National Semiconductor

August 1995

74F569
4-Bit Bidirectional Counter with TRI-STATE® Outputs

General Description

The 'F569 is a fully synchronous, reversible counter with TRI-STATE outputs. The 'F569 is a binary counter, featuring preset capability for programmable operation, carry lookahead for easy cascading, and a U/$\overline{D}$ input to control the direction of counting. For maximum flexibility there are both synchronous and master asynchronous reset inputs as well as both Clocked Carry ($\overline{CC}$) and Terminal Count ($\overline{TC}$) outputs. All state changes except Master Reset are initiated by the rising edge of the clock. A HIGH signal on the Output Enable ($\overline{OE}$) input forces the output buffers into the high impedance state but does not prevent counting, resetting or parallel loading.

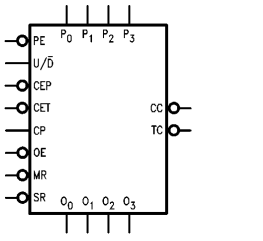
Features

- Synchronous counting and loading
- Lookahead carry capability for easy cascading
- Preset capability for programmable operation
- TRI-STATE outputs for bus organized systems

Commercial	Package Number	Package Description
74F569PC	N20A	20-Lead (0.300″ Wide) Molded Dual-In-Line
74F569SC (Note 1)	M20B	20-Lead (0.300″ Wide) Molded Small Outline, JEDEC
74F569SJ (Note 1)	M20D	20-Lead (0.300″ Wide) Molded Small Outline, EIAJ

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

Logic Symbols



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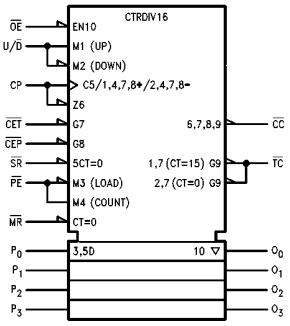
IEEE/IEC



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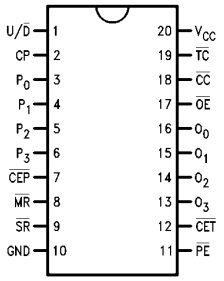
Connection Diagram

Pin Assignment for DIP, SOIC



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Unit Loading/Fan Out

Pin Names	Description	74F	
		U.L. HIGH/LOW	Input I_{IH}/I_{IL} Output I_{OH}/I_{OL}
P_0-P_3	Parallel Data Inputs	1.0/1.0	20 μA/−0.6 mA
$\overline{CEP}$	Count Enable Parallel Input (Active LOW)	1.0/1.0	20 μA/−0.6 mA
$\overline{CET}$	Count Enable Trickle Input (Active LOW)	1.0/1.0	20 μA/−1.2 mA
CP	Clock Pulse Input (Active Rising Edge)	1.0/1.0	20 μA/−0.6 mA
$\overline{PE}$	Parallel Enable Input (Active LOW)	1.0/1.0	20 μA/−1.2 mA
U/$\overline{D}$	Up/Down Count Control Input	1.0/1.0	20 μA/−0.6 mA
$\overline{OE}$	Output Enable Input (Active LOW)	1.0/1.0	20 μA/−0.6 mA
$\overline{MR}$	Master Reset Input (Active LOW)	1.0/1.0	20 μA/−0.6 mA
$\overline{SR}$	Synchronous Reset Input (Active LOW)	1.0/1.0	20 μA/−0.6 mA
O_0-O_3	TRI-STATE Parallel Data Outputs	150/40(33.3)	−3 mA/24 mA (20 mA)
$\overline{TC}$	Terminal Count Output (Active LOW)	50/33.3	−1 mA/20 mA
$\overline{CC}$	Clocked Carry Output (Active LOW)	50/33.3	−1 mA/20 mA

Functional Description

The 'F569 counts in the modulo-16 binary sequence. From state 15 it will increment to state 0 in the Up mode; in the Down mode it will decrement from 0 to 15. The clock inputs of all flip-flops are driven in parallel through a clock buffer. All state changes (except due to Master Reset) occurs synchronously with the LOW-to-HIGH transition of the Clock Pulse (CP) input signal.

The circuits have five fundamental modes of operation, in order of precedence: asynchronous reset, synchronous reset, parallel load, count and hold. Five control inputs—Master Reset ($\overline{MR}$), Synchronous Reset ($\overline{SR}$), Parallel Enable ($\overline{PE}$), Count Enable Parallel ($\overline{CEP}$) and Count Enable Trickle $\overline{CET}$)—plus the Up/Down (U/$\overline{D}$) input, determine the mode of operation, as shown in the Mode Select Table. A LOW signal on $\overline{MR}$ overrides all other inputs and asynchronously forces the flip-flop Q outputs LOW. A LOW signal on $\overline{SR}$ overrides counting and parallel loading and allows the Q outputs to go LOW on the next rising edge of CP. A LOW signal on $\overline{PE}$ overrides counting and allows information on the Parallel Data (P_n) inputs to be loaded into the flip-flops on the next rising edge of CP. With $\overline{MR}$, $\overline{SR}$ and $\overline{PE}$ HIGH, $\overline{CEP}$ and $\overline{CET}$ permit counting when both are LOW. Conversely, a HIGH signal on either $\overline{CEP}$ or $\overline{CET}$ inhibits counting.

The 'F569 uses edge-triggered flip-flops and changing the $\overline{SR}$, $\overline{PE}$, $\overline{CEP}$, $\overline{CET}$ or U/$\overline{D}$ inputs when the CP is in either state does not cause errors, provided that the recommended setup and hold times, with respect to the rising edge of CP, are observed.

Two types of outputs are provided as overflow/underflow indicators. The Terminal Count ($\overline{TC}$) output is normally HIGH and goes LOW providing $\overline{CET}$ is LOW, when the counter reaches zero in the Down mode, or reaches maximum (15) in the Up mode. $\overline{TC}$ will then remain LOW until a state change occurs, whether by counting or presetting, or until U/$\overline{D}$ or $\overline{CET}$ is changed. To implement synchronous multistage counters, the connections between the $\overline{TC}$ output and the $\overline{CEP}$ and $\overline{CET}$ inputs can provide either slow or fast carry propagation.

Figure 1 shows the connections for simple ripple carry, in which the clock period must be longer than the CP to $\overline{TC}$ delay of the first stage, plus the cumulative $\overline{CET}$ to $\overline{TC}$ delays of the intermediate stages, plus the $\overline{CET}$ to CP setup time of the last stage. This total delay plus setup time sets the upper limit on clock frequency. For faster clock rates, the carry lookahead connections shown in *Figure 2* are recommended. In this scheme the ripple delay through the intermediate stages commences with the same clock that causes the first stage to tick over from max to min in the Up mode, or min to max in the Down mode, to start its final cycle. Since this final cycle takes 16 clocks to complete, there is plenty of time for the ripple to progress through the intermediate stages. The critical timing that limits the clock period is the CP to $\overline{TC}$ delay of the first stage plus the $\overline{CEP}$ to CP setup time of the last stage. The $\overline{TC}$ output is subject to decoding spikes due to internal race conditions and is therefore not recommended for use as a clock or asynchronous reset for flip-flops, registers or counters. For such applications, the Clocked Carry ($\overline{CC}$) output is provided. The $\overline{CC}$ output is normally HIGH. When $\overline{CEP}$, $\overline{CET}$, and $\overline{TC}$ are LOW, the $\overline{CC}$ output will go LOW when the clock next goes LOW and will stay LOW until the clock goes HIGH again, as shown in the $\overline{CC}$ Truth Table. When the Output Enable ($\overline{OE}$) is LOW, the parallel data outputs O_0-O_3 are active and follow the flip-flop Q outputs. A HIGH signal on $\overline{OE}$ forces O_0-O_3 to the High Z state but does not prevent counting, loading or resetting.

Logic Equations

Count Enable = $\overline{CEP} \bullet \overline{CET} \bullet PE$
Up: $\overline{TC} = Q_0 \bullet Q_1 \bullet Q_2 \bullet Q_3 \bullet (Up) \bullet \overline{CET}$
Down: $\overline{TC} = \overline{Q}_0 \bullet \overline{Q}_1 \bullet \overline{Q}_2 \bullet \overline{Q}_3 \bullet (Down) \bullet \overline{CET}$

$\overline{CC}$ Truth Table

Inputs						Output
$\overline{SR}$	$\overline{PE}$	$\overline{CEP}$	$\overline{CET}$	$\overline{TC}$*	CP	$\overline{CC}$
L	X	X	X	X	X	H
X	L	X	X	X	X	H
X	X	H	X	X	X	H
X	X	X	H	X	X	H
X	X	X	X	H	X	H
H	H	L	L	L	⌐⌐	⌐⌐

*$\overline{TC}$ is generated internally
H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial
⌐⌐ = HIGH-to-LOW-to-HIGH Clock Transition

Mode Select Table

Inputs						Operating Mode
$\overline{MR}$	$\overline{SR}$	$\overline{PE}$	$\overline{CEP}$	$\overline{CET}$	U/$\overline{D}$	
L	X	X	X	X	X	Asynchronous Reset
H	L	X	X	X	X	Synchronous Reset
H	H	L	X	X	X	Parallel Load
H	H	H	H	X	X	Hold
H	H	H	X	H	X	Hold
H	H	H	L	L	H	Count Up
H	H	H	L	L	L	Count Down

H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial

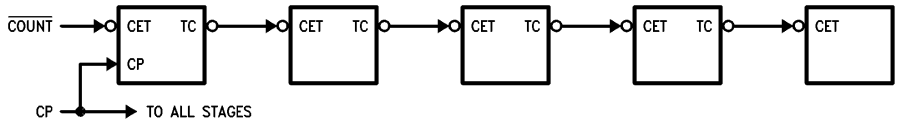

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FIGURE 1: Multistage Counter with Ripple Carry

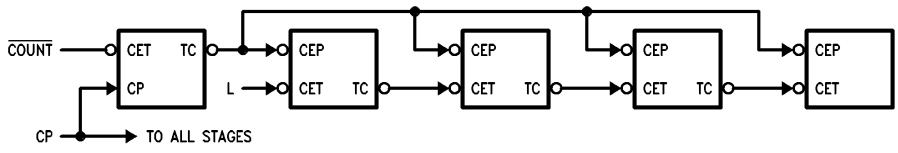

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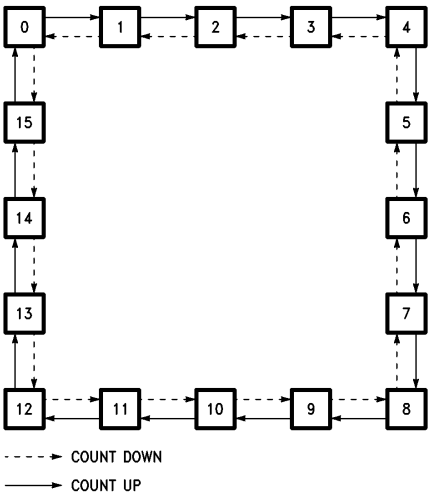
FIGURE 2: Multistage Counter with Lookahead Carry

State Diagram



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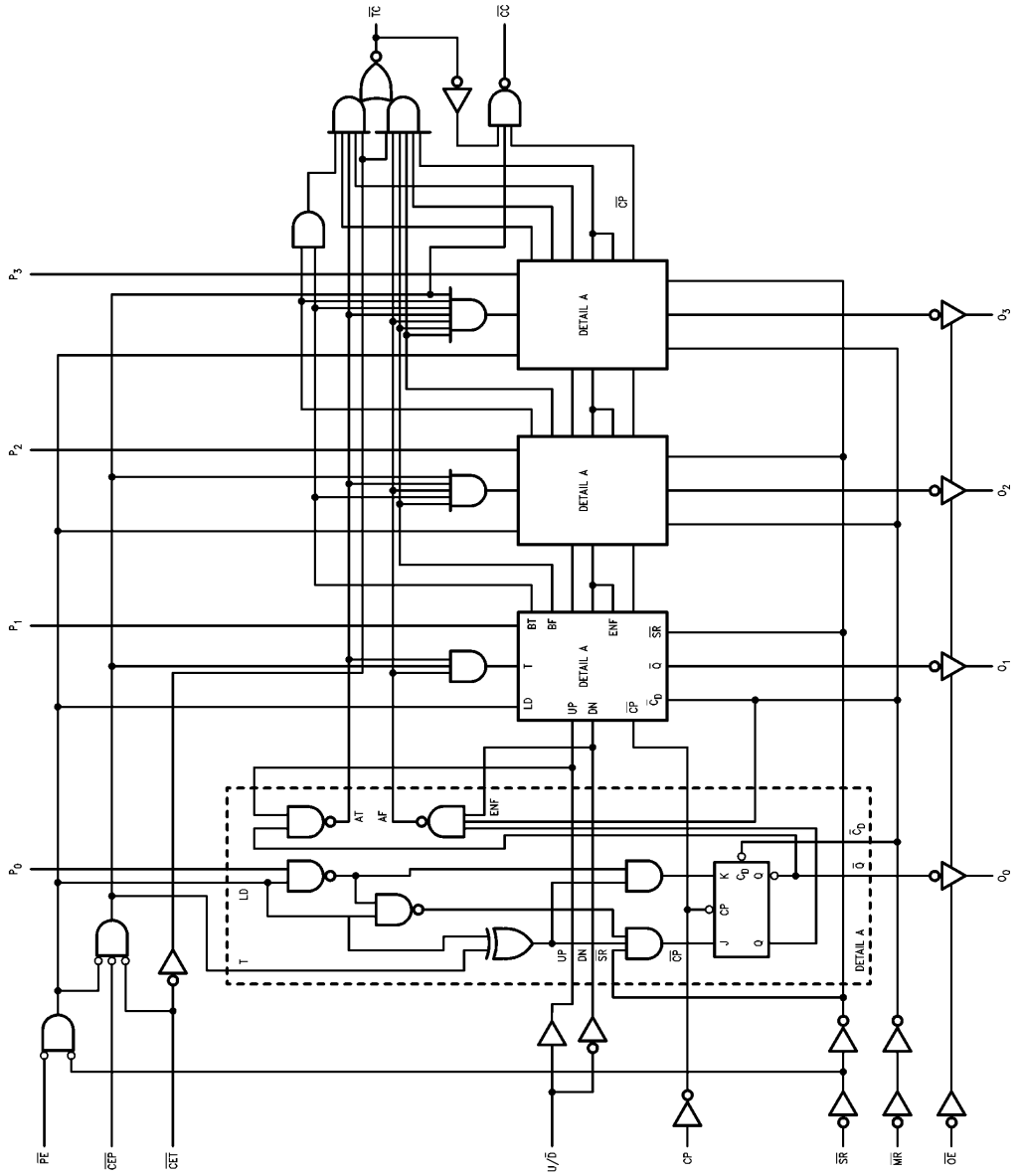
Logic Diagram



Please note that these diagrams are provided only for the understanding of logic operations and should not be used to estimate propagation delays.

Absolute Maximum Ratings (Note 1)

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
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)

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	
Commercial	0°C to +70°C
Supply Voltage	
Commercial	+4.5V to +5.5V

DC Electrical Characteristics

Symbol	Parameter		74F Min	74F Typ	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	74F 10% V_{CC}	2.5			V	Min	I_{OH} = −1 mA ($\overline{TC}$, $\overline{CC}$, O_n)
		74F 10% V_{CC}	2.4					I_{OH} = −3 mA (O_n)
		74F 5% V_{CC}	2.7					I_{OH} = −1 mA ($\overline{TC}$, $\overline{CC}$, O_n)
		74F 5% V_{CC}	2.7					I_{OH} = −3 mA (O_n)
V_{OL}	Output LOW Voltage	74F 10% V_{CC}			0.5	V	Min	I_{OL} = 20 mA ($\overline{TC}$, $\overline{CC}$)
		74F 10% V_{CC}			0.5			I_{OL} = 24 mA (O_n)
I_{IH}	Input HIGH Current	74F			5.0	μA	Max	V_{IN} = 2.7V
I_{BVI}	Input HIGH Current Breakdown Test	74F			7.0	μA	Max	V_{IN} = 7.0V
I_{CEX}	Output HIGH Leakage Current	74F			50	μA	Max	V_{OUT} = V_{CC} ($\overline{TC}$, $\overline{CC}$, O_n)
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 (P_n, $\overline{CEP}$, CP, U/$\overline{D}$, $\overline{OE}$, $\overline{MR}$, $\overline{SR}$)
					−1.2	mA	Max	V_{IN} = 0.5V ($\overline{PE}$, $\overline{CET}$)

DC Electrical Characteristic (Continued)

Symbol	Parameter	74F			Units	V_{CC}	Conditions
		Min	Typ	Max			
I_{OZH}	Output Leakage Current			50	μA	Max	V_{OUT} = 2.7V (O_n)
I_{OZL}	Output Leakage Current			−50	μA	Max	V_{OUT} = 0.5V (O_n)
I_{OS}	Output Short-Circuit Current	−60		−150	mA	Max	V_{OUT} = 0V ($\overline{TC}$, $\overline{CC}$, O_n)
I_{ZZ}	Bus Drainage Test			500	μA	0.0V	V_{OUT} = 5.25V (O_n)
I_{CCH}	Power Supply Current		45	67	mA	Max	V_O = HIGH
I_{CCL}	Power Supply Current		45	67	mA	Max	V_O = LOW
I_{CCZ}	Power Supply Current		45	67	mA	Max	V_O = HIGH Z

AC Electrical Characteristics

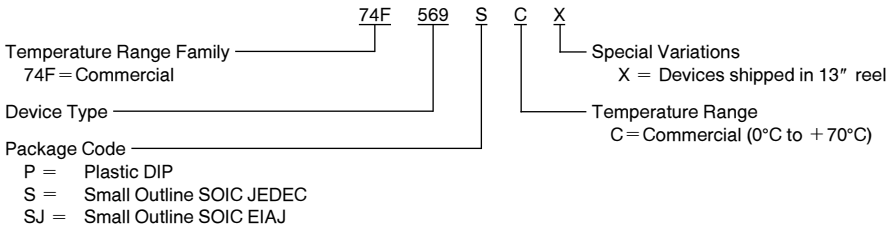
Symbol	Parameter	74F			74F		Units
		T_A = +25°C, V_{CC} = +5.0V, C_L = 50 pF			T_A, V_{CC} = Com, C_L = 50 pF		
		Min	Typ	Max	Min	Max	
f_{max}	Maximum Clock Frequency	90			70		MHz
t_{PLH} t_{PHL}	Propagation Delay CP to O_n ($\overline{PE}$ HIGH or LOW)	3.0 4.0	6.5 9.0	8.5 11.5	3.0 4.0	9.5 13.0	ns
t_{PLH} t_{PHL}	Propagation Delay CP to $\overline{TC}$	5.5 4.0	12.0 8.5	15.5 12.5	5.5 4.0	17.5 13.0	ns
t_{PLH} t_{PHL}	Propagation Delay $\overline{CET}$ to $\overline{TC}$	2.5 2.5	4.5 6.0	6.5 11.0	2.5 2.5	7.0 12.0	ns
t_{PLH} t_{PHL}	Propagation Delay U/$\overline{D}$ to $\overline{TC}$	3.5 4.0	8.5 8.0	11.5 12.0	3.5 4.0	12.5 13.0	ns
t_{PLH} t_{PHL}	Propagation Delay CP to $\overline{CC}$	2.5 2.0	5.5 4.5	7.0 6.0	2.0 2.0	8.0 7.0	ns
t_{PLH} t_{PHL}	Propagation Delay $\overline{CEP}$, $\overline{CET}$ to $\overline{CC}$	2.5 4.0	5.0 8.5	6.5 11.0	2.0 4.0	7.5 12.5	ns
t_{PHL}	Propagation Delay $\overline{MR}$ to O_n	5.0	10.0	13.0	5.0	14.5	ns
t_{PZH} t_{PZL}	Output Enable Time $\overline{OE}$ to O_n	2.5 3.0	5.5 6.0	8.0 9.0	2.5 3.0	8.5 10.0	ns
t_{PHZ} t_{PLZ}	Output Disable Time $\overline{OE}$ to O_n	1.5 2.0	5.0 4.5	7.0 6.0	1.5 2.0	8.0 7.0	

AC Operating Requirements

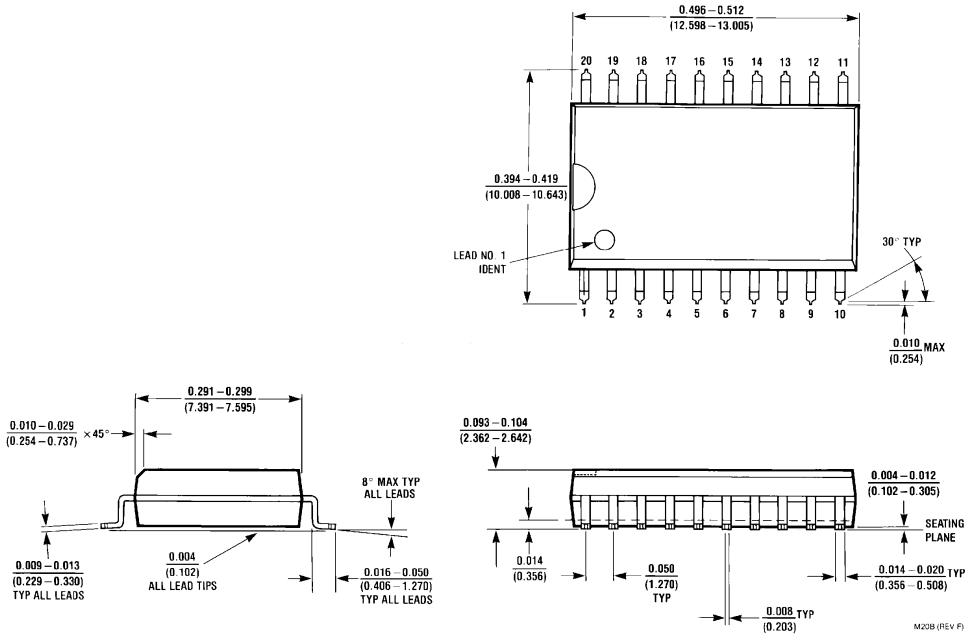
Symbol	Parameter	74F $T_A = +25°C$, $V_{CC} = +5.0V$		74F T_A, V_{CC} = Com		Units
		Min	Max	Min	Max	
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW P_n to CP	4.0 4.0		4.5 4.5		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW P_n to CP	3.0 3.0		3.5 3.5		ns
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW $\overline{CEP}$ or $\overline{CET}$ to CP	7.0 5.0		8.0 6.5		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW $\overline{CEP}$ or $\overline{CET}$ to CP	0 0.5		0 0.5		ns
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW $\overline{PE}$ to CP	8.0 8.0		9.0 9.0		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW $\overline{PE}$ to CP	0.0 0		1.0 0		ns
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW $U/\overline{D}$ to CP	11.0 7.0		12.5 8.5		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW $U/\overline{D}$ to CP	0 0		0 0		ns
$t_s(H)$ $t_s(L)$	Setup Time, HIGH or LOW $\overline{SR}$ to CP	10.5 8.5		11.0 9.5		ns
$t_h(H)$ $t_h(L)$	Hold Time, HIGH or LOW $\overline{SR}$ to CP	0 0		0 0		ns
$t_w(H)$ $t_w(L)$	CP Pulse Width, HIGH or LOW	4.0 7.0		4.5 8.0		ns
$t_w(L)$	$\overline{MR}$ Pulse Width, LOW	4.5		6.0		ns
t_{rec}	$\overline{MR}$ Recovery Time	6.0		8.0		ns

Ordering Information

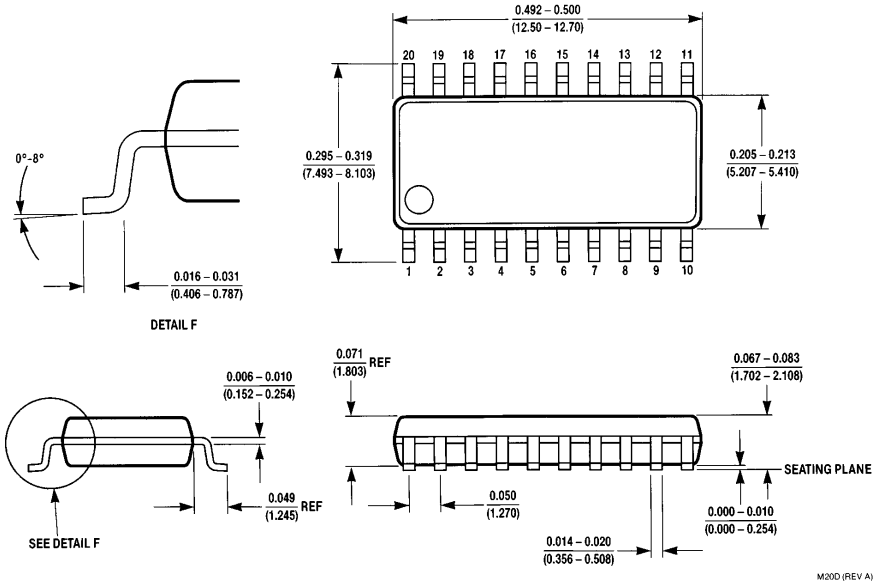
The device number is used to form part of a simplified purchasing code where the package type and temperature range are defined as follows:



Physical Dimensions inches (millimeters)

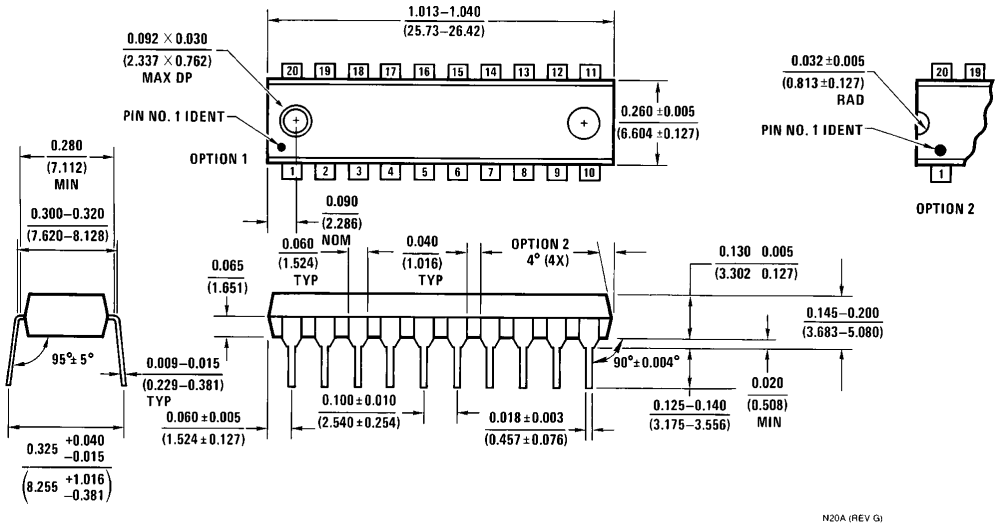


20-Lead (0.300″ Wide) Molded Small Outline Package, JEDEC (S)
NS Package Number M20B



20-Lead (0.300″ Wide) Small Outline Package, EIAJ (S)
NS Package Number M20D

Physical Dimensions inches (millimeters) (Continued)



20-Lead (0.300″ Wide) Molded Dual-In-Line Package (P)
NS Package Number N20A

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