



National Semiconductor

September 1998

SCAN18374T

D Flip-Flop with TRI-STATE® Outputs

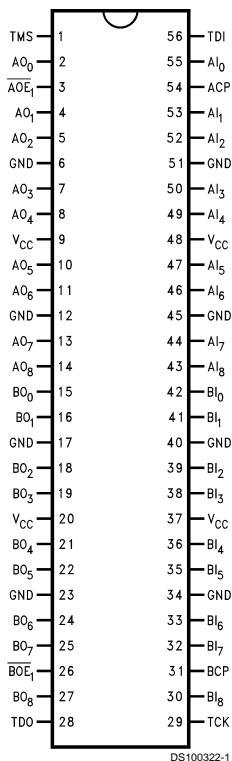
General Description

The SCAN18374T is a high speed, low-power D-type flip-flop featuring separate D-type inputs organized into dual 9-bit bytes with byte-oriented clock and output enable control signals. This device is compliant with IEEE 1149.1 Standard Test Access Port and BOUNDARY-SCAN Architecture with the incorporation of the defined BOUNDARY-SCAN test logic and test access port consisting of Test Data Input (TDI), Test Data Out (TDO), Test Mode Select (TMS), and Test Clock (TCK).

Features

- IEEE 1149.1 (JTAG) Compliant
- Buffered positive edge-triggered clock
- TRI-STATE outputs for bus-oriented applications
- 9-bit data busses for parity applications
- Reduced-swing outputs source 24 mA/sink 48 mA (Mil)
- Guaranteed to drive 50Ω transmission line to TTL input levels of 0.8V and 2.0V
- TTL compatible inputs
- 25 mil pitch Cerpak packaging
- Includes CLAMP and HIGHZ instructions
- Standard Microcircuit Drawing (SMD) 5962-9320701

Connection Diagram



Pin Names	Description
AOE ₁ , BOE ₁	TRI-STATE Output Enable Inputs
AO ₍₀₋₈₎ , BO ₍₀₋₈₎	TRI-STATE Outputs

Pin Names	Description
AI ₍₀₋₈₎ , BI ₍₀₋₈₎	Data Inputs
ACP, BCP	Clock Pulse Inputs

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SCAN18374T D Flip-Flop with TRI-STATE Outputs

Truth Tables

Inputs			$AO_{(0-8)}$
ACP	\overline{AOE}_1	$AI_{(0-8)}$	
X	H	X	Z
N	L	L	L
N	L	H	H

Inputs			$BO_{(0-8)}$
BCP	\overline{BOE}_1	$BI_{(0-8)}$	
X	H	X	Z
N	L	L	L
N	L	H	H

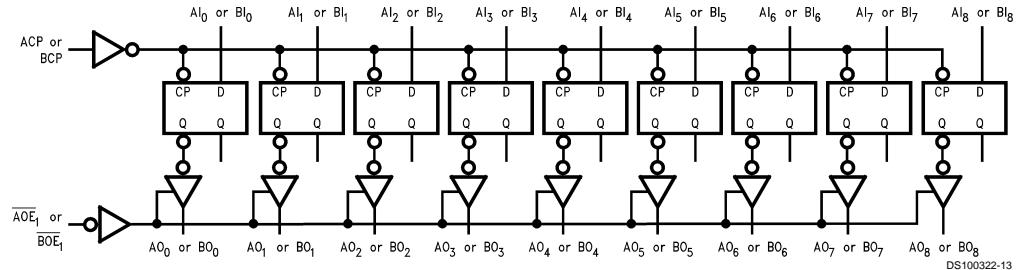
H= HIGH Voltage Level
 L= LOW Voltage Level
 X= Immaterial
 Z= High Impedance
 N= L-to-H Transition

Functional Description

The SCAN18374 consists of two sets of nine edge-triggered flip-flops with individual D-type inputs and TRI-STATE true outputs. The buffered clock and buffered Output Enable pins are common to all flip-flops. Each set of the nine flip-flops will store the state of their individual D inputs that meet the setup and hold time requirements on the LOW-to-HIGH Clock

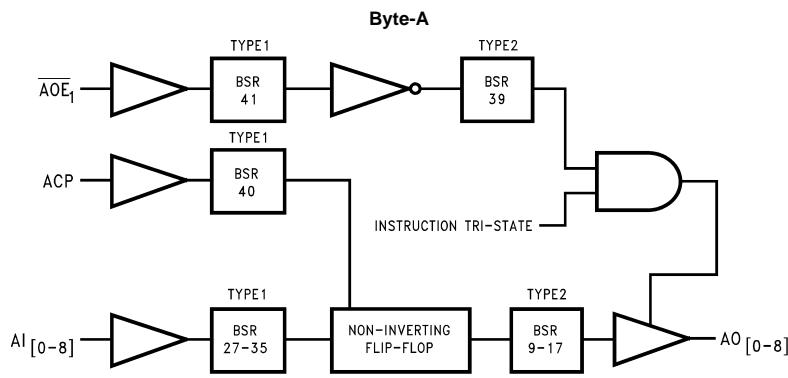
(ACP or BCP) transition. With the Output Enable (\overline{AOE}_1 or \overline{BOE}_1) LOW, the contents of the nine flip-flops are available at the outputs. When the Output Enable is HIGH, the outputs go to the high impedance state. Operation of the Output Enable input does not affect the state of the flip-flops.

Logic Diagram



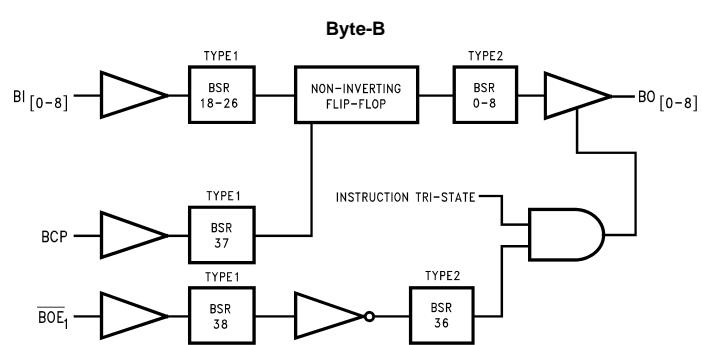
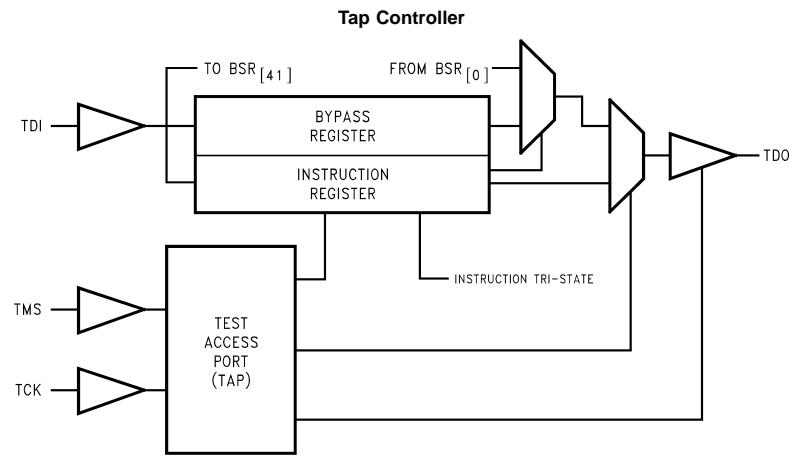
Please note that this diagram is provided only for the understanding of logic operations and should not be used to estimate propagation delays.

Block Diagrams



Note: BSR stands for Boundary Scan Register

Block Diagrams (Continued)



Note: BSR stands for Boundary Scan Register

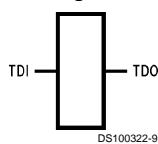
Description of Boundary-Scan Circuitry

The scan cells used in the BOUNDARY-SCAN register are one of the following two types depending upon their location. Scan cell TYPE1 is intended to solely observe system data, while TYPE2 has the additional ability to control system data. (See IEEE Standard 1149.1 *Figure 10-11* for a further description of scan cell TYPE1 and *Figure 10-12* for a further description of scan cell TYPE2.)

Scan cell TYPE1 is located on each system input pin while scan cell TYPE2 is located at each system output pin as well as at each of the two internal active-high output enable signals. AOE controls the activity of the A-outputs while BOE controls the activity of the B-outputs. Each will activate their respective outputs by loading a logic high.

The BYPASS register is a single bit shift register stage identical to scan cell TYPE1. It captures a fixed logic low.

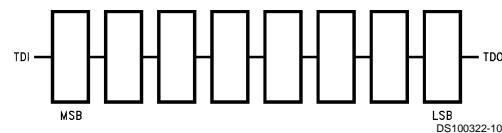
Bypass Register Scan Chain Definition Logic 0



The INSTRUCTION register is an eight-bit register which captures the value 00111101.

The two least significant bits of this captured value (01) are required by IEEE Std 1149.1. The upper six bits are unique to the SCAN18374T device. SCAN CMOS Test Access Logic devices do not include the IEEE 1149.1 optional identification register. Therefore, this unique captured value can be used as a "pseudo ID" code to confirm that the correct device is placed in the appropriate location in the boundary scan chain.

Instruction Register Scan Chain Definition

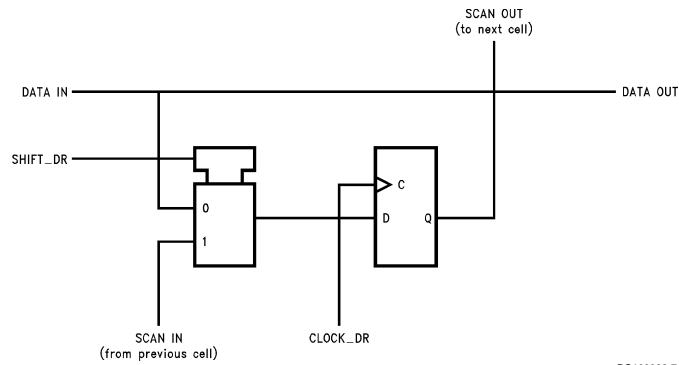


MSB → LSB

Instruction Code	Instruction
00000000	EXTEST
10000001	SAMPLE/PRELOAD
10000010	CLAMP
00000011	HIGHZ
All Others	BYPASS

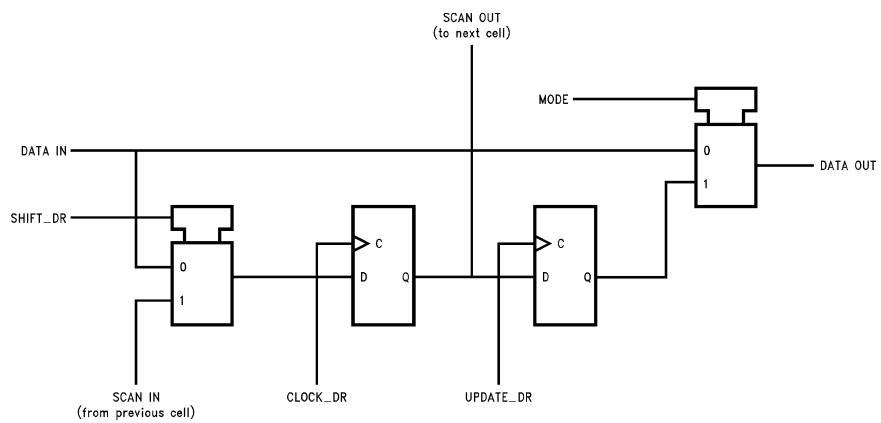
Description of Boundary-Scan Circuitry (Continued)

Scan Cell TYPE1



DS100322-7

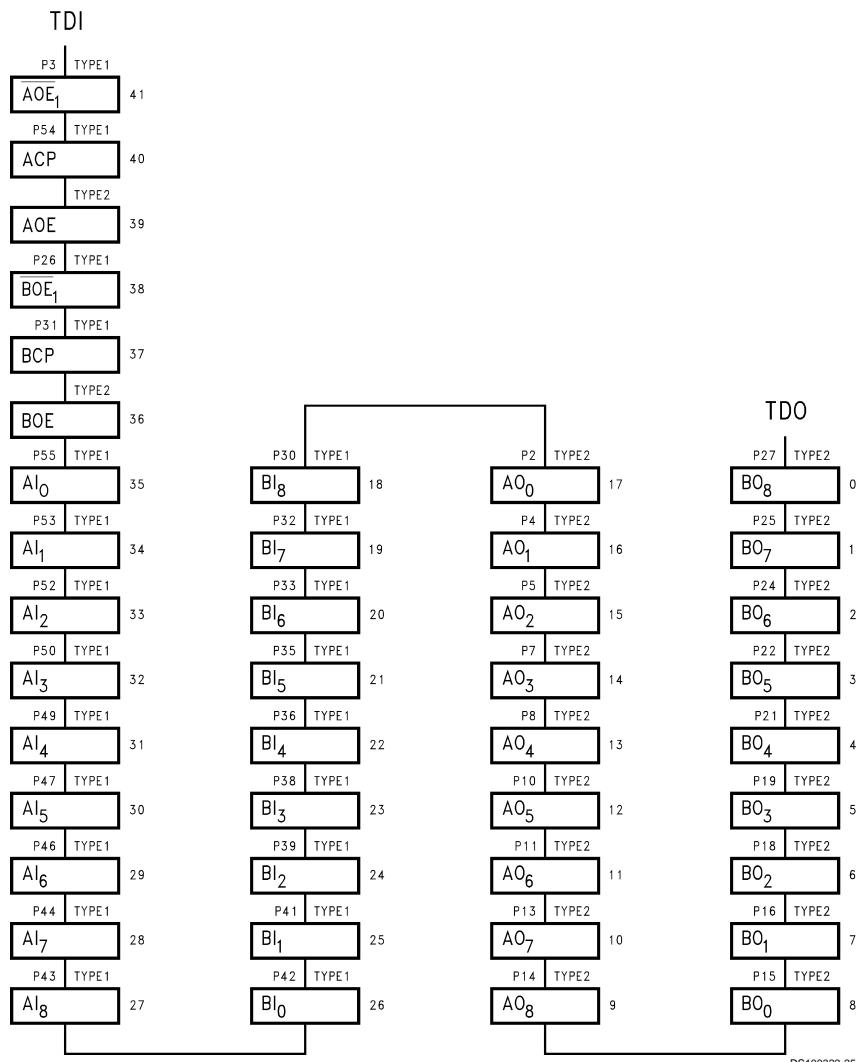
Scan Cell TYPE2



DS100322-8

Description of Boundary-Scan Circuitry (Continued)

Boundary-Scan Register
Scan Chain Definition (42 Bits in Length)



Description of Boundary-Scan Circuitry (Continued)

Boundary-Scan Register Definition Index

Bit No.	Pin Name	Pin No.	Pin Type	Scan Cell Type	
41	\overline{AOE}_1	3 54 Internal 26 31 Internal	Input	TYPE1	Control Signals
40	ACP		Input	TYPE1	
39	AOE		Internal	TYPE2	
38	\overline{BOE}_1		Input	TYPE1	
37	BCP		Input	TYPE1	
36	BOE		Internal	TYPE2	
35	AI ₀	55	Input	TYPE1	A-in
34	AI ₁	53	Input	TYPE1	
33	AI ₂	52	Input	TYPE1	
32	AI ₃	50	Input	TYPE1	
31	AI ₄	49	Input	TYPE1	
30	AI ₅	47	Input	TYPE1	
29	AI ₆	46	Input	TYPE1	
28	AI ₇	44	Input	TYPE1	
27	AI ₈	43	Input	TYPE1	
26	BI ₀	42	Input	TYPE1	B-in
25	BI ₁	41	Input	TYPE1	
24	BI ₂	39	Input	TYPE1	
23	BI ₃	38	Input	TYPE1	
22	BI ₄	36	Input	TYPE1	
21	BI ₅	35	Input	TYPE1	
20	BI ₆	33	Input	TYPE1	
19	BI ₇	32	Input	TYPE1	
18	BI ₈	30	Input	TYPE1	
17	AO ₀	2	Output	TYPE2	A-out
16	AO ₁	4	Output	TYPE2	
15	AO ₂	5	Output	TYPE2	
14	AO ₃	7	Output	TYPE2	
13	AO ₄	8	Output	TYPE2	
12	AO ₅	10	Output	TYPE2	
11	AO ₆	11	Output	TYPE2	
10	AO ₇	13	Output	TYPE2	
9	AO ₈	14	Output	TYPE2	
8	BO ₀	15	Output	TYPE2	B-out
7	BO ₁	16	Output	TYPE2	
6	BO ₂	18	Output	TYPE2	
5	BO ₃	19	Output	TYPE2	
4	BO ₄	21	Output	TYPE2	
3	BO ₅	22	Output	TYPE2	
2	BO ₆	24	Output	TYPE2	
1	BO ₇	25	Output	TYPE2	
0	BO ₈	27	Output	TYPE2	

Absolute Maximum Ratings (Note 1)		ESD (Min)	2000V		
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 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/Sink Current (I_O)	± 70 mA				
DC V_{CC} or Ground Current					
Per Output Pin	± 70 mA				
Junction Temperature					
Cerpack	+175°C				
Storage Temperature	-65°C to +150°C				
Recommended Operating Conditions					
Supply Voltage (V_{CC})					
SCAN Products	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)					
Military	-55°C to +125°C				
Minimum Input Edge Rate dV/dt	125 mV/ns				
V_{IN} from 0.8V to 2.0V					
V_{CC} @ 4.5V, 5.5V					
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 SCAN circuits outside databook specifications.					
DC Electrical Characteristics					
Symbol	Parameter	V_{CC} (V)	Military	Units	Conditions
			$T_A = -55^\circ C$ to $+125^\circ C$		
			Guaranteed Limits		
V_{IH}	Minimum High Input Voltage	4.5	2.0	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
		5.5	2.0		
V_{IL}	Maximum Low Input Voltage	4.5	0.8	V	$V_{OUT} = 0.1V$ or $V_{CC} - 0.1V$
		5.5	0.8		
V_{OH}	Minimum High Output Voltage	4.5	3.15	V	$I_{OUT} = -50 \mu A$
			4.15		
		4.5	2.4	V	$V_{IN} = V_{IL}$ or V_{IH} $I_{OH} = -24 mA$
			2.4		
V_{OL}	Maximum Low Output Voltage	4.5	0.1	V	$I_{OUT} = 50 \mu A$
			0.1		
		4.5	0.55	V	$V_{IN} = V_{IL}$ or V_{IH} $I_{OL} = 48 mA$
			0.55		
I_{IN}	Maximum Input Leakage Current	5.5	± 1.0	μA	$V_I = V_{CC}$, GND
I _{IN} TDI, TMS	Maximum Input Leakage	5.5	3.7	μA	$V_I = V_{CC}$
			-385	μA	$V_I = GND$
	Minimum Input Leakage	5.5	-160	μA	$V_I = GND$
I_{OLD}	Minimum Dynamic Output Current (Note 3)	5.5	63	mA	$V_{OLD} = 0.8V$ Max
			-27	mA	$V_{OHD} = 2.0V$ Min
I_{OZ}	Maximum Output Leakage Current	5.5	± 10.0	μA	V_I (OE) = V_{IL} , V_{IH}
I_{OS}	Output Short Circuit Current	5.5	-100	mA (min)	$V_O = 0V$
I_{CC}	Maximum Quiescent Supply Current	5.5	168	μA	$V_O = Open$ TDI, TMS = V_{CC}
			930	μA	$V_O = Open$ TDI, TMS = GND

DC Electrical Characteristics (Continued)

Symbol	Parameter	V _{CC} (V)	Military		Units	Conditions		
			T _A = -55°C to +125°C					
			Guaranteed Limits					
I _{CC1}	Maximum I _{CC} Per Input	5.5	2.0	mA	V _I = V _{CC} - 2.1V			
		5.5	2.15		V _I = V _{CC} - 2.1V TDI/TMS Pin, Test One with the Other Floating			

Note 2: All outputs loaded; thresholds associated with output under test.

Note 3: Maximum test duration 2.0 ms, one output loaded at a time.

Noise Specifications

Symbol	Parameter	V _{CC} (V)	Military		Units	
			T _A = -55°C to +125°C			
			Guaranteed Limits			
V _{OLP}	Maximum High Output Noise (Notes 4, 5)		5.0	0.8	V	
V _{OLV}	Minimum Low Output Noise (Notes 4, 5)		5.0	-0.8	V	

Note 4: Maximum number of outputs that can switch simultaneously is n. (n - 1) outputs are switched LOW and one output held LOW.

Note 5: Maximum number of outputs that can switch simultaneously is n. (n - 1) outputs are switched HIGH and one output held HIGH.

AC Electrical Characteristics

Normal Operation

Symbol	Parameter	V _{CC} (V) (Note 6)	Military		Units	
			T _A = -55°C to +125°C			
			Min	Max		
t _{PLH}	Propagation Delay CP to Q	5.0	2.5	11.0	ns	
t _{PHL}			2.5	12.0		
t _{PLZ}	Disable Time	5.0	1.5	10.5	ns	
t _{PHZ}			1.5	10.3		
t _{PZL}	Enable Time	5.0	2.0	13.0	ns	
t _{PZH}			2.0	11.0		

AC Operating Requirements

Normal Operation

Symbol	Parameter	V _{CC} (V) (Note 6)	Military		Units	
			T _A = -55°C to +125°C			
			C _L = 50 pF			
Guaranteed Minimum						
t _S	Setup Time, H or L Data to CP	5.0	3.0		ns	
t _H	Hold Time, H or L CP to Data	5.0	1.5		ns	
t _W	CP Pulse Width	5.0	5.0		ns	
f _{max}	Maximum ACP/BCP Clock Frequency	5.0	70		MHz	

Note 6: Voltage Range 5.0 is 5.0V ±0.5V.

AC Electrical Characteristics

Scan Test Operation

Symbol	Parameter	V_{CC} (V) (Note 7)	Military		Units	
			$T_A = -55^{\circ}C$ to $+125^{\circ}C$			
			Min	Max		
t_{PLH} , t_{PHL}	Propagation Delay TCK to TDO	5.0	3.5 3.5	15.8 15.5	ns	
t_{PLZ} , t_{PHZ}	Disable Time TCK to TDO	5.0	2.5 2.5	12.8 12.6	ns	
t_{PZL} , t_{PZH}	Enable Time TCK to TDO	5.0	3.0 3.0	16.7 15.0	ns	
t_{PLH} , t_{PHL}	Propagation Delay TCK to Data Out During Update-DR State	5.0	5.0 5.0	21.2 21.7	ns	
t_{PLH} , t_{PHL}	Propagation Delay TCK to Data Out During Update-IR State	5.0	5.0 5.0	21.2 21.0	ns	
t_{PLH} , t_{PHL}	Propagation Delay TCK to Data Out During Test Logic Reset State	5.0	5.5 5.5	21.5 23.0	ns	
t_{PLZ} , t_{PHZ}	Propagation Delay TCK to Data Out During Update-DR State	5.0	4.5 4.0	19.6 18.9	ns	
t_{PLZ} , t_{PHZ}	Propagation Delay TCK to Data Out During Update-IR State	5.0	5.0 5.0	22.4 22.4	ns	
t_{PLZ} , t_{PHZ}	Propagation Delay TCK to Data Out During Test Logic Reset State	5.0	5.5 5.0	23.3 22.9	ns	
t_{PZL} , t_{PZH}	Propagation Delay TCK to Data Out During Update-DR State	5.0	5.0 5.0	22.6 19.7	ns	
t_{PZL} , t_{PZH}	Propagation Delay TCK to Data Out During Update-IR State	5.0	7.0 6.5	26.2 23.1	ns	
t_{PZL} , t_{PZH}	Propagation Delay TCK to Data Out During Test Logic Reset State	5.0	7.0 7.0	27.4 24.5	ns	

Note 7: Voltage Range 5.0 is $5.0V \pm 0.5V$.

All Propagation Delays involving TCK are measured from the falling edge of TCK.

AC Operating Requirements

Scan Test Operation

Symbol	Parameter	V_{CC} (V) (Note 8)	Military		Units
			$T_A = -55^{\circ}C$ to $+125^{\circ}C$	$C_L = 50 \text{ pF}$	
			Guaranteed Minimum		
t_S	Setup Time, H or L Data to TCK (Note 9)	5.0	3.0		ns
t_H	Hold Time, H or L TCK to Data (Note 9)	5.0	4.5		ns
t_S	Setup Time, H or L $\overline{AOE_1}, \overline{BOE_1}$ to TCK (Note 11)	5.0	3.0		ns
t_H	Hold Time, H or L TCK to $\overline{AOE_1}, \overline{BOE_1}$ (Note 11)	5.0	4.5		ns
t_S	Setup Time, H or L Internal AOE, BOE to TCK (Note 10)	5.0	3.0		ns
t_H	Hold Time, H or L TCK to Internal AOE, BOE (Note 10)	5.0	3.0		ns
t_S	Setup Time ACP, BCP (Note 12) to TCK	5.0	3.0		ns
t_H	Hold Time TCK to ACP, BCP (Note 12)	5.0	3.5		ns
t_S	Setup Time, H or L TMS to TCK	5.0	8.0		ns
t_H	Hold Time, H or L TCK to TMS	5.0	2.0		ns
t_S	Setup Time, H or L TDI to TCK	5.0	4.0		ns
t_H	Hold Time, H or L TCK to TDI	5.0	4.5		ns
t_W	Pulse Width TCK	5.0			
		H	15.0		
		L	5.0		
f_{max}	Maximum TCK Clock Frequency	5.0	25		MHz
T_{pu}	Wait Time, Power Up to TCK	5.0	100		ns
T_{dn}	Power Down Delay	0.0	100		ms

Note 8: Voltage Range 5.0 is $5.0V \pm 0.5V$.

All Input Timing Delays involving TCK are measured from the rising edge of TCK.

Note 9: This delay represents the timing relationship between the data Input and TCK at the associated scan cells numbered 0–8, 9–17, 18–26 and 27–35.

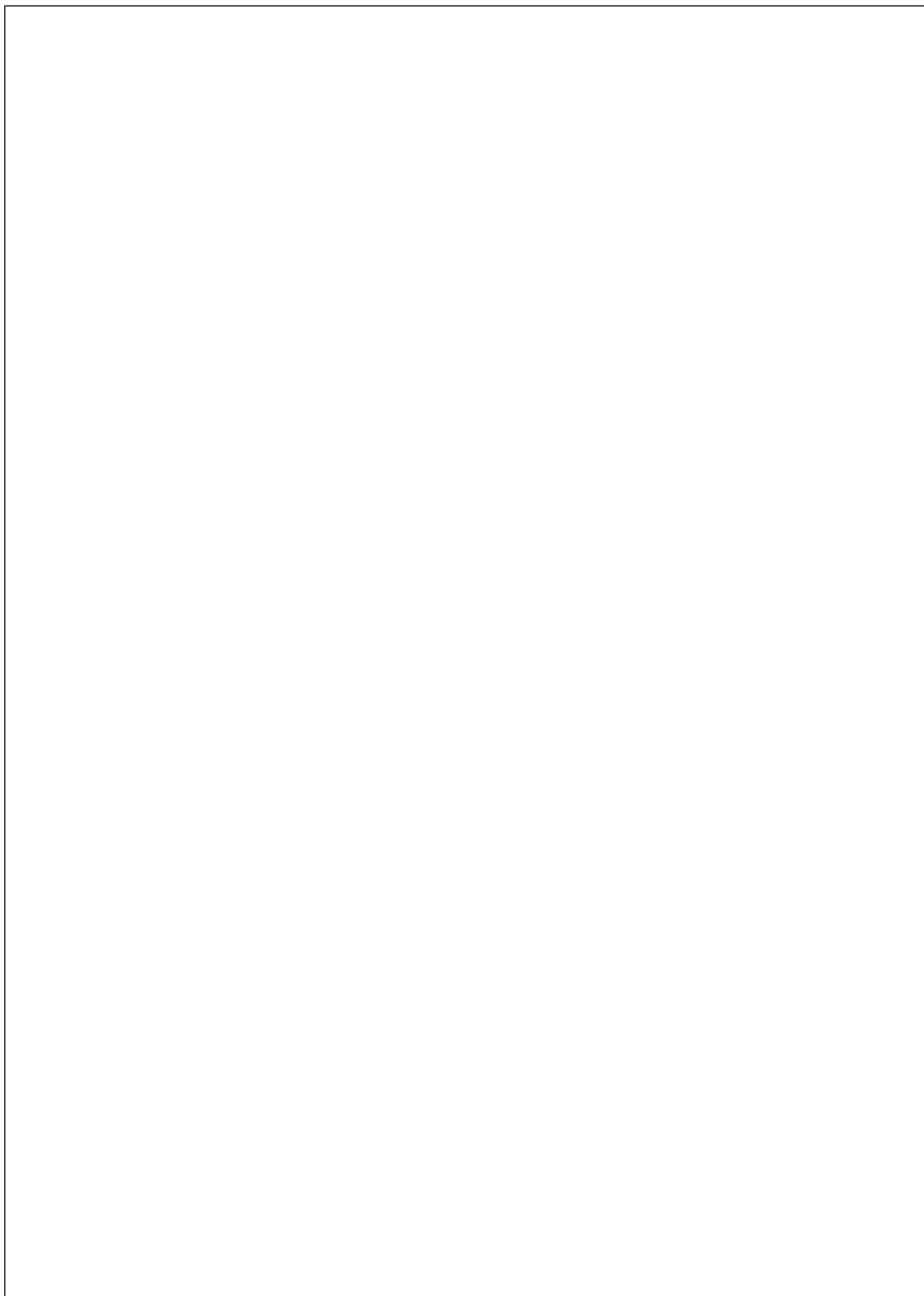
Note 10: This delay represents the timing relationship between AOE, BOE and TCK at scan cells 36 and 39 only.

Note 11: Timing pertains to BSR 38 and 41 only.

Note 12: Timing pertains to BSR 37 and 40 only.

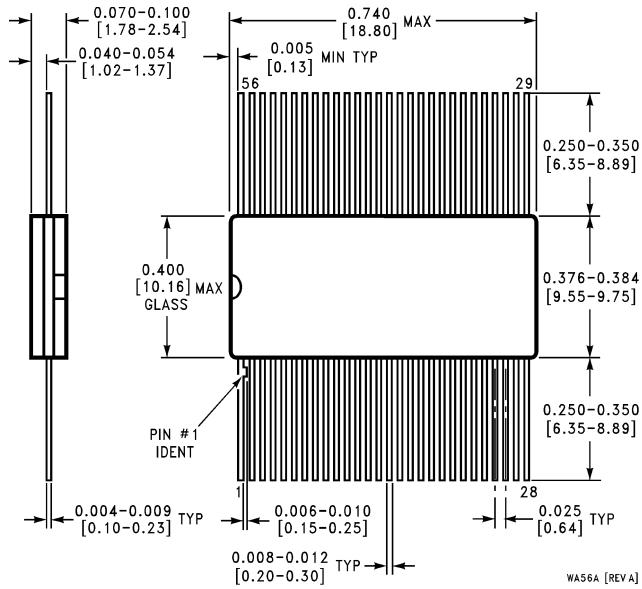
Capacitance

Symbol	Parameter	Typ	Units	Conditions
C_{IN}	Input Pin Capacitance	4.0	pF	$V_{CC} = 5.0V$
C_{OUT}	Output Pin Capacitance	13.0	pF	$V_{CC} = 5.0V$
C_{PD}	Power Dissipation Capacitance	34.0	pF	$V_{CC} = 5.0V$



SCAN18374T D Flip-Flop with TRI-STATE Outputs

Physical Dimensions inches (millimeters) unless otherwise noted



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