

## DC MOTOR PULSE WIDTH MODULATOR

### DESCRIPTION

The SG1731 is a pulse width modulator circuit designed specifically for DC motor control. It provides a bi-directional pulse train output in response to the magnitude and polarity of an analog error signal input. The device is useful as the control element in motor-driven servo systems for precision positioning and speed control, as well as in audio modulators and amplifiers using carrier frequencies to 350 KHz.

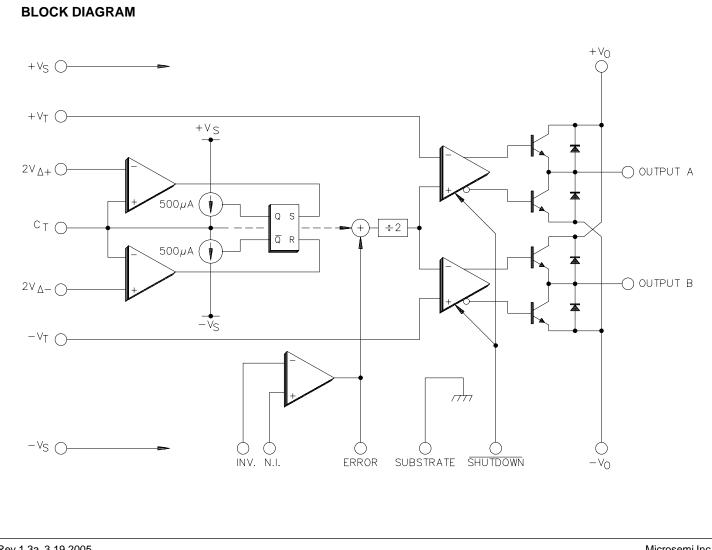
The circuit contains a triangle waveform oscillator, a wideband operational amplifier for error voltage generation, a summing/scaling network for level-shifting the triangle waveform, externally programmable PWM comparators and dual  $\pm 100$ mA,  $\pm 22$ V totem pole drivers with commutation diodes for full bridge output. A SHUTDOWN terminal forces the drivers into a floating high-impedance state when driven LOW. Supply voltage to the control circuitry and to the output drivers may be from either dual positive and negative supplies, or single-ended.

### **FEATURES**

- ±3.5V to ±15V control supply
- ±2.5V to ±22V driver supply
- Dual 100mA source/sink output drivers
- 5KHz to 350KHz oscillator range
- High slew rate error amplifier
- Adjustable deadband operation
- Digital SHUTDOWN input

#### HIGH RELIABILITY FEATURES - SG1731

- ♦ Available to MIL-STD-883
- ♦ LMI level "S" processing available



# SG1731/SG2731/SG3731

## ABSOLUTE MAXIMUM RATINGS (Note1)

Supply Voltage (±V <sub>s</sub> )	±18V
Analog Inputs	±V <sub>s</sub>
Digital Inputs (SHUTDOWN)	
Output Driver Supply Voltage (±V <sub>o</sub> )	<u>±</u> 25V
Source/Sink Output Current (continuous)	200mA
Source/Sink Output Current (peak, 500ns	s) 400mA

Note 1. Values beyond which damage may occur.

## THERMAL DATA

Output Driver Diode Current (continuous) 200mA
Output Driver Diode Current (peak, 500ns) 400mA
Operating Junction Temperature
Hermetic (J - Package) 150°C
Plastic (N - Package) 150°C
Storage Temperature Range65°C to 150°C
Lead Temperature (Soldering, 10 Seconds) 300°C
RoHS Peak Package Solder Reflow Temp.(40 sec. max. exp.) 260°C (+0, -5)

Note A. Junction Temperature Calculation:  $T_J = T_A + (P_D x \theta_{JA})$ .

Note B. The above numbers for  $\theta_{JC}$  are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The  $\theta_{JA}$  numbers are meant to be guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

## **RECOMMENDED OPERATING CONDITIONS** (Note 2)

Supply Voltage Range (±V <sub>s</sub> )	±3.5V to ±15V
Error Amp Common-Mode Range	$-V_s + 3V$ to $V_s - 3V$
Output Driver Supply Voltage Range	±2.5V to ±22V
Source/Sink Output Current (continuous)	100mA
Source/Sink Output Current (peak, 500ns)	200mA
Output Driver Diode Current (continuous)	100mA
Output Driver Diode Current (peak, 500ns)	200mA

Oscillator Frequency Range	. 10Hz to 350KHz
Oscillator Voltage (Peak-to-Peak)	1V to 10V
Oscillator Timing Capacitor $(C_{\tau})$	200pF to 2.5µF
Operating Ambient Temperature Range	
SG1731	55°C to 125°C
SG2731	25°C to 85°C
SG3731	0°C to 70°C

Note 2. Range over which the device is functional and parameter limits are guaranteed.

## **ELECTRICAL CHARACTERISTICS**

(Unless otherwise specified, these specifications apply over the operating ambient temperatures for SG1731 with -55°C  $\leq T_A \leq 125°C$ , SG2731 with -25°C  $\leq T_A \leq 85°C$ , SG3731 with 0°C  $\leq T_A \leq 70°C$ ,  $V_S = \pm 15V$ , and  $V_O = \pm 22V$ . Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG173	SG1731/2731/3731		
Falameter	Test conditions	Min.	Тур.	Max.	Units
Oscillator Section					
$C_{T}$ Charging Current	$T_A = 25^{\circ}C$	450	500	550	μA
	$T_A = T_{MIN}$ to $T_{MAX}$	400		600	μΑ
2VA± Input Bias Current	$V_{\rm CM} = \pm 5 V$			-20	μΑ
Initial Oscillator Frequency	$C_T = 1000 \text{pF}, 2V\Delta \pm = \pm 5\text{V}, T_A = 25^{\circ}\text{C}$ $C_T = 1000 \text{pF}, 2V\Delta \pm = \pm 5\text{V}$	22.5	25.0	27.5	KHz
Temperature Stability (Note 3)	$C_{T} = 1000 \text{pF}, 2V\Delta \pm = \pm 5V$			10	%
Error Amplifier Section (Note 5)					
Input Offset Voltage				10	mV
Input Bias Current				3	μΑ
Input Offset Current				600	nA
Open Loop Voltage Gain	$R_{L} = 2K\Omega$ $R_{L} = 2K\Omega$	70			dB
Output Voltage Swing	$R_1 = 2K\Omega$	±10			V
Common-Mode Rejection Ratio		70			dB
Slew Rate (Notes 3 and 4)	$T_{A} = 25^{\circ}C$	5	10		V/µs
Unity Gain Bandwidth (Notes 3 and 4)	$T_{A} = 25^{\circ}C$ $T_{A} = 25^{\circ}C$	0.7	1		MHz
PWM Comparators					
Input Bias Current	$\pm V_{T} = \pm 3V$			6	μA

# SG1731/SG2731/SG3731

## ELECTRICAL CHARACTERISTICS (continued)

Parameter	Test Conditions	SG1731/2731/3731 Min. ∣ Typ. ∣ Max.	Units
SHUTDOWN Section			
Logic Threshold	$-V_s = -3.5V$ to $-15V$	V <sub>s</sub> +0.8 V <sub>s</sub> +2.0	
SHUTDOWN HIGH Current	$V_{\text{SHUTDOWN}} = -V_{\text{S}} + 2.4 \text{V}$	400	μΑ
SHUTDOWN LOW Current	$-V_{s} = -3.5V \text{ to } -15V$ $V_{SHUTDOWN} = -V_{s} + 2.4V$ $V_{SHUTDOWN} = -V_{s}$	-1.0	mA
Output Drivers (Each Output)	<del>Shulbown</del> 3		
HIGH Output Voltage	I <sub>SOURCE</sub> = 20mA	19.2	
	I <sub>SOURCE</sub> = 100mA	19.0	V
LOW Output Voltage	I <sub>SINK</sub> = 20mA	-19.2	V V
	I <sub>SINK</sub> = 100mA	-19.0	l v
Driver Risetime	$\vec{C}_1 = 1000 \text{pF}$	300	ns
Driver Falltime	$C_{1} = 1000 \text{pF}$	300	ns
Total Supply Current			
V <sub>s</sub> Supply Current	$V_{autrown} = -V_a + 0.8V$	14	mA
V <sub>o</sub> Supply Current	$V_{SHUTDOWN} = -V_{S} + 0.8V$ $V_{SHUTDOWN} = -V_{S} + 0.8V$	6	mA

Note 4. Unity Gain Inverting  $10K\Omega$  Feedback Resistance.

#### **APPLICATION INFORMATION**

#### SUPPLY VOLTAGE

The SG1731 requires a supply voltage for the control circuitry ( $V_s$ ) and for the power output drivers ( $V_o$ ). Each supply may be either balanced positive and negative with respect to ground, or single-ended. The only restrictions are:

- 1. The voltage between +V  $_{\rm S}$  and -V  $_{\rm S}$  must be at least 7.0V; but no more than 44V.
- 2. The voltage between +V $_{\rm o}$  and -V $_{\rm o}$  must be at least 5.0V; but no more than 44V.
- 3. +V<sub>o</sub> must be at least 5V more positive than -V<sub>s</sub>. This eliminates the combination of a single-ended positive control supply with a single-ended negative driver supply.

#### SUBSTRATE CONNECTION

The substrate connection (Pin 10) must always be connected to either  $-V_s$  or  $-V_o$ , whichever is more negative. The substrate must also be well bypassed to ground with a high quality capacitor.

#### OSCILLATOR

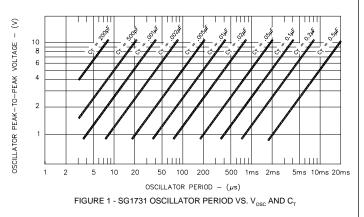
The triangle oscillator consists of two voltage comparators, a set/ reset flip-flop, a bi-directional 500µA current source, and an external timing capacitor C<sub>T</sub>. A positive reference voltage (2V $\Delta$ +) applied to Pin 2 determines the positive peak value of the triangle, and a negative reference voltage (2V $\Delta$ -) at Pin 7 sets the negative peak value of the triangle waveform.

Since the value of the internal current source is fixed at a nominal  $\pm 500\mu$ A, the oscillator period is a function of the selected peak-to-peak voltage excursion and the value of C<sub>T</sub>. The theoretical expression for the oscillator period is:

$$T_{\rm OSC} = \frac{2C_{\rm T} \, {\rm dV}}{5 \, {\rm x} \, 10^{-4}} \tag{Eq.1}$$

where  $C_{_{\rm T}}$  is the timing capacitor in Farads and dV is  $V_{_{OSC}}$  in Volts peak-to-peak.

As a design aid, the solutions to Equation 1 over the recommended range of  $T_{\rm osc}$  and  $V_{\rm osc}$  are given in graphic form in Figure 1. The lower limit on  $T_{\rm osc}$  is 1.85µs, corresponding to a maximum frequency of 350 KHz. The maximum value of  $V_{\rm osc}$ , (2VΔ+) - (2VΔ-), is 10V peak-to-peak for linear waveforms.



#### ERROR AMPLIFIER

The error amplifier of the SG1731 is a conventional internallycompensated operational amplifier with low output impedance. All of the usual feedback and frequency compensation techniques may be use to control the closed-loop gain characteristics. The control supply voltage  $\pm V_s$  will determine the input common mode range and output voltage swing; both will extend to within 3V of the  $V_s$  supply.

#### PULSE WIDTH MODULATION

Pulse width modulation occurs by comparing the triangle waveform to a fixed upper  $(+V_{T})$  and lower  $(-V_{T})$  threshold voltage. A crossing above the upper threshold causes Output A to switch to the HIGH state, and a crossing below

### APPLICATION INFORMATION (continued)

the lower threshold causes Output B to switch to the HIGH state. If  $\pm V_s$  is less than  $\pm 8V$  then  $\pm V_\tau$  can be obtained with resistors from  $\pm V_s$ . If  $\pm V_s$  is greater than  $\pm 8V$  use zeners.

Threshold crossings are generated by shifting the triangle waveform up and down with the error voltage (Pin 5). A positive error voltage will result in a pulse width modulated output at Driver A (Pin 13). Similarly, a negative error voltage produces a pulse train at Driver B (Pin 12). Figure 2 illustrates this process for the case where  $V_{\Delta+}$  is greater than  $V_{\tau}$ .

It is important to note that the triangle shifting circuit also attenuates the waveform seen at C<sub>T</sub> by a factor of 2. This results in a waveform at the PWM comparators with a positive peak of V $\Delta$ + and a negative peak of V $\Delta$ -, and must be taken into account when selecting the values for +V<sub>T</sub> and -V<sub>T</sub>.

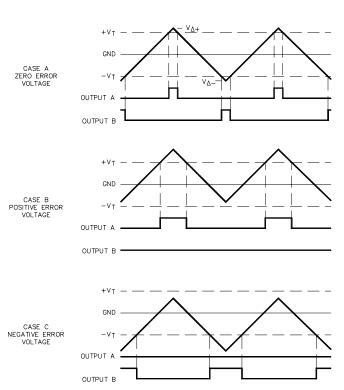
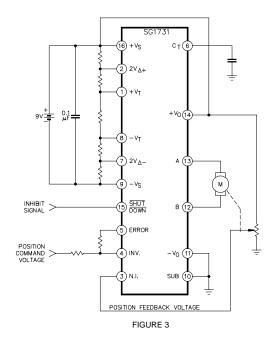
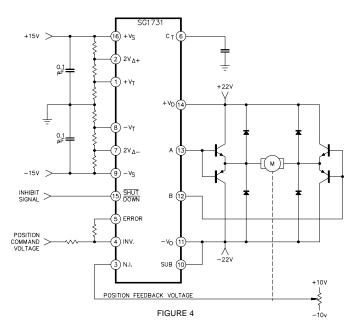


FIGURE 2 - PULSE WIDTH MODULATION WITH NO DEADBAND

#### **APPLICATION CIRCUITS**



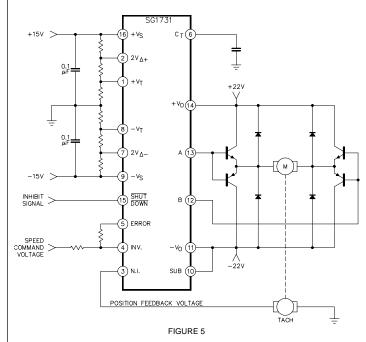


In this simple battery-powered position servo, the control supply and driver supply are both single-ended positive with respect to ground.

A high torque position servo is obtained by buffering the output drivers to obtain higher output current.

# SG1731/SG2731/SG3731

## **APPLICATION CIRCUITS**



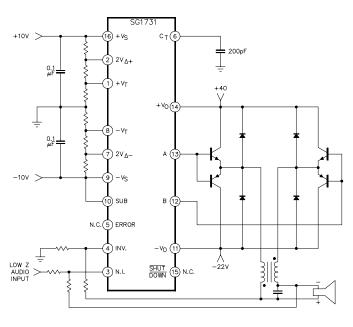


FIGURE 6

Bi-directional speed control results when the feedback voltage transducer is a tachometer.

The two-quadrant transfer function of the SG1731 is ideal for pulse width modulated audio power amplifiers.

## CONNECTION DIAGRAMS & ORDERING INFORMATION (See Note Below)

Package	Part No.	Ambient Temperature Range	Connection Diagram
16-PIN CERAMIC DIP J - PACKAGE	SG1731J/883B SG1731J SG2731J SG3731J	-55°C to 125°C -55°C to 125°C -25°C to 85°C 0°C to 65°C	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
16-PIN PLASTIC DIP N - PACKAGE	SG2731N SG3731N N Package: RoHS / Pb-free	-25°C to 85°C 0°C to 65°C e 100% Matte Tin Lead Finish	$\begin{array}{c cccc} C_{\tau} & \begin{array}{c} 6 & 11 \\ 2V_{\Delta} & 7 & 10 \\ -V_{\tau} & \begin{array}{c} 8 & 9 \\ \end{array} & \begin{array}{c} -V_{s} \\ -V_{s} \end{array}$ N Package: RoHS Compliant / Pb-free Transition DC: 0503

Note 1. All packages are viewed from the top.

Note 2. Contact factory for flatpack and leadless chip carrier availability.