National Semiconductor

November 1994

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 ($\overline{PL}$) and the Master Reset (MR) inputs asynchronously override the clocks.

Features

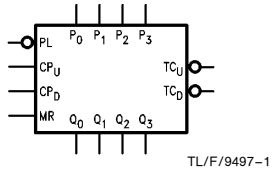
- Guaranteed 4000V minimum ESD protection

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



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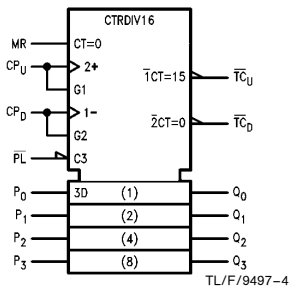
IEEE/IEC



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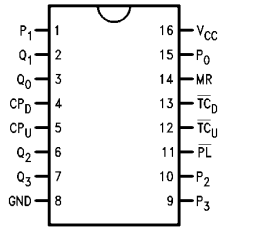
Connection Diagrams

Pin Assignment for DIP, SOIC and Flatpak



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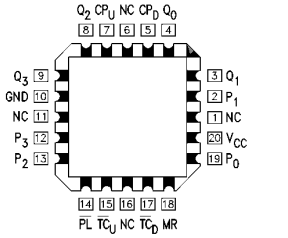
Pin Assignment for LCC



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Unit Loading/Fan Out

Pin Names	Description	54F/74F	
		U.L. HIGH/LOW	Input I_{IH}/I_{IL} Output I_{OH}/I_{OL}
CP_U	Count Up Clock Input (Active Rising Edge)	1.0/3.0	20 μA/ −1.8 mA
CP_D	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_0-P_3	Parallel Data Inputs	1.0/1.0	20 μA/ −0.6 mA
Q_0-Q_3	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_U 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.

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

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

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_0-P_3) 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.

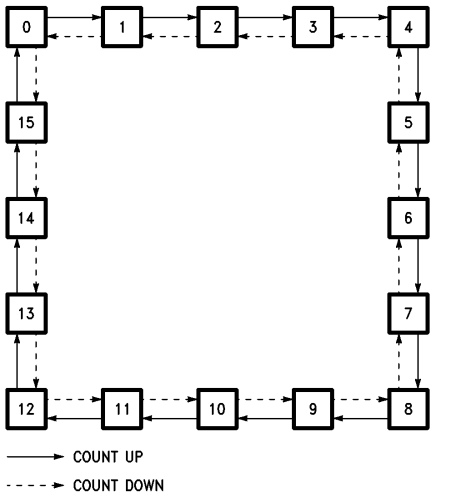
If one of the clock inputs is LOW during and after a reset or load operation, the next LOW-to-HIGH transition of that clock will be interpreted as a legitimate signal and will be counted.

Function Table

MR	$\overline{PL}$	CP_U	CP_D	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



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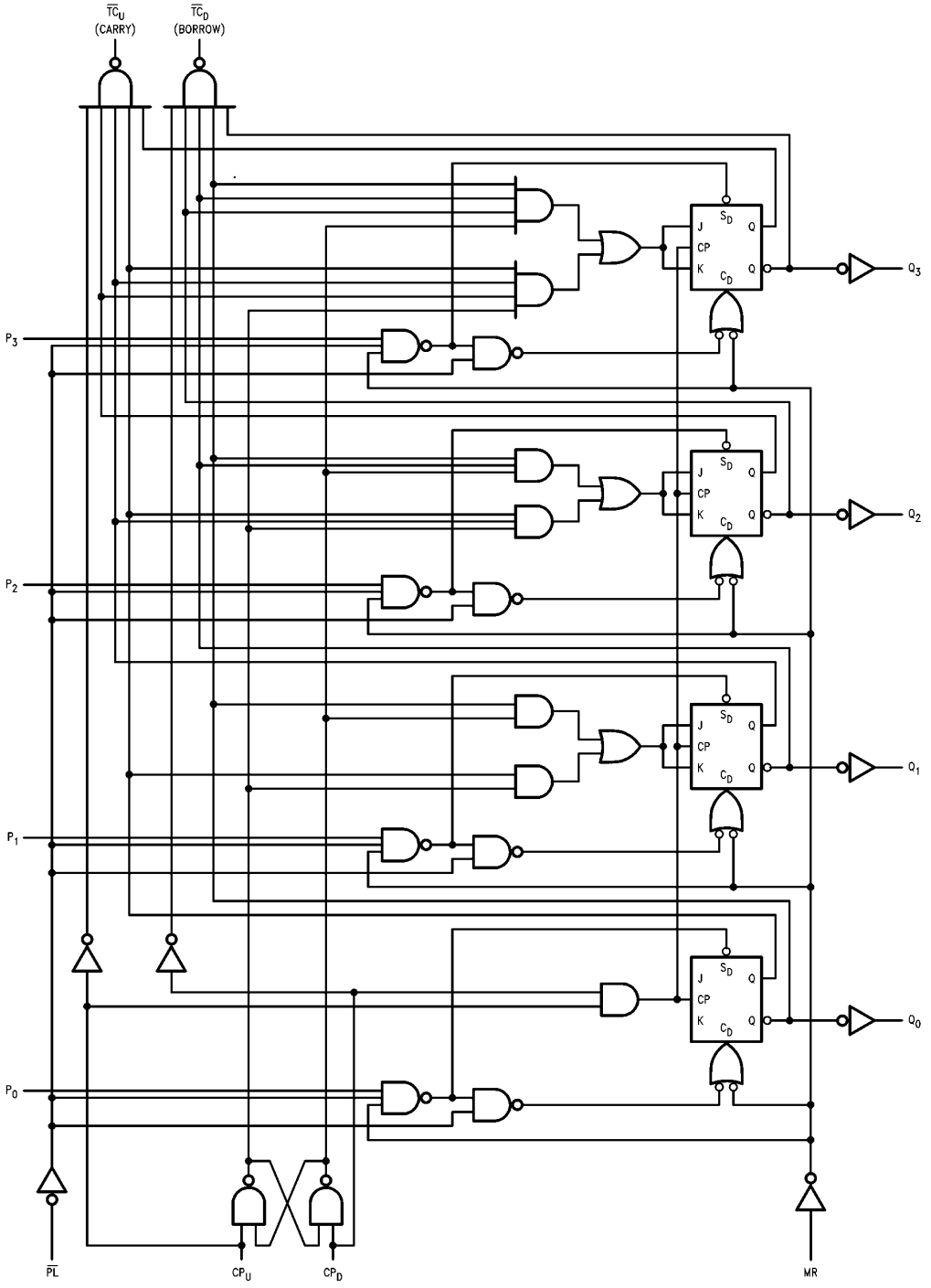
Logic Diagram



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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_{CC} 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_{CC} = 0V)	
Standard Output	−0.5V to V_{CC}
TRI-STATE® Output	−0.5V to +5.5V
Current Applied to Output in LOW State (Max)	twice the rated I_{OL} (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 Min	54F/74F Typ	54F/74F Max	Units	V_{CC}	Conditions
V_{IH}	Input HIGH Voltage		2.0			V		Recognized as a HIGH Signal
V_{IL}	Input LOW Voltage				0.8	V		Recognized as a LOW Signal
V_{CD}	Input Clamp Diode Voltage				−1.2	V	Min	I_{IN} = −18 mA
V_{OH}	Output HIGH Voltage	54F 10% V_{CC}	2.5			V	Min	I_{OH} = −1 mA
		74F 10% V_{CC}	2.5					I_{OH} = −1 mA
		74F 5% V_{CC}	2.7					I_{OH} = −1 mA
V_{OL}	Output LOW Voltage	54F 10% V_{CC}			0.5	V	Min	I_{OL} = 20 mA
		74F 10% V_{CC}			0.5			I_{OL} = 20 mA
I_{IH}	Input HIGH Current	54F			20.0	μA	Max	V_{IN} = 2.7V
		74F			5.0			
I_{BVI}	Input HIGH Current Breakdown Test	54F			100	μA	Max	V_{IN} = 7.0V
		74F			7.0			
I_{CEX}	Output HIGH Leakage Current	54F			250	μA	Max	V_{OUT} = V_{CC}
		74F			50			
V_{ID}	Input Leakage Test	74F	4.75			V	0.0	I_{ID} = 1.9 μA All Other Pins Grounded
I_{OD}	Output Leakage Circuit Current	74F			3.75	μA	0.0	V_{IOD} = 150 mV All Other Pins Grounded
I_{IL}	Input LOW Current				−0.6	mA	Max	V_{IN} = 0.5V (MR, $\overline{PL}$, P_n)
					−1.8			V_{IN} = 0.5V (CP_u, CP_D)
I_{OS}	Output Short-Circuit Current		−60		−150	mA	Max	V_{OUT} = 0V
I_{CC}	Power Supply Current			38	55	mA	Max	

AC Electrical Characteristics

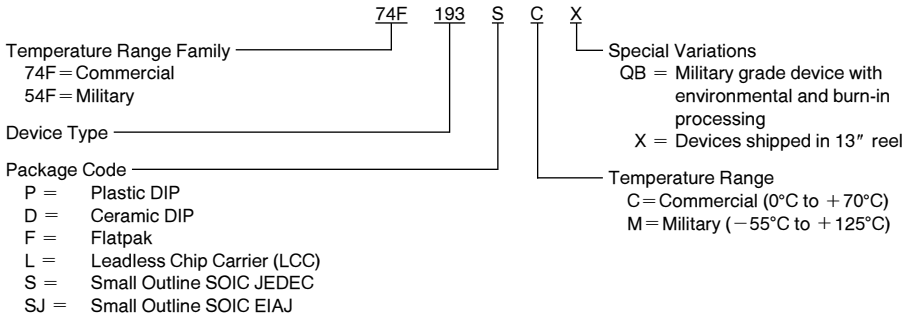
Symbol	Parameter	74F $T_A = +25°C$ $V_{CC} = +5.0V$ $C_L = 50$ pF			54F $T_A, V_{CC} =$ Mil $C_L = 50$ pF		74F $T_A, V_{CC} =$ Com $C_L = 50$ pF		Units
		Min	Typ	Max	Min	Max	Min	Max	
f_{max}	Maximum Count Frequency	100	125		75		90		MHz
t_{PLH} t_{PHL}	Propagation Delay CP_U or CP_D to $\overline{TC}_U$ 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_{PLH} t_{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_{PLH} t_{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_{PLH} t_{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_{PHL}	Propagation Delay MR to Q_n	5.5	11.0	14.5	5.0	16.0	5.5	15.5	ns
t_{PLH}	Propagation Delay MR to $\overline{TC}_U$	6.0	10.5	13.5	5.0	15.0	6.0	14.5	
t_{PHL}	Propagation Delay MR to $\overline{TC}_D$	6.0	11.5	14.5	6.0	16.0	6.0	15.5	
t_{PLH} t_{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_{PLH} t_{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

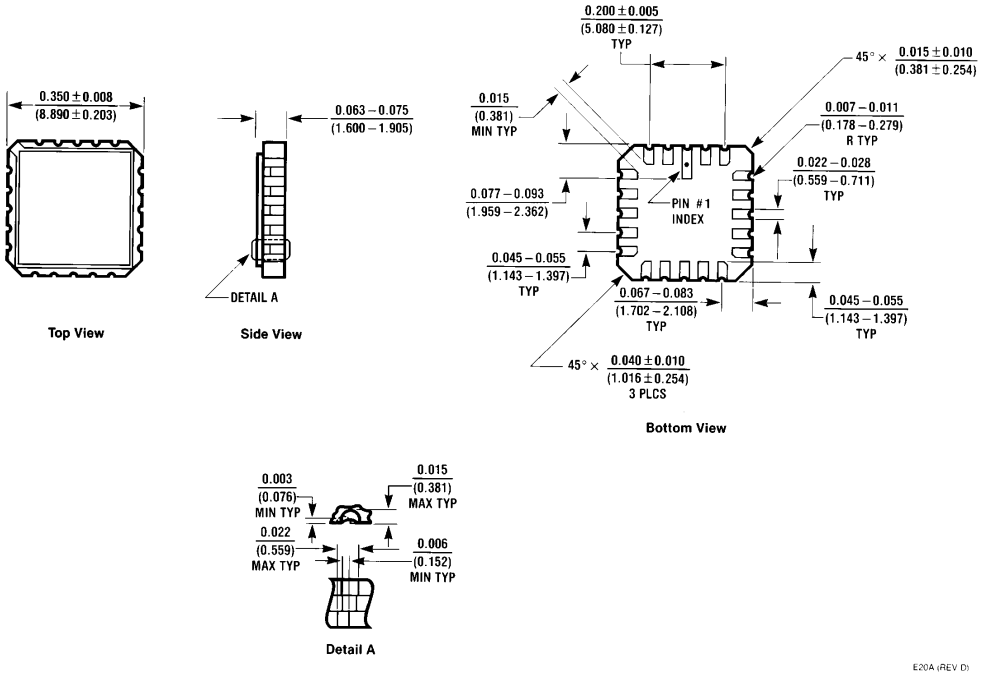
Symbol	Parameter	74F $T_A = +25°C$ $V_{CC} = +5.0V$		54F $T_A, V_{CC} =$ Mil		74F $T_A, V_{CC} =$ Com		Units
		Min	Max	Min	Max	Min	Max	
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW P_n to $\overline{PL}$	4.5 4.5		6.0 6.0		5.0 5.0		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW P_n to $\overline{PL}$	2.0 2.0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

Ordering Information

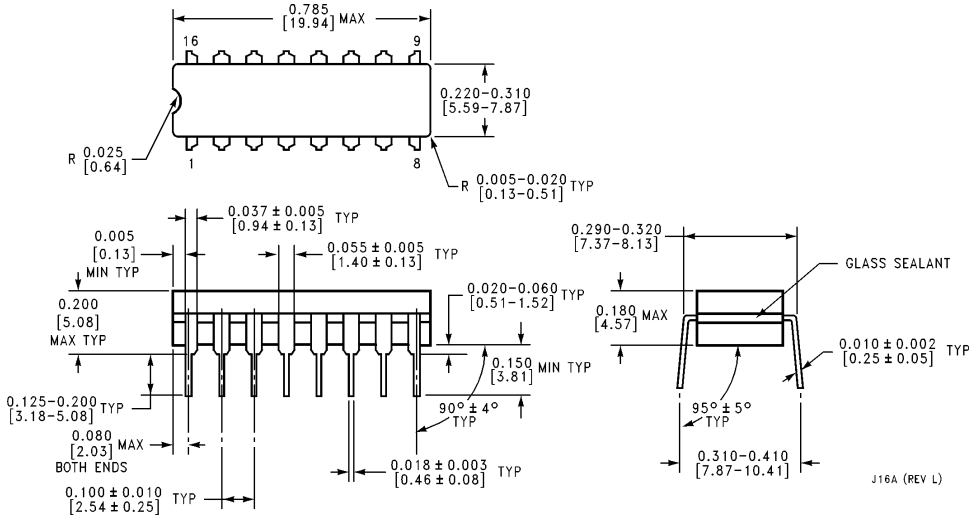
The device number is used to form part of a simplified purchasing code where the package type and temperature range are defined as follows:



Physical Dimensions inches (millimeters)

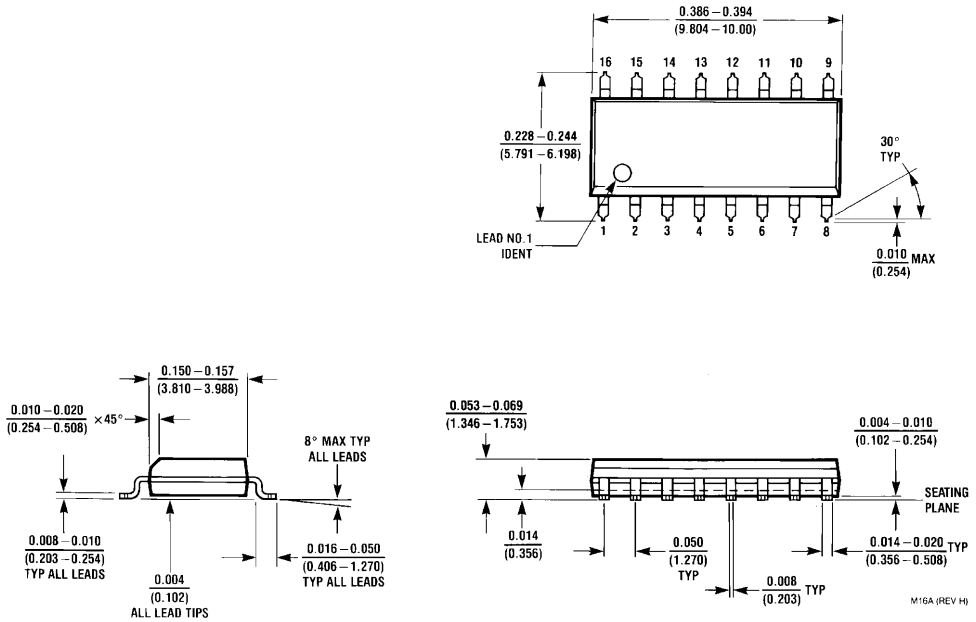


20-Lead Ceramic Leadless Chip Carrier (L)
NS Package Number E20A

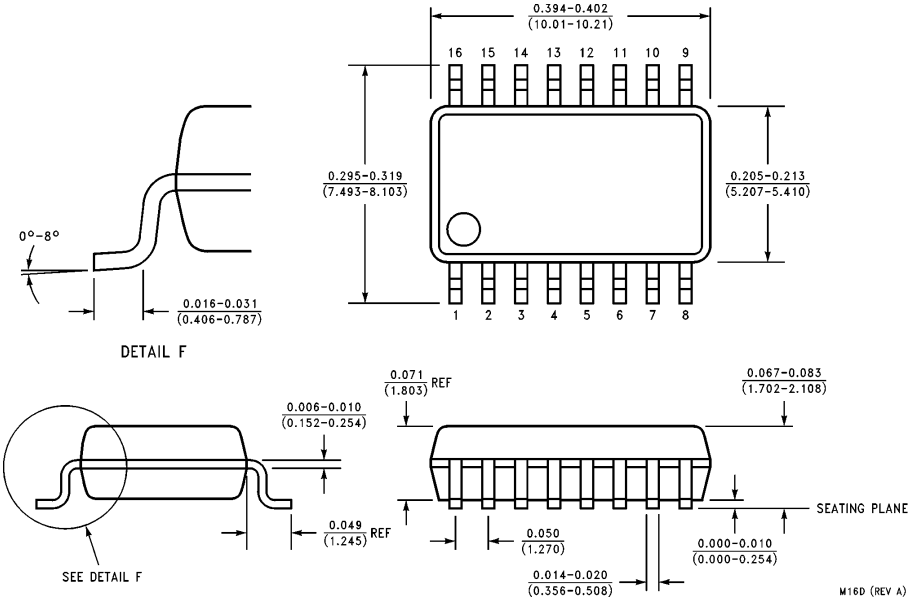


16-Lead Ceramic Dual-In-Line Package (D)
NS Package Number J16A

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

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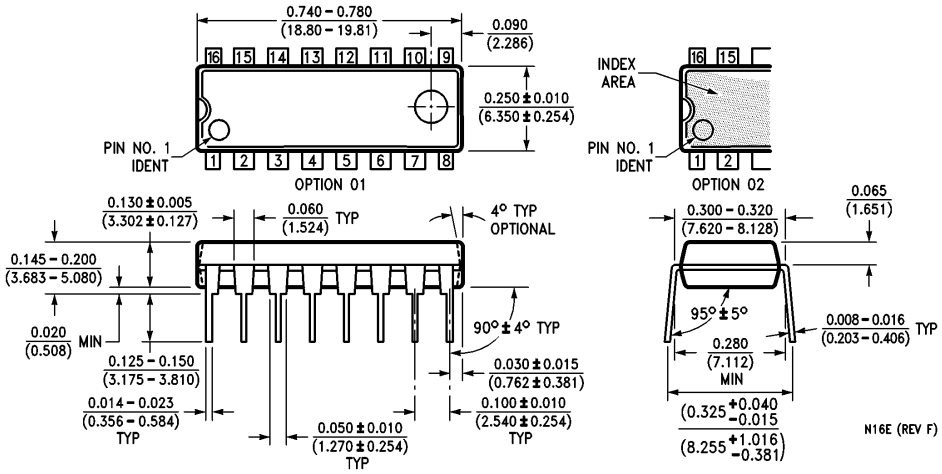

16-Lead (0.300″ Wide) Molded Dual-In-Line Package (P)
NS Package Number N16E

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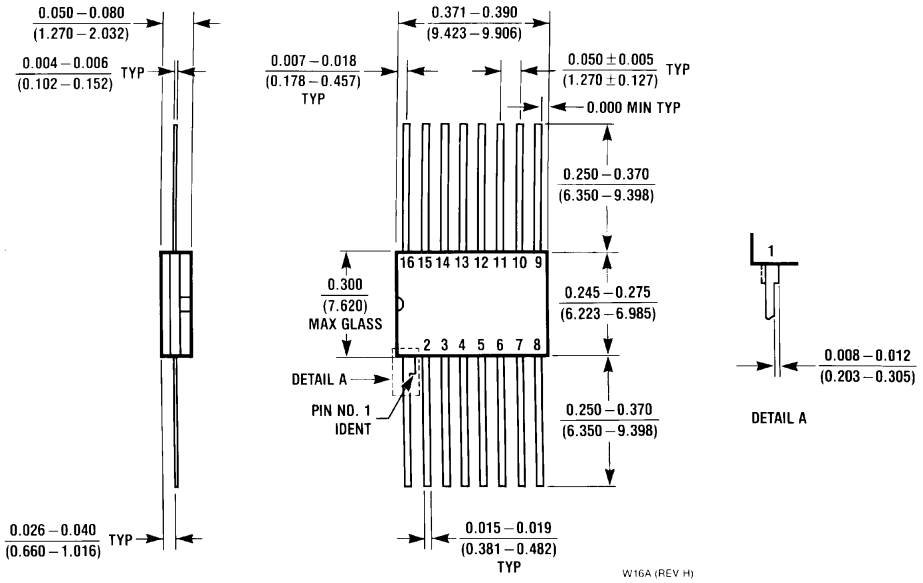

16-Lead Ceramic Flatpak (F)
NS Package Number W16A

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