

# APPLICATION NOTE

## **AN1511**

Low-voltage gated function generator:  
NE5230

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## INTRODUCTION

Described herein is a low-voltage, gated function generator using the NE5230 and two AA batteries. The outputs are a square, triangular and sine wave. The sine wave-generating circuit and the square and triangular circuits are independent. Some ideas for refinement of the circuits are also presented.

## APPLICATIONS

The use of signal sources is universal. Over the years, a great many practical circuits have been developed which have numerous desirable features. These circuits are typified by high power outputs, or speed, or precision, or combinations of these. They are housed in rugged, handsome cases and are available for a few hundred dollars. Most require AC line cords and are somewhat cumbersome to use. With the advent of low-voltage op amps such as the NE5230, it is now possible to design good, stable, battery-operated signal sources.

## SINE WAVE GENERATOR

The circuit used is a Wien bridge sine wave oscillator. This circuit has been used since the days of vacuum tubes (see Figure 1). It is simple, stable and requires few components. The circuit utilizes both positive and negative feedback to achieve balanced operation. The oscillator will stop working if too much negative feedback is used and will saturate in both states if too much positive feedback is used. In the practical implementation, some non-linear element must be employed to realize this stable condition. The gain of the amplifier must be large enough at the frequency of oscillation to make the input excursions small enough to be compensable by this non-linear element. Among others, diodes and FETs have been used to accomplish this. One of the most popular is the lamp; small, inexpensive and readily available, its voltage variable resistance makes it an ideal candidate for this application. It works like this: as the negative feedback voltage increases across the lamp, its resistance increases, and thereby reduces the output voltage. When the output voltage decreases, the amount of negative feedback voltage across the lamp decreases and thereby increases the resistance of the lamp. This balancing act continues until a stable condition is achieved. It is important to note that the lamp resistance is changing due to the thermal effects caused by the changing voltage across it. The frequency of oscillation is determined by:

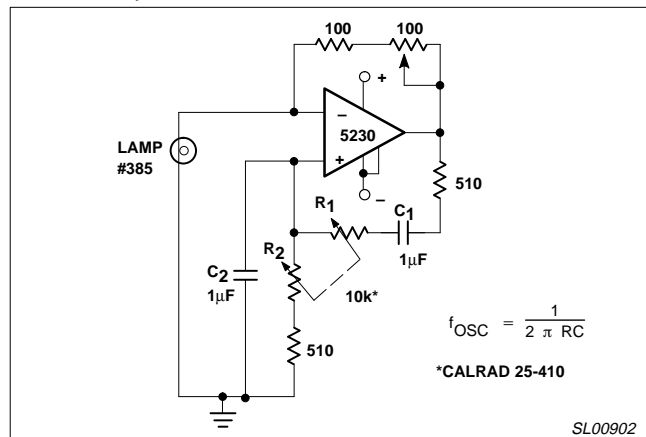


Figure 1. Sine Wave Generator

$$f_{osc} = \frac{1}{2\pi RC}$$

## VCO

Another classic oscillator circuit uses a comparator and an integrator. The output of the comparator is fed back to the input of the integrator. The output of the integrator is connected to the input of the comparator. Upon application of power, the comparator output goes into one state or the other. This comparator output voltage is fed back into the input of the integrator which begins ramping up or down, depending on the polarity of the first pulse from the comparator. When the voltage threshold of the comparator is reached, the output changes state. The cycle then repeats.

If an inversion in the feedback loop can be achieved, and external energy can be introduced at the right time, some interesting modifications of the previously described circuit will result—namely, a voltage-controlled oscillator. It works as follows: the transistor inverts the output of the comparator. This voltage is presented to the inverting input of the integrator to begin the cycle. When the comparator threshold is reached, the comparator changes state as before. This time, however, because the external applied voltage to the same inverting input is present, the amount of current available to the input is controlled by the external voltage and not by the feedback voltage. Once the component values are selected, the applied voltage,  $V_C$ , sets the frequency of oscillation because the current available to the integrating capacitor determines the charging time constant and, therefore, the frequency. The more positive the  $V_C$ , the more current that is available and the higher the frequency of oscillation. The converse is also true with minor differences. It is interesting to note here that other low-voltage amplifiers are not able to perform as well as the NE5230 in this circuit. One reason is that the NE5230 input voltage swing is able to exceed the rails by 250mV and still operate within its linear region. For a given set of conditions, then, the frequency range of the NE5230 is wider than conventional low-voltage op amps. The frequency of this circuit can also be changed by changing the value of the integrating capacitor. The smaller the capacitor, the higher the frequency for a given set of conditions.

## PERFORMANCE

The circuit in Figure 2 is the complete low-voltage function generator. The measurements were taken at room temperature with only two AA batteries supplying the power. The outputs were loaded with 200Ω for the sine and triangular wave outputs and 50Ω for the square wave output. The output voltage for the sine wave was ±1V. The square wave output swung from rail to rail while the output voltage of the triangular wave varied with the input voltage,  $V_C$ . This was due, of course, to the collector-emitter voltage requirements of the transistor.

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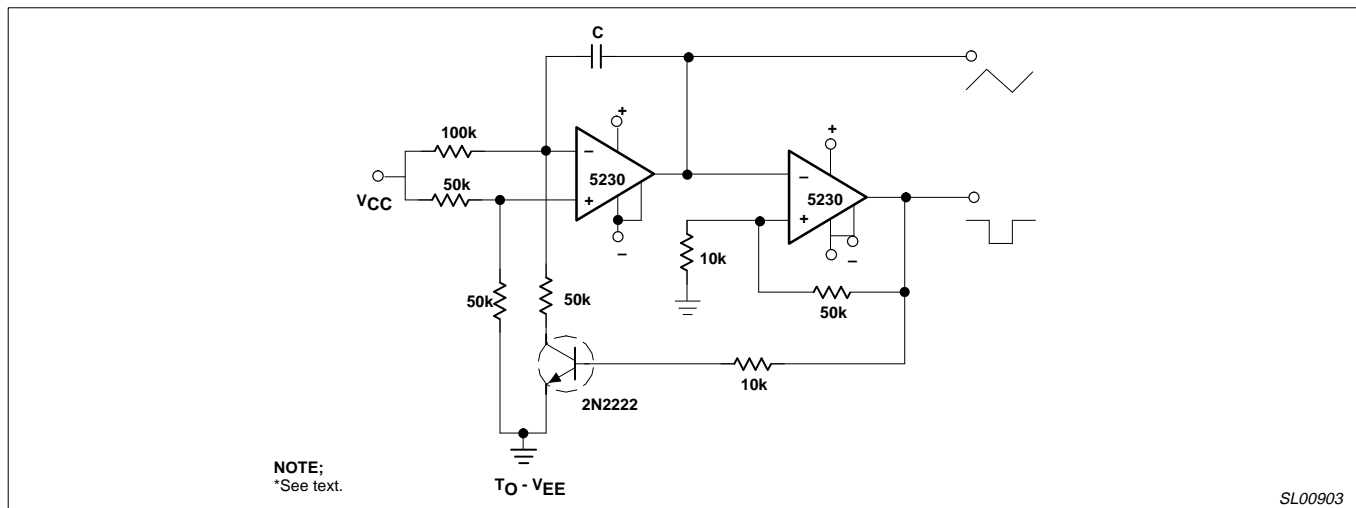


Figure 2. Function Generator

**PERFORMANCE**

The circuit in Figure 2 is the complete low-voltage function generator. The measurements were taken at room temperature with only two AA batteries supplying the power. The outputs were loaded with  $200\Omega$  for the sine and triangular wave outputs and  $50\Omega$  for the square wave output. The output voltage for the sine wave was  $\pm 1V$ . The square wave output swung from rail to rail while the output voltage of the triangular wave varied with the input voltage,  $V_C$ . This was due, of course, to the collector-emitter voltage requirements of the transistor.

The distortion of the Wien bridge was 0.015% at the lowest frequency and 0.09% at the highest. Using the different capacitor values, the frequency was varied from minimum to maximum using the ganged  $10k\Omega$  pot. The frequencies could be changed from 20Hz to 2.5kHz. It was necessary to include a  $500\Omega$  resistor in each leg of the bridge to prevent the complete saturation of the amplifier when the potentiometer was in one extreme of its travel. In addition, a small adjustment resistor was used in the negative feedback loop to adjust the gain and to compensate for the slow thermal time constant of the lamp.

The maximum frequency obtained by the VCO was 9.7kHz with  $V_C=1.65V$  with  $\pm 1.4V$  batteries. The frequency varied from 8.4kHz to 1.6kHz with  $\pm 1(V_C)$  applied with a  $0.001\mu F$  integrating capacitor.

**CONCLUSIONS**

Some things could have been done differently to improve the operation of these circuits. The thermal time constant of the non-linear elements was an inhibiting factor in the low-frequency

operation of the Wien bridge. A diode or FET will work better here. Extreme ambient temperature will change the operating point of the lamp and, therefore, the output amplitude. Some non-symmetrical output was seen when operating the VCO at the lower frequencies. This is due to the influence of the transistor, as described previously.

Finally, the NE5230 has yet another feature: the bias adjust pin. This pin is intended to be used to control the power supply current. The power supply current is controlled by decreasing the internal bias current of the op amp. When the bias current is decreased, the transconductance,  $g_m$ , of the input stage is reduced; this, in turn, lowers the -3dB bandwidth. In addition, this pin can be used to turn the op amp on or off. If the voltage at the bias adjust pin is moved to 50mV above the voltage at the  $V_{EE}$  pin, the output becomes severely attenuated. The op amp, for all intents and purpose, is off. If, on the other hand, the bias adjust pin is moved to 50mV below the voltage at the  $V_{EE}$  pin, the band width and the slew rate are increased. The user should exercise care when doing this.

The NE5230 is a versatile, low-voltage op amp. It has been demonstrated that the device can be used in a variety of different ways. Its ability to swing within 100mV of the output, its input voltage which can exceed the power supply voltage, and its programmable power supply current, make it a leader of low-voltage op amps.

**REFERENCES:**

Modern Electronic Circuit Reference Manual, John Markus  
Raytheon 1984 Data Manual