SILICON GENERAL

LINEAR INTEGRATED CIRCUITS

FOUR-QUADRANT MULTIPLIER

DESCRIPTION

The SG1595 and SG1495 four-quadrant analog multipliers are designed for applications where the output voltage required is a linear product of two input voltages. Both types provide excellent linearity and operation over a wide supply range and input voltage range. Applications include use as multipliers, dividers, squarers, phase detectors, frequency doublers, and as balanced modulators.

The SG1595 is rated for military ambient temperature applications over the -55°C to 125°C range; the SG1495 offers identical performance for 0°C to 70°C requirements.

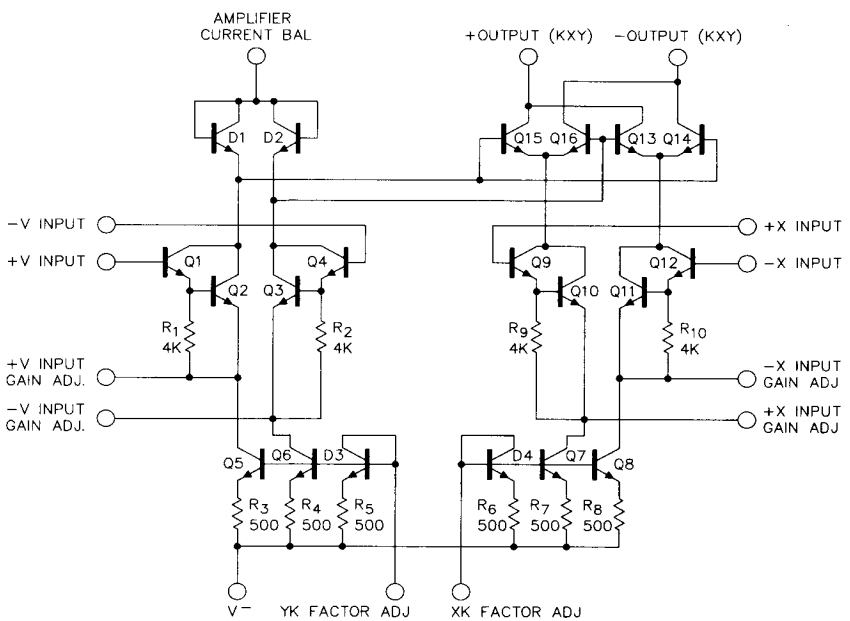
FEATURES

- **Excellent linearity**
- **Adjustable scale factor**
- **Excellent temperature stability**
- **Wide bandwidth**
- **High input voltage range**
- **Wide supply voltage operation**

HIGH RELIABILITY FEATURES -SG1595

- **Available to MIL-STD-883**
- **SG level "S" processing available**

CIRCUIT SCHEMATIC



10

April 1990

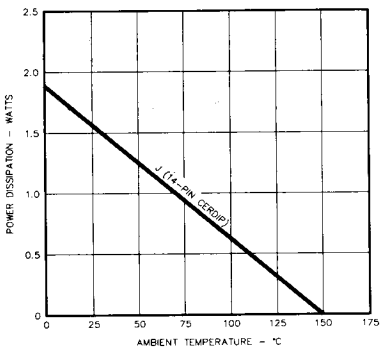
ABSOLUTE MAXIMUM RATINGS (Note 1)

Applied Voltage (Note 2) 30V
Differential Input Signal ..... $V_9 - V_{12} = \pm(6 + I_{13} R_X)$
$V_4 - V_8 = \pm(6 + I_3 R_Y)$
Factor Adjust Current 10mA

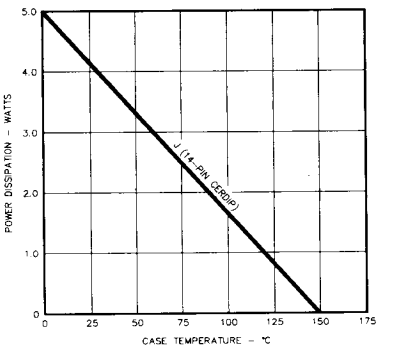
Operating Junction Temperature
Hermetic (J-Package) ..... 150°C
Storage Temperature Range ..... -65°C to 150°C
Lead Temperature (Soldering, 10 Seconds) ..... 300°C

Note 1. Exceeding these ratings could cause damage to the device.
Note 2. Voltage applied between pins 2-1, 14-1, 1-9, 1-12, 1-4, 1-8, 12-7, 9-7, 8-7, 4-7.

THERMAL DERATING CURVES



MAXIMUM POWER DISSIPATION vs AMBIENT TEMPERATURE



MAXIMUM POWER DISSIPATION vs CASE TEMPERATURE

RECOMMENDED OPERATING CONDITIONS (Note 3)

Applied Voltage 28V
Differential Input Signal ..... $V_9 - V_{12} = \pm(5 + I_{13} R_X)$
$V_4 - V_8 = \pm(5 + I_3 R_Y)$
Factror Adjust Current $(I_3),(I_{13})$ 5mA

Operating Ambient Temperature Range
SG1595 ..... -55°C to 125°C
SG1495 ..... 0°C to 70°C

Note 3. Range over which the device is functional.

ELECTRICAL SPECIFICATIONS

(Unless otherwise specified, these specifications apply for the operating ambient temperature of T_A=25°C. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG1595			SG1495			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Linearity Error (% of Full Scale)	$-10 < V_X < 10$ ($V_Y = \pm 10V$)		0.5	2.0		1.0	4.0	%
	$-10 < V_Y < 10$ ($V_X = \pm 10V$)		1.0	4.0		2.0	8.0	%
	$T_A = T_{MIN}$ to T_{MAX}							
	$-10 < V_X < 10$ ($V_Y = \pm 10V$)		0.75	2.0		1.5	4.0	%
	$-10 < V_Y < 10$ ($V_X = \pm 10V$)		1.50	4.0		3.0	8.0	%
Squaring Mode Error (Note 4)			0.50			0.75		%
	$T_A = T_{MIN}$ to T_{MAX}		0.75			1.00		%
Scale Factor (adjustable) (Note 4 and 5)			0.1			0.1		
Input Resistance (Note 4)	f = 20Hz		35			20		MΩ
Differential Output Resistance (Note 4)	f = 20Hz		300			300		KΩ
Input Bias Current (Note 4)	$T_A = T_{MIN}$ to T_{MAX}		2.0	8.0		2.0	12	µA
Input Offset Current (Note 4)	$T_A = T_{MIN}$ to T_{MAX}		0.2	1.0		0.4	2.0	µA
Common-Mode Gain (Note 4)	$T_A = T_{MIN}$ to T_{MAX}	-50	-60		-40	-50		dB
Output Common-Mode Voltage			21			21		V
Differential Output Voltage Swing (Note 4)	$V_X = V_Y = 10V$, $T_A = T_{MIN}$ to T_{MAX}	±8	±14		±8	±14		V
Positive Supply Voltage Rejection Ratio			5			5		mV/V
Negative Supply Voltage Rejection Ratio			10			10		mV/V
Negative Supply Current (Note 4)	$T_A = T_{MIN}$ to T_{MAX}		6.0	7.0		6.0	7.0	mA

ELECTRICAL SPECIFICATIONS (continued)

Parameter	Test Conditions	SG1595			SG1495			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Power Consumption (Note 4)			135	170		135	170	mW
Average Temperature Coefficient of Input Offset Current	$T_A = T_{MIN}$ to T_{MAX}		2.5			2.5		nA/°C
Frequency Response	–3dB bandwidth		3.0			3.0		MHz
	3° relative phase shift		750			750		KHz
	1% absolute error due to input–output phase shift		30			30		KHz

Note 4. These parameters are guaranteed by design and process control but are not tested in production.

Note 5. $K = \frac{2R_L}{I_S R_X R_Y}$

CHARACTERISTIC CURVES

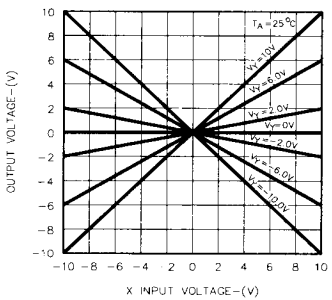


FIGURE 1.
STANDBY CURRENT

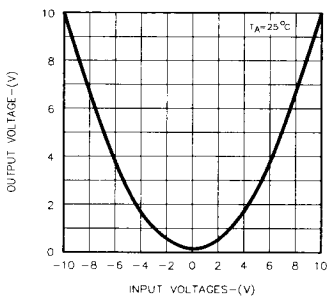


FIGURE 2.
MINIMUM INPUT-OUTPUT VOLTAGE

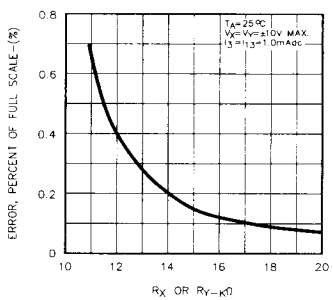


FIGURE 3.
MINIMUM INPUT-OUTPUT VOLTAGE

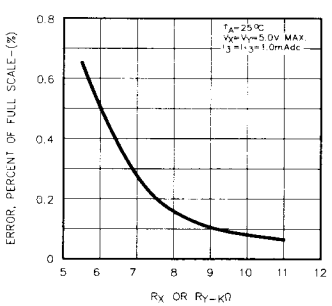


FIGURE 4.
CURRENT LIMITING

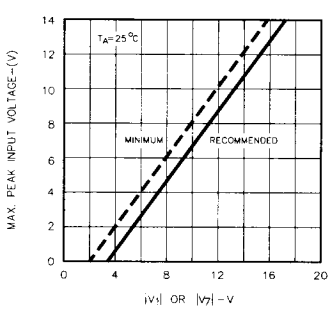


FIGURE 5.
RIPPLE REJECTION

10

APPLICATION INFORMATION

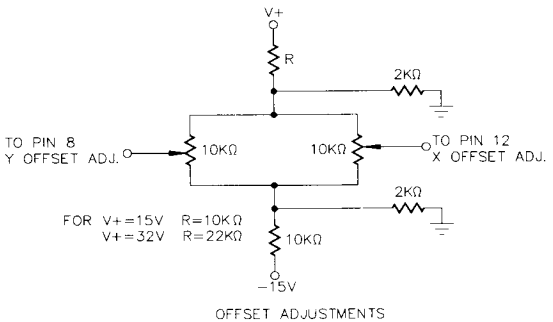


FIGURE 6

For best output accuracy, use above network and follow procedure at right.

RECOMMENDED ZERO ADJUSTMENT AND SCALE SETTING PROCEDURE

With $V_X = V_Y = 0V$ adjust the output offset adjustment until the output of the external amplifier reads 0V. Set $V_X = 5.000V$, $V_Y = 0.000V$, and adjust the Y-input offset control until the output amplifier reads 0V. Repeat this procedure for $V_X = 0.000V$, $V_Y = 5.000V$ and adjust the X-input offset control until the output amplifier reads 0V. This procedure should be repeated until complete null is achieved.

Next, set $V_X = V_Y = 5.000V$ and adjust the K-factor potentiometer until the output reads the desired output.

$V_{OUT} = 2.500V = K V_X V_Y$ for a K-factor of 0.100.

When a high degree of accuracy is unnecessary for small output signals, the above procedure may be simplified by eliminating the output offset adjustment.

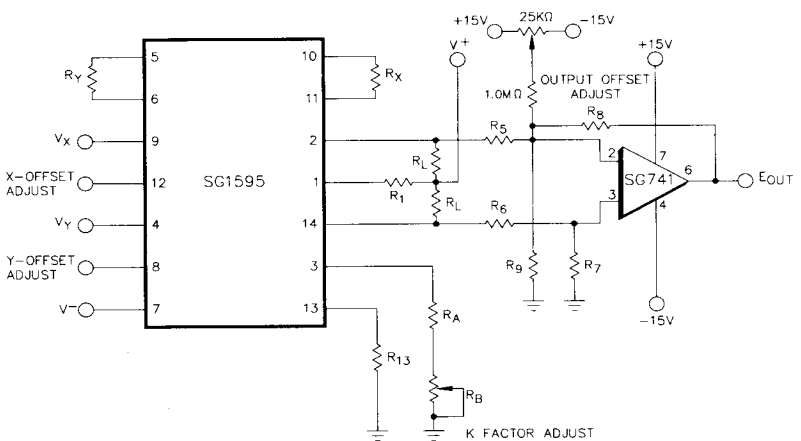


FIGURE 7 - MULTIPLY WITH OP AMP LEVEL SHIFT

SET UP	RESISTOR*	R_1	R_5	R_6	R_7	R_8	R_9	R_{13}	R_A	R_B	R_L	R_X	R_Y
	TOLERANCE	5%	1%	1%	1%	1%	1%	1%	5%	20%	0.5%	5%	5%
1	V+ = 32V, V- = -15V, -10V ≤ V_X ≤ 10V, -10V ≤ V_Y ≤ 10V	9.1	121	100	11	121	15	13.7	12	5.0	11	15	15
2	V+ = 15V, V- = -15V, -5V ≤ V_X ≤ 5V, -5V ≤ V_Y ≤ 5V	3.0	300	100	100	300		13.7	12	5.0	3.4	8.2	8.2
3	V+ = 15V, V- = -15V, -10V ≤ V_X ≤ 10V, -10V ≤ V_Y ≤ 10V	1.2	121	100	11	910	13.7	13.7	12	5.0	1.5	15	15

* All resistor values are in KΩ

APPLICATION INFORMATION (continued)

SUGGESTIONS AND GENERAL PRECAUTIONS

The high frequency performance of the SG1595 is primarily determined by two conditions. One, by the load resistors and the associated stray output capacitance of the multiplier and two, the operational amplifier used at the output. For maximum frequency of operation, low value load resistors and a wideband high slew rate operational amplifier should be used.

Phase shift at higher frequencies due to load resistors and output stray capacitances and relative phase shift between X and Y channels should be considered for maximum accuracy. As an example if the input to output phase shift is only 0.6°, the output product of two sine waves will exhibit a vector error of 1%. A 3° relative phase shift between the input signals will result in a vector error of 5%.

The normal circuit precautions should be taken to avoid parasitic oscillation. Leads should be as short as possible and the power supplies should be decoupled with a 0.1μF high frequency capacitor. An RC parasitic suppression network of 510Ω in series with a 10pF from each input to ground can be used to reduce the Q of a source-tuned circuit, which may cause the oscillation. As an alternate solution, a 510Ω resistor network can be placed in series with each input of the SG1595.

APPLICATION CIRCUITS

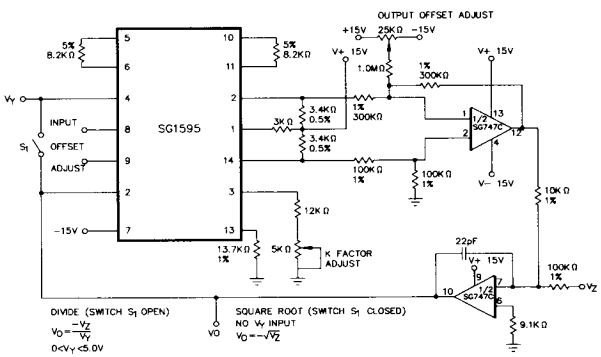


FIGURE 8 - DIVIDE AND SQUARE ROOT

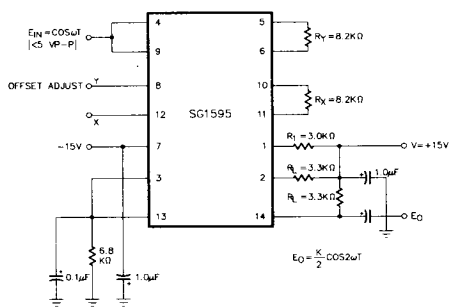


FIGURE 9 - FREQUENCY DOUBLER

CONNECTION DIAGRAMS & ORDERING INFORMATION (See Notes Below)

Package	Part No.	Ambient Temperature Range	Connection Diagram
14-PIN CERAMIC DIP J - PACKAGE	SG1595J/883B SG1595J SG1495J	-55°C to 125°C -55°C to 125°C 0°C to 70°C	AMPLIFIER CURRENT BALANCE 1 / + OUTPUT (KXY) 2 / YK FACTOR ADJUST 3 / +Y INPUT 4 / +Y INPUT GAIN ADJUST 5 / -Y INPUT GAIN ADJUST 6 / V- 7 — 14 / - OUTPUT (KXY) / 13 XK FACTOR ADJUST / 12 -X INPUT / 11 -X INPUT GAIN ADJUST / 10 +X INPUT GAIN ADJUST / 9 +X INPUT / 8 -Y INPUT

Note 1. Contact factory for JAN and DESC product availablity.
2. All packages are viewed from the top.