
| | | Commercial Grade | ● | | | 0.30 | mV/V |
| | | Industrial Grade | ● | | | 0.35 | mV/V |
| t_{PD} | Propagation Delay | Overdrive = 10mV | | | 25 | | μs |
| | | Overdrive = 100mV | | | 12 | | μs |
| V_{OH} | Output High Voltage | $I_{OUT} = -2mA$ | ● | $V_{CC} - 0.2$ | | | V |
| V_{OL} | Output Low Voltage | $I_{OUT} = 1.8mA$ | ● | | | $V_{SS} + 0.3$ | V |
| Op Amp | | | | | | | |
| V_{OS} | Input Offset Voltage | $V_{CM} = 1.5V$ (SO-8) | | | | 0.70 | mV |
| | | Commercial Grade (SO-8) | ● | | | 1.25 | mV |
| | | Industrial Grade (SO-8) | ● | | | 1.50 | mV |
| | | $V_{CM} = 1.5V$ (MSOP) | ● | | | 1.00 | mV |
| I_B | Input Bias Current | $V_{CM} = 1.5V$ | ● | | 0.01 | 1 | nA |
| A_{VOL} | Large-Signal Gain | AMPOUT = 0.5V to 2.5V, No Load | | 80.0 | 1000 | | V/mV |
| | | AMPOUT = 0.5V to 2.5V, $R_{LOAD} = 100k$ | | 45.5 | 500 | | V/mV |
| | | Commercial Grade | ● | 22.0 | | | V/mV |
| | | Industrial Grade | ● | 20.0 | | | V/mV |
| GBW | Gain Bandwidth | $A_V = 1V/V$ | | | 12 | | kHz |
| SR | Slew Rate | $A_V = 1V/V$ | | | 8 | | V/ms |
| V_{CM} | Input Common Mode Range | | ● | V_{SS} | | $V_{CC} - 1.3$ | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = V_{SS}$ to $V_{CC} - 1.3V$ | | | | 0.4 | mV/V |
| | | Commercial Grade | ● | | | 0.5 | mV/V |
| | | Industrial Grade | ● | | | 1.0 | mV/V |
| PSRR | Power Supply Rejection Ratio | $V_{CC} = 3V$ to $12V$ | | | | 0.19 | mV/V |
| | | Commercial Grade | ● | | | 0.21 | mV/V |
| | | Industrial Grade | ● | | | 0.23 | mV/V |
| V_{OH} | Output High Voltage | $R_{LOAD} = 100k$ to V_{SS} | | $V_{CC} - 0.07$ | | | V |
| | | Commercial Grade | ● | $V_{CC} - 0.10$ | | | V |
| | | Industrial Grade | ● | $V_{CC} - 0.12$ | | | V |
| V_{OL} | Output Low Voltage | $R_{LOAD} = 100k$ to V_{CC} | | | | $V_{CC} + 0.05$ | V |
| | | Commercial Grade | ● | | | $V_{CC} + 0.10$ | V |
| | | Industrial Grade | ● | | | $V_{CC} + 0.12$ | V |

ELECTRICAL CHARACTERISTICS $V_{CC} = 3V$, $V_{SS} = 0V$, $T_A = 25^\circ C$, unless otherwise noted.

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|--------------|-----------------------|-------------------------|------------|------|-----|---------------|
| I_{SOURCE} | Output Source Current | | 0.6 0.4 | 0.95 | | mA mA |
| I_{SINK} | Output Sink Current | | 1.2 0.8 | 1.8 | | mA mA |
| e_n | Input Noise Voltage | $f_0 = 0.1Hz$ to $10Hz$ | | 3 | | μV_{P-P} |

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

Note 1: Supply current is tested with $COMPIN^+ = 0V$, $COMPIN^- = 100mV$.

Note 2: Input offset voltage is defined as the center of the input referred hysteresis, $V_{CM} = 1/2V_{CC}$.

Note 3: Trip point is defined as the differential input voltage required to make the comparator output change state. The difference between upper and lower trip point is equal to the width of the input referred hysteresis.

PIN FUNCTIONS

AMPOUT (Pin 1): Op Amp Output. The output can swing from rail to rail while driving a capacitive load of up to $1000pF$. The output can source and sink $0.7mA$ minimum.

AMPIN⁻ (Pin 2): Inverting Input of Op Amp. The input common mode ranges from V_{SS} to $V_{CC} - 1.3V$. The input current is typically $10pA$ at $25^\circ C$.

AMPIN⁺ (Pin 3): Noninverting Input of Op Amp. The input common mode ranges from V_{SS} to $V_{CC} - 1.3V$. The input current is typically $10pA$ at $25^\circ C$.

V_{SS} (Pin 4): Negative Supply or Ground Connection.

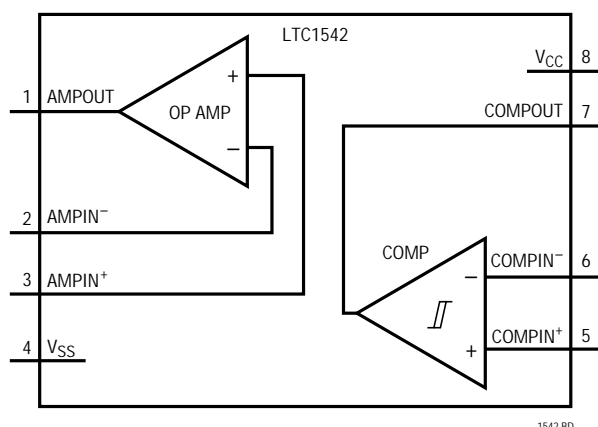
COMPIN⁺ (Pin 5): Noninverting Input of Comparator. The input common mode ranges from V_{SS} to $V_{CC} - 1.3V$. The input current is typically $10pA$ at $25^\circ C$.

COMPIN⁻ (Pin 6): Inverting Input of Comparator. The input common mode ranges from V_{SS} to $V_{CC} - 1.3V$. The input current is typically $10pA$ at $25^\circ C$.

COMPOUT (Pin 7): Comparator Output. The output can source $20mA$ and sink $5mA$.

V_{CC} (Pin 8): Positive Supply, $2.5V \leq V_{CC} \leq 12.6V$. The supply bypass capacitors are not required if the supply impedance is low. For single supply applications, it is a good general practice to bypass V_{CC} with a $0.1\mu F$ capacitor to ground.

BLOCK DIAGRAM



1542 BD

APPLICATIONS INFORMATION

The LTC1542 is a combination of a micropower op amp and comparator in an 8-pin package. The supply voltage range is from 2.5V to 12.6V for a single supply and $\pm 1.25\text{V}$ to $\pm 6.3\text{V}$ for dual supplies. The supply current is a mere $5\mu\text{A}$ (typical) with a 5V single supply.

Op Amp

The op amp is internally compensated to be unity-gain stable, with typical GBW at 12kHz and slew rate of 8V/ms. The output can drive a capacitive load of up to 1000pF and swings from rail to rail. The input range is from the negative rail to within 1.3V of the positive rail. The input bias current is less than 1nA maximum at the extended temperature range.

Comparator

The comparator has a high impedance differential input stage with a common input range from the negative rail to within 1.3V of the positive rail. The CMOS output stage can swing from rail to rail and source up to 20mA continuously. The output stage has been designed to eliminate the power supply glitches that normally occur when the output changes logic state. In addition, an internal hysteresis ($\pm 3\text{mV}$) ensures clean output switching even with slow moving input signals.

Op Amp Stability

Unlike other industry standard micropower CMOS op amps, the op amp in the LTC1542 maintains stability in unity-gain configuration while driving heavy capacitive loads of up to 1000pF.

Although this family is primarily designed for low frequency applications, good layout is extremely important. Low power, high impedance circuits may increase the effects of board leakage and stray capacitance. For example, the combination of a 10M resistance (from leakage between traces on a contaminated, poorly designed PC board) and a 1pF stray capacitance provides a pole at approximately 16kHz, which is near the amplifier's bandwidth. Board routing and layout should minimize leakage and stray capacitance. In some cases, stray capacitance may be unavoidable and it may be necessary to add a small capacitor across the feedback resistor to compensate (Figure 1); select the smallest capacitor value that ensures stability.

Inputs

The input common mode range for both the op amp and comparator is from the negative supply to within 1.3V of the positive supply. The inputs can be taken more than 300mV below the negative supply without damaging the device if the current out of the pin is limited to less than 1mA. Unlike the bipolar input op amp and comparator, the output of the LTC1542 will not reverse phase when the inputs are taken above the common mode input range.

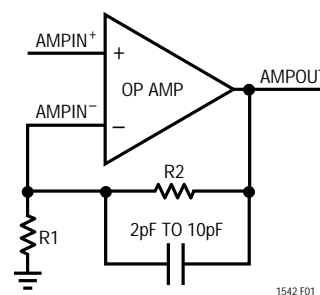
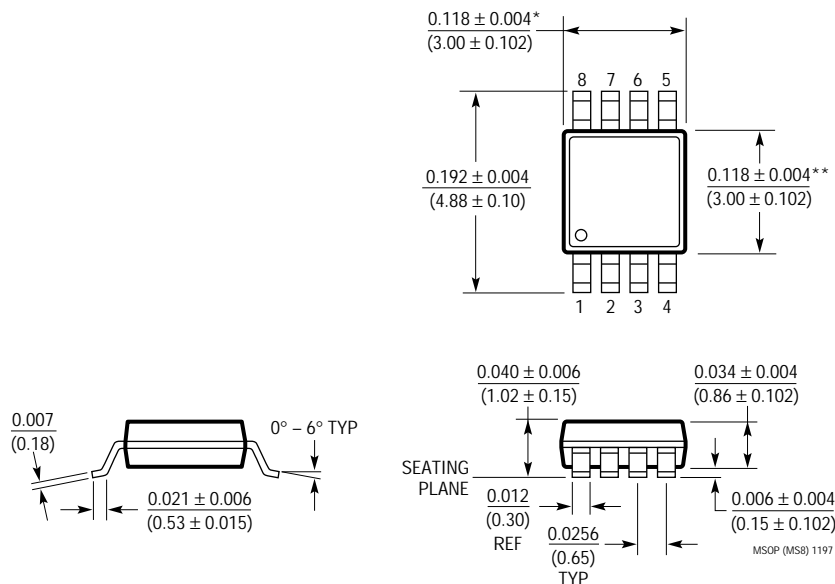


Figure 1. Compensation for Feedback Node Capacitance

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

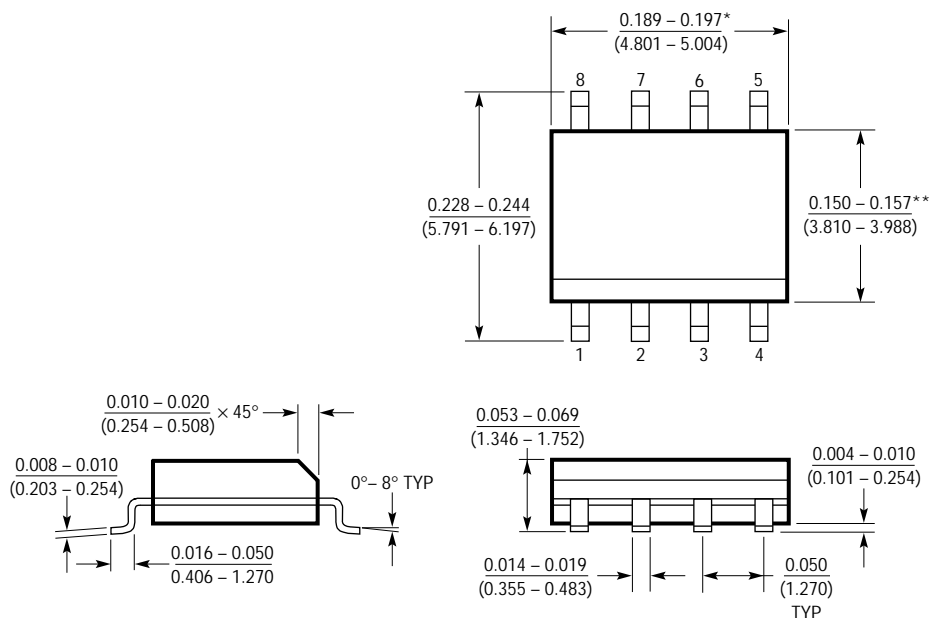
MS8 Package 8-Lead Plastic MSOP (LTC DWG # 05-08-1660)



* 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

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



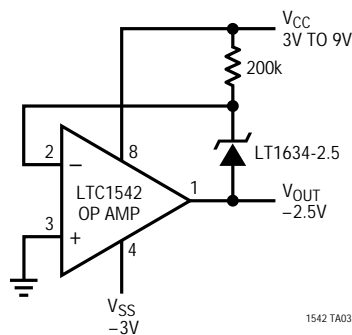
* DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

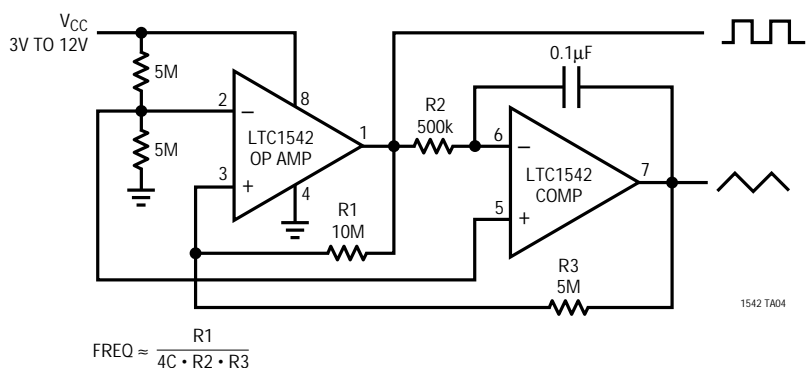
SOP 0996

TYPICAL APPLICATIONS

Negative Reference



Single Supply Function Generator



RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|----------------|--|---|
| LT®1078/LT1079 | Dual/Quad Micropower, Single Supply Precision Op Amps | 70µV, V _{OS} Max and 0.4µV/°C Drift, 200kHz GBW, 0.07V/µs Slew Rate, Input/Output Common Mode Includes Ground |
| LT1178/LT1179 | Dual/Quad 17µA Max, Single Supply Precision Op Amps | 70µV, V _{OS} Max and 2.5µV/°C Drift Max, 85kHz GBW, 0.04V/µs Slew Rate, Input/Output Common Mode Includes Ground |
| LT1490/LT1491 | Dual/Quad Micropower Rail-to-Rail Input and Output Op Amps | Single Supply Input Range: -0.4V to 44V, Micropower 50µA Amplifier, Rail-to-Rail Input and Output, 200kHz GBW |
| LT1635 | Micropower Rail-to-Rail Op Amp and Reference | 130µA of Supply Current, 1.3mV V _{OS} Max |
| LT2078/LT2079 | Dual/Quad Micropower, Single Supply Precision Op Amps | SO-8 and 14-Lead Standard Pinout, 70µV V _{OS} Max, 200kHz GBW |
| LT2178/LT2179 | Dual/Quad 17µA Max, Single Supply Precision Op Amps | SO-8 and 14-Lead Standard Pinout, 70µV V _{OS} Max, 85kHz GBW |
| LTC1541 | Micropower Op Amp, Comparator and Reference | Internal 1.2V ± 0.8% Reference with Comparator and Op Amp |