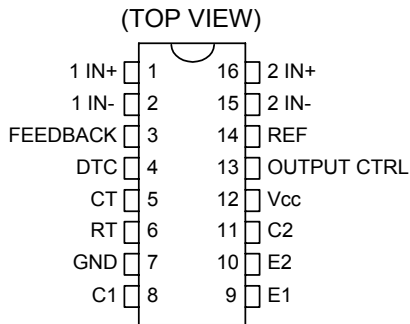


## Voltage Mode PWM Controller

### ■ Features

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply with 3% Tolerance
- Circuit Architecture allows Easy Synchronization

### ■ Connection Diagram



### ■ Description

The AP494 incorporates on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, this device offers the systems engineer the flexibility to tailor the power supply control circuitry to a specific application.

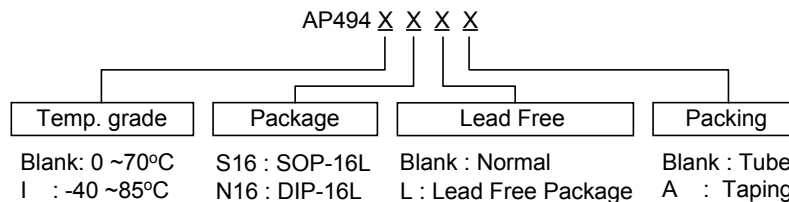
The AP494 contains two error amplifiers, one adjustable on-chip oscillator, a dead-time control (DTC) comparator, a pulse-steering control flip-flop, a 5-V, 3%-precision regulator, and output-control circuits.

The error amplifiers exhibit a common-mode voltage range from  $-0.3V$  to  $V_{CC} - 2V$ . The dead-time control comparator has a fixed offset that provides approximately 5% dead time. The on-chipped oscillator may be bypassed in two ways. One is to terminate RT to the reference output and the other one is to provide a sawtooth input to CT, or it may drive the common circuits in synchronous multiple-rail power supplies.

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. The AP494 provides for push-pull or single-ended output operation, which may be selected through the output-control function. The architecture of this device prohibits the possibility of either output being pulsed twice during push-pull operation.

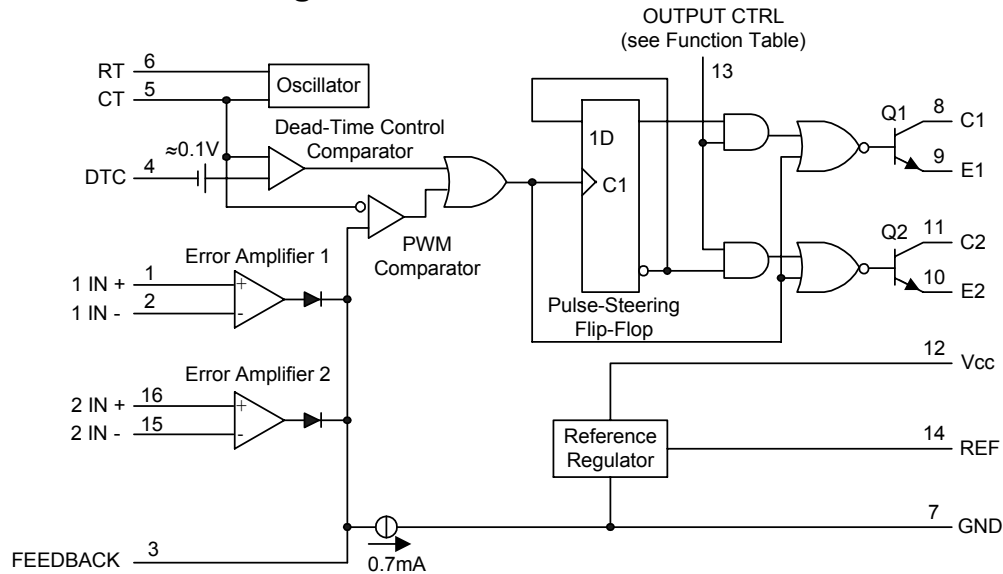
The AP494 is characterized for operation from  $0^{\circ}C$  to  $70^{\circ}C$ .

### ■ Ordering Information



## Voltage Mode PWM Controller

### Functional Block Diagram



### Absolute Maximum Ratings

Rating	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	40	V
Collector Output Voltage	$V_{C1}, V_{C2}$	40	V
Collector Output Current (Each transistor)	$I_{C1}, I_{C2}$	250	mA
Amplifier Input Voltage Range	$V_{IR}$	-0.3 to +40	V
Power Dissipation @ $T_A \leq 45^\circ\text{C}$	$P_D$	1000	mW
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	80	$^\circ\text{C/W}$
Operating Junction Temperature	$T_J$	125	$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-55 to +125	$^\circ\text{C}$
Operating Ambient Temperature Range	$T_A$	0 to +70	$^\circ\text{C}$
Derating Ambient Temperature	$T_A$	45	$^\circ\text{C}$

### Recommended Operating Conditions

Characteristics	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	$V_{CC}$	7.0	15	40	V
Collector Output Voltage	$V_{C1}, V_{C2}$	-	30	40	V
Collector Output Current (Each transistor)	$I_{C1}, I_{C2}$	-	-	200	mA
Amplified Input Voltage	$V_{in}$	-0.3	-	$V_{CC}-2.0$	V
Current Into Feedback Terminal	$I_{fb}$	-	-	0.3	mA
Reference Output Current	$I_{ref}$	-	-	10	mA
Timing Resistor	$R_T$	1.8	30	500	$k\Omega$
Timing Capacitor	$C_T$	0.0047	0.001	10	$\mu\text{F}$
Oscillator Frequency	$f_{OSC}$	1.0	40	200	kHz



Voltage Mode PWM Controller

■ Electrical Characteristics

(V<sub>CC</sub>=15V, C<sub>T</sub>=0.01μF, R<sub>T</sub>=12 kΩ, unless otherwise noted.) For typical values T<sub>A</sub>=25°C, for min/max values T<sub>A</sub> is the operating ambient temperature range that applies, unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
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REFERENCE SECTION

Reference Voltage (I <sub>O</sub> =1.0mA)	V <sub>ref</sub>	4.85	5.0	5.15	V
Line Regulation (V <sub>CC</sub> =7.0 V to 40V)	Reg <sub>line</sub>	-	2.0	25	mV
Load Regulation (I <sub>O</sub> =1.0mA to 20mA)	Reg <sub>load</sub>	-	3.0	15	mV
Short Circuit Output Current (I <sub>ref</sub> =0 V)	I <sub>SC</sub>	4.5	60	75	mA

OUTPUT SECTION

Collector Off-State Current (V <sub>CC</sub> =40V, V <sub>CE</sub> =40V)	I <sub>C(off)</sub>	-	2.0	100	μA
Emitter Off-State Current (V <sub>CC</sub> =40V, V <sub>C</sub> =40V, V <sub>E</sub> =0V)	I <sub>E(off)</sub>	-	-	-100	μA
Collector-Emitter Saturation Voltage (Note 1)					
Common-Emitter (V <sub>E</sub> =0V, I <sub>C</sub> =200mA)	V <sub>sat(C)</sub>	-	1.1	1.5	V
Emitter-Follower (V <sub>C</sub> =15V, I <sub>E</sub> =-200mA)	V <sub>sat(E)</sub>	-	1.5	2.5	
Output Control Pin Current					
Low State (V <sub>OC</sub> ≤0.4V)	I <sub>OCL</sub>	-	10	-	μA
High State (V <sub>OC</sub> =V <sub>ref</sub> )	I <sub>OCH</sub>	-	0.2	3.5	mA
Output Voltage Rise Time					
Common-Emitter (See Figure 4)	t <sub>r</sub>	-	100	200	ns
Emitter-Follower (See Figure 5)		-	100	200	
Output Voltage Fall Time					
Common-Emitter (See Figure 4)	t <sub>f</sub>	-	25	100	ns
Emitter-Follower (See Figure 5)		-	40	100	

NOTE: 1. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.

ERROR AMPLIFIER SECTION

Input Offset Voltage (V <sub>O (Pin 3)</sub> =2.5V)	V <sub>IO</sub>	-	2.0	10	mV
Input Offset Current (V <sub>O (Pin 3)</sub> =2.5V)	I <sub>IO</sub>	-	5.0	250	nA
Input Bias Current (V <sub>O (Pin 3)</sub> =2.5V)	I <sub>IB</sub>	-	-0.1	-0.1	μA
Input Common Mode Voltage Range (V <sub>CC</sub> =40V, T <sub>A</sub> =25°C)	V <sub>ICR</sub>	-0.3 to V <sub>CC</sub> -2.0			V
Open Loop Voltage Gain (ΔV <sub>O</sub> =3.0V, V <sub>O</sub> =0.5V to 3.5V, R <sub>L</sub> =2.0 kΩ)	A <sub>VOL</sub>	70	95	-	dB
Unity-Gain Crossover Frequency (V <sub>O</sub> =0.5V to 3.5V, R <sub>L</sub> =2.0 kΩ)	f <sub>C</sub>	-	350	-	kHz
Common Mode Rejection Ratio (V <sub>CC</sub> =40V)	CMRR	64	90	-	dB
Output Sink Current (V <sub>O (Pin 3)</sub> =0.7V)	I <sub>O-</sub>	0.3	0.7	-	mA
Output Source Current (V <sub>O (Pin 3)</sub> =3.5V)	I <sub>O+</sub>	-10	-15	-	mA

PWM COMPARATOR SECTION (Test Circuit Figure 1)

Input Threshold Voltage (Zero Duty Cycle)	V <sub>TH</sub>	-	4	4.5	V
Input Sink Current (V <sub>(Pin 3)</sub> =0.7V)	I <sub>L</sub>	0.3	0.7	-	mA

DEADTIME CONTROL SECTION (Test Circuit Figure 1)

Input Bias Current (Pin 4)(V <sub>Pin4</sub> =0V to 5.25V)	I <sub>IB(DT)</sub>	-	-2.0	-10	μA
Maximum Duty Cycle, Each Output, Push-Pull Mode (V <sub>Pin4</sub> =0V, C <sub>T</sub> =0.01μF, R <sub>T</sub> =12 kΩ)	DC <sub>max</sub>	45	48	50	%
Input Threshold Voltage (Pin4) (Zero Duty Cycle)	V <sub>th</sub>	-	2.8	3.3	V
(Maximum Duty Cycle)		0	-	-	

## Voltage Mode PWM Controller

### ■ Electrical Characteristics(Continued)

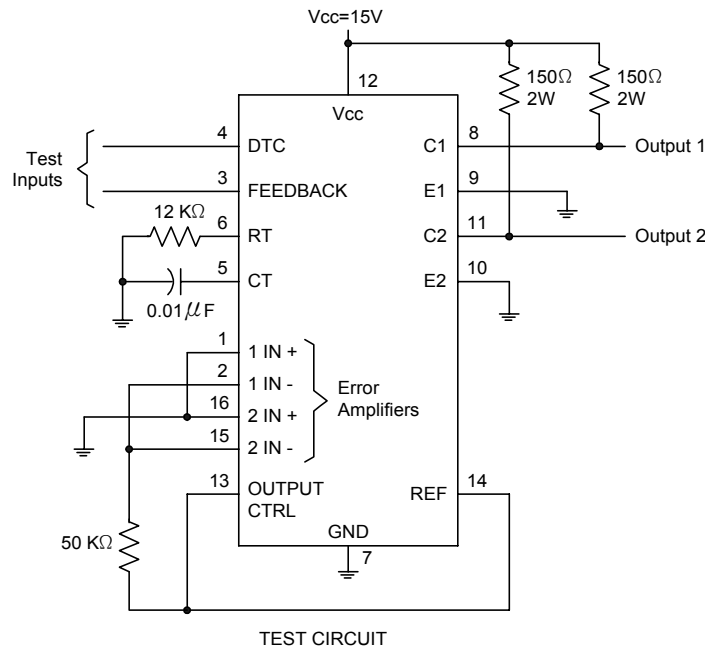
(V<sub>CC</sub>=15V, C<sub>T</sub>=0.01μF, R<sub>T</sub>=12 kΩ, unless otherwise noted.) For typical values T<sub>A</sub>=25°C, for min/max values T<sub>A</sub> is the operating ambient temperature range that applies, unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
<b>OSCILLATOR SECTION</b>					
Frequency (C <sub>T</sub> =0.01μF, R <sub>T</sub> =12 kΩ)	f <sub>OSC</sub>	-	10	-	kHz
Standard Deviation of Frequency* (C <sub>T</sub> =0.001μF, R <sub>T</sub> =30 kΩ)	σ f <sub>OSC</sub>	-	3.0	-	%
Frequency Change with Voltage (V <sub>CC</sub> =7.0V to 40V, T <sub>A</sub> =25°C)	Δ f <sub>OSC</sub> (Δ V)	-	0.1	-	%
Frequency Change with Temperature (Δ T <sub>A</sub> =T <sub>low</sub> to T <sub>high</sub> ) (C <sub>T</sub> =0.01μF, R <sub>T</sub> =12 kΩ)	Δ f <sub>OSC</sub> (Δ T)	-	-	12	%
<b>TOTAL DEVICE</b>					
Standby Supply Current(Pin6 at V <sub>ref</sub> , All other inputs and outputs open) (V <sub>CC</sub> =15V) (V <sub>CC</sub> =40V)	I <sub>CC</sub>	-	5.5 7.0	10 15	mA
Average Supply Current (C <sub>T</sub> =0.01μF, R <sub>T</sub> =12 kΩ, V <sub>(Pin4)</sub> =2.0V) (V <sub>CC</sub> =15V) (See Figure 4)		-	7.0	-	mA

\*Standard deviation is a measure of the statistical distribution about the mean as derived from the formula,

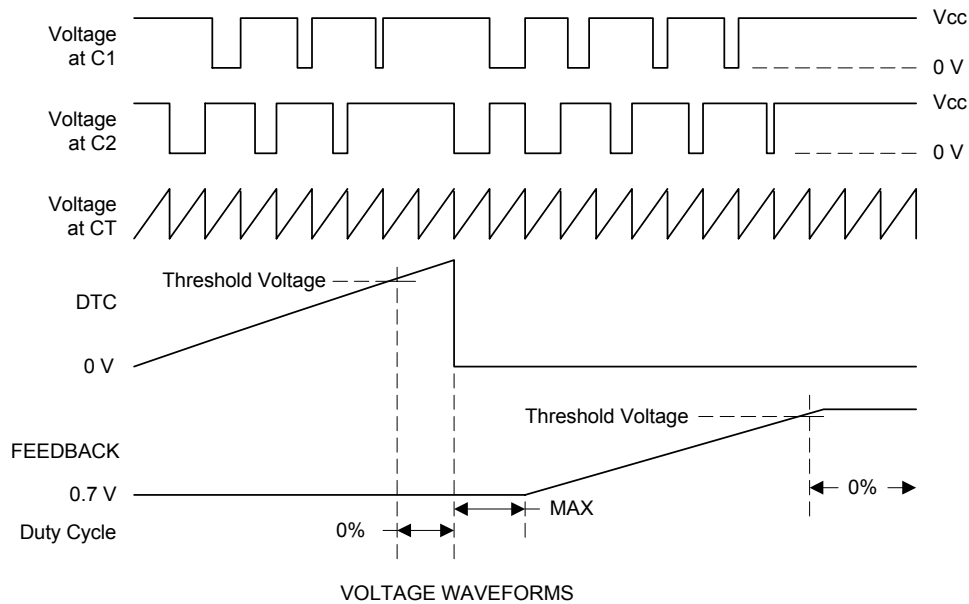
$$\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N - 1}}$$

Figure 1. PARAMETER MEASUREMENT INFORMATION

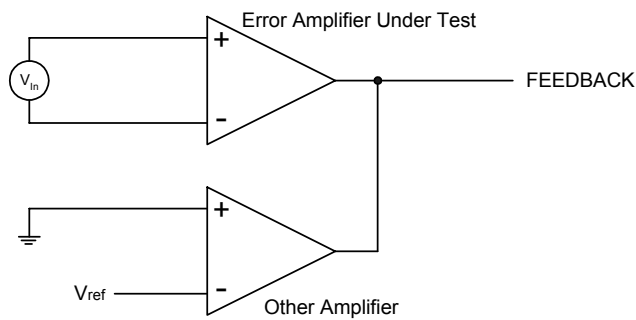


## Voltage Mode PWM Controller

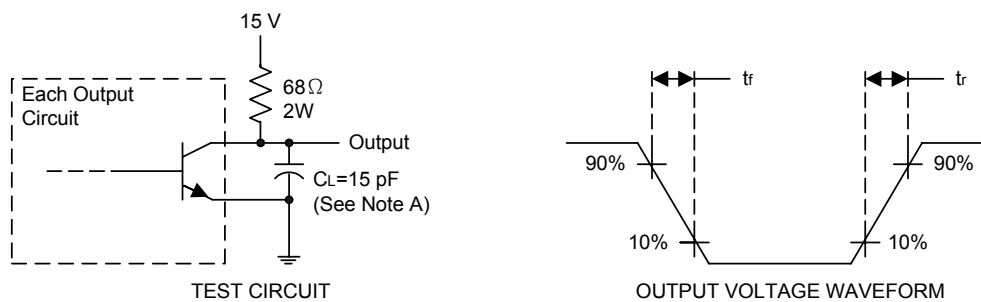
**Figure 2. OPERATIONAL TEST CIRCUIT AND WAVEFORMS**



**Figure 3. AMPLIFIER CHARACTERISTICS**



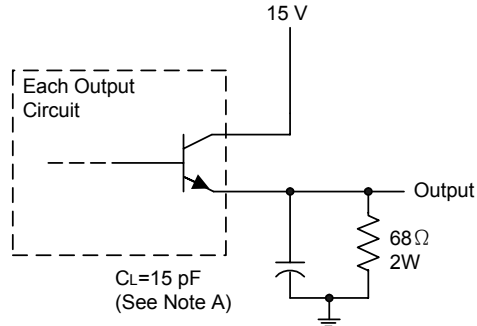
**Figure 4. COMMON-EMITTER CONFIGURATION**



NOTE A.  $C_L$  includes probe and jig capacitance.

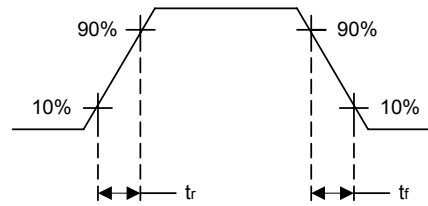
## Voltage Mode PWM Controller

**Figure 5. EMITTER-FOLLOWER CONFIGURATION**



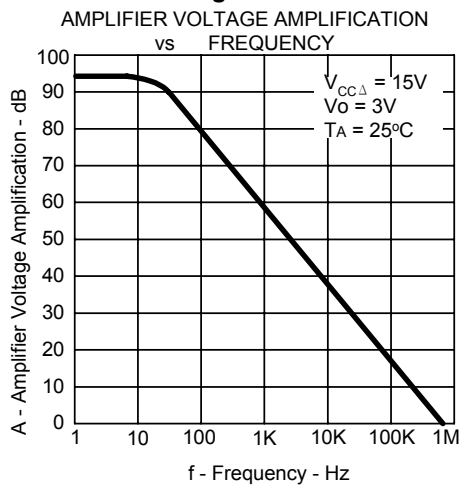
TEST CIRCUIT

NOTE A. CL includes probe and jig capacitance.

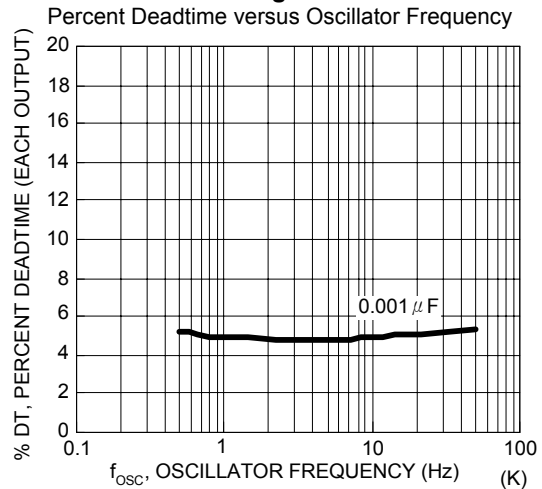


OUTPUT VOLTAGE WAVEFORM

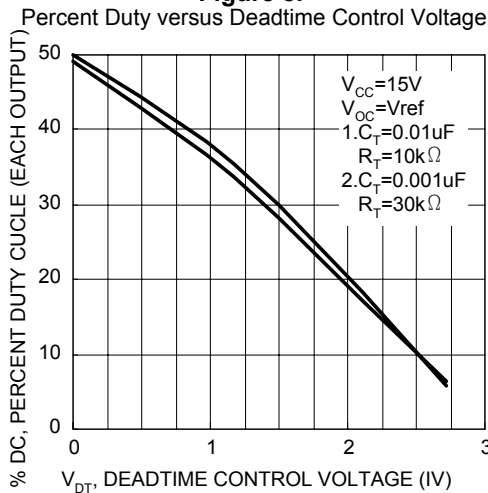
**Figure 6.**



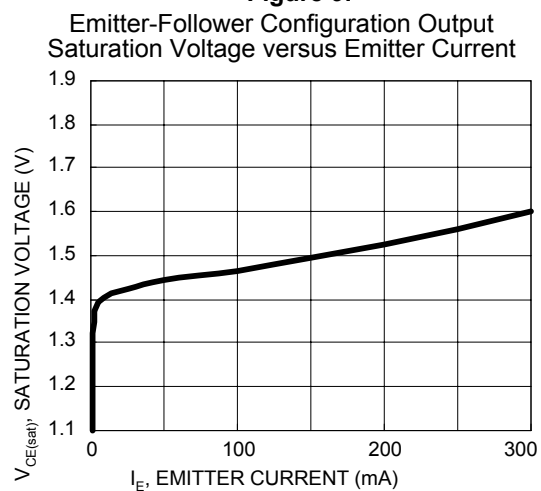
**Figure 7.**



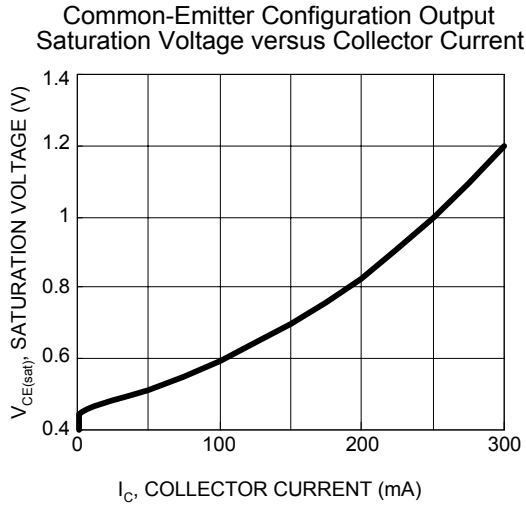
**Figure 8.**



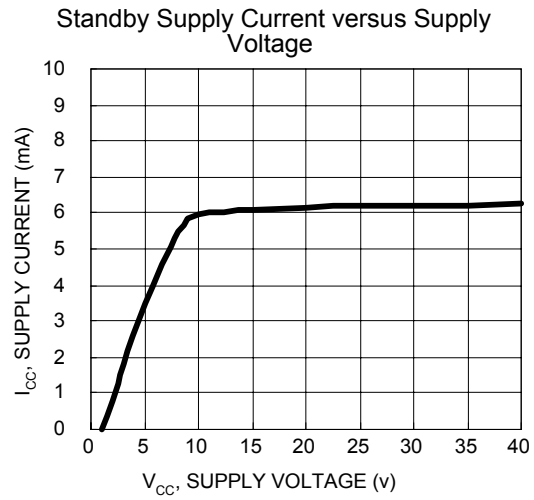
**Figure 9.**



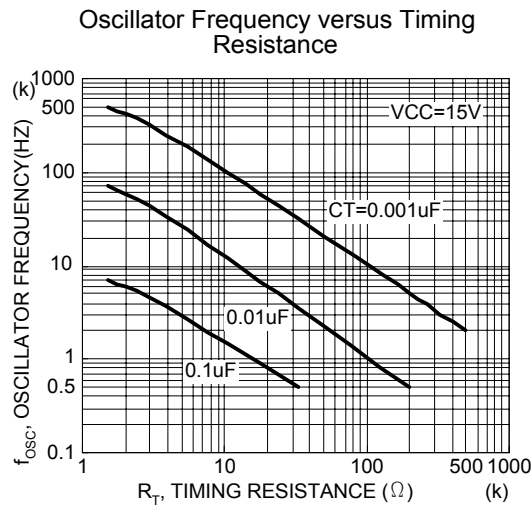
**Figure 10.**



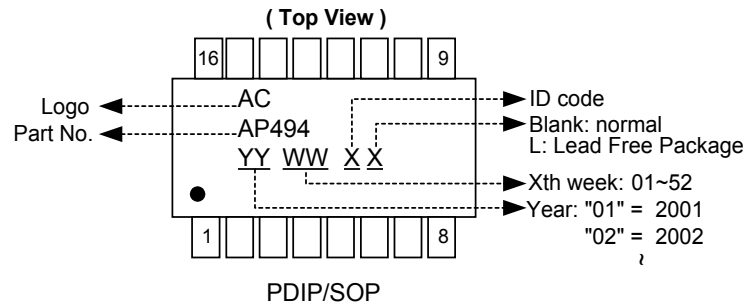
**Figure 11.**



**Figure 12.**

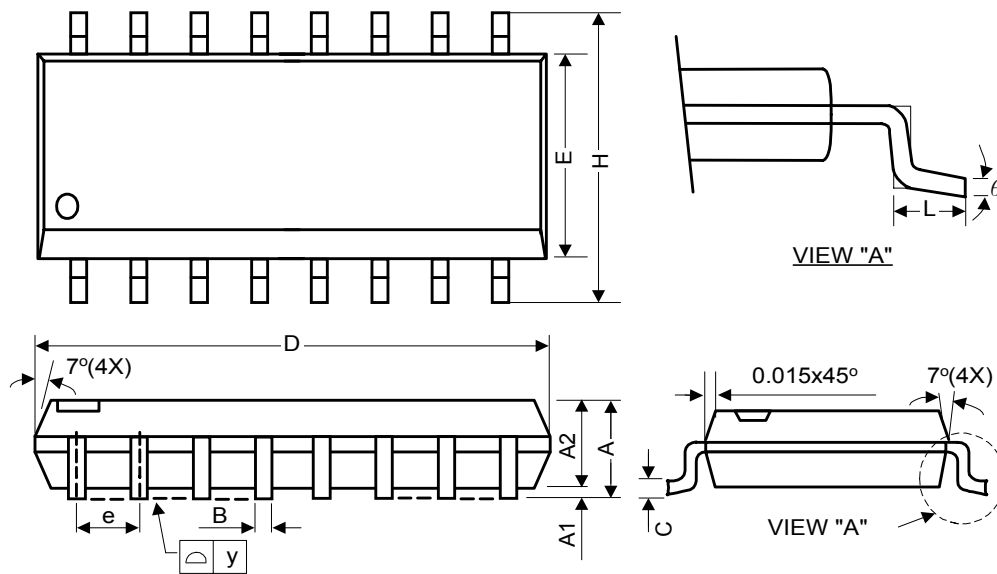


### ■ Marking Information



### ■ Package Dimension

#### (1) Package Type: SOP-16L

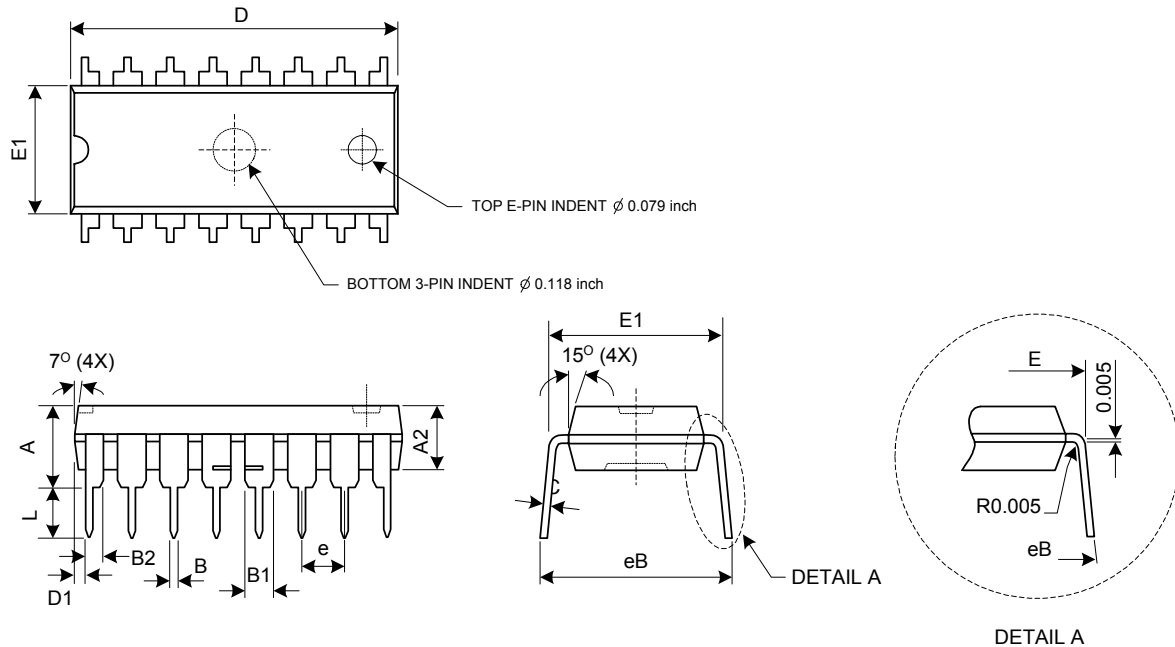


Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	-	0.25	0.040	-	0.010
A2	1.30	1.45	1.50	0.051	0.057	0.059
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.0098
D	9.80	9.90	10.00	0.386	0.390	0.394
E	3.80	3.90	4.00	0.150	0.154	0.157
e	-	1.27	-	-	0.050	-
H	5.80	6.00	6.20	0.228	0.236	0.244
L	0.38	0.71	1.27	0.015	0.028	0.050
θ	0	-	8	0	-	8



### ■ Package Information (Continued)

#### (2) Package Type: PDIP-16L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	4.57	-	-	0.180
A1	0.38	-	-	0.015	-	-
A2	3.15	3.33	3.50	0.124	0.131	0.138
B	0.36	0.46	0.56	0.014	0.018	0.022
B1	1.14	1.27	1.52	0.045	0.050	0.060
B2	0.81	0.99	1.17	0.032	0.039	0.046
C	0.20	0.25	0.33	0.008	0.010	0.013
D	18.90	19.10	19.30	0.744	0.752	0.760
D1	0.56	0.69	0.76	0.022	0.027	0.030
E	7.62	-	8.26	0.3000	-	0.325
E1	6.15	6.35	6.55	0.242	0.250	0.258
e	-	2.54	-	-	0.100	-
L	2.92	-	3.81	0.115	-	0.150
eB	8.38	-	9.40	0.330	-	0.370