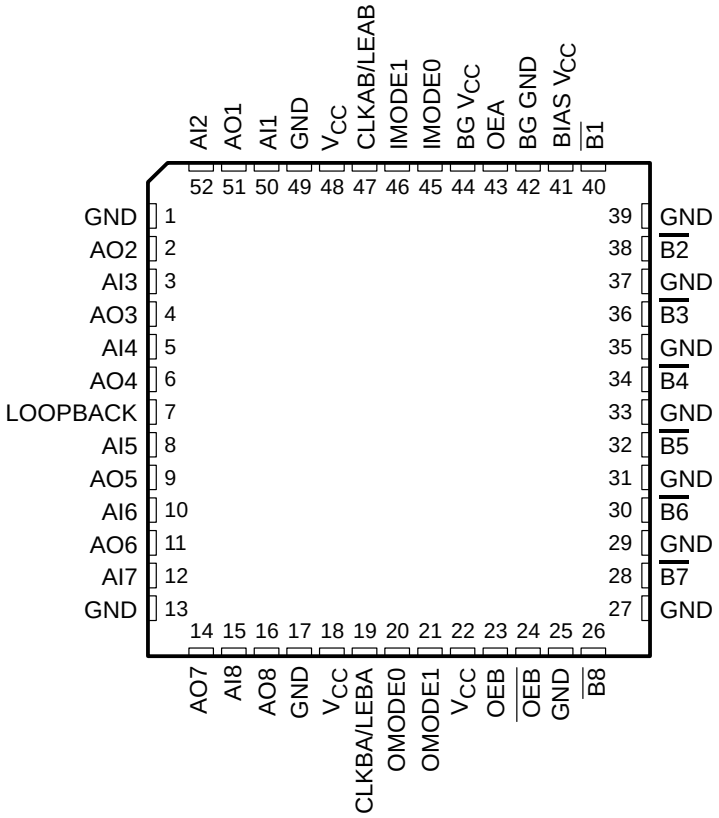
- **Compatible With IEEE Std 1194.1-1991 (BTL)**
- **TTL A Port, Backplane Transceiver Logic (BTL) $\overline{B}$ Port**
- **Open-Collector $\overline{B}$-Port Outputs Sink 100 mA**
- **BIAS V_{CC} Pin Minimizes Signal Distortion During Live Insertion/Withdrawal**
- **High-Impedance State During Power Up and Power Down**
- **$\overline{B}$-Port Biasing Network Preconditions the Connector and PC Trace to the BTL High-Level Voltage**
- **TTL-Input Structures Incorporate Active Clamping Networks to Aid in Line Termination**

RC PACKAGE
(TOP VIEW)



description

The SN74FB2033K is an 8-bit transceiver featuring a split input (AI) and output (AO) bus on the TTL-level A port. The common I/O, open-collector $\overline{B}$ port operates at backplane transceiver logic (BTL) signal levels. The SN74FB2033K is specifically designed to be compatible with IEEE Std 1194.1-1991.

The logic element for data flow in each direction is configured by two mode inputs (IMODE1 and IMODE0 for B-to-A, OMODE1 and OMODE0 for A-to-B) as a buffer, a D-type flip-flop, or a D-type latch. When configured in the buffer mode, the inverted input data appears at the output port. In the flip-flop mode, data is stored on the rising edge of the appropriate clock input (CLKAB/LEAB or CLKBA/LEBA). In the latch mode, the clock inputs serve as active-high transparent latch enables.

description (continued)

Data flow in the B-to-A direction, regardless of the logic element selected, is further controlled by the LOOPBACK input. When LOOPBACK is low, $\overline{B}$-port data is the B-to-A input. When LOOPBACK is high, the output of the selected A-to-B logic element (before inversion) is the B-to-A input.

The AO port-enable/-disable control is provided by OEA. When OEA is low or when V_{CC} is less than 2.5 V, the AO port is in the high-impedance state. When OEA is high, the AO port is active (high or low logic levels).

The $\overline{B}$ port is controlled by OEB and $\overline{OEB}$. If OEB is low, or $\overline{OEB}$ is high, or when V_{CC} is less than 2.5 V, the $\overline{B}$ port is inactive. If OEB is high and $\overline{OEB}$ is low, the $\overline{B}$ port is active.

BG V_{CC} and BG GND are the bias-generator reference inputs.

The A-to-B and B-to-A logic elements are active, regardless of the state of their associated outputs. The logic elements can enter new data (in flip-flop and latch modes) or retain previously stored data while the associated outputs are in the high-impedance (AO port) or inactive ($\overline{B}$ port) states.

Output clamps are provided on the BTL outputs to reduce switching noise. One clamp reduces inductive ringing effects on V_{OH} during a low-to-high transition. The other clamps out ringing below the BTL V_{OL} voltage of 0.75 V. Both of these clamps are active only during ac switching and do not affect the BTL outputs during steady-state conditions.

BIAS V_{CC} establishes a voltage between 1.62 V and 2.1 V on the BTL outputs when V_{CC} is not connected.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	QFP – RC	Tube	SN74FB2033KRC	FB2033K

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

Function Tables

FUNCTION

INPUTS								FUNCTION/MODE
OEA	OEB	$\overline{OEB}$	OMODE1	OMODE0	IMODE1	IMODE0	LOOPBACK	
L	L	X	X	X	X	X	X	Isolation
L	X	H	X	X	X	X	X	
X	H	L	L	L	X	X	X	AI to $\overline{B}$, buffer mode
X	H	L	L	H	X	X	X	AI to $\overline{B}$, flip-flop mode
X	H	L	H	X	X	X	X	AI to $\overline{B}$, latch mode
H	L	X	X	X	L	L	L	$\overline{B}$ to AO, buffer mode
H	X	H	X	X	L	L	L	
H	L	X	X	X	L	H	L	$\overline{B}$ to AO, flip-flop mode
H	X	H	X	X	L	H	L	
H	L	X	X	X	H	X	L	$\overline{B}$ to AO, latch mode
H	X	H	X	X	H	X	L	
H	L	X	X	X	L	L	H	AI to AO, buffer mode
H	X	H	X	X	L	L	H	
H	L	X	X	X	L	H	H	AI to AO, flip-flop mode
H	X	H	X	X	L	H	H	
H	L	X	X	X	H	X	H	AI to AO, latch mode
H	X	H	X	X	H	X	H	
H	H	L	X	X	X	X	L	AI to $\overline{B}$, $\overline{B}$ to AO

ENABLE/DISABLE

INPUTS			OUTPUTS	
OEA	OEB	$\overline{OEB}$	AO	B
L	X	X	Hi Z	
H	X	X	Active	
X	L	L		Inactive (H)
X	L	H		Inactive (H)
X	H	L		Active
X	H	H		Inactive (H)

BUFFER

INPUT	OUTPUT
L	H
H	L

LATCH

INPUTS		OUTPUT
CLK/LE	DATA	
H	L	H
H	H	L
L	X	Q_0

Function Tables (Continued)

LOOPBACK

LOOPBACK	Q†
L	$\overline{B}$ port
H	Point P‡

† Q is the input to the B-to-A logic element.
‡ P is the output of the A-to-B logic element (see functional block diagram).

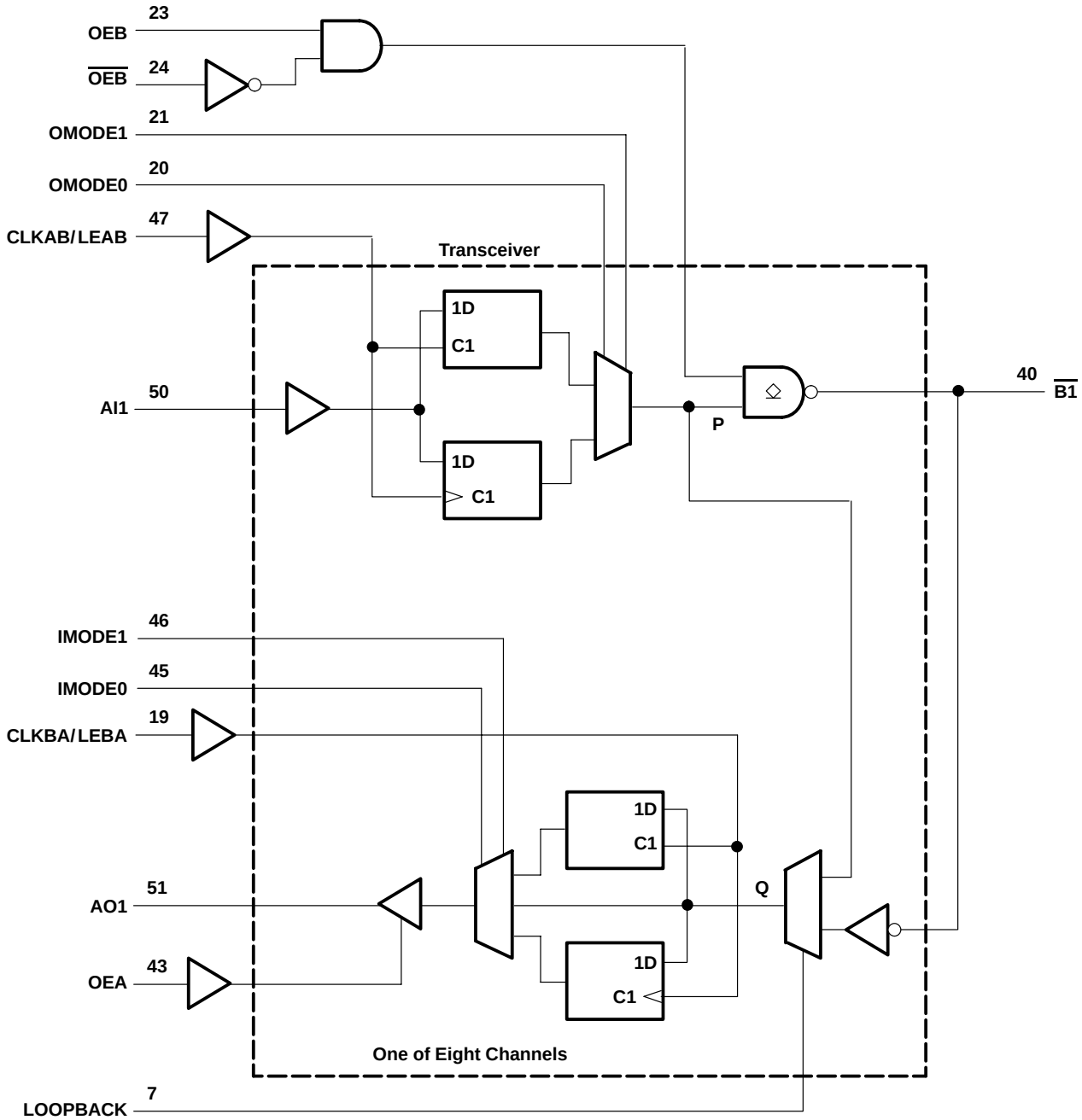
SELECT

INPUTS		SELECTED-LOGIC ELEMENT
MODE1	MODE0	
L	L	Buffer
L	H	Flip-flop
H	X	Latch

FLIP-FLOP

INPUTS		OUTPUT
CLK/LE	DATA	
L	X	Q_0
↑	L	H
↑	H	L

functional block diagram



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

Supply voltage range, V_{CC} . . . . . –0.5 V to 7 V
Voltage range applied to any B output in the disabled or power-off state, V_O . . . . . –0.5 V to 3.5 V
Voltage range applied to any output in the high state, V_O: A port . . . . . –0.5 V to V_{CC}
Input voltage range, V_I: Except $\overline{B}$ port . . . . . –1.2 V to 7 V
$\overline{B}$ port . . . . . –1.2 V to 3.5 V
Input clamp current, I_{IK}: Except $\overline{B}$ port . . . . . –40 mA
$\overline{B}$ port . . . . . –18 mA
Current applied to any single output in the low state, I_O: A port . . . . . 48 mA
$\overline{B}$ port . . . . . 200 mA
Package thermal impedance, θ_{JA} (see Note 1) . . . . . 44°C/W
Storage temperature range, T_{stg} . . . . . –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.

NOTE 1: The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 2)

			MIN	NOM	MAX	UNIT
V_{CC}, BG V_{CC}	Supply voltage		4.75	5	5.25	V
BIAS V_{CC}	Supply voltage		4.5	5	5.5	V
V_{IH}	High-level input voltage	$\overline{B}$ port	1.62		2.3	V
		Except $\overline{B}$ port	2			
V_{IL}	Low-level input voltage	$\overline{B}$ port	0.75		1.47	V
		Except $\overline{B}$ port			0.8	
I_{OH}	High-level output current	AO port			–3	mA
I_{OL}	Low-level output current	AO port			24	mA
		$\overline{B}$ port			100	
$\Delta t/\Delta v$	Input transition rise or fall rate	Except $\overline{B}$ port			10	ns/V
T_A	Operating free-air temperature		0		70	°C

NOTE 2: To ensure proper device operation, all unused inputs must be terminated as follows: A and control inputs to V_{CC}(5 V) or GND, and B inputs to GND only. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

electrical characteristics over recommended operating free-air temperature range

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{IK}	$\overline{B}$ port	V_{CC} = 4.75 V,	I_I = –18 mA			–1.2	V
	Except $\overline{B}$ port	V_{CC} = 4.75 V,	I_I = –40 mA			–0.5	
V_{OH}	AO port	V_{CC} = 4.75 V to 5.25 V,	I_{OH} = –10 µA			V_{CC}–1.1	V
		V_{CC} = 4.75 V	I_{OH} = –3 mA	2.5	2.85	3.4	
			I_{OH} = –32 mA	2			
V_{OL}	AO port	V_{CC} = 4.75 V	I_{OL} = 20 mA		0.33	0.5	V
			I_{OL} = 55 mA			0.8	
	$\overline{B}$ port	V_{CC} = 4.75 V	I_{OL} = 100 mA	0.75		1.1	
			I_{OL} = 4 mA	0.5			
I_I	Except $\overline{B}$ port	V_{CC} = 0,	V_I = 5.25 V			100	µA
I_{IH}	Except $\overline{B}$ port	V_{CC} = 5.25 V,	V_I = 2.7 V			50	µA
	$\overline{B}$ port‡	V_{CC} = 0 to 5.25 V,	V_I = 2.1 V			100	
I_{IL}	Except $\overline{B}$ port	V_{CC} = 5.25 V,	V_I = 0.5 V			–50	µA
	$\overline{B}$ port‡	V_{CC} = 5.25 V,	V_I = 0.75 V			–100	
I_{OH}	$\overline{B}$ port	V_{CC} = 0 to 5.25 V,	V_O = 2.1 V			100	µA
I_{OZH}	AO port	V_{CC} = 2.1 V to 5.25 V,	V_O = 2.7 V			50	µA
I_{OZL}	AO port	V_{CC} = 2.1 V to 5.25 V,	V_O = 0.5 V			–50	µA
I_{OZPU}	A port	V_{CC} = 0 to 2.1 V,	V_O = 0.5 V to 2.7 V			50	µA
I_{OZPD}	A port	V_{CC} = 2.1 V to 0,	V_O = 0.5 V to 2.7 V			–50	µA
I_{OS}§	AO port	V_{CC} = 5.25 V,	V_O = 0	–40	–80	–150	mA
I_{CC}	All outputs on	V_{CC} = 5.25 V,	I_O = 0		45	70	mA
C_i	AI port and control inputs	V_I = 0.5 V or 2.5 V			5		pF
C_o	AO port	V_O = 0.5 V or 2.5 V			5		pF
C_{io}	$\overline{B}$ port per IEEE Std 1194.1-1991	V_{CC} = 0 to 4.75 V				6	pF
		V_{CC} = 4.75 V to 5.25 V				6	

† All typical values are at V_{CC} = 5 V, TA = 25°C
‡ For I/O ports, the parameters I_{IH} and I_{IL} include the off-state output current.
§ Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second.

live-insertion characteristics over recommended operating free-air temperature range (see Note 3)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
I_{CC} (BIAS V_{CC})		V_{CC} = 0 to 4.75 V,	V_B = 0 to 2 V,	BIAS V_{CC} = 4.5 V to 5.5 V		1.2	mA
		V_{CC} = 4.75 V to 5.25 V,	V_B = 0 to 2 V,	BIAS V_{CC} = 4.5 V to 5.5 V		10	µA
V_O	$\overline{B}$ port	V_{CC} = 0,	BIAS V_{CC} = 5 V		1.62	2.1	V
I_O	$\overline{B}$ port	V_{CC} = 0,	V_B = 1 V,	V_I (BIAS V_{CC}) = 4.75 V to 5.25 V	–1		µA
		V_{CC} = 0 to 5.25 V,	OEB = 0 to 0.8 V			100	
		V_{CC} = 0 to 2.2 V,	OEB = 0 to 5 V			100	

NOTE 3: Power-up sequence is GND, BIAS V_{CC}, V_{CC}.

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

		V_{CC} = 5 V, T_A = 25°C		MIN	MAX	UNIT
		MIN	MAX			
f_{clock}	Clock frequency	0	150	0	150	MHz
t_w	Pulse duration, CLKAB/LEAB or CLKBA/LEBA	3.3		3.3		ns
t_{su}	Setup time, data before CLKAB/LEAB or CLKBA/LEBA↑	2.7		2.7		ns
t_h	Hold time, data after CLKAB/LEAB or CLKBA/LEBA↑	0.7		0.7		ns

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

PARAMETER		FROM (INPUT)	TO (OUTPUT)	V_{CC} = 5 V, T_A = 25°C			MIN	MAX	UNIT
				MIN	TYP	MAX			
f_{max}				150			150		MHz
t_{PLH}		AI (through mode)	$\overline{B}$	2.8	5.1	6.8	2.8	8.1	ns
t_{PHL}				2.5	4.2	5.7	2.5	6.1	
t_{PLH}		$\overline{B}$ (through mode)	AO	3.1	4.3	5.1	2.2	6.6	ns
t_{PHL}				3.1	4.2	5.1	2.6	6	
t_{PLH}		AI (transparent)	$\overline{B}$	2.8	5.1	6.8	2.8	8.1	ns
t_{PHL}				2.6	4.2	5.7	2.6	6.1	
t_{PLH}		$\overline{B}$ (transparent)	AO	2.2	4.3	6	2.2	6.6	ns
t_{PHL}				2.5	4.2	5.6	2.5	6	
t_{PLH}		OEB	$\overline{B}$	2.7	5.1	6.8	2.7	8.3	ns
t_{PHL}				2.4	4.2	5.7	2.4	6.1	
t_{PLH}		$\overline{OEB}$	$\overline{B}$	2.5	4.8	6.4	2.5	7.7	ns
t_{PHL}				2.5	4.3	5.9	2.5	6.4	
t_{PZH}		OEA	AO	1.6	3.6	5.1	1.6	5.6	ns
t_{PZL}				2.3	4.3	5.7	2.3	6	
t_{PHZ}		OEA	AO	1.7	4	5.5	1.7	5.9	ns
t_{PLZ}				1.2	2.9	4.4	1.2	4.7	
t_{PLH}		CLKAB/LEAB	$\overline{B}$	5.2	6.5	7.8	3.7	9.9	ns
t_{PHL}				3.8	5.4	7.1	3.4	7.7	
t_{PLH}		CLKBA/LEBA	AO	1.7	3.8	5.5	1.7	5.9	ns
t_{PHL}				1.8	3.6	5.1	1.8	5.5	
t_{PLH}		OMODE	$\overline{B}$	2.9	6.6	8.4	2.9	10	ns
t_{PHL}				3	5.7	7.5	3	8.3	
t_{PLH}		IMODE	AO	1.4	4.1	5.8	1.4	6.4	ns
t_{PHL}				1.9	4.2	5.7	1.9	5.9	
t_{PLH}		LOOPBACK	AO	2	5.2	7.3	2	8.2	ns
t_{PHL}				2.6	4.8	6.3	2.6	6.4	
t_{PLH}		AI	AO	1.7	3.9	5.6	1.7	6.1	ns
t_{PHL}				2.2	4.3	5.7	2.2	5.9	
t_r	Rise time, 1.3 V to 1.8 V, $\overline{B}$ port			1.8	2.5	3.8	1.7	4	ns
t_f	Fall time, 1.8 V to 1.3 V, $\overline{B}$ port			1.7	2.5	3.8	1.5	4	
t_r	Rise time, 10% to 90%, AO			2.5	3.4	4.8	2	5	ns
t_f	Fall time, 90% to 10%, AO			1.5	2.5	3.8	1	5	
$\overline{B}$-port input pulse rejection							1		ns

output-voltage characteristics

PARAMETER			TEST CONDITIONS	MIN	MAX	UNIT
V_{OHP}	Peak output voltage during turnoff of 100 mA into 40 nH	$\overline{B}$ port	See Figure 1		3	V
V_{OHV}	Minimum output voltage during turnoff of 100 mA into 40 nH	$\overline{B}$ port	See Figure 1	1.62		V
V_{OLV}	Minimum output voltage during high-to-low switch	$\overline{B}$ port	I_{OL} = –50 mA	0.3		V

PARAMETER MEASUREMENT INFORMATION

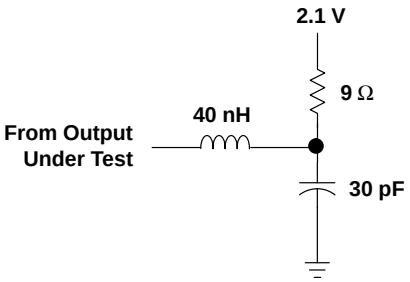
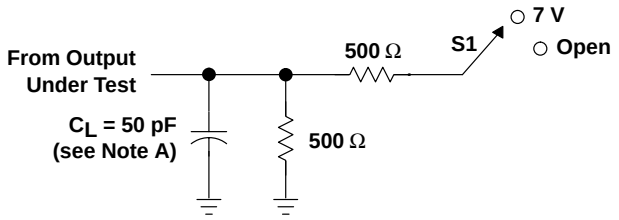
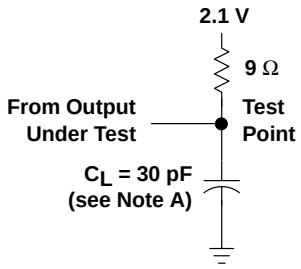


Figure 1. Load Circuit for V_{OHP} and V_{OHV}

PARAMETER MEASUREMENT INFORMATION

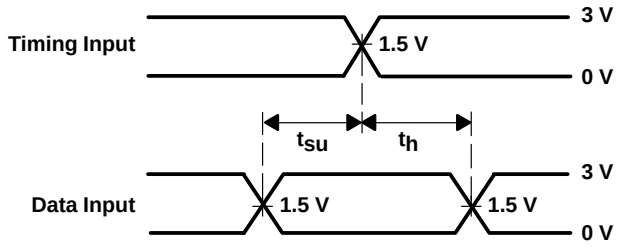


LOAD CIRCUIT FOR A OUTPUTS

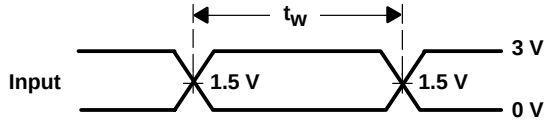


LOAD CIRCUIT FOR B OUTPUTS

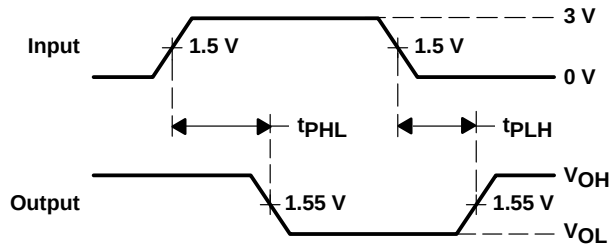
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	7 V
t_{PHZ}/t_{PZH}	Open



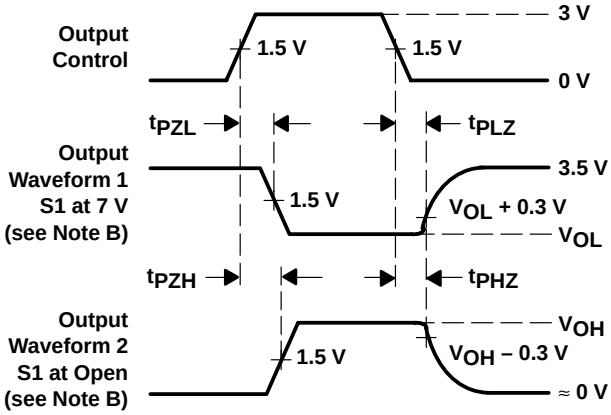
VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



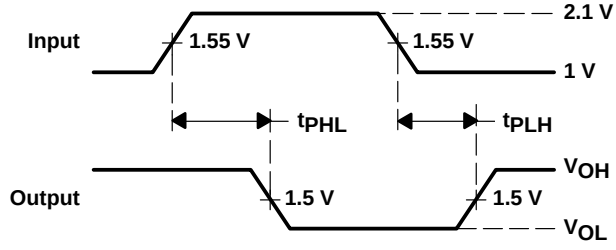
VOLTAGE WAVEFORMS
PULSE DURATION



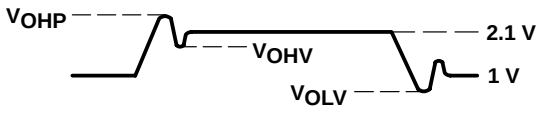
VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES (A TO B)



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES (A PORT)



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES (B TO A)



VOLTAGE WAVEFORMS

NOTES: A. C_L includes probe and jig capacitance.
B. 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.
C. All input pulses are supplied by generators having the following characteristics: TTL inputs: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns; BTL inputs: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
D. The outputs are measured one at a time with one transition per measurement.

Figure 2. Load Circuit and Voltage Waveforms

PACKAGING INFORMATION

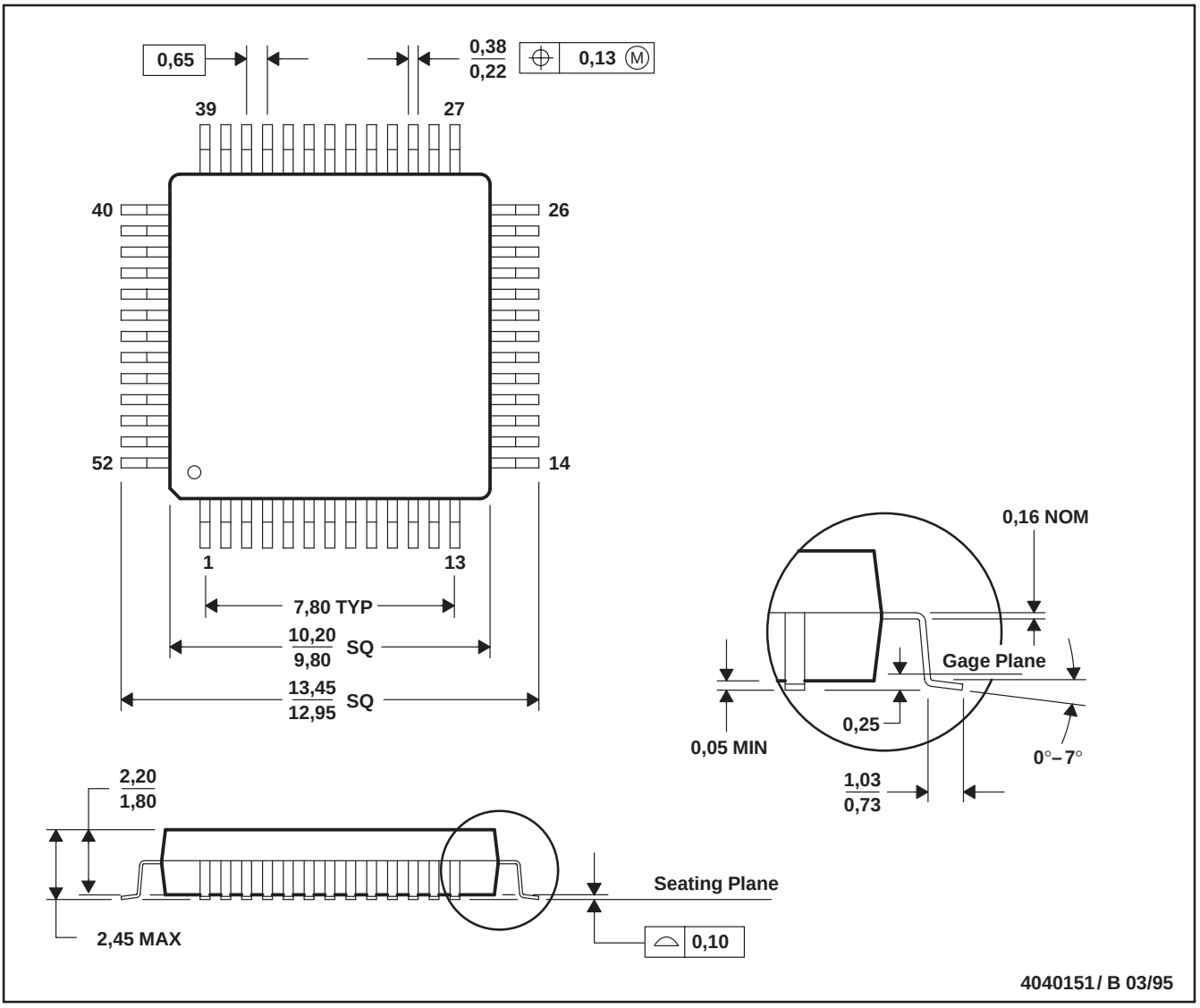
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
SN74FB2033KRC	ACTIVE	QFP	RC	52	96	TBD	CU SNPB	Level-2-240C-1 YEAR	Purchase Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

RC (S-PQFP-G52) **PLASTIC QUAD FLATPACK**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-022

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