National Semiconductor

March 1993

74ACQ377 • 54ACTQ/74ACTQ377
Quiet Series Octal D Flip-Flop with Clock Enable

General Description

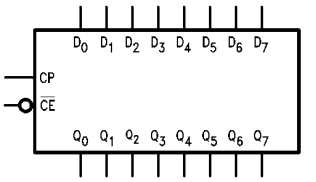
The 'ACQ/'ACTQ377 has 8 edge-triggered D-type flip-flops with individual D inputs and Q outputs. The common buffered Clock (CP) input loads all flip-flops simultaneously, when the Clock Enable ($\overline{CE}$) is low. The register is fully edge-triggered. The state of each D input, one set-up time before the LOW-to-HIGH clock transition, is transferred to the corresponding flip-flop's Q output. The $\overline{CE}$ input must be stable only one set-up time prior to the LOW-to-HIGH clock transition for predictable operation.

The 'ACQ/'ACTQ utilizes NSC Quiet Series technology to guarantee quiet output switching and improved dynamic threshold performance. FACT Quiet Series™ features GTO™ output control and undershoot corrector in addition to a split ground bus for superior performance.

Features

- I_{CC} reduced by 50%
- Guaranteed simultaneous switching noise level and dynamic threshold performance
- Guaranteed pin-to-pin skew AC performance
- Ideal for addressable register applications
- Clock enable for address and data synchronization applications
- Eight edge-triggered D flip-flops
- Buffered common clock
- Outputs source/sink 24 mA
- Faster prop delays than the standard 'AC/'ACT377
- 4 kV minimum ESD immunity
- 'ACTQ has TTL-compatible inputs
- Standard Military Drawing (SMD)
  54ACTQ377: 5962-9219001

Logic Symbols



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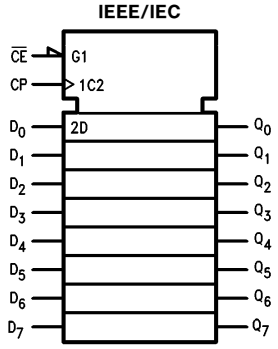
IEEE/IEC



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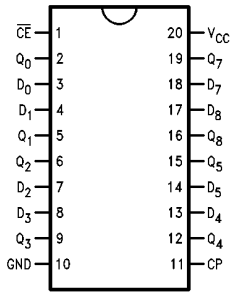
Pin Names	Description
D_0–D_7	Data Inputs
$\overline{CE}$	Clock Enable (Active LOW)
Q_0–Q_7	Data Outputs
CP	Clock Pulse Input

Connection Diagrams

Pin Assignment for DIP, Flatpak and SOIC



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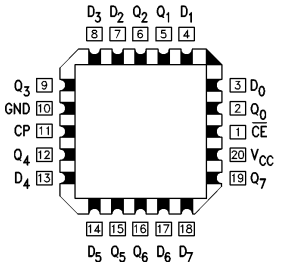
Pin Assignment for LCC



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RRD-B30M75/Printed in U. S. A.

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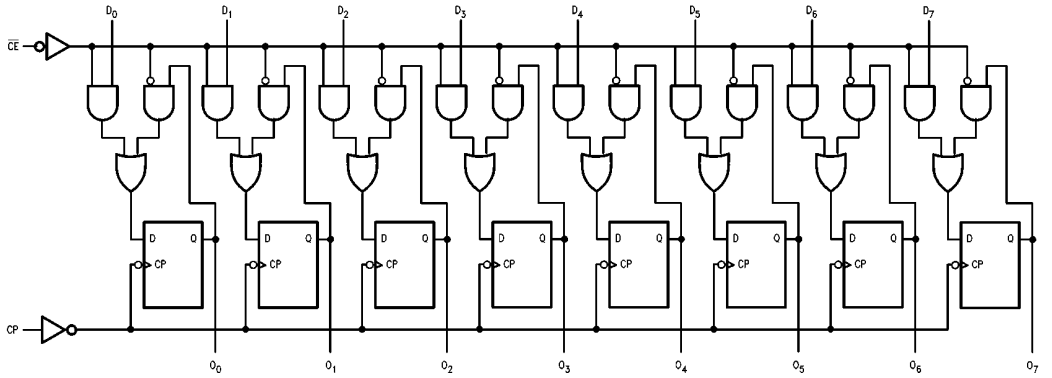
Quiet Series Octal D Flip-Flop with Clock Enable

Mode Select-Function Table

Operating Mode	Inputs			Outputs
	CP	$\overline{CE}$	D_n	Q_n
Load '1'	⌐‾	L	H	H
Load '0'	⌐‾	L	L	L
Hold (Do Nothing)	⌐‾	H	X	No Change
	X	H	X	No Change

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

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 Rating (Note 1)

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

Supply Voltage (V_{CC})	−0.5V to +7.0V
DC Input Diode Current (I_{IK})	
$V_I = -0.5V$	−20 mA
$V_I = V_{CC} + 0.5V$	+20 mA
DC Input Voltage (V_I)	−0.5V to V_{CC} + 0.5V
DC Output Diode Current (I_{OK})	
$V_O = -0.5V$	−20 mA
$V_O = V_{CC} + 0.5V$	+20 mA
DC Output Voltage (V_O)	−0.5V to V_{CC} + 0.5V
DC Output Source or Sink Current (I_O)	±50 mA
DC V_{CC} or Ground Current per Output Pin (I_{CC} or I_{GND})	±50 mA
Storage Temperature (T_{STG})	−65°C to +150°C
DC Latch-up Source or Sink Current	±300 mA
Junction Temperature (T_J)	
CDIP	175°C
PDIP	140°C

Note 1: Absolute maximum ratings are those values beyond which damage to the device may occur. The databook specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. National does not recommend operation of FACT™ circuits outside databook specifications.

Recommended Operating Conditions

Supply Voltage (V_{CC})	
'ACQ	2.0V to 6.0V
'ACTQ	4.5V to 5.5V
Input Voltage (V_I)	0V to V_{CC}
Output Voltage (V_O)	0V to V_{CC}
Operating Temperature (T_A)	
74ACQ/ACTQ	−40°C to +85°C
54ACTQ	−55°C to +125°C
Minimum Input Edge Rate $\Delta V/\Delta t$ 'ACQ Devices V_{IN} from 30% to 70% of V_{CC} V_{CC} @ 3.0V, 4.5V, 5.5V	125 mV/ns
Minimum Input Edge Rate $\Delta V/\Delta t$ 'ACTQ Devices V_{IN} from 0.8V to 2.0V V_{CC} @ 4.5V, 5.5V	125 mV/ns

Note: All commercial packaging is not recommended for applications requiring greater than 2000 temperature cycles from −40°C to +125°C.

DC Characteristics for 'ACQ Family Devices

Symbol	Parameter	V_{CC} (V)	74ACQ $T_A = +25°C$	74ACQ $T_A = -40°C$ to $+85°C$		Units	Conditions
			Typ	Guaranteed Limits			
V_{IH}	Minimum High Level Input Voltage	3.0	1.5	2.1	2.1	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
		4.5	2.25	3.15	3.15		
		5.5	2.75	3.85	3.85		
V_{IL}	Maximum Low Level Input Voltage	3.0	1.5	0.9	0.9	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
		4.5	2.25	1.35	1.35		
		5.5	2.75	1.65	1.65		
V_{OH}	Minimum High Level Output Voltage	3.0	2.99	2.9	2.9	V	$I_{OUT} = -50\ \mu A$
		4.5	4.49	4.4	4.4		
		5.5	5.49	5.4	5.4		
		3.0		2.56	2.46	V	*$V_{IN} = V_{IL}$ or V_{IH} I_{OH} −12 mA
		4.5		3.86	3.76		I_{OH} −24 mA
		5.5		4.86	4.76		−24 mA
V_{OL}	Maximum Low Level Output Voltage	3.0	0.002	0.1	0.1	V	$I_{OUT} = 50\ \mu A$
		4.5	0.001	0.1	0.1		
		5.5	0.001	0.1	0.1		
		3.0		0.36	0.44	V	*$V_{IN} = V_{IL}$ or V_{IH} 12 mA
		4.5		0.36	0.44		I_{OL} 24 mA
		5.5		0.36	0.44		24 mA
I_{IN}	Maximum Input Leakage Current	5.5		±0.1	±1.0	μA	$V_I = V_{CC}$, GND (Note 1)

*All outputs loaded; thresholds on input associated with output under test.

DC Characteristics for 'ACQ Family Devices (Continued)

Symbol	Parameter	V_{CC} (V)	74ACQ $T_A = +25°C$		74ACQ $T_A = -40°C$ to $+85°C$	Units	Conditions
			Typ	Guaranteed Limits			
I_{OLD}	†Minimum Dynamic Output Current	5.5			75	mA	$V_{OLD} = 1.65V$ Max
I_{OHD}		5.5			−75	mA	$V_{OHD} = 3.85V$ Min
I_{CC}	Maximum Quiescent Supply Current	5.5		4.0	40.0	μA	$V_{IN} = V_{CC}$ or GND (Note 1)
V_{OLP}	Quiet Output Maximum Dynamic V_{OL}	5.0	1.1	1.5		V	*Figures 2–12, 13* (Notes 2, 3)
V_{OLV}	Quiet Output Minimum Dynamic V_{OL}	5.0	−0.6	−1.2		V	*Figures 2–12, 13* (Notes 2, 3)
V_{IHD}	Minimum High Level Dynamic Input Voltage	5.0	3.1	3.5		V	(Notes 2, 4)
V_{ILD}	Maximum Low Level Dynamic Input Voltage	5.0	1.9	1.5		V	(Notes 2, 4)

†Maximum test duration 2.0 ms, one output loaded at a time.

Note 1: I_{IN} and I_{CC} @ 3.0V are guaranteed to be less than or equal to the respective limit @ 5.5V V_{CC}.

Note 2: Plastic DIP package.

Note 3: Max number of outputs defined as (n). Data Inputs are driven 0V to 5V. One output @ GND.

Note 4: Max number of Data Inputs (n) switching. (n−1) Inputs switching 0V to 5V ('ACQ). Input-under-test switching: 5V to threshold (V_{ILD}), 0V to threshold (V_{IHD}), f = 1 MHz.

DC Characteristics for 'ACTQ Family Devices

Symbol	Parameter	V_{CC} (V)	74ACTQ		54ACTQ	74ACTQ	Units	Conditions
			$T_A = +25°C$		$T_A = -55°C$ to $+125°C$	$T_A = -40°C$ to $+85°C$		
			Typ	Guaranteed Limits				
V_{IH}	Minimum High Level Input Voltage	4.5 5.5	1.5 1.5	2.0 2.0	2.0 2.0	2.0 2.0	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
V_{IL}	Maximum Low Level Input Voltage	4.5 5.5	1.5 1.5	0.8 0.8	0.8 0.8	0.8 0.8	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
V_{OH}	Minimum High Level Output Voltage	4.5 5.5	4.49 5.49	4.4 5.4	4.4 5.4	4.4 5.4	V	$I_{OUT} = -50\ \mu A$
		4.5 5.5		3.86 4.86	3.70 4.70	3.76 4.76	V	*$V_{IN} = V_{IL}$ or V_{IH} I_{OH} -24 mA I_{OH} -24 mA
V_{OL}	Maximum Low Level Output Voltage	4.5 5.5	0.001 0.001	0.1 0.1	0.1 0.1	0.1 0.1	V	$I_{OUT} = 50\ \mu A$
		4.5 5.5		0.36 0.36	0.50 0.50	0.44 0.44	V	*$V_{IN} = V_{IL}$ or V_{IH} I_{OL} 24 mA I_{OL} 24 mA
I_{IN}	Maximum Input Leakage Current	5.5		± 0.1	± 1.0	± 1.0	μA	$V_I = V_{CC}$, GND
I_{CCT}	Maximum I_{CC}/Input	5.5	0.6		1.6	1.5	mA	$V_I = V_{CC} - 2.1V$
I_{OLD}	†Minimum Dynamic Output Current	5.5			50	75	mA	$V_{OLD} = 1.65V$ Max
I_{OHD}		5.5			-50	-75	mA	$V_{OHD} = 3.85V$ Min
I_{CC}	Maximum Quiescent Supply Current	5.5		4.0	80.0	40.0	μA	$V_{IN} = V_{CC}$ or GND (Note 1)
V_{OLP}	Quiet Output Maximum Dynamic V_{OL}	5.0	1.1	1.5			V	*Figures 2–12, 13* (Notes 2, 3)
V_{OLV}	Quiet Output Minimum Dynamic V_{OL}	5.0	-0.6	-1.2			V	*Figures 2–12, 13* (Notes 2, 3)
V_{IHD}	Minimum High Level Dynamic Input Voltage	5.0	1.9	2.2			V	(Notes 2, 4)
V_{ILD}	Maximum Low Level Dynamic Input Voltage	5.0	1.2	0.8			V	(Notes 2, 4)

*All outputs loaded; thresholds on input associated with output under test.

†Maximum test duration 2.0 ms, one output loaded at a time.

Note 1: I_{CC} for 54ACTQ @ 25°C is identical to 74ACTQ @ 25°C.

Note 2: Plastic DIP package.

Note 3: Max number of outputs defined as (n). (n − 1) Data Inputs are driven 0V to 3V; one output @ GND.

Note 4: Max number of Data Inputs (n) switching. (n − 1) Inputs switching 0V to 3V ('ACTQ). Input-under-test switching: 3V to threshold (V_{ILD}), 0V to threshold (V_{IHD}), f = 1 MHz.

AC Electrical Characteristics

Symbol	Parameter	V_{CC}* (V)	74ACQ $T_A = +25°C$, $C_L = 50$ pF			74ACQ $T_A = -40°C$ to $+85°C$, $C_L = 50$ pF		Units
			Min	Typ	Max	Min	Max	
f_{max}	Maximum Clock Frequency	3.3 5.0	71 95			67 91		MHz
t_{PLH}, t_{PHL}	Propagation Delay CP to Q_n	3.3 5.0	3.0 2.0	8.0 5.5	10.0 7.5	3.0 1.5	11.0 8.0	ns
t_{OSHL}, t_{OSLH}	Output to Output Skew** CP to Q_n	3.3 5.0		1.0 0.5	1.5 1.0		1.5 1.0	ns

*Voltage Range 5.0 is 5.0V ±0.5V
Voltage Range 3.3 is 3.3V ±0.3V

**Skew is defined as the absolute value of the difference between the actual propagation delay for any two outputs within the same package device. The specification applies to any outputs switching in the same direction, either HIGH to LOW (t_{OSHL}) or LOW to HIGH (t_{OSLH}). Parameter guaranteed by design. Not tested.

AC Operating Requirements

Symbol	Parameter	V_{CC}* (V)	74ACQ $T_A = +25°C$, $C_L = 50$ pF		74ACQ $T_A = -40°C$ to $+85°C$, $C_L = 50$ pF	Units
			Typ	Guaranteed Minimum		
t_s	Setup Time, HIGH or LOW D_n to CP	3.3 5.0		4.0 3.5	4.0 3.5	ns
t_h	Hold Time, HIGH or LOW D_n to CP	3.3 5.0		0.0 1.5	0.0 1.5	ns
t_s	Setup Time, HIGH or LOW $\overline{CE}$ to CP	3.3 5.0		5.5 4.5	5.5 4.5	ns
t_h	Hold Time, HIGH or LOW $\overline{CE}$ to CP	3.3 5.0		0.0 1.5	0.0 1.5	ns
t_w	CP Pulse Width HIGH or LOW	3.3 5.0		5.5 4.0	6.0 4.0	ns

*Voltage Range 5.0 is 5.0V ±0.5V
Voltage Range 3.3 is 3.3V ±0.3V

AC Electrical Characteristics

Symbol	Parameter	V_{CC}* (V)	74ACTQ			54ACTQ		74ACTQ		Units
			$T_A = +25°C$, $C_L = 50$ pF			$T_A = -55°C$ to $+125°C$, $C_L = 50$ pF		$T_A = -40°C$ to $+85°C$, $C_L = 50$ pF		
			Min	Typ	Max	Min	Max	Min	Max	
f_{max}	Maximum Clock Frequency	5.0	87			85		83		MHz
t_{PLH}, t_{PHL}	Propagation Delay CP to Q_n	5.0	2.0	6.0	8.0	1.5	10.0	1.5	8.5	ns
t_{OSHL}, t_{OSLH}	Output to Output Skew** CP to Q_n	5.0		0.5	1.0				1.0	ns

*Voltage Range 5.0 is 5.0V ±0.5V

**Skew is defined as the absolute value of the difference between the actual propagation delay for any two outputs within the same packaged device. The specification applies to any outputs switching in the same direction, either HIGH-to-LOW (t_{OSHL}) or LOW-to-HIGH (t_{OSLH}). Parameter guaranteed by design. Not tested.

AC Operating Requirements

Symbol	Parameter	V_{CC}* (V)	74ACTQ		54ACTQ	74ACTQ	Units
			$T_A = +25°C$, $C_L = 50$ pF		$T_A = -55°C$ to $+125°C$, $C_L = 50$ pF	$T_A = -40°C$ to $+85°C$, $C_L = 50$ pF	
			Typ	Guaranteed Minimum			
t_s	Setup Time, HIGH or LOW D_n to CP	5.0		3.5	4.0	3.5	ns
t_h	Hold Time, HIGH or LOW D_n to CP	5.0		1.5	1.5	1.5	ns
t_s	Setup Time, HIGH or LOW $\overline{CE}$ to CP	5.0		4.5	5.0	4.5	ns
t_h	Hold Time, HIGH or LOW $\overline{CE}$ to CP	5.0		1.5	1.5	1.5	ns
t_w	CP Pulse Width HIGH or LOW	5.0		4.0	5.0	4.0	ns

*Voltage Range 5.0 is 5.0V ±0.5V

Capacitance

Symbol	Parameter	Typ	Units	Conditions
C_{IN}	Input Capacitance	4.5	pF	V_{CC} = OPEN
C_{PD}	Power Dissipation Capacitance	45.0	pF	V_{CC} = 5.0V

FACT Noise Characteristics

The setup of a noise characteristics measurement is critical to the accuracy and repeatability of the tests. The following is a brief description of the setup used to measure the noise characteristics of FACT.

Equipment:

Hewlett Packard Model 8180A Word Generator
PC-163A Test Fixture
Tektronics Model 7854 Oscilloscope

Procedure:

1. Verify Test Fixture Loading: Standard Load 50 pF, 500Ω.
2. Deskew the word generator so that no two channels have greater than 150 ps skew between them. This requires that the oscilloscope be deskewed first. Swap out the channels that have more than 150 ps of skew until all channels being used are within 150 ps. It is important to deskew the word generator channels before testing. This will ensure that the outputs switch simultaneously.
3. Terminate all inputs and outputs to ensure proper loading of the outputs and that the input levels are at the correct voltage.
4. Set V_{CC} to 5.0V.
5. Set the word generator to toggle all but one output at a frequency of 1 MHz. Greater frequencies will increase DUT heating and affect the results of the measurement.

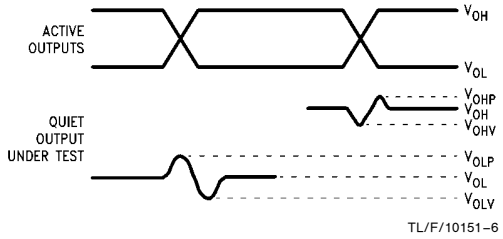

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FIGURE 8. Quiet Output Noise Voltage Waveforms

Note A. V_{OHV} and V_{OLP} are measured with respect to ground reference.

Note B. Input pulses have the following characteristics: f = 1 MHz, t_r = 3 ns, t_f = 3 ns, skew < 150 ps.

6. Set the word generator input levels at 0V LOW and 3V HIGH for ACT devices and 0V LOW and 5V HIGH for AC devices. Verify levels with a digital volt meter.

V_{OLP}/V_{OLV} and V_{OHP}/V_{OHV}:

- Determine the quiet output pin that demonstrates the greatest noise levels. The worst case pin will usually be the furthest from the ground pin. Monitor the output voltages using a 50Ω coaxial cable plugged into a standard SMB type connector on the test fixture. Do not use an active FET probe.
- Measure V_{OLP} and V_{OLV} on the quiet output during the HL transition. Measure V_{OHP} and V_{OHV} on the quiet output during the LH transition.
- Verify that the GND reference recorded on the oscilloscope has not drifted to ensure the accuracy and repeatability of the measurements.

V_{ILD} and V_{IHD}:

- Monitor one of the switching outputs using a 50Ω coaxial cable plugged into a standard SMB type connector on the test fixture. Do not use an active FET probe.
- First increase the input LOW voltage level, V_{IL}, until the output begins to oscillate. Oscillation is defined as noise on the output LOW level that exceeds V_{IL} limits, or on output HIGH levels that exceed V_{IH} limits. The input LOW voltage level at which oscillation occurs is defined as V_{ILD}.
- Next increase the input HIGH voltage level on the word generator, V_{IH} until the output begins to oscillate. Oscillation is defined as noise on the output LOW level that exceeds V_{IL} limits, or on output HIGH levels that exceed V_{IH} limits. The input HIGH voltage level at which oscillation occurs is defined as V_{IHD}.
- Verify that the GND reference recorded on the oscilloscope has not drifted to ensure the accuracy and repeatability on the measurements.

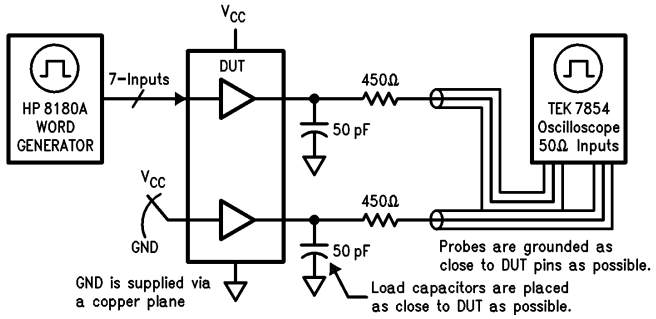

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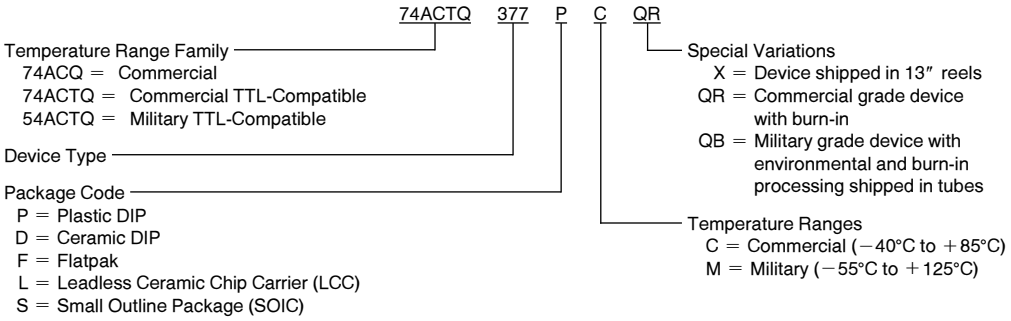
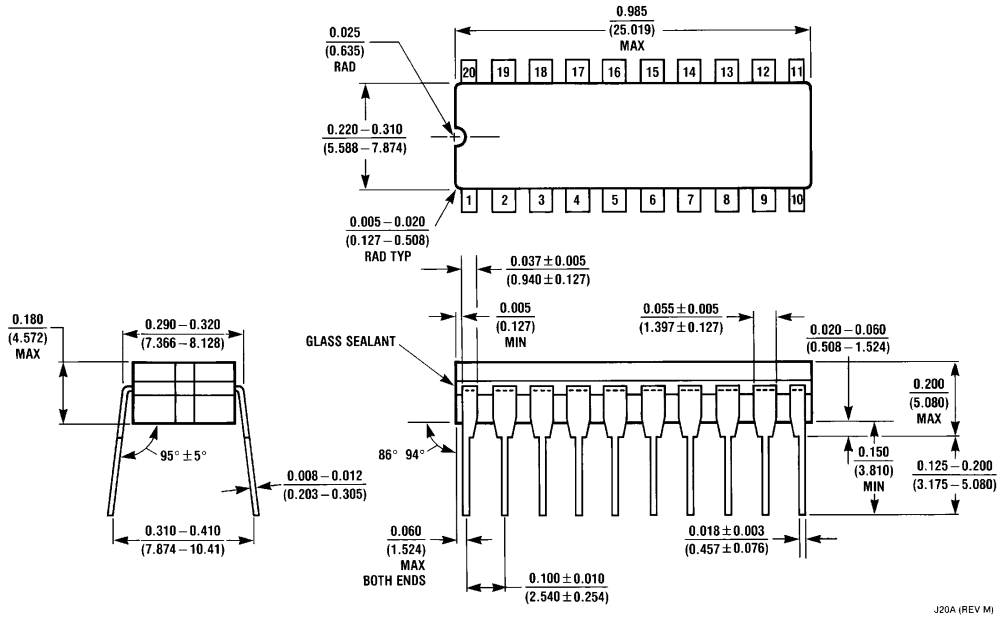
FIGURE 9. Simultaneous Switching Test Circuit

Ordering Information

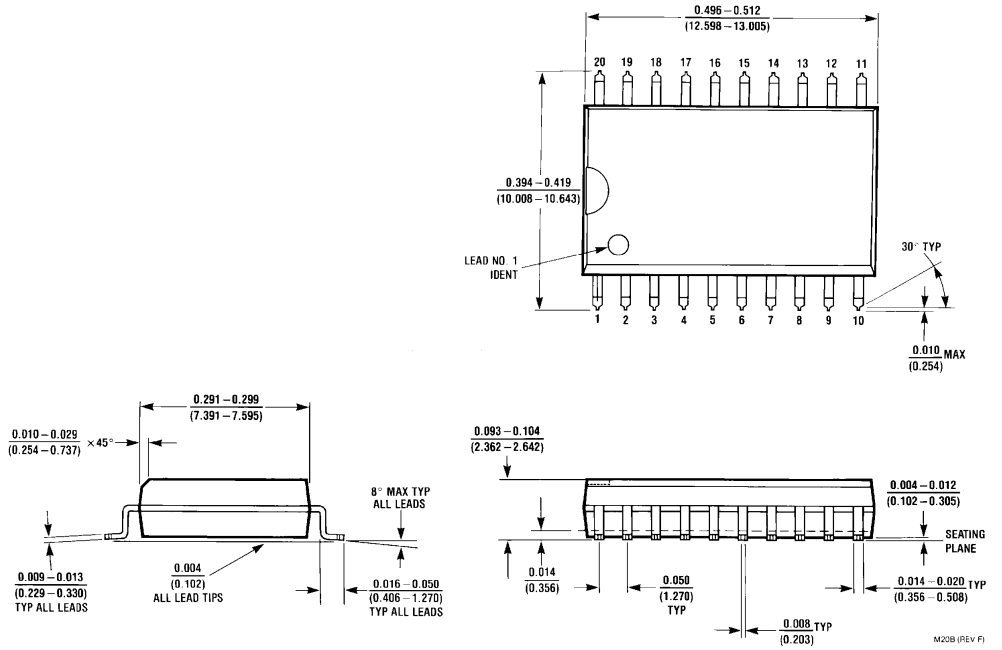
The device number is used to form part of a simplified purchasing code where the package type and temperature range are defined as follows:



Physical Dimensions inches (millimeters)

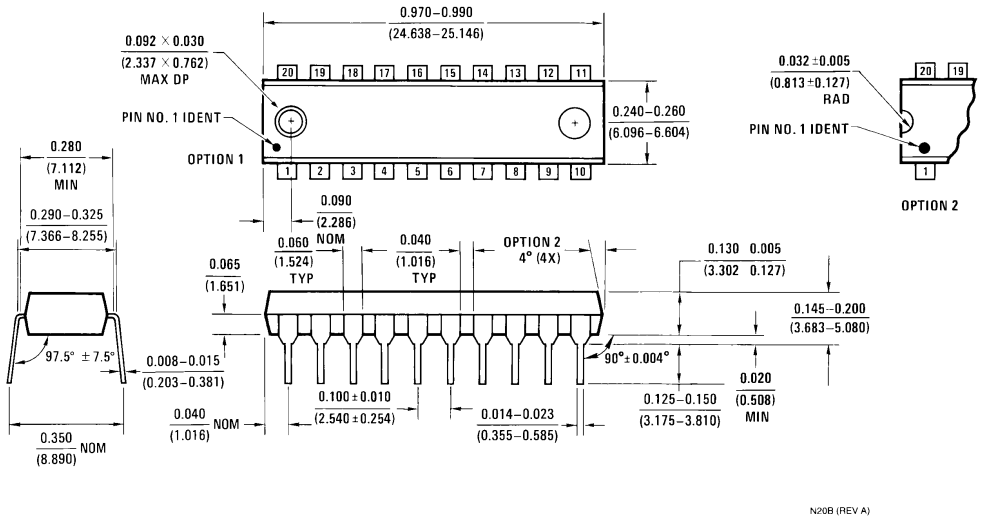


20-Lead Ceramic Dual-In-Line Package (D)
NS Package Number J20A



20-Lead Small Outline Integrated Circuit (S)
NS Package Number M20B

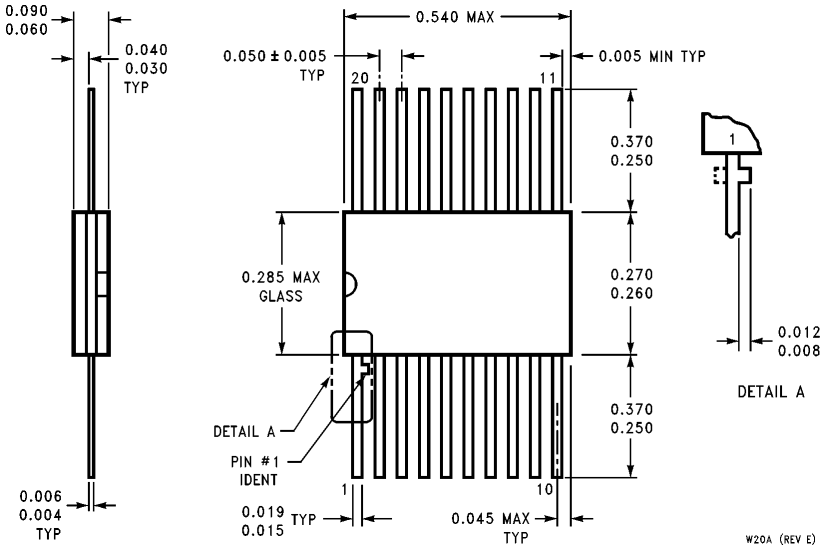
Physical Dimensions inches (millimeters) (Continued)



20-Lead Plastic Dual-In-Line Package (P)
NS Package Number N20B

Physical Dimensions inches (millimeters) (Continued)

Lit. # 114663



20-Lead Ceramic Flatpak (F)
NS Package Number W20A

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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