SCAN16512A

SCAN16512A Low Voltage Universal 16-bit IEEE 1149.1 Bus Transceiver with TRI-STATE Outputs

Literature Number: SNLS169A

National Semiconductor

SCAN16512A

OBSOLETE
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Low Voltage Universal 16-bit IEEE 1149.1 Bus Transceiver with TRI-STATE Outputs

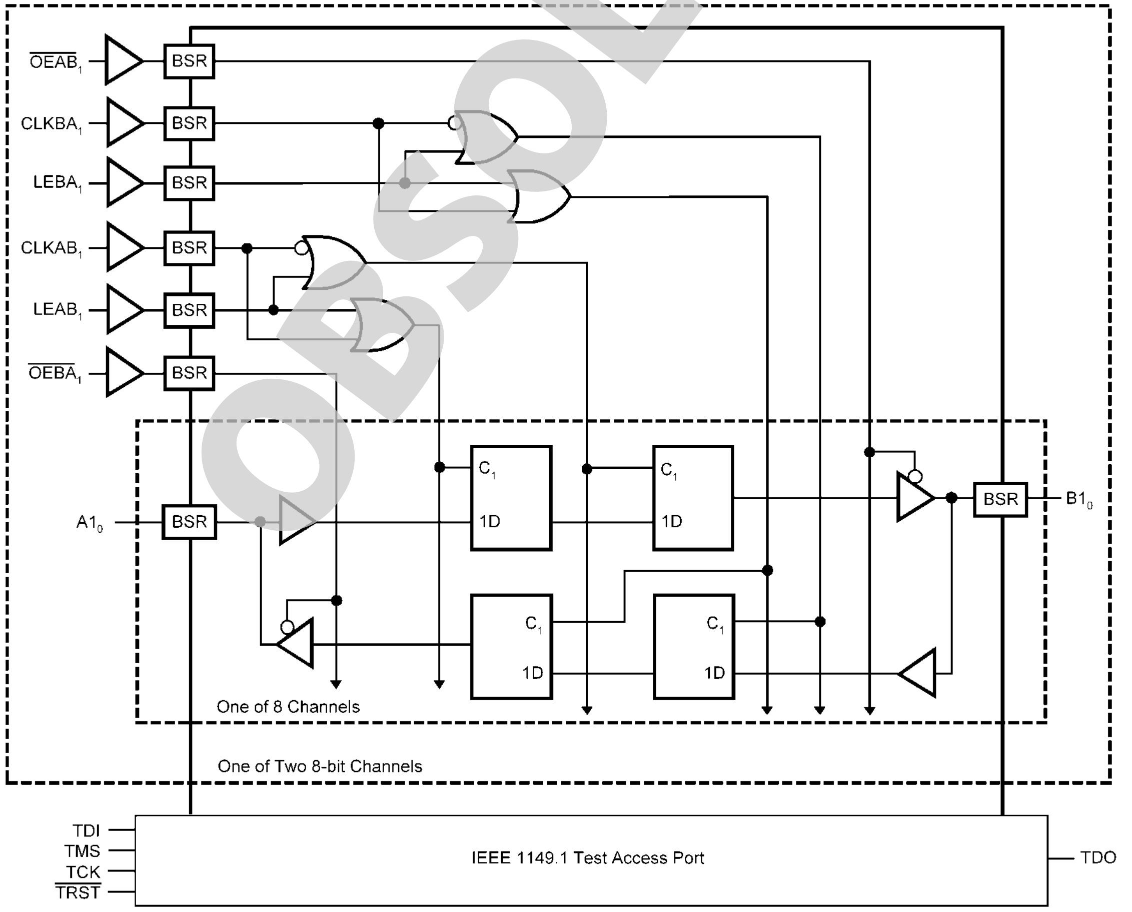
General Description

The SCAN16512A is a high speed, low-power universal bus transceiver featuring data inputs organized into two 8-bit bytes with output enable and latch enable control signals. This function is configurable as a D-type Latch or Flip-Flop, and can operate in transparent, latched, or clocked mode. 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), Test Clock (TCK), and Test Reset ($\overline{\text{TRST}}$).

Features

- IEEE 1149.1 (JTAG) Compliant
- 2.7V to 3.6V V_{CC} Operation
- TRI-STATE outputs for bus-oriented applications
- Dual byte-wide data for bus applications
- Power down high Impedance inputs and outputs
- Optional Bus Hold on data inputs eliminates the need for external pullup/pulldown resistors (SCANH16512A, SCANH162512A versions)
- Optional 25Ω series resistors in outputs to minimize noise and eliminate termination resistors (SCAN162512A, SCANH162512A versions)
- Supports live insertion/withdrawal
- Includes CLAMP and HIGHZ instructions

Block Diagram



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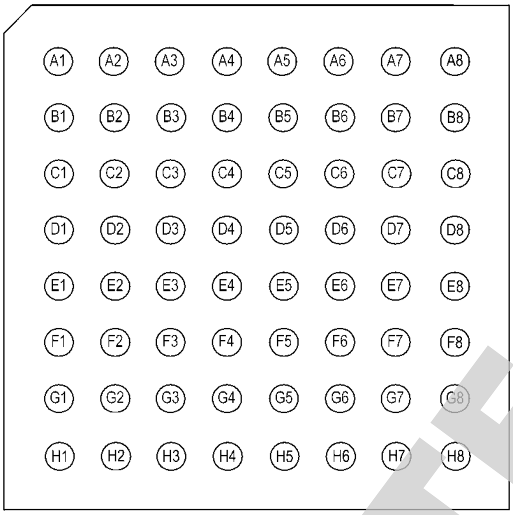
Pin Descriptions

Pin Name	Description
$A1_0$-$A1_7$, **$A2_0$-$A2_7$**	Normal-function A-bus I/O ports. See function table for normal-mode logic.
$B1_0$-$B1_7$, **$B2_0$-$B2_7$**	Normal-function B-bus I/O ports. See function table for normal-mode logic.
$CLKAB_1$, **$CLKBA_1$,** **$CLKAB_2$,** **$CLKBA_2$**	Normal-function clock inputs.See function table for normal-mode logic.
GND	Ground
V_{CC}	Supply Voltage
$LEAB_1$, **$LEBA_1$,** **$LEAB_2$,** **$LEBA_2$**	Normal-function latch enables. See function table for normal-mode logic.
$\overline{OEAB}_1$, **$\overline{OEBA}_1$,** **$\overline{OEAB}_2$,** **$\overline{OEBA}_2$**	Normal-function output enables. See function table for normal-mode logic.
TDO	The Test Data Output to support IEEE Std 1149.1-1990. TDO is the serial output for shifting data through the instruction register or selected data register.
TMS	The Test Mode Select input to support IEEE Std 1149.1-1990. TMS directs the device through it's TAP controller states. An internal pull-up forces TMS high if left unconnected.
TCK	The Test Clock input to support IEEE Std 1149.1-1990. Test operations of the device are synchronous to TCK. Data is captured on the rising edge of TCK and outputs change on the falling edge of TCK.
TDI	The Test Data Input to support IEEE Std 1149.1-1990. TDI is the serial input to shift data through the instruction register or the selected data register. An internal pull-up resistor forces TDI high if left unconnected.
$\overline{TRST}$	The Test Reset Input to support IEEE Std 1149.1-1990. TRST is the asynchronous reset pin which will force the TAP controller to it's initialization state when active. An internal pullup resistor forces $\overline{TRST}$ high if left unconnected.

BGA Pinout

	1	2	3	4	5	6	7	8
A	$A1_0$	$A1_2$	$A1_4$	$A1_6$	$A2_0$	$A2_2$	$A2_4$	$A2_6$
B	$A1_1$	$A1_3$	$A1_5$	$A1_7$	$A2_1$	$A2_3$	$A2_5$	$A2_7$
C	$\overline{TRST}$	$CLKAB_1$	$LEAB_1$	$\overline{OEAB}_1$	GND	$CLKAB_2$	$LEAB_2$	$\overline{OEAB}_2$
D	TMS	GND	V_{CC}	GND	V_{CC}	GND	TDI	TDO
E	TCK	GND	V_{CC}	V_{CC}	GND	GND	N/C	V_{CC}
F	$CLKBA_1$	$LEBA_1$	$\overline{OEBA}_1$	GND	N/C	$CLKBA_2$	$LEBA_2$	$\overline{OEBA}_2$
G	$B1_1$	$B1_3$	$B1_5$	$B1_7$	$B2_1$	$B2_3$	$B2_5$	$B2_7$
H	$B1_0$	$B1_2$	$B1_4$	$B1_6$	$B2_0$	$B2_2$	$B2_4$	$B2_6$

Connection Diagram



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Top View
See NS Package Number SLC64A

Truth Table

Function Table (*Note 1*)

Inputs				Outputs
$\overline{\text{OEAB}}$	LEAB	CLKAB	A	B
L	L	L	X	B_0 (*Note 2*)
L	L	↑	L	L
L	L	↑	H	H
L	H	X	L	L
L	H	X	H	H
H	X	X	X	Z

H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial (HIGH or LOW, inputs may not float)
Z = High Impedance

Note 1: A-to-B data flow is shown. B-to-A data flow is similar, but uses $\overline{\text{OEBA}}$, LEBA, and CLKBA.

Note 2: Output level before the indicated steady-state input conditions were established.

Functional Description

In the normal mode, these devices are 16-bit universal bus transceivers that combine D-type latches and D-type flip-flops to allow data flow in transparent, latched, or clocked modes. They can be used as two 8-bit transceivers, or as one 16-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 may affect the normal functional operation of the universal bus transceivers. When the TAP is activated, the test circuitry performs boundary-scan test operations according to the protocol described in IEEE Std 1149.1-1990.

Data flow in each direction is controlled by output-enable ($\overline{\text{OEAB}}$ and $\overline{\text{OEBA}}$), latch-enable (LEAB and LEBA), and clock (CLKAB and CLKBA) inputs. For A-to-B data flow, the devices operate in the transparent mode when LEAB is high. When LEAB is low, the A data is latched while CLKAB is held at a static low or high logic level. Otherwise, if LEAB is low, A data is stored on a low-to-high transition of CLKAB. When $\overline{\text{OEAB}}$ is LOW, the B outputs are active. When $\overline{\text{OEAB}}$ is HIGH, the B outputs are in the high-impedance state. B-to-A data flow is similar to A-to-B data flow but uses the $\overline{\text{OEBA}}$, LEBA, and CLKBA inputs.

Five 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), test clock (TCK), and test reset ($\overline{\text{TRST}}$). All testing and scan operations are synchronized to the TAP interface.

For details about the sequence of boundary scan cells in the SCAN16512A, please refer to the BSDL (Boundary Scan Description Language) file available on our website.

Absolute Maximum Ratings (Note 3)

Supply Voltage (V_{CC})	−0.5V to +4.6V
DC Input Diode Current (I_{IK})	
V_I = −0.5V	−50 mA
DC Output Diode Current (I_{OK})	
V_O = −0.5V	−50 mA
DC Input Voltage (V_I)	−0.5V to 4.6V
DC Output Voltage (V_O)	−0.5V to 4.6V
DC Output Source/Sink Current (I_O)	±50 mA
DC V_{CC} or Ground Current	
Per Supply Pin	±100 mA
Junction Temperature	+150°C
Storage Temperature	−65°C to +150°C
Lead Temperature (Solder, 4sec)	
64L BGA	220 °C
Thermal Resistance	
BGA θ_{JA}	62°C/W
Package Derating	16.1mW/°C above 25°C
ESD (Min)	2000V

Recommended Operating Conditions

Supply Voltage (V_{CC})	
SCAN16512A	2.7V to 3.6V
Input Voltage (V_I)	0V to 3.6V
Output Voltage (V_O)	0V to 3.6V
Operating Temperature (T_A)	
Industrial	−40°C to +85°C

Note 3: 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)	Industrial		Units	Conditions
			T_A = −40°C to +85°C			
			Min	Max		
V_{IH}	Minimum High Input Voltage	2.7	2.0		V	V_{OUT} = 0.1V or V_{CC} −0.1V
		3.6	2.0			
V_{IL}	Maximum Low Input Voltage	2.7		0.8	V	V_{OUT} = 0.1V or V_{CC} −0.1V
		3.6		0.8		
V_{OH}	Minimum High Output Voltage All Outputs, All Options	2.7	2.5		V	I_{OUT} = −100 µA
		3.6	3.4			
	Minimum High Output Voltage TDO Outputs, All Options	2.7	2.2		V	V_{IN} = V_{IL} or V_{IH}, I_{OH} = −12mA
		3.0	2.2		V	V_{IN} = V_{IL} or V_{IH} I_{OH} = −24mA
	Minimum High Output Voltage A and B Ports: SCAN16512A and SCANH16512A options	2.7	2.2		V	V_{IN} = V_{IL} or V_{IH} I_{OH} = −12mA
		3.0	2.2		V	V_{IN} = V_{IL} or V_{IH} I_{OH} = −24mA
	Minimum High Output Voltage A and B Ports: SCAN162512A and SCANH162512A options (25Ω series resistor options)	2.7	2.2		V	V_{IN} = V_{IL} or V_{IH} I_{OH} = -4mA
		3.0	2.2		V	V_{IN} = V_{IL} or V_{IH} I_{OH} = -12mA

Symbol	Parameter	V_{CC} (V)	Industrial T_A = –40°C to +85°C		Units	Conditions
			Min	Max		
V_{OL}	Maximum Low Output Voltage All Outputs, All Options	2.7		0.2	V	I_{OUT} = 100 µA
		3.6		0.2		
	Maximum Low Output Voltage TDO Outputs, All Options	2.7		0.4	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 12mA
		3.0		0.55	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 24mA
	Maximum Low Output Voltage A and B Ports: SCAN16512A and SCANH16512A Options	2.7		0.4	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 12mA
		3.0		0.55	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 24mA
	Maximum Low Output Voltage A and B Ports: SCAN162512A and SCANH162512A Options (25Ω series resistor options)	2.7		0.4	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 4mA
		3.0		0.6	V	$V_{IN} = V_{IL}$ or V_{IH}, I_{OL} = 12mA
I_{IN}	Maximum Input Leakage Current	3.6		±5.0	µA	$V_I = V_{CC}$, GND
I_{ILR}	Input Low Current	3.6	-20	-250	µA	V_{IN} = GND
I_{OZ}	Maximum I/O Leakage Current	3.6		±10.0	µA	V_I (OE) = V_{IL}, V_{IH} $V_I = V_{CC}$, GND $V_O = V_{CC}$, GND
$I_{I(HOLD)}$	Bus Hold Input Minimum Drive Hold Current (Note 4)	2.7	±35		µA	V_I = 0.8V or 2.0V
		3.6		±500		V_I = 0 to 3.6V
V_{IKL}	Input Clamp Diode Voltage	2.7		-1.5	V	I_{IN} = -18mA
I_{OFF}	Power-off Leakage Current	0.0		±10.0	µA	$V_O = V_{CC}$, GND
I_{CC}	Maximum Quiescent Supply Current	3.6		20	µA	
I_{CCt}	Maximum I_{CC} Per Input	3.6		0.5	mA	$V_I = V_{CC}$–0.6V

Note 4: Applies to devices with Bus Hold feature only.

Noise Specifications

Applies to SCAN16512A and SCANH16512A options, C_L = 30pF, R_L = 500Ω to GND

Symbol	Parameter	V_{CC} (V)	Industrial	Units
			T_A = 25°C	
			Typical Limits	
V_{OLP}	Quiet Output Maximum Dynamic VOL (*Note 5*)	3.3	1.2	V
V_{OLV}	Quiet Output Minimum Dynamic VOL (*Note 5*)	3.3	-1.5	V
V_{OHP}	Quiet Output Maximum Dynamic VOH (*Note 6*)	3.3	VOH + 0.9	V
V_{OHV}	Quiet Output Minimum Dynamic VOH (*Note 6*)	3.3	VOH - 1.5	V

Noise Specifications

Applies to SCAN162512A and SCANH162512A options, C_L = 30pF, R_L = 500Ω to GND

Symbol	Parameter	V_{CC} (V)	Industrial	Units
			T_A = 25°C	
			Typical Limits	
V_{OLP}	Quiet Output Maximum Dynamic VOL (*Note 5*)	3.3	0.5	V
V_{OLV}	Quiet Output Minimum Dynamic VOL (*Note 5*)	3.3	-0.4	V
V_{OHP}	Quiet Output Maximum Dynamic VOH (*Note 6*)	3.3	VOH + 0.5	V
V_{OHV}	Quiet Output Minimum Dynamic VOH (*Note 6*)	3.3	VOH - 0.5	V

Note 5: Maximum number of outputs is defined as n. (n-1) outputs are switched LOW while the quiet output is monitored in a LOW (VOL) state. Also, (n-1) outputs are switched HIGH while the quiet output is monitored in a LOW (VOL) state.

Note 6: Maximum number of outputs is defined as n. (n-1) outputs are switched LOW while the quiet output is monitored in a HIGH (VOH) state. Also, (n-1) outputs are switched HIGH while the quiet output is monitored in a HIGH (VOH) state.

AC Electrical Characteristics

Normal Operation, over recommended operating supply voltage and temperature ranges unless otherwise specified.

Symbol	Parameter	SCAN16512A, SCANH16512A T_A = −40°C to +85°C C_L = 30 pF R_L = 500Ω to GND		Units
		Min	Max	
t_{PLH}, t_{PHL}	Propagation Delay A to B, B to A		5.5 5.5	ns
t_{PLH}, t_{PHL}	Propagation Delay CLKAB to B, CLKBA to A		6.0 6.0	ns
t_{PLH}, t_{PHL}	Propagation Delay LEAB to B, LEBA to A		6.0 6.0	ns
t_{PLZ}, t_{PHZ}	Disable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		7.5 7.5	ns
t_{PZL}, t_{PZH}	Enable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		7.5 7.5	ns

AC Electrical Characteristics

Normal Operation, over recommended operating supply voltage and temperature ranges unless otherwise specified.

Symbol	Parameter	SCAN162512A T_A = −40°C to +85°C C_L = 30 pF R_L = 500Ω to GND		Units
		Min	Max	
t_{PLH}, t_{PHL}	Propagation Delay A to B, B to A		6.0 6.0	ns
t_{PLH}, t_{PHL}	Propagation Delay CLKAB to B, CLKBA to A		6.5 6.5	ns
t_{PLH}, t_{PHL}	Propagation Delay LEAB to B, LEBA to A		6.5 6.5	ns
t_{PLZ}, t_{PHZ}	Disable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		8.0 8.0	ns
t_{PZL}, t_{PZH}	Enable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		8.0 8.0	ns

AC Electrical Characteristics

Normal Operation, over recommended operating supply voltage and temperature ranges unless otherwise specified.

Symbol	Parameter	SCANH162512A		Units
		T_A = −40°C to +85°C C_L = 30 pF R_L = 500Ω to GND		
		Min	Max	
t_{PLH}, t_{PHL}	Propagation Delay A to B, B to A		6.0 6.0	ns
t_{PLH}, t_{PHL}	Propagation Delay CLKAB to B, CLKBA to A		6.5 6.5	ns
t_{PLH}, t_{PHL}	Propagation Delay LEAB to B, LEBA to A		6.5 6.5	ns
t_{PLZ}, t_{PHZ}	Disable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		8.0 8.0	ns
t_{PZL}, t_{PZH}	Enable Time, $\overline{\text{OEAB}}$ to B, $\overline{\text{OEBA}}$ to A		8.0 8.0	ns

AC Operating Requirements

Normal Operation, over recommended operating supply voltage and temperature ranges unless otherwise specified

Symbol	Parameter	All Options	Units
		T_A = −40°C to +85°C C_L = 30 pF, R_L = 500Ω to GND	
		Guaranteed Minimum	
t_S	Setup Time, A to CLKAB or B to CLKBA	1.5	ns
t_H	Hold Time, A to CLKAB or B to CLKBA	2.0	ns
t_S	Setup Time, A to LEAB or B to LEBA	1.5	ns
t_H	Hold Time, A to LEAB or B to LEBA	2.5	ns
t_W	Pulse Width, CLKAB or CLKBA, high or low	2.0	ns
t_W	Pulse Width, LEAB or LEBA high	2.0	ns
f_{max}	Maximum CLKAB or CLKBA Clock Frequency	250	MHz

AC Operating Requirements

can Test Operation, over recommended operating supply voltage and temperature ranges unless otherwise specified

Symbol	Parameter	All Options	Units
		T_A = −40°C to +85°C C_L = 30 pF, R_L = 500Ω to GND	
		Guaranteed Minimum	
t_S	Setup Time, H or L, TMS to TCK	2.0	ns
t_H	Hold Time, H or L, TCK to TMS	1.0	ns
t_S	Setup Time, H or L, TDI to TCK	1.0	ns
t_H	Hold Time, H or L, TCK to TDI	2.0	ns
t_W	Pulse Width TCK High or Low	10	ns
t_W	Pulse Width $\overline{\text{TRST}}$, Low	2.5	ns
f_{max}	Maximum TCK Clock Frequency	25	MHz
t_{REC}	Recovery Time, $\overline{\text{TRST}}$ to TCK	2.0	ns

AC Loading and Waveforms

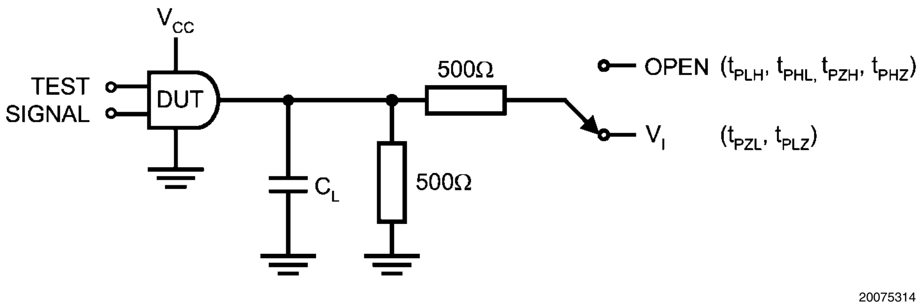
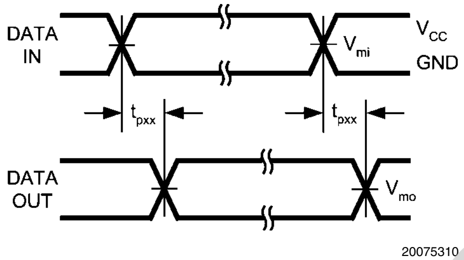
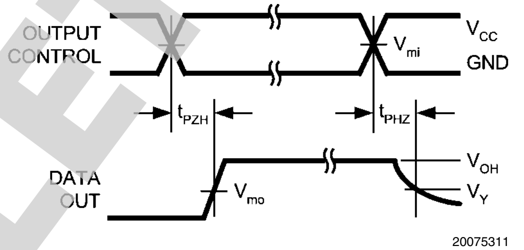


FIGURE 1. AC Test Circuit (C_L includes probe and jig capacitance)

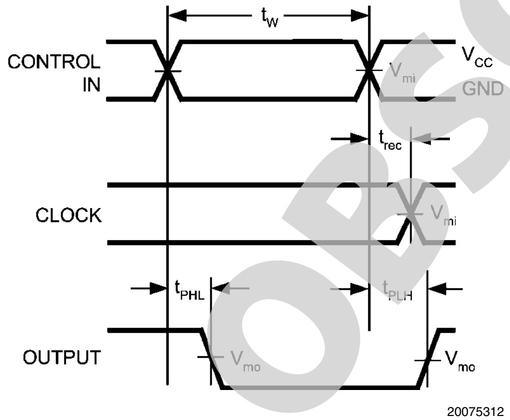
V_I	C_L
V_{CC} * 2	30pF



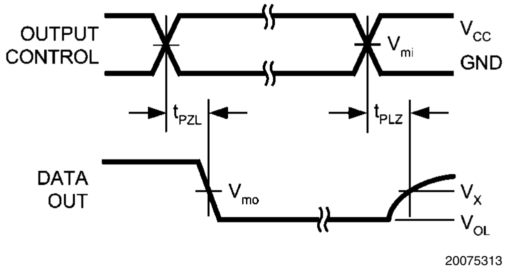
Waveform for Inverting and Non-inverting Functions



Tristate Output High Enable and Disable Times for Logic



Propagation Delay, Pulse Width and t_{REC} Waveforms



Tristate Output Low Enable and Disable Times for Logic

FIGURE 2. Timing Waveforms
(Input Characteristics; f = 1MHz, $t_r = t_f = 2.5$ns)

Symbol	V_{CC}
	2.7 - 3.6V
V_{mi}	1.5V
V_{mo}	1.5V
V_x	V_{OL} + 0.3V
V_y	V_{OH} - 0.3V

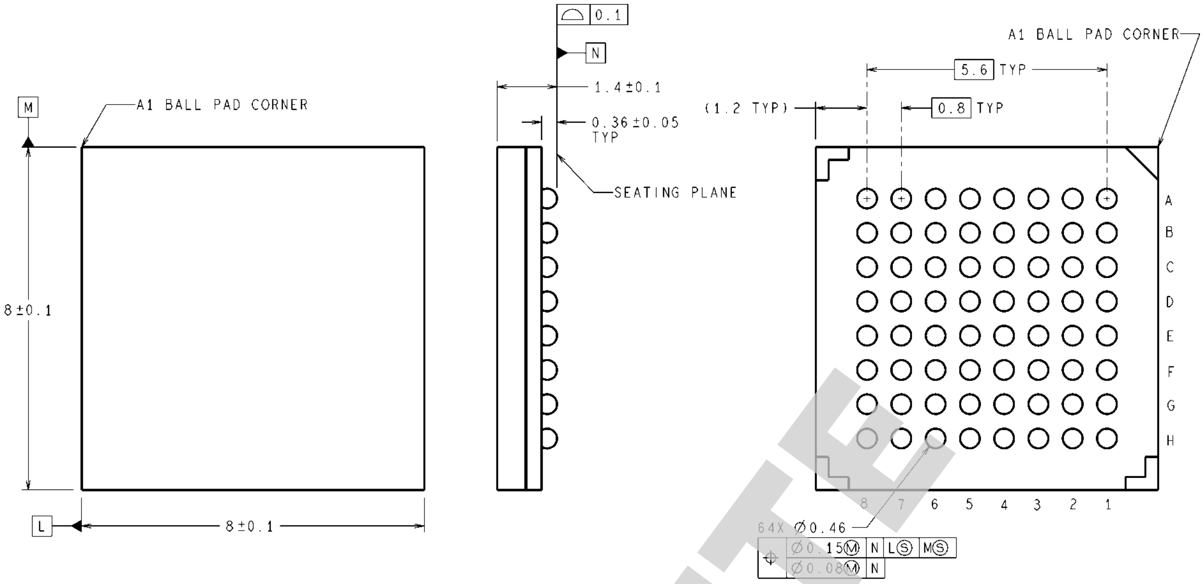
Capacitance and I/O Characteristics

Refer to National's website for IBIS models at http://www.national.com/scan

Device ID Register

Ordering Code	Features	Device ID	Manufacturer & LSB
SCAN16512ASM	No bus hold, no series resistor	FC30	01F
SCANH16512ASM	With bus hold only	FC31	01F
SCAN162512ASM	With 25Ω series resistors in outputs	FC32	01F
SCANH162512ASM	With 25Ω series resistors and bus hold	FC33	01F

Physical Dimensions inches (millimeters) unless otherwise noted



DIMENSIONS ARE IN MILLIMETERS

SLC64A (Rev C)

64-Lead Ball Grid Array Package
Order Number SCAN16512ASM,
SCANH16512ASM, SCAN162512ASM, SCANH162512ASM
NS Package Number SLC64A

Notes

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Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
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