UNITRODE

UC1637
UC2637
UC3637

Switched Mode Controller for DC Motor Drive

FEATURES

- Single or Dual Supply Operation
- ±2.5V to ±20V Input Supply Range
- ±5% Initial Oscillator Accuracy; ± 10% Over Temperature
- Pulse-by-Pulse Current Limiting
- Under-Voltage Lockout
- Shutdown Input with Temperature Compensated 2.5V Threshold
- Uncommitted PWM Comparators for Design Flexibility
- Dual 100mA, 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 ±100mA output stages as standard features. Protection circuitry includes under-voltage lockout, pulse-by-pulse current limiting, and a shutdown port with a 2.5V temperature compensated threshold.

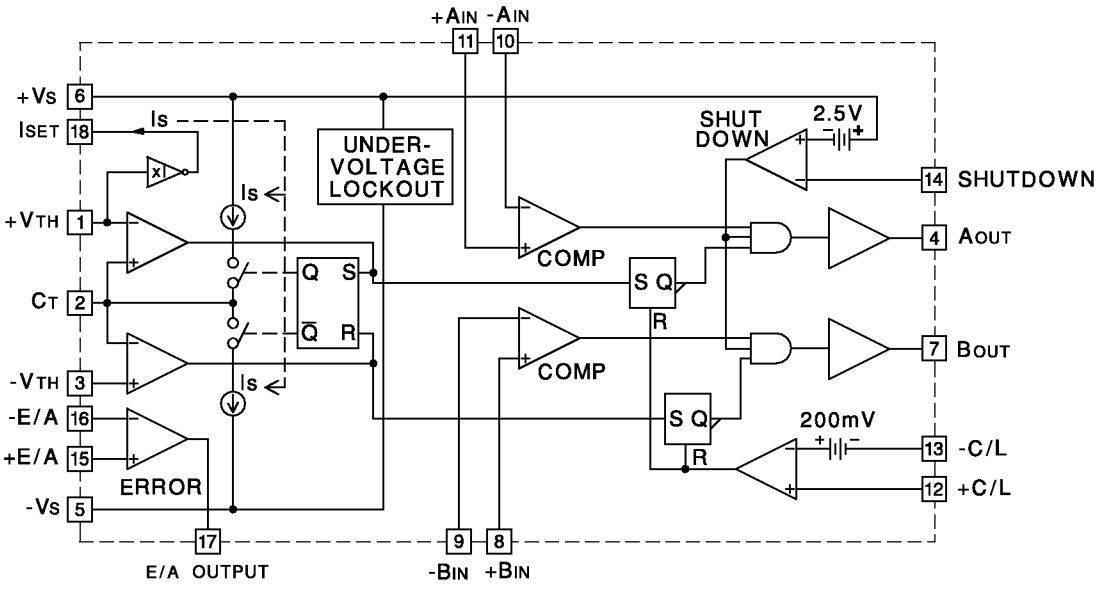
The UC1637 is characterized for operation over the full military temperature range of -55°C to +125°C, while the UC2637 and UC3637 are characterized for -25°C to +85°C and 0°C to +70°C, respectively.

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (±Vs)	±20V
Output Current, Source/Sink (Pins 4, 7)	500mA
Analog Inputs (Pins 1, 2, 3, 8, 9, 10, 11 12, 13, 14, 15, 16)	±Vs
Error Amplifier Output Current (Pin 17)	±20mA
Oscillator Charging Current (Pin 18)	-2mA
Power Dissipation at T_A = 25°C (Note 2)	1000mW
Power Dissipation at T_C = 25°C (Note 2)	2000mW
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 Seconds)	+300°C

Note 1: Currents are positive into, negative out of the specified terminal.
Note 2: Consult Packaging Section of Databook for thermal limitations and considerations of package.

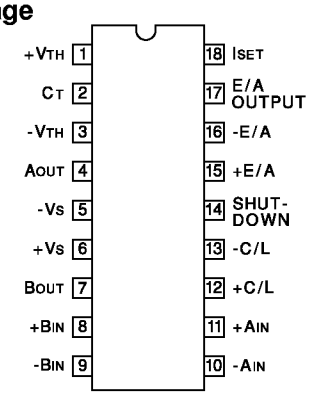
BLOCK DIAGRAM



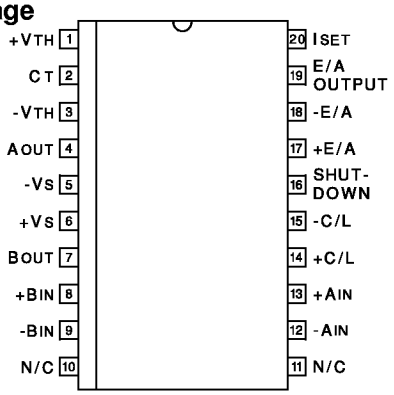
Note: Fault latches are reset dominant.

CONNECTION DIAGRAM

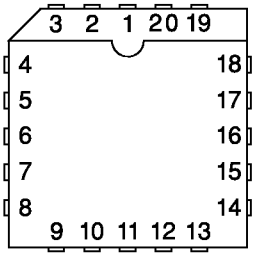
DIL-18 (TOP VIEW)
J or N Package



SOIC-20 (TOP VIEW)
DW Package



PLCC-20, LCC-20
(TOP VIEW)
Q, L Packages



PACKAGE PIN FUNCTION	
FUNCTION	**PIN**
+VTH	1
CT	2
-VTH	3
AOUT	4
-VS	5
N/C	6
+VS	7
BOUT	8
+BIN	9
-BIN	10
-AIN	11
+AIN	12
+C/L	13
-C/L	14
SHUTDOWN	15
N/C	16
+E/A	17
-E/A	18
E/A OUTPUT	19
ISET	20

ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these specifications apply for T_A = -55°C to +125°C for the UC1637; -25°C to +85°C for the UC2637; and 0°C to +70°C for the UC3637; +V_S= +15V, -V_S = - 15V, +V_{TH} = 5V, -V_{TH} = -5V, R_T = 16.7kΩ, C_T = 1500pF, T_A=T_J.

PARAMETER	TEST CONDITIONS	UC1637/UC2637			UC3637			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Oscillator								
Initial Accuracy	T_J = 25°C (Note 6)	9.4	10	10.6	9	10	11	kHz
Voltage Stability	V_S = ±5V to ±20V, $V_{PIN\ 1}$ = 3V, $V_{PIN\ 3}$ = -3V		5	7		5	7	%
Temperature Stability	Over Operating Range (Note 3)		0.5	2		0.5	2	%
+V_{TH} Input Bias Current	$V_{PIN\ 2}$ = 6V	-10	0.1	10	-10	0.1	10	µA
-V_{TH} Input Bias Current	$V_{PIN\ 2}$ = 0V	-10	-0.5		-10	-0.5		µA
+V_{TH}, -V_{TH} Input Range		+V_S-2		-V_S+2	+V_S-2		-V_S+2	V
Error Amplifier								
Input Offset Voltage	V_{CM} = 0V		1.5	5		1.5	10	mV
Input Bias Current	V_{CM} = 0V		0.5	5		0.5	5	µA
Input Offset Current	V_{CM} = 0V		0.1	1		0.1	1	µA
Common Mode Range	V_S = ±2.5 to 20V	-V_S+2		+V_S	-V_S+2		+V_S	V
Open Loop Voltage Gain	R_L = 10k	75	100		80	100		dB
Slew Rate			15			15		V/µs
Unity Gain Bandwidth			2			2		MHz
CMRR	Over Common Mode Range	75	100		75	100		dB
PSRR	V_S = ±2.5 to ±20V	75	110		75	110		dB

ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these specifications apply for T_A = -55°C to +125°C for the UC1637; -25°C to +85°C for the UC2637; and 0°C to +70°C for the UC3637: V_S= +15V, $-V_S$ = - 15V, $+V_{TH}$ = 5V, $-V_{TH}$ = -5V, R_T = 16.7kΩ, C_T = 1500pF, T_A=T_J.

PARAMETERS	TEST CONDITIONS	UC1637/UC2637			UC3637			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Error Amplifier (Continued)								
Output Sink Current	$V_{PIN\ 17}$ = 0V		-50	-20		-50	-20	mA
Output Source Current	$V_{PIN\ 17}$ = 0V	5	11		5	11		mA
High Level Output Voltage		13	13.6		13	13.6		V
Low Level Output Voltage			-14.8	-13		-14.8	-13	V
PWM Comparators								
Input Offset Voltage	V_{CM} = 0V		20			20		mV
Input Bias Current	V_{CM} = 0V		2	10		2	10	µA
Input Hysteresis	V_{CM} = 0V		10			10		mV
Common Mode range	V_S = ±5V to ±20V	$-V_S$+1		$+V_S$-2	$-V_S$+1		$+V_S$-2	V
Current Limit								
Input Offset Voltage	V_{CM} = 0V, T_J = 25°C	190	200	210	180	200	220	mV
Input Offset Voltage T.C.			-0.2			-0.2		mV/°C
Input Bias Current		-10	-1.5		-10	-1.5		µA
Common Mode Range	V_S = ±2.5V to ±20V	$-V_S$		$+V_S$-3	$-V_S$		$+V_S$-3	V
Shutdown								
Shutdown Threshold	(Note 4)	-2.3	-2.5	-2.7	-2.3	-2.5	-2.7	V
Hysteresis			40			40		mV
Input Bias Current	$V_{PIN\ 14}$ = +V_S to -V_S	-10	-0.5		-10	-0.5		µA
Under-Voltage Lockout								
Start Threshold	(Note 5)		4.15	5.0		4.15	5.0	V
Hysteresis			0.25			0.25		mV
Total Standby Current								
Supply Current			8.5	15		8.5	15	mA
Output Section								
Output Low Level	I_{SINK} = 20mA		-14.9	-13		-14.9	-13	V
	I_{SINK} = 100mA		-14.5	-13		-14.5	-13	
Output High Level	I_{SOURCE} = 20mA	13	13.5		13	13.5		V
	I_{SOURCE} = 100mA	12	13.5		12	13.5		
Rise Time	(Note 3) C_L = Inf, T_J = 25°C		100	600		100	600	ns
Fall Time	(Note 3) C_L = Inf, T_J = 25°C		100	300		100	300	ns

Note 3: These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.
Note 4: Parameter measured with respect to +V_S (Pin 6).
Note 5: Parameter measured at +V_S (Pin 6) with respect to -V_S (Pin 5).
Note 6: R_T and C_T referenced to Ground.

FUNCTIONAL DESCRIPTION

Following is a description of each of the functional blocks shown in the 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 I_{SET} 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 oscillators frequency and voltage amplitude is determined by the external components using the formulas given in Figure 1.

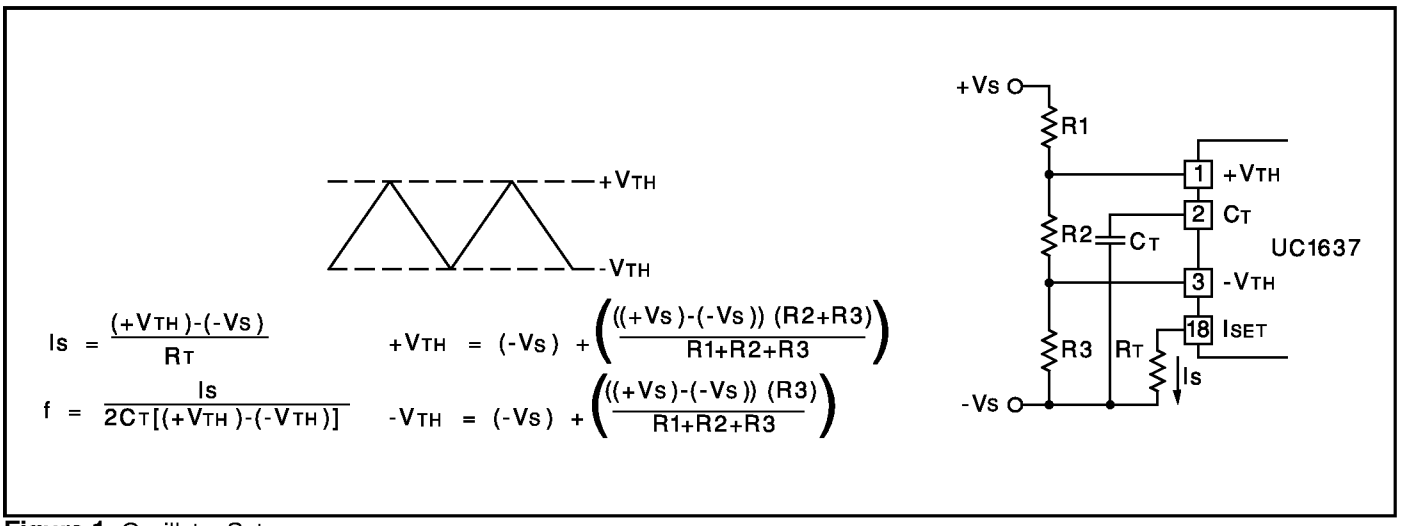


Figure 1. Oscillator Setup

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 Pin 10 and 8 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 Pin 9 and 11.

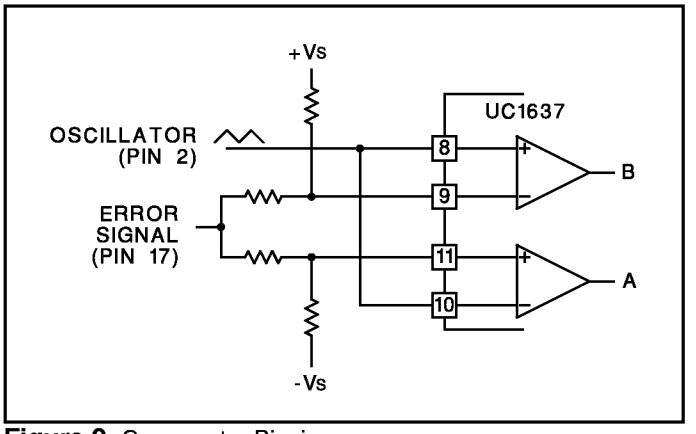


Figure 2. Comparator Biasing

MODULATION SCHEMES

Case A Zero Deadtime (Equal voltage on Pin 9 and Pin 11)
In this configuration, maximum holding torque or stiffness and position accuracy is achieved. However, the power input into the motor is increased. Figure 3A shows this configuration.

Case B Small Deadtime (Voltage on Pin 9 > Pin 11)
A small differential voltage between Pin 9 and 11 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 3B.

Case C Increased Deadtime and Deadband Mode
(Voltage on Pin 9 > Pin 11)
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 3C.

Output Drivers

Each output driver is capable of both sourcing and sinking 100mA steady state and up to 500mA on a pulsed basis for rapid switching of either POWERFET or bipolar transistors. Output levels are typically -Vs + 0.2V @50mA low level and +Vs - 2.0V @50mA high level.

Error Amplifier

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

Under-Voltage Lockout

An under-voltage lockout circuit holds the outputs in the low state until a minimum of 4V 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.

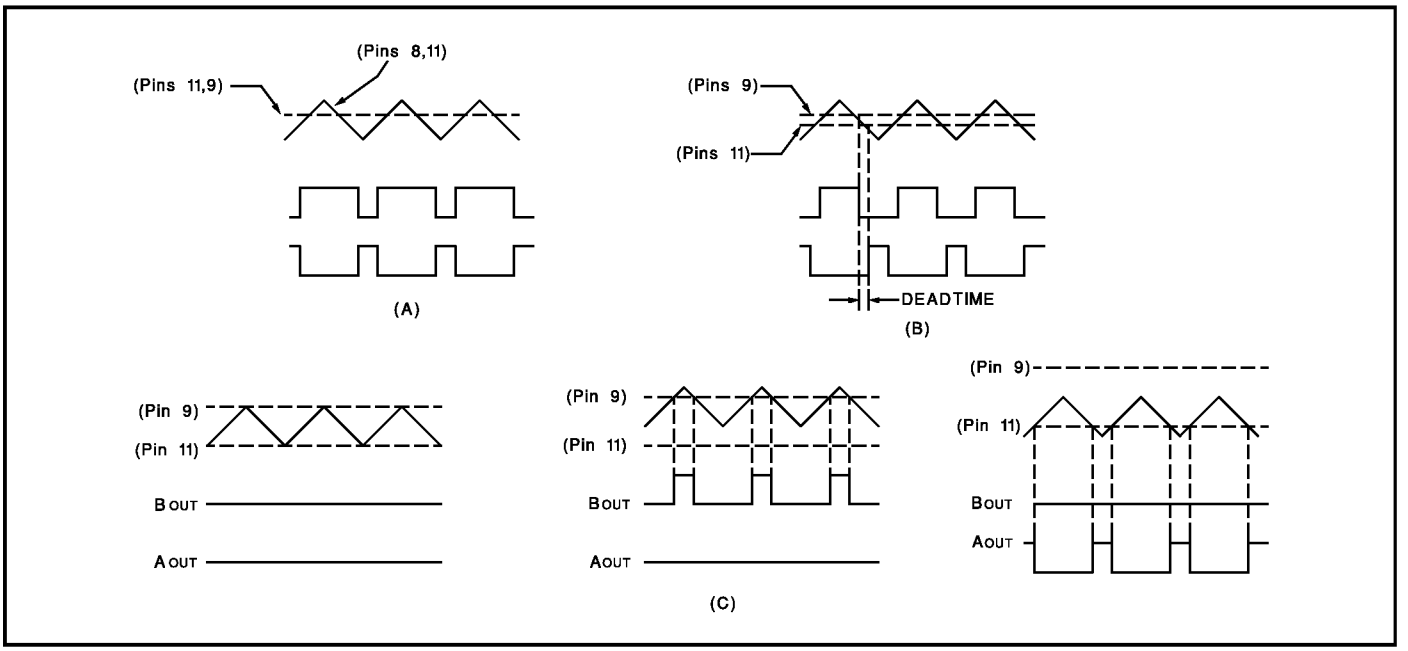


Figure 3. Modulation Schemes Showing (A) Zero Deadtime (B) Deadtime and (C) Deadband Configurations

Shutdown Comparator

The shutdown terminal may be used for implementing various shutdown and protection schemes. By pulling the terminal more than 2.5V below VIN, 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.

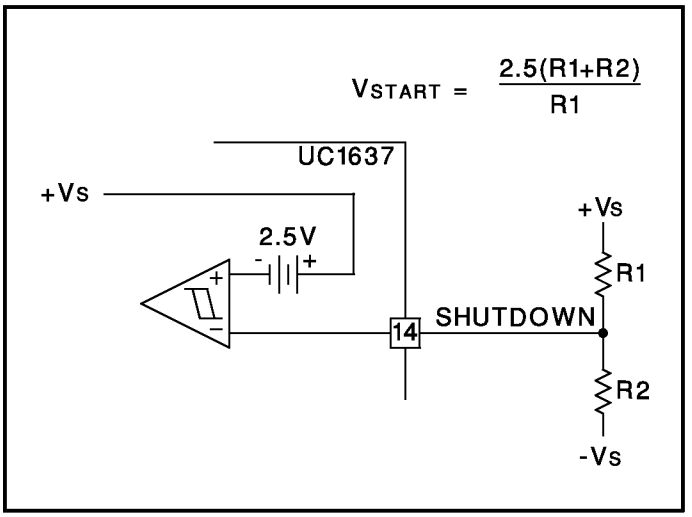


Figure 4. External Under-Voltage Lockout

Current Limit

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

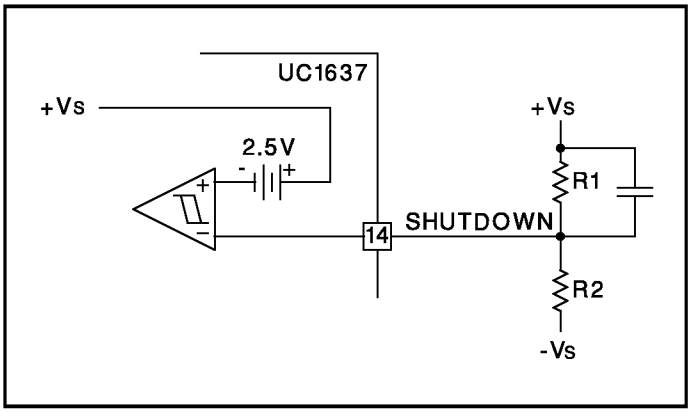


Figure 5. Delayed Start-Up

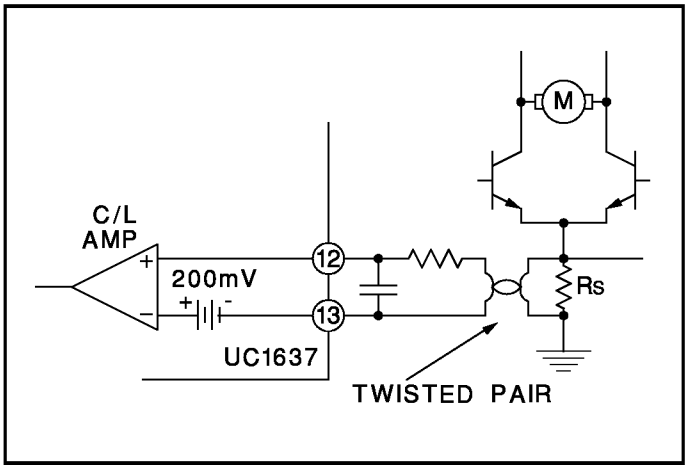


Figure 6. Current Limit Sensing

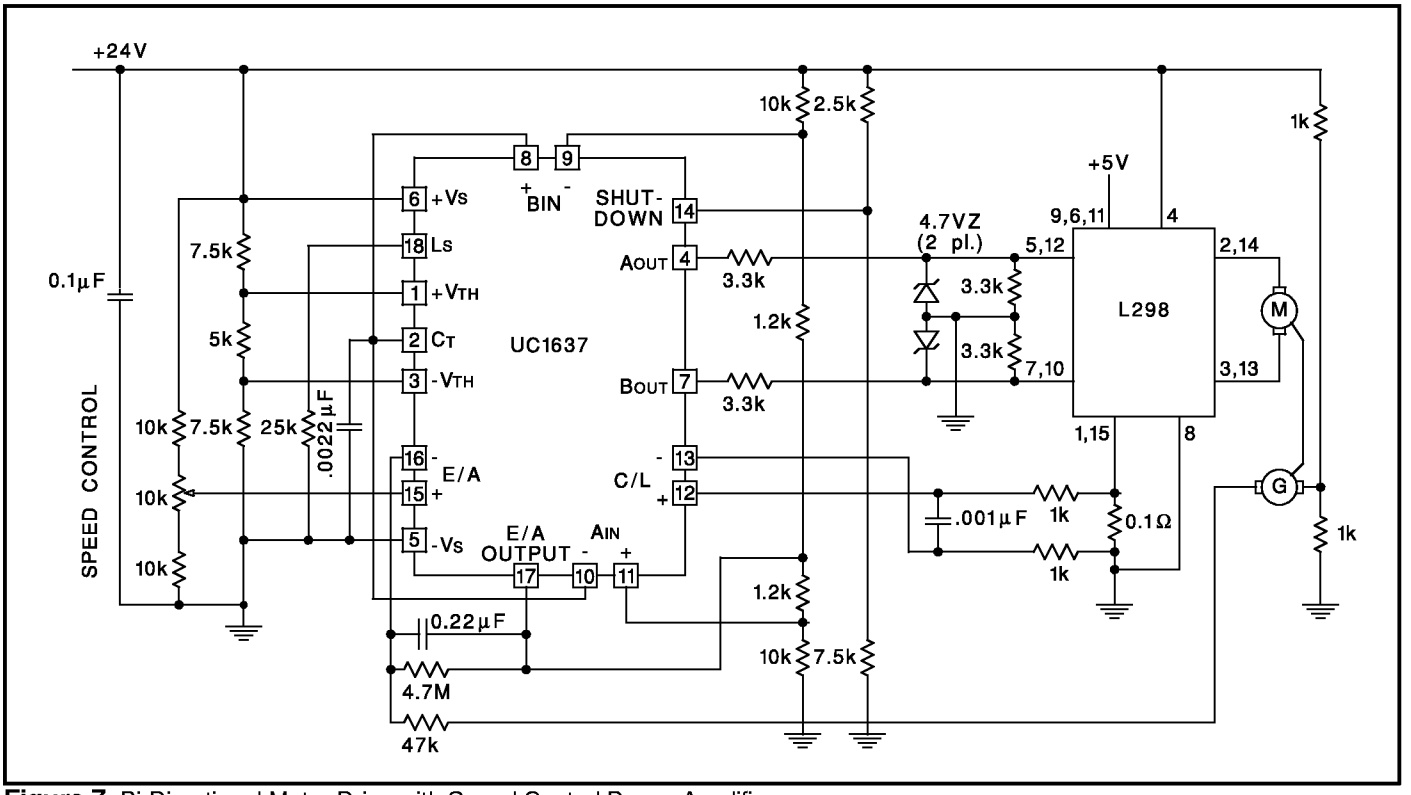


Figure 7. Bi-Directional Motor Drive with Speed Control Power-Amplifier

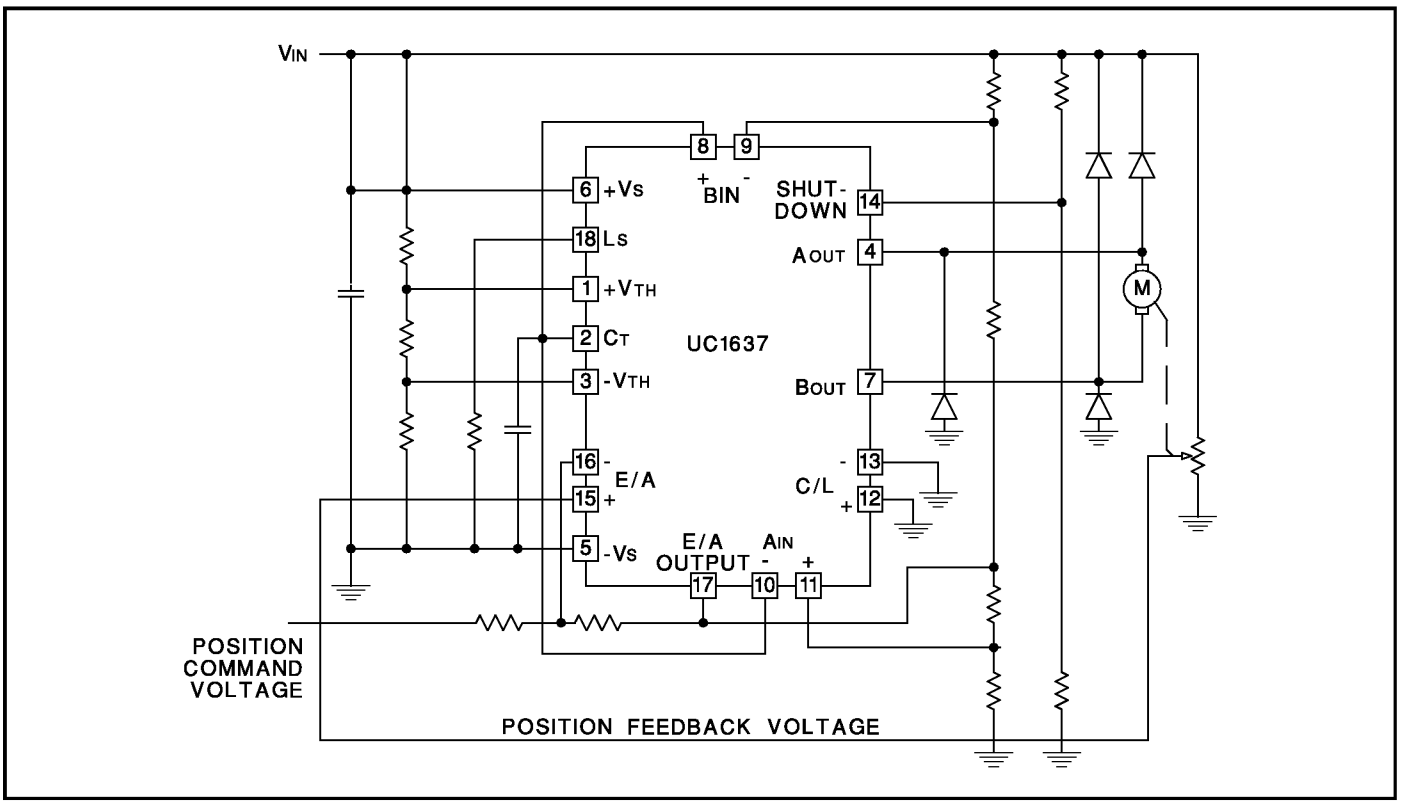


Figure 8. Single Supply Position Servo Motor Drive

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Mechanical Drawings

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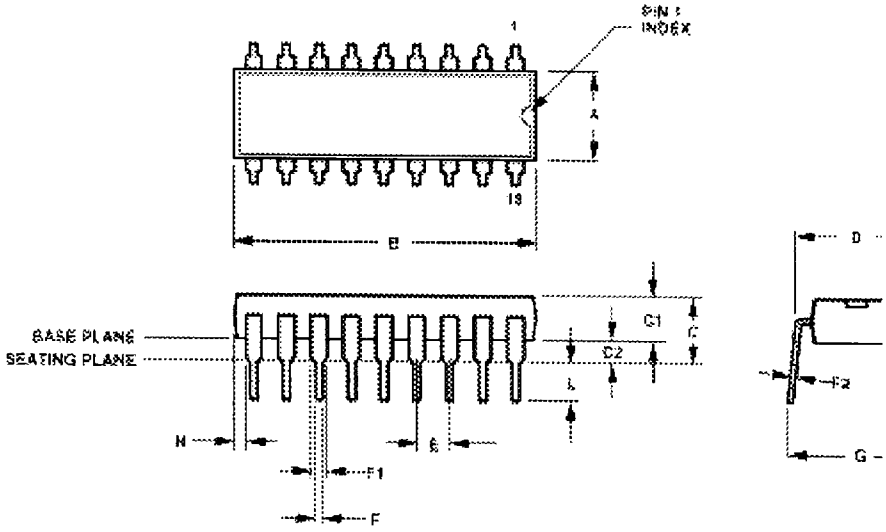
18-PIN PLASTIC DIP ~ N PACKAGE SUFFIX

	DIMENSIONS				
	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	.245	.260	6.22	6.60	1
B	.890	.920	22.61	23.39	1
C	-	.210	-	5.33	
C1	.125	.150	3.18	3.81	
C2	.015	.055	0.38	1.40	2
D	.300	.325	7.62	8.26	3
E	.100 BSC		2.54 BSC		4
F	.014	.022	0.35	0.56	
F1	.045	.070	1.14	1.78	
F2	.008	.014	0.20	0.35	
G	.300	.400	7.62	10.16	5
H	.005	-	0.13	-	
L	.115	.160	2.92	4.06	



NOTES:

1. 'A' AND 'B' DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 IN. PER SIDE.
2. 'C2' SHALL BE MEASURED FROM THE SEATING PLANE TO THE BASE PLANE.
3. 'D' SHALL BE MEASURED WITH THE LEADS CONSTRAINED TO BE PERPENDICULAR TO THE BASE PLANE.
4. THE BASIC LEAD SPACING IS 0.100 IN. BETWEEN CENTERLINES. EACH LEAD CENTERLINE SHALL BE LOCATED WITHIN ±0.010 IN. OF ITS EXACT TRUE POSITION.
5. 'G' SHALL BE MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
6. CONTROLLING DIMENSION: INCHES. MILLIMETERS SHOWN FOR REFERENCE ONLY.

P-4

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Mechanical Drawings

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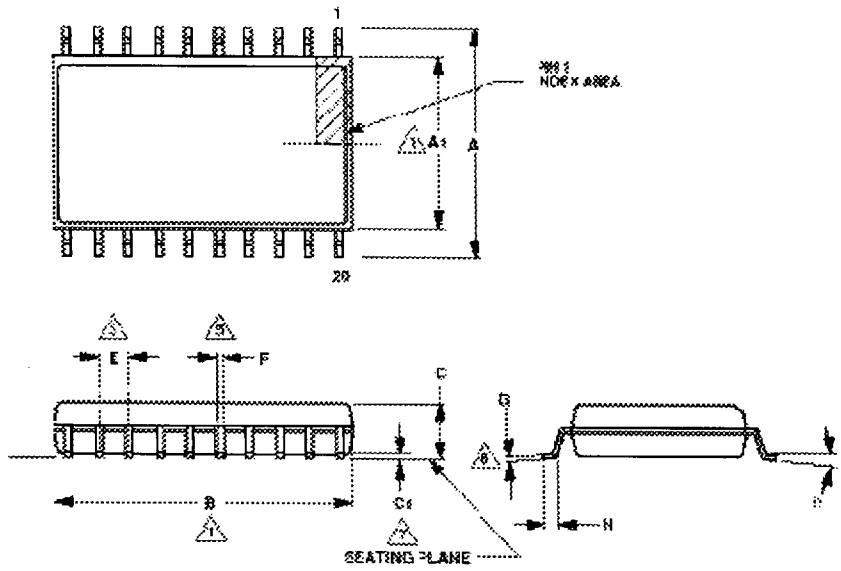
20-PIN SOIC SURFACE MOUNT~ DW PACKAGE SUFFIX

DIMENSIONS				
	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.394	.419	10.00	10.64
A1	.292	.299	7.42	7.59
B	.504	.511	12.80	12.98
C	.097	.104	2.46	2.64
C1	.004	.011	0.10	0.28
E	.050 BSC		1.27 BSC	
F	.014	.019	0.36	0.48
G	.009	.012	0.23	0.30
H	.018	.035	0.46	0.89
θ	0°	8°	0°	8°



NOTES:

1. 'A1' AND 'B' DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 IN. PER SIDE.
2. LEADS SHALL BE COPLANAR WITHIN 0.004 IN. AT THE SEATING PLANE.
3. THE BASIC LEAD SPACING IS 0.050 IN. BETWEEN CENTERLINES. EACH LEAD CENTERLINE SHALL BE LOCATED WITHIN ±0.004 IN. OF ITS EXACT TRUE POSITION.
4. CONTROLLING DIMENSION: INCHES. MILLIMETERS SHOWN FOR REFERENCE ONLY.
5. DIMENSION 'F' DOES NOT INCLUDE DAMBAR PROTRUSION. THE DAMBAR PROTRUSION(S) SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED 'F' MAXIMUM BY MORE THAN 0.003 IN. DAMBAR CAN NOT BE LOCATED ON THE LOWER RADIUS OR THE LEAD FOOT.
6. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.004 IN. AND 0.010 IN. FROM THE LEAD TIP.
7. 'C1' IS DEFINED AS THE DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT OF THE PACKAGE BODY (BASE PLANE).

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Mechanical Drawings

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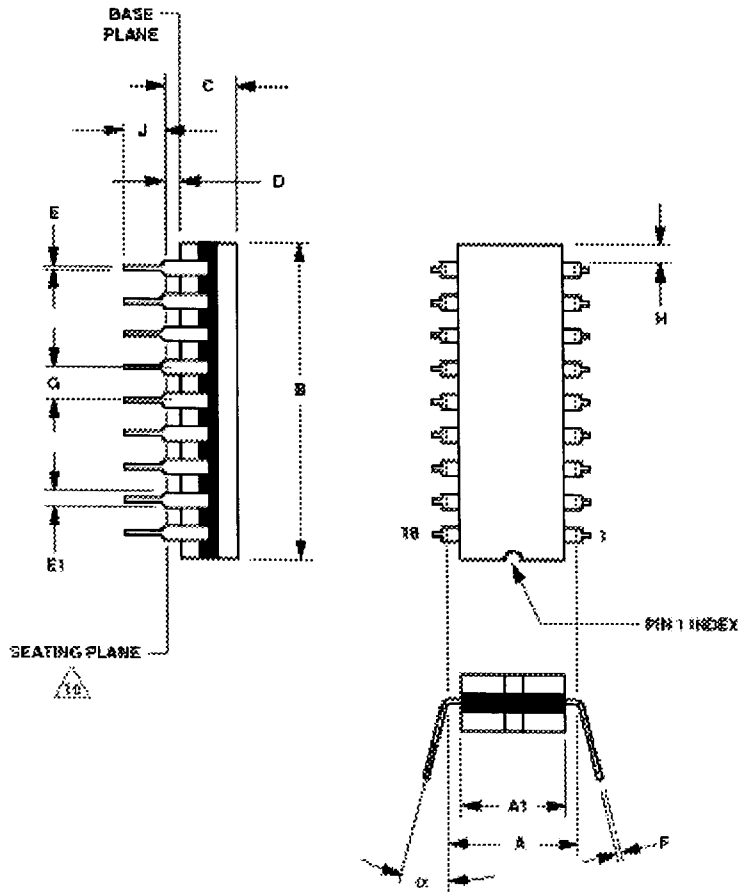
18-PIN CERAMIC DIP ~ J PACKAGE SUFFIX

DIMENSIONS					
	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.290	0.320	7.37	8.13	7
A1	0.220	0.310	5.59	7.87	4
B	-	0.960	-	24.38	4
C	-	0.200	-	5.08	
D	0.015	0.060	0.38	1.52	3
E	0.014	0.026	0.36	0.66	8
E1	0.045	0.065	1.14	1.65	2
F	0.008	0.018	0.20	0.46	8
G	0.100 BSC		2.54 BSC		5
H	0.005	-	0.13	-	6
J	0.125	0.200	3.18	5.08	
α	0°	15°	0°	15°	



NOTES:

1. INDEX AREA: A NOTCH OR A PIN ONE IDENTIFICATION MARK SHALL BE LOCATED ADJACENT TO PIN ONE. THE MANUFACTURER'S IDENTIFICATION SHALL NOT BE USED AS A PIN ONE IDENTIFICATION MARK.
2. THE MINIMUM LIMIT FOR DIMENSION 'E1' MAY BE 0.023 (0.58mm) FOR LEADS NUMBER 1, 9, 10 AND 18 ONLY.
3. DIMENSION 'D' SHALL BE MEASURED FROM THE SEATING PLANE TO THE BASE PLANE.
4. THIS DIMENSION ALLOWS FOR OFF-CENTER LID, MENISCUS AND GLASS OVERRUN.
5. THE BASIC PIN SPACING IS 0.100 (2.54mm) BETWEEN CENTERLINES. EACH PIN CENTERLINE SHALL BE LOCATED WITHIN ±0.010 (0.25mm) OF ITS EXACT TRUE POSITION.
6. APPLIES TO ALL FOUR CORNERS (LEADS NUMBER 1, 9, 10 AND 18).
7. DIMENSION 'A' SHALL BE MEASURED AT THE CENTERLINE OF THE LEADS WHEN $\alpha = 0°$.
8. THE MAXIMUM LIMITS OF DIMENSIONS 'E' AND 'F' SHALL BE MEASURED AT THE CENTER OF THE FLAT WHEN SOLDER DIP IS APPLIED.

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Mechanical Drawings

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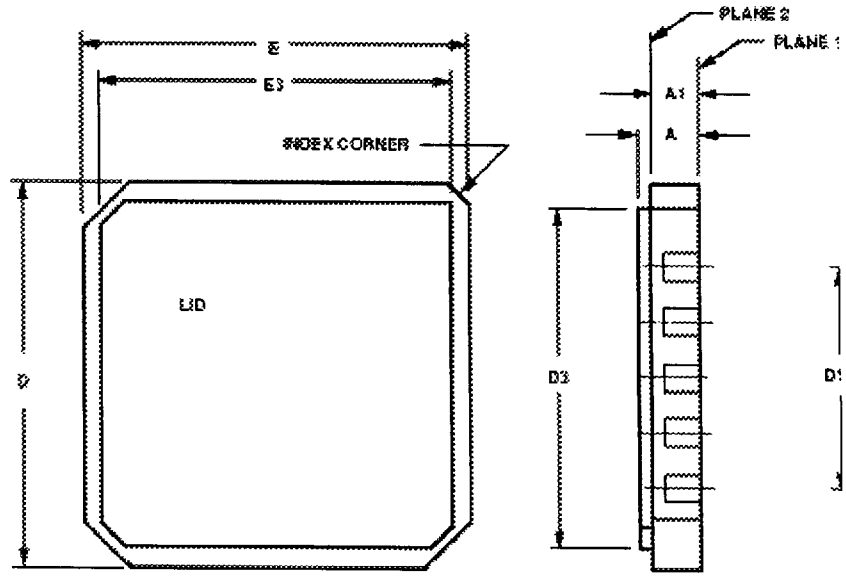
20-PIN CERAMIC LEADLESS SURFACE MOUNT ~ L PACKAGE SUFFIX

DIMENSIONS					
	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	.060	.100	1.52	2.54	6
A1	.050	.088	1.27	2.24	
B1	.022	.028	0.56	0.71	1,3
B2	.072 REF.		1.83 REF.		
B3	.006	.022	0.15	0.56	8
D/E	.342	.358	8.69	9.09	
D1/E1	.200 BSC		5.08 BSC		
D2/E2	.100 BSC		2.54 BSC		
D3/E3	-	.358	-	9.09	4
L	.045	.055	1.14	1.40	
L1	.045	.055	1.14	1.40	
L2	.075	.095	1.90	2.41	5
L3	.003	.015	0.08	0.38	
N	20		20		2
ND/NE	5		5		2
e	.050 BSC		1.27 BSC		10



NOTES:

1. A MINIMUM CLEARANCE OF 0.015 IN. (0.38mm) SHALL BE MAINTAINED BETWEEN ADJACENT TE
2. 'N' IS THE MAXIMUM QUANTITY OF TERMINAL POSITIONS. 'ND' AND 'NE' ARE THE NUMBERS OF AND 'E' RESPECTIVELY.
3. ELECTRICAL CONNECTION TERMINALS ARE REQUIRED ON PLANE 1 AND OPTIONAL ON PLANE THEY SHALL BE ELECTRICALLY CONNECTED TO OPPOSING TERMINALS ON PLANE 1.
4. A MINIMUM CLEARANCE OR 0.015 IN. (0.38mm) SHALL BE MAINTAINED BETWEEN A METAL LID TERMINALS, METALLIZED CASTELLATIONS, ETC.) THE LID SHALL NOT EXTEND BEYOND THE E
5. THE INDEX FEATURE FOR NUMBER 1 TERMINAL IDENTIFICATION, OPTIONAL ORIENTATION OR AREA DEFINED BY DIMENSIONS 'B2' AND 'L2' ON PLANE 1.
6. DIMENSION 'A' CONTROLS THE OVERALL PACKAGE THICKNESS.
7. CONTROLLING DIMENSION: INCHES. MILLIMETERS SHOWN FOR REFERENCE ONLY.
8. CASTELLATIONS ARE REQUIRED ON BOTTOM TWO LAYERS. CASTELLATIONS IN THE TOP LAYE
9. WHEN SOLDER DIP LEAD FINISH APPLIES, SOLDER BUMP HEIGHT SHALL NOT EXCEED 0.007 INC NOT EXCEED 0.006 INCHES.
10. THE BASIC TERMINAL SPACING IS 0.050 INCHES BETWEEN CENTERLINES. EACH TERMINAL CEN INCHES OF ITS EXACT TRUE POSITION.

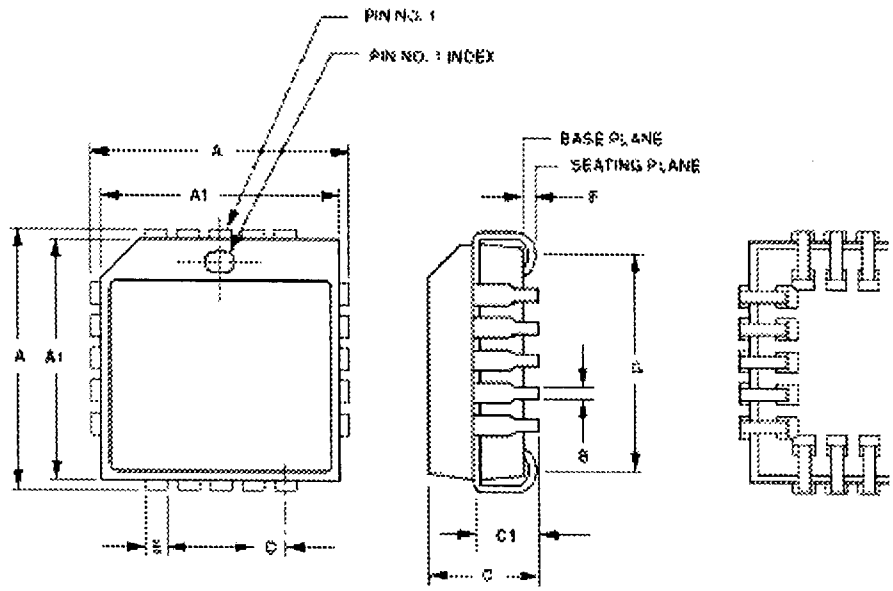
UNITRODE

Mechanical Drawings

Back to Packaging Index

20-PIN PLASTIC PLCC SURFACE MOUNT~ Q PACKAGE SUFFIX

DIMENSIONS					
	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	.385	.395	9.78	10.03	
A1	.350	.356	8.89	9.04	1
B	.013	.021	0.33	0.53	
C	.170	.180	4.32	4.57	
C1	.100	.110	2.54	2.79	
D	.050 BSC		1.27 BSC		2
E	.026	.032	0.66	0.81	
F	.020	-	0.51	-	3, 4
G	.290	.330	7.37	8.38	



NOTES:

1. 'A1' DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 IN. PER SIDE.
2. THE BASIC LEAD SPACING IS 0.050 IN. BETWEEN CENTERLINES. EACH LEAD CENTERLINE SHALL LOCATED WITHIN ±0.004 IN. OF ITS EXACT TRUE POSITION.
3. 'F' IS MEASURED FROM THE SEATING PLANE TO THE BASE PLANE.
4. LEADS SHALL BE COPLANAR WITHIN 0.004 IN. AT THE SEATING PLANE.
5. CONTROLLING DIMENSION: INCHES. MILLIMETERS SHOWN FOR REFERENCE ONLY.