

54F/74F181 4-Bit Arithmetic Logic Unit

General Description

The 'F181 is a 4-bit Arithmetic logic Unit (ALU) which can perform all the possible 16 logic operations on two variables and a variety of arithmetic operations. It is 40% faster than the Schottky ALU and only consumes 30% as much power.

Features

- Full lookahead for high-speed arithmetic operation on long words
- Guaranteed 4000V minimum ESD protection

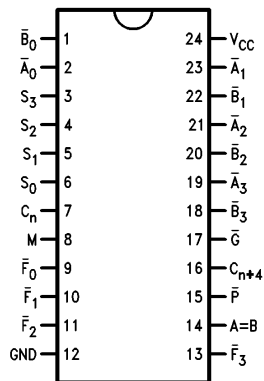
| Commercial | Military | Package Number | Package Description |
|-------------------|--------------------|----------------|---|
| 74F181PC | | N24A | 24-Lead (0.600" Wide) Molded Dual-In-Line |
| 74F181SPC | | N24C | 24-Lead (0.300" Wide) Molded Dual-In-Line |
| | 54F181DM (Note 2) | J24A | 24-Lead Ceramic Dual-In-Line |
| | 54F181SDM (Note 2) | J24F | 24-Lead (0.300") Ceramic Dual-In-Line |
| 74F181SC (Note 1) | | M24B | 24-Lead (0.300") Molded Small Outline, JEDEC |
| | 54F181FM (Note 2) | W24C | 24-Lead Cerpack |
| | 54F181LM (Note 2) | E28A | 24-Lead Ceramic Leadless Chip Carrier, Type C |

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

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

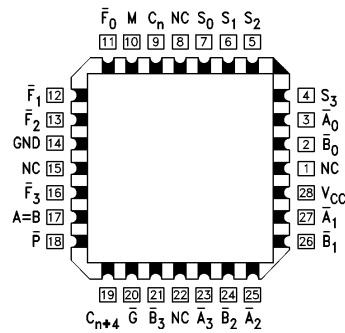
Connection Diagrams

Pin Assignment
for DIP, SOIC and Flatpak



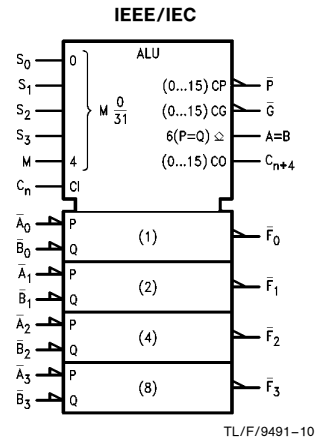
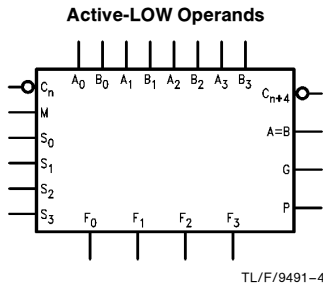
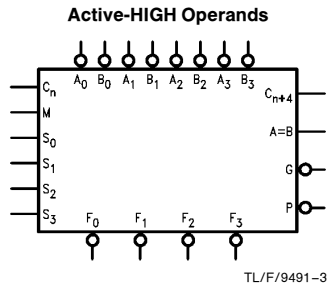
TL/F/9491-1

Pin Assignment
for LCC



TL/F/9491-2

Logic Symbols



Unit Loading/Fan Out

| Pin Names | Description | 54F/74F | |
|---------------------------|-------------------------------------|------------------|---|
| | | U.L. HIGH/LOW | Input I _{IH} /I _{IL} Output I _{OH} /I _{OL} |
| \bar{A}_0 – \bar{A}_3 | A Operand Inputs (Active LOW) | 1.0/3.0 | 20 μ A/ –1.8 mA |
| \bar{B}_0 – \bar{B}_3 | B Operand Inputs (Active LOW) | 1.0/3.0 | 20 μ A/ –1.8 mA |
| S_0 – S_3 | Function Select Inputs | 1.0/4.0 | 20 μ A/ –2.4 mA |
| M | Mode Control Input | 1.0/1.0 | 20 μ A/ –0.6 mA |
| C_n | Carry Input | 1.0/5.0 | 20 μ A/ –3.0 mA |
| \bar{F}_0 – \bar{F}_3 | Function Outputs (Active LOW) | 50/33.3 | –1 mA/20 mA |
| A = B | Comparator Output | OC*/33.3 | */20 mA |
| \bar{G} | Carry Generate Output (Active LOW) | 50/33.3 | –1 mA/20 mA |
| \bar{P} | Carry Propagate Output (Active LOW) | 50/33.3 | –1 mA/20 mA |
| C_{n+4} | Carry Output | 50/33.3 | –1 mA/20 mA |

*OC-Open Collector

Functional Description

The 'F181 is a 4-bit high-speed parallel Arithmetic Logic Unit (ALU). Controlled by the four Function Select inputs (S_0 – S_3) and the Mode Control input (M), it can perform all the 16 possible logic operations or 16 different arithmetic operations on Active HIGH or Active LOW operands. The Function Table lists these operations.

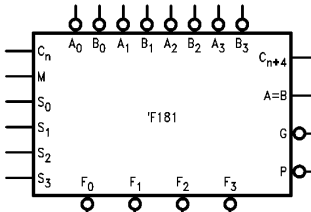
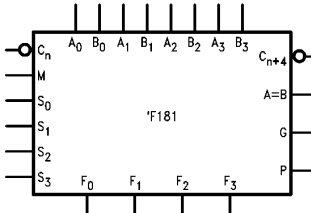
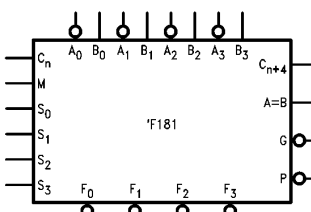
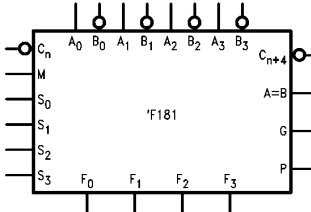
When the Mode Control input (M) is HIGH, all internal carries are inhibited and the device performs logic operations on the individual bits as listed. When the Mode Control input is LOW, the carries are enabled and the device performs arithmetic operations on the two 4-bit words. The device incorporates full internal carry lookahead and provides for either ripple carry between devices using the C_{n+4} output, or for carry lookahead between packages using the signals \bar{P} (Carry Propagate) and \bar{G} (Carry Generate). In the Add mode, \bar{P} indicates that \bar{F} is 15 or more, while \bar{G} indicates that \bar{F} is 16 or more. In the Subtract mode \bar{P} indicates that \bar{F} is zero or less, while \bar{G} indicates that \bar{F} is less than zero. \bar{P} and \bar{G} are not affected by carry in. When speed requirements are not stringent, the 'F181 can be used in a simple Ripple Carry mode by connecting the Carry output (C_{n+4}) signal to the Carry input (C_n) of the next unit. For high speed operation the device is used in conjunction with a carry lookahead circuit. One carry lookahead package is required for

each group of four 'F181 devices. Carry lookahead can be provided at various levels and offers high speed capability over extremely long word lengths.

The A = B output from the device goes HIGH when all four \bar{F} outputs are HIGH and can be used to indicate logic equivalence over four bits when the unit is in the Subtract mode. The A = B output is open collector and can be wired AND with other A = B outputs to give a comparison for more than four bits. The A = B signal can also be used with the C_{n+4} signal to indicate $A > B$ and $A < B$.

The Function Table lists the arithmetic operations that are performed without a carry in. An incoming carry adds a one to each operation. Thus, select code LHHH generates A minus B minus 1 (2s complement notation) without a carry in and generates A minus B when a carry is applied. Because subtraction is actually performed by complementary addition (1s complement), a carry out means borrow; thus a carry is generated when there is no underflow and no carry is generated when there is underflow. As indicated, this device can be used with either active LOW inputs producing active LOW outputs or with active HIGH inputs producing active HIGH outputs. For either case the table lists the operations that are performed to the operands labeled inside the logic symbol.

'F181 Operation Table

| | S ₀ | S ₁ | S ₂ | S ₃ | Logic (M=H) | Arithmetic (M=L, C ₀ =Inactive) | Arithmetic (M=L, C ₀ =Active) |
|--|----------------|----------------|----------------|----------------|--------------------------|---|---|
|  <p align="center">a. All Input Data Inverted</p> | L | L | L | L | \bar{A} | A minus 1 | A |
| | H | L | L | L | $\bar{A} \cdot \bar{B}$ | A • B minus 1 | A • B |
| | L | H | L | L | $\bar{A} + B$ | A • \bar{B} minus 1 | A • \bar{B} |
| | H | H | L | L | Logic "1" | minus 1 (2s comp.) | Zero |
| | L | L | H | L | $\bar{A} + \bar{B}$ | A plus (A + \bar{B}) | A plus (A + \bar{B}) plus 1 |
| | H | L | H | L | \bar{B} | A • B plus (A + \bar{B}) | A • B plus (A + \bar{B}) plus 1 |
| | L | H | H | L | $\bar{A} \oplus \bar{B}$ | A minus B minus 1 | A minus B |
| | H | H | H | L | A + \bar{B} | A + \bar{B} | A + \bar{B} plus 1 |
| | L | L | L | H | $\bar{A} \cdot B$ | A plus (A + B) | A plus (A + B) plus 1 |
| | H | L | L | H | A ⊕ B | A plus B | A plus B plus 1 |
| | L | H | L | H | B | A • \bar{B} plus (A + B) | A • \bar{B} plus (A + B) plus 1 |
| | H | H | L | H | A + B | A + B | A + B plus 1 |
| | L | L | H | H | Logic "0" | A plus A (2 × A) | A plus A (2 × A) plus 1 |
| | H | L | H | H | A • \bar{B} | A plus A • B | A plus A • B plus 1 |
| L | H | H | H | A • B | A plus A • \bar{B} | A plus A • \bar{B} plus 1 | |
| H | H | H | H | A | A | A plus 1 | |
|  <p align="center">b. All Input Data True</p> | L | L | L | L | \bar{A} | A | A plus 1 |
| | H | L | L | L | $\bar{A} + \bar{B}$ | A + B | A + \bar{B} plus 1 |
| | L | H | L | L | $\bar{A} \cdot B$ | A + \bar{B} | A + \bar{B} plus 1 |
| | H | H | L | L | Logic "0" | minus 1 (2s comp.) | Zero |
| | L | L | H | L | $\bar{A} \cdot \bar{B}$ | A plus (A • \bar{B}) | A plus A • \bar{B} plus 1 |
| | H | L | H | L | \bar{B} | A • \bar{B} plus (A + B) | A • B plus (A + B) plus 1 |
| | L | H | H | L | A ⊕ B | A minus B minus 1 | A minus B |
| | H | H | H | L | A • \bar{B} | A • \bar{B} minus 1 | A • \bar{B} |
| | L | L | L | H | $\bar{A} + B$ | A plus A • B | A plus A • B plus 1 |
| | H | L | L | H | $\bar{A} \oplus \bar{B}$ | A plus B | A plus B plus 1 |
| | L | H | L | H | B | A • B plus (A + \bar{B}) | A • B plus (A + \bar{B}) plus 1 |
| | H | H | L | H | A • B | A • B minus 1 | A • B |
| | L | L | H | H | Logic "1" | A plus A (2 × A) | A plus A (2 × A) plus 1 |
| | H | L | H | H | A + \bar{B} | A plus (A + B) | A plus (A + B) plus 1 |
| L | H | H | H | A + B | A plus (A + \bar{B}) | A plus (A + \bar{B}) plus 1 | |
| H | H | H | H | A | A minus 1 | A | |
|  <p align="center">c. A Input Data Inverted; B Input Data True</p> | L | L | L | L | \bar{A} | A minus 1 | A |
| | H | L | L | L | $\bar{A} + B$ | A • \bar{B} minus 1 | A • B |
| | L | H | L | L | $\bar{A} \cdot \bar{B}$ | A • B minus 1 | A • B |
| | H | H | L | L | Logic "1" | minus 1 (2s comp.) | Zero |
| | L | L | H | L | $\bar{A} \cdot B$ | A plus (A + B) | A plus (A + B) plus 1 |
| | H | L | H | L | B | A • \bar{B} plus (A + B) | A • \bar{B} plus (A + B) plus 1 |
| | L | H | H | L | A ⊕ B | A plus B | A plus B plus 1 |
| | H | H | H | L | A + B | A + B | A + B plus 1 |
| | L | L | L | H | $\bar{A} + \bar{B}$ | A plus (A + \bar{B}) | A plus (A + \bar{B}) plus 1 |
| | H | L | L | H | $\bar{A} \oplus \bar{B}$ | A minus B minus 1 | A minus B |
| | L | H | L | H | \bar{B} | A • B plus (A + \bar{B}) | A • B plus (A + \bar{B}) plus 1 |
| | H | H | L | H | A + \bar{B} | A + \bar{B} | A + \bar{B} plus 1 |
| | L | L | H | H | Logic "0" | A plus A (2 × A) | A plus A (2 × A) plus 1 |
| | H | L | H | H | A • B | A plus A • \bar{B} | A plus A • \bar{B} plus 1 |
| L | H | H | H | A • \bar{B} | A plus A • B | A plus A • B plus 1 | |
| H | H | H | H | A | A | A plus 1 | |
|  <p align="center">d. A Input Data True; B Input Data Inverted</p> | L | L | L | L | \bar{A} | A | A plus 1 |
| | H | L | L | L | $\bar{A} \cdot B$ | A + \bar{B} | A + \bar{B} plus 1 |
| | L | H | L | L | $\bar{A} + \bar{B}$ | A + B | A + B plus 1 |
| | H | H | L | L | Logic "0" | minus 1 (2s comp.) | Zero |
| | L | L | H | L | $\bar{A} + B$ | A plus A • B | A plus A • B plus 1 |
| | H | L | H | L | B | A • B plus (A + \bar{B}) | A • \bar{B} plus (A + B) plus 1 |
| | L | H | H | L | $\bar{A} \oplus \bar{B}$ | A plus B | A plus B plus 1 |
| | H | H | H | L | A • B | A • B minus 1 | A • B |
| | L | L | L | H | $\bar{A} \cdot \bar{B}$ | A plus A • \bar{B} | A plus A • B plus 1 |
| | H | L | L | H | A ⊕ B | A minus B minus 1 | A minus B |
| | L | H | L | H | \bar{B} | A • \bar{B} plus (A + B) | A • \bar{B} plus (A + B) plus 1 |
| | H | H | L | H | A • \bar{B} | A • \bar{B} minus 1 | A • \bar{B} |
| | L | L | H | H | Logic "1" | A plus A (2 × A) | A plus A (2 × A) plus 1 |
| | H | L | H | H | A + B | A plus (A + \bar{B}) | A plus (A + \bar{B}) plus 1 |
| L | H | H | H | A + \bar{B} | A plus (A + B) | A plus (A + B) plus 1 | |
| H | H | H | H | A | A minus 1 | A | |

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

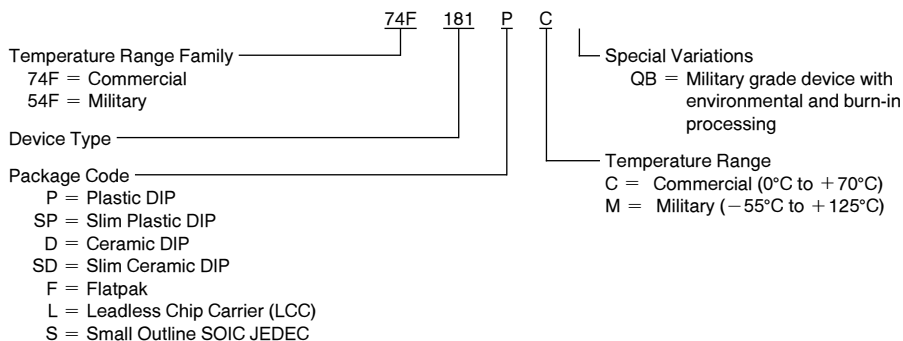
| Symbol | Parameter | 54F/74F | | | Units | V _{CC} | Conditions |
|------------------|---|--|-------------------|------------------------------|-------|-----------------|--|
| | | Min | Typ | Max | | | |
| V _{IH} | Input HIGH Voltage | 2.0 | | | V | | Recognized as a HIGH Signal |
| V _{IL} | Input 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} 74F 10% V _{CC} 74F 5% V _{CC} | 2.5 2.5 2.7 | | V | Min | I _{OH} = -1 mA I _{OH} = -1 mA I _{OH} = -1 mA |
| V _{OL} | Output LOW Voltage | 54F 10% V _{CC} 74F 10% V _{CC} | | 0.5 0.5 | V | Min | I _{OL} = 20 mA I _{OL} = 20 mA |
| I _{IH} | Input HIGH Current | 54F 74F | | 20.0 5.0 | μA | Max | V _{IN} = 2.7V |
| I _{BVI} | Input HIGH Current Breakdown Test | 54F 74F | | 100 7.0 | μA | Max | V _{IN} = 7.0V |
| I _{CEX} | Output HIGH Leakage Current | 54F 74F | | 250 50 | μA | Max | V _{OUT} = V _{CC} ($\bar{F}_n, \bar{G}, \bar{P}, C_{n+4}$) |
| 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 -1.8 -2.4 -3.0 | mA | Max | V _{IN} = 0.5V (M) V _{IN} = 0.5V ($\bar{A}_0, \bar{A}_1, \bar{A}_3, \bar{B}_0, \bar{B}_1, \bar{B}_3$) V _{IN} = 0.5V (S _n , \bar{A}_2, \bar{B}_2) V _{IN} = 0.5V (C _n) |
| I _{OS} | Output Short-Circuit Current | | -60 | -150 | mA | Max | V _{OUT} = 0V ($\bar{F}_n, \bar{G}, \bar{P}, C_{n+4}$) |
| I _{OHC} | Open Collector, Output OFF Leakage Test | | | 250 | μA | Min | V _O = V _{CC} (A = B) |
| I _{CCH} | Power Supply Current | | 43 | 65.0 | mA | Max | V _O = HIGH |
| I _{CCL} | Power Supply Current | | 43 | 65.0 | mA | Max | V _O = LOW |

AC Electrical Characteristics

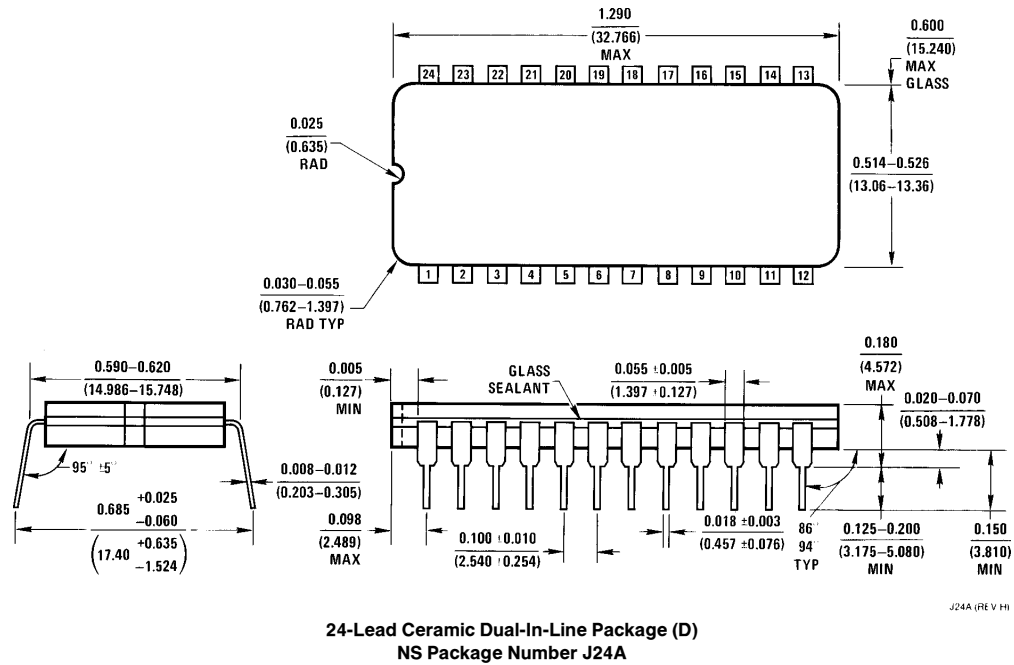
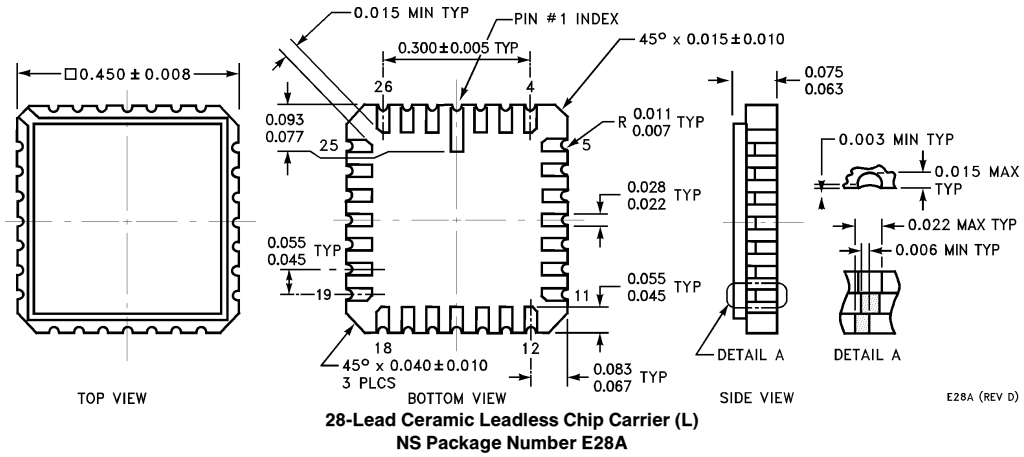
| Symbol | Parameter | | 74F | | | 54F | | 74F | | Units |
|------------------------|--|-------|--|--------------|--------------|--|--------------|--|--------------|-------|
| | | | $T_A = +25^\circ\text{C}$ $V_{CC} = +5.0\text{V}$ $C_L = 50\text{ pF}$ | | | $T_A, V_{CC} = \text{Mil}$ $C_L = 50\text{ pF}$ | | $T_A, V_{CC} = \text{Com}$ $C_L = 50\text{ pF}$ | | |
| | | | Path | Mode | Min | Typ | Max | Min | Max | |
| t_{PLH} t_{PHL} | Propagation Delay C_n to C_{n+4} | | 3.0 3.0 | 6.4 6.1 | 8.5 8.0 | 3.0 3.0 | 10.0 9.5 | 3.0 3.0 | 9.5 9.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to C_{n+4} | Sum | 5.0 4.0 | 10.0 9.4 | 13.0 12.0 | 5.0 3.5 | 15.5 16.5 | 5.0 4.0 | 14.0 13.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to C_{n+4} | Dif | 5.0 5.0 | 10.8 10.0 | 14.0 13.0 | 5.0 4.0 | 17.0 15.0 | 5.0 5.0 | 15.0 14.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay C_n to \bar{F} | Any | 3.0 3.0 | 6.7 6.5 | 8.5 8.5 | 2.5 2.5 | 16.0 12.0 | 3.0 3.0 | 9.5 9.5 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} or \bar{G} | Sum | 3.0 3.0 | 5.7 5.8 | 7.5 7.5 | 2.5 2.5 | 9.0 9.5 | 3.0 3.0 | 8.5 8.5 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to \bar{G} | Dif | 3.0 3.0 | 6.5 7.3 | 8.5 9.5 | 2.5 2.5 | 11.5 11.0 | 3.0 3.0 | 9.5 10.5 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to \bar{P} | Sum | 3.0 3.0 | 5.0 5.5 | 7.0 7.5 | 2.5 3.0 | 8.5 9.5 | 3.0 3.0 | 8.0 8.5 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to \bar{P} | Dif | 3.0 4.0 | 5.8 6.5 | 7.5 8.5 | 2.5 3.0 | 11.0 11.0 | 3.0 4.0 | 8.5 9.5 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A}_i or \bar{B}_i to \bar{F}_i | Sum | 3.0 3.0 | 7.0 7.2 | 9.0 10.0 | 3.0 3.0 | 14.5 14.5 | 3.0 3.0 | 10.0 10.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A}_i or \bar{B}_i to \bar{F}_i | Dif | 3.0 3.0 | 8.2 5.0 | 11.0 11.0 | 3.0 3.0 | 17.5 14.5 | 3.0 3.0 | 12.0 12.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay Any \bar{A} or \bar{B} to Any \bar{F} | Sum | 4.0 4.0 | 8.0 7.8 | 10.5 10.0 | 3.5 4.0 | 16.5 13.5 | 4.0 4.0 | 11.5 11.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay Any \bar{A} or \bar{B} to Any \bar{F} | Dif | 4.5 3.5 | 9.4 9.4 | 12.0 12.0 | 3.5 3.0 | 17.5 14.0 | 4.5 3.5 | 13.0 13.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to \bar{F} | Logic | 4.0 4.0 | 6.0 6.0 | 9.0 10.0 | 3.5 3.0 | 14.5 15.5 | 4.0 4.0 | 10.0 11.0 | ns |
| t_{PLH} t_{PHL} | Propagation Delay \bar{A} or \bar{B} to $A = B$ | Dif | 11.0 6.0 | 18.5 9.8 | 27.0 12.5 | 8.0 5.5 | 35.0 21.0 | 11.0 6.0 | 29.0 13.5 | ns |

Ordering Information

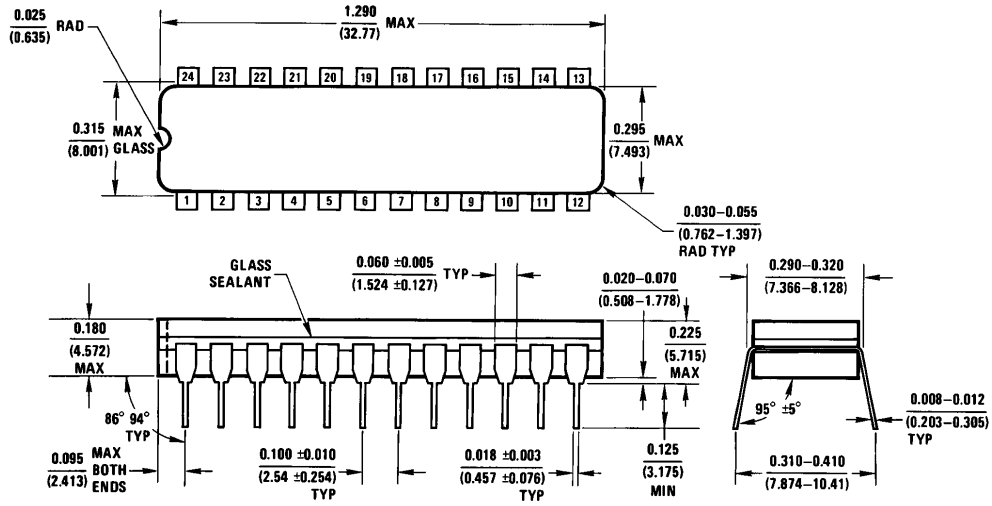
The device number is used to form part of a simplified purchasing code where the package type and temperature range are defined as follows:



Physical Dimensions inches (millimeters)

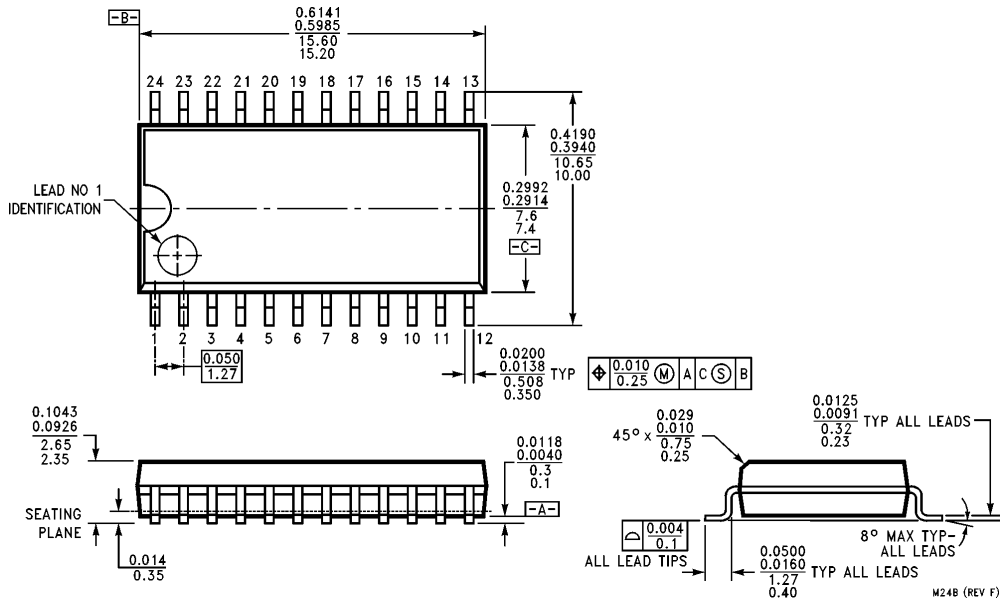


Physical Dimensions inches (millimeters) (Continued)



24-Lead (0.300" Wide) Ceramic Dual-In-Line Package (SD)
NS Package Number J24F

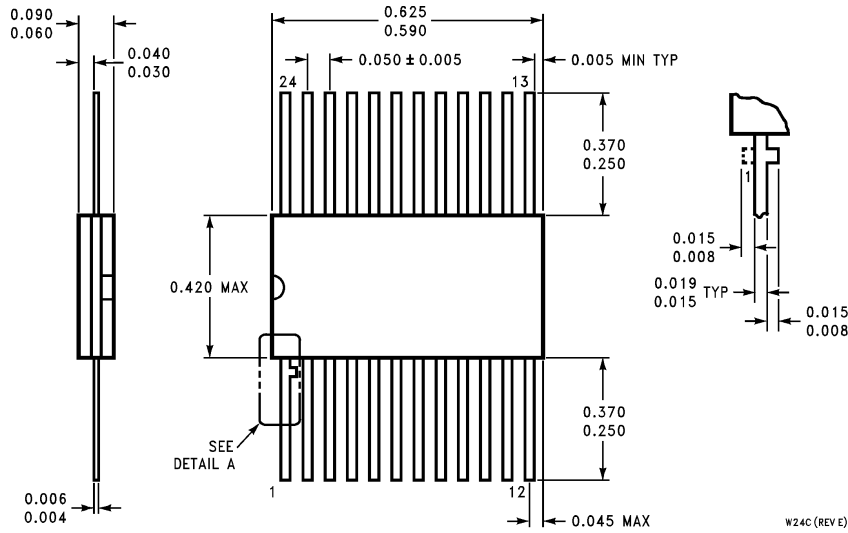
J24F (REV G)



24-Lead (0.300" Wide) Molded Small Outline Package, JEDEC (S)
NS Package Number M24B

M24B (REV F)

Physical Dimensions inches (millimeters) (Continued)



**24-Lead Ceramic Flatpak (F)
NS Package Number W24C**

W24C (REV E)

LIFE SUPPORT POLICY

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