LINFINITY
MICROELECTRONICS

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 ±100mA, ±22V 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.

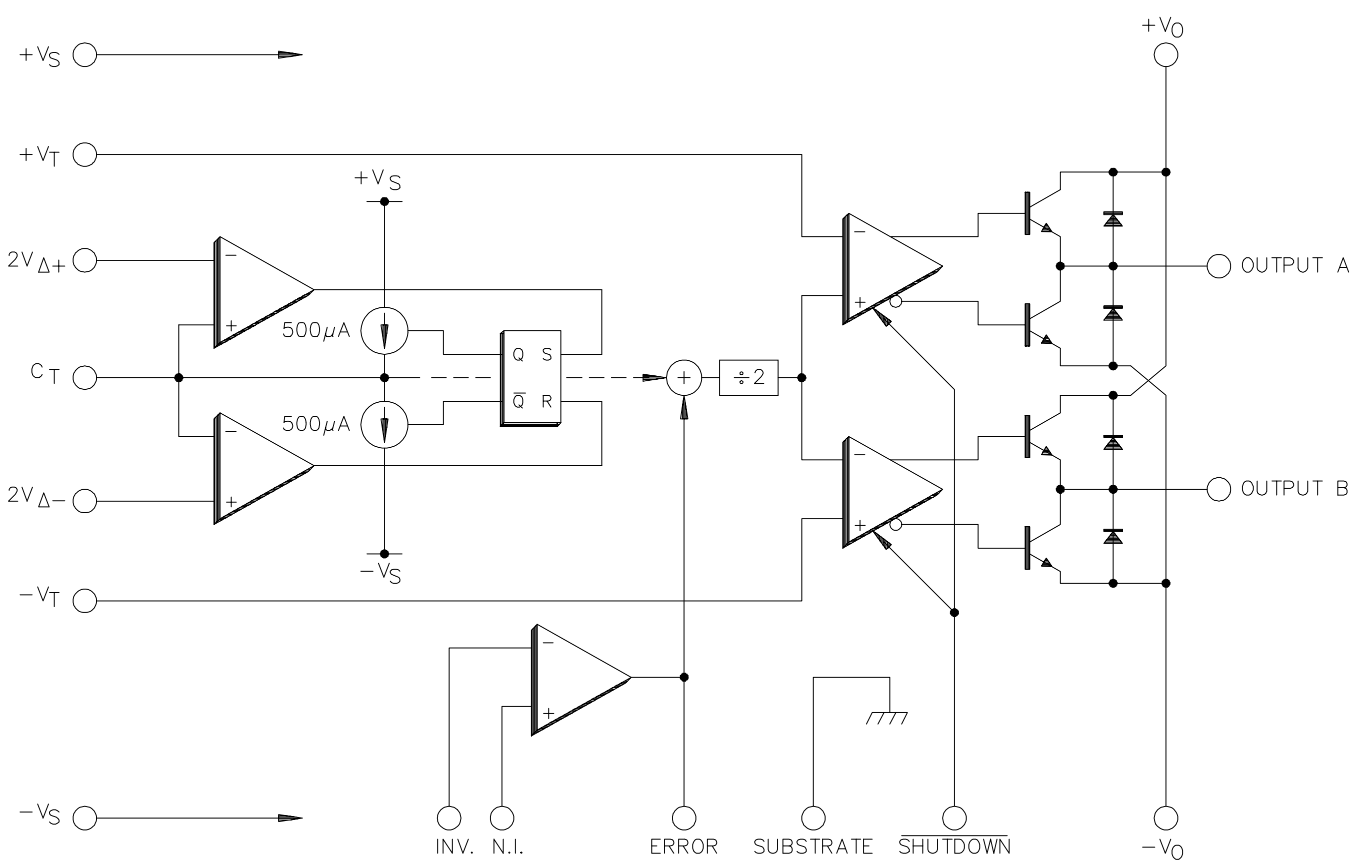
FEATURES

- **±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**

BLOCK DIAGRAM



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ABSOLUTE MAXIMUM RATINGS (Note1)

Supply Voltage ($\pm V_S$) .... $\pm$18V
Analog Inputs .... $\pm V_S$
Digital Inputs (~~SHUTDOWN~~) .... $-V_S$-0.3V to $-V_S$+18V
Output Driver Supply Voltage ($\pm V_O$) .... $\pm$25V
Source/Sink Output Current (continuous) 200mA
Source/Sink Output Current (peak, 500ns) 400mA

Note 1. Values beyond which damage may occur.

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 Range .... -65°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)

THERMAL DATA

J Package:
- Thermal Resistance-Junction to Case, θ_{JC} .... 30°C/W
- Thermal Resistance-Junction to Ambient, θ_{JA} .... 80°C/W

N Package:
- Thermal Resistance-Junction to Case, θ_{JC} .... 40°C/W
- Thermal Resistance-Junction to Ambient, θ_{JA} .... 65°C/W

Note A. Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.
Note B. The above numbers for θ_{JC} are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The θ_{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 ($\pm V_S$) .... $\pm$3.5V to $\pm$15V
Error Amp Common-Mode Range .... $-V_S$ + 3V to V_S - 3V
Output Driver Supply Voltage Range .... $\pm$2.5V to $\pm$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_T) .... 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 specfiications apply over the operating ambient temperatures for SG1731 with -55°C ≤ T_A ≤ 125°C, SG2731 with -25°C ≤ T_A ≤ 85°C, SG3731 with 0°C ≤ T_A ≤ 70°C, V_S = ±15V, and V_O = ±22V. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG1731/2731/3731 Min.	Typ.	Max.	Units
Oscillator Section					
C_T Charging Current	T_A = 25°C	450	500	550	µA
	$T_A = T_{MIN}$ to T_{MAX}	400		600	µA
2V∆± Input Bias Current	V_{CM} = ±5V			-20	µA
Initial Oscillator Frequency	C_T = 1000pF, 2V∆± = ±5V, T_A = 25°C	22.5	25.0	27.5	KHz
Temperature Stability (Note 3)	C_T = 1000pF, 2V∆± = ±5V			10	%
Error Amplifier Section (Note 5)					
Input Offset Voltage				10	mV
Input Bias Current				3	µA
Input Offset Current				600	nA
Open Loop Voltage Gain	R_L = 2KΩ	70			dB
Output Voltage Swing	R_L = 2KΩ	±10			V
Common-Mode Rejection Ratio		70			dB
Slew Rate (Notes 3 and 4)	T_A = 25°C	5	10		V/µs
Unity Gain Bandwidth (Notes 3 and 4)	T_A = 25°C	0.7	1		MHz
PWM Comparators					
Input Bias Current	$\pm V_T$ = ±3V			6	µA

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ELECTRICAL CHARACTERISTICS (continued)

Parameter	Test Conditions	SG1731/2731/3731 Min.	Typ.	Max.	Units
SHUTDOWN Section					
Logic Threshold	$-V_S$ = -3.5V to -15V	V_S+0.8		V_S+2.0	V
SHUTDOWN HIGH Current	$V_{SHUTDOWN} = -V_S+2.4V$			400	µA
SHUTDOWN LOW Current	$V_{SHUTDOWN} = -V_S$			-1.0	mA
Output Drivers (Each Output)					
HIGH Output Voltage	I_{SOURCE} = 20mA	19.2			V
	I_{SOURCE} = 100mA	19.0			V
LOW Output Voltage	I_{SINK} = 20mA			-19.2	V
	I_{SINK} = 100mA			-19.0	V
Driver Risetime	C_L = 1000pF			300	ns
Driver Falltime	C_L = 1000pF			300	ns
Total Supply Current					
V_S Supply Current	$V_{SHUTDOWN} = -V_S + 0.8V$			14	mA
V_O Supply Current	$V_{SHUTDOWN} = -V_S + 0.8V$			6	mA

Note 3. These parameters, although guaranteed, are not tested in production.
Note 4. Unity Gain Inverting 10KΩ Feedback Resistance.
Note 5. V_{CM} = ±12V.

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 $+V_S$ and $-V_S$ must be at least 7.0V; but no more than 44V.
2. The voltage between $+V_O$ and $-V_O$ must be at least 5.0V; but no more than 44V.
3. $+V_O$ must be at least 5V more positive than $-V_S$. 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_T. A positive reference voltage (2VΔ+) applied to Pin 2 determines the positive peak value of the triangle, and a negative reference voltage (2VΔ-) 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 ±500µA, the oscillator period is a function of the selected peak-to-peak voltage excursion and the value of C_T. The theoretical expression for the oscillator period is:

$$T_{OSC} = \frac{2C_T\,dV}{5 \times 10^{-4}} \quad \text{(Eq.1)}$$

where C_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_{OSC} and V_{OSC} are given in graphic form in Figure 1. The lower limit on T_{OSC} is 1.85µs, corresponding to a maximum frequency of 350 KHz. The maximum value of V_{OSC}, (2VΔ+) - (2VΔ-), is 10V peak-to-peak for linear waveforms.

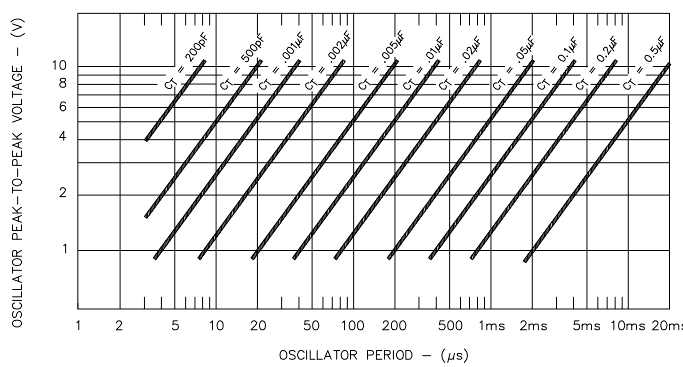

FIGURE 1 - SG1731 OSCILLATOR PERIOD VS. V_{OSC} AND C_T

ERROR AMPLIFIER

The error amplifier of the SG1731 is a conventional internally-compensated 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

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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 $\pm V_T$ 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_T.

It is important to note that the triangle shifting circuit also attenuates the waveform seen at C_T 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 $+V_T$ and $-V_T$.

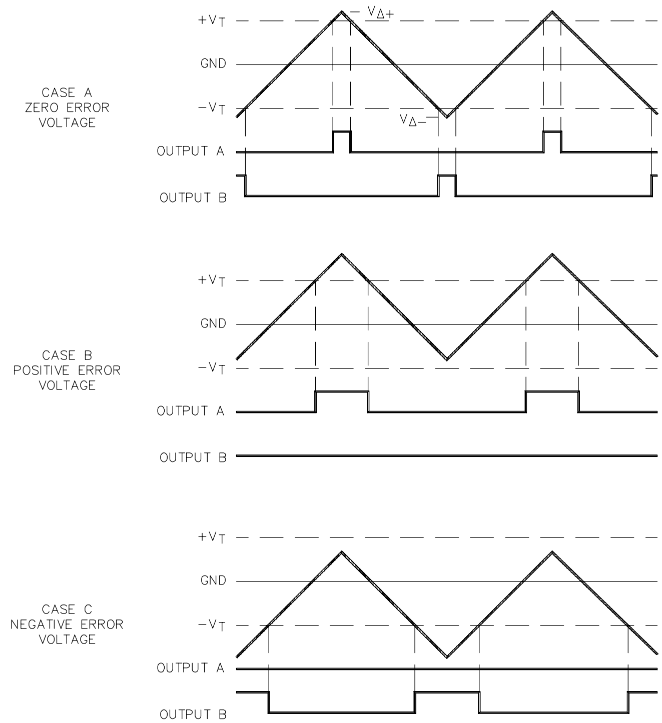

FIGURE 2 - PULSE WIDTH MODULATION WITH NO DEADBAND

APPLICATION CIRCUITS

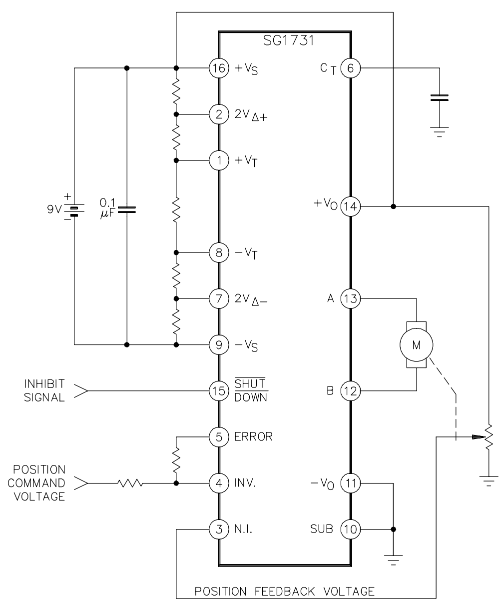

FIGURE 3

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

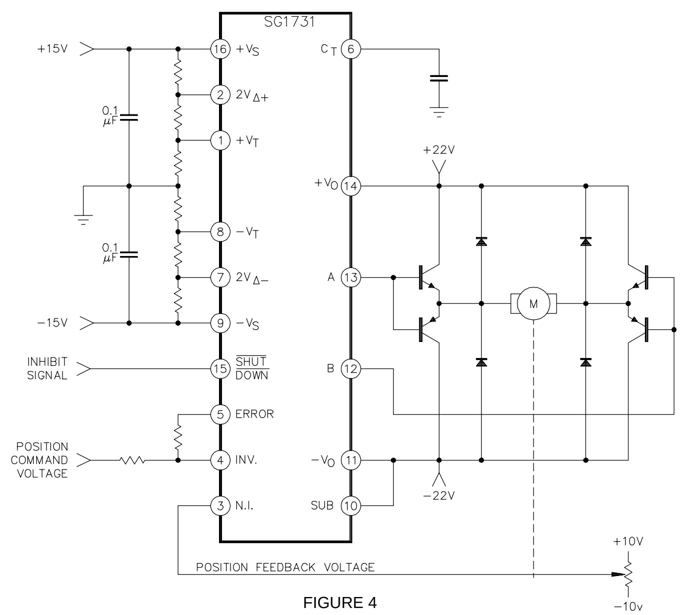

FIGURE 4

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

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APPLICATION CIRCUITS

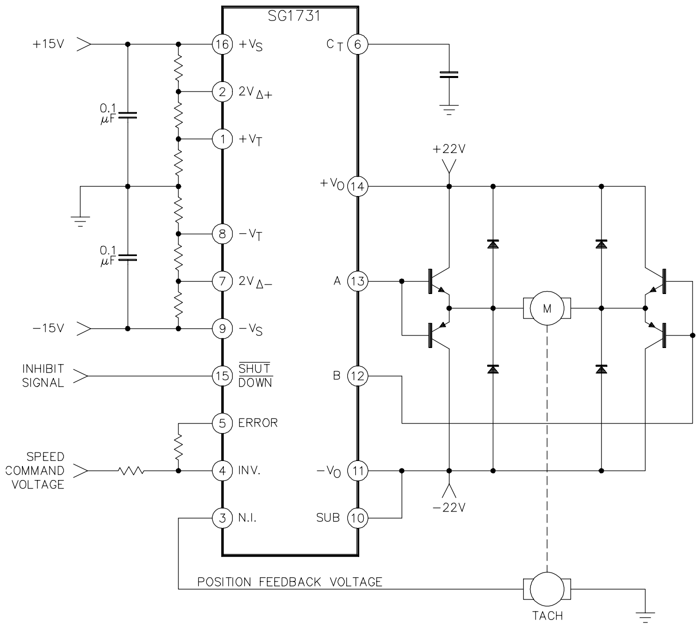


FIGURE 5

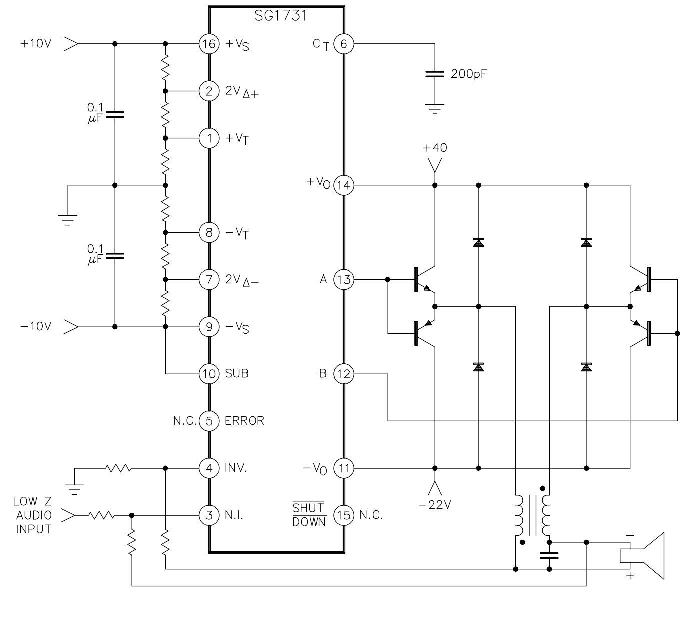
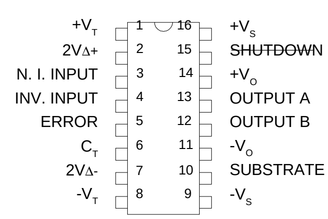


FIGURE 6

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	
16-PIN PLASTIC DIP N - PACKAGE	SG2731N SG3731N	-25°C to 85°C 0°C to 65°C	
	N Package: RoHS / Pb-free 100% Matte Tin Lead Finish		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.

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