National Semiconductor

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# 54LS193/DM54LS193/DM74LS193 Synchronous 4-Bit Up/Down Binary Counters with Dual Clock

## General Description

This circuit is a synchronous up/down 4-bit binary counter. Synchronous operation is provided by having all flip-flops clocked simultaneously, so that the outputs change together when so instructed by the steering logic. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple-clock) counters.

The outputs of the four master-slave flip-flops are triggered by a low-to-high level transition of either count (clock) input. The direction of counting is determined by which count input is pulsed while the other count input is held high.

The counter is fully programmable; that is, each output may be preset to either level by entering the desired data at the inputs while the load input is low. The output will change independently of the count pulses. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

A clear input has been provided which, when taken to a high level, forces all outputs to the low level; independent of the count and load inputs. The clear, count, and load inputs are buffered to lower the drive requirements of clock drivers, etc., required for long words.

These counters were designed to be cascaded without the need for external circuitry. Both borrow and carry outputs are available to cascade both the up and down counting functions. The borrow output produces a pulse equal in width to the count down input when the counter underflows.

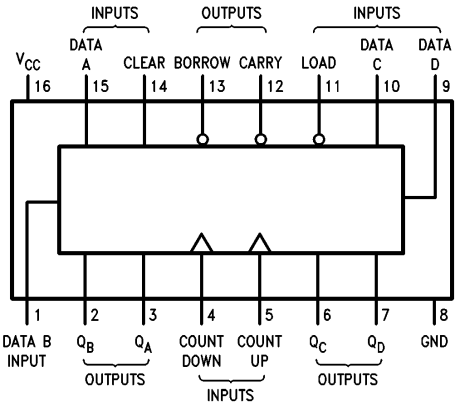
Similarly, the carry output produces a pulse equal in width to the count down input when an overflow condition exists. The counters can then be easily cascaded by feeding the borrow and carry outputs to the count down and count up inputs respectively of the succeeding counter.

## Features

- Fully independent clear input
- Synchronous operation
- Cascading circuitry provided internally
- Individual preset each flip-flop
- Alternate Military/Aerospace device (54LS193) is available. Contact a National Semiconductor Sales Office/ Distributor for specifications.

## Connection Diagram

**Dual-In-Line Package**




TL/F/6406–1

**Order Number 54LS193DMQB, 54LS193FMQB, 54LS193LMQB, DM54LS193J, DM54LS193W, DM74LS193M or DM74LS193N**
**See NS Package Number E20A, J16A, M16A, N16E or W16A**

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## Absolute Maximum Ratings (Note)

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

| | |
|---|---|
| Supply Voltage | 7V |
| Input Voltage | 7V |
| Operating Free Air Temperature Range | |
| DM54LS and 54LS | −55°C to +125°C |
| DM74LS | 0°C to +70°C |
| Storage Temperature Range | −65° C to +150° C |

Note: *The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.*

## Recommended Operating Conditions

| Symbol | Parameter | DM54LS193 | | | DM74LS193 | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min | Nom | Max | Min | Nom | Max | |
| $V_{CC}$ | Supply Voltage | 4.5 | 5 | 5.5 | 4.75 | 5 | 5.25 | V |
| $V_{IH}$ | High Level Input Voltage | 2 | | | 2 | | | V |
| $V_{IL}$ | Low Level Input Voltage | | | 0.7 | | | 0.8 | V |
| $I_{OH}$ | High Level Output Current | | | −0.4 | | | −0.4 | mA |
| $I_{OL}$ | Low Level Output Current | | | 4 | | | 8 | mA |
| $f_{CLK}$ | Clock Frequency (Note 1) | 0 | | 25 | 0 | | 25 | MHz |
| | Clock Frequency (Note 2) | 0 | | 20 | 0 | | 20 | MHz |
| $t_W$ | Pulse Width of Any Input (Note 6) | 20 | | | 20 | | | ns |
| $t_{SU}$ | Data Setup Time (Note 6) | 20 | | | 20 | | | ns |
| $t_H$ | Data Hold Time (Note 6) | 0 | | | 0 | | | ns |
| $t_{REL}$ | Release Time (Note 6) | 40 | | | 40 | | | ns |
| $T_A$ | Free Air Operating Temperature | −55 | | 125 | 0 | | 70 | °C |

## Electrical Characteristics over recommended operating free air temperature range (unless otherwise noted)

| Symbol | Parameter | Conditions | | Min | Typ (Note 3) | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_I$ | Input Clamp Voltage | $V_{CC}$ = Min, $I_I$ = −18 mA | | | | −1.5 | V |
| $V_{OH}$ | High Level Output Voltage | $V_{CC}$ = Min, $I_{OH}$ = Max, $V_{IL}$ = Max, $V_{IH}$ = Min | DM54 | 2.5 | 3.4 | | V |
| | | | DM74 | 2.7 | 3.4 | | |
| $V_{OL}$ | Low Level Output Voltage | $V_{CC}$ = Min, $I_{OL}$ = Max, $V_{IL}$ = Max, $V_{IH}$ = Min | DM54 | | 0.25 | 0.4 | V |
| | | | DM74 | | 0.35 | 0.5 | |
| | | $I_{OL}$ = 4 mA, $V_{CC}$ = Min | DM74 | | 0.25 | 0.4 | |
| $I_I$ | Input Current @ Max Input Voltage | $V_{CC}$ = Max, $V_I$ = 7V | | | | 0.1 | mA |
| $I_{IH}$ | High Level Input Current | $V_{CC}$ = Max, $V_I$ = 2.7V | | | | 20 | μA |
| $I_{IL}$ | Low Level Input Current | $V_{CC}$ = Max, $V_I$ = 0.4V | | | | −0.4 | mA |
| $I_{OS}$ | Short Circuit Output Current | $V_{CC}$ = Max (Note 4) | DM54 | −20 | | −100 | mA |
| | | | DM74 | −20 | | −100 | |
| $I_{CC}$ | Supply Current | $V_{CC}$ = Max (Note 5) | | | 19 | 34 | mA |

**Note 1:** $C_L$ = 15 pF, $R_L$ = 2 kΩ, $I_A$ = 25°C and $V_{CC}$ = 5V.

**Note 2:** $C_L$ = 50 pF, $R_L$ = 2 kΩ, $I_A$ = 25°C and $V_{CC}$ = 5V.

**Note 3:** All typicals are at $V_{CC}$ = 5V, $T_A$ = 25°C.

**Note 4:** Not more than one output should be shorted at a time, and the duration should not exceed one second.

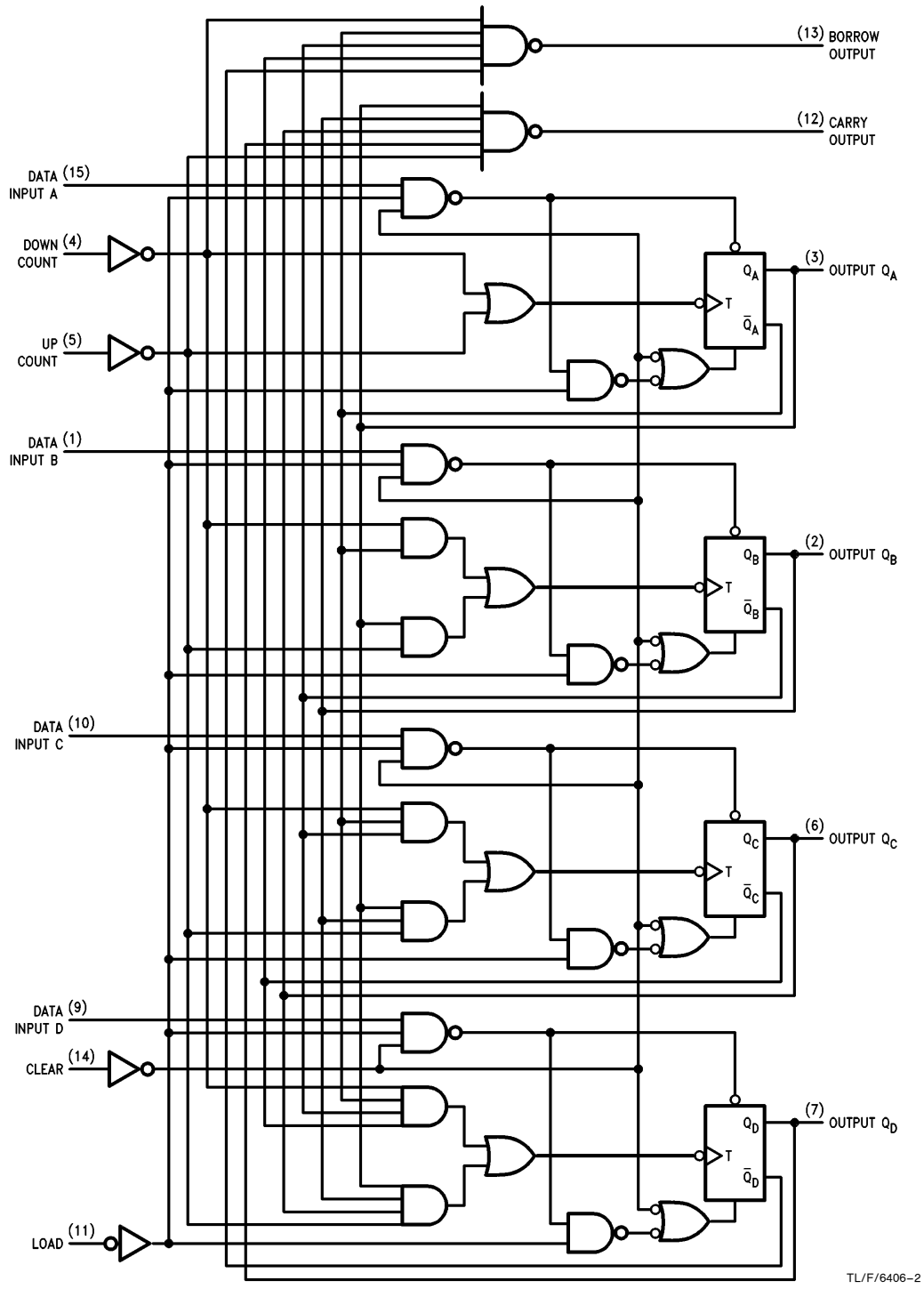
**Note 5:** $I_{CC}$ is measured with all outputs open, CLEAR and LOAD inputs grounded, and all other inputs at 4.5V.

**Note 6:** $T_A$ = 25°C and $V_{CC}$ = 5V.

## Switching Characteristics at $V_{CC} = 5V$ and $T_A = 25°C$ (See Section 1 for Test Waveforms and Output Load)

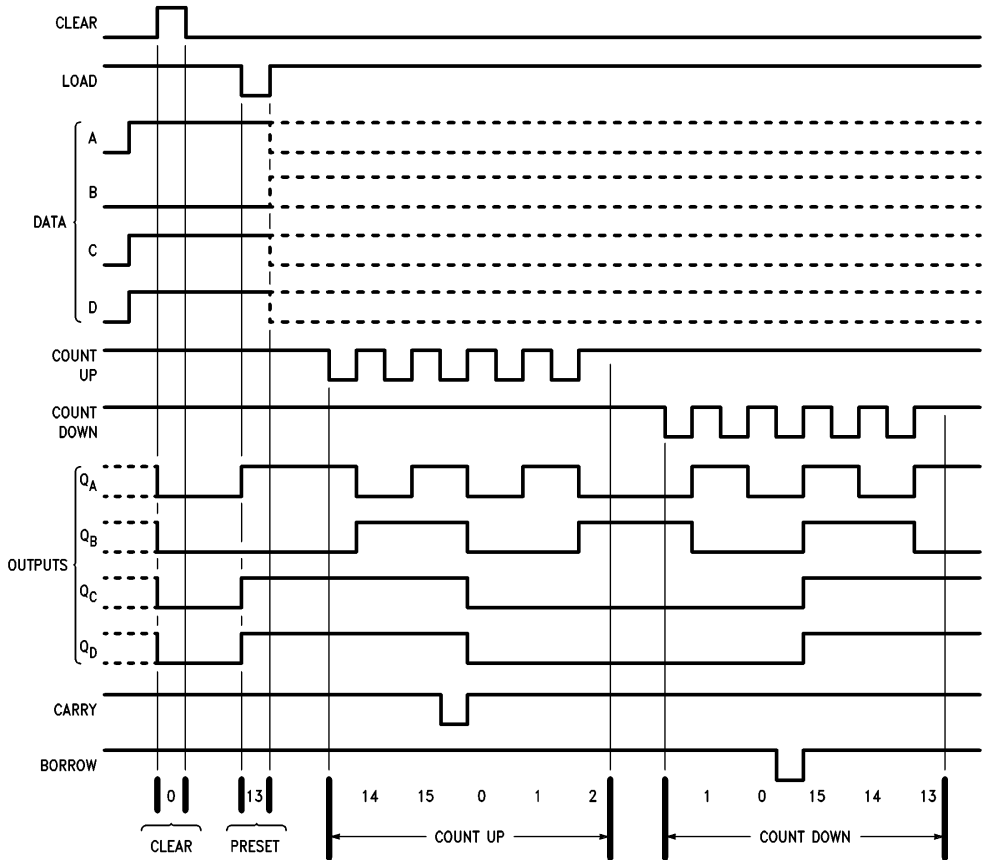
| Symbol | Parameter | From (Input) To (Output) | $R_L = 2\ k\Omega$ | | | | Units |
|---|---|---|---|---|---|---|---|
| | | | $C_L = 15$ pF | | $C_L = 50$ pF | | |
| | | | Min | Max | Min | Max | |
| $f_{MAX}$ | Maximum Clock Frequency | | 25 | | 20 | | MHz |
| $t_{PLH}$ | Propagation Delay Time Low to High Level Output | Count Up to Carry | | 26 | | 30 | ns |
| $t_{PHL}$ | Propagation Delay Time High to Low Level Output | Count Up to Carry | | 24 | | 36 | ns |
| $t_{PLH}$ | Propagation Delay Time Low to High Level Output | Count Down to Borrow | | 24 | | 29 | ns |
| $t_{PHL}$ | Propagation Delay Time High to Low Level Output | Count Down to Borrow | | 24 | | 32 | ns |
| $t_{PLH}$ | Propagation Delay Time Low to High Level Output | Either Count to Any Q | | 38 | | 45 | ns |
| $t_{PHL}$ | Propagation Delay Time High to Low Level Output | Either Count to Any Q | | 47 | | 54 | ns |
| $t_{PLH}$ | Propagation Delay Time Low to High Level Output | Load to Any Q | | 40 | | 41 | ns |
| $t_{PHL}$ | Propagation Delay Time High to Low Level Output | Load to Any Q | | 40 | | 47 | ns |
| $t_{PHL}$ | Propagation Delay Time High to Low Level Output | Clear to Any Q | | 35 | | 44 | ns |

## Logic Diagram



## Timing Diagrams

**Typical Clear, Load, and Count Sequences**

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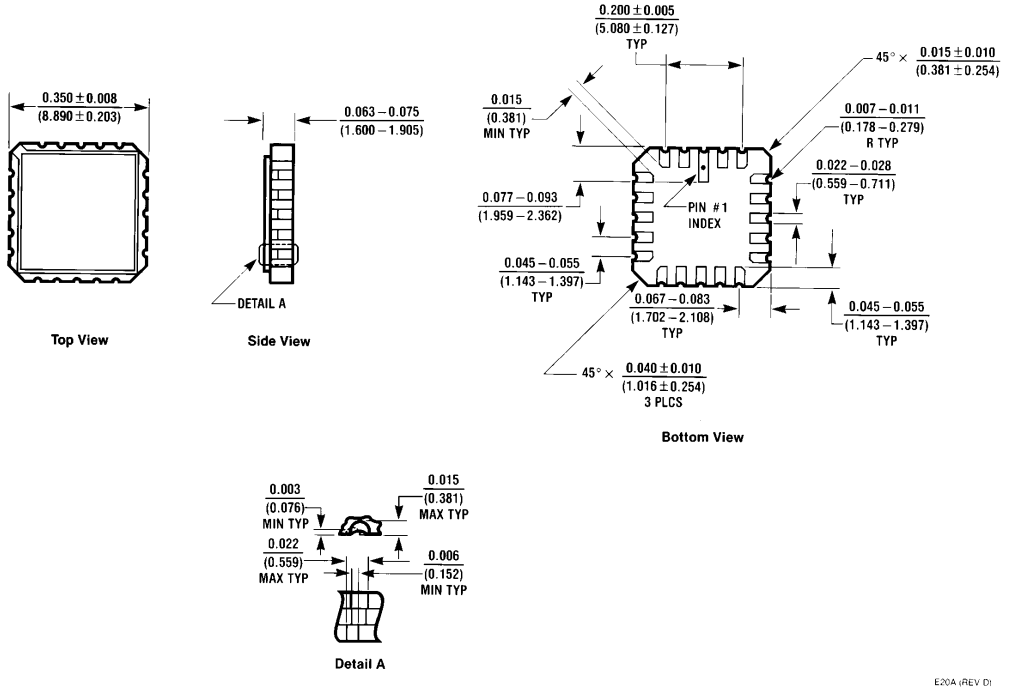
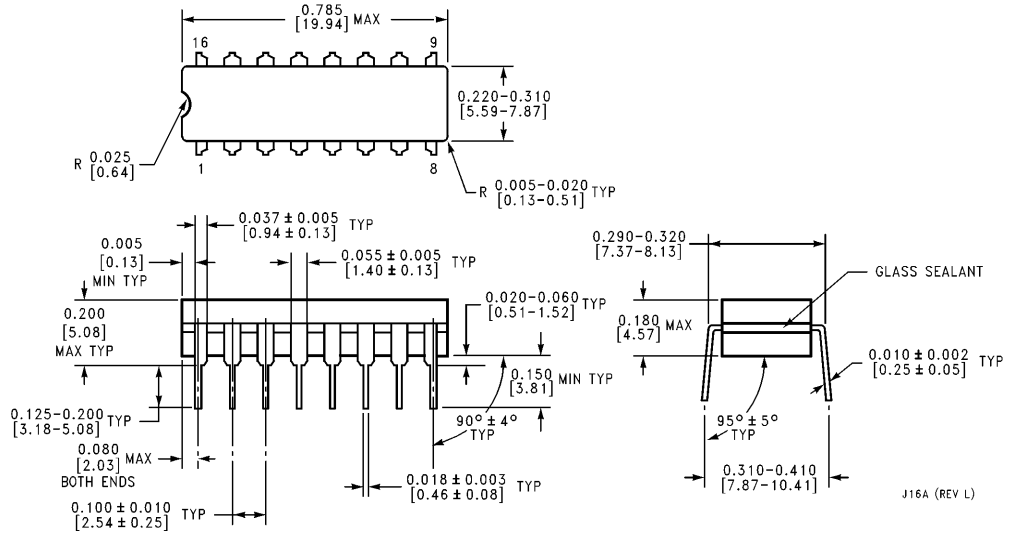
**Note A:** Clear overrides load, data, and count inputs.

**Note B:** When counting up, count-down input must be high; when counting down, count-up input must be high.

## Physical Dimensions inches (millimeters)

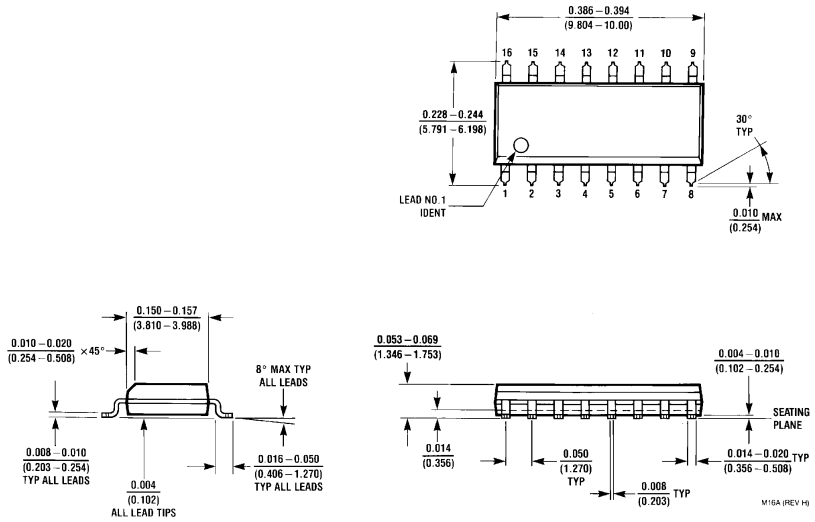



**Ceramic Leadless Chip Carrier Package (E)**
**Order Number 54LS193LMQB**
**NS Package Number E20A**

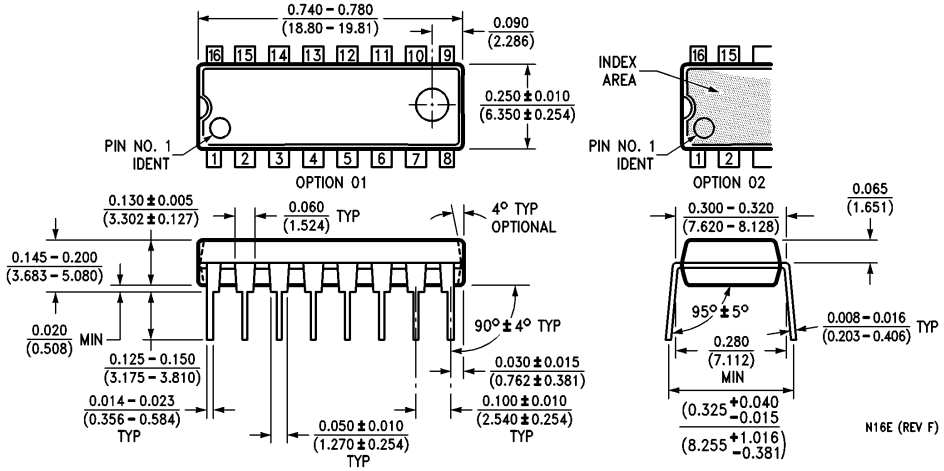



**16-Lead Ceramic Dual-In-Line Package (J)**
**Order Number 54LS193DMQB or DM54LS193J**
**NS Package Number J16A**

## Physical Dimensions inches (millimeters) (Continued)

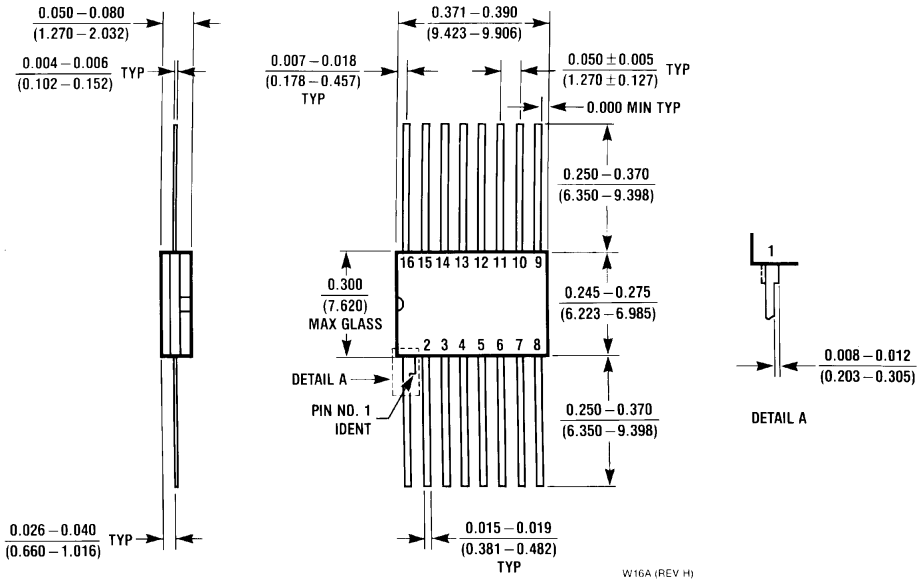



**16-Lead Small Outline Molded Package (M)**
**Order Number DM74LS193M**
**NS Package Number M16A**




**16-Lead Molded Dual-In-Line Package (N)**
**Order Number DM74LS193N**
**NS Package Number N16E**

## Physical Dimensions inches (millimeters) (Continued)




**16-Lead Ceramic Flat Package (W)**
**Order Number 54LS193FMQB or DM54LS193W**
**NS Package Number W16A**

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