SILICON GENERAL

LINEAR INTEGRATED CIRCUITS

DUAL SOLENOID / MOTOR DRIVER

DESCRIPTION

The SG3663 is a dual high-voltage, high-current monolithic I.C. recommended for driving solenoids and stepper motors. Each output stage contains sink/source drivers rated to ±3.5A peak currents with breakdowns in excess of 50V. Internal suppression diodes provide protection when switching inductive loads. The output stage can be configured to drive two separate loads or a single load in an H-bridge configuration.

The SG3663 offers load current control through the implementation of an internal current sense comparator to control the high side driver. Peak and average currents are set by controlling the threshold voltage on the sense comparator. A mode select pin determines if the SG3663 is operating in the chop or non-chop mode.

The SG3663 is available in two types of power SIP and is rated to junction temperatures of 0°C to 125°C.

FEATURES

- **Dual outputs rated at ±3.5A peak current**
- **Chop or non-chop load current control**
- **Current sense comparator with variable threshold and hysteresis**
- **Internal clamp diodes for transient suppression**
- **Single supply operation (8V to 50V)**
- **Thermal shutdown protection**
- **Available in two different power SIP's rated at $\theta_{JC} < 2°C/W$**

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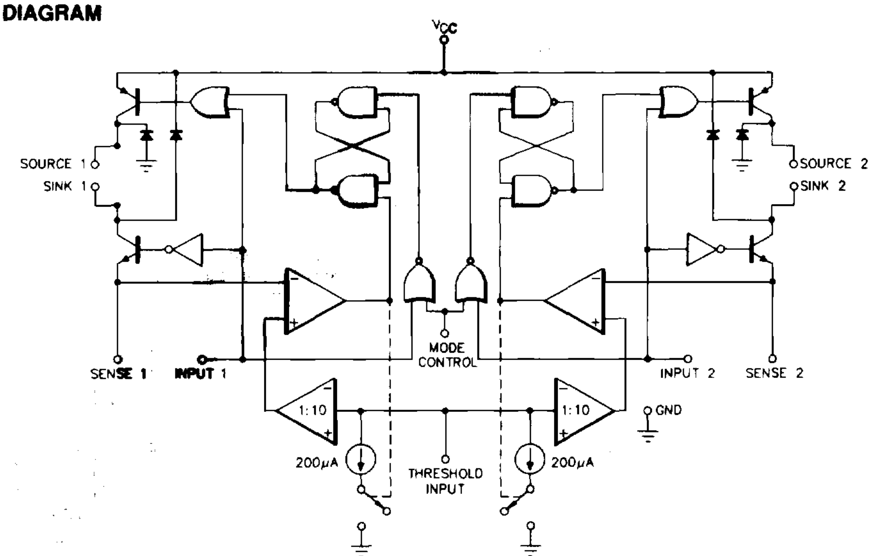
BLOCK DIAGRAM



TRUTH TABLE

INPUT	MODE CONTROL	V_{SENSE}	SOURCE DRIVER	SINK DRIVER
0	0 (Non-chop)	$< V_{TH}/10$	ON	ON
0	0 (Non-chop)	$> V_{TH}/10$	OFF	ON
0	1 (Chop)	$< V_{TH}/10$	ON	ON
0	1 (Chop)	$> V_{TH}/10$	OFF	ON
1	DC	DC	OFF	OFF

DC = Don't care

April 1990

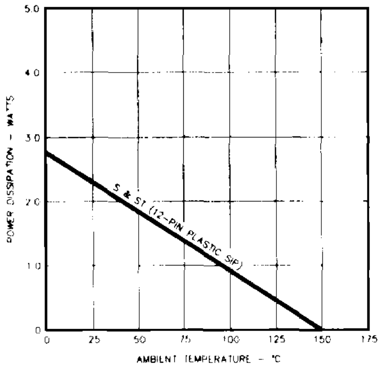
ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (V_{CC}) 55V
Logic Input Voltage 7V
Threshold Input Voltage (V_{TH}) 5V
Source/Sink Output Current (Each Output):
Continuous .... ±3.5A
Peak .... ±4.4A

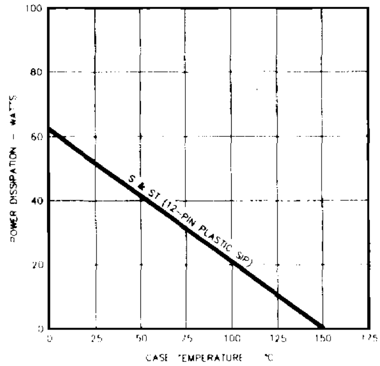
Operating Junction Temperature .... 150°C
Storage Temperature Range .... -65°C to 150°C
Lead Temperature (Soldering, 10 Seconds) .... 300°C

Note 1. Exceeding these ratings could cause damage to the device. All currents are positive into the specified terminal.

THERMAL DERATING CURVES



MAXIMUM POWER DISSIPATION vs AMBIENT TEMPERATURE



MAXIMUM POWER DISSIPATION vs CASE TEMPERATURE

RECOMMENDED OPERATING CONDITIONS (Note 2)

Supply Voltage (V_{CC}) .... 8V to 50V
Source/Sink Output Current (Each Output):
Continuous .... ±3.0A
Peak .... ±3.5A

Threshold Input Voltage (V_{TH}) .... 0.6V to 5.0V
Ambient Temperature Range (T_A) .... 0°C to 70°C

Note 2. 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, V_{CC} = 50V, and R_{SENSE} = 0.1Ω. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG3663 Min.	Typ.	Max.	Units
Supply Current ($I_{CC(ON)}$)	**V_{IN} = V_{MODE} = 0V, I_{OUT} = 0A**		**12**	**25**	**mA**
($I_{CC(OFF)}$)	V_{IN} = V_{MODE} = 2.7V		12	25	mA
Logic 1 Input Voltage (V_{IH})	**Input / Mode Control**	**2.0**			**V**
Logic 0 Input Voltage (V_{IL})	Input / Mode Control			0.8	V
Logic 1 Input Current (I_{IH})	**V_{IN} = V_{MODE} = 2.4V**			**100**	**µA**
Logic 0 Input Current (I_{IL})	V_{IN} = V_{MODE} = 0.4V			-1.0	mA
Threshold Input Current (I_{THH})	**V_{TH} = 0.6V to 5.0V, $V_{TH} \geq V_{SENSE}$ x 10**			**-100**	**µA**
Threshold Hysteresis Current (I_{HYS})	V_{TH} = 0.6V to 5.0V, $V_{TH} \geq V_{SENSE}$ x 10	140	200	260	µA
Source Output Saturation Voltage	**V_{IN} = 0V, I_{OUT} = -2A**		**1.85**	**2.2**	**V**
(V_{SAT}) (Note 3)	V_{IN} = 0V, I_{OUT} = -3.5A		2.0	2.6	V
Sink Output Saturation Voltage	**V_{IN} = 0V, I_{OUT} = 2A**		**1.3**	**1.8**	**V**
(V_{SAT}) (Note 3)	V_{IN} = 0V, I_{OUT} = 3.5A		2.1	2.6	V
Source/Sink Leakage Current (I_{CEX})	**V_{IN} = 2.4V, V_{SOURCE} = 0V**			**100**	**µA**
	V_{IN} = 2.4V, V_{SINK} = 50V			100	µA
Source Diode Forward Voltage (V_F)	**V_{IN} = 2.4V, I_{SOURCE} = -2A**		**-1.2**	**-1.6**	**V**
	V_{IN} = 2.4V, I_{SOURCE} = -3.5A		-1.4	-2.0	V

ELECTRICAL SPECIFICATIONS (continued)

Parameter	Test Conditions	SG3663 Min.	SG3663 Typ.	SG3663 Max.	Units
Sink Diode Forward Voltage (V_F)	**V_{IN} = 2.4V, I_{SINK} = 2A**		**1.75**	**2.2**	**V**
	V_{IN} = 2.4V, I_{SINK} = 3.5A		2.3	2.8	V
Diode Leakage Current (I_R)	**V_{IN} = 2.4V, V_{SOURCE} = 50V**			**100**	**µA**
	V_{IN} = 2.4V, V_{SOURCE} = 0V			100	µA
Output Current Regulation (I_{REG})	**V_{TH} = 2.0V to 3.6V**	**-5**		**5**	**%**
	V_{TH} = 1.0V to 2.0V	-10		10	%
	V_{TH} = 0.6V to 1.0V	**-25**		**25**	**%**
Propagation Delay (Note 4) (T_{PLH})	50% V_{IN} to 50% V_{OUT}			2.5	µs
(T_{PHL})	**I_{OUT} = 2A (resistive)**			**3.0**	**µs**
Thermal Shutdown (T_{TH})			160		°C

Note 3. These parameters are tested using pulse techniques to minimize device heating.
Note 4. These parameters are guaranteed by design but not 100% tested in production.

CHARACTERISTIC CURVES

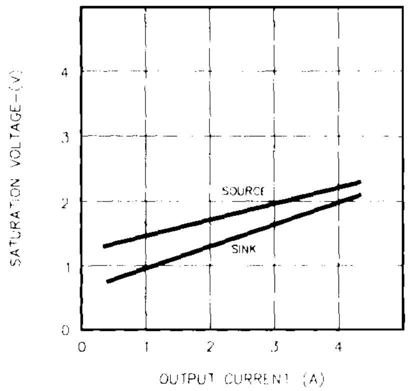


FIGURE 1.
OUTPUT SATURATION VOLTAGE
VS. OUTPUT CURRENT

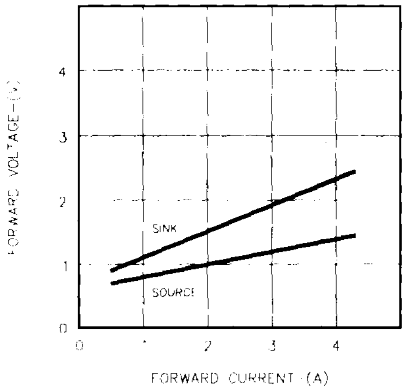


FIGURE 2.
DIODE FORWARD VOLTAGE
VS. FORWARD CURRENT

APPLICATION NOTES

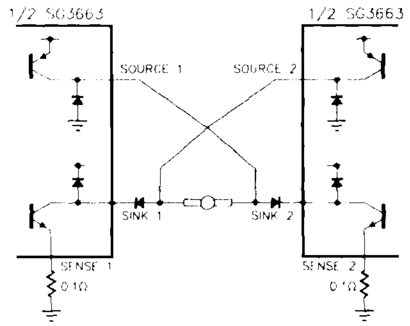


FIGURE 3 - H-BRIDGE CONFIGURATION

1. When using the SG3663 in an H-bridge configuration, external diodes must be used. These diodes must be high speed with voltage ratings above 70V and capable of handling 5A. Care should also be taken not to simultaneously turn on both inputs.

2. PC Board layout - The output current is controlled by both the voltage of the Sense pin and the sense resistor. Because of the large currents and low resistance, it is critical to have extremely good PC board layout to reduce parasitic wiring resistances which could add to the sense resistor and reduce the output current.

3. Decoupling of the V_{CC} supply with a 10µF electrolytic is recommended.

FUNCTIONAL DESCRIPTION

NON-CHOP MODE

A logic "0" applied to the Mode Control pin will cause the SG3663 to operate in the non-chop mode. If a logic "0" then appears on the Input pin, both the sink and source transistors will turn-on causing the load current to rise according to:

$$V_{CC} - V_{SAT1} - V_{SAT2} - L\frac{d_i}{d_t} - IR_{SENSE} = 0$$

solving for I(t)

$$1)\qquad I(t) = \frac{V_{CC} - V_{SAT1} - V_{SAT2}}{R_{SENSE}}\left(1 - e^{-(R/L)t}\right)$$

for I(t=0) = 0A

This current will rise exponentially until it reaches a peak value described in Equation 2.

$$2)\qquad I_{PEAK} = \frac{V_{TH}/10}{R_{SENSE}}$$

The comparator then trips, setting the latch and turning off the source transistor.

Since the source transistor has been disabled and the coil current cannot change instantaneously the current flow will be through D2 and will exponentially decay per the following:

$$3)\qquad I(t) = -I_{PEAK}\, e^{-(R/L)(t - T)}$$

The load current will decay to "0" unless the latch is reset by pulling the input high and then low again to activate the source driver.

When the input goes high both the sink and source turn off and the current path is through D2, L, and D1. Figure 5 is a graphical representation of the above discussion.

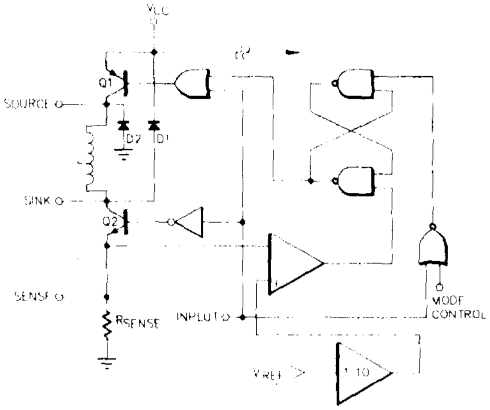


FIGURE 4 - TYPICAL APPLICATION IN NON-CHOP MODE (Refer to Figures 4 & 5)

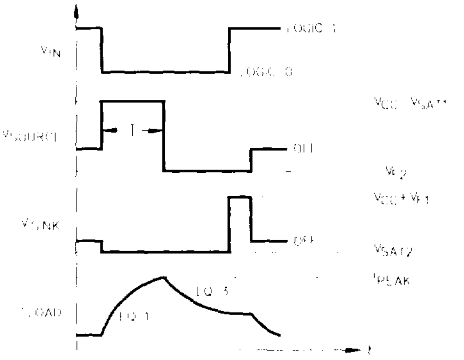


FIGURE 5 - NON-CHOP MODE

CHOP MODE (Note: Only one section can be used at one time.)

A logic signal "1" on the Mode Control pin will cause the SG3663 to operate in the chop mode. As in the non-chop mode a logic "0" on the Input pin will cause the sink and source transistor to turn on with Equation 4 describing the current in the load.

$$4)\qquad I(t) = \frac{V_{CC} - V_{SAT1} - V_{SAT2}}{R_{SENSE}}\left(1 - e^{-(R/L)t}\right)$$

Once I_{PEAK} is reached the source transistor turns-off and a current source ($I_{HYS} \approx +200\mu A$) is activated on the threshold pin. This current source lowers the effective threshold voltage by an amount determined by a resistor value R_{HYS}. The load current will decay until the new threshold is reached at which time the source transistor is activated and the threshold is restored to its original value by turning off the current source. The output current will rise again until the original peak value has been reached. This chopping action will continue until the Input pin is taken high causing the load current to decay to 0A. Figure 6 is a graphical representation of the chop-mode action.

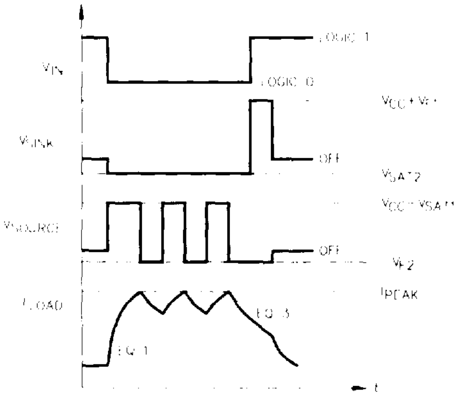


FIGURE 6 - CHOP MODE (Refer to Figure 4)

DESIGN EXAMPLES - CHOP MODE (Refer to Figure 4)

Example 1 -

Desired: 3.0A Peak, 20KHz Chop Frequency

Given: V_{CC} = 50V, L = 2mH, R_{SENSE} = 0.1Ω

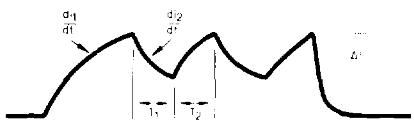


FIGURE 7.

1) $V_{SENSE} = (3.0A) \times (0.1\Omega) = 300mV$

$V_{TH} = 300mV \times 10 = 3V$

2) $T = T_1 + T_2 = \dfrac{1}{20KHz}$

$V = L\dfrac{d_{i1}}{d_t}$ $\qquad V = L\dfrac{d_{i2}}{d_t}$

$\dfrac{d_{i1}}{d_t} = \dfrac{V_{CC} - V_{SAT1} - V_{SAT2}}{L}$ $\qquad \dfrac{d_{i2}}{d_t} = \dfrac{-V_{SAT2} - V_{R2}}{L}$

$= \dfrac{50V - 2.0V - 2.0V}{2mH}$ $\qquad = \dfrac{-2.0V - 2.0V}{2mH}$

$= 23A/ms$ $\qquad = -2.0A/ms$

$\therefore T \cong \dfrac{\Delta I}{23A/ms} + \dfrac{\Delta I}{2.0A/ms}$

$\Delta I \cong \dfrac{\frac{1}{20KHz}}{\left(\frac{1}{2.0} + \frac{1}{23}\right) \times -10^{-3}} = 92mA$

3) $\% HYS = \dfrac{\Delta I}{I_{PEAK}}$

$= \dfrac{0.092A}{3A}$

$= 3\%$

4) $\Delta V_{TH} = (3\%)\,(3V)$

$= 90mV$

5) $R_{HYS} = \dfrac{\Delta V_{TH}}{200\mu A}$

$= \dfrac{90mV}{200\mu A}$

$= 450\Omega$

Example 2 -

A voltage divider on the reference supply can be used to establish the necessary peak and hysterisis current.

Desired: 3.0A Peak, 10% Hysterisis Current

Given: V_{REF} = 5.0V, R_{SENSE} = 0.1Ω

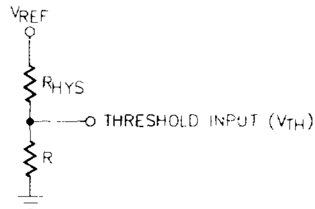


FIGURE 8.

$R_{HYS} = \dfrac{V_{REF} \times \%\ Hysterisis}{200\mu A}$

$R = \dfrac{R_{HYS} \times V_{TH}\,(peak)}{V_{REF} - V_{TH}\,(peak)}$

$R = \dfrac{R_{HYS}\,(I_{PEAK} \times R_{SENSE} \times 10)}{V_{REF} - (I_{PEAK} \times R_{SENSE} \times 10)}$

$\therefore R_{HYS} = \dfrac{5.0V \times 10\%}{200\mu A}$

$= 2.5K\Omega$

$R = \dfrac{2.5K\Omega\,(3.0A \times 0.1\Omega \times 10)}{5.0V - (3.0A \times 0.1\Omega \times 10)}$

$= 3.75K\Omega$

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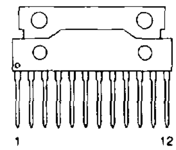
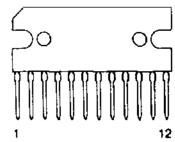
CONNECTION DIAGRAMS & ORDERING INFORMATION (See Notes Below)

Package	Part No.	Ambient Temperature Range	Connection Diagram
12-PIN PLASTIC SIP ST - PACKAGE	SG3663ST	0°C to 70°C	 1. GROUND 2. IN 1 3. SENSE 1 4. SINK 1 5. SOURCE 1 6. THRESHOLD INPUT 7. V_{CC} 8. SOURCE 2 9. SINK 2 10. SENSE 2 11. IN 2 12. MODE CONTROL
12-PIN PLASTIC SIP S - PACKAGE	SG3663S	0°C to 70°C	 1. GROUND 2. IN 1 3. SENSE 1 4. SINK 1 5. SOURCE 1 6. THRESHOLD INPUT 7. V_{CC} 8. SOURCE 2 9. SINK 2 10. SENSE 2 11. IN 2 12. MODE CONTROL

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