TOSHIBA CMOS Digital Integrated Circuit   Silicon Monolithic

TC7MAR2245FK

Low-Voltage Octal Bus Transceiver with 3.6 V Tolerant Inputs and Outputs

The TC7MAR2245FK is a high performance CMOS octal bus transceiver. Designed for use in 1.8, 2.5 or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

The direction of data transmission is determined by the level of the DIR inputs. The $\overline{\text{OE}}$ inputs can be used to disable the device so that the busses are effectively isolated.

The 26-Ω series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.

VSSOP20-P-0030-0.50
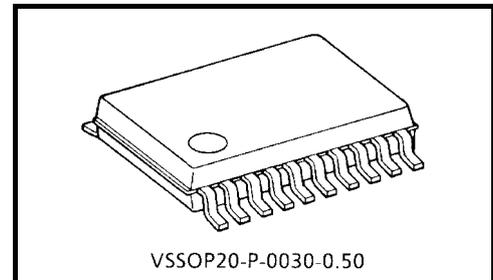
Weight: 0.03 g (typ.)

Features

- 26-Ω series resistors on outputs.
- Low voltage operation: V_{CC} = 1.8~3.6 V
- High speed operation:
 - t_{pd} = 4.4 ns (max) (V_{CC} = 3.0~3.6 V)
  - t_{pd} = 5.6 ns (max) (V_{CC} = 2.3~2.7 V)
  - t_{pd} = 9.8 ns (max) (V_{CC} = 1.8 V)
- 3.6 V tolerant inputs and outputs.
- Output current: I_{OH}/I_{OL} = ±12 mA (min) (V_{CC} = 3.0 V)
  - I_{OH}/I_{OL} = ±8 mA (min) (V_{CC} = 2.3 V)
  - I_{OH}/I_{OL} = ±4 mA (min) (V_{CC} = 1.8 V)
- Latch-up performance: −300 mA
- ESD performance: Machine model ≥ ±200 V
  - Human body model ≥ ±2000 V
- Package: VSSOP (US)
- Bidirectional interface between 2.5 V and 3.3 V signals. (*1)
- Power down protection is provided on all inputs and outputs. (*2)
- Supports live insertion/withdrawal (*3)
- Bidirectional interface between 2.5 V and 3.3 V signals. (*1)
- Power down protection is provided on all inputs and outputs. (*2)
- Supports live insertion/withdrawal (*3)

*1: Do not apply a signal to any bus terminal when it is in the output mode. Damage may result.

*2: All floating (high impedance) bus terminal must have their input level fixed by means of pull up or pull down resistors.

*3: To ensure the high-impedance state during power up or power down, $\overline{\text{OE}}$ should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

Pin Assignment (top view)
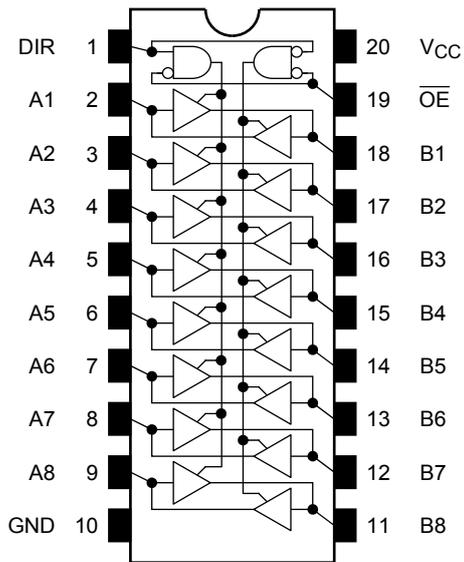
IEC Logic Symbol
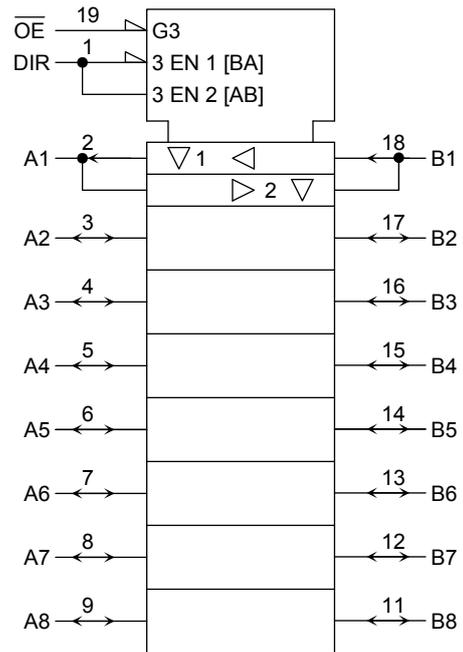
Truth Table

Inputs		Outputs	Function	
$\overline{OE}$	DIR		A-Bus	B-Bus
L	L	A = B	Output	Input
L	H	B = A	Input	Output
H	X	Z	Z	

X: Don't care

Z: High impedance

Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	$-0.5 \sim 4.6$	V
DC input voltage (DIR, $\overline{OE}$)	V_{IN}	$-0.5 \sim 4.6$	V
DC bus I/O voltage	$V_{I/O}$	$-0.5 \sim 4.6$ (Note 2)	V
		$-0.5 \sim V_{CC} + 0.5$ (Note 3)	
Input diode current	I_{IK}	-50	mA
Output diode current	I_{OK}	± 50 (Note 4)	mA
DC output current	I_{OUT}	± 50	mA
Power dissipation	P_D	180	mW
DC V_{CC}/ground current	I_{CC}/I_{GND}	± 100	mA
Storage temperature	T_{stg}	$-65 \sim 150$	°C

Note 1: 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).

Note 2: Off-state

Note 3: High or low state. I_{OUT} absolute maximum rating must be observed.

Note 4: $V_{OUT} < $ GND, $V_{OUT} > V_{CC}$

Operating Ranges (Note 1)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	$1.8 \sim 3.6$	V
		$1.2 \sim 3.6$ (Note 2)	
Input voltage (DIR, $\overline{OE}$)	V_{IN}	$-0.3 \sim 3.6$	V
Bus I/O voltage	$V_{I/O}$	$0 \sim 3.6$ (Note 3)	V
		$0 \sim V_{CC}$ (Note 4)	
Output current	I_{OH}/I_{OL}	± 12 (Note 5)	mA
		± 8 (Note 6)	
		± 4 (Note 7)	
Operating temperature	T_{opr}	$-40 \sim 85$	°C
Input rise and fall time	dt/dv	$0 \sim 10$ (Note 8)	ns/V

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs and bus inputs must be tied to either VCC or GND. Please connect both bus inputs and the bus outputs with VCC or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 2: Data retention only

Note 3: Off-state

Note 4: High or low state

Note 5: $V_{CC} = 3.0 \sim 3.6$ V

Note 6: $V_{CC} = 2.3 \sim 2.7$ V

Note 7: $V_{CC} = 1.8$ V

Note 8: $V_{IN} = 0.8 \sim 2.0$ V, $V_{CC} = 3.0$ V

Electrical Characteristics

DC Characteristics (Ta = −40~85°C, 2.7 V < V$_{CC}$ ≦ 3.6 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (V)	Min	Max	Unit
Input voltage	High level	V$_{IH}$	—		2.7~3.6	2.0	—	V
	Low level	V$_{IL}$	—		2.7~3.6	—	0.8	
Output voltage	High level	V$_{OH}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OH}$ = −100 μA	2.7~3.6	V$_{CC}$ − 0.2	—	V
				I$_{OH}$ = −6 mA	2.7	2.2	—	
				I$_{OH}$ = −8 mA	3.0	2.4	—	
				I$_{OH}$ = −12 mA	3.0	2.2	—	
	Low level	V$_{OL}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OL}$ = 100 μA	2.7~3.6	—	0.2	
				I$_{OL}$ = 6 mA	2.7	—	0.4	
				I$_{OL}$ = 8 mA	3.0	—	0.55	
				I$_{OL}$ = 12 mA	3.0	—	0.8	
Input leakage current		I$_{IN}$	V$_{IN}$ = 0~3.6 V		2.7~3.6	—	±5.0	μA
3-state output off-state current		I$_{OZ}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$ V$_{OUT}$ = 0~3.6 V		2.7~3.6	—	±10.0	μA
Power off leakage current		I$_{OFF}$	V$_{IN}$, V$_{OUT}$ = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I$_{CC}$	V$_{IN}$ = V$_{CC}$ or GND		2.7~3.6	—	20.0	μA
			V$_{CC}$ ≦ (V$_{IN}$, V$_{OUT}$) ≦ 3.6 V		2.7~3.6	—	±20.0	
Increase in I$_{CC}$ per input		ΔI$_{CC}$	V$_{IH}$ = V$_{CC}$ − 0.6 V		2.7~3.6	—	750	

DC Characteristics (Ta = −40~85°C, 2.3 V ≦ V$_{CC}$ ≦ 2.7 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (V)	Min	Max	Unit
Input voltage	High level	V$_{IH}$	—		2.3~2.7	1.6	—	V
	Low level	V$_{IL}$	—		2.3~2.7	—	0.7	
Output voltage	High level	V$_{OH}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OH}$ = −100 μA	2.3~2.7	V$_{CC}$ − 0.2	—	V
				I$_{OH}$ = −4 mA	2.3	2.0	—	
				I$_{OH}$ = −6 mA	2.3	1.8	—	
				I$_{OH}$ = −8 mA	2.3	1.7	—	
	Low level	V$_{OL}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OL}$ = 100 μA	2.3~2.7	—	0.2	
				I$_{OL}$ = 6 mA	2.3	—	0.4	
				I$_{OL}$ = 8 mA	2.3	—	0.6	
Input leakage current		I$_{IN}$	V$_{IN}$ = 0~3.6 V		2.3~2.7	—	±5.0	μA
3-state output off-state current		I$_{OZ}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$ V$_{OUT}$ = 0~3.6 V		2.3~2.7	—	±10.0	μA
Power off leakage current		I$_{OFF}$	V$_{IN}$, V$_{OUT}$ = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I$_{CC}$	V$_{IN}$ = V$_{CC}$ or GND		2.3~2.7	—	20.0	μA
			V$_{CC}$ ≦ (V$_{IN}$, V$_{OUT}$) ≦ 3.6 V		2.3~2.7	—	±20.0	

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DC Characteristics (Ta = −40~85°C, 1.8 V ≦ V$_{CC}$ < 2.3 V)

Characteristics		Symbol	Test Condition		V$_{CC}$ (V)	Min	Max	Unit
Input voltage	High level	V$_{IH}$	—		1.8~2.3	0.7 × V$_{CC}$	—	V
	Low level	V$_{IL}$	—		1.8~2.3	—	0.2 × V$_{CC}$	
Output voltage	High level	V$_{OH}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OH}$ = −100 μA	1.8	V$_{CC}$ − 0.2	—	V
				I$_{OH}$ = −4 mA	1.8	1.4	—	
	Low level	V$_{OL}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$	I$_{OL}$ = 100 μA	1.8	—	0.2	
				I$_{OL}$ = 4 mA	1.8	—	0.3	
Input leakage current		I$_{IN}$	V$_{IN}$ = 0~3.6 V		1.8	—	±5.0	μA
3-state output off-state current		I$_{OZ}$	V$_{IN}$ = V$_{IH}$ or V$_{IL}$ V$_{OUT}$ = 0~3.6 V		1.8	—	±10.0	μA
Power off leakage current		I$_{OFF}$	V$_{IN}$, V$_{OUT}$ = 0~3.6 V		0	—	10.0	μA
Quiescent supply current		I$_{CC}$	V$_{IN}$ = V$_{CC}$ or GND		1.8	—	20.0	μA
			V$_{CC}$ ≦ (V$_{IN}$, V$_{OUT}$) ≦ 3.6 V		1.8	—	±20.0	

AC Characteristics (Ta = −40~85°C, Input: t$_r$ = t$_f$ = 2.0 ns, C$_L$ = 30 pF, R$_L$ = 500 Ω)

Characteristics	Symbol	Test Condition	V$_{CC}$ (V)	Min	Max	Unit
Propagation delay time	t$_{pLH}$ t$_{pHL}$	Figure 1, Figure 2	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	5.6	
			3.3 ± 0.3	0.6	4.4	
3-state output enable time	t$_{pZL}$ t$_{pZH}$	Figure 1, Figure 3	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	6.6	
			3.3 ± 0.3	0.6	5.0	
3-state output disable time	t$_{pLZ}$ t$_{pHZ}$	Figure 1, Figure 3	1.8	1.5	8.5	ns
			2.5 ± 0.2	0.8	4.7	
			3.3 ± 0.3	0.6	4.2	
Output to output skew	t$_{osLH}$ t$_{osHL}$	(Note)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

For C$_L$ = 50 pF, add approximately 300 ps to the AC maximum specification.

Note: This parameter is guaranteed by design.

(t$_{osLH}$ = |t$_{pLHm}$ − t$_{pLHn}$|, t$_{osHL}$ = |t$_{pHLm}$ − t$_{pHLn}$|)

Dynamic Switching Characteristics (Ta = 25°C, Input: t_r = t_f = 2.0 ns, C_L = 30 pF)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note)	1.8	0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	0.35	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note)	1.8	−0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	−0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	−0.35	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note)	1.8	1.55	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	2.05	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	2.65	

Note: This parameter is guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}	DIR, $\overline{OE}$		1.8, 2.5, 3.3	6	pF
Bus I/O capacitance	$C_{I/O}$	An, Bn		1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	f_{IN} = 10 MHz	(Note)	1.8, 2.5, 3.3	20	pF

Note: C_{PD} is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/8$ (per bit)

AC Test Circuit
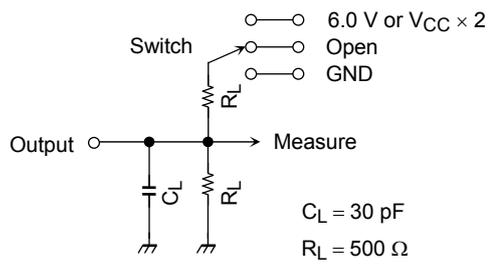
Parameter	Switch	
t_{pLH}, t_{pHL}	Open	
t_{pLZ}, t_{pZL}	6.0 V $V_{CC} \times 2$	@V_{CC} = 3.3 ± 0.3 V @V_{CC} = 2.5 ± 0.2 V @V_{CC} = 1.8 V
t_{pHZ}, t_{pZH}	GND	

Figure 1

AC Waveform
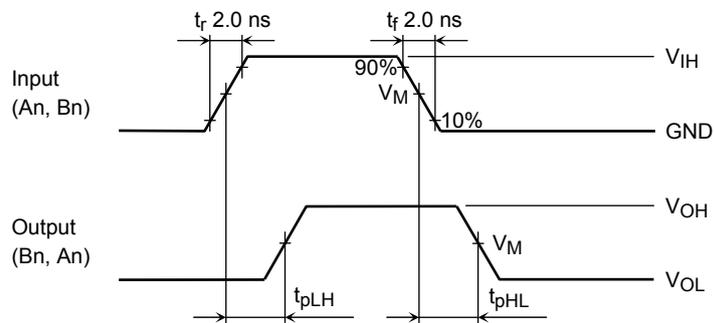
Figure 2 t_{pLH}, t_{pHL}
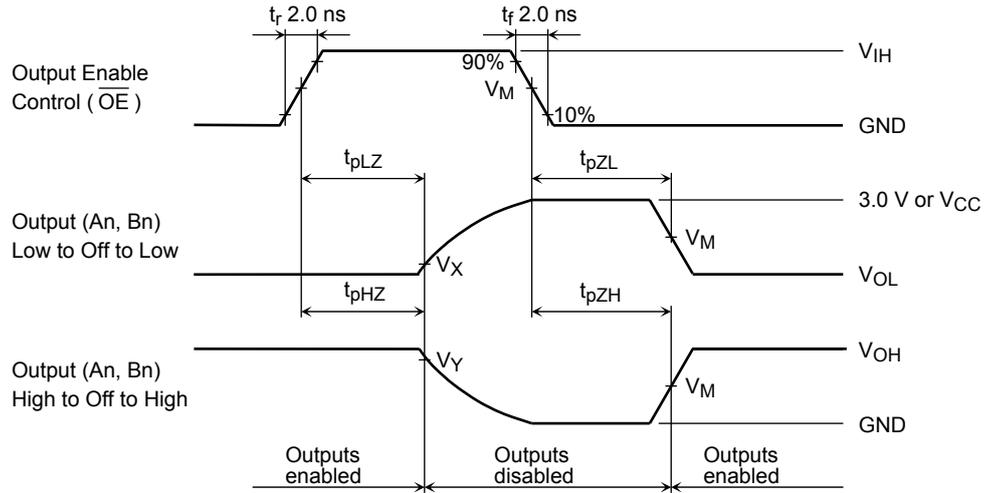
Figure 3 t_{pLZ}, t_{pHZ}, t_{pZL}, t_{pZH}

Symbol	V_{CC}		
	3.3 ± 0.3 V	2.5 ± 0.2 V	1.8 V
V_{IH}	2.7 V	V_{CC}	V_{CC}
V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$
V_X	$V_{OL} + 0.3$ V	$V_{OL} + 0.15$ V	$V_{OL} + 0.15$ V
V_Y	$V_{OH} - 0.3$ V	$V_{OH} - 0.15$ V	$V_{OH} - 0.15$ V

Package Dimensions

VSSOP20-P-0030-0.50   Unit : mm
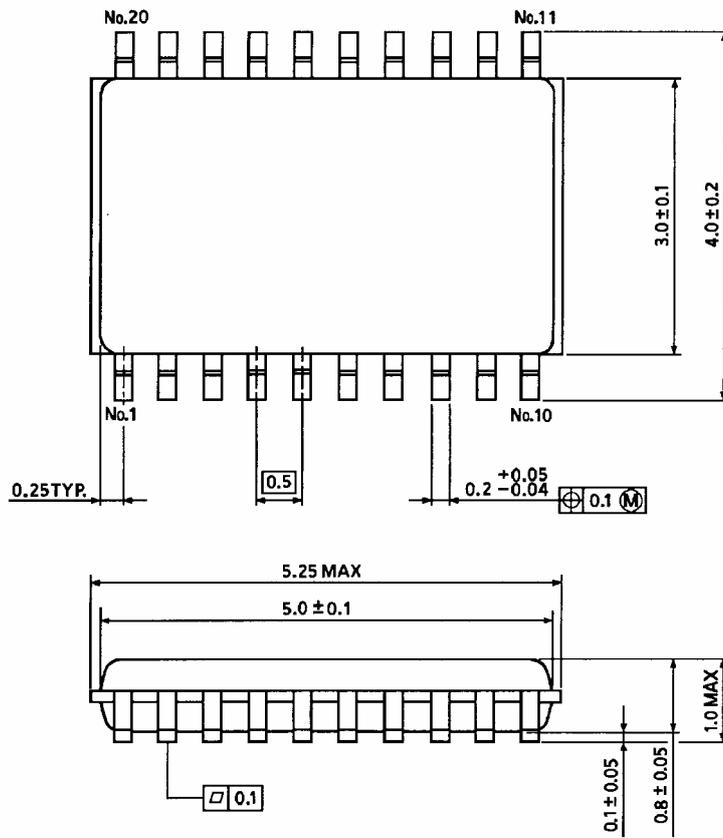
Weight: 0.03 g (typ.)

RESTRICTIONS ON PRODUCT USE