The NE568A as a wideband FM modulator AN1882

INTRODUCTION

The NE/SA568A used as an FM modulator for frequencies up to 140MHz is described. This device is fabricated on 8GHz integrated bipolar technology and operates at 5V. The VCO gain constant, K_O, is 4.2 x 10 rad/ volt-sec at a center frequency of 70MHz. This is equal to approximately 670MHz per volt. The gain, K_O, is calculated from the magnitude of the frequency deviation as a function of the differential voltage present at Pins 17 and 18. Figure 1 shows the equivalent VCO circuit as used in this application.

The internal phase detector reference *inputs* are hard wired to the VCO as shown in Figure 2. When used as a modulator the phase detector error voltage *outputs* (Pins 19 and 20) are no longer tied to the VCO inputs as with normal PLL operation. Instead these pins become the *output* for the modulator.

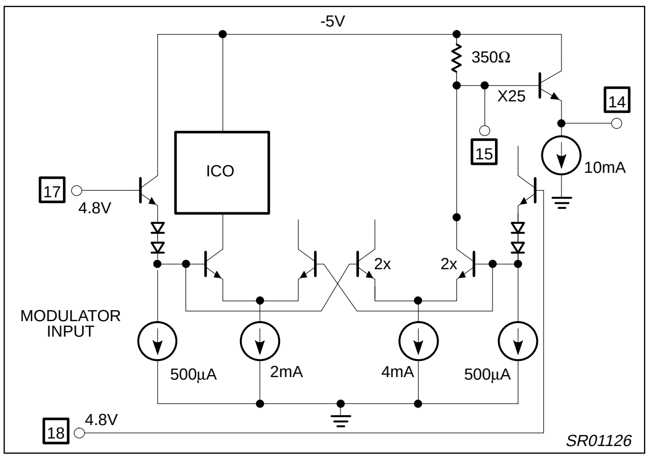

Figure 1. VCO

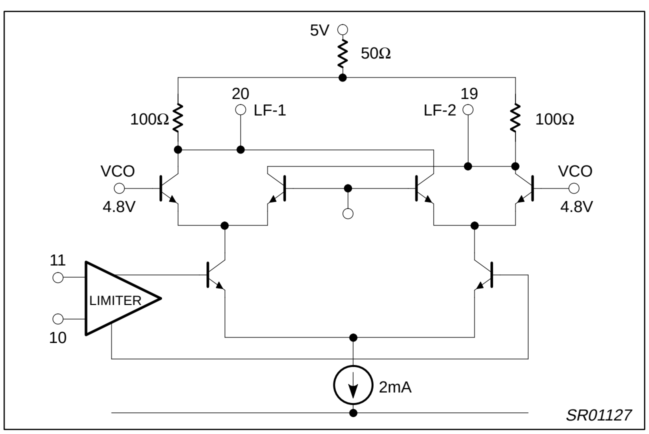

Figure 2. Limiter — Phase Detector

Linearization of the Modulator

In order to change the transfer function of the VCO-Phase Detector block from an exponential small signal function to a linear voltage-to-frequency converter, the output buffer amplifier signal is fed back from Pin 14 to Pin 18 (inverting input) of the VCO (see Figure 3). The output buffer amplifier has a gain of approximately 25dB. Pin 15 of the buffer amplifier allows for the addition of a shunt oriented passive filter to the feedback loop. The filter -3dB frequency is calculated based on a Pin 15 source impedance of 350Ω. A typical shunt lowpass filter consists of a 100pF capacitor from Pin 15 to ground and has a break frequency of 4.5MHz.

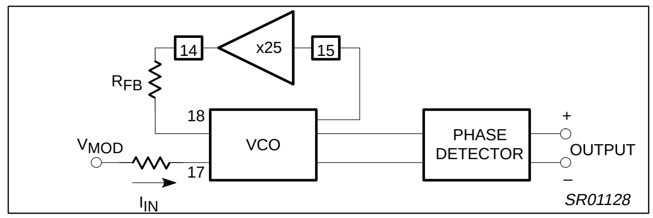

Figure 3. Closed Loop Linearization

Modulator Frequency Deviation

The modulator frequency is determined by the frequency set capacitor, C_O, attached to Pins 4 and 5. The value of the frequency set capacitor is calculated by the formula given below for F_O equal to 70MHz.

$C_O = (0.0013 / f_O)$ Farad; @ f_O = 70MHz, k_O = 0.0013

A linearizing DC bias current is fed into Pin 17 through an RF choke and series resistor R_{IN} as shown in Figure 4. This reduces the harmonic content of the output signal while also increasing its amplitude. The AC modulator output signal appears on Pins 19 and 20 superimposed on a DC common mode voltage 4.8V above ground. In order to provide a low impedance ground referenced output signal, a gain-of-two buffer amplifier (NE5539) is added. The output impedance is 75Ω. Note that the buffer amp differential input resistance is kept relatively high in order to reduce loading on the internal differential stage (R_S = 200Ω.) This also decreases the harmonic distortion of the modulator output waveform. Harmonic distortion and added sideband interference may be further reduced by the addition of low pass filters around the buffer amplifier, but caution is required due to the critical stability requirements of very wideband amplifiers such as the NE5539.

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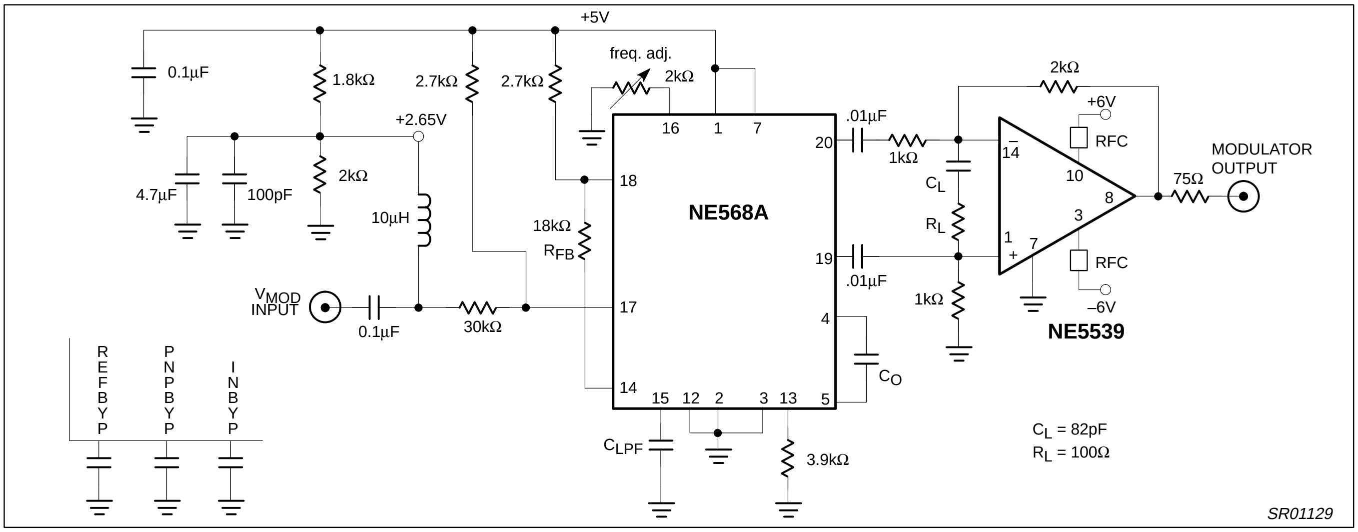

Figure 4. NE568A FM Modulation

Calibration of the Frequency Deviation

The single-sided frequency deviation is a function of the amplitude of the modulating signal and can be estimated by use of the graph in Figure 5. Alternately, the exact modulation input amplitude required for a given frequency deviation may be determined by use of the standard Bessel function using the first carrier null method at the assigned center frequency as described in the example below.

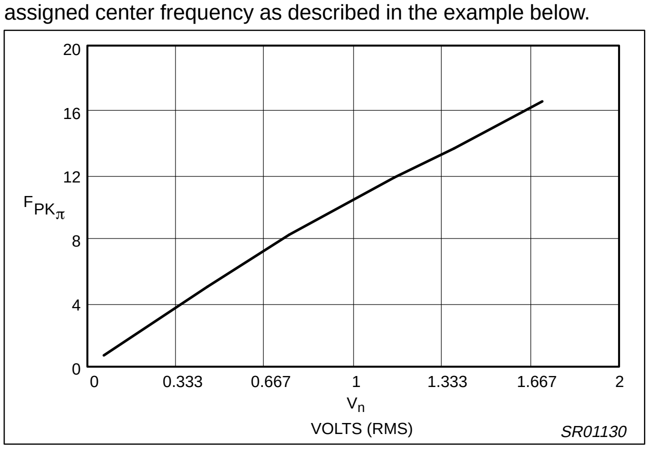

Figure 5. Modulator Frequency Deviation vs Input Volts (RMS)

Example: The first carrier null Bessel constant, B, is 2.4048. Using this relationship and the modulation index equation as shown below, the modulator can be accurately calibrated to the desired deviation. For a center frequency of 70MHz and a desired modulator peak frequency deviation of 10% (±7MHz), the proper modulating signal frequency is first calculated by the relationship,

FMOD = FDEV/B

= 7 MHz/2.4048

= 2.9 MHz

Next, a sine wave generator is set to FMOD and this signal fed into the NE568A modulator. The modulator output signal is now monitored with a spectrum analyzer as shown in the setup diagram below (Figure 6). The input signal amplitude is increased from zero amplitude upward until the 70MHz carrier spectral line begins to fall (see Figure 7). As the amplitude is carefully increased, a definite null will occur. Record the amplitude of the 2.9MHz generator at the null. This is the required modulation input amplitude for operating at a frequency deviation of 10% for any modulating frequency.

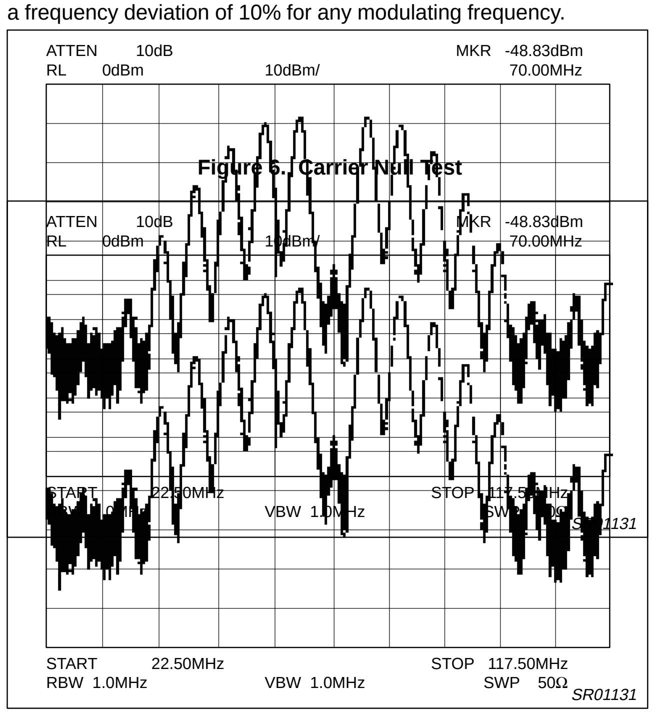

Figure 7. First Carrier Null Spectrum at 70MHz

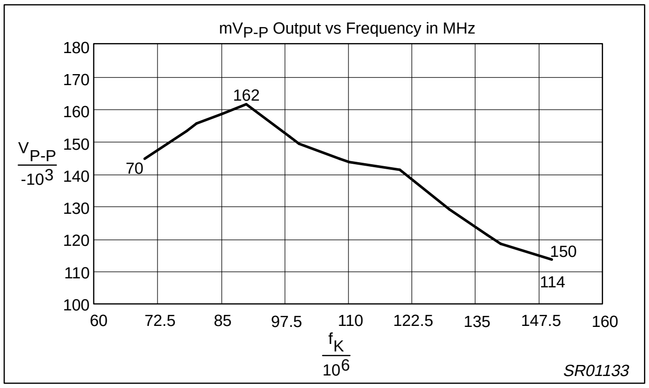

Figure 8. Output Level vs Frequency for C_O = 18pF

Modulator Output versus Frequency

The modulator output voltage amplitude as a function of frequency is shown in the graph below (Figure 8). The timing capacitor is set to 18pF.

Millivolts p-p Output vs Frequency in MHz

The typical output waveform at 100MHz is shown in Figure 9 below.

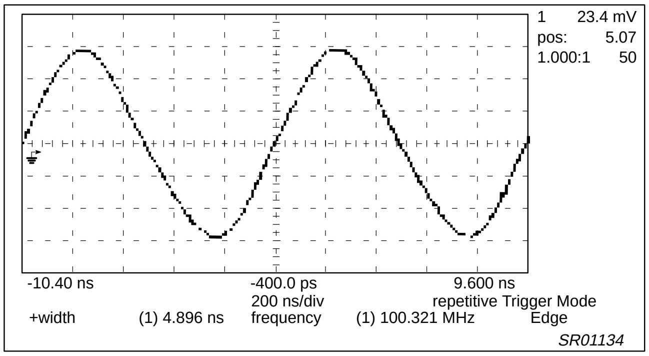

Figure 9. Typical Output Waveform at 100MHz

CONCLUSION

The NE/SA568A is capable of working as a linear FM modulator at frequencies up to 140MHz by the addition of external feedback and DC biasing circuitry. A wideband amplifier is also necessary to provide a differential to single-ended gain stage for ease of interface to the transmission media. Widely diverse technologies for signal communications may consist of VHF coaxial cable for wideband color video or infrared fiber optics links for still higher quality digital RGB signal systems.

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