National Semiconductor

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# LMC568
# Low Power Phase-Locked Loop

## General Description

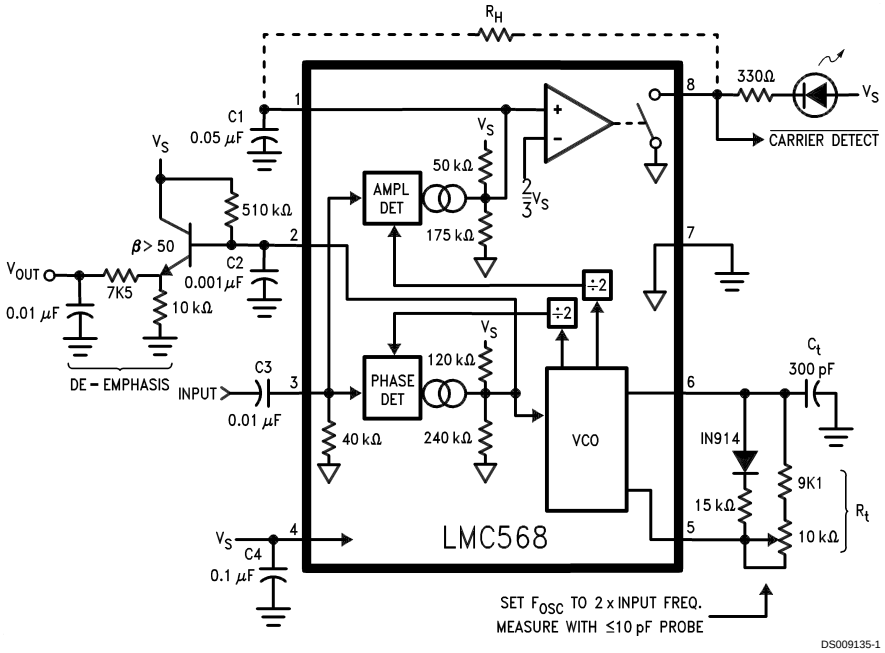
The LMC568 is an amplitude-linear phase-locked loop consisting of a linear VCO, fully balanced phase detectors, and a carrier detect output. LMCMOS™ technology is employed for high performance with low power consumption.

The VCO has a linearized control range of ±30% to allow demodulation of FM and FSK signals. Carrier detect is indicated when the PLL is locked to an input signal greater than 26 mVrms. LMC568 applications include FM SCA and TV second audio program decoders, FSK data demodulators, and voice pagers.

## Features

- Demodulates ±15% deviation FM/FSK signals
- Carrier Detect Output with hysteresis
- Operation to 500 kHz input frequency
- Low THD — 0.5% typ. for ±10% deviation
- 2V to 9V supply voltage range
- Low supply current drain

## Typical Application (100 kHz input frequency, refer to notes pg. 3)




**Order Number LMC568CM or LMC568CN**
**See NS Package Number M08A or N08E**

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## Absolute Maximum Ratings (Note 1)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**

| | |
|---|---|
| Input Voltage, Pin 3 | 2 $V_{p-p}$ |
| Supply Voltage, Pin 4 | 10V |
| Output Voltage, Pin 8 | 13V |
| Voltage at All Other Pins | $V_s$ to Gnd |
| Output Current, Pin 8 | 30 mA |
| Package Dissipation | 500 mW |
| Operating Temperature Range ($T_A$) | −25˚C to +125˚C |
| Storage Temperature Range | −55˚C to +150˚C |

Soldering Information

| | |
|---|---|
| Dual-In-Line Package | |
| Soldering (10 seconds) | 260˚C |
| Small Outline Package | |
| Vapor Phase (60 seconds) | 215˚C |
| Infrared (15 seconds) | 220˚C |

See AN-450 "Surface Mounting Methods and their Effect on Product Reliability" for other methods of soldering surface mount devices.

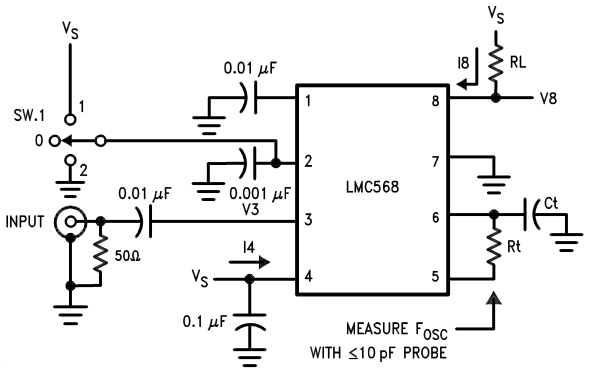
**Note 1:** "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

## Electrical Characteristics

Test Circuit, $T_A$= 25˚C, $V_S$= 5V, RtCt #2, Sw. 1 Pos. 0; and no input unless otherwise noted.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| I4 | Power Supply Current | RtCt # 1, Quiescent or Activated | $V_S$ = 2V | | 0.35 | | mAdc |
| | | | $V_S$ = 5V | | 0.75 | 1.5 | |
| | | | $V_S$ = 9V | | 1.2 | 2.4 | |
| V3 | Input D.C. Bias | | | | 0 | | mVdc |
| R3 | Input Resistance | | | | 40 | | kΩ |
| I8 | Output Leakage | | | | 1 | 100 | nAdc |
| $f_0$ | Center Frequency $F_{osc}$ ÷ 2 | RtCt #2, Measure Oscillator Frequency and Divide by 2 | $V_S$ = 2V | | 98 | | kHz |
| | | | $V_S$ = 5V | 90 | 103 | 115 | |
| | | | $V_S$ = 9V | | 105 | | |
| $\Delta f_0$ | Center Frequency Shift with Supply | $\frac{f_0\|_{9V} - f_0\|_{2V}}{7 f_0\|_{5V}} \times 100$ | | | 1.0 | 2.0 | %/V |
| $V_{in}$ | Input Threshold | Set Input Frequency Equal to $f_0$ Measured Above, Increase Input Level until Pin 8 Goes Low. | $V_S$ = 2V | 8 | 16 | 25 | mVrms |
| | | | $V_S$ = 5V | 15 | 26 | 42 | |
| | | | $V_S$ = 9V | | 45 | | |
| $\Delta V_{in}$ | Input Hysteresis | Starting at Input Threshold, Decrease Input Level until Pin 8 Goes High | | | 1.5 | | mVrms |
| V8 | Output "Sat" Voltage | Input Level > Threshold Choose RL for Specified I8 | I8 = 2 mA | | 0.06 | 0.15 | Vdc |
| | | | I8 = 20 mA | | 0.7 | | |
| L.D.B.W. | Largest Detection Bandwidth | Measure $F_{osc}$ with Sw. 1 in Pos. 0, 1, and 2; $L.D.B.W. = \frac{F_{osc}\|_{P2} - F_{osc}\|_{P1}}{F_{osc}\|_{P0}} \times 100$ | $V_S$ = 2V | | 30 | | % |
| | | | $V_S$ = 5V | 40 | 55 | | |
| | | | $V_S$ = 9V | | 60 | | |
| ΔBW | Bandwidth Skew | $Skew = \left( \frac{F_{osc}\|_{P2} - F_{osc}\|_{P1}}{2 F_{osc}\|_{P0}} - 1 \right) \times 100$ | | | 1 | ±5 | % |
| $V_{out}$ | Recovered Audio | Typical Application Circuit Input = 100 mVrms, F = 100 kHz $F_{mod}$ = 400 Hz, ± 10 kHz Dev. | $V_S$ = 2V | | 170 | | mVrms |
| | | | $V_S$ = 5V | | 270 | | |
| | | | $V_S$ = 9V | | 400 | | |
| THD | Total Harmonic Distortion | Typical Application Circuit as Above, Measure $V_{out}$ Distortion. | | | 0.5 | | % |
| $\frac{S+N}{N}$ | Signal to Noise Ratio | Typical Application Circuit Remove Modulation, Measure $V_n$ (S + N)/N = 20 log ($V_{out}/V_n$). | | | 65 | | dB |
| $f_{max}$ | Highest Center Freq. | RtCt #3, Measure Oscillator Frequency and Divide by 2 | | | 700 | | kHz |

## Test Circuit




| RtCt | Rt | Ct |
|---|---|---|
| #1 | 100k | 300 pF |
| #2 | 10k | 300 pF |
| #3 | 5.1k | 62 pF |

## Notes to Typical Application

### SUPPLY DECOUPLING

The decoupling of supply pin 4 becomes more critical at high supply voltages with high operating frequencies, requiring C4 to be placed as close to possible to pin 4. Also, due to pin voltages tracking supply, a large C4 is necessary for low frequency PSRR.

### OSCILLATOR TIMING COMPONENTS

The voltage-controlled oscillator (VCO) on the LMC568 must be set up to run at twice the frequency of the input signal. The components shown in the typical application are for $F_{osc}$ = 200 kHz (100 kHz input frequency). For operation at lower frequencies, increase the capacitor value; for higher frequencies proportionally reduce the resistor values.

If low distortion is not a requirement, the series diode/resistor between pins 6 and 5 may be omitted. This will reduce VCO supply dependence and increase $V_{out}$ by approximately 2 dB with THD = 2% typical. The center frequency as a function of Rt and Ct is given by:

$$F_{OSC} \cong \frac{1}{1.4\ RtCt}\ Hz$$

To allow for I.C. and component value tolerences, the oscillator timing components will require a trim. This is generally accomplished by using a variable resistor as part of Rt, although Ct could also be padded. The amount of initial frequency variation due to the LMC568 itself is given in the electrical specifications; the total trim range must also accommodate the tolerances of Rt and Ct.

### INPUT PIN

The input pin 3 is internally ground-referenced with a nominal 40 kΩ resistor. Signals that are centered on 0V may be directly coupled to pin 3; however, any d.c. potential must be isolated via C3.

### OUTPUT TAKEOFF

The output signal is taken off the loop filter at pin 2. Pin 2 is the combined output of the phase detector and control input of the VCO for the phase-locked loop (PLL). The nominal pin 2 source resistance is 80 kΩ, requiring the use of an external buffer transistor to drive nominal loads.

For small values of C2, the PLL will have a fast acquisition time and the pull-in range will be set by the built-in VCO frequency stops, which also determine the largest detection bandwidth (LDBW). Increasing C2 results in improved noise immunity at the expense of acquisition time, and the pull-in range will become narrower than the LDBW. However, the maximum hold-in range will always equal the LDBW. The 2 kHz de-emphasis pole shown may be modified or omitted as required by the application.

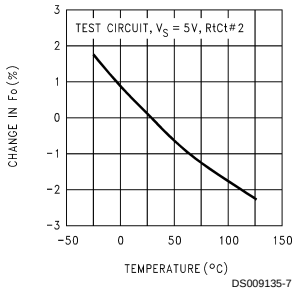
### CARRIER DETECT

Pin 1 is the output of a negative-going amplitude detector which has a nominal 0 signal output of 7/9 $V_s$. The output at pin 8 is an N-channel FET switch to ground which is activated when the PLL is locked and the input is of sufficient amplitude to cause pin 1 to fall below 2/3 $V_s$. The carrier detect threshold is internally set to 26 mVrms typical on a 5V supply.

Capacitor C1 in conjunction with the nominal 40 kΩ pin 1 internal resistance forms the output filter. The size of C1 is a tradeoff between slew rate and carrier ripple at the output comparator. Optional resistor $R_H$ increases the hysteresis in the pin 8 output for applications such as audio mute control. The minimum allowable value for $R_H$ is 330 kΩ.

## LMC568 Typical Performance Characteristics

**Frequency Drift with Temperature**

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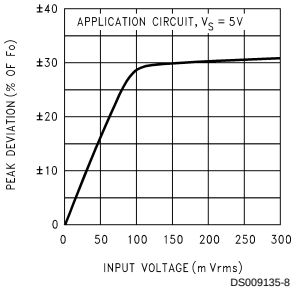
**Peak Deviation vs Input Signal Level**

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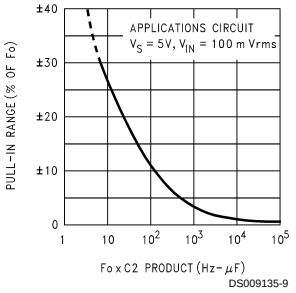
**Pull-In Range as a Function of C2**

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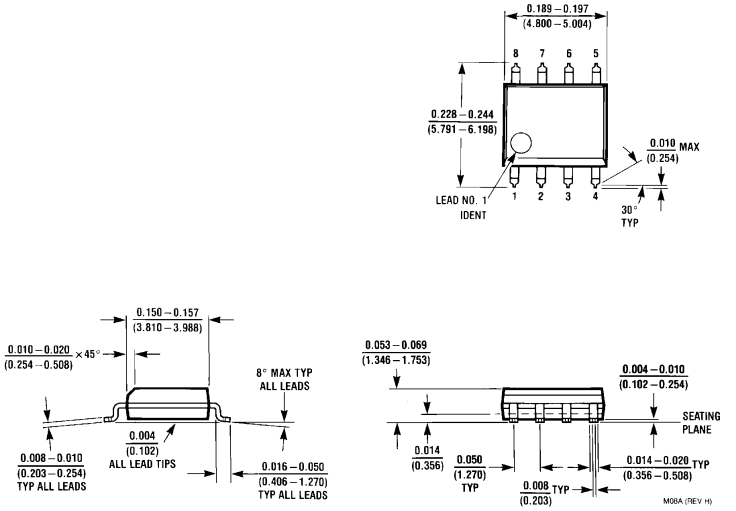
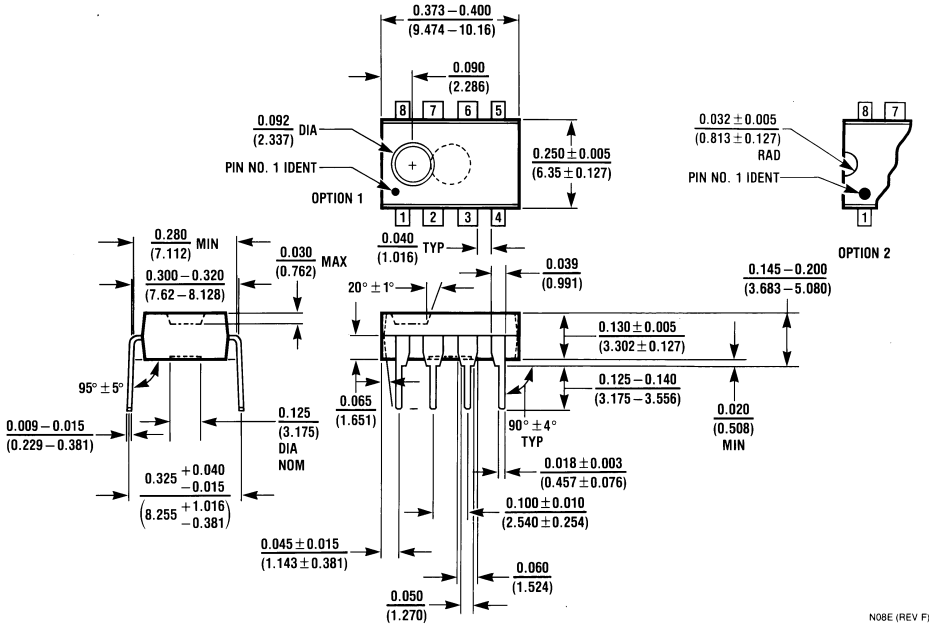
## Physical Dimensions inches (millimeters) unless otherwise noted




**SO Package (M)**
**Order Number LMC568CM**
**NS Package Number M08A**




**Molded Dual-In-Line Package (N)**
**Order Number LMC568CN**
**NS Package Number N08E**

## Notes

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