

TCUA231WBG

1. Functional Description

- USB 2.0 High-Speed, UART, and Audio Switch with Negative Signal Capability

2. General

The TCUA231WBG is a dual SP3T switch for combined USB 2.0 High-Speed , audio and UART signals.

The audio switch is designed to allow audio signals to swing below ground.

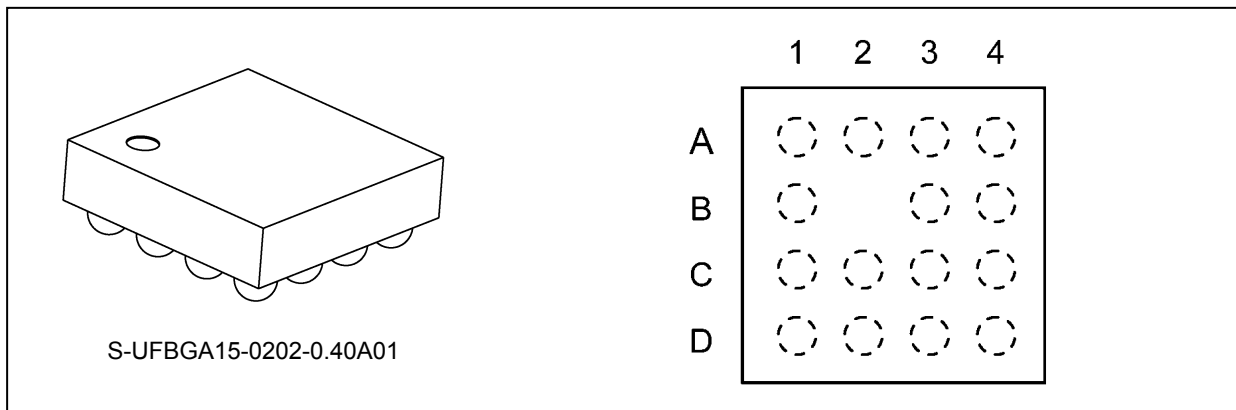
When V_{BUS} is High, the USB switches (D+ and D-) are selected, regardless of the logic levels of the Head and Man inputs. When V_{BUS} is Low or left open and Head is Low, the Audio switches (R and L) are selected. When V_{BUS} is Low or left open, Head is High and Man is Low, the UART switches (TX and RX) are selected.

All the inputs are protected against electrostatic discharge.

3. Features

- (1) Supply voltage: $V_{CC} = 2.3$ to 3.6 V
- (2) Switch terminal ON-capacitance (D+, D-): $C_{I/O} = 8$ pF Switch ON (typ.) @ $V_{CC} = 3.3$ V
- (3) ON-resistance (D+, D-): $R_{ON} = 6.5 \Omega$ (typ.) @ $V_{CC} = 3$ V, $V_{IS} = 0$ V
- (4) ON-resistance (R, L): $R_{ON} = 5.5 \Omega$ (typ.) @ $V_{CC} = 3$ V, $V_{IS} = 0$ V
- (5) ON-resistance flatness (R, L): $R_{ON(flat)} = 2 \Omega$ (typ.) @ $V_{CC} = 3$ V
- (6) ESD performance: Machine model $\geq \pm 200$ V, Human body model $\geq \pm 2000$ V
- (7) Package: WCSP15 (1.6 mm \times 1.6 mm)

4. Packaging and Pin Assignment (Top View)



4.1. Pin Assignment

	1	2	3	4
A	COM+	XSTDT	R	L
B	COM-	No Ball	V_{CC}	D+
C	V_{BUS}	GND	GND	D-
D	Head	Man	TX	RX

5. Marking

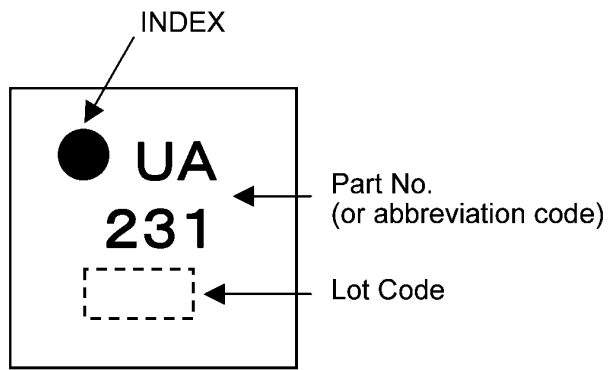


Fig. 5.1 Marking

6. Block Diagram

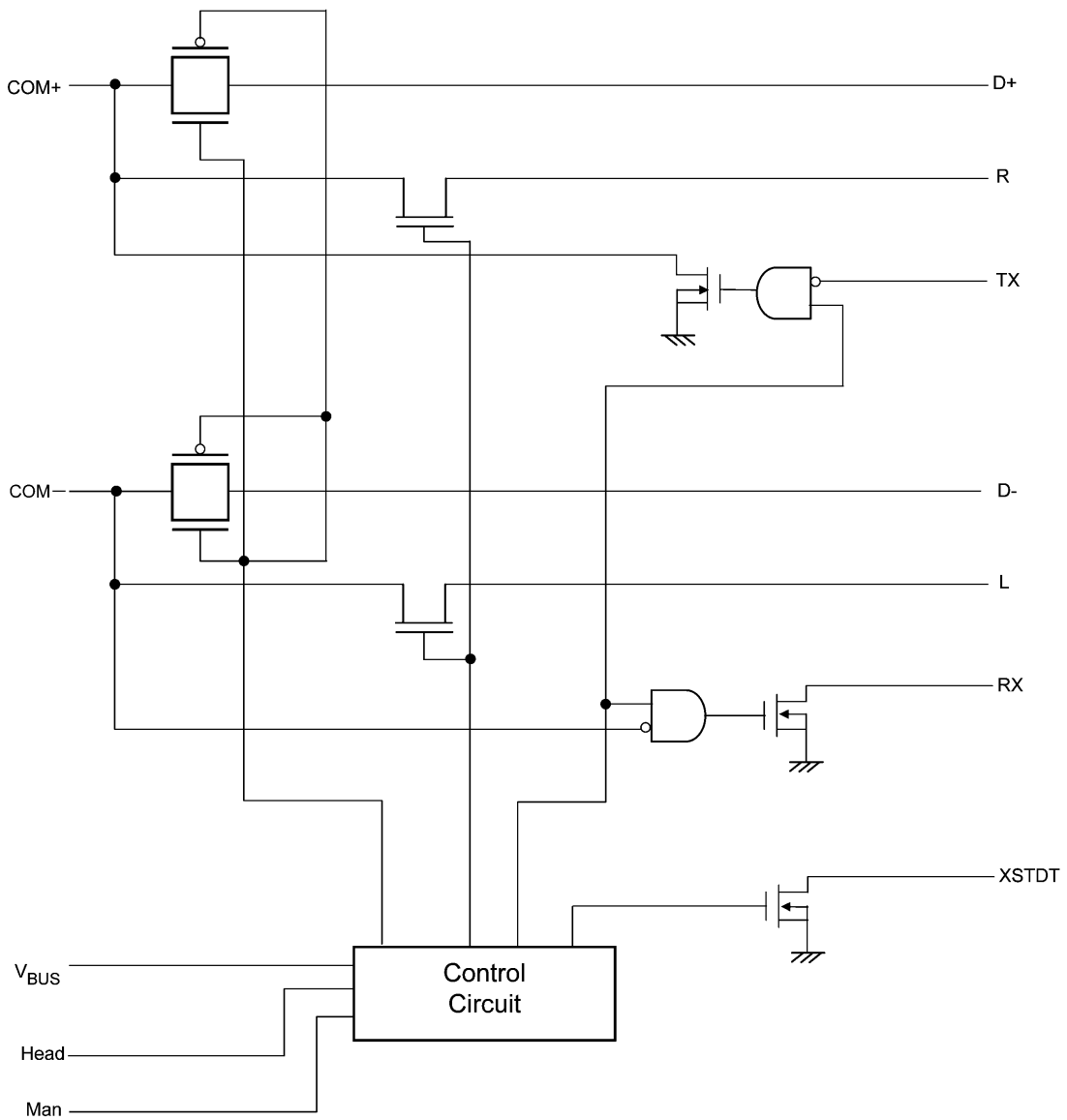


Fig. 6.1 Block Diagram

7. Principle of Operation

7.1. Truth Table

Input Head	Input Man	Input V _{BUS}	Output XSTDT	Switch D+/D-	Switch R/L	Switch TX/RX
L or H	L or H	5 V	Z	ON	OFF	Z
L	L or H	L	L	OFF	ON	Z
L	L or H	Open	Z	OFF	ON	Z
H	L	L or Open	Z	OFF	OFF	ON
H	H	L or Open	Z	OFF	OFF	Z

8. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Pin Name	Note	Test Condition	Rating	Unit
Supply voltage	V _{CC}			—	-0.5 to 4.6	V
Input voltage	V _{IN}	Head, Man		—	-0.5 to 4.6	
		V _{BUS}			-0.5 to 6.0	
Switch I/O voltage	V _S	D+, D-		Switch ON	-0.5 to V _{CC} +0.5	
		R, L		Switch ON -0.5 ≤ V _{CC} - V _S ≤ 6	-2.0 to V _{CC} +0.5	
		TX, RX		Switch ON	-0.5 to V _{CC} +0.5	
		COM+, COM-		Switch ON -0.5 ≤ V _{CC} - V _S ≤ 6	-2.0 to V _{CC} +0.5	
Switch I/O voltage	V _S	D+, D-		Switch OFF or V _{CC} = 0 V	-0.5 to 4.6	
		R, L			-0.5 to 4.6	
		TX, RX			-0.5 to 4.6	
		COM+, COM-			-2.0 to 4.0	
Switch I/O current	I _S			—	50	mA
Power dissipation	P _D			—	180	mW
V _{CC} /ground current	I _{CC} /I _{GND}			—	±100	mA
Storage temperature	T _{stg}			—	-65 to 150	°C

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

9. Operating Ranges (Note)

Characteristics	Symbol	Pin Name	Note	Test Condition	Rating	Unit
Supply voltage	V_{CC}			—	2.3 to 3.6	V
Input voltage	V_{IN}	Head, Man		—	0 to 3.6	
		V_{BUS}			0 to 5.5	
Switch I/O voltage	V_S	D+, D-		Switch ON	0 to V_{CC}	
		R, L			-1.5 to V_{CC}	
		TX, RX			0 to V_{CC}	
		COM+, COM-			-1.5 to V_{CC}	
Switch I/O voltage	V_S	D+, D-		Switch OFF or $V_{CC} = 0\text{ V}$	0 to 3.6	
		R, L			0 to 3.6	
		TX, RX			0 to 3.6	
		COM+, COM-			-1.5 to 3.6	
Operating temperature	T_{opr}			—	-40 to 85	°C
Input rise time	dt/dv			—	0 to 10	ns/V
Input fall time			0 to 10			

Note: The operating ranges must be maintained to ensure the normal operation of the device.
 Unused inputs and bus inputs must be tied to either V_{CC} or GND.

10. Electrical Characteristics

10.1. DC Characteristics (Unless otherwise specified, $T_a = -40$ to 85°C)

Characteristics	Symbol	Pin Name	Note	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
High-level input voltage	V_{IH}	V_{BUS}		—	2.3 to 3.6	$V_{CC} + 0.6$	—	—	V
Low-level input voltage	V_{IL}	V_{BUS}		—	2.3 to 3.6	—	—	$V_{CC} - 0.5$	
High-level input voltage	V_{IH}	Head, Man		—	2.3 to 2.5	$0.50 \times V_{CC}$	—	—	
					2.7 to 3.0	$0.45 \times V_{CC}$	—	—	
					3.3 to 3.6	$0.40 \times V_{CC}$	—	—	
Low-level input voltage	V_{IL}	Head, Man		—	2.3 to 3.6	—	—	$0.15 \times V_{CC}$	
High-level input voltage	V_{IH}	COM-, TX		Head = V_{CC} , Man = 0 V	2.3 to 2.5	$0.70 \times V_{CC}$	—	—	
					2.7 to 3.0	$0.65 \times V_{CC}$	—	—	
					3.3 to 3.6	$0.60 \times V_{CC}$	—	—	
Low-level input voltage	V_{IL}	COM-, TX		Head = V_{CC} , Man = 0 V	2.3 to 3.6	—	—	$0.20 \times V_{CC}$	
Input leakage current	I_{IN}	V_{BUS}		$V_{IN} = 0$ to 5.5 V	2.3 to 3.6	—	—	± 10	μA
		Head, Man		$V_{IN} = 0$ to 3.6 V	2.3 to 3.6	—	—	± 1	
Power-OFF leakage current	I_{OFF}	D+, D-, R, L, TX, RX		$V_{IS} = 0$ to 3.6 V	0	—	—	± 10	
		COM+, COM-		$V_{IS} = -1.5$ to 3.6 V	0	—	—	± 10	
Switch OFF-state leakage current	I_{SZ}	D+, D-, R, L, TX, RX		$V_{IS} = 0$ V to V_{CC} , Switch OFF	2.3 to 3.6	—	—	± 10	
		COM+, COM-		$V_{IS} = -1.5$ V to V_{CC} , switch OFF	2.3 to 3.6	—	—	± 10	
ON-resistance	R_{ON}	D+, D-	(Note 1)	$V_{BUS} = 4.25$ V, $V_{IS} = 0$ V, $I_{IS} = 30$ mA	3.0	—	6.5	10	
				$V_{BUS} = 4.25$ V, $V_{IS} = 1.0$ V, $I_{IS} = 30$ mA	3.0	—	7.5	12	
				$V_{BUS} = 4.25$ V, $V_{IS} = 3.0$ V, $I_{IS} = 30$ mA	3.0	—	22	40	
		R, L		$V_{IS} = -1.0$ V, $I_{IS} = 30$ mA	3.0	—	5.0	8	
				$V_{IS} = 0$ V, $I_{IS} = 30$ mA	3.0	—	5.5	9	
				$V_{IS} = 1.0$ V, $I_{IS} = 30$ mA	3.0	—	7.0	11	
ON-resistance flatness	$R_{ON(\text{flat})}$	R, L	(Note 1)	$V_{IS} = -1.0$ to 1.0 V, $I_{IS} = 30$ mA	3.0	—	2.0	—	
Low-level output voltage	V_{OL}	COM+, RX		Head = V_{CC} , Man = 0 V, $I_{OL} = 50$ μA	3.0	—	—	0.1	
				Head = V_{CC} , Man = 0 V, $I_{OL} = 4$ mA	3.0	—	—	0.44	
		XSTDT		Head = 0 V, $V_{BUS} = 0$ V, $I_{OL} = 50$ μA	3.0	—	—	0.1	
				Head = 0 V, $V_{BUS} = 0$ V, $I_{OL} = 1$ mA	3.0	—	—	0.44	
Quiescent supply current	I_{CC}			$V_{IN} = V_{CC}$ or GND, $I_{OUT} = 0$ A	3.6	—	—	2	
				ΔI_{CC}	$V_{IN} = 1.8$ V (one input)	3.6	—	—	40
								2.7	—

Note 1: All typical values are at $T_a = 25^\circ\text{C}$.

10.2. AC Characteristics (Unless otherwise specified, $T_a = -40$ to 85°C)

Characteristics	Symbol	Pin Name	Note	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
Propagation delay time	t_{PLH}/t_{PHL}		(Note 1)	$C_L = 5$ pF, See Fig. 11.1	3.3 ± 0.3	—	0.25	—	ns
Turn-ON time	t_{on}	Control to Output		$R_L = 50 \Omega$, $C_L = 5$ pF, See Fig. 11.2		—	—	1	μs
Turn-OFF time	t_{off}			$R_L = 50 \Omega$, $C_L = 5$ pF, See Fig. 11.2		—	—	1	
Break before Make	TBBM			$R_L = 50 \Omega$, $C_L = 5$ pF, See Fig. 11.3		2.0	—	15	ns

Note 1: Parameter guaranteed by design.

10.3. Analog Switch (Note) (Unless otherwise specified, $T_a = -40$ to 85°C)

Characteristics	Symbol	Pin Name	Note	Test Condition	V_{CC} (V)	Min	Typ.	Max	Unit
OFF isolation (non-adjacent)	OIRR	D+, D-		$R_T = 50 \Omega$, $f = 240$ MHz, See Fig. 11.4	3.3 ± 0.3	—	-27	—	dB
		R, L		$R_T = 50 \Omega$, $f = 20$ kHz, See Fig. 11.4		—	-72	—	
Crosstalk (non-adjacent)	X_{talk}	D+, D-		$R_T = 50 \Omega$, $f = 240$ MHz, See Fig. 11.5		—	-36	—	dB
		R, L		$R_T = 50 \Omega$, $f = 20$ kHz, See Fig. 11.5		—	-84	—	
-3dB Bandwidth	BW	D+, D-		$R_T = 50 \Omega$, $C_L = 0$ pF, See Fig. 11.6	—	720	—	MHz	
Total harmonic distortion	THD	R, L		$V_{IN} = 2 V_{p-p}$, $R_L = 1$ k Ω , $f = 1$ kHz	—	0.1	—	%	

Note: Parameter guaranteed by design.

10.4. Capacitive Characteristics (Unless otherwise specified, $T_a = 25^\circ\text{C}$)

Characteristics	Symbol	Pin Name	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}	V_{BUS}	(Note 1)	$V_{IN} = 0$ V	3.3	20	pF
		Head, Man				5	
Switch terminal OFF-capacitance	$C_{I/O}$	D+, D-		$V_{I/O} = 0$ V, $V_{BUS} = \text{GND}$ or Open		3	
		R, L		$V_{I/O} = 0$ V, Head = V_{CC}		3.5	
		TX, RX		$V_{I/O} = 0$ V, Man = V_{CC}		5	
		COM+, COM-		$V_{I/O} = 0$ V, $V_{BUS} = \text{GND}$ or Open, Head = V_{CC} , Man = V_{CC}		4.5	
Switch terminal ON-capacitance	$C_{I/O}$	D+, D-		$V_{I/O} = 0$ V, $V_{BUS} = 4.25$ V		8	
		R, L		$V_{I/O} = 0$ V, $V_{BUS} = \text{GND}$ or Open, Head = GND		8.5	
		TX, RX		$V_{I/O} = 0$ V, $V_{BUS} = \text{GND}$ or Open, Head = V_{CC} , Man = GND		7.5	

Note 1: Parameter guaranteed by design.

11. AC Test Circuits and Waveforms

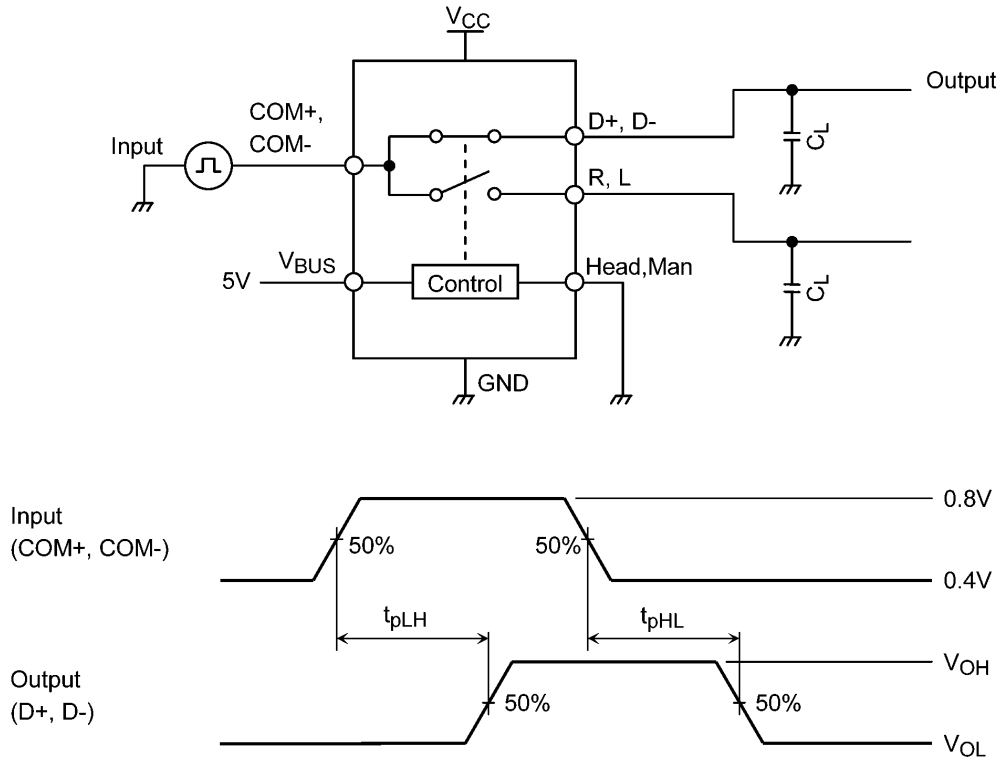


Fig. 11.1 Propagation Delay Time (t_{pLH} , t_{pHL})

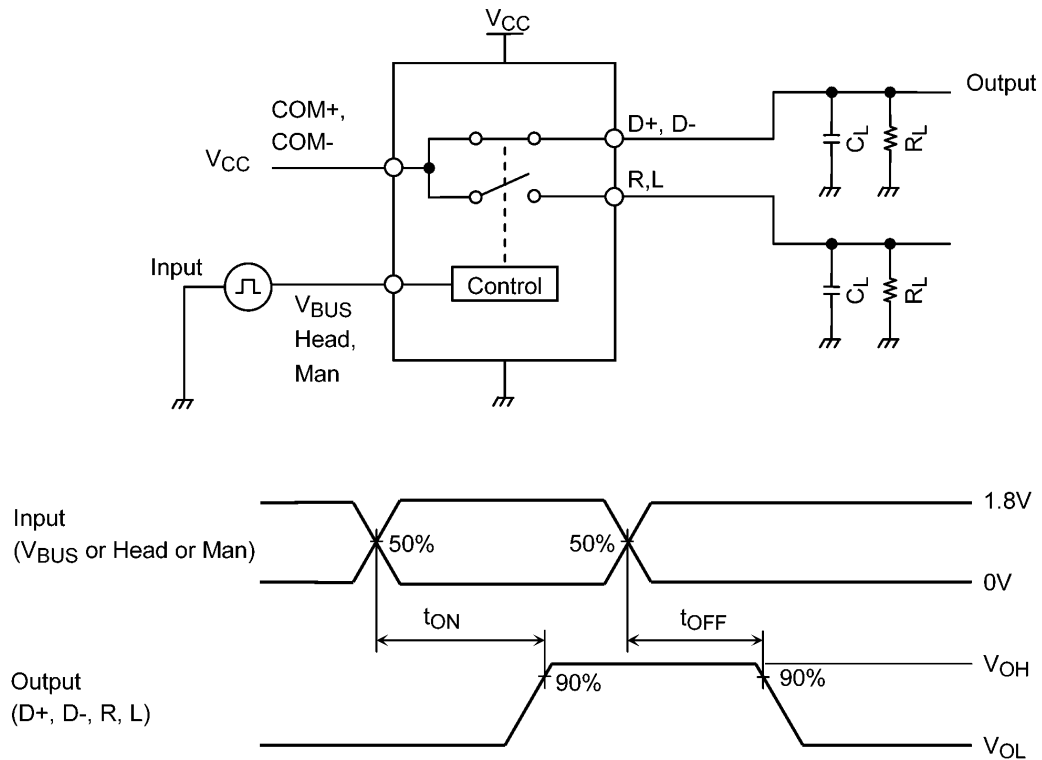


Fig. 11.2 Turn-ON and Turn-OFF Times (t_{ON} , t_{OFF})

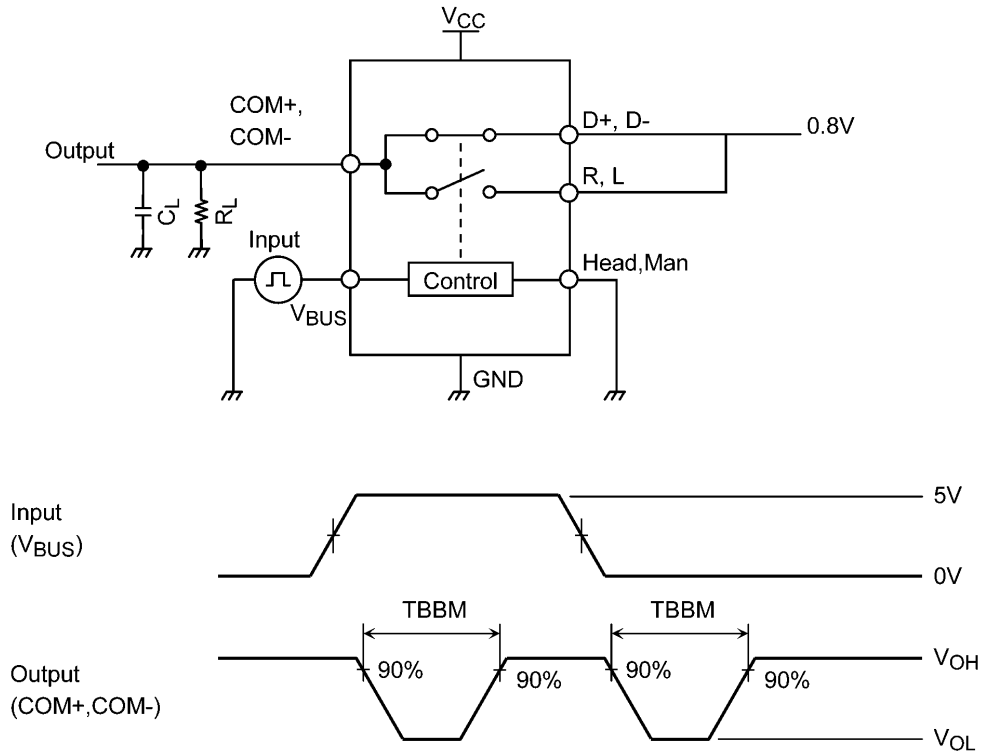


Fig. 11.3 Break Before Make (TBBM)

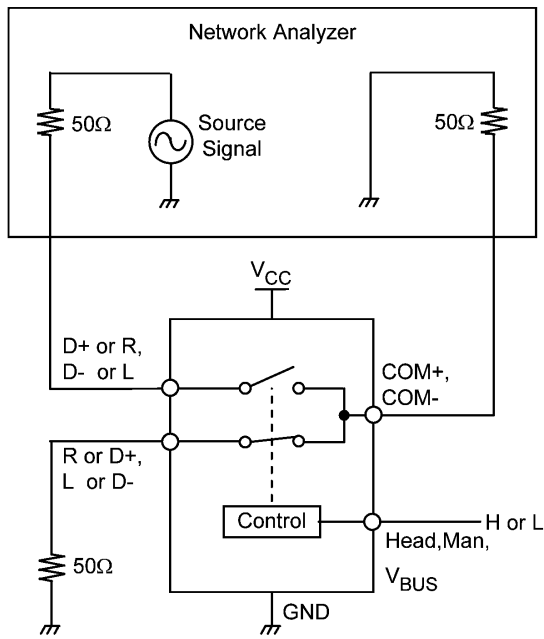


Fig. 11.4 OFF Isolation

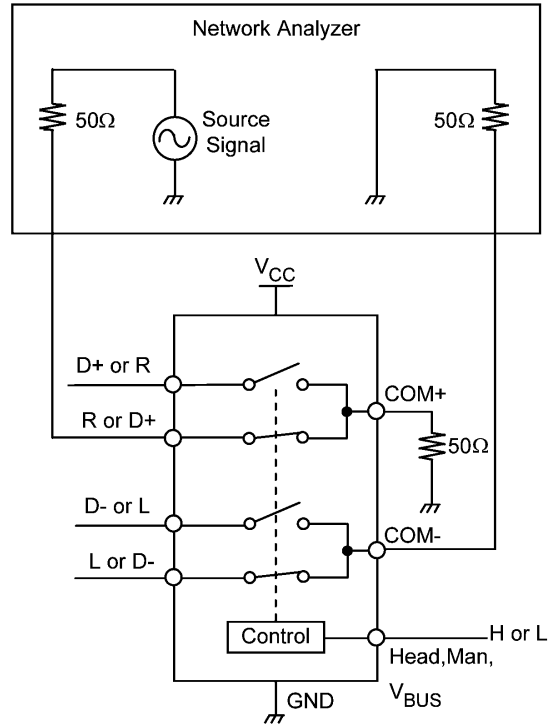


Fig. 11.5 Crosstalk

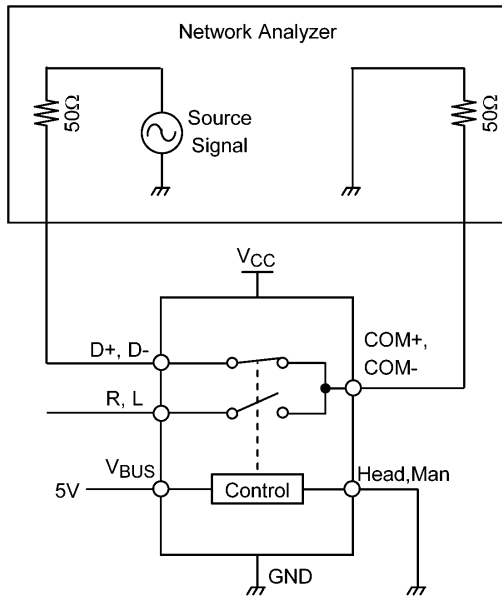
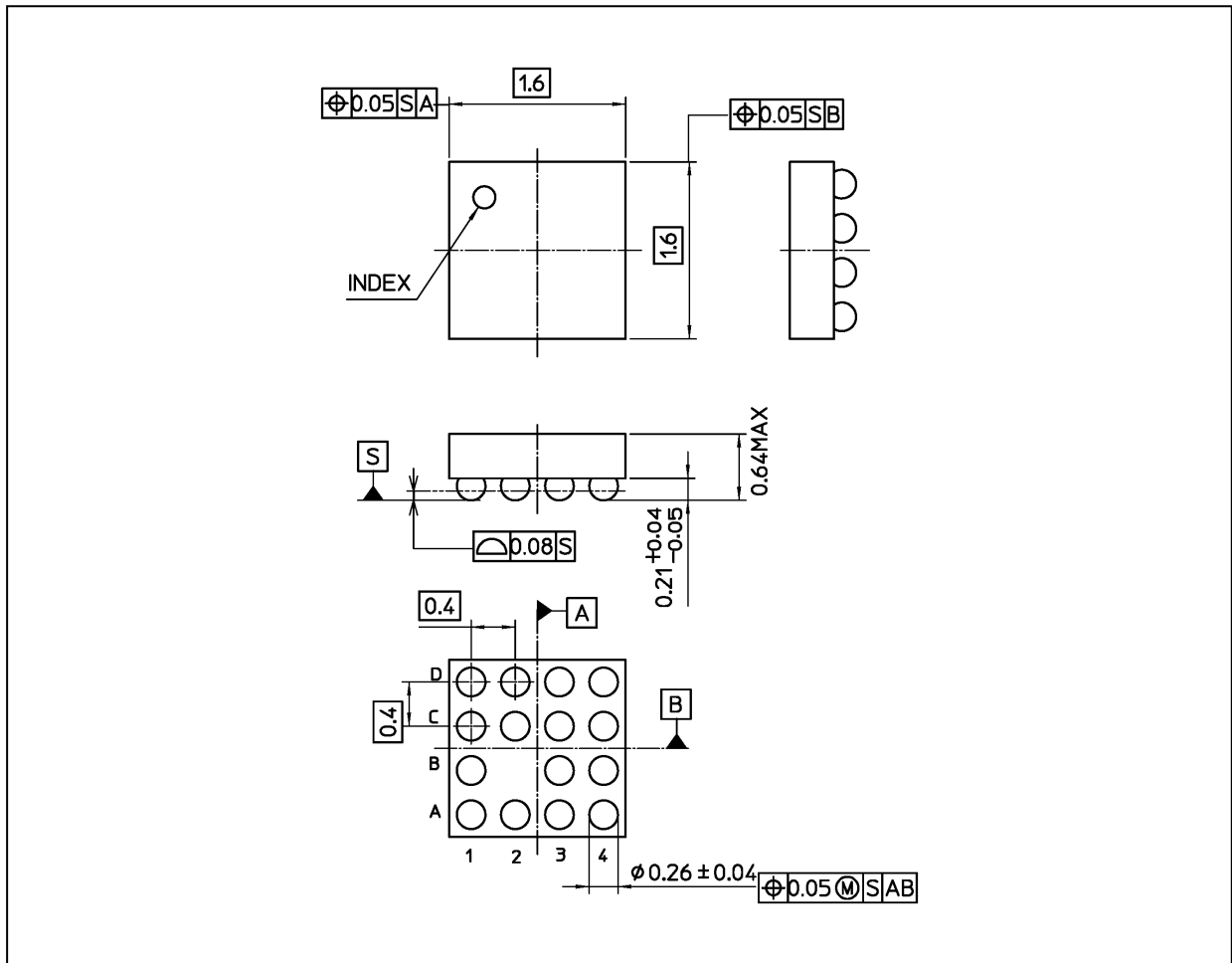


Fig. 11.6 -3dB Bandwidth

Package Dimensions

Unit: mm



This resins used in this product include no flame retardants.

Weight: 0.003 g (typ.)

Package Name(s)
TOSHIBA: S-UFBGA15-0202-0.40A01
Nickname: WCSP15

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