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National Semiconductor

February 1995

## LM1596/LM1496 Balanced Modulator-Demodulator

### General Description

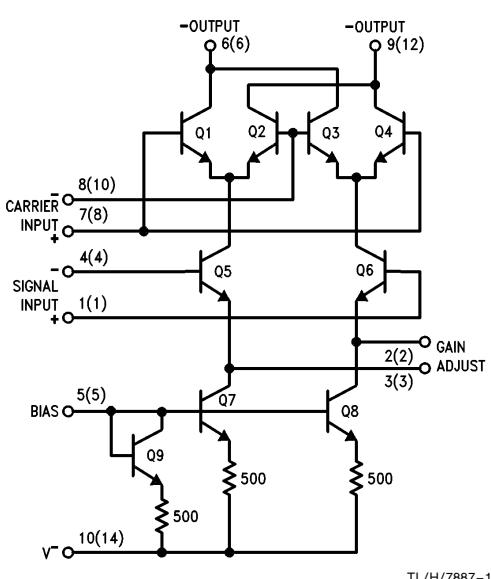
The LM1596/LM1496 are doubled balanced modulator-demodulators which produce an output voltage proportional to the product of an input (signal) voltage and a switching (carrier) signal. Typical applications include suppressed carrier modulation, amplitude modulation, synchronous detection, FM or PM detection, broadband frequency doubling and chopping.

The LM1596 is specified for operation over the  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  military temperature range. The LM1496 is specified for operation over the  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  temperature range.

### Features

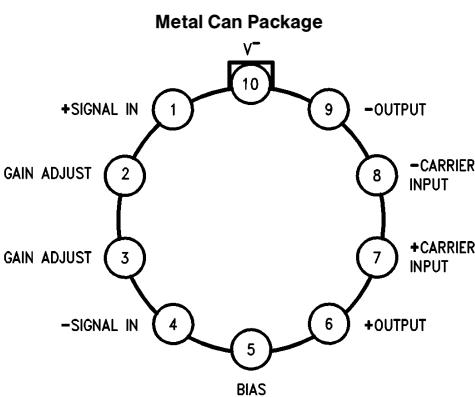
- Excellent carrier suppression  
65 dB typical at 0.5 MHz  
50 dB typical at 10 MHz
- Adjustable gain and signal handling
- Fully balanced inputs and outputs
- Low offset and drift
- Wide frequency response up to 100 MHz

### Schematic and Connection Diagrams



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Numbers in parentheses show DIP connections.

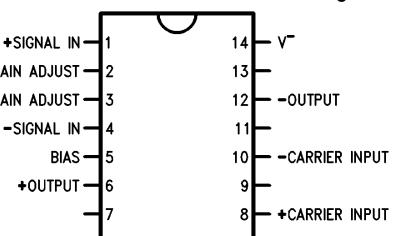


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**Note:** Pin 10 is connected electrically to the case through the device substrate.

**Order Number LM1496H or LM1596H**  
See NS Package Number H08C

### Dual-In-Line and Small Outline Packages



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**Order Number LM1496M or LM1496N**  
See NS Package Number M14A or N14A

## Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Internal Power Dissipation (Note 1)	500 mW
Applied Voltage (Note 2)	30V
Differential Input Signal ( $V_7 - V_8$ )	$\pm 5.0V$
Differential Input Signal ( $V_4 - V_1$ )	$\pm (5 + I_5 R_0)V$
Input Signal ( $V_2 - V_1, V_3 - V_4$ )	5.0V
Bias Current ( $I_5$ )	12 mA
Operating Temperature Range LM1596	-55°C to +125°C
LM1496	0°C to +70°C
Storage Temperature Range	-65°C to +150°C

### Soldering Information

- Dual-In-Line Package  
Soldering (10 seconds) 260°C
- Small Outline Package  
Vapor Phase (60 seconds) 215°C  
Infrared (15 seconds) 220°C

See AN-450 "Surface Mounting Methods and their effects on Product Reliability" for other methods of soldering surface mount devices.

## Electrical Characteristics ( $T_A = 25^\circ C$ , unless otherwise specified, see test circuit)

Parameter	Conditions	LM1596			LM1496			Units
		Min	Typ	Max	Min	Typ	Max	
Carrier Feedthrough	$V_C = 60 \text{ mVrms sine wave}$ $f_C = 1.0 \text{ kHz, offset adjusted}$		40			40		$\mu\text{Vrms}$
	$V_C = 60 \text{ mVrms sine wave}$ $f_C = 10 \text{ kHz, offset adjusted}$		140			140		$\mu\text{Vrms}$
	$V_C = 300 \text{ mVpp square wave}$ $f_C = 1.0 \text{ kHz, offset adjusted}$		0.04	0.2		0.04	0.2	$\text{mVrms}$
	$V_C = 300 \text{ mVpp square wave}$ $f_C = 1.0 \text{ kHz, not offset adjusted}$		20	100		20	150	$\text{mVrms}$
	$f_S = 10 \text{ kHz, } 300 \text{ mVrms}$ $f_C = 500 \text{ kHz, } 60 \text{ mVrms sine wave offset adjusted}$	50	65		50	65		$\text{dB}$
Carrier Suppression	$f_S = 10 \text{ kHz, } 300 \text{ mVrms}$ $f_C = 10 \text{ MHz, } 60 \text{ mVrms sine wave offset adjusted}$		50			50		$\text{dB}$
	$R_L = 50\Omega$ Carrier Input Port, $V_C = 60 \text{ mVrms sine wave}$ $f_S = 1.0 \text{ kHz, } 300 \text{ mVrms sine wave}$		300			300		$\text{MHz}$
	Signal Input Port, $V_S = 300 \text{ mVrms sine wave}$ $V_7 - V_8 = 0.5 \text{ Vdc}$		80			80		$\text{MHz}$
	$V_S = 100 \text{ mVrms, } f = 1.0 \text{ kHz}$ $V_7 - V_8 = 0.5 \text{ Vdc}$	2.5	3.5		2.5	3.5		$\text{V/V}$
Input Resistance, Signal Port	$f = 5.0 \text{ MHz}$ $V_7 - V_8 = 0.5 \text{ Vdc}$		200			200		$\text{k}\Omega$
Input Capacitance, Signal Port	$f = 5.0 \text{ MHz}$ $V_7 - V_8 = 0.5 \text{ Vdc}$		2.0			2.0		$\text{pF}$
Single Ended Output Resistance	$f = 10 \text{ MHz}$		40			40		$\text{k}\Omega$
Single Ended Output Capacitance	$f = 10 \text{ MHz}$		5.0			5.0		$\text{pF}$
Input Bias Current	$(I_1 + I_4)/2$		12	25		12	30	$\mu\text{A}$
Input Bias Current	$(I_7 + I_8)/2$		12	25		12	30	$\mu\text{A}$
Input Offset Current	$(I_1 - I_4)$		0.7	5.0		0.7	5.0	$\mu\text{A}$
Input Offset Current	$(I_7 - I_8)$		0.7	5.0		5.0	5.0	$\mu\text{A}$
Average Temperature Coefficient of Input Offset Current	$(-55^\circ C < T_A < +125^\circ C)$ $(0^\circ C < T_A < +70^\circ C)$		2.0			2.0		$\text{nA}/^\circ C$ $\text{nA}/^\circ C$
Output Offset Current	$(I_6 - I_9)$		14	50		14	60	$\mu\text{A}$
Average Temperature Coefficient of Output Offset Current	$(-55^\circ C < T_A < +125^\circ C)$ $(0^\circ C < T_A < +70^\circ C)$		90			90		$\text{nA}/^\circ C$ $\text{nA}/^\circ C$

## Electrical Characteristics ( $T_A = 25^\circ\text{C}$ , unless otherwise specified, see test circuit) (Continued)

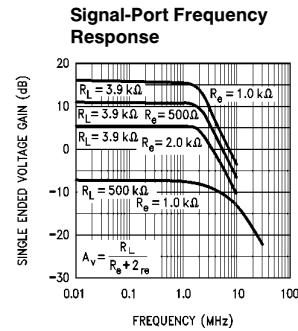
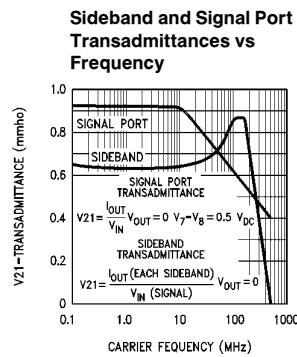
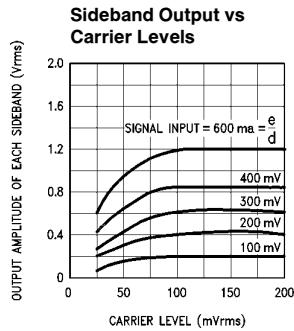
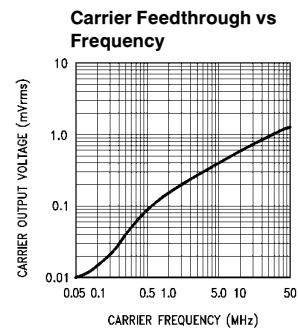
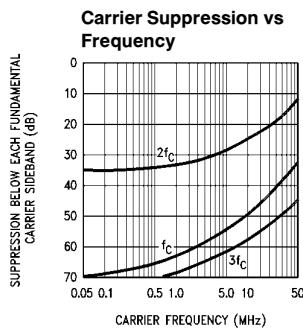
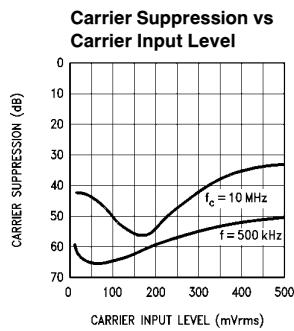
Parameter	Conditions	LM1596			LM1496			Units
		Min	Typ	Max	Min	Typ	Max	
Signal Port Common Mode Input Voltage Range	$f_S = 1.0 \text{ kHz}$		5.0			5.0		$\text{V}_{\text{p-p}}$
Signal Port Common Mode Rejection Ratio	$V_7 - V_8 = 0.5 \text{ Vdc}$		-85			-85		dB
Common Mode Quiescent Output Voltage			8.0			8.0		$\text{Vdc}$
Differential Output Swing Capability			8.0			8.0		$\text{V}_{\text{p-p}}$
Positive Supply Current	$(I_6 + I_9)$		2.0	3.0		2.0	3.0	mA
Negative Supply Current	$(I_{10})$		3.0	4.0		3.0	4.0	mA
Power Dissipation			33			33		mW

**Note 1:** LM1596 rating applies to case temperatures to  $+125^\circ\text{C}$ ; derate linearly at  $6.5 \text{ mW}/^\circ\text{C}$  for ambient temperature above  $75^\circ\text{C}$ . LM1496 rating applies to case temperatures to  $+70^\circ\text{C}$ .

**Note 2:** Voltage applied between pins 6-7, 8-1, 9-7, 9-8, 7-8, 7-1, 8-4, 6-8, 2-5, 3-5.

**Note 3:** Refer to rets1596x drawing for specifications of military LM1596H versions.

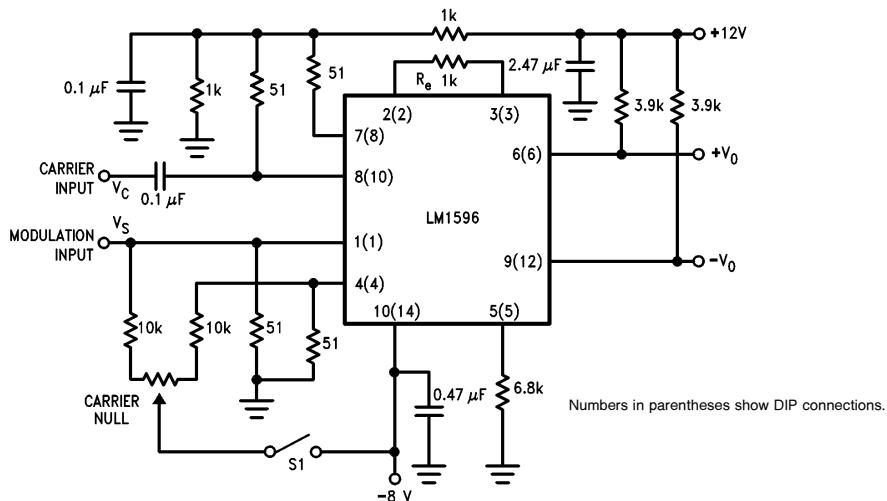
## Typical Performance Characteristics



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## Typical Application and Test Circuit

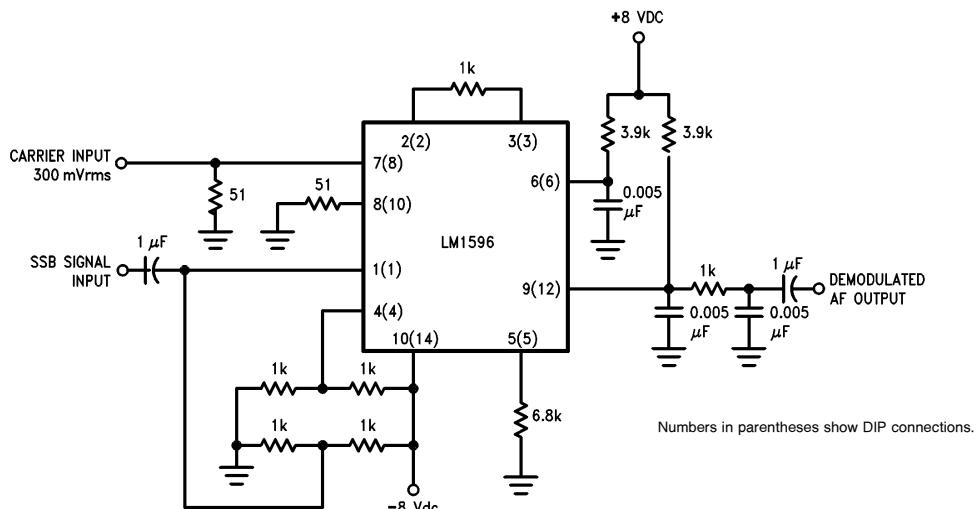
### Suppressed Carrier Modulator



**Note:**  $S_1$  is closed for “adjusted” measurements.

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## SSB Product Detector

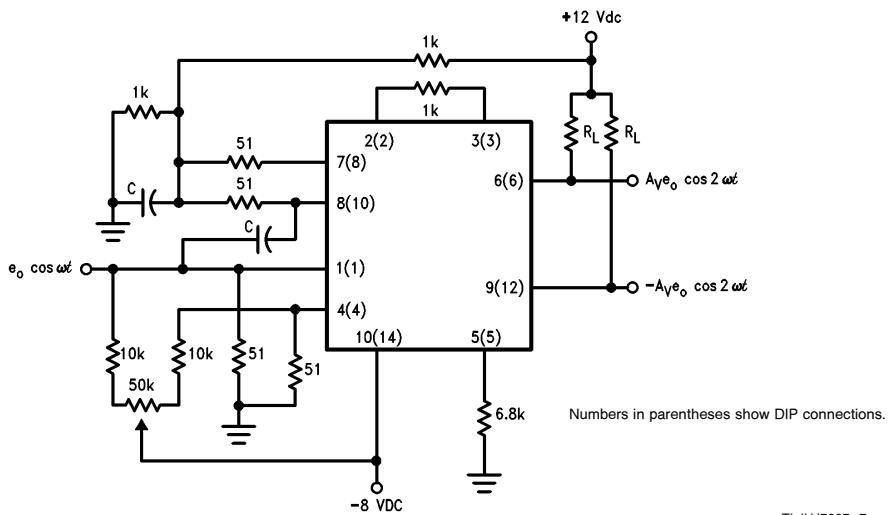


T1 / H/7887-6

This figure shows the LM1596 used as a single sideband (SSB) suppressed carrier demodulator (product detector). The carrier signal is applied to the carrier input port with sufficient amplitude for switching operation. A carrier input level of 300 mVrms is optimum. The composite SSB signal is applied to the signal input port with an amplitude of 5.0 to 500 mVrms. All output signal components except the desired demodulated audio are filtered out, so that an offset adjustment is not required. This circuit may also be used as an AM detector by applying composite and carrier signals in the same manner as described for product detector operation.

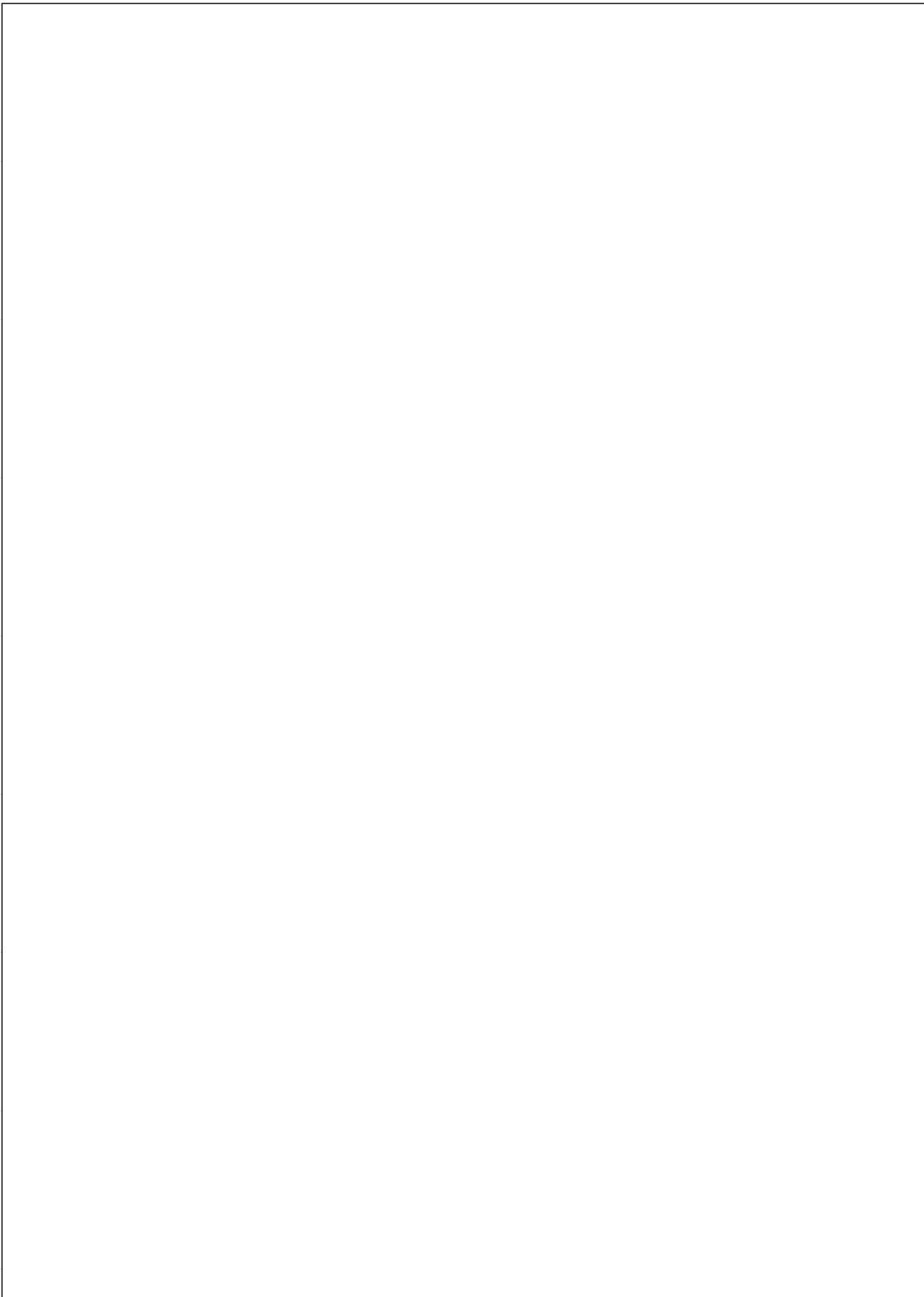
## Typical Applications (Continued)

**Broadband Frequency Doubler**

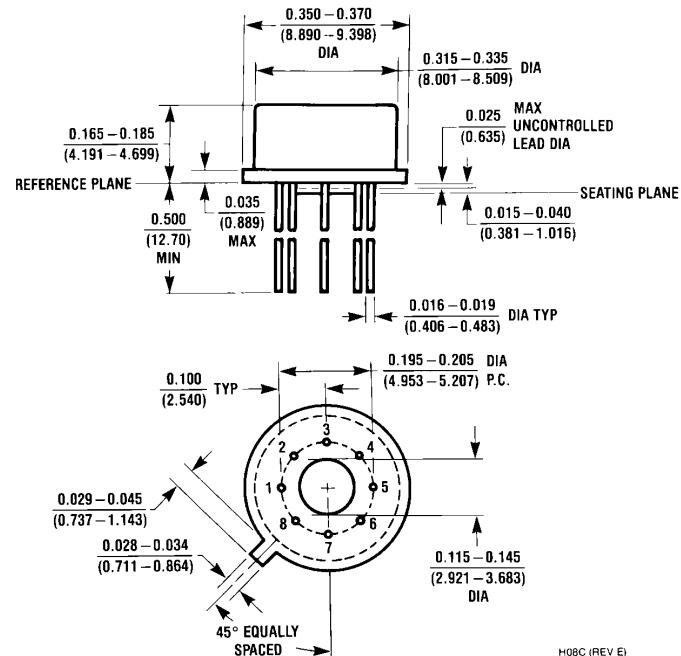


TL/H/7887-7

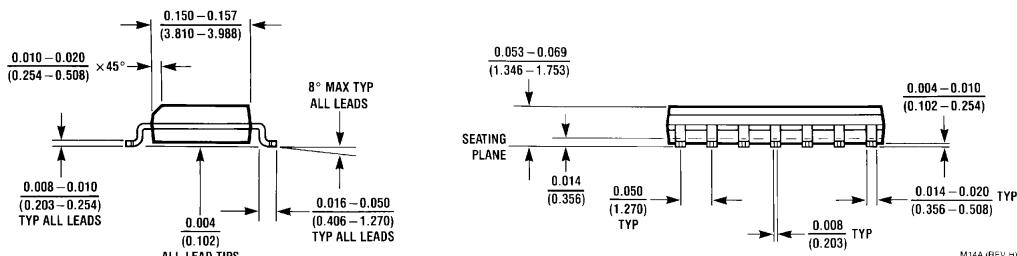
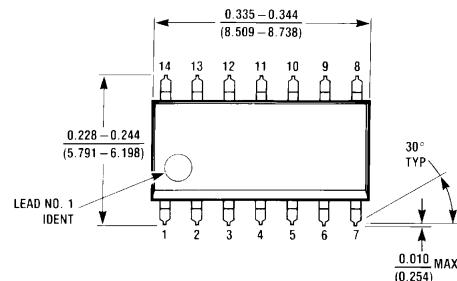
The frequency doubler circuit shown will double low-level signals with low distortion. The value of C should be chosen for low reactance at the operating frequency. Signal level at the carrier input must be less than 25 mV peak to maintain operation in the linear region of the switching differential amplifier. Levels to 50 mV peak may be used with some distortion of the output waveform. If a larger input signal is available a resistive divider may be used at the carrier input, with full signal applied to the signal input.



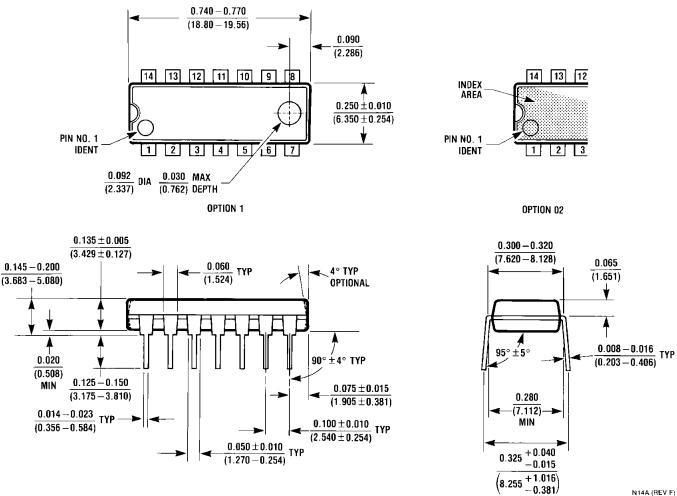
**Physical Dimensions** inches (millimeters)



**Metal Can Package (H)**  
Order Number LM1496H or LM1596H  
NS Package Number H08C



**Molded Small Outline Package (M)**  
Order Number LM1496M  
NS Package Number M14A

**Physical Dimensions** inches (millimeters) (Continued)**Molded Dual-In-Line Package (N)**

Order Number LM1496N

NS Package Number N14A

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