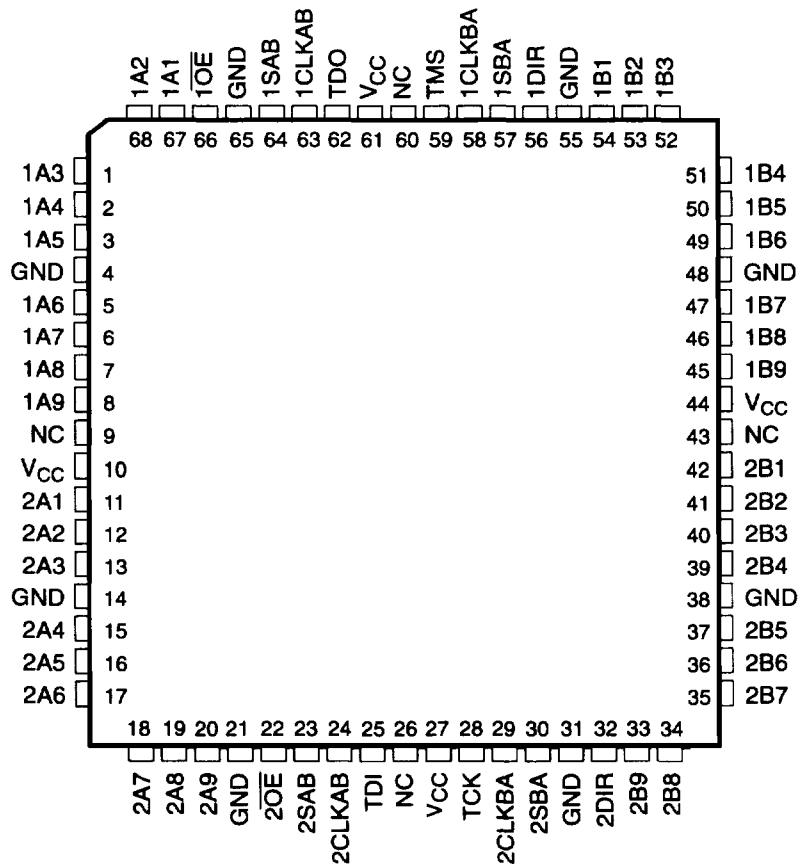


# SN54ABT18646, SN74ABT18646 SCAN TEST DEVICES WITH 18-BIT TRANSCEIVERS AND REGISTERS

SCBS131-AUGUST 1992-REVISED OCTOBER 1992

- Members of the Texas Instruments **SCOPE™** Family of Testability Products
- Members of the Texas Instruments **Widebus™** Family
- Compatible With the IEEE Standard 1149.1-1990 (JTAG) Test Access Port and Boundary-Scan Architecture
- Include D-Type Flip-Flops and Control Circuitry to Provide Multiplexed Transmission of Stored and Real-Time Data
- Two Boundary-Scan Cells per I/O for Greater Flexibility
- State-of-the-Art **EPIC-II B™** BiCMOS Design Significantly Reduces Power Dissipation
- **SCOPE™** Instruction Set
  - IEEE Standard 1149.1-1990 Required Instructions, Optional INTEST, and P1149.1A CLAMP and HIGHZ
  - Parallel Signature Analysis at Inputs With Masking Option
  - Pseudo-Random Pattern Generation From Outputs
  - Sample Inputs/Toggle Outputs
  - Binary Count From Outputs
  - Device Identification
  - Even-Parity Opcodes
- Packaged in 64-Pin Plastic Shrink Quad Flat Pack (PM) and 68-Pin Ceramic Quad Flat Pack (HV)

SN54ABT18646 . . . HV PACKAGE  
(TOP VIEW)



NC - No internal connection

PRODUCT PREVIEW



SCOPE, Widebus, and EPIC-II B are trademarks of Texas Instruments Incorporated.

PRODUCT PREVIEW information concerns products in the formative or design phase of development. Characteristic data and other specifications are design goals. Texas Instruments reserves the right to change or discontinue these products without notice.

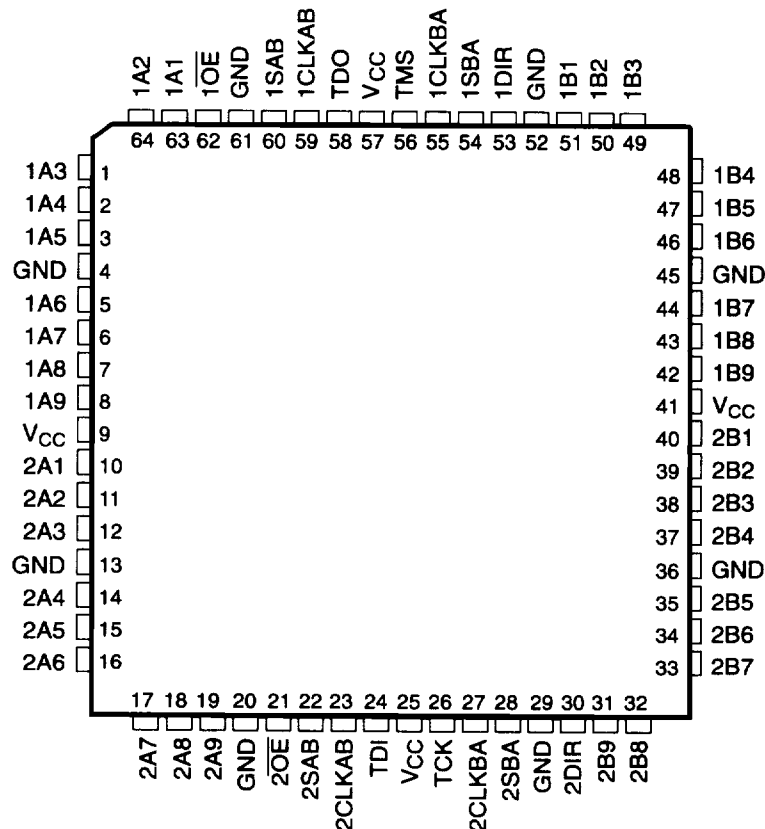
Copyright © 1992, Texas Instruments Incorporated



**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**

SCBS131—AUGUST 1992—REVISED OCTOBER 1992

**SN74ABT18646 . . . PM PACKAGE**  
**(TOP VIEW)**



**PRODUCT PREVIEW**

**description**

The SN54ABT18646 and SN74ABT18646 scan test devices with 18-bit bus transceivers and registers are members of the Texas Instruments SCOPE™ testability IC family. This family of devices supports IEEE Standard 1149.1-1990 boundary scan to facilitate testing of complex circuit board assemblies. Scan access to the test circuitry is accomplished via the 4-wire test access port (TAP) interface.

In the normal mode, these devices are 18-bit bus transceivers and registers that allow for multiplexed transmission of data directly from the input bus or from the internal registers. They can be used either as two 9-bit transceivers or one 18-bit transceiver. The test circuitry can be activated by the TAP to take snapshot samples of the data appearing at the device pins or to perform a self test on the boundary test cells. Activating the TAP in the normal mode does not affect the functional operation of the SCOPE™ bus transceivers and registers.

Transceiver function is controlled by output-enable ( $\overline{OE}$ ) and direction (DIR) inputs. When  $\overline{OE}$  is low, the transceiver is active and operates in the A-to-B direction when DIR is high or in the B-to-A direction when DIR is low. When  $\overline{OE}$  is high, both the A and B outputs are in the high-impedance state, effectively isolating both buses.

Data flow is controlled by clock (CLKAB and CLKBA) and select (SAB and SBA) inputs. Data on the A bus is clocked into the associated registers on the low-to-high transition of CLKAB. When SAB is low, real-time A data is selected for presentation to the B bus (transparent mode). When SAB is high, stored A data is selected for presentation to the B bus (registered mode). The function of the CLKBA and SBA inputs mirrors that of CLKAB and SAB, respectively. Figure 1 illustrates the four fundamental bus-management functions that can be performed with the 'ABT18646.



**description (continued)**

In the test mode, the normal operation of the SCOPE™ bus transceivers and registers is inhibited, and the test circuitry is enabled to observe and control the I/O boundary of the device. When enabled, the test circuitry can perform boundary scan test operations according to the protocol described in IEEE Standard 1149.1-1990.

Four dedicated test pins are used to observe and control the operation of the test circuitry: test data input (TDI), test data output (TDO), test mode select (TMS), and test clock (TCK). Additionally, the test circuitry can perform other testing functions such as parallel signature analysis on data inputs and pseudo-random pattern generation from data outputs. All testing and scan operations are synchronized to the TAP interface.

Additional flexibility is provided in the test mode through the use of two boundary scan cells (BSCs) for each I/O pin. This allows independent test data to be captured and forced at either bus (A or B). A PSA/COUNT instruction is also included to ease the testing of memories and other circuits where a binary count addressing scheme is useful.

The SN54ABT18646 is characterized over the full military temperature range of -55°C to 125°C. The SN74ABT18646 is characterized for operation from -40°C to 85°C.

**FUNCTION TABLE**  
 (normal mode, each 9-bit section)

INPUTS						DATA I/O		OPERATION OR FUNCTION
OE	DIR	CLKAB	CLKBA	SAB	SBA	A1 THRU A9	B1 THRU B9	
X	X	↑	X	X	X	Input	Unspecified†	Store A, B unspecified†
X	X	X	↑	X	X	Unspecified†	Input	Store B, A unspecified†
H	X	↑	↑	X	X	Input	Input	Store A and B data
H	X	L	L	X	X	Input disabled	Input disabled	Isolation, hold storage
L	L	X	X	X	L	Output	Input	Real-time B data to A bus
L	L	X	L	X	H	Output	Input disabled	Stored B data to A bus
L	H	X	X	L	X	Input	Output	Real-time A data to B bus
L	H	L	X	H	X	Input disabled	Output	Stored A data to B bus

† The data output functions can be enabled or disabled by various signals at the OE and DIR inputs. Data input functions are always enabled; i.e., data at the bus pins will be stored on every low-to-high transition of the clock inputs.

**PRODUCT PREVIEW**

PRODUCT PREVIEW

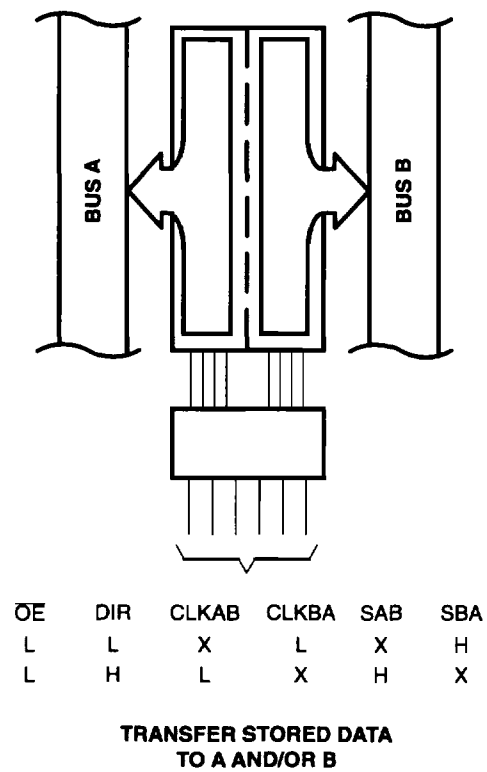
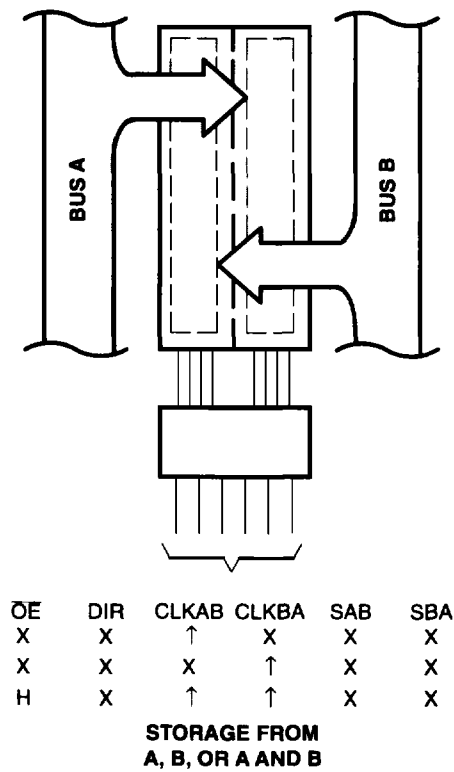
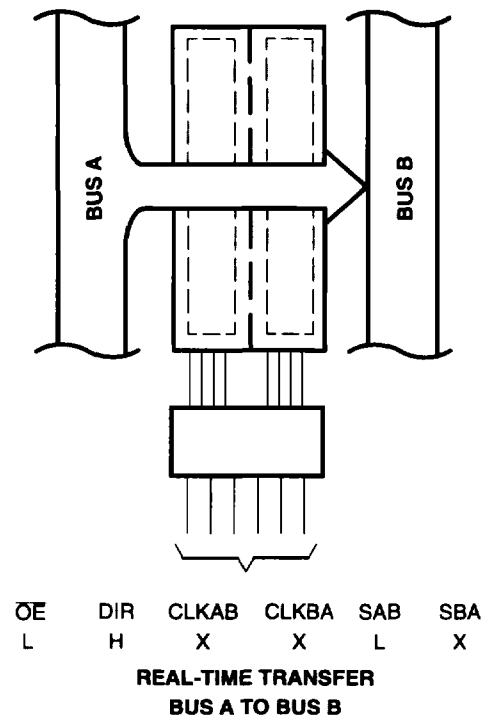
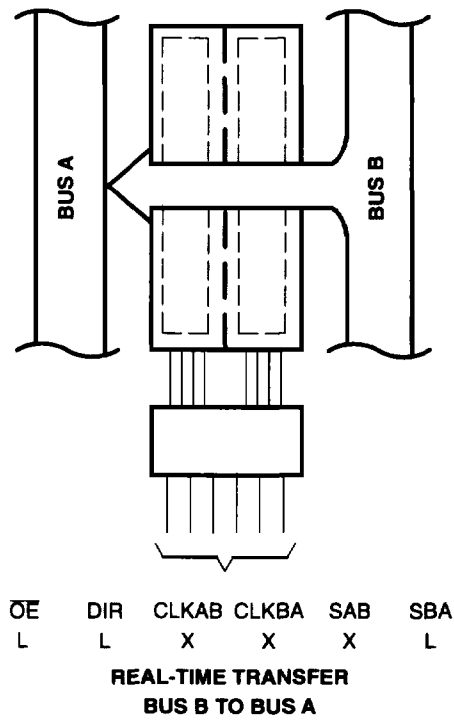
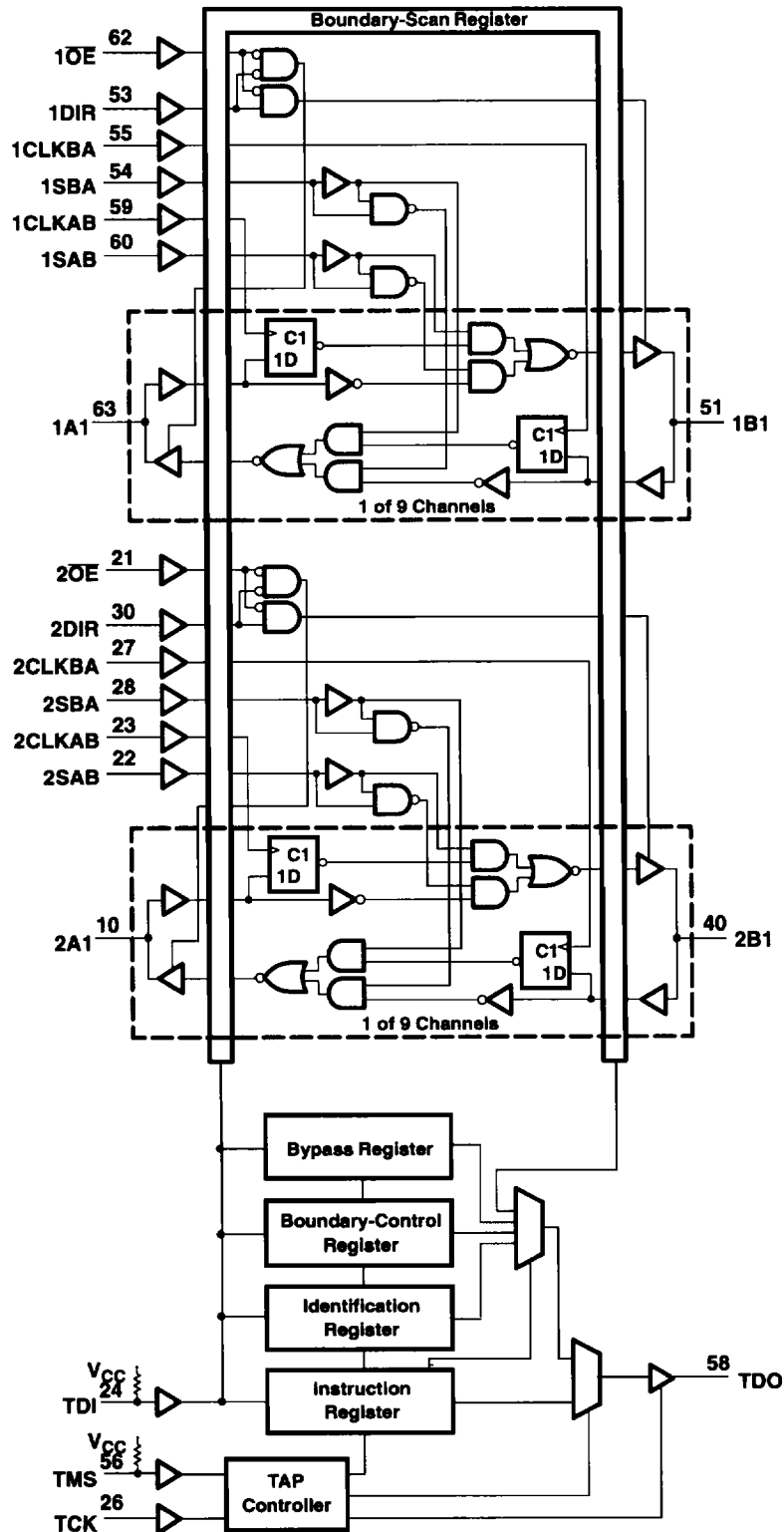


Figure 1. Bus-Management Functions

functional block diagram



PRODUCT PREVIEW

Pin numbers shown are for the PM package.

**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**

SCBS131—AUGUST 1992—REVISED OCTOBER 1992

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage range, $V_{CC}$ .....	-0.5 V to 7 V
Input voltage range, $V_I$ (except I/O ports) (see Note NO TAG) .....	-0.5 V to 7 V
Input voltage range, $V_I$ (I/O ports) (see Note NO TAG) .....	-0.5 V to 5.5 V
Voltage range applied to any output in the high state or power-off state, $V_O$ .....	-0.5 V to 5.5 V
Current into any output in the low state, $I_O$ : SN54ABT18646 .....	96 mA
SN74ABT18646 .....	128 mA
Input clamp current, $I_{IK}$ ( $V_I < 0$ ) .....	-18 mA
Output clamp current, $I_{OK}$ ( $V_O < 0$ ) .....	-50 mA
Maximum package power dissipation at $T_A = 55^\circ\text{C}$ (in still air) (see Note 2) .....	885 mW
Storage temperature range .....	-65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.  
 2. For the SN74ABT18646 (PM package), the power derating factor for ambient temperatures greater than 55°C is -10.5 mW/°C.

**recommended operating conditions (see Note 3)**

	SN54ABT18646		SN74ABT18646		UNIT
	MIN	MAX	MIN	MAX	
$V_{CC}$ Supply voltage	4.5	5.5	4.5	5.5	V
$V_{IH}$ High-level input voltage	2		2		V
$V_{IL}$ Low-level input voltage		0.8		0.8	V
$V_I$ Input voltage	0	$V_{CC}$	0	$V_{CC}$	V
$I_{OH}$ High-level output current		-24		-32	mA
$I_{OL}$ Low-level output current		48		64	mA
$\Delta t/\Delta v$ Input transition rise or fall rate		10		10	ns/V
$T_A$ Operating free-air temperature	-55	125	-40	85	°C

NOTE 3: Unused or floating pins (input or I/O) must be held high or low.

**PRODUCT PREVIEW**



**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**  
 SCBS131-AUGUST 1992-REVISED OCTOBER 1992

**electrical characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Note 4)**

PARAMETER	TEST CONDITIONS		T <sub>A</sub> = 25°C			SN54ABT18646		SN74ABT18646		UNIT
			MIN	TYP†	MAX	MIN	MAX	MIN	MAX	
V <sub>IK</sub>	V <sub>CC</sub> = 4.5 V, I <sub>I</sub> = -18 mA				-1.2		-1.2		-1.2	V
V <sub>OH</sub>	V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = -3 mA		2.5			2.5		2.5		V
	V <sub>CC</sub> = 5 V, I <sub>OH</sub> = -3 mA		3			3		3		
	V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = -24 mA		2			2				
	V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = -32 mA		2‡					2		
V <sub>OL</sub>	V <sub>CC</sub> = 4.5 V	I <sub>OL</sub> = 48 mA			0.55		0.55			V
		I <sub>OL</sub> = 64 mA			0.55‡			0.55		
I <sub>I</sub>	V <sub>CC</sub> = 5.5 V, V <sub>I</sub> = V <sub>CC</sub> or GND	CLK, DIR, OE, S, TCK			±1		±1		±1	μA
		A or B ports			±100		±100		±100	
I <sub>IH</sub>	V <sub>CC</sub> = 5.5 V, V <sub>I</sub> = V <sub>CC</sub>	TDI, TMS			10		10		10	μA
I <sub>IL</sub>	V <sub>CC</sub> = 5.5 V, V <sub>I</sub> = GND	TDI, TMS			-160		-160		-160	μA
I <sub>OZH</sub> §	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 2.7 V				50		50		50	μA
I <sub>OZL</sub> §	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 0.5 V				-50		-50		-50	μA
I <sub>off</sub>	V <sub>CC</sub> = 0, V <sub>I</sub> or V <sub>O</sub> ≤ 5.5 V				±100				±100	μA
I <sub>CEX</sub>	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 5.5 V	Outputs high			50		50		50	μA
I <sub>O</sub> ¶	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 2.5 V		-50	-100	-180	-50	-180	-50	-180	mA
I <sub>CC</sub>	V <sub>CC</sub> = 5.5 V, I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND	A or B ports								
		Outputs high	0.9	2		2		2		mA
		Outputs low	30	38		38		38		
Outputs disabled	0.9	2		2		2				
ΔI <sub>CC</sub> #	V <sub>CC</sub> = 5.5 V, One input at 3.4 V, Other inputs at V <sub>CC</sub> or GND				1.5		1.5		1.5	mA
C <sub>i</sub>	V <sub>I</sub> = 2.5 V or 0.5 V	Control inputs			3					pF
C <sub>io</sub>	V <sub>O</sub> = 2.5 V or 0.5 V	A or B ports			10					pF
C <sub>o</sub>	V <sub>O</sub> = 2.5 V or 0.5 V	TDO			8					pF

NOTE 4: Preliminary specifications based on SPICE analysis

† All typical values are at V<sub>CC</sub> = 5 V.

‡ On products compliant to MIL-STD-883, Class B, this parameter does not apply.

§ The parameters I<sub>OZH</sub> and I<sub>OZL</sub> include the input leakage current.

¶ Not more than one output should be tested at a time, and the duration of the test should not exceed one second.

# This is the increase in supply current for each input that is at the specified TTL voltage level rather than V<sub>CC</sub> or GND.

**PRODUCT PREVIEW**



**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**

SCBS131-AUGUST 1992-REVISED OCTOBER 1992

timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (normal mode) (see Note 4 and Figure 2)

			SN54ABT18646		SN74ABT18646		UNIT
			MIN	MAX	MIN	MAX	
$f_{\text{clock}}$	Clock frequency	CLKAB or CLKBA	0	100	0	100	MHz
$t_w$	Pulse duration	CLKAB or CLKBA high or low			3		ns
$t_{\text{su}}$	Setup time	A before CLKAB $\uparrow$ or B before CLKBA $\uparrow$			5		ns
$t_h$	Hold time	A after CLKAB $\uparrow$ or B after CLKBA $\uparrow$			0		ns

timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (test mode) (see Note 4 and Figure 2)

			SN54ABT18646		SN74ABT18646		UNIT
			MIN	MAX	MIN	MAX	
$f_{\text{clock}}$	Clock frequency	TCK	0	50	0	50	MHz
$t_w$	Pulse duration	TCK high or low			5		ns
$t_{\text{su}}$	Setup time	A, B, CLK, DIR, $\overline{\text{OE}}$ , or S before TCK $\uparrow$			5		ns
		TDI before TCK $\uparrow$			6		
		TMS before TCK $\uparrow$			6		
$t_h$	Hold time	A, B, CLK, DIR, $\overline{\text{OE}}$ , or S after TCK $\uparrow$			0		ns
		TDI after TCK $\uparrow$			0		
		TMS after TCK $\uparrow$			0		
$t_d$	Delay time	Power up to TCK $\uparrow$			50		ns
$t_r$	Rise time	V <sub>CC</sub> power up			1		$\mu\text{s}$

NOTE 4: Preliminary specifications based on SPICE analysis

PRODUCT PREVIEW



**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**  
SCBS131-AUGUST 1992-REVISED OCTOBER 1992

**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (normal mode) (see Note 4 and Figure 2)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 5\text{ V}, T_A = 25^\circ\text{C}$			SN54ABT18646		SN74ABT18646		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$	CLKAB or CLKBA		100	130		100		100		MHz
$t_{PLH}$	A or B	B or A						1	6	ns
$t_{PHL}$									1	
$t_{PLH}$	CLKAB or CLKBA	B or A						2	6	ns
$t_{PHL}$									2	
$t_{PLH}$	SAB or SBA	B or A						2	8	ns
$t_{PHL}$									2	
$t_{PZH}$	DIR	B or A						2	7.5	ns
$t_{PZL}$									2	
$t_{PZH}$	$\overline{OE}$	B or A						2	7.5	ns
$t_{PZL}$									2	
$t_{PHZ}$	DIR	B or A						2	7.5	ns
$t_{PLZ}$									2	
$t_{PHZ}$	$\overline{OE}$	B or A						2	7.5	ns
$t_{PLZ}$									2	

**switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (test mode) (see Note 4 and Figure 2)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 5\text{ V}, T_A = 25^\circ\text{C}$			SN54ABT18646		SN74ABT18646		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$	TCK		50	90		50		50		MHz
$t_{PLH}$	TCK↓	A or B						3	12	ns
$t_{PHL}$									3	
$t_{PLH}$	TCK↓	TDO						2	7	ns
$t_{PHL}$									2	
$t_{PZH}$	TCK↓	A or B						3	14	ns
$t_{PZL}$									3	
$t_{PZH}$	TCK↓	TDO						2	8	ns
$t_{PZL}$									2	
$t_{PHZ}$	TCK↓	A or B						3	14	ns
$t_{PLZ}$									3	
$t_{PHZ}$	TCK↓	TDO						2	8	ns
$t_{PLZ}$									2	

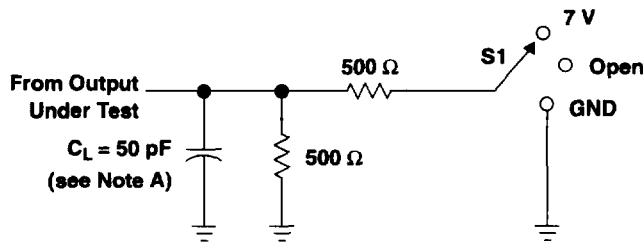
NOTE 4: Preliminary specifications based on SPICE analysis

**PRODUCT PREVIEW**

**SN54ABT18646, SN74ABT18646**  
**SCAN TEST DEVICES WITH**  
**18-BIT TRANSCEIVERS AND REGISTERS**

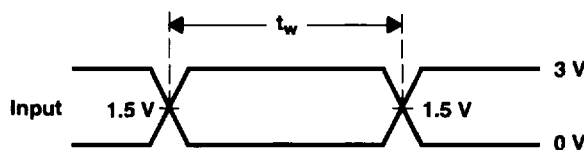
SCBS131—AUGUST 1992—REVISED OCTOBER 1992

**PARAMETER MEASUREMENT INFORMATION**

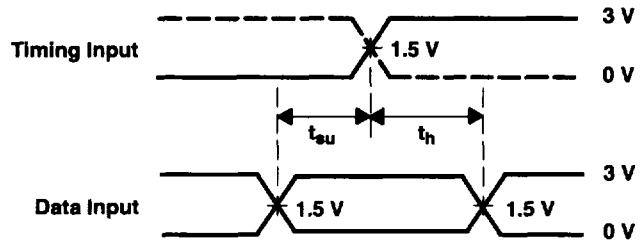


TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	7 V
$t_{PHZ}/t_{PZH}$	Open

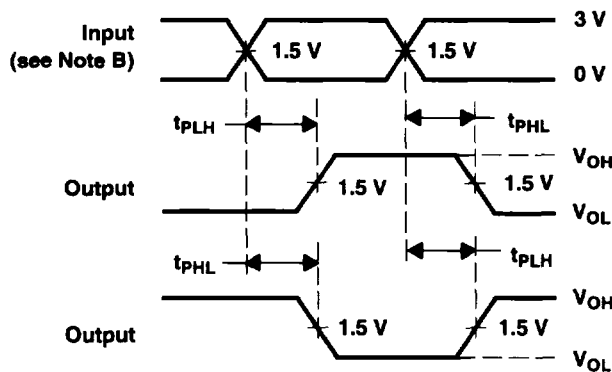
**LOAD CIRCUIT FOR OUTPUTS**



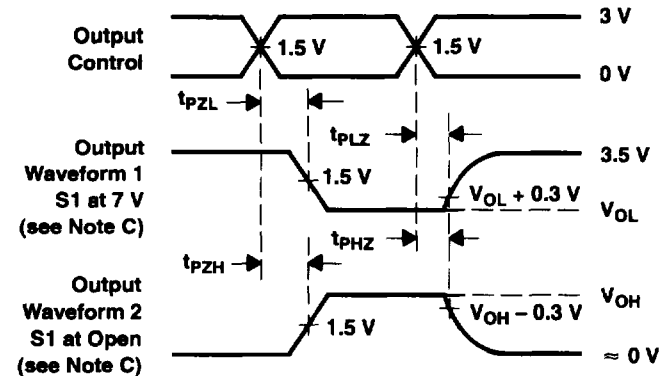
**VOLTAGE WAVEFORMS**  
**PULSE DURATION**



**VOLTAGE WAVEFORMS**  
**SETUP AND HOLD TIMES**



**VOLTAGE WAVEFORMS**  
**PROPAGATION DELAY TIMES**  
**INVERTING AND NON-INVERTING OUTPUTS**



**VOLTAGE WAVEFORMS**  
**ENABLE AND DISABLE TIMES**  
**LOW- AND HIGH-LEVEL ENABLING**

- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5$  ns,  $t_f \leq 2.5$  ns.  
 C. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.  
 D. The outputs are measured one at a time with one transition per measurement.

**Figure 2. Load Circuit and Voltage Waveforms**

**PRODUCT PREVIEW**

## **IMPORTANT NOTICE**

Texas Instruments (TI) reserves the right to make changes to its products or to discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information being relied on is current.

TI warrants performance of its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Certain applications using semiconductor products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications").

**TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.**

Inclusion of TI products in such applications is understood to be fully at the risk of the customer. Use of TI products in such applications requires the written approval of an appropriate TI officer. Questions concerning potential risk applications should be directed to TI through a local SC sales office.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein. Nor does TI warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used.

Copyright © 1996, Texas Instruments Incorporated

Printed in U.S.A. by  
The Hibbert Group  
Denver, Colorado

# TI Worldwide Sales and Representative Offices

**AUSTRALIA / NEW ZEALAND:** Texas Instruments Australia Ltd.: Melbourne [61] 3-9696-1211, Fax 3-9696-4446; Sydney 2-910-3100, Fax 2-805-1186.

**BELGIUM:** Texas Instruments Belgium S.A./N.V.: Brussels [32] (02) 726 75 80, Fax (02) 726 72 76.

**BRAZIL:** Texas Instrumentos Electronicos do Brasil Ltda.: Sao Paulo [55] 11-535-5133.

**CANADA:** Texas Instruments Canada Ltd.: Montreal (514) 421-2750; Ottawa (613) 726-3201; Fax 726-6363; Toronto (905) 884-9181; Fax 884-0062.

**DENMARK:** Texas Instruments A/S: Ballerup [45] (44) 68 74 00.

**FRANCE/MIDDLE EAST/AFRICA:** Texas Instruments France: Velizy-Villacoublay [33] (1) 30 70 10 01, Fax (1) 30 70 10 54.

**GERMANY:** Texas Instruments Deutschland GmbH.: Freising [49] (08161) 800, Fax (08161) 80 45 16; Hannover (0511) 90 49 60, Fax (0511) 64 90 331; Ostfildern (0711) 340 30, Fax (0711) 340 32 57.

**HONG KONG:** Texas Instruments Hong Kong Ltd.: Kowloon [852] 2956-7288, Fax 2956-2200.

**HUNGARY:** Texas Instruments Representation: Budapest [36] (1) 319 2748/2767/2768, Fax (1) 319 2814.

**IRELAND:** Texas Instruments Ireland Ltd.: Dublin [353] (01) 475 52 33, Fax (01) 478 14 63.

**ITALY:** Texas Instruments Italia S.p.A.: Agrate Brianza [39] (039) 684 21, Fax (039) 684 29 12; Rome (06) 657 26 51.

**JAPAN:** Texas Instruments Japan Ltd.: Kanazawa [81] 0762-23-5471, Fax 0762-23-1583; Kita Kanto 0485-22-2440, Fax 0485-23-5787; Kyoto 075-341-7713, Fax 075-341-7724; Kyushu 0977-73-1557, Fax 0977-73-1583; Matsumoto 0263-33-1060, Fax 0263-35-1025; Nagoya 052-232-5601, Fax 052-232-7888; Osaka 06-204-1881, Fax 06-204-1895; Tachikawa 0425-27-6760, Fax 0425-27-6426; Tokyo 03-3769-8700, Fax 03-3457-6777; Yokohama 045-338-1220, Fax 045-338-1255.

**KOREA:** Texas Instruments Korea Ltd.: Seoul [82] 2-551-2804, Fax 2-551-2828.

**MAINLAND CHINA:** Texas Instruments China Inc.: Beijing [86] 10-500-2255, Ext. 3750/3751/3752, Fax 10-500-2705.

**MALAYSIA:** Texas Instruments Malaysia Sdn Bhd: Kuala Lumpur [60] 3-208-6001, Fax 3-230-6605.

**MEXICO:** Texas Instruments de Mexico S.A. de C.V.: Colonia del Valle [52] 5-639-9740.

**NORWAY:** Texas Instruments Norge A/S: Oslo [47] (02) 264 75 70.

**PHILIPPINES:** Texas Instruments Asia Ltd.: Metro Manila [63] 2-636-0980, Fax 2-631-7702.

**SINGAPORE (& INDIA, INDONESIA, THAILAND):** Texas Instruments Singapore (PTE) Ltd.: Singapore [65] 390-7100, Fax 390-7062.

**SPAIN/PORTUGAL:** Texas Instruments España S.A.: Madrid [34] (1) 372 80 51, Fax (1) 307 68 64.

**SUOMI/FINLAND:** Texas Instruments/OY: Espoo [358] (0) 43 54 20 33, Fax (0) 46 73 23.

**SWEDEN:** Texas Instruments International Trade Corporation (Sverigefilialen): Kista [46] (08) 752 58 00, Fax (08) 751 97 15.

**SWITZERLAND:** Texas Instruments Switzerland AG: Dietlikon [41] 886-2-3771450.

**TAIWAN:** Texas Instruments Taiwan Limited: Taipei [886] 2-378-6800, Fax 2-377-2718.

**THE NETHERLANDS:** Texas Instruments Holland, B.V. Amsterdam [31] (020) 546 98 00, Fax (020) 646 31 36.

**UNITED KINGDOM:** Texas Instruments Ltd.: Northampton [44] (01604) 66 30 00, Fax (01604) 66 30 01.

**UNITED STATES:** Texas Instruments Incorporated: **ALABAMA:** Huntsville (205) 430-0114; **ARIZONA:** Phoenix (602) 224-7800; **CALIFORNIA:** Irvine (714) 660-1200; Los Angeles (818) 704-8100; San Diego (619) 278-9600; San Jose (408) 894-9000; **COLORADO:** Denver (303) 488-9300; **CONNECTICUT:** Wallingford (203) 269-0074; **FLORIDA:** Fort Lauderdale (214) 644-5580 Orlando (407) 667-5308; Tampa (813) 573-0331; **GEORGIA:** Atlanta (770) 662-7967; **ILLINOIS:** Chicago (708) 517-4500; **INDIANA:** Indianapolis (317) 573-6400; **KANSAS:** Kansas City (913) 451-4511; **MARYLAND:** Baltimore (410) 312-7900; **MASSACHUSETTS:** Boston (617) 895-9100; **MICHIGAN:** Detroit (810) 305-5700; **MINNESOTA:** Minneapolis (612) 828-9300; **NEW JERSEY:** Edison (908) 906-0033; **NEW MEXICO:** Albuquerque (505) 345-2555; **NEW YORK:** Long Island (516) 454-6600; Poughkeepsie (914) 897-2900; Rochester (716) 385-6770; **NORTH CAROLINA:** Charlotte (704) 522-5487; Raleigh (919) 876-2725; **OHIO:** Cleveland (216) 328-2149; Dayton (513) 427-6200; **OREGON:** Portland (503) 643-6758; **PENNSYLVANIA:** Philadelphia (610) 825-9500; **PUERTO RICO:** Hato Rey (809) 753-8700; **TEXAS:** Austin (512) 250-6769; Dallas (214) 917-1264; Houston (713) 778-6592; Midland (915) 561-6521; **WISCONSIN:** Milwaukee (414) 798-5021.

## North American Authorized Distributors

### COMMERCIAL

Almac / Arrow	800-426-1410 / 800-452-9185 Oregon only
Anthem Electronics	800-826-8436
Arrow / Schweber	800-777-2776
Future Electronics (Canada)	800-388-8731
Hamilton Hallmark	800-332-8638
Marshall Industries	800-522-0084 or <a href="http://www.marshall.com">www.marshall.com</a>
Wyle	800-414-4144

### OBsolete PRODUCTS

Rochester Electronics	508-462-9332
-----------------------	--------------

### MILITARY

Alliance Electronics Inc	800-608-9494
Future Electronics (Canada)	800-388-8731
Hamilton Hallmark	800-332-8638
Zeus, An Arrow Company	800-524-4735

### TI DIE PROCESSORS

Chip Supply	(407) 298-7100
Elmo Semiconductor	(818) 768-7400
Minco Technology Labs	(512) 834-2022

### CATALOG

Allied Electronics	800-433-5700
Arrow Advantage	800-777-2776
Newark Electronics	800-367-3573

*For Distributors outside North America, contact your local Sales Office.*

**Important Notice:** Texas Instruments (TI) reserves the right to make changes to or to discontinue any product or service identified in this publication without notice. TI advises its customers to obtain the latest version of the relevant information to verify, before placing orders, that the information being relied upon is current.

Please be advised that TI warrants its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. TI assumes no liability for applications assistance, software performance, or third-party product information, or for infringement of patents or services described in this publication. TI assumes no responsibility for customers' applications or product designs.

A040896

© 1996 Texas Instruments Incorporated

Printed in the USA

