APPLICATION NOTE

AN144
Applications for the NE/SA/SE5512

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Philips Semiconductors

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DESCRIPTION

The NE/SA/SE5512 series of high-performance operational amplifiers provides very good input characteristics. These amplifiers feature low input bias and voltage characteristics such as a 108 op amp with improved CMRR and a high differential input voltage limit achieved through the use of a bias cancellation and PNP input circuits with collector-to-emitter clamping. The output characteristics are like those of a 741 op amp with improved slew rate and drive capability, yet have low supply quiescent current.

BRIDGE TRANSDUCER AMPLIFIER

In applications involving strain gauges, accelerometers and thermal sensors, a bridge transducer is often used. Frequently the sensor elements are high resistance units requiring equally high bridge resistance for good sensitivity. This type of circuit then demands an amplifier with high input impedance, low bias current and low drift. The circuit shown represents a solution to these general requirements (Figure 1).

For V_S=10V, the common-mode voltage is approximately +5V, well within the common-mode limits of the NE5512.

The sensitivity of the input stage is approximately

$$\frac{R_F \cdot V_S}{2R}$$

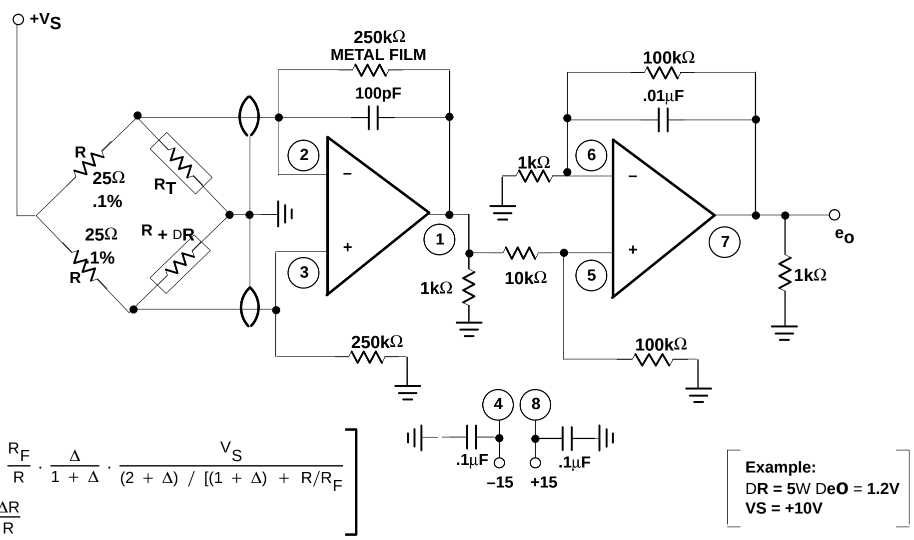
to a change in transducer resistance ΔR. This gives a gain factor of ≈ 50 for V_S=10V and R=25kΩ. The second stage gain is x100 giving a total gain of ≈ 5000.

Noise is minimized by shielding the transducer leads and taking special care to determine a good signal ground.

Common-mode noise rejection is particularly important, making matched differential impedance critical. The NE5512 typically provides 100dB of common-mode rejection and will considerably reduce this undesirable effect.

The following are sensitivity figures for the transducer circuits.

	ΔR	ΔE_{OUT}
Leg 1	10Ω	-2.6V
	5Ω	-1.3V
Leg 2	10Ω	+2.4V
	5Ω	+1.2V



$$e_O \approx \frac{R_F}{R} \cdot \frac{\Delta}{1+\Delta} \cdot \frac{V_S}{(2+\Delta)\ /\ [(1+\Delta) + R/R_F}$$

$$\Delta = \frac{\Delta R}{R}$$

NOTE:
Thermal compensation transducer (non-active)

Figure 1. NE/SE5512 Bridge Transducer Amplifier

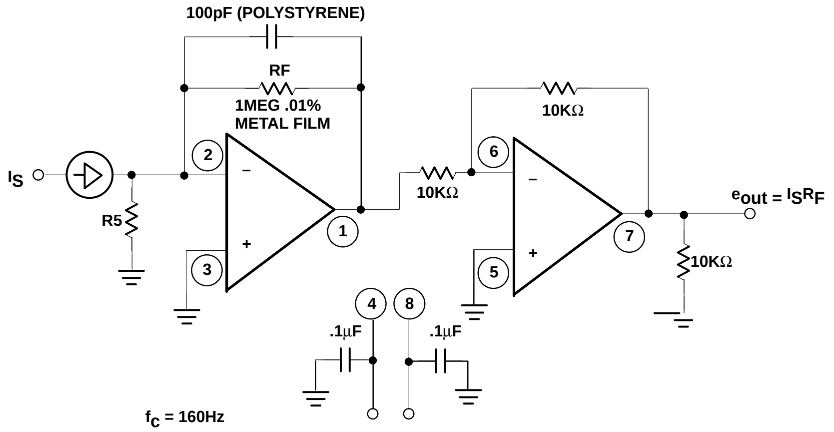


Figure 2. NE/SE5512 Current-to-Voltage Converter With 1% Accuracy [Sensitivity: 1V/µA]

Temperature compensation of the bridge element is accomplished by using low drift metal film resistors and also by providing a complimentary non-active sensor element to thermally track the offset in the active element.

High frequency roll-off provides attenuation of unwanted noise above the pass band of the transducer. The shunt capacitors across both stage feedback resistors are for this purpose.

CURRENT-TO-VOLTAGE CONVERTER

Taking advantage of the very low bias current and offset of the NE5512 is demonstrated in its adaptation to a current-to-voltage converter as shown in Figure 2.

The lower limit of measuring accuracy is determined by I_B (inverting), which is typically 6nA. In order to attain a measurement accuracy of 1%, the following inequality must hold:

$I_B \leq (0.01)\ I_{Smin}$

Where I_B=input bias current and I_{Smin}=minimum measured current. For I_B=6nA and I_{Smin}=1µA,

6nA≤(0.01) 1µA=10nA and the inequality hold.

DC offset and current noise gain is determined by

$$\frac{R_F + R_S}{R_S}$$

which ≈ 1 for $R_S >> R_F$.

The measured results for this circuit appear below (V_{CC} = ±15V).

INPUT CURRENT	OUTPUT VOLTAGE
1µA	1.008V
5µA	5.00V
10.00µA	10.00V

NE5512 OPERATIONAL DIFFERENTIATOR

By utilizing the very high input impedance characteristic of the NE5512, an excellent active differentiator can be realized. Using the circuit shown (Figure 3), good results were obtained as shown by the waveforms in Figures 4, 5 and 6. One of the primary problems with such circuits is the tendency towards instability and distortion either due to loading caused by input bias currents or amplifier non-linearity. In addition, gain increases with frequency, requiring low input noise in the amplifier.

The relative stability is shown by the output signal waveforms mentioned above. Adding R_1 provides added compensation in the form of a zero near the amplifier unity gain frequency. Frequency range is 100Hz to 10kHz.

In order to obtain good differentiation, the network time constant, RC, must be small relative to the period of the highest frequency present at the input. Since the differentiator will attenuate the signal by a factor of ωRC, which may be 100:1 in the operating region, the second amplifier stage is used to compensate for this loss. Various circuits are easily interfaced with the differentiator block due to the inherently low output impedance of the NE5512.

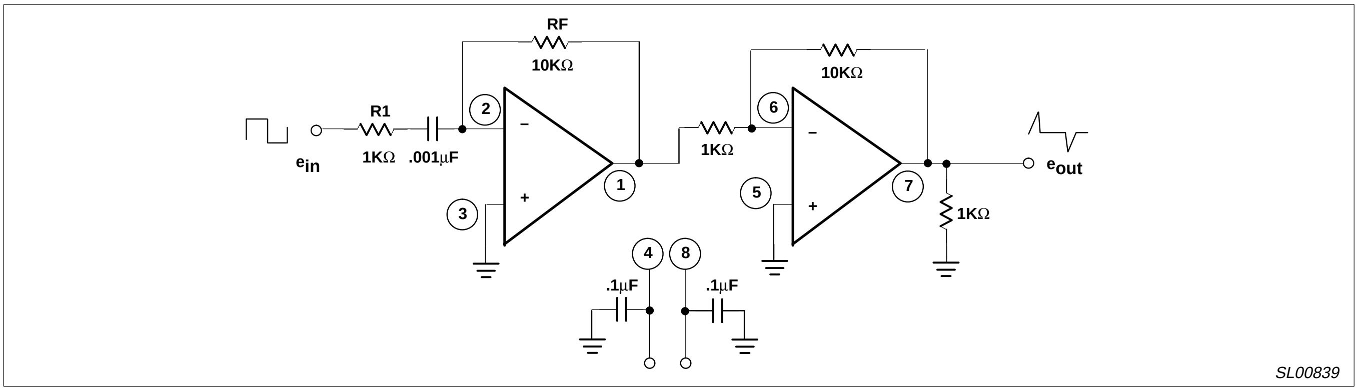


Figure 3. NE/SE5512 Active Differentiator With Inverting x 10 Buffer

DIFFERENTIATOR WAVEFORMS

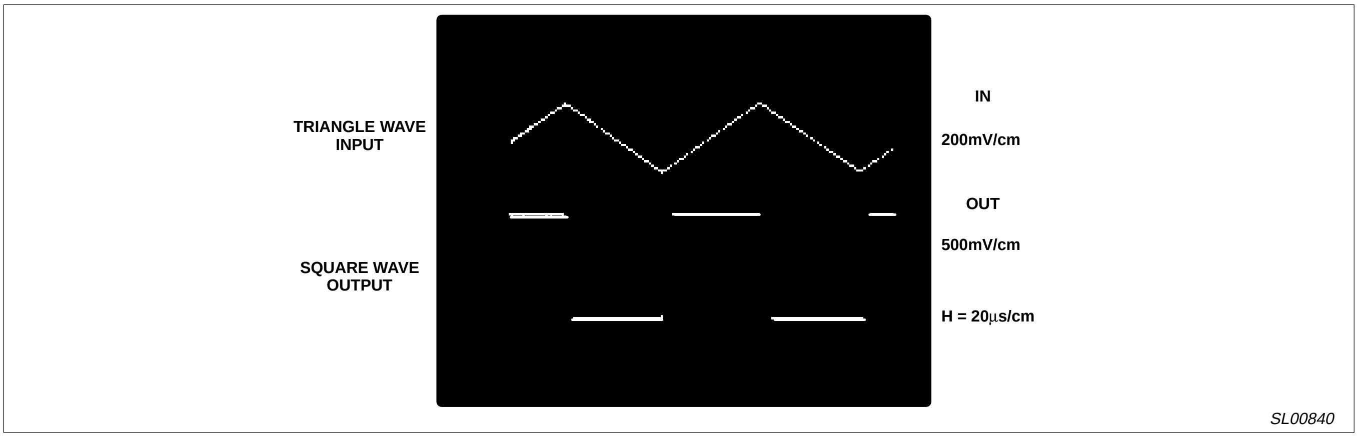


Figure 4.

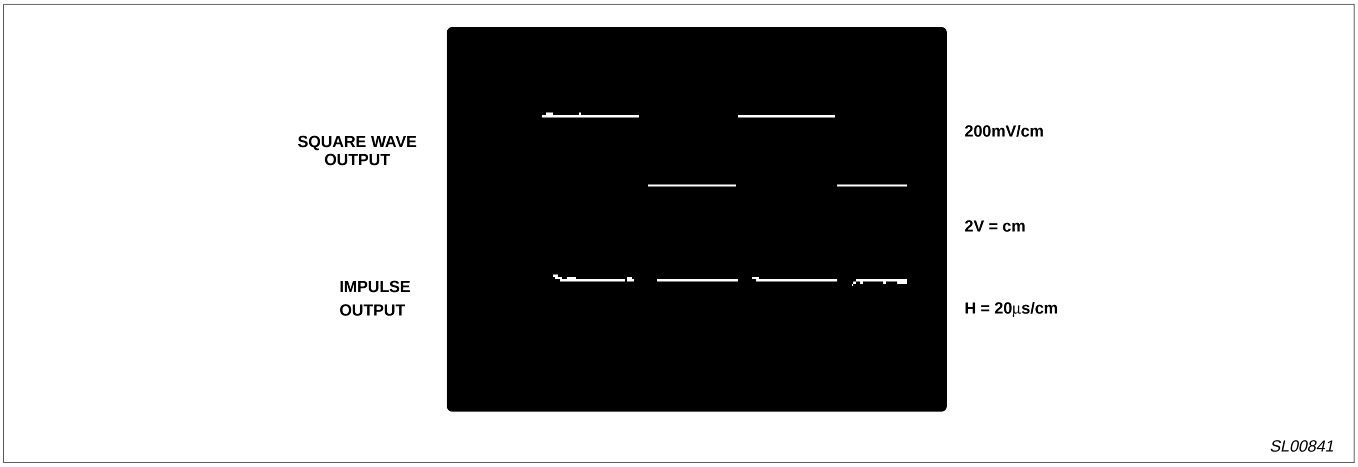


Figure 5.

THE OPERATIONAL INTEGRATOR

The operational complement of the active differentiator is the active integrator. The NE5512 is easily adapted to this function as shown in the circuit below (Figure 7). To obtain satisfactory integration, the time constant must fulfill the following requirement:

$RC \geq 15T$

Where T is the period of the input waveform.

For the ideal integrator

$$e_{OUT} = \frac{1}{RC} \quad e_{IN}\ dt$$

The factor 1/RC represents an attenuation of the input signal. The low signal level is increased by using the second half of the NE5512 as a gain stage following the operational integration. The waveforms in Figures 8 and 9 show the input-output relationship for both a sine wave and a square wave function. A good integrator must exhibit a phase shift of ≥89° for sine wave input over the active frequency range. For a square wave, the resultant output must be a linear ramp. The circuit shown fulfills this requirement (see Figure 7). No external compensation is required since the amplifier is unity gain stable.

DIFFERENTIATOR WAVEFORMS

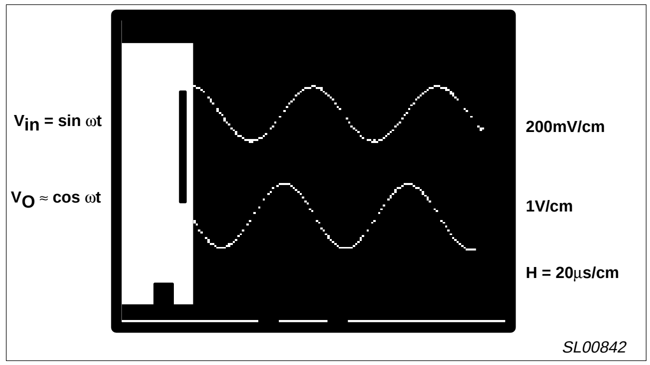


Figure 6.

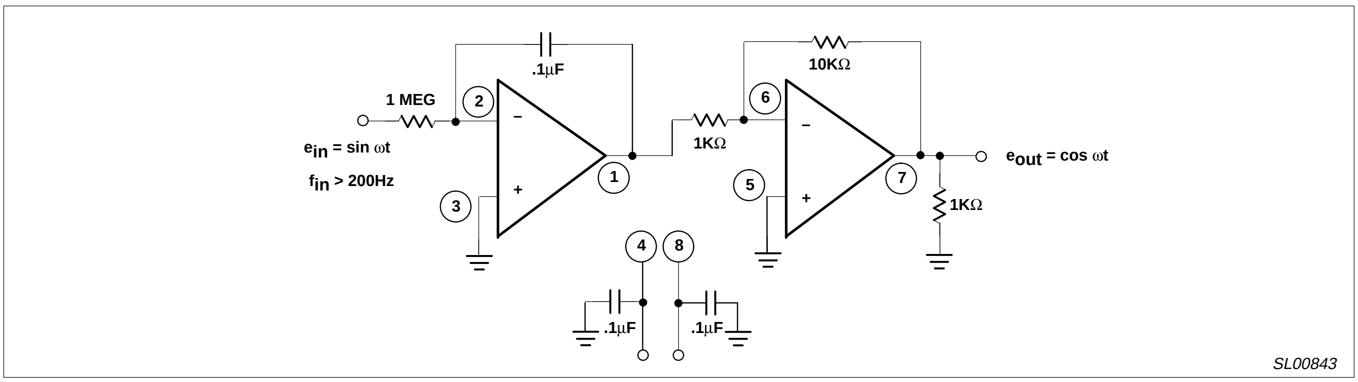


Figure 7. NE/SE5512 Active Integrator

INTEGRATOR WAVEFORMS

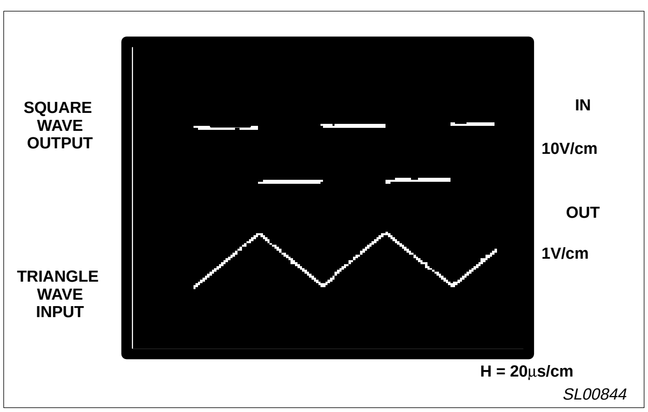


Figure 8.

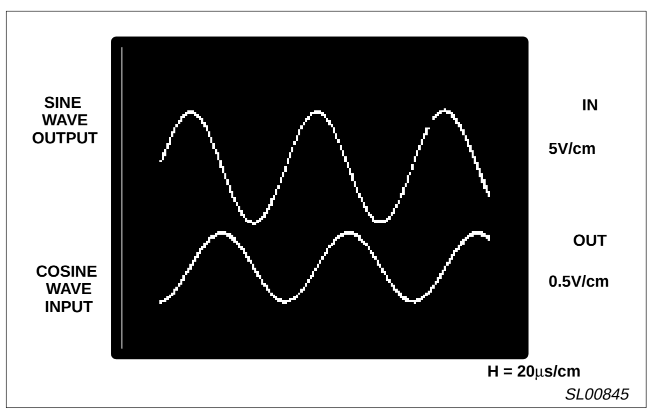


Figure 9.