FAIRCHILD SEMICONDUCTOR®

June 2008

FXM2IC102
Dual Supply 2-Bit I²C Interface Voltage Translator with Configurable Voltage Supplies and Signal Levels and Auto Direction Sensing

Features

- Bi-directional interface between any two levels from 1.65V to 5.5V
- Buffer isolates capacitance and allows 400pF on each port
- Open-drain inputs/outputs
- Accommodates Standard-mode and Fast-mode I²C-bus devices
- Fully configurable: Inputs and outputs track V_{CC} level
- Non-preferential power-up; either V_{CC} may be powered-up first
- Outputs remain in 3-state until active V_{CC} level is reached
- Outputs switch to 3-state if either V_{CC} is at GND
- Power off high impedance
- Active high output enable referenced to V_{CCA} voltage
- 5V tolerant output enable
- Packaged in 8-terminal leadless MicroPak (1.6mm x 1.6mm)
- Direction control not needed
- ESD protection exceeds:
  - 8kV HBM ESD (per JESD22-A114 & Mil Std 883e 3015.7)
  - 15kV HBM I/O to GND ESD (per JESD22-A114 & Mil Std 883e 3015.7)

General Description

The FXM2IC102 is a configurable dual-voltage-supply translator designed for bi-directional voltage translation over a wide range of input and output voltages levels.

The FXM2IC102 is intended for use as a voltage translator in applications using the I²C bus interface. Input and output voltage levels are compatible with I²C device specification voltage levels.

The device is designed so that the A port tracks the V_{CCA} level, and the B port tracks the V_{CCB} level. This allows for bi-directional voltage translation over the voltage ranges: 1.8V, 2.5V, 3.3V, 5.0V.

The device remains in 3-state until both V_{CC}s reach active levels allowing either V_{CC} to be powered-up first. Internal power down control circuits place the device in 3-state if either V_{CC} is removed.

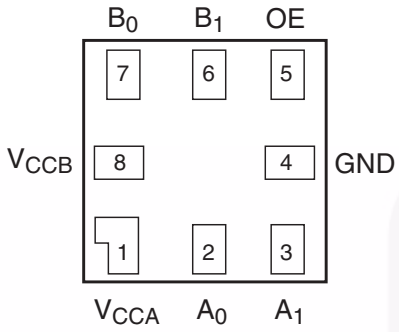
The two ports of the device have auto-direction sense capability. Either port may sense an input signal and transfer it as an output signal to the other port.

Ordering Information

Order Number	Package Number	Product Code Top Mark	Package Description	Supplied As
FXM2IC102L8X	MAC08A	XG	8-Lead MicroPak, 1.6 mm Wide	3k Units on Tape and Reel

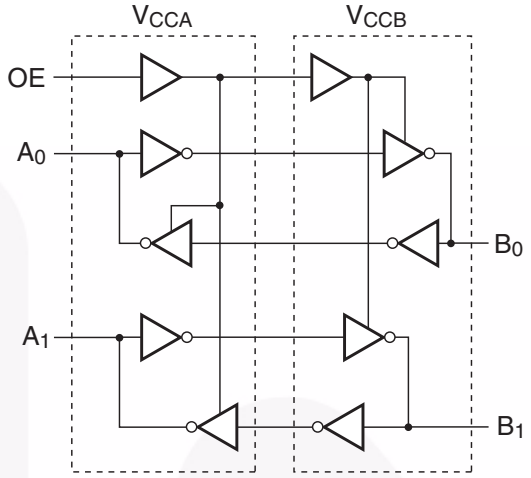
All packages are lead free per JEDEC: J-STD-020B standard.

Connection Diagram



(Top Thru View)

Functional Diagram



Pin Description

Number	Name	Description
1	V_{CCA}	A Side Power Supply
2, 3	A_0, A_1	A Side Inputs or 3-State Outputs
4	GND	
5	OE	Output Enable Input
6, 7	B_1, B_0	B Side Inputs or 3-State Outputs
8	V_{CCB}	B Side Power Supply

Function Table

Control	
OE	**Outputs**
L	3-State
H	Normal Operation

H = HIGH Logic Level

L = LOW Logic Level

Power-Up/Power-Down Sequencing

FXM translators offer an advantage in that either V_{CC} may be powered up first. This benefit derives from the chip design. When either V_{CC} is at 0V, outputs are in a high-impedance state. The control input (OE) is designed to track the V_{CCA} supply. A pull-down resistor tying OE to GND should be used to ensure that bus contention, excessive currents, or oscillations do not occur during power-up/power-down. The size of the pull-down resistor is based upon the current-sinking capability of the device driving the OE pin.

The recommended power-up sequence is the following:

1. Apply power to the first V_{CC}.
2. Apply power to the second V_{CC}.
3. Drive the OE input high to enable the device.

The recommended power-down sequence is the following:

1. Drive OE input low to disable the device.
2. Remove power from either V_{CC}.
3. Remove power from other V_{CC}.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Rating
V_{CCA}, V_{CCB}	Supply Voltage	–0.5V to +7.0V
V_I	DC Input Voltage	
	A Port	–0.5V to +7.0V
	B Port	–0.5V to +7.0V
	Control Input (OE)	–0.5V to +7.0V
V_O	Output Voltage(1)	
	A_n Outputs 3-State	–0.5V to +7.0V
	B_n Outputs 3-State	–0.5V to +7.0V
	A_n Outputs Active	–0.5V to V_{CCA} + 0.5V
	B_n Outputs Active	–0.5V to V_{CCB} + 0.5V
I_{IK}	DC Input Diode Current @ V_I < 0V	–50mA
I_{OK}	DC Output Diode Current @	
	V_O < 0V	–50mA
	V_O > V_{CC}	+50mA
I_{OH} / I_{OL}	DC Output Source/Sink Current	–50mA / +50mA
I_{CC}	DC V_{CC} or Ground Current per Supply Pin	±100mA
T_{STG}	Storage Temperature Range	–65°C to +150°C

Note:

1. I_O Absolute Maximum Rating must be observed.

Recommended Operating Conditions(2)

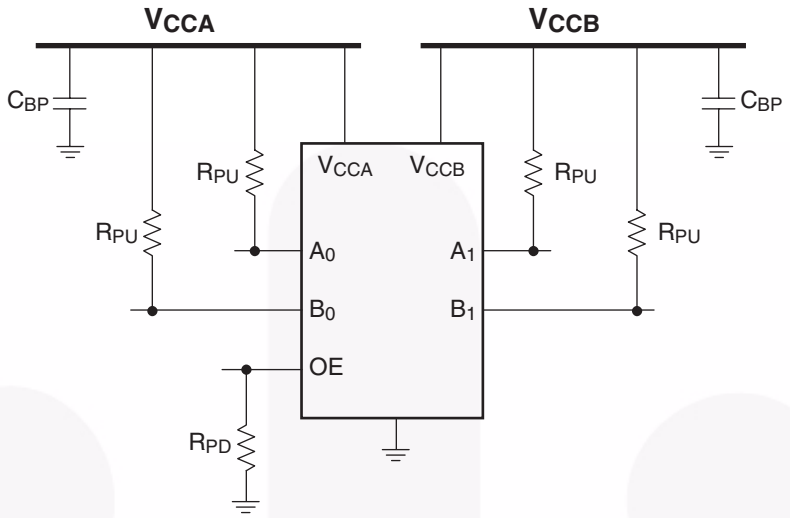
The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Rating
V_{CCA} or V_{CCB}	Power Supply Operating	1.65V to 5.5V
V_I	Input Voltage	
	A Port	0.0V to 5.5V
	B Port	0.0V to 5.5V
	Control Input (OE)	0.0V to V_{CCA}
$\Delta t / \Delta v$	Maximum Input Edge Rate $V_{CCA/B}$ = 1.65V to 5.5V	200ns/V
T_A	Free Air Operating Temperature	–40°C to +85°C

Note:

2. All unused inputs and I/O pins must be held at V_{CCI} or GND.

FXM2IC102 Application Circuit



Application Notes

The FXM2IC102 has open-drain outputs and requires pull-up resistors on the four data I/O pins as shown in the above figure. If a pair of data I/O pins (A_n/B_n) are not used, they both should be tied to Gnd (or both to V_{CC}). In this case, pull-down or pull-up resistors are not required.

The recommended values for the pull-up resistors (R_{PU}) are 1kΩ minimum to 10kΩ maximum. The recommended value for the bypass capacitors (C_{BP}) is 1.1µF. The recommended value for the pull-down resistor (R_{PD}) on OE is 1kΩ or higher and may depend upon the current-sinking capability of the device driving the OE pin.

DC Electrical Characteristics (T_A = –40°C to +85°C)

Symbol	Parameter	V_{CCA} (V)	V_{CCB} (V)	Conditions		Min.	Max.	Units
V_{IHA}	High Level Input Voltage	1.65–5.5	1.65–5.5	Data Inputs A_n		0.7 x V_{CCA}		V
		1.65–5.5	1.65–5.5	Control Input OE		0.9 x V_{CCA}		
V_{IHB}		1.65–5.5	1.65–5.5	Data Inputs B_n		0.7 x V_{CCB}		V
V_{ILA}	Low Level Input Voltage	1.65–5.5	1.65–5.5	Data Inputs A_n			0.3 x V_{CCA}	V
		1.65–5.5	1.65–5.5	Control Input OE			0.1 x V_{CCA}	
V_{ILB}		1.65–5.5	1.65–5.5	Data Inputs B_n			0.3 x V_{CCB}	V
V_{OLA}[3]	Low Level Output Voltage	1.65–2.3	1.65–5.5	A Port	I_{OL} = 3mA		0.1 x V_{CCA}	V
		3.0–5.5	1.65–5.5		I_{OL} = 6mA		0.2	
V_{OLB}[3]		1.65–5.5	1.65–2.3	B Port	I_{OL} = 3mA		0.1 x V_{CCB}	V
		1.65–5.5	3.0–5.5		I_{OL} = 6mA		0.2	
I_I	Input Leakage Current	1.65–5.5	1.65–5.5	Control input OE, V_I = V_{CCA} or GND			±1.0	µA
I_{OFF}	Power Off Leakage Current	0	5.5	A_n	V_I or V_O = 0V to 5.5V		±2.0	µA
		5.5	0	B_n	V_I or V_O = 0V to 5.5V		±2.0	
I_{OZ}[4]	3-State Output Leakage	5.5	5.5	A_n, B_n	V_O = 0V to 5.5V, OE = V_{IL}		±2.0	µA
		5.5	0	A_n	V_O = 0V to 5.5V, OE = Don't Care		±2.0	
		0	5.5	B_n	V_O = 0V to 5.5V, OE = Don't Care		±2.0	
$I_{CCA/B}$[5][6]	Quiescent Supply Current	1.65–5.5	1.65–5.5	V_I = V_{CCI} or GND, I_O = 0			5.0	µA
I_{CCZ}[5]	Quiescent Supply Current	1.65–5.5	1.65–5.5	V_I = V_{CCI} or GND, I_O = 0, OE = V_{IL}			5.0	µA
I_{CCA}	Quiescent Supply Current	0	1.65–5.5	V_I = 5.5V or GND, I_O = 0, OE = Don't Care, B_n to A_n			–2.0	µA
		1.65–5.5	0				2.0	
I_{CCB}	Quiescent Supply Current	1.65–5.5	0	V_I = 5.5V or GND, I_O = 0, OE = Don't Care, A_n to B_n			–2.0	µA
		0	1.65–5.5				2.0	

Notes:

3. This is the output voltage for static conditions. Dynamic drive specifications are given in "Dynamic Output Electrical Characteristics."
4. "Don't Care" indicates any valid logic level.
5. V_{CCI} is the V_{CC} associated with the input side.
6. Reflects current per supply, V_{CCA} or V_{CCB}.

Dynamic Output Electrical Characteristics

Output Rise/Fall Time and Dynamic Output Current[7]

Output Load: C_L = 50pF, R_L = 1kΩ

Symbol[8]	Parameter	T_A = -40°C to +85°C, V_{CCO} =								Units
		4.5V to 5.5V		3.0V to 3.6V		2.3V to 2.7V		1.65V to 1.95V		
		Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	
t_{rise}[9]	Output Rise Time, A Port, B Port		4.0		5.0		6.0		8.0	ns
t_{fall}[10]	Output Fall Time, A Port, B Port		4.0		5.0		6.0		8.0	ns
I_{OHD}[9]	Dynamic Output Current HIGH	-45		-24		-15		-8.0		mA
I_{OLD}[10]	Dynamic Output Current LOW	+45		+24		+15		+8.0		mA

Maximum Data Rate[11]

Output Load: C_L = 50pF, R_L = 1kΩ

V_{CCA} =	T_A = -40°C to +85°C, V_{CCB} =				Units
	4.5V to 5.5V	3.0V to 3.6V	2.3V to 2.7V	1.65V to 1.95V	
	Min.	Min.	Min.	Min.	
4.5V to 5.5V	40	35	30	20	MHz
3.0V to 3.6V	35	35	30	20	MHz
2.3V to 2.7V	30	30	25	20	MHz
1.65V to 1.95V	20	20	20	20	MHz

Notes:

7. Dynamic output characteristics are guaranteed but not tested.
8. V_{CCO} is the V_{CC} associated with the output side.
9. See Figure 5.
10. See Figure 6.
11. Maximum data rate is guaranteed but not tested.

AC Characteristics (Output Load: C_L = 50pF, R_L = 1kΩ)

V_{CCA} = 4.5V to 5.5V

Symbol	Parameter	T_A = -40°C to +85°C, V_{CCB} = 4.5V to 5.5V		V_{CCB} = 3.0V to 3.6V		V_{CCB} = 2.3V to 2.7V		V_{CCB} = 1.65V to 1.95V		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PLH}	A to B	1.0	4.5	1.5	5.5	2.0	7.0	3.0	11.5	ns
	B to A	1.0	4.5	1.5	5.5	1.5	6.5	2.5	9.5	
t_{PHL}	A to B	2.0	6.0	2.5	6.5	3.0	8.0	4.0	12.5	ns
	B to A	2.0	6.0	2.5	7.0	3.0	8.0	3.5	12.0	
t_{PZL}	OE to A		9.5		10.0		11.5		18.0	ns
	OE to B		9.0		11.0		13.5		22.0	
t_{PLZ}	OE to A		26.5		26.5		26.5		26.5	ns
	OE to B		26.0		26.5		20.5		15.5	
t_{skew}(12)	A Port, B Port		0.5		0.5		0.5		0.5	ns

V_{CCA} = 3.0V to 3.6V

Symbol	Parameter	T_A = -40°C to +85°C, V_{CCB} = 4.5V to 5.5V		V_{CCB} = 3.0V to 3.6V		V_{CCB} = 2.3V to 2.7V		V_{CCB} = 1.65V to 1.95V		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PLH}	A to B	1.5	5.5	1.5	6.5	2.0	8.0	3.0	12.0	ns
	B to A	1.5	5.5	1.5	6.5	2.0	7.5	2.5	10.5	
t_{PHL}	A to B	2.5	7.0	2.5	7.5	3.0	9.0	4.0	13.0	ns
	B to A	2.5	6.5	2.5	7.5	3.0	9.5	4.0	13.0	
t_{PZL}	OE to A		12.5		13.0		15.5		21.0	ns
	OE to B		10.0		12.5		14.5		22.5	
t_{PLZ}	OE to A		27.5		28.0		28.0		28.0	ns
	OE to B		27.5		28.0		28.5		22.5	
t_{skew}(12)	A Port, B Port		0.5		0.5		0.5		0.5	ns

V_{CCA} = 2.3V to 2.7V

Symbol	Parameter	T_A = -40°C to +85°C, V_{CCB} = 4.5V to 5.5V		V_{CCB} = 3.0V to 3.6V		V_{CCB} = 2.3V to 2.7V		V_{CCB} = 1.65V to 1.95V		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PLH}	A to B	1.5	6.5	2.0	7.5	2.5	8.5	3.5	12.5	ns
	B to A	2.0	7.5	2.0	8.0	2.5	8.5	3.0	11.5	
t_{PHL}	A to B	3.0	8.5	3.0	9.5	3.0	10.0	4.0	13.5	ns
	B to A	3.0	8.0	3.0	9.0	3.0	10.0	4.5	14.0	
t_{PZL}	OE to A		16.0		16.5		18.0		23.5	ns
	OE to B		11.0		14.0		15.5		23.5	
t_{PLZ}	OE to A		29.0		29.0		29.5		29.5	ns
	OE to B		29.0		29.0		29.5		29.5	
t_{skew}(12)	A Port, B Port		0.5		0.5		0.5		0.5	ns

AC Characteristics (Continued) (Output Load: C_L = 50pF, R_L = 1kΩ)

V_{CCA} = 1.65V to 1.95V

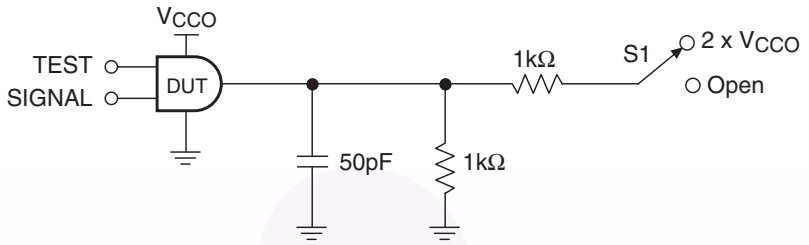
Symbol	Parameter	T_A = -40°C to +85°C, V_{CCB} =								Units
		4.5V to 5.5V		3.0V to 3.6V		2.3V to 2.7V		1.65V to 1.95V		
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PLH}	A to B	2.5	9.5	2.5	10.5	3.0	11.5	4.0	15.0	ns
	B to A	3.0	11.5	3.0	12.0	3.5	12.5	4.0	15.0	
t_{PHL}	A to B	3.5	11.5	4.0	12.5	4.5	14.0	5.0	15.5	ns
	B to A	4.0	12.5	4.0	13.0	4.0	13.5	5.0	15.5	
t_{PZL}	OE to A		27.0		27.0		27.0		30.0	ns
	OE to B		18.0		19.5		22.5		29.0	
t_{PLZ}	OE to A		34.0		34.0		34.5		35.0	ns
	OE to B		31.5		32.5		33.5		36.5	
t_{skew}(12)	A Port, B Port		0.5		0.5		0.5		0.5	ns

Note:

12. Skew is the variation of propagation delay between output signals and applies only to output signals on the same port (An or Bn) and switching with the same polarity (LOW-to-HIGH or HIGH-to-LOW). See Figure 8. Skew is guaranteed but not tested

Capacitance

Symbol	Parameter	Conditions	T_A = +25°C	Units
			Typical	
Cin	Input Capacitance Control pin (OE)	V_{CCA} = V_{CCB} = GND	4	pF
Ci/o	Input/Output Capacitance, A_n, B_n	V_{CCA} = V_{CCB} = 5.0V, OE = V_{CCA}	6	pF
Cpd	Power Dissipation Capacitance	V_{CCA} = V_{CCB} = 5.0V, V_I = 0V or V_{CC}, f = 10MHz	40	pF

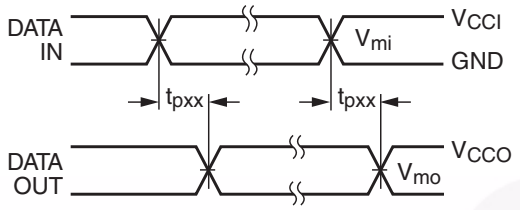


Test	Input Signal	Output Enable Control	S1 Position
t_{PLH}, t_{PHL}	Data Pulses	V_{CCA}	Open
t_{PZL} (OE to A_n, B_n)	0V	LOW to HIGH Switch	2 x V_{CCO}
t_{PLZ} (OE to A_n, B_n)	0V	HIGH to LOW Switch	2 x V_{CCO}

AC Load Table

V_{CCO}	Cl	Rl
1.8V ± 0.15V	50pF	1kΩ
2.5V ± 0.2V	50pF	1kΩ
3.3V ± 0.3V	50pF	1kΩ
5.0V ± 0.5V	50pF	1kΩ

Figure 1. AC Test Circuit and AC Load Table



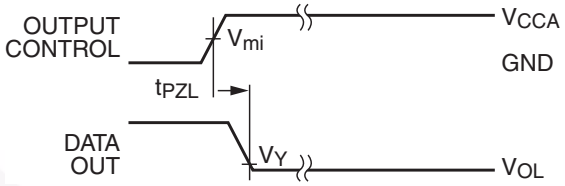
Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 1.65V to 1.95V

Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 2.3 to 2.7V

Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 3.0V to 3.6V only

Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 4.5V to 5.5 only

Figure 2. Waveform for Inverting and Non-inverting Functions



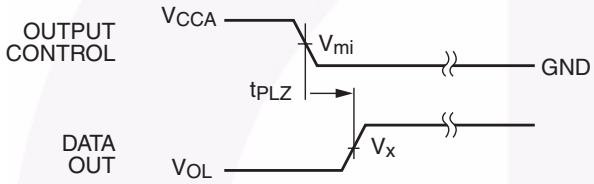
Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 1.65V to 1.95V

Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 2.3 to 2.7V

Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 3.0V to 3.6V only

Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 4.5V to 5.5 only

Figure 3. 3-STATE Output Low Enable Time



Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 1.65V to 1.95V

Input $t_R = t_F$ = 2.0ns, 10% to 90% @ V_I = 2.3 to 2.7V

Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 3.0V to 3.6V only

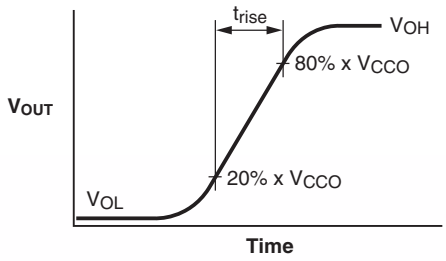
Input $t_R = t_F$ = 2.5ns, 10% to 90%, @ V_I = 4.5V to 5.5 only

Figure 4. 3-STATE Output High Enable Time

Symbol	Vcc
Vmi[13]	V_{CCI} / 2
Vmo	V_{CCO} / 2
V_X	0.5 x V_{CCO}
V_Y	0.1 x V_{CCO}

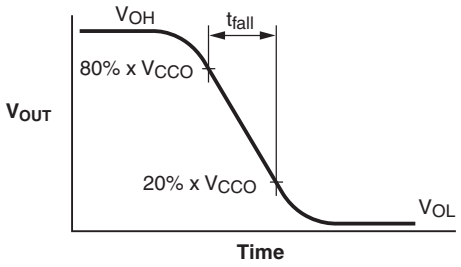
Note:

13. $V_{CCI} = V_{CCA}$ for control pin OE or Vmi = (V_{CCA} / 2).



$$I_{OHD} \approx (C_L + C_{I/O}) \times \frac{\Delta V_{OUT}}{\Delta t} = (C_L + C_{I/O}) \times \frac{(20\% - 80\%) \times V_{CCO}}{t_{RISE}}$$

Figure 5. Active Output Rise Time and Dynamic Output Current High



$$I_{OLD} \approx (C_L + C_{I/O}) \times \frac{\Delta V_{OUT}}{\Delta t} = (C_L + C_{I/O}) \times \frac{(80\% - 20\%) \times V_{CCO}}{t_{FALL}}$$

Figure 6. Active Output Fall Time and Dynamic Output Current Low

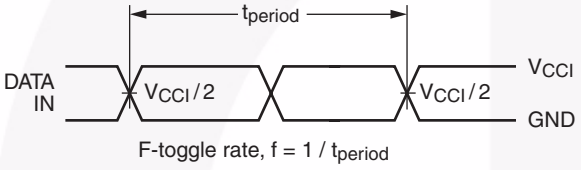
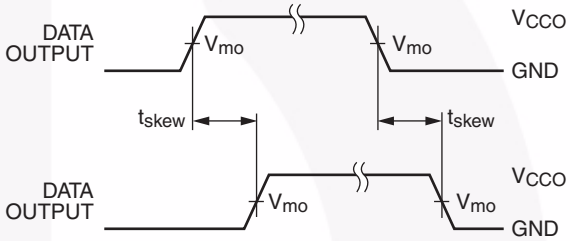


Figure 7. Maximum Data Rate (or F-toggle) in MHz



$$t_{skew} = (t_{pHLmax} - t_{pHLmin}) \text{ or } (t_{pLHmax} - t_{pLHmin})$$

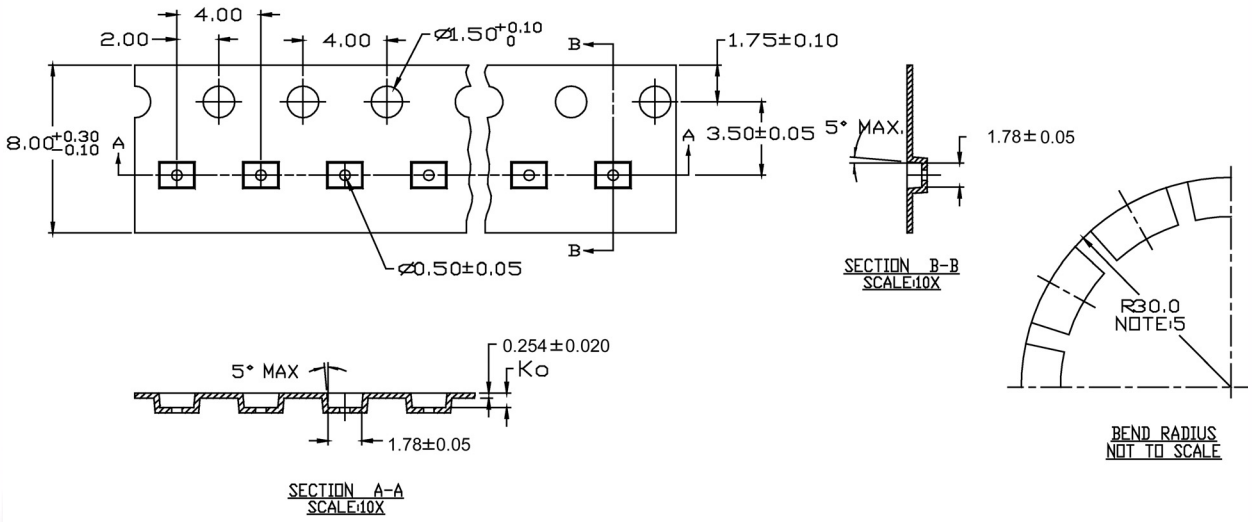
Figure 8. Output Skew Time

Tape and Reel Specification

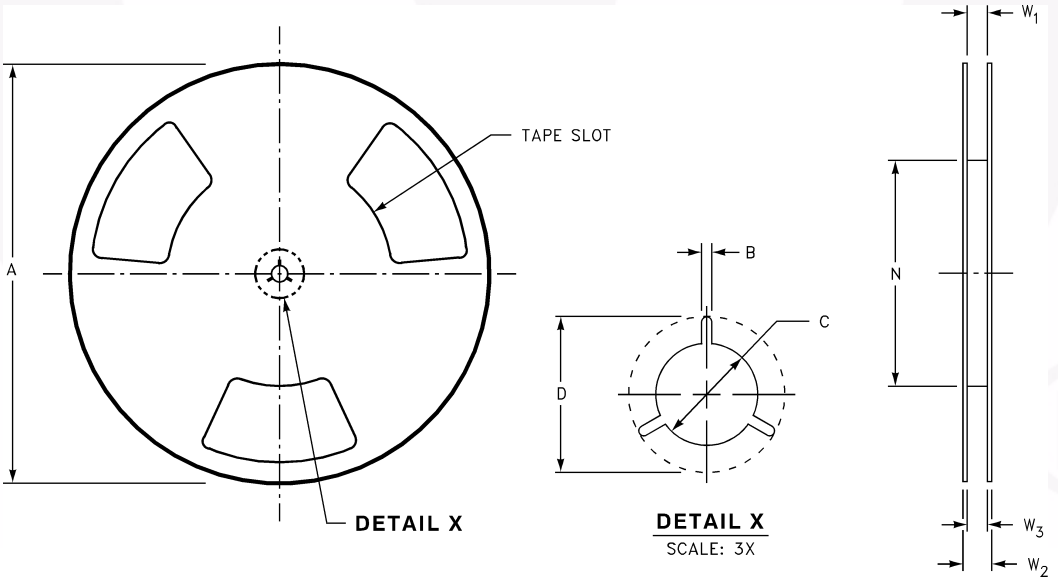
Tape Format for MicroPak

Package Designator	Tape Section	Number of Cavities	Cavity Status	Cover Tape Status
L8X	Leader (Start End)	125 (typ.)	Empty	Sealed
	Carrier	3000	Filled	Sealed
	Trailer (Hub End)	75 (typ.)	Empty	Sealed

Tape Dimensions inches (millimeters)

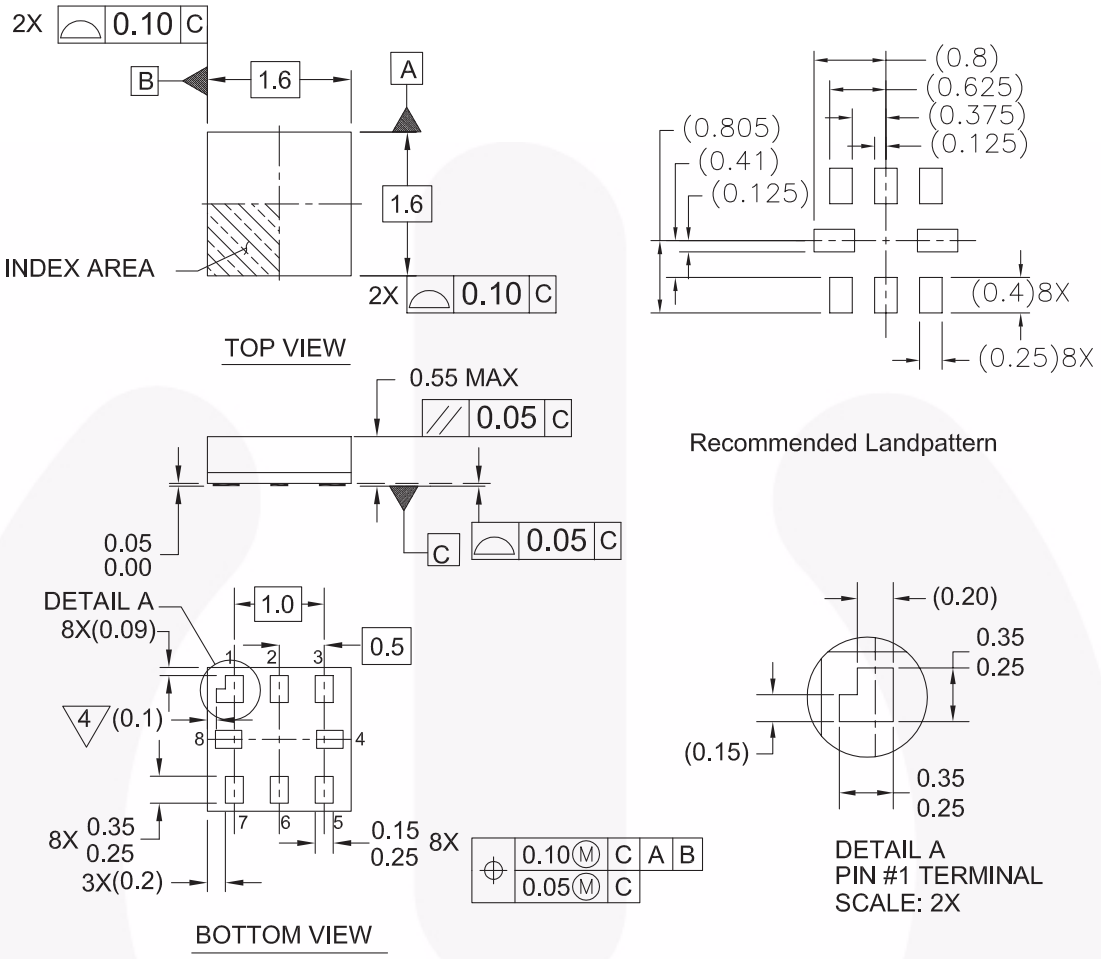


Reel Dimensions inches (millimeters)



Tape Size	A	B	C	D	N	W1	W2	W3
8mm	7.0 (177.8)	0.059 (1.50)	0.512 (13.00)	0.795 (20.20)	2.165 (55.00)	0.331 +0.059/–0.000 (8.40 +1.50/–0.00)	0.567 (14.40)	W1 +0.078/–0.039 (W1 +2.00/–1.00)

Physical Dimensions



Notes:

1. PACKAGE CONFORMS TO JEDEC MO-255 VARIATION UAAD
2. DIMENSIONS ARE IN MILLIMETERS
3. DRAWING CONFORMS TO ASME Y.14M-1994
4. PIN 1 FLAG, END OF PACKAGE OFFSET
5. DRAWING FILE NAME: MKT-MAC08AREV4

MAC08AREV4

Figure 9. 8-Lead MicroPak, 1.6 mm Wide

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