NE/SE5535

Dual High Slew Rate Op Amp

Product Specification

DESCRIPTION

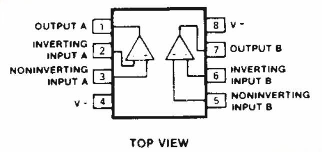
The NE/SE5535 is a new generation operational amplifier featuring high slew rates combined with improved input characteristics. The 5535 is a dual configuration. Internally compensated for unity gain, the SE5535 features a guaranteed unity gain slew rate of 10V/µs with 4mV maximum offset voltage. Industry standard pinout and internal compensation allow the user to upgrade system performance by directly replacing general purpose amplifiers, such as 747 and 1558.

FEATURES

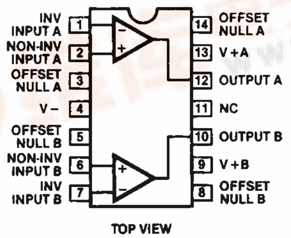
- **15V/µs unity gain slew rate**
- **Internal frequency compensation**
- **Low input offset voltage — 2mV**
- **Low input bias current 80nA max**
- **Short-circuit protected**
- **Large common-mode and differential voltage ranges**
- **Pin compatibility** $\frac{5535}{747,1558}$
- **Dual configuration**
- **Low noise current 0.15pA/$\sqrt{Hz}$ typ.**

PIN CONFIGURATION

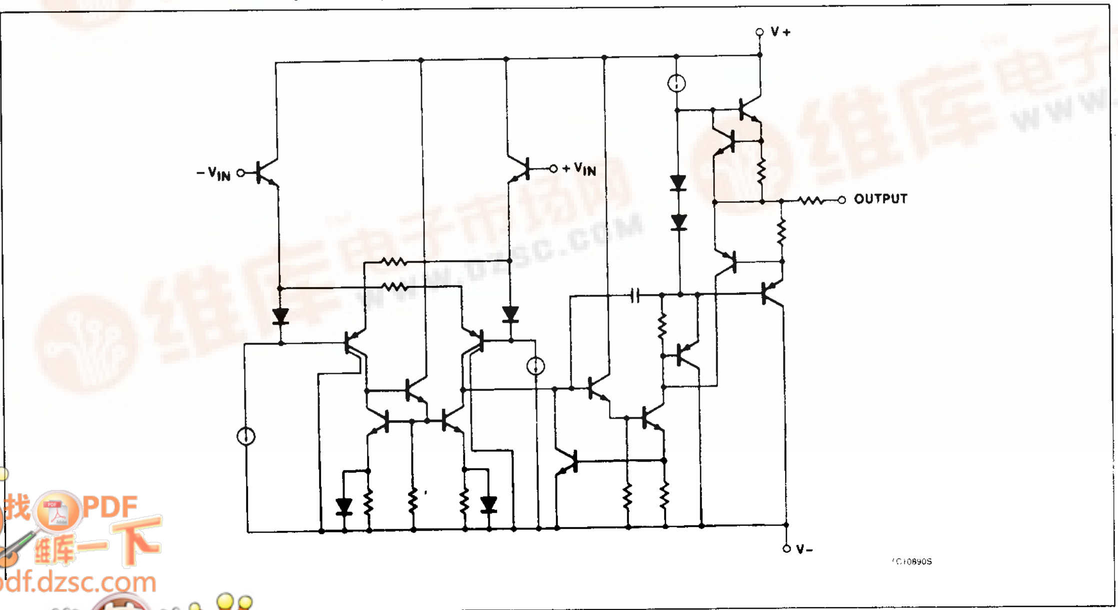
N Package



F Package



EQUIVALENT SCHEMATIC (one amplifier)



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ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE
8-Pin Plastic DIP	0 to +70°C	NE5535N
8-Pin Plastic DIP	-55°C to +125°C	SE5535N
14-Pin Cerdip	0 to +70°C	NE5535F
14-Pin Cerdip	-55 to +125°C	SE5535F

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	SE5535	NE5535	UNIT
V_S	Supply voltage	±22	±18	V
P_D	Internal power dissipation[1] N package F package	 1275 1250	 1275 1250	 mW mW
V_{IN}	Differential input voltage	±30	±30	V
V_{IN}	Input voltage[2]	±15	±15	V
T_A	Operating temperature range	-55 to +125	0 to +70	°C
T_{STG}	Storage temperature range	-65 to +150	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	300	300	°C
I_{SC}	Output short-circuit[3]	Indefinite	Indefinite	

NOTES:

1. Rating applies at T_A = 25°C for thermal resistances junction to ambient of 98°C/W and 100°C/W for N and F packages, respectively. Maximum junction temperature is 150°C.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to 125°C case temperature or 75°C ambient temperature.

Dual High Slew Rate Op Amp

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DC ELECTRICAL CHARACTERISTICS $T_A = 25°C$, $V_S = \pm 15V$, unless otherwise specified.*

SYMBOL	PARAMETER	TEST CONDITIONS	SE5535			NE5535			UNIT
			Min	Typ	Max	Min	Typ	Max	
V_{OS}	Input offset voltage	$R_S \leq 10k\Omega$ $R_S \leq 10k\Omega$, over temp.		0.7	4.0 5.0		2.0	6.0 7.0	mV mV
$\Delta V_{OS}/\Delta T$		$R_S = 0\Omega$, over temp.		4.0			6.0		$\mu V/°C$
I_{OS}	Input offset current	 Over temp.		5	20 40		15	40 80	nA nA
$\Delta I_{OS}/\Delta T$		Over temp.		25			40		pA/°C
I_B	Input bias current	 Over temp.		45	80 200		65	150 200	nA nA
$\Delta I_B/\Delta T$		Over temp.		50			80		pA/°C
V_{CM}	Common-mode voltage range		±12	±13		±12	±13		V
CMRR	Common-mode rejection ratio	$R_S \leq 10k\Omega$, over temp.	70	90		70	90		dB
PSRR	Power supply rejection ratio	$R_S \leq 10k\Omega$, over temp.		30	150		30	150	$\mu V/V$
R_{IN}	Input resistance		3	10		1	6		$M\Omega$
A_{VOL}	Large-signal voltage gain	$R_L \geq 2k\Omega$, $V_{OUT} = \pm 10V$ $R_L = 2k\Omega$, $V_{OUT} = \pm 10V$, over temp.	50 25	500		50 25	500		V/mV V/mV
V_{OUT}	Output voltage	$R_L \geq 2k\Omega$, over temp. $R_L \geq 10k\Omega$, over temp.	±10 ±12	±13 ±14		±10 ±12	±13 ±14		V V
I_{CC}	Supply current	Per amplifier Per amplifier, over temp.		1.8 2	2.8 3.3		1.8 2	2.8	mA mA
P_D	Power dissipation	Per amplifier Per amplifier, over temp.		54 60	84 99		54 60	84	mW mW
I_{SC}	Output short-circuit current		10	25	50	10	25	50	mA
R_{OUT}	Output resistance			100			100		Ω

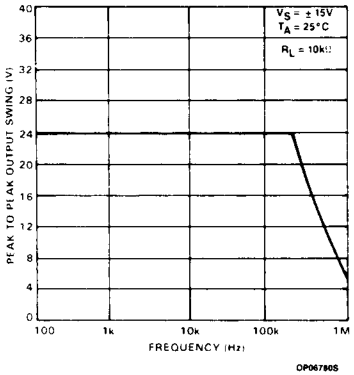
NOTE:
* Temperature range:
  SE types $-55°C \leq T_A \leq 125°C$
  NE types $0°C \leq T_A \leq 70°C$

AC ELECTRICAL CHARACTERISTICS $T_A = 25°C$, unless otherwise specified.

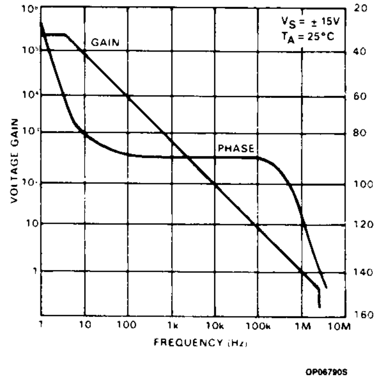
SYMBOL	PARAMETER	TEST CONDITIONS	SE5535			NE5535			UNIT
			Min	Typ	Max	Min	Typ	Max	
GBW	Gain bandwidth product			1			1		MHz
 t_R t_S SR	Transient response Small-signal rise time Small-signal overshoot Settling time Slew rate	 To 0.1% $R_L \geq 10k\Omega$, unity gain, non-inverting	 10	 0.25 6 3 15		 10	 0.25 6 3 15		 μs % μs $V/\mu s$
	Input noise voltage	$f = 1kHz$, $T_A = 25°C$		30			30		$nV/\sqrt{Hz}$

TYPICAL PERFORMANCE CHARACTERISTICS

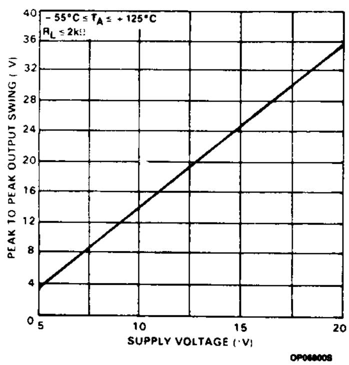
Output Voltage Swing as a Function of Frequency



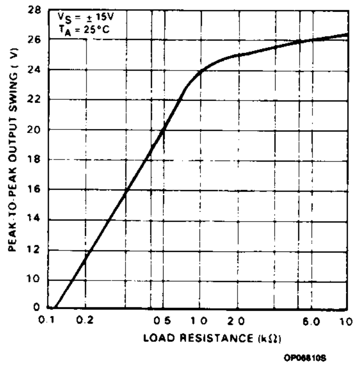
Open-Loop Voltage Gain as a Function of Frequency



Output Voltage Swing as a Function of Supply Voltage

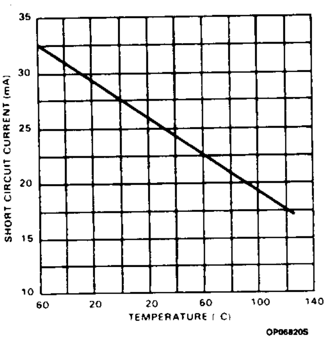


Output Voltage Swing as a Function of Load Resistance

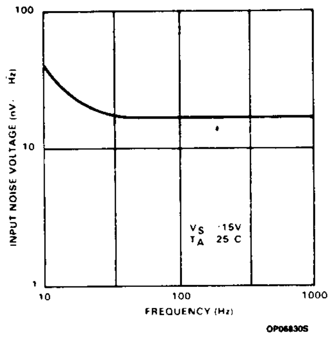


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

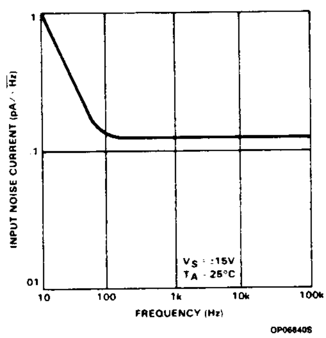
Output Short-Circuit Current as a Function of Ambient Temperature



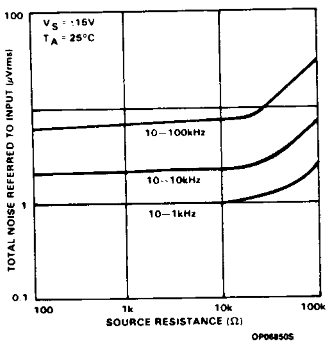
Input Noise Voltage as a Function of Frequency



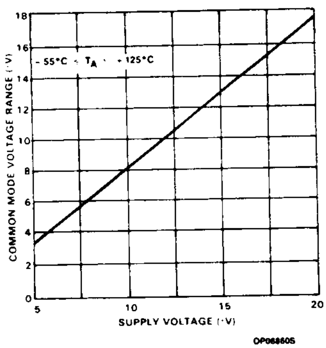
Input Noise Current as a Function of Frequency



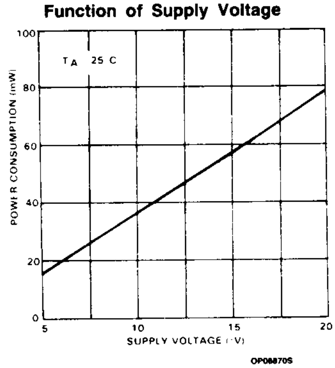
Broadband Noise for Various Bandwidths



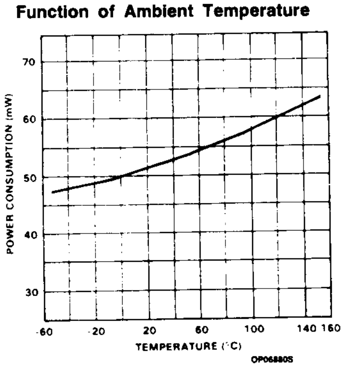
Input Common-Mode Voltage Range as a Function of Supply Voltage



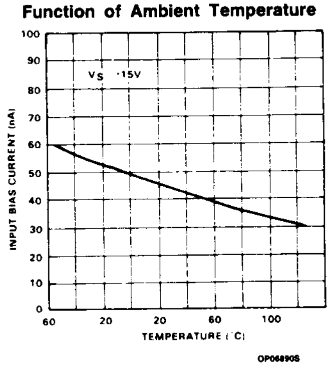
Power Consumption as a Function of Supply Voltage



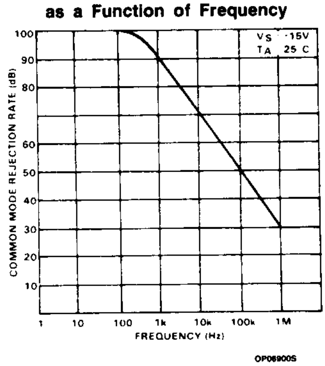
Power Consumption as a Function of Ambient Temperature



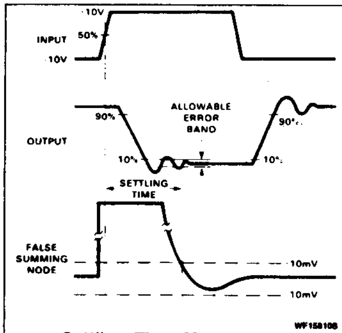
Input Bias Current as a Function of Ambient Temperature



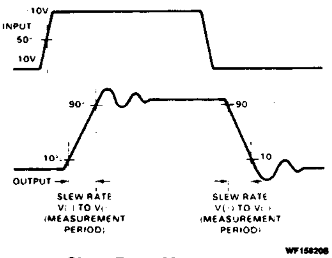
Common-Mode Rejection Ratio as a Function of Frequency



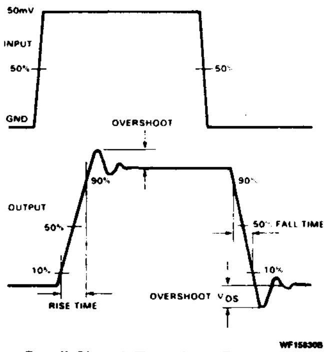
VOLTAGE WAVEFORMS



Settling Time Measurement

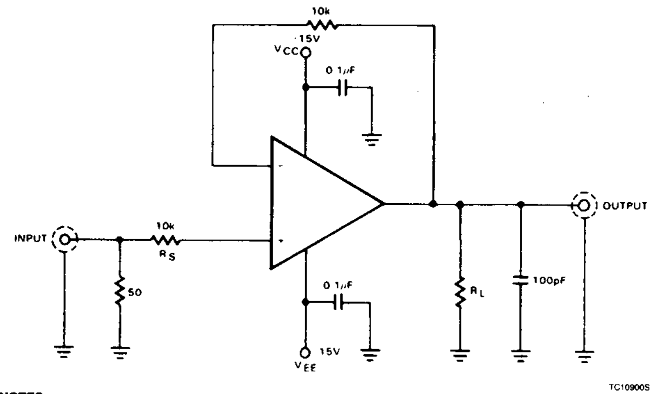


Slew Rate Measurement



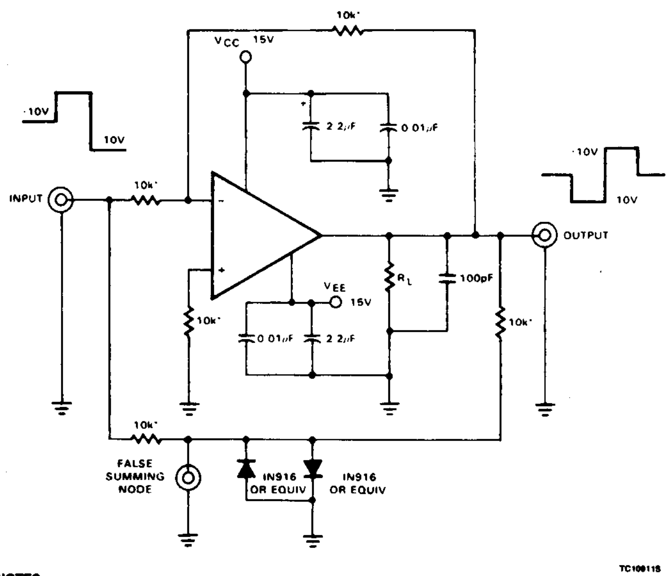
Small-Signal Transient Response Definitions

TEST CIRCUITS



NOTES:
1. Pins not shown are not connected.
2. All resistor values are typical and in ohms.

Slew Rate and Small-Signal Transient Response



NOTES:
1. Pins not shown are not connected.
2. All resistor values are typical and in ohms.
   *Match to within 0.01%.

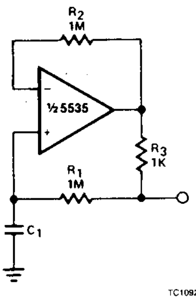
Settling Time

Dual High Slew Rate Op Amp

NE/SE5535

INTRODUCTION

The NE5535 is a new generation monolithic op amp which features improved input characteristics. The device is compensated to unity gain and has a minimum guaranteed unity gain slew rate of 10Vμs. This is achieved by employing a clamped super beta input stage which has lower input bias current.



NOTE:
All resistor values are in ohms.

Figure 1. Capacitance Multiplier

APPLICATIONS

These improved parameters can be put to good use in applications such as sample and hold circuits which require low input current and in voltage-follower circuits which require high slew rates. The circuit that follows will yield maximum small-signal transient response and slew rate for the NE5535 at unity gain.

It is always good practice in designing a system to use dual tracking regulators to power the dual-supply op amps. This will guarantee the positive and negative supply voltage will be equal during power-up. With the NE5535, it is possible to degrade the input circuit characteristics by not applying the power supplies simultaneously. The NE5535 is capable of directly replacing the μA741 with higher input resistance which will improve such designs as active filters, sample and hold, as well as voltage-followers.

The NE5535 can be used either with single or split power supplies.

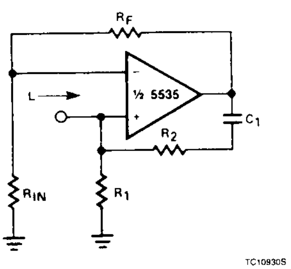
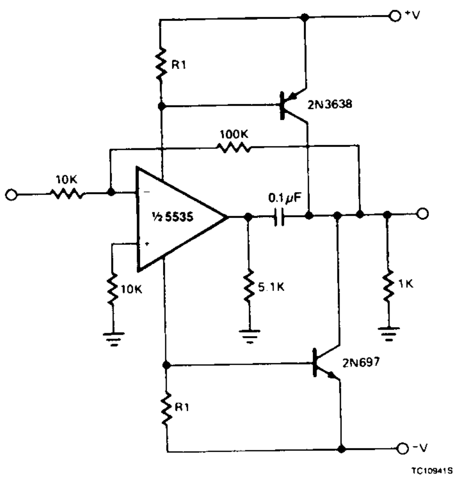


Figure 2. Virtual Inductor



NOTE:
All resistor values are in ohms.

Figure 3. Power Booster

Capacitance Multiplier

The circuit in Figure 1 can be used to simulate large capacitances using small value components. With the values shown and C = 10μF, an effective capacitance of 10,000μF was obtained. The Q available is limited by the effective series resistance. So R1 should be as large as practical.

Simulated Inductor

With a constant current excitation, the voltage dropped across an inductance increases with frequency. Thus, an active device whose output increases with frequency can be characterized as an inductance. The circuit of Figure 2 yields such a response with the effective inductance being equal to:

$$L = R_1R_2C$$

The Q of this inductance depends upon R_1 being equal to R_2. At the same time, however, the positive and negative feedback paths of the amplifier are equal leading to the distinct possibility of instability at high frequencies. R_1 should therefore always be slightly smaller than R_2 to assure stable operation.

Power Amplifier

For most applications, the available power from op amps is sufficient. There are times when more power handling capability is necessary. A simple power booster capable of driving moderate loads is offered in Figure 3.

The circuit as shown uses an NE5535 device. Other amplifiers may be substituted only if R_1 values are changed because of the I_{CC} current required by the amplifier. R_1 should be calculated from the expression

$$R_1 = \frac{600mV}{I_{CC}}$$

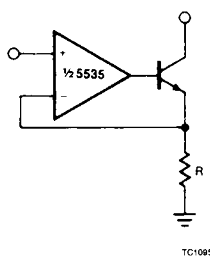
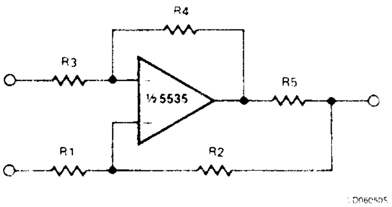


Figure 4. Voltage-to-Current Converter



NOTES:

$\frac{R_2}{R_1} = \frac{R_4}{R_3}$

$I_{OUT} = \frac{V_{IN} \cdot R_2}{R_5 \cdot R_1}$

Figure 5. Voltage-to-Current Converter

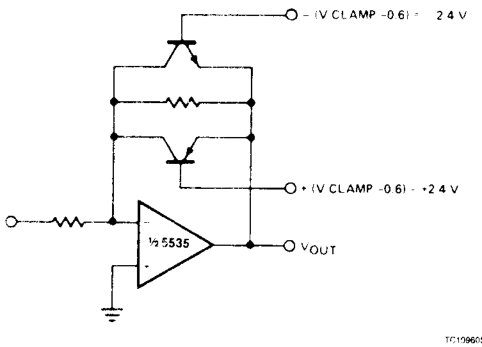
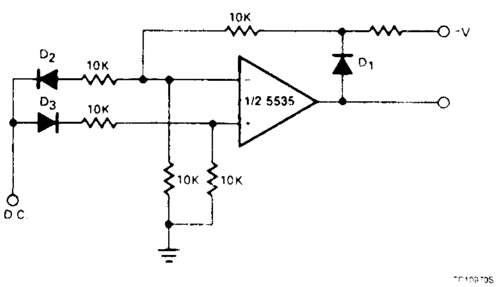


Figure 6. Active Clamp-Limiting Amplifier



NOTE:
All resistor values are in ohms.

Figure 7. Absolute Value Amplifier

Voltage-to-Current Converters

A simple voltage-to-current converter is shown in Figure 4. The current out is $I_{OUT} \cong V_{IN}/R$. For negative currents, a PNP can be used and, for better accuracy, a Darlington pair can be substituted for the transistor. With careful design, this circuit can be used to control currents of many amps. Unity gain compensation is necessary.

The circuit in Figure 5 has a different input and will produce either polarity of output current. The main disadvantages are the error current flowing in R_2 and the limited current available.

Active Clamp-Limiting Amplifier

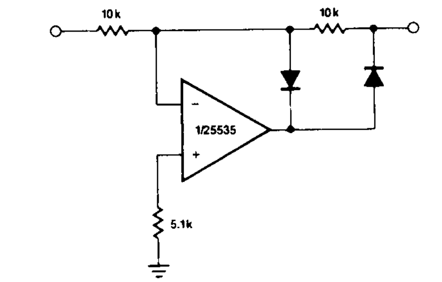
The modified inverting amplifier in Figure 6 uses an active clamp to limit the output swing with precision. Allowance must be made for the V_{BE} of the transistors. The swing is limited by the base-emitter breakdown of the transistors. A simple circuit uses two back-to-back zener diodes across the feedback resistor, but tends to give less precise limiting and cannot be easily controlled.

Absolute Value Amplifier

The circuit in Figure 7 generates a positive output voltage for either polarity of input. For positive signals, it acts as a noninverting amplifier and for negative signals, as an inverting amplifier. The accuracy is poor for input voltages under 1V, but for less stringent applications, it can be effective.

Half-Wave Rectifier

Figure 8 provides a circuit for accurate half-wave rectification of the incoming signal. For positive signals, the gain is 0; for negative signals, the gain is −1. By reversing both diodes, the polarity can be inverted. This circuit provides an accurate output, but the output impedance differs for the two input polarities and buffering may be needed. The output must slew through two diode drops when the input polarity reverses. The NE5535 device will work up to 10kHz with less than 5% distortion.



NOTE:
All resistor values are in ohms.

Figure 8. Half-Wave Rectifier

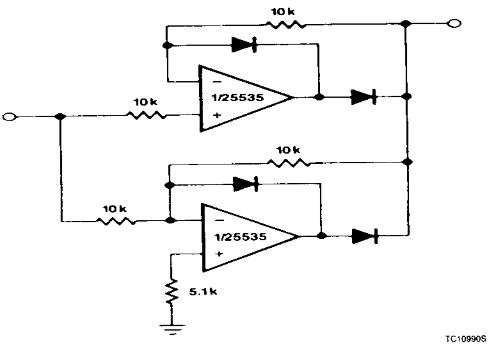
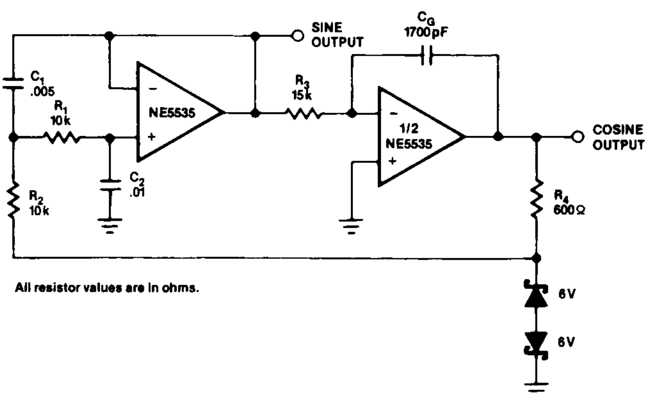


Figure 9. Precision Full-Wave Rectifier



All resistor values are in ohms.

NOTE:
All resistor values are in ohms.

o-Phase Sine Wave Oscillator

Precision Full-Wave Rectifier

The circuit in Figure 9 provides accurate full-wave rectification. The output impedance is low for both input polarities, and the errors are small at all signal levels. Note that the output will not sink heavy currents, except a small amount through the 10kΩ resistors. Therefore, the load applied should be referenced to ground or a negative voltage. Reversal of all diode polarities will reverse the polarity of the output. Since the outputs of the amplifiers must slew through two diode drops when the input polarity changes, 741 type devices give 5% distortion at about 300Hz.

Two-Phase Sine Wave Oscillator

The circuit (refer to Figure 10) uses a 2-pole pass Butterworth, followed by a phase-shifting single-pole stage, fed back through a voltage limiter to achieve sine and cosine outputs. The values shown using the μA741 amplifiers give about 1.5% distortion at the sine output and about 3% distortion at the cosine output. By careful trimming of C_G and/or the limiting network, better distortion figures are possible. The component values shown give a frequency of oscillation of about 2kHz. The values can be readily selected for other frequencies. The NE5535 should be used at higher frequencies to reduce distortion due to slew limiting.