

# 54F/74F193 Up/Down Binary Counter with Separate Up/Down Clocks

## General Description

The 'F193 is an up/down modulo-16 binary counter. Separate Count Up and Count Down Clocks are used, and in either counting mode the circuits operate synchronously. The outputs change state synchronously with the LOW-to-HIGH transitions on the clock inputs. Separate Terminal Count Up and Terminal Count Down outputs are provided that are used as the clocks for subsequent stages without extra logic, thus simplifying multi-stage counter designs.

Individual preset inputs allow the circuit to be used as a programmable counter. Both the Parallel Load (PL) and the Master Reset (MR) inputs asynchronously override the clocks.

## Features

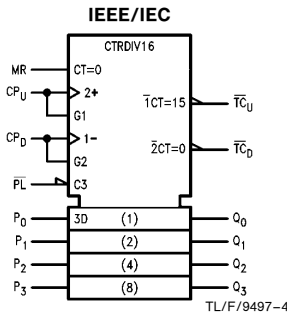
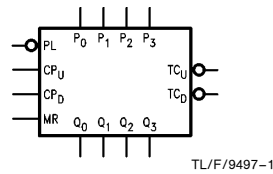
- Guaranteed 4000V minimum ESD protection

Commercial	Military	Package Number	Package Description
74F193PC		N16E	16-Lead (0.300" Wide) Molded Dual-In-Line
	54F193DM (Note 2)	J16A	16-Lead Ceramic Dual-In-Line
74F193SC (Note 1)		M16A	16-Lead (0.150" Wide) Molded Small Outline, JEDEC
74F193SJ (Note 1)		M16D	16-Lead (0.300" Wide) Molded Small Outline, EIAJ
	54F193FM (Note 2)	W16A	16-Lead Cerpack
	54F193LM (Note 2)	E20A	20-Lead Ceramic Leadless Chip Carrier, Type C

**Note 1:** Devices also available in 13" reel. Use suffix = SCX and SJX.

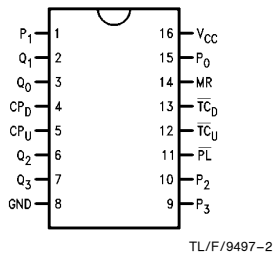
**Note 2:** Military grade device with environmental and burn-in processing. Use suffix = DMQB, FMQB and LMQB.

## Logic Symbols

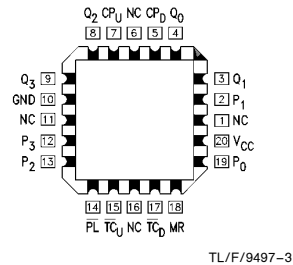


## Connection Diagrams

Pin Assignment for DIP, SOIC and Flatpak



Pin Assignment for LCC



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## Unit Loading/Fan Out

Pin Names	Description	54F/74F	
		U.L. HIGH/LOW	Input I <sub>IH</sub> /I <sub>IL</sub> Output I <sub>OH</sub> /I <sub>OL</sub>
CP <sub>U</sub>	Count Up Clock Input (Active Rising Edge)	1.0/3.0	20 μA/ -1.8 mA
CP <sub>D</sub>	Count Down Clock Input (Active Rising Edge)	1.0/3.0	20 μA/ -1.8 mA
MR	Asynchronous Master Reset Input (Active HIGH)	1.0/1.0	20 μA/ -0.6 mA
$\overline{PL}$	Asynchronous Parallel Load Input (Active LOW)	1.0/1.0	20 μA/ -0.6 mA
P <sub>0</sub> -P <sub>3</sub>	Parallel Data Inputs	1.0/1.0	20 μA/ -0.6 mA
Q <sub>0</sub> -Q <sub>3</sub>	Flip-Flop Outputs	50/33.3	-1 mA/20 mA
$\overline{TC}_D$	Terminal Count Down (Borrow) Output (Active LOW)	50/33.3	-1 mA/20 mA
$\overline{TC}_U$	Terminal Count Up (Carry) Output (Active LOW)	50/33.3	-1 mA/20 mA

## Functional Description

The 'F193 is a 4-bit binary synchronous up/down (reversible) counter. It contains four edge-triggered flip-flops, with internal gating and steering logic to provide master reset, individual preset, count up and count down operations.

A LOW-to-HIGH transition on the CP input to each flip-flop causes the output to change state. Synchronous switching, as opposed to ripple counting, is achieved by driving the steering gates of all stages from a common Count Up line and a common Count Down line, thereby causing all state changes to be initiated simultaneously. A LOW-to-HIGH transition on the Count Up input will advance the count by one; a similar transition on the Count Down input will decrease the count by one. While counting with one clock input, the other should be held HIGH, as indicated in the Function Table.

The Terminal Count Up ( $\overline{TC}_U$ ) and Terminal Count Down ( $\overline{TC}_D$ ) outputs are normally HIGH. When the circuit has reached the maximum count state 15, the next HIGH-to-LOW transition of the Count Up Clock will cause  $\overline{TC}_U$  to go LOW.  $\overline{TC}_U$  will stay LOW until CP<sub>U</sub> goes HIGH again, thus effectively repeating the Count Up Clock, but delayed by two gate delays. Similarly, the  $\overline{TC}_D$  output will go LOW when the circuit is in the zero state and the Count Down Clock goes LOW. Since the  $\overline{TC}$  outputs repeat the clock waveforms, they can be used as the clock input signals to the next higher order circuit in a multistage counter.

$$\overline{TC}_U = Q_0 \cdot Q_1 \cdot Q_2 \cdot Q_3 \cdot \overline{CP}_U$$

$$\overline{TC}_D = \overline{Q}_0 \cdot \overline{Q}_1 \cdot \overline{Q}_2 \cdot \overline{Q}_3 \cdot \overline{CP}_D$$

The 'F193 has an asynchronous parallel load capability permitting the counter to be preset. When the Parallel Load ( $\overline{PL}$ ) and the Master Reset (MR) inputs are LOW, information present on the Parallel Data input (P<sub>0</sub>-P<sub>3</sub>) is loaded into the counter and appears on the outputs regardless of the conditions of the clock inputs. A HIGH signal on the Master Reset input will disable the preset gates, override both clock inputs, and latch each Q output in the LOW state.

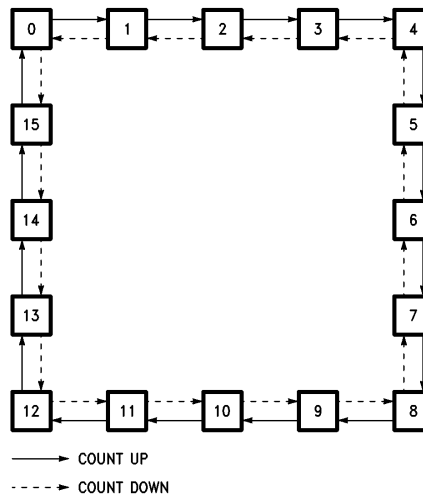
If one of the clock inputs is LOW during and after a reset or load operation, the next LOW-to-HIGH transition of that clock will be interpreted as a legitimate signal and will be counted.

Function Table

MR	$\overline{PL}$	CP <sub>U</sub>	CP <sub>D</sub>	Mode
H	X	X	X	Reset (Asyn.)
L	L	X	X	Preset (Asyn.)
L	H	H	H	No Change
L	H	↗	H	Count Up
L	H	H	↘	Count Down

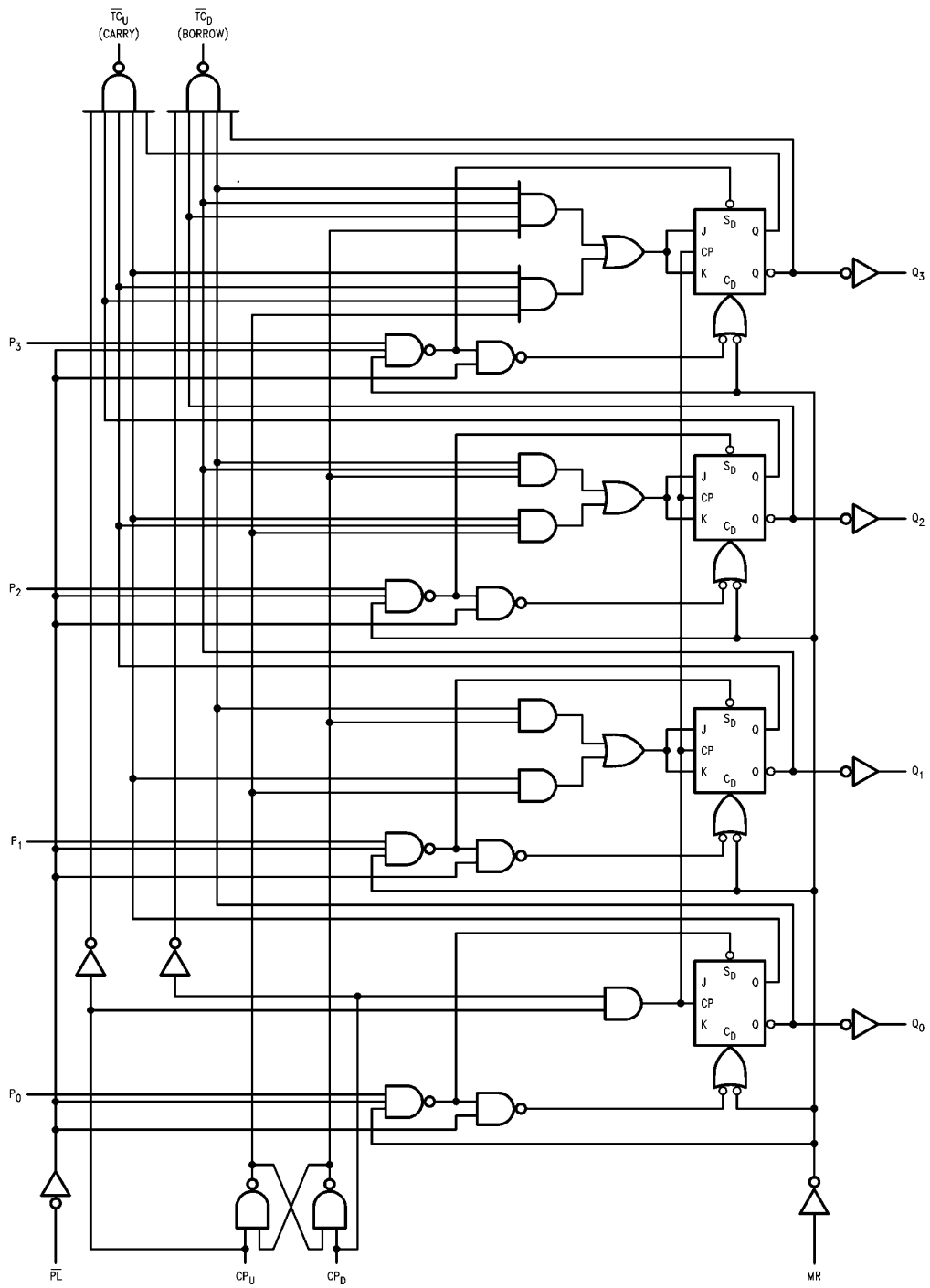
H = HIGH Voltage Level  
 L = LOW Voltage Level  
 X = Immaterial  
 ↗ = LOW-to-HIGH Clock Transition

## State Diagram



TL/F/9497-5

# Logic Diagram



TL/F/9497-6

Please note that this diagram is provided only for the understanding of logic operations and should not be used to estimate propagation delays.

## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature	–65°C to +150°C
Ambient Temperature under Bias	–55°C to +125°C
Junction Temperature under Bias	–55°C to +175°C
Plastic	–55°C to +150°C
V <sub>CC</sub> Pin Potential to Ground Pin	–0.5V to +7.0V
Input Voltage (Note 2)	–0.5V to +7.0V
Input Current (Note 2)	–30 mA to +5.0 mA
Voltage Applied to Output in HIGH State (with V <sub>CC</sub> = 0V)	
Standard Output	–0.5V to V <sub>CC</sub>
TRI-STATE® Output	–0.5V to +5.5V
Current Applied to Output in LOW State (Max)	twice the rated I <sub>OL</sub> (mA)
ESD Last Passing Voltage (Min)	4000V

**Note 1:** Absolute maximum ratings are values beyond which the device may be damaged or have its useful life impaired. Functional operation under these conditions is not implied.

**Note 2:** Either voltage limit or current limit is sufficient to protect inputs.

## Recommended Operating Conditions

Free Air Ambient Temperature	
Military	–55°C to +125°C
Commercial	0°C to +70°C
Supply Voltage	
Military	+4.5V to +5.5V
Commercial	+4.5V to +5.5V

## DC Electrical Characteristics

Symbol	Parameter	54F/74F			Units	V <sub>CC</sub>	Conditions
		Min	Typ	Max			
V <sub>IH</sub>	Input HIGH Voltage	2.0			V		Recognized as a HIGH Signal
V <sub>IL</sub>	Input LOW Voltage	0.8			V		Recognized as a LOW Signal
V <sub>CD</sub>	Input Clamp Diode Voltage	–1.2			V	Min	I <sub>IN</sub> = –18 mA
V <sub>OH</sub>	Output HIGH Voltage	54F 10% V <sub>CC</sub>	2.5		V	Min	I <sub>OH</sub> = –1 mA I <sub>OH</sub> = –1 mA I <sub>OH</sub> = –1 mA
		74F 10% V <sub>CC</sub>	2.5				
		74F 5% V <sub>CC</sub>	2.7				
V <sub>OL</sub>	Output LOW Voltage	54F 10% V <sub>CC</sub>		0.5	V	Min	I <sub>OL</sub> = 20 mA I <sub>OL</sub> = 20 mA
		74F 10% V <sub>CC</sub>		0.5			
I <sub>IH</sub>	Input HIGH Current	54F		20.0	μA	Max	V <sub>IN</sub> = 2.7V
		74F		5.0			
I <sub>BVI</sub>	Input HIGH Current Breakdown Test	54F		100	μA	Max	V <sub>IN</sub> = 7.0V
		74F		7.0			
I <sub>CEX</sub>	Output HIGH Leakage Current	54F		250	μA	Max	V <sub>OUT</sub> = V <sub>CC</sub>
		74F		50			
V <sub>ID</sub>	Input Leakage Test	74F	4.75		V	0.0	I <sub>ID</sub> = 1.9 μA All Other Pins Grounded
I <sub>OD</sub>	Output Leakage Circuit Current	74F		3.75	μA	0.0	V <sub>IOD</sub> = 150 mV All Other Pins Grounded
I <sub>IL</sub>	Input LOW Current			–0.6 –1.8	mA	Max	V <sub>IN</sub> = 0.5V (MR, $\overline{P_L}$ , P <sub>n</sub> ) V <sub>IN</sub> = 0.5V (CP <sub>U</sub> , CP <sub>D</sub> )
I <sub>OS</sub>	Output Short-Circuit Current		–60	–150	mA	Max	V <sub>OUT</sub> = 0V
I <sub>CC</sub>	Power Supply Current		38	55	mA	Max	

## AC Electrical Characteristics

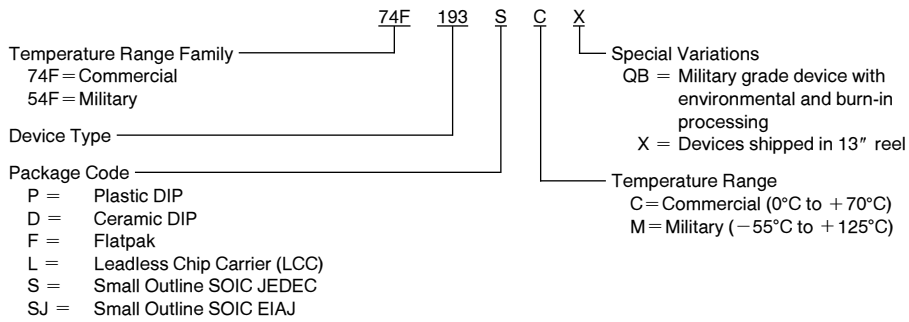
Symbol	Parameter	74F			54F		74F		Units
		$T_A = +25^\circ\text{C}$ $V_{CC} = +5.0\text{V}$ $C_L = 50\text{ pF}$			$T_A, V_{CC} = \text{Mil}$ $C_L = 50\text{ pF}$		$T_A, V_{CC} = \text{Com}$ $C_L = 50\text{ pF}$		
		Min	Typ	Max	Min	Max	Min	Max	
$f_{\text{max}}$	Maximum Count Frequency	100	125		75		90		MHz
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $CP_U$ or $CP_D$ to $\overline{TC}_U$ or $\overline{TC}_D$	4.0 3.5	7.0 6.0	9.0 8.0	4.0 3.5	10.5 9.5	4.0 3.5	10.0 9.0	ns
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $CP_U$ or $CP_D$ to $Q_n$	4.0 5.5	6.5 9.5	8.5 12.5	3.5 5.5	10.0 14.0	4.0 5.5	9.5 13.5	ns
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $P_n$ to $Q_n$	3.0 6.0	4.5 11.0	7.0 14.5	3.0 6.0	8.5 16.5	3.0 6.0	8.0 15.5	ns
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $\overline{PL}$ to $Q_n$	5.0 5.5	8.5 10.0	11.0 13.0	5.0 5.5	13.5 15.0	5.0 5.5	12.0 14.0	ns
$t_{\text{PHL}}$	Propagation Delay MR to $Q_n$	5.5	11.0	14.5	5.0	16.0	5.5	15.5	ns
$t_{\text{PLH}}$	Propagation Delay MR to $\overline{TC}_U$	6.0	10.5	13.5	5.0	15.0	6.0	14.5	
$t_{\text{PHL}}$	Propagation Delay MR to $\overline{TC}_D$	6.0	11.5	14.5	6.0	16.0	6.0	15.5	
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $\overline{PL}$ to $\overline{TC}_U$ or $\overline{TC}_D$	7.0 7.0	12.0 11.5	15.5 14.5	7.0 6.0	18.5 17.5	7.0 7.0	16.5 15.5	ns
$t_{\text{PLH}}$ $t_{\text{PHL}}$	Propagation Delay $P_n$ to $\overline{TC}_U$ or $\overline{TC}_D$	7.0 6.5	11.5 11.0	14.5 14.0	6.0 5.0	16.5 16.5	7.0 6.5	15.5 15.0	ns

## AC Operating Requirements

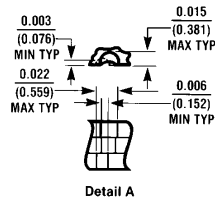
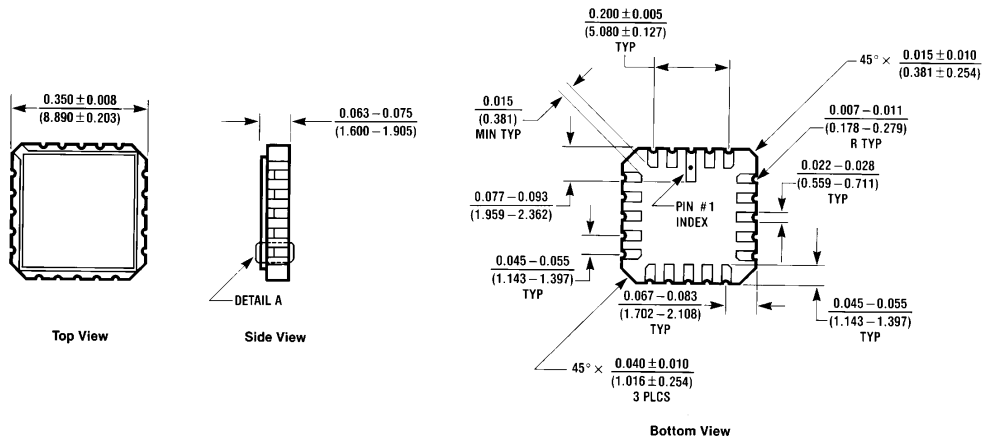
Symbol	Parameter	74F		54F		74F		Units
		$T_A = +25^\circ\text{C}$ $V_{CC} = +5.0\text{V}$		$T_A, V_{CC} = \text{Mil}$		$T_A, V_{CC} = \text{Com}$		
		Min	Max	Min	Max	Min	Max	
$t_{\text{s(H)}}$ $t_{\text{s(L)}}$	Setup Time, HIGH or LOW $P_n$ to PL	4.5 4.5		6.0 6.0		5.0 5.0		ns
$t_{\text{h(H)}}$ $t_{\text{h(L)}}$	Hold Time, HIGH or LOW $P_n$ to $\overline{PL}$	2.0 2.0		2.0 2.0		2.0 2.0		
$t_{\text{w(L)}}$	$\overline{PL}$ Pulse Width, LOW	6.0		7.5		6.0		ns
$t_{\text{w(L)}}$	$CP_U$ or $CP_D$ Pulse Width, LOW	5.0		7.0		5.0		ns
$t_{\text{w(L)}}$	$CP_U$ or $CP_D$ Pulse Width, LOW (Change of Direction)	10.0		12.0		10.0		ns
$t_{\text{w(H)}}$	MR Pulse Width, HIGH	6.0		6.0		6.0		ns
$t_{\text{rec}}$	Recovery Time $\overline{PL}$ to $CP_U$ or $CP_D$	6.0		8.0		6.0		ns
$t_{\text{rec}}$	Recovery Time MR to $CP_U$ or $CP_D$	4.0		4.5		4.0		ns

## Ordering Information

The device number is used to form part of a simplified purchasing code where the package type and temperature range are defined as follows:

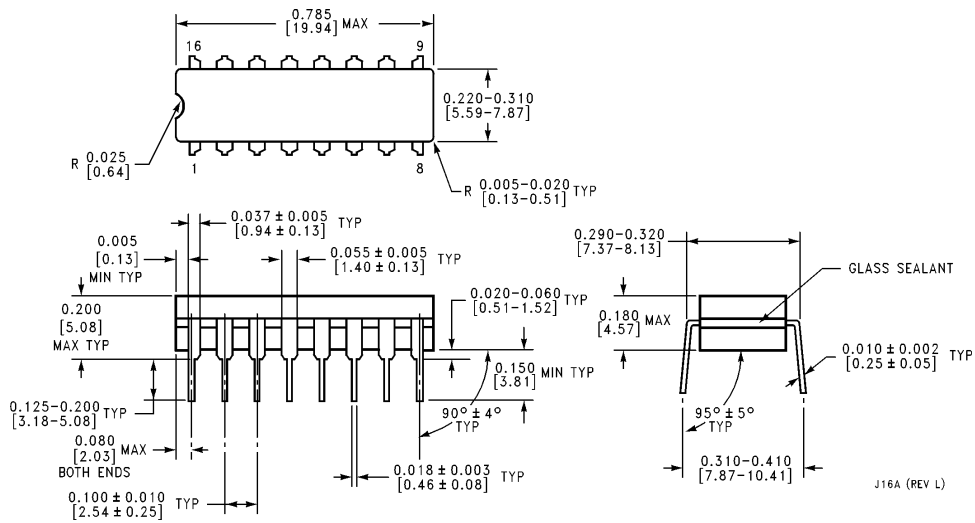


**Physical Dimensions** inches (millimeters)



**20-Lead Ceramic Leadless Chip Carrier (L)**  
**NS Package Number E20A**

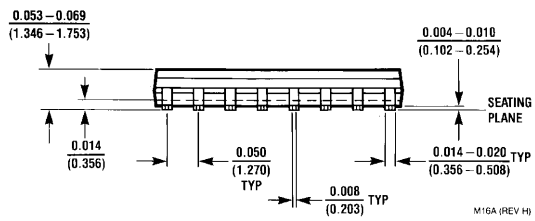
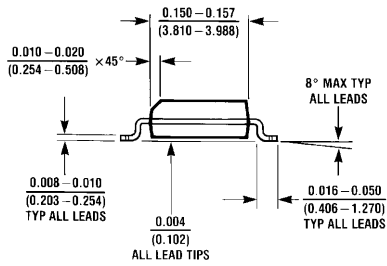
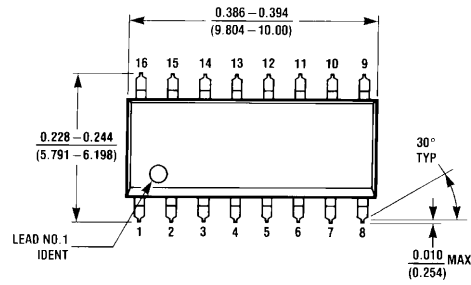
E20A (REV D)



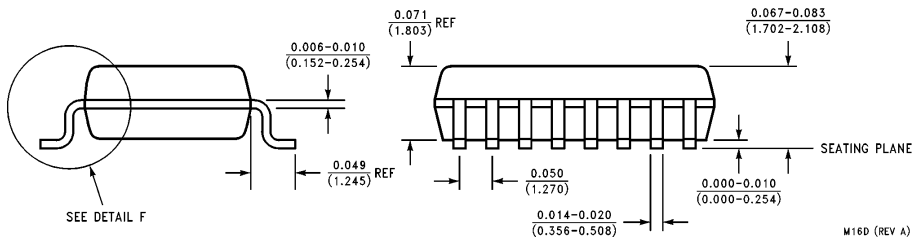
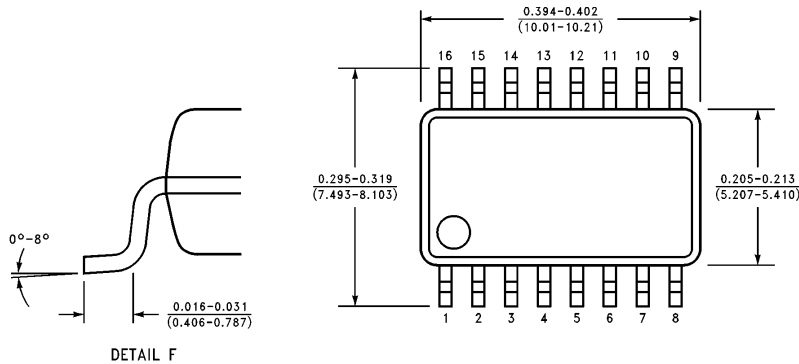
**16-Lead Ceramic Dual-In-Line Package (D)**  
**NS Package Number J16A**

J16A (REV L)

**Physical Dimensions** inches (millimeters) (Continued)



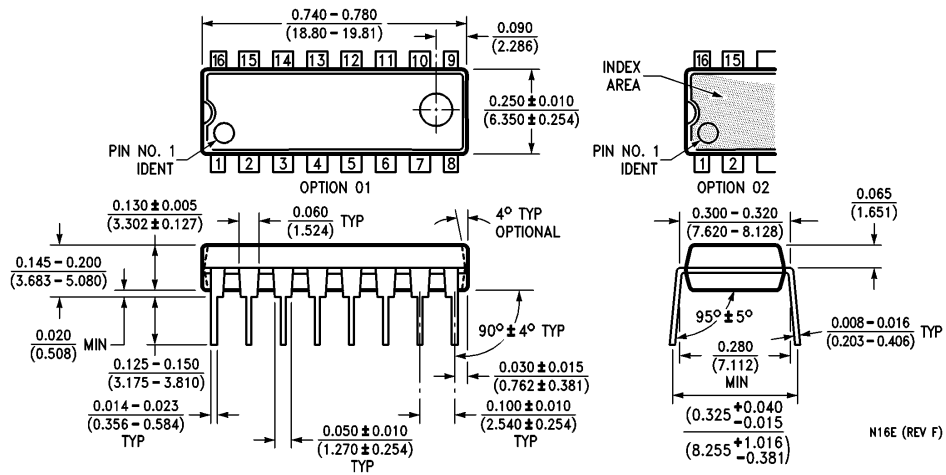
**16-Lead (0.150" Wide) Molded Small Outline Package, JEDEC (S)  
NS Package Number M16A**



**16-Lead (0.300" Wide) Molded Small Outline Package, EIAJ (SJ)  
NS Package Number M16D**



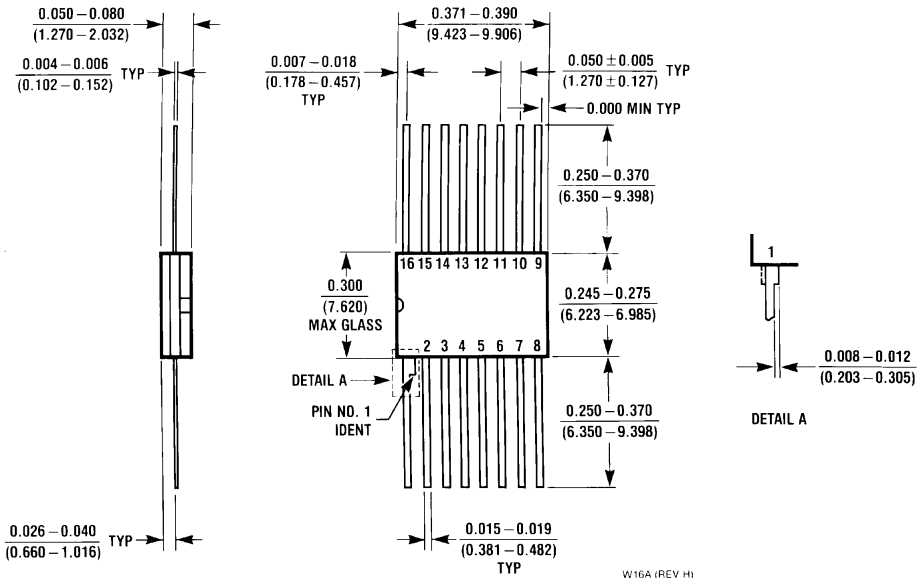
**Physical Dimensions** inches (millimeters) (Continued)



**16-Lead (0.300" Wide) Molded Dual-In-Line Package (P)**  
**NS Package Number N16E**

N16E (REV F)

**Physical Dimensions** inches (millimeters) (Continued)



**16-Lead Ceramic Flatpak (F)  
NS Package Number W16A**

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