

APPLICATION NOTE

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AN145

**NE5517/A transconductance amplifier
applications**

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DESCRIPTION

The Philips Semiconductors NE5517 is a truly versatile dual operational transconductance amplifier. In plain language, it is a voltage-to-current converter governed by the transconductance g_m , which is equivalent to I_{OUT}/V_{IN} . The g_m is increased or decreased linearly by varying the amplifier bias current (I_{ABC}) through an external pin (see Figure 1). From the proper use of the I_{ABC} pin, many control circuits can be realized.

For more insight into the way the part operates, the transconductance can be thought of as gain and is governed by the following equation:

$$g_m = \frac{I_{OUT}}{V_{IN}} = \frac{I_{ABC}q}{2KT} \quad (1)$$

where the transconductance is dependent on the constant KT/q (which is 26mV at 25°C, and I_{ABC} (which is controlled by the user).

To make the device more universal and adaptable for many functions, two impedance buffers for voltage output applications are also included with the amps so that the part can be used as a programmable operational amplifier.

Linearizing diodes provide another useful option. These should be applied when large input voltages or wide temperature variations are encountered. To show the significance of the diodes, compare the difference between Equation 1 without diodes and Equation 2 with diodes:

$$\frac{I_{OUT}}{V_{IN}} = \frac{2I_{ABC}}{R_{IN} I_D} \quad (2)$$

for I_{IN} greater than $\frac{I_D}{2}$

Here, it can be seen that the transconductance is not temperature dependent. R_{IN} is the signal input resistance and I_{IN} is the signal current. I_{IN} must not exceed half the diode current (I_D , nominally 1mA). The diode current is set by a resistor tied to $+V_{CC}$. A graph showing the output distortion improvement versus differential input voltage when using the diodes is shown in Figure 2.

An advantage that the NE5517 has over similar devices is a special biasing network between the amplifier and output impedance buffers. This network eliminates output offset current changes with a sudden change in the

bias current (I_{ABC}). This is particularly important in audio applications where an audible offset would be produced.

APPLICATIONS

An application employing both amplifiers and buffers internal to the NE5517 is the adjustable triangle-square wave generator shown in Figure 3.

The center oscillating frequency is set by the capacitor C at the output of amplifier A. The output amplitude is set by the resistor R connected between the non-inverting inputs, amplifier B output, buffer B input and ground.

The oscillating frequency is varied by changing V_C , which in turn controls the amplifier bias current (I_{ABC1}). If a positive voltage is applied to V_C , the center frequency will increase linearly with

increasing voltage. If a negative is applied, the center frequency will decrease linearly with increasing negative voltage. This makes a very good programmable oscillator with variable amplitude.

By using a large value capacitor and negative control voltage, oscillations in the fractions of Hertz can be realized; a small capacitor and positive control voltage will give frequencies up to 500kHz. Graphs showing the linearity of control voltage versus frequency for different capacitor values are shown in Figure 4.

Pertinent calculations are:

$$f_C = \frac{I_{ABC1}}{2(C) (I_{ABC2}) (R)}$$

Where : f_C = center frequency
 I_{ABC1} = oscillator control current
 I_{ABC2} = amplitude control current
 R = amplitude control resistor
 C = oscillator control capacitor

Also : Amplitude = $(I_{ABC2}) (R)$

Another very useful application is to use the NE5517 as a digitally-programmable amplifier. The entire circuit is shown in Figure 5.

The circuit consists of a Philips Semiconductors microprocessor-compatible DAC, a transistor array, and the NE5517 configured as a voltage-controlled amplifier. This arrangement can also be used with the VCO explained earlier to program its oscillating frequency.

The pertinent equations governing this application are as follows:

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{BW(10)}{256} \times \frac{I_{DACMAX} \times q \times R_L}{2 \times KT}$$

Where : $BW(10)$ = binary word decimal
 I_{DACMAX} = maximum DAC output current (1mA)
 R_L = load resistance (30k)
 q/KT = 38.5 at 25°C

Also:

$$I_{DACMAX} = 2 \times \frac{V_{REF}}{R_{REF}} = 2 \times \frac{5k}{10k} = 1mA$$

Where : V_{REF} = supplied by DAC (5V)
 R_{REF} = referenced resistor (10kΩ)

The I_{DACMAX} of 1mA is used to keep the transconductance within the linear range.

The current mirror matches the current flow into the DAC and supplies the same amount to the 5517 control pin. Using a current output DAC is much faster than using a voltage output device to control the part. (If speed is not important, this can be done and the current mirror can be replaced with a resistor.) Also, the gain equation pertains to the signal after the input divider.

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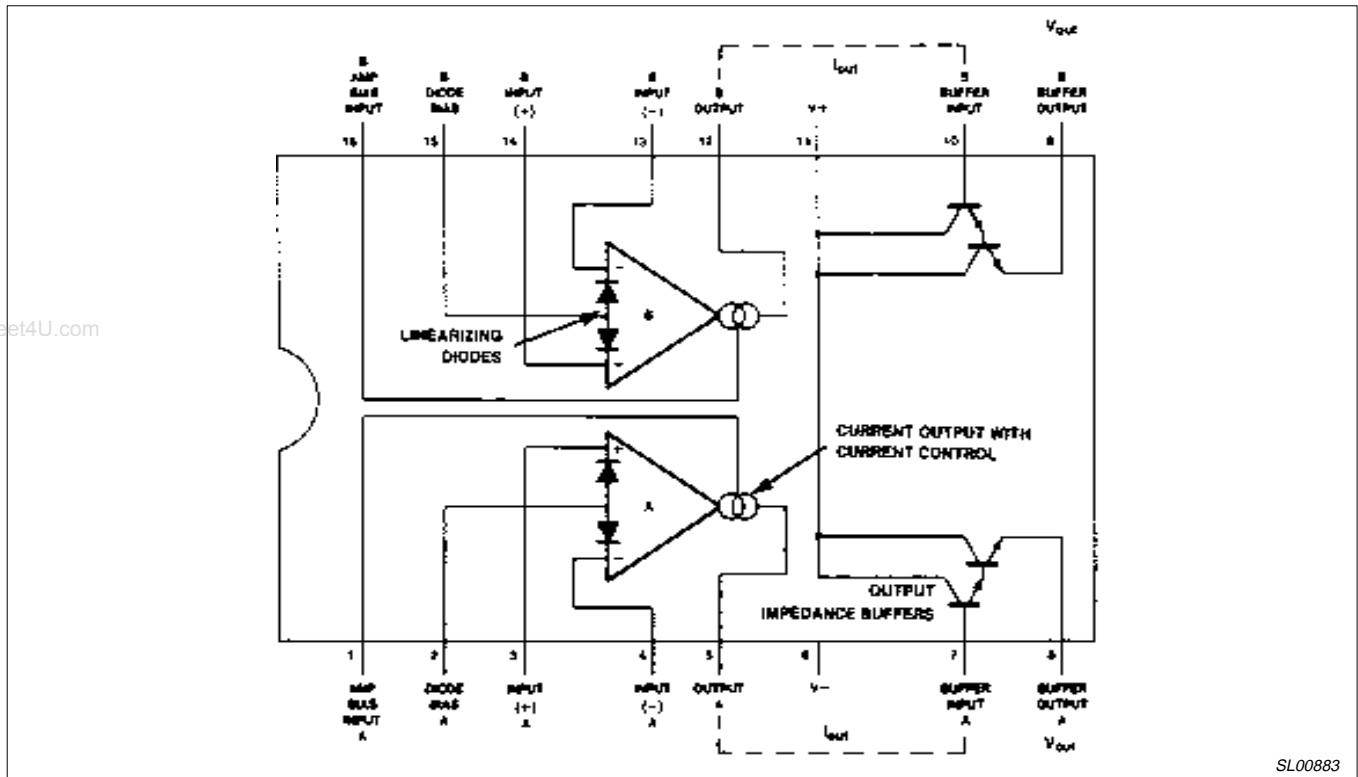


Figure 1. Pin Designation and Functional Diagram

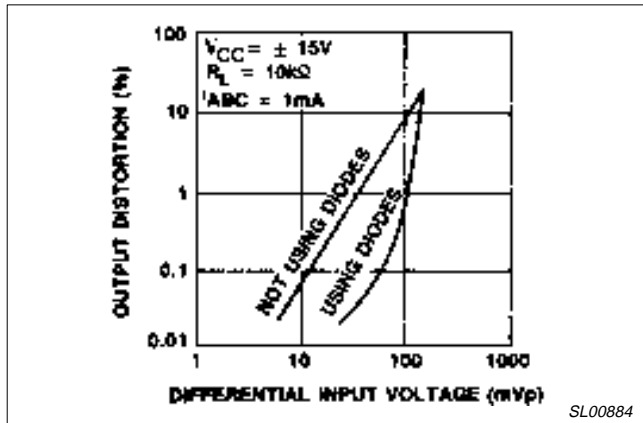


Figure 2. Output Distortion vs Input Voltage Showing Benefit of Diodes

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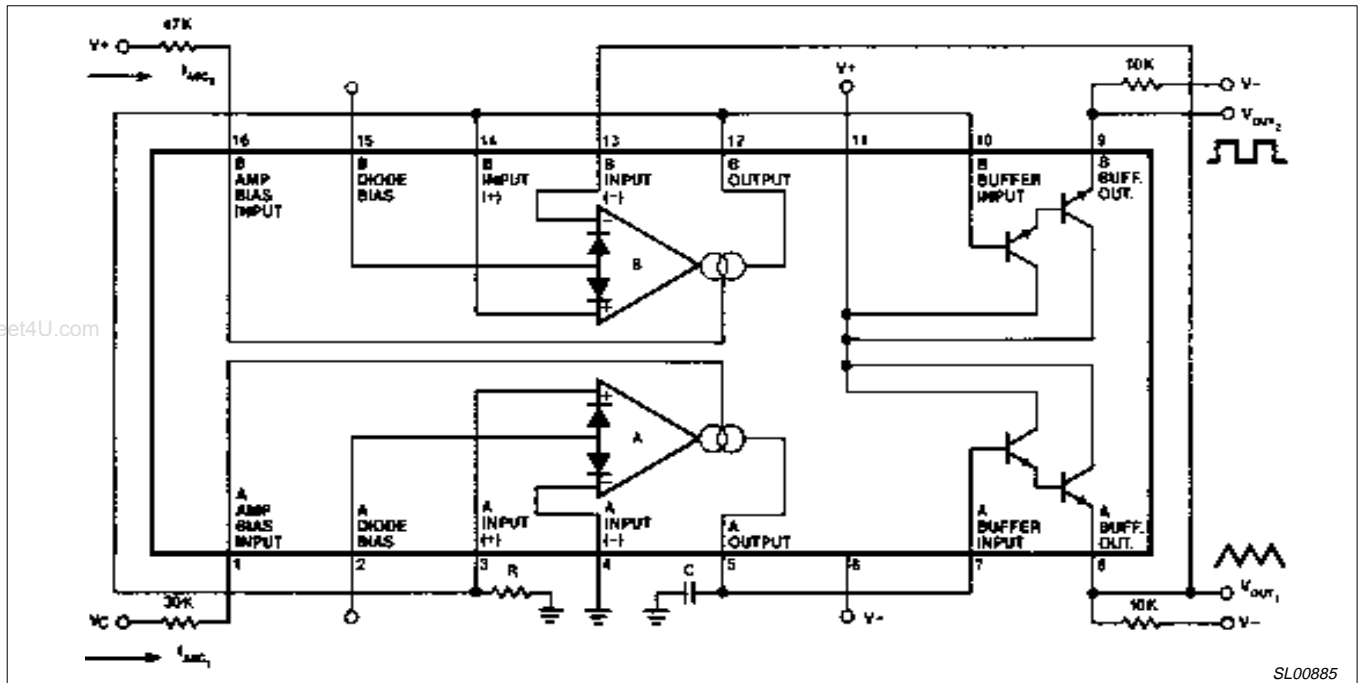


Figure 3. Triangle-Square Wave Generator

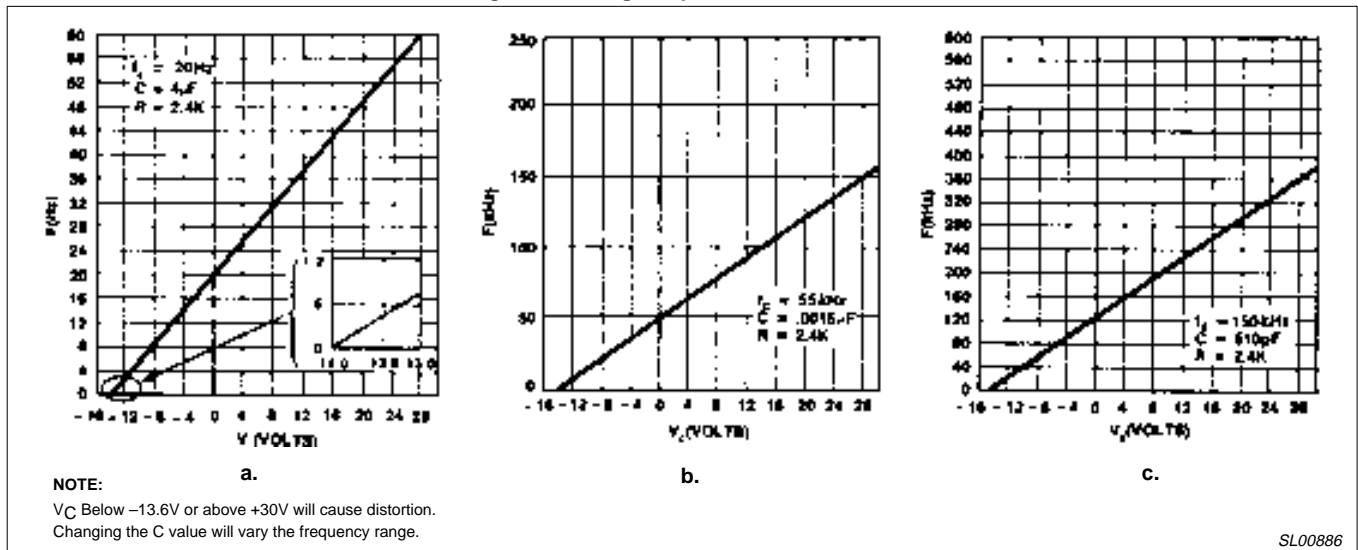


Figure 4. Control Voltage (V_C) vs Frequency Data

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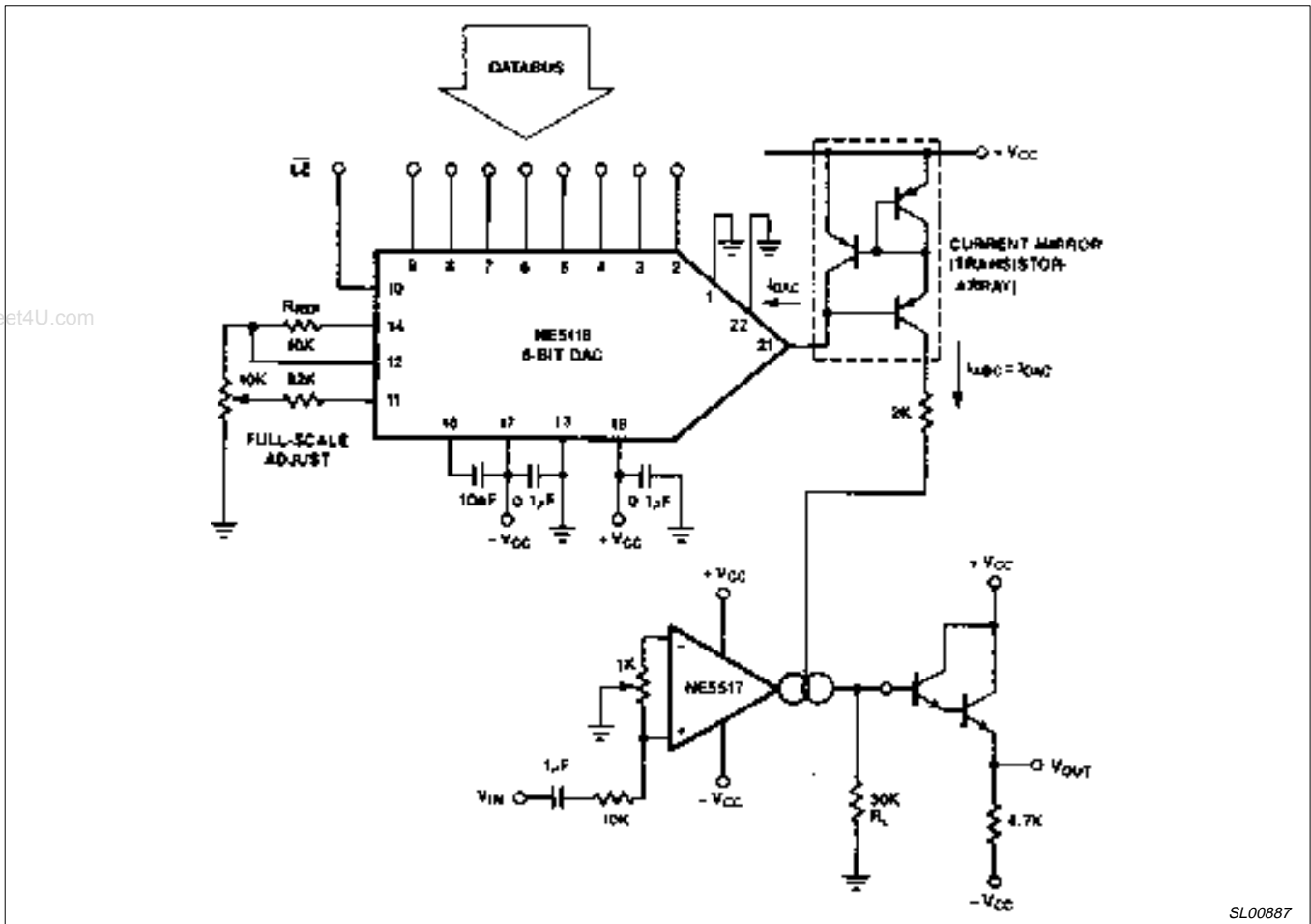


Figure 5. Digitally-Programmable Amplifier

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