

**DESCRIPTION**

The NE560 Phase Locked Loop (PLL) is a monolithic signal conditioner and demodulator system comprising a VCO, Phase Comparator, Amplifier and Low Pass Filter, interconnected as shown in the accompanying block diagram. The center frequency of the PLL is determined by the free running frequency ( $f_0$ ) of the VCO. This VCO frequency is set by an external capacitor and can be fine tuned by an optional potentiometer. The low pass filter, which determines the capture characteristics of the loop, is formed by the two capacitors and two resistors at the Phase Comparator output.

The PLL system has a set of self biased inputs which can be utilized in either a differential or single ended mode. The VCO output, in differential form, is available for signal conditioning, frequency synchronization, multiplication and division applications. Terminals are provided for optional extended control of the tracking range, VCO frequency, and output dc level.

The monolithic signal conditioner-demodulator system is useful over a wide range of frequencies from less than 1Hz to more than 15MHz with an adjustable tracking range of  $\pm 1\%$  to  $\pm 15\%$ .

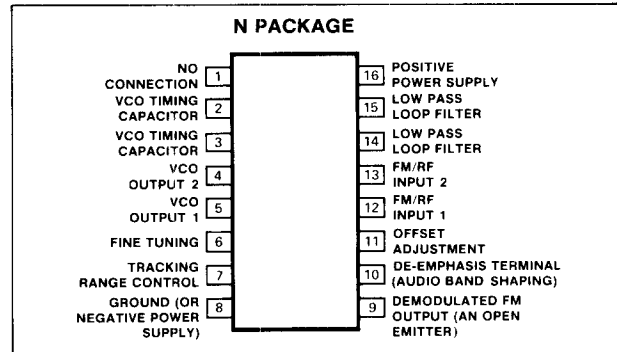
**FEATURES**

- FM demodulation without tuned circuits
- Narrow bandpass:  $\pm 14\%$  adjustable
- Exact frequency duplication in high noise environment
- Wide tracking range:  $\pm 15\%$
- High linearity: 1% distortion max
- Frequency multiplication and division

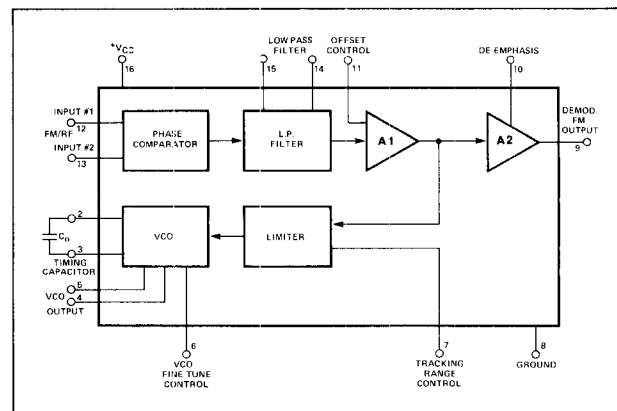
**APPLICATIONS**

- Tone decoders
- FM IF strips
- Telemetry decoders
- Data synchronizers
- Signal reconstitution
- Signal generators
- Modems
- Tracking filters
- SCA receivers
- FSK receivers
- Wide band high linearity detectors

**PIN CONFIGURATION**



**BLOCK DIAGRAM**



**ABSOLUTE MAXIMUM RATINGS**

PARAMETER	RATING	UNIT
Maximum operating voltage	26	V
Input voltage	1	Vrms
Storage temperature	-65 to +150	°C
Operating temperature	0 to +70	°C
Power dissipation	300	mW

**NOTE**

Limiting values above which serviceability may be impaired.

**GENERAL ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ\text{C}$  unless otherwise specified.<sup>1</sup>

PARAMETER	TEST CONDITIONS	NE560			UNIT
		Min	Typ	Max	
Lowest practical operating frequency		15	0.1		Hz
Maximum operating frequency			30		MHz
Supply current		7	9	12	mA
Minimum input signal for lock			100		$\mu\text{V}$
Dynamic range			60		dB
VCO Temp. coefficient <sup>2</sup>	Measured at 2MHz, with both inputs ac grounded.		$\pm 0.06$	$\pm 0.12$	$\% / ^\circ\text{C}$
VCO Supply voltage regulation	Measured at 2MHz		$\pm 0.3$	$\pm 2$	$\% / \text{V}$
Input resistance			2		$\text{k}\Omega$
Input capacitance			4		pF
dc level (pins 14 & 15)		+10.6	+12	+13.4	V
Input dc level (pins 12 & 13)		+2.8	+4	+6.2	V
Output dc level (pin 10)		+12.5	+14	+17	V
(pin 9)		+12	+14	+16	V
Available output swing			4		$V_{p-p}$
AM rejection <sup>2</sup>		30	40		dB
De-emphasis resistance	Measured at pin 9 (see Figure 1)		8		$\text{k}\Omega$

NOTES

- 15k $\Omega$  Pin 9 to GND; input Pin 12 or Pin 13 (ac ground unused input); optional controls not connected; V+ = 18V unless otherwise specified.
- Acceptance Test Sub Group C.

**ELECTRICAL CHARACTERISTICS** FM Applications (see Figure 2)  
 $T_A = 25^\circ\text{C}$ , V+ = 18V unless otherwise specified.<sup>1</sup>

PARAMETER	TEST CONDITIONS	NE560			UNIT
		Min	Typ	Max	
<b>10.7MHz OPERATION—DEVIATION 75kHz, SOURCE IMPEDANCE = 50<math>\Omega</math></b>					
Detection threshold	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz	30	120	300	$\mu\text{V}$
Demodulated output amplitude			60		mV
Distortion <sup>2</sup>	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz		0.3	1	%T.H.D.
Signal to noise ratio ( $\frac{S+N}{N}$ )	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz		35		dB
<b>4.5MHz OPERATION— DEVIATION = 25kHz, SOURCE IMPEDANCE = 50<math>\Omega</math></b>					
Detection threshold	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz	30	120	300	$\mu\text{V}$
Demodulation output amplitude			60		mV
Distortion <sup>2</sup>	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz		0.3	1.0	%T.H.D.
Signal to noise ratio ( $\frac{S+N}{N}$ )	$V_{IN} = 1\text{mVrms}$ , modulation frequency 1kHz		35		dB
<b>WIDE DEVIATION—<math>\Delta F/f_o = 5\%</math>, <math>f_o = 4.5\text{MHz}</math>, DEVIATION = 225kHz @ 1kHz MODULATION RATE</b>					
Detection threshold	$V_{IN} = 5\text{mVrms}$	0.2	1	5	mV
Demodulated output			0.5		Vrms
Distortion <sup>2</sup>	$V_{IN} = 5\text{mVrms}$		0.8		%T.H.D.
Signal to noise ratio ( $\frac{S+N}{N}$ )	$V_{IN} = 5\text{mVrms}$		50		dB

**ELECTRICAL CHARACTERISTICS** (Cont'd) Tracking Filter (see Figure 3)  
 $T_A = 25^\circ\text{C}$ ,  $V_+ = 18\text{V}$  unless otherwise specified.1

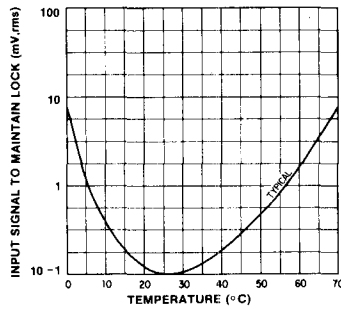
PARAMETER	TEST CONDITIONS	NE560			UNIT
		Min	Typ	Max	
Tracking range Minimum signal to sustain lock	$V_{IN} = 5\text{mVrms}$ See typical performance characteristics	$\pm 5$	$\pm 15$ 0.8		% of $f_o$ mVrms
VCO Output impedance	Measured with high impedance probe with less than 10pF capacitance		1		k $\Omega$
VCO Output swing	with 100kHz sideband separation and 3kHz low pass filter.	0.4	0.6		$V_{p-p}$
VCO Output dc level	$C_1 = .001\mu\text{F}$ , $R_1 = 50\Omega$		+6.5		V
Side band suppression	Input = 1mV peak for carrier and each sideband.		35		dB

NOTES

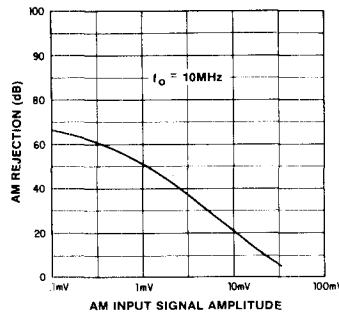
- 15K $\Omega$  Pin 9 to GND; input Pin 12 or 13 (AC ground unused input); optional controls not connected.
- Acceptance Test Sub Group C.

**TYPICAL PERFORMANCE CHARACTERISTICS**

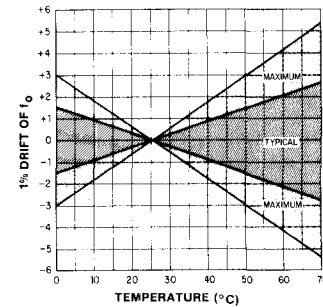
**MINIMUM INPUT SIGNAL AMPLITUDE NECESSARY TO MAINTAIN LOCK AS A FUNCTION OF TEMPERATURE WITH  $f_{IN} = f_o = 2.0\text{MHz}$**



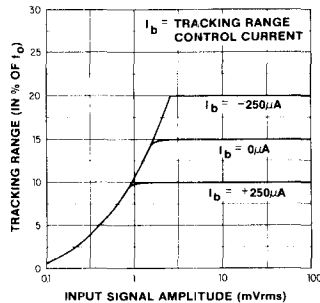
**AM REJECTION AS A FUNCTION OF INPUT SIGNAL LEVEL**



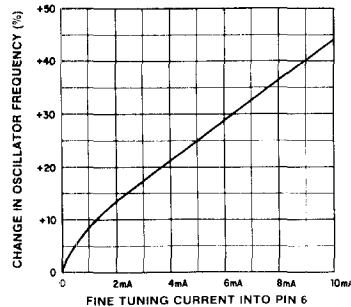
**THERMAL DRIFT OF VCO FREE RUNNING FREQUENCY ( $f_o$ )**



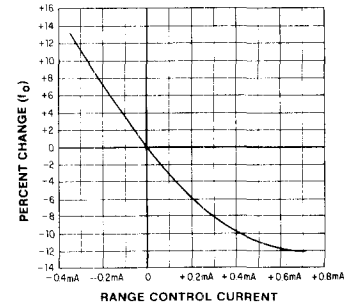
**TYPICAL TRACKING RANGE AS A FUNCTION OF INPUT SIGNAL**



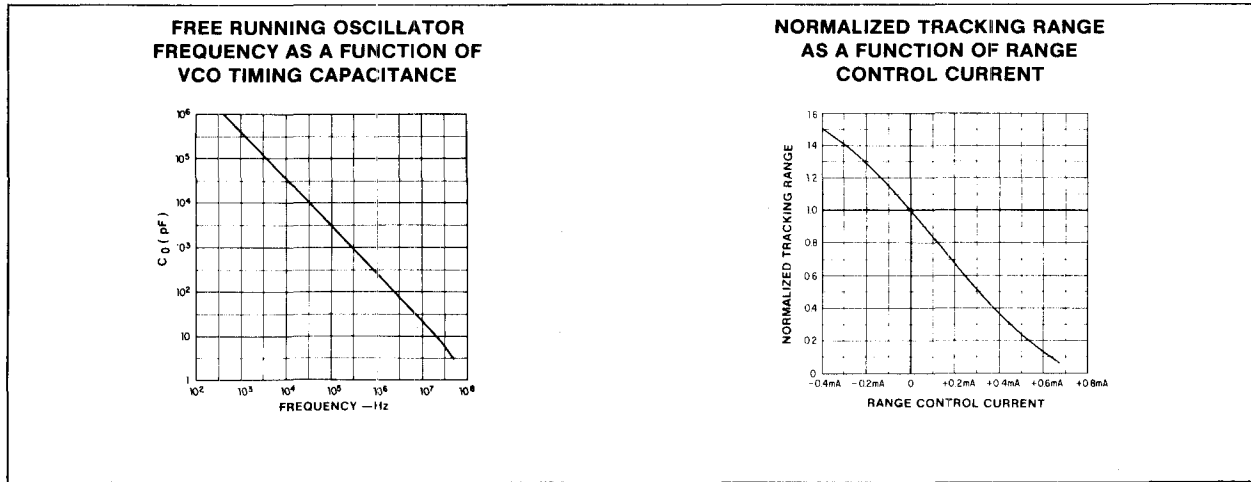
**CHANGE OF FREE RUNNING OSCILLATOR FREQUENCY AS A FUNCTION OF FINE TUNING CURRENT**



**CHANGE OF FREE RUNNING OSCILLATOR FREQUENCY AS A FUNCTION OF RANGE CONTROL CURRENT**



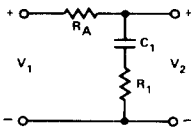
TYPICAL PERFORMANCE CHARACTERISTICS (Cont'd)



EXTERNAL CONTROLS

1. Loop Low Pass Filter (Pins 14 and 15)

The equivalent circuit for the loop low-pass filter can be represented as:



where R<sub>A</sub> (6KΩ) is the effective resistance seen looking into pin 14 or pin 15.

The corresponding filter transfer characteristics are:

$$\frac{V_2}{V_1} (S) = \frac{1 + S R_1 C_1}{1 + S(R_1 + R_A)C_1}$$

where S is the complex frequency variable.

2. Loop Gain (Threshold) Control

The overall phase locked loop gain can be reduced by connecting a feedback resistor, R<sub>F</sub>, across the low-pass filter terminals, pins 14 and 15. This causes the loop gain and the detection sensitivity to decrease by a factor α, (α < 1)

where:

$$\alpha = \frac{R_F}{2 R_A + R_F}$$

Reduction of loop gain may be desirable at high input signal levels (V<sub>IN</sub> > 30mV) and at high frequencies (f<sub>o</sub> > 5MHz) where excessively high loop gain may cause instability.

3. Tracking Range Control (Pin 7)

Any bias current, I<sub>b</sub>, injected into the tracking range control reduces the tracking range of the PLL by decreasing the output of the limiter. The variations of the tracking range and the center frequency, as a function of I<sub>b</sub>, are shown in the characteristic curves with I<sub>b</sub> defined positive going into the tracking range control terminal. This terminal is normally at a dc level of +0.6 volts and presents an impedance of 600Ω.

4. External Fine Tuning (Pin 6)

Any bias current injected into the fine tuning terminal increases the frequency of oscillation, f<sub>o</sub>, as shown in the characteristic curves. This current is defined positive into the fine tuning terminal. This terminal is at a typical dc level of +1.3 volts and has a dynamic impedance of 100Ω to ground.

5. Offset Adjustment (Pin 11)

Application of a bias voltage to the offset adjustment terminal modifies the current in the output amplifier, setting the dc level at the output. The effect on the loop is to modify the relationship between the VCO free running frequency and the lock range, allowing the VCO free running frequency to be positioned at different points throughout the lock range.

Nominally this terminal is at +4Vdc and has an input impedance of 3kΩ. The offset adjustment is optional. The characteristics specified correspond to operation of the circuit with this terminal open circuited.

6. De-emphasis Filter (Pin 10)

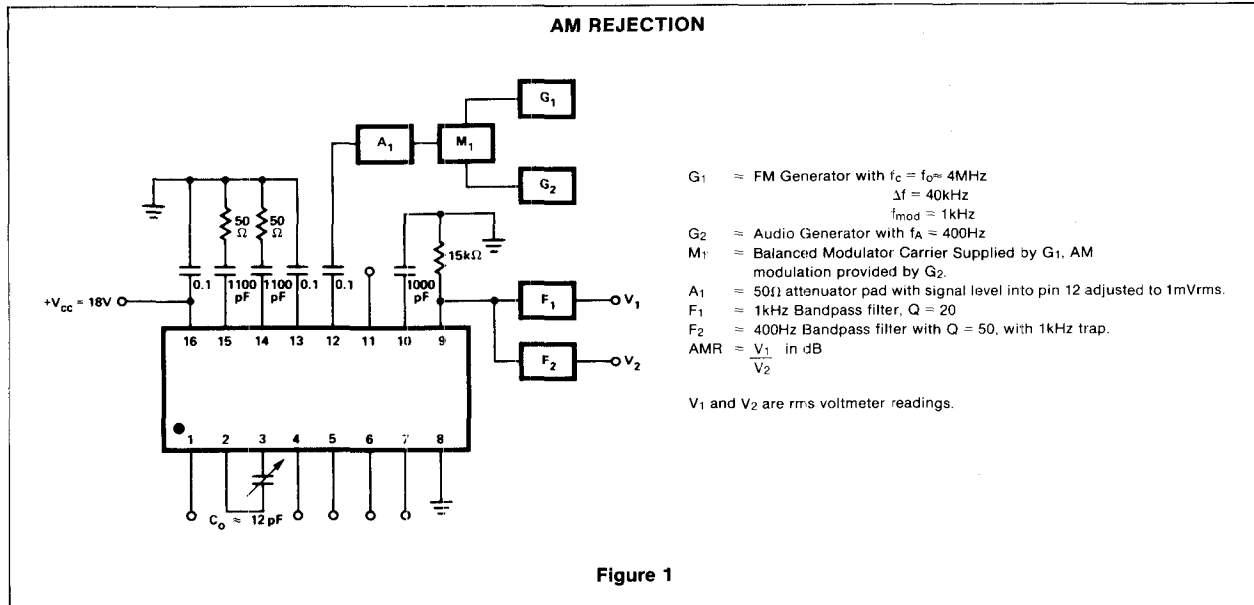
The de-emphasis terminal is normally used when the PLL is used to demodulate frequency modulated audio signals. In this application, a capacitor from this terminal to ground provides the required de-emphasis. For other applications, this terminal may be used for band shaping the output signal. The 3dB bandwidth of the output amplifier (see Figure 2) is related to the de-emphasis capacitor, C<sub>D</sub>, as:

$$f_{3dB} = \frac{1}{2\pi R_D C_D}$$

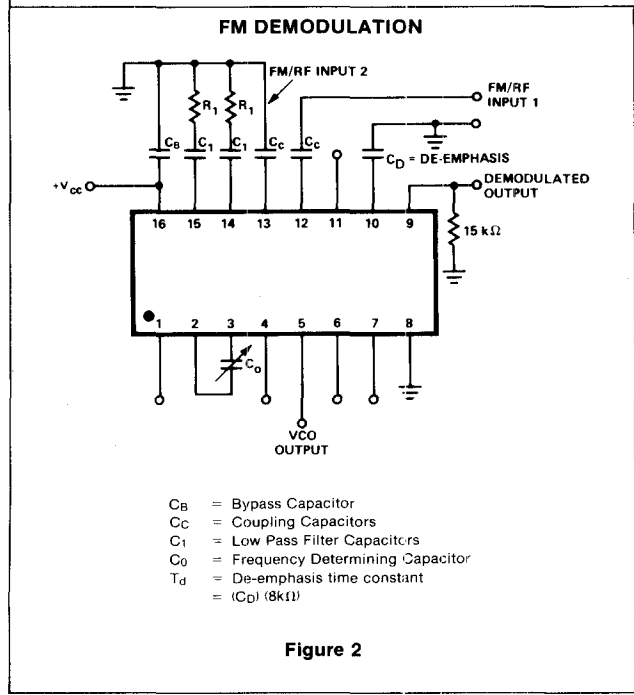
where R<sub>D</sub> is the 8000 ohm resistance seen looking into the de-emphasis terminal.

When the PLL system is utilized for signal conditioning, and the loop error voltage is not utilized, the de-emphasis terminal should be ac grounded.

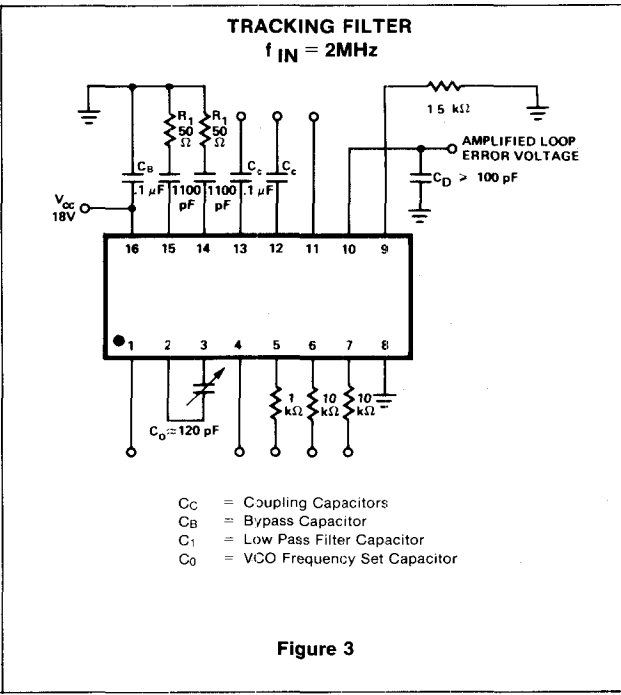
TEST CIRCUITS



- G<sub>1</sub> = FM Generator with  $f_c = f_{o\approx} 4\text{MHz}$   
 $\Delta f = 40\text{kHz}$   
 $f_{\text{mod}} = 1\text{kHz}$
  - G<sub>2</sub> = Audio Generator with  $f_A = 400\text{Hz}$
  - M<sub>1</sub> = Balanced Modulator Carrier Supplied by G<sub>1</sub>, AM modulation provided by G<sub>2</sub>.
  - A<sub>1</sub> = 50Ω attenuator pad with signal level into pin 12 adjusted to 1mVrms.
  - F<sub>1</sub> = 1kHz Bandpass filter, Q = 20
  - F<sub>2</sub> = 400Hz Bandpass filter with Q = 50, with 1kHz trap.
  - AMR =  $\frac{V_1}{V_2}$  in dB
- V<sub>1</sub> and V<sub>2</sub> are rms voltmeter readings.



- C<sub>B</sub> = Bypass Capacitor
- C<sub>C</sub> = Coupling Capacitors
- C<sub>1</sub> = Low Pass Filter Capacitors
- C<sub>0</sub> = Frequency Determining Capacitor
- T<sub>d</sub> = De-emphasis time constant = (C<sub>D</sub>) (8kΩ)



- C<sub>C</sub> = Coupling Capacitors
- C<sub>B</sub> = Bypass Capacitor
- C<sub>1</sub> = Low Pass Filter Capacitor
- C<sub>0</sub> = VCO Frequency Set Capacitor