

## RAD-TOLERANT CLASS-V, SWITCHED MODE CONTROLLER FOR DC MOTOR DRIVE

Check for Samples: [UC1637-SP](#)

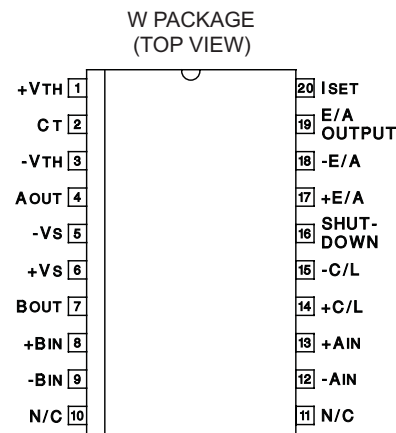
### FEATURES

- QML-V Qualified, SMD 5962-89957
- Rad Tolerant: 30 kRad(Si) TID <sup>(1)</sup>
  - TID Dose Rate = 10 mRad/sec
- Single or Dual Supply Operation
- $\pm 2.5\text{-V}$  to  $\pm 20\text{-V}$  Input Supply Range
- $\pm 5\%$  Initial Oscillator Accuracy;  $\pm 10\%$  Over Temperature
- Pulse-by-Pulse Current Limiting
- Under-Voltage Lockout
- Shutdown Input with Temperature Compensated 2.5-V Threshold
- Uncommitted PWM Comparators for Design

(1) Radiation tolerance is a typical value based upon initial device qualification. Radiation Lot Acceptance Testing is available - contact factory for details.

### Flexibility

- Dual 100-mA Source/Sink Output Drivers



### DESCRIPTION

The UC1637 is a pulse width modulator circuit intended to be used for a variety of PWM motor drive and amplifier applications requiring either uni-directional or bi-directional drive circuits. When used to replace conventional drivers, this circuit can increase efficiency and reduce component costs for many applications. All necessary circuitry is included to generate an analog error signal and modulate two bi-directional pulse train outputs in proportion to the error signal magnitude and polarity.

This monolithic device contains a sawtooth oscillator, error amplifier, and two PWM comparators with  $\pm 100\text{-mA}$  output stages as standard features. Protection circuitry includes under-voltage lockout, pulse-by-pulse current limiting, and a shutdown port with a 2.5-V temperature compensated threshold.

The UC1637 is characterized for operation over the full space temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

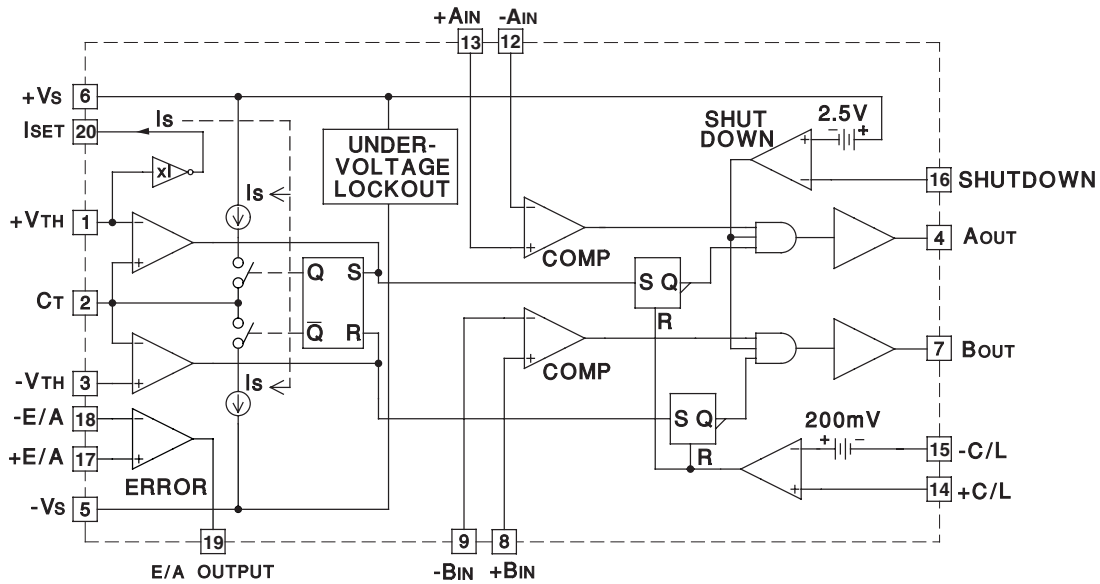
### ORDERING INFORMATION

$T_A$	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
$-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$	CFP-20	5962-8995701VSA	UC1637W-SP



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**FUNCTIONAL BLOCK DIAGRAM**



Note: Fault latches are reset dominant.

**ABSOLUTE MAXIMUM RATINGS<sup>(1) (2)</sup>**

over operating free-air temperature range (unless otherwise noted)

		VALUE	UNIT
$V_S$	Supply voltage	$\pm 20$	V
$I_O$	Output current, source/sink ( $A_{OUT}$ , $B_{OUT}$ )	Peak	500
		Steady-state	100
Analog inputs ( $+V_{TH}$ , $C_T$ , $-V_{TH}$ , $+B_{IN}$ , $-B_{IN}$ , $-A_{IN}$ , $+A_{IN}$ , $+C/L$ , $-C/L$ , SHUTDOWN, $+E/A$ , $-E/A$ )		$\pm V_S$	V
Error amplifier output current ( $E/A_{OUTPUT}$ )		$\pm 20$	mA
Oscillator charging current ( $I_{SET}$ )		-2	mA
$T_J$	Junction temperature	150	$^{\circ}C$
$T_{stg}$	Storage temperature range	-65 to 150	$^{\circ}C$
	Lead temperature (soldering, 10 seconds)	300	$^{\circ}C$

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Currents are positive into, negative out of the specified terminal.

## ELECTRICAL CHARACTERISTICS

over operating free-air temperature range,  $V_S = 15\text{ V}$ ,  $-V_S = -15\text{ V}$ ,  $+V_{TH} = 5\text{ V}$ ,  $-V_{TH} = -5\text{ V}$ ,  $R_T = 16.7\text{ k}\Omega$ ,  $C_T = 1500\text{ pF}$ ,  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C} = T_J$  (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>OSCILLATOR</b>						
Initial accuracy <sup>(1)</sup>		$T_J = 25^\circ\text{C}$	9.4	10	10.6	kHz
		$T_J = -55^\circ\text{C}$ to $125^\circ\text{C}$	9.2		10.8	
Voltage stability		$V_S = \pm 5\text{ V}$ to $\pm 20\text{ V}$ , $+V_{TH} = 3\text{ V}$ , $-V_{TH} = -3\text{ V}$		5	7	%
Temperature stability		Over operating range		0.5		%
Input bias current	$+V_{TH}$	$C_T = 6\text{ V}$	-10	0.1	10	$\mu\text{A}$
	$-V_{TH}$	$C_T = 0\text{ V}$	-10	-0.5		
Input range ( $+V_{TH}$ , $-V_{TH}$ )			$-V_S+2$		$+V_S-2$	V
<b>ERROR AMPLIFIER</b>						
Input offset voltage		$V_{CM} = 0\text{ V}$		1.5	$\pm 5$	mV
Input bias current		$V_{CM} = 0\text{ V}$		0.5	5	$\mu\text{A}$
Input offset current		$V_{CM} = 0\text{ V}$		0.1	$\pm 1$	$\mu\text{A}$
Common mode range		$V_S = \pm 2.5\text{ V}$ to $\pm 20\text{ V}$	$-V_S+2$		$+V_S$	V
Open loop voltage gain		$R_L = 10\text{ k}$	75	100		dB
Slew rate				15		V/ $\mu\text{s}$
Unity gain bandwidth				1		MHz
CMRR		Over common mode range	75	100		dB
PSRR		$V_S = \pm 2.5\text{ V}$ to $\pm 20\text{ V}$	75	110		dB
Output sink current		$E/A_{\text{OUTPUT}} = 0\text{ V}$	20	50		mA
Output source current		$E/A_{\text{OUTPUT}} = 0\text{ V}$		-11	-5	mA
High level output voltage			13	13.6		V
Low level output voltage				-14.8	-13	V
<b>PWM COMPARATORS</b>						
Input offset voltage		$V_{CM} = 0\text{ V}$	-10	20	50	mV
Input bias current		$V_{CM} = 0\text{ V}$		2	10	$\mu\text{A}$
Input Hysteresis		$V_{CM} = 0\text{ V}$		10	30	mV
Common mode range		$V_S = \pm 5\text{ V}$ to $\pm 20\text{ V}$	$-V_S+1$		$+V_S-2$	V
<b>CURRENT LIMIT</b>						
Input offset voltage		$V_{CM} = 0\text{ V}$ , $T_J = 25^\circ\text{C}$	190	200	210	mV
		$V_{CM} = 0\text{ V}$ , $T_J = -55^\circ\text{C}$ to $125^\circ\text{C}$	160		370	
Input offset voltage T.C.				-0.2		mV/ $^\circ\text{C}$
Input bias current			-10	-1.5		$\mu\text{A}$
Common mode range		$V_S = \pm 2.5\text{ V}$ to $\pm 20\text{ V}$	$-V_S$		$+V_S-3$	V
<b>SHUTDOWN</b>						
Shutdown threshold <sup>(2)</sup>			-2.7	-2.5	-2.3	V
Hysteresis				40		mV
Input bias current		SHUTDOWN = $+V_S$ to $-V_S$	-10	-0.5		$\mu\text{A}$
<b>UNDER-VOLTAGE LOCKOUT</b>						
Start threshold <sup>(3)</sup>				4.15	5	V
Hysteresis			75	250	500	mV
<b>TOTAL STANDBY CURRENT</b>						
Supply current				8.5	15	mA

(1)  $R_T$  and  $C_T$  referenced to ground.

(2) Parameter measured with respect to  $+V_S$  (Pin 6).

(3) Parameter measured at  $+V_S$  (Pin 6) with respect to  $-V_S$  (Pin 5).

## ELECTRICAL CHARACTERISTICS (continued)

over operating free-air temperature range,  $V_S = 15\text{ V}$ ,  $-V_S = -15\text{ V}$ ,  $+V_{TH} = 5\text{ V}$ ,  $-V_{TH} = -5\text{ V}$ ,  $R_T = 16.7\text{ k}\Omega$ ,  $C_T = 1500\text{ pF}$ ,  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C} = T_J$  (unless otherwise noted).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>OUTPUT SECTION</b>					
Output low level	$I_{SINK} = 20\text{ mA}$		-14.9	-13	V
	$I_{SINK} = 100\text{ mA}$		-14.5	-13	
Output high level	$I_{SOURCE} = 20\text{ mA}$	13	13.5		V
	$I_{SOURCE} = 100\text{ mA}$	12	13.5		
Rise time	$C_L = 1\text{ nF}$ , $T_J = 25^\circ\text{C}^{(4)}$		100	600	ns
Fall time	$C_L = 1\text{ nF}$ , $T_J = 25^\circ\text{C}^{(4)}$		100	300	ns

(4) Parameters ensured by design and/or characterization, if not production tested.

## FUNCTIONAL DESCRIPTION

The following is a description of each of the functional blocks shown in the Functional Block Diagram.

### Oscillator

The oscillator consists of two comparators, a charging and discharging current source, a current source set terminal,  $I_{SET}$ , and a flip-flop. The upper and lower threshold of the oscillator waveform is set externally by applying a voltage at pins  $+V_{TH}$  and  $-V_{TH}$  respectively. The  $+V_{TH}$  terminal voltage is buffered internally and also applied to the ISET terminal to develop the capacitor charging current through  $R_T$ . If  $R_T$  is referenced to  $-V_S$  as shown in Figure 1, both the threshold voltage and charging current will vary proportionally to the supply differential, and the oscillator frequency will remain constant. The triangle waveform oscillator's frequency and voltage amplitude are determined by the external components using the formulas given in Figure 1.

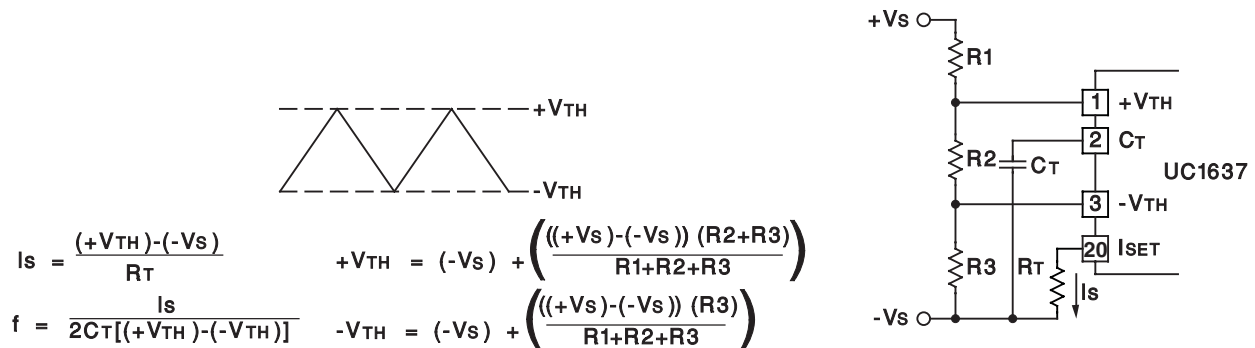


Figure 1. Oscillator Setup

## PWM Comparators

Two comparators are provided to perform pulse width modulation for each of the output drivers. Inputs are uncommitted to allow maximum flexibility. The pulse width of the outputs A and B is a function of the sign and amplitude of the error signal. A negative signal at -AIN and +BIN will lengthen the high state of output A and shorten the high state of output B. Likewise, a positive error signal reverses the procedure. Typically, the oscillator waveform is compared against the summation of the error signal and the level set on -BIN and +AIN.

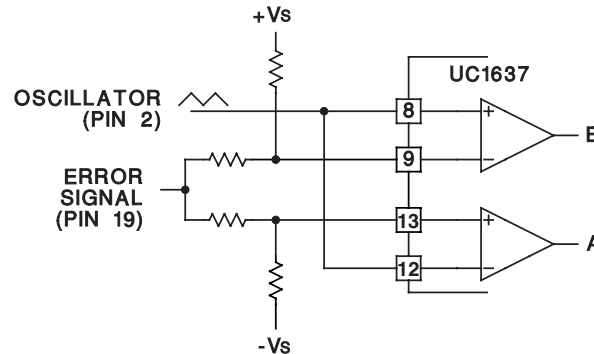


Figure 2. Comparator Biasing

## MODULATION SCHEMES

### Case A Zero Deadtime (Equal voltage on -BIN and +AIN)

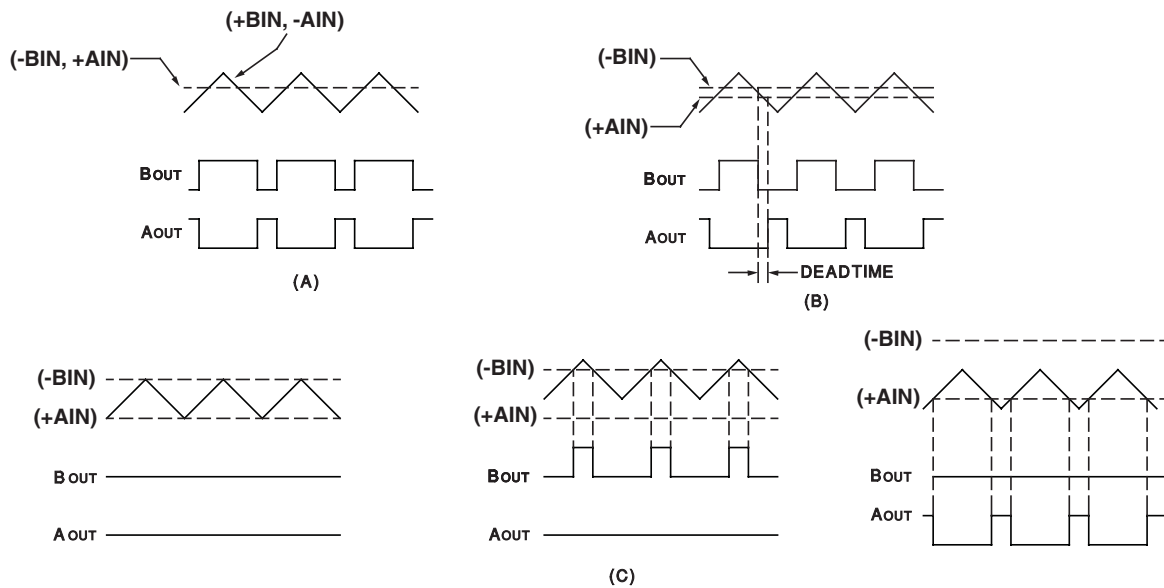
In this configuration, maximum holding torque or stiffness and position accuracy is achieved. However, the power input into the motor is increased. [Figure 3 \(A\)](#) shows this configuration.

### Case B Small Deadtime (Voltage on -BIN > +AIN)

A small differential voltage between -BIN and +AIN provides the necessary time delay to reduce the chances of momentary short circuit in the output stage during transitions, especially where power-amplifiers are used. Refer to [Figure 3 \(B\)](#).

### Case C Increased Deadtime and Deadband Mode (Voltage on -BIN > +AIN)

With the reduction of stiffness and position accuracy, the power input into the motor around the null point of the servo loop can be reduced or eliminated by widening the window of the comparator circuit to a degree of acceptance. Where position accuracy and mechanical stiffness is unimportant, deadband operation can be used. This is shown in [Figure 3 \(C\)](#).



**Figure 3. Modulation Schemes Showing (A) Zero Deadtime, (B) Deadtime and (C) Deadband Configurations**

### Output Drivers

Each output driver is capable of both sourcing and sinking 100 mA steady state and up to 500 mA on a pulsed basis for rapid switching of either POWERFET or bipolar transistors. Output levels are typically  $-V_S+0.2$  V at 50 mA low level and  $+V_S-2$  V at 50 mA high level.

### Error Amplifier

The error amplifier consists of a high slew rate (15 V/ $\mu$ s) op-amp with a typical 1-MHz bandwidth and low output impedance. Depending on the  $\pm V_S$  supply voltage, the common mode range and the voltage output swing is within 2 V of the  $V_S$  supply.

### Under-Voltage Lockout

An under-voltage lockout circuit holds the outputs in the low state until a minimum of 4 V is reached. At this point, all internal circuitry is functional and the output drivers are enabled. If external circuitry requires a higher starting voltage, an over-riding voltage can be programmed through the shutdown terminal as shown in [Figure 4](#).

### Shutdown Comparator

The shutdown terminal may be used for implementing various shutdown and protection schemes. By pulling the terminal more than 2.5 V below  $V_{IN}$ , the output drivers will be enabled. This can be realized using an open collector gate or NPN transistor biased to either ground or the negative supply. Since the threshold is temperature stabilized, the comparator can be used as an accurate low voltage lockout ([Figure 4](#)) and/or delayed start as in [Figure 5](#). In the shutdown mode the outputs are held in the low state.

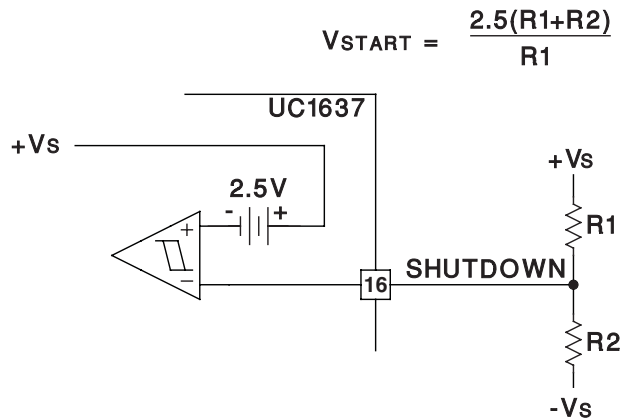


Figure 4. External Under-Voltage Lockout

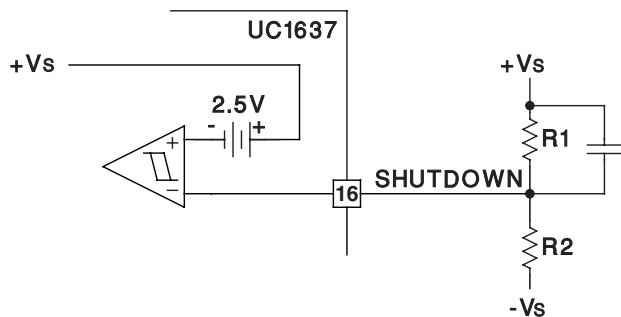


Figure 5. Delayed Start-up

### Current Limit

A latched current limit amplifier with an internal 200-mV offset is provided to allow pulse-by-pulse current limiting. Differential inputs will accept common mode signals from  $-V_S$  to within 3 V of the  $+V_S$  supply while providing excellent noise rejection. Figure 6 shows a typical current sense circuit.

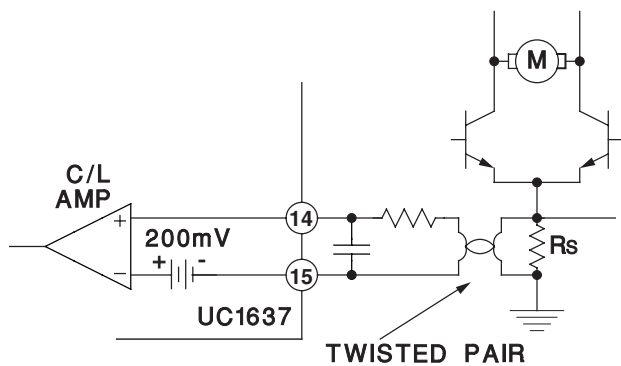


Figure 6. Current Limit Sensing

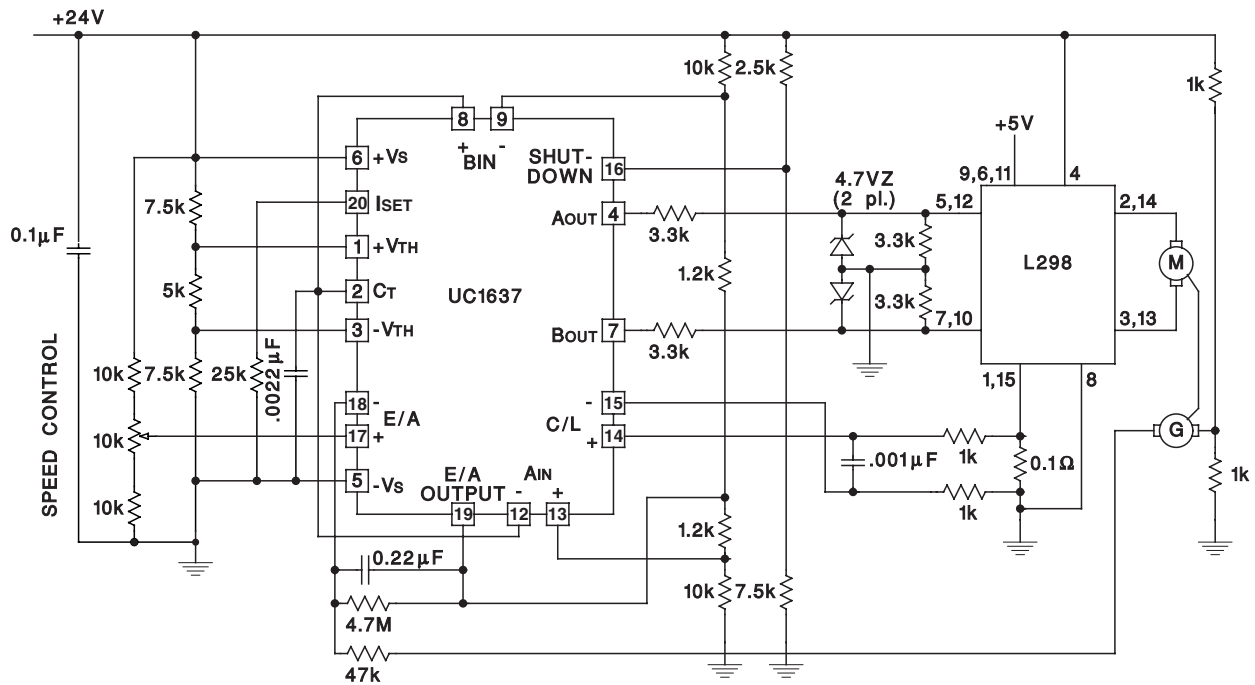


Figure 7. Bi-Directional Motor Drive With Speed Control Power-Amplifier

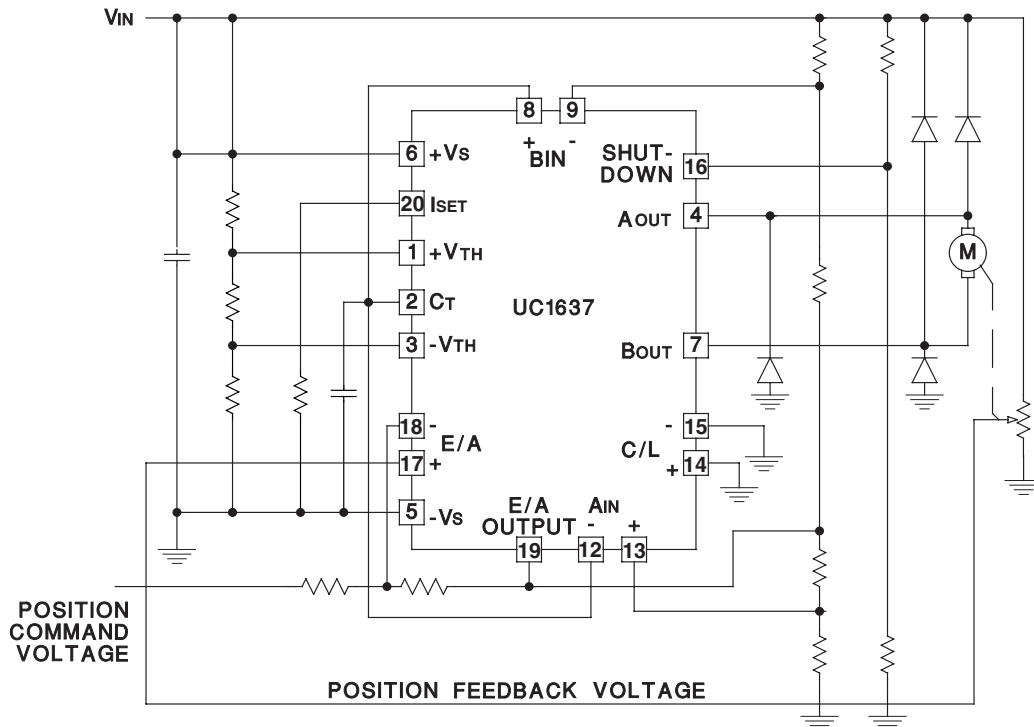


Figure 8. Single Supply Position Servo Motor Drive



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
5962-8995701VSA	ACTIVE	CFP	W	20	25	TBD	Call TI	N / A for Pkg Type	Contact TI Distributor or Sales Office

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

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**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**OTHER QUALIFIED VERSIONS OF UC1637-SP :**

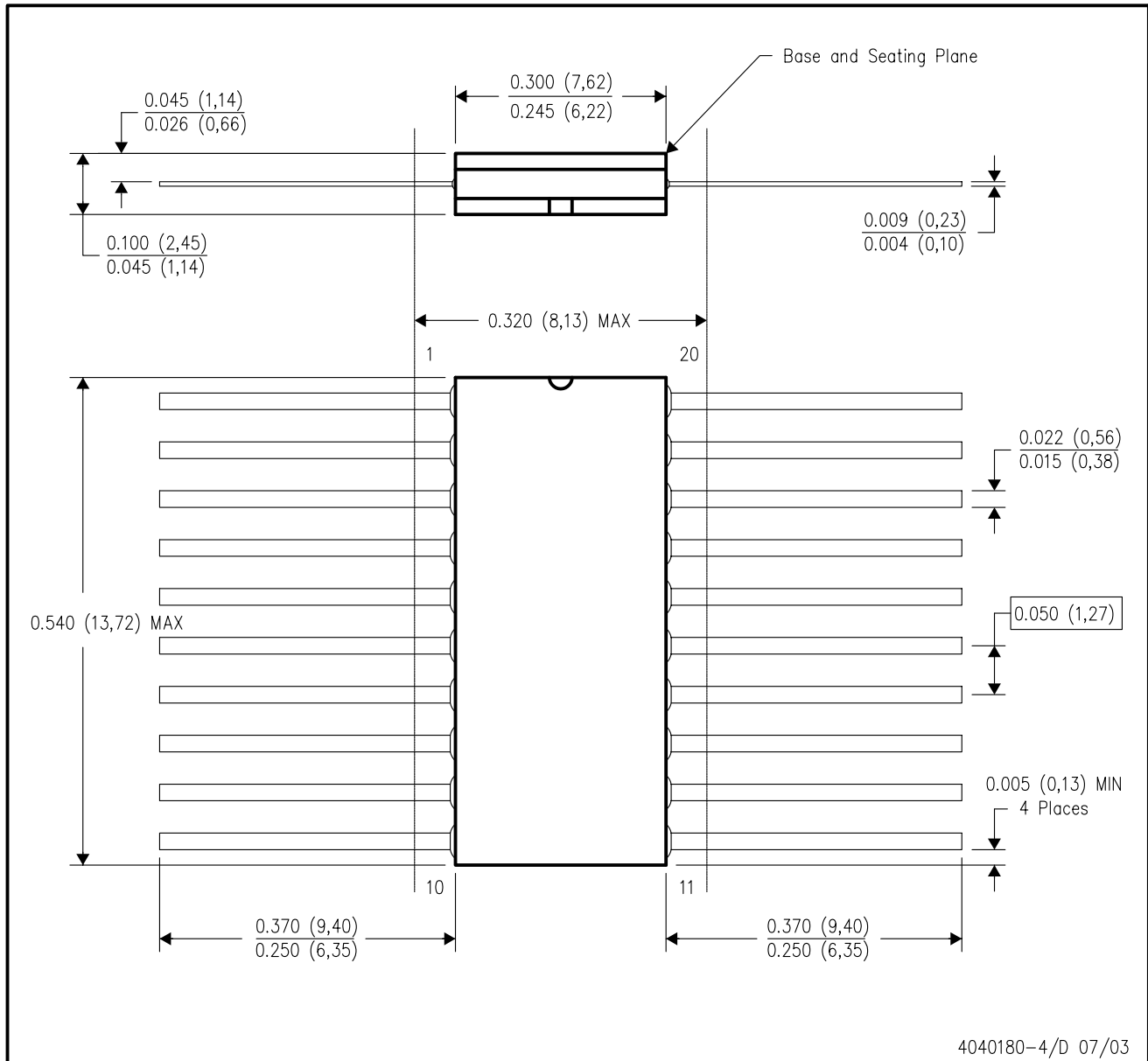
- Catalog: [UC1637](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

W (R-GDFP-F20)

CERAMIC DUAL FLATPACK



4040180-4/D 07/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only.
  - E. Falls within Mil-Std 1835 GDFP2-F20

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DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	Space, Avionics & Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
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