2 Channel Auto-Bidirectional Multi-Voltage Level Translator for Open-Drain and Push-Pull Applications

General Description

The ETF0102 supports bidirectional voltage translation without the need for DIR pin which minimizes system effort. The ETF0102 supports 5V tolerance on I/O port which makes it compatible with TTL levels in industrial and telecom applications. The ETF0102 is able to set up different voltage translation levels which makes it very flexible.

The ETF0102 is available in DFN8(1.4mm ×1mm) or SOP8(3.9mm × 4.9mm) packages.

Features

- No Directional Control Required
- Allows Bidirectional Voltage-level Translation Between: 0.95V~3.3V ↔ 1.8V~5.0V
- Low Standby Current
- 5V Tolerance I/O Port to Support TTL
- Low R_{ON} Provides Less Signal Distortion
- Flow-through Pin-out for Easy PCB Trace Routing
- Extended Temperature Rang: -40°C to 85°C
- Part No. and Package Information

Part No.	Package	MSL	Packing Option
ETF0102Y	DFN8(1.4mm × 1mm)	1	Tape and Reel, 5K/Reel
ETF0102M	SOP8(3.9mm × 4.9mm)	3	Tape and Reel, 2.5K/Reel

Applications

- I^2C, I^3C, MDIO, UART, SDIO, GPIO, and Other Two-signal Interfaces
- Enterprise Systems
- Communications Equipment
- Personal Computers
- Industrial Automation

Pin Configuration

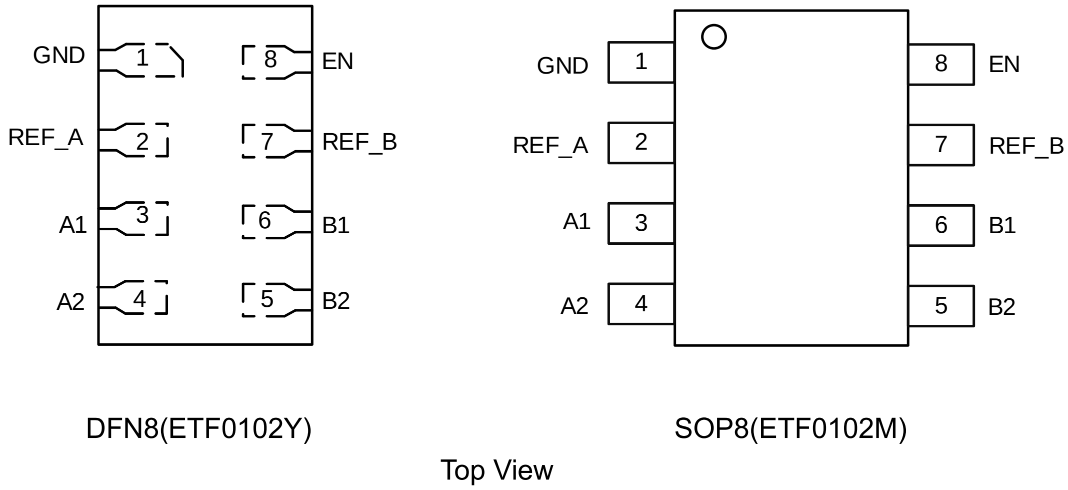


Figure 1. Pin Configuration

Pin Function

Pin No.	Pin Name	Pin Function
1	GND	Ground pin.
2	REF_A	Reference supply voltage.
3,4	An	Auto-Bidirectional Data port.
5,6	Bn	Auto-Bidirectional Data port.
7	REF_B	Reference supply voltage.
8	EN	Enable input. Connect to REF_B and pull-up through a high resistor(200kΩ).

Block Diagram

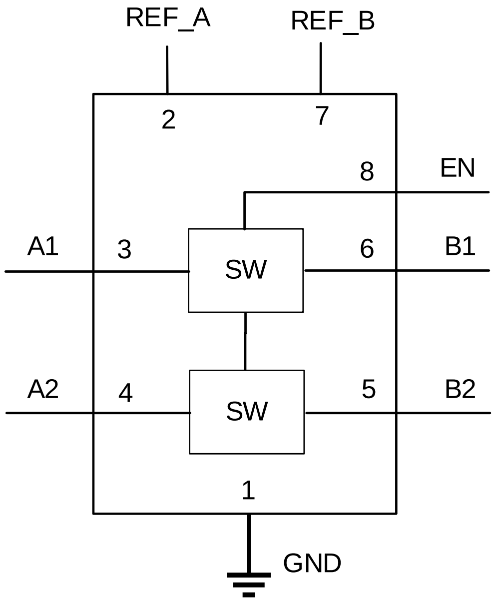


Figure 2. Block Diagram

Functional Description

The ETF0102 can be used in level-translation applications for interfacing devices or systems operating with one another that operate at different interface voltages. The ETF0102 is ideal for use in applications where an open-drain driver is connected to the data I/Os. The ETF0102 can also be used in applications where a push-pull driver is connected to the data I/Os.

Auto Bidirectional Voltage Translation

The device is an auto bidirectional voltage level translator that is operational from 0.95 to 5.5V on REF_A and 1.8 to 5.5V on REF_B. This allows bidirectional voltage translation between 0.95V and 5.5V without the need for a direction pin in open-drain or push-pull applications. Both the output driver of the controller and the peripheral device output can be push-pull or open-drain (pull-up resistors may be required). In both up and down translation, the B-side is often referred to as the high side and refers to devices connected to the B ports. The A-side can be referred to as the low side.

Output Enable

To enable the I/O pins, the EN input should be tied directly to REF_B during operation and both pins must be pulled up to the HIGH side (V_{CCB}) through a bias resistor (typically 200kΩ). To be in the high impedance state during power-up, power-down, or during operation, the EN pin must be LOW. The EN pin should always be tied directly to the REF_B pin and is recommended to be disabled by an open-drain driver without a pull-up resistor. This allows REF_B to regulate the EN input and bias the channels for proper translation. A filter capacitor on REF_B is recommended for a stable supply at the device.

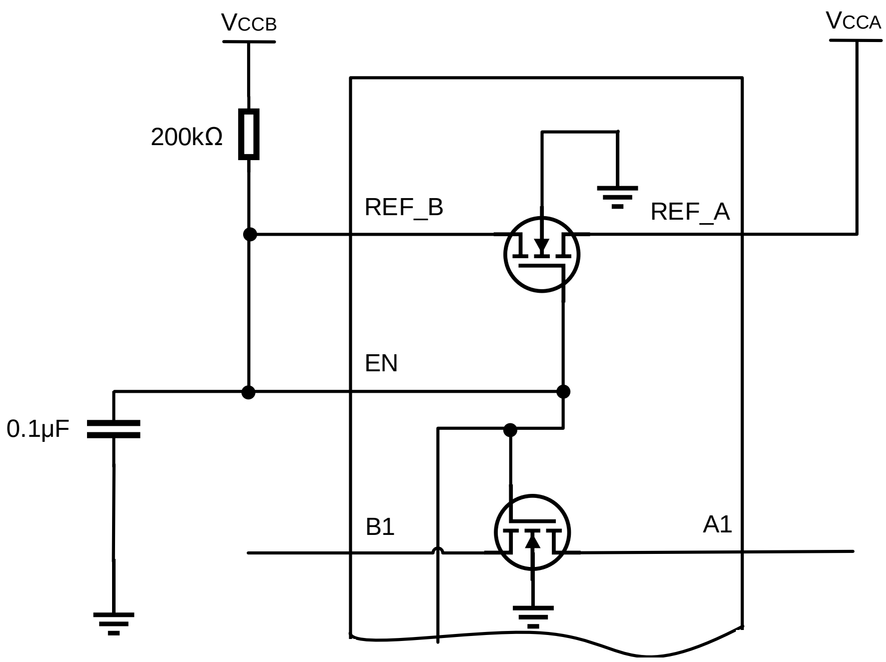


Figure 3. Enable Pin Tied to REF_B Directly and to V_{CCB} Through a Bias Resistor

The supply voltage of open drain I/O devices can be completely different from the supplies used for the ETF0102 and has no impact on the operation.

Table 1. Enable Pin Function Table (EN is controlled by V_{CCB} logic levels.)

EN PIN	Data Port State
Tied directly to REF_B	An = Bn
L	Hi-Z

Device Functional Modes

For each channel (n), when either the An or Bn port is LOW, the switch provides a low impedance path between the An and Bn ports; the corresponding Bn or An port will be pulled LOW. The low R_{ON} of the switch allows connections to be made with minimal propagation delay and signal distortion. Table 2. provides a summary of device operation.

Table 2. Device Functionality

Signal Direction[1]	Input State	Switch State	Functionality
B to A (Down Translation)	B = LOW	ON (Low Impedance)	A-side voltage is pulled low through the switch to the B-side voltage
	B = HIGH	OFF (High Impedance)	A-side voltage is clamped at V_{REF_A} [2]
A to B (Up Translation)	A = LOW	ON (Low Impedance)	B-side voltage is pulled low through the switch to the A-side voltage
	A = HIGH	OFF (High Impedance)	B-side voltage is clamped at V_{REF_A} and then pulled up to the V_{PU} supply voltage

Note1: The downstream channel should not be actively driven through a low impedance driver, or else bus contention may occur.

Note2: The A-side can have a pullup to V_{REF_A} for additional current drive capability or may also be pulled above V_{REF_A} with a pullup resistor. Specifications in the Recommended Operating Conditions section should always be followed.

Up Translation

When the signal is being driven from A to B and the An port is HIGH, the switch will be OFF and the Bn port will then be driven to a voltage higher than V_{REF_A} by the pull-up resistor that is connected to the pull-up supply voltage (V_{PU}). This functionality allows seamless translation between higher and lower voltages selected by the user, without the need for directional control. Pull-up resistors are always required on the high side, and pull-ups are only required on the low side, if the low side of the device's output is open drain or its input has a leakage greater than 1µA.

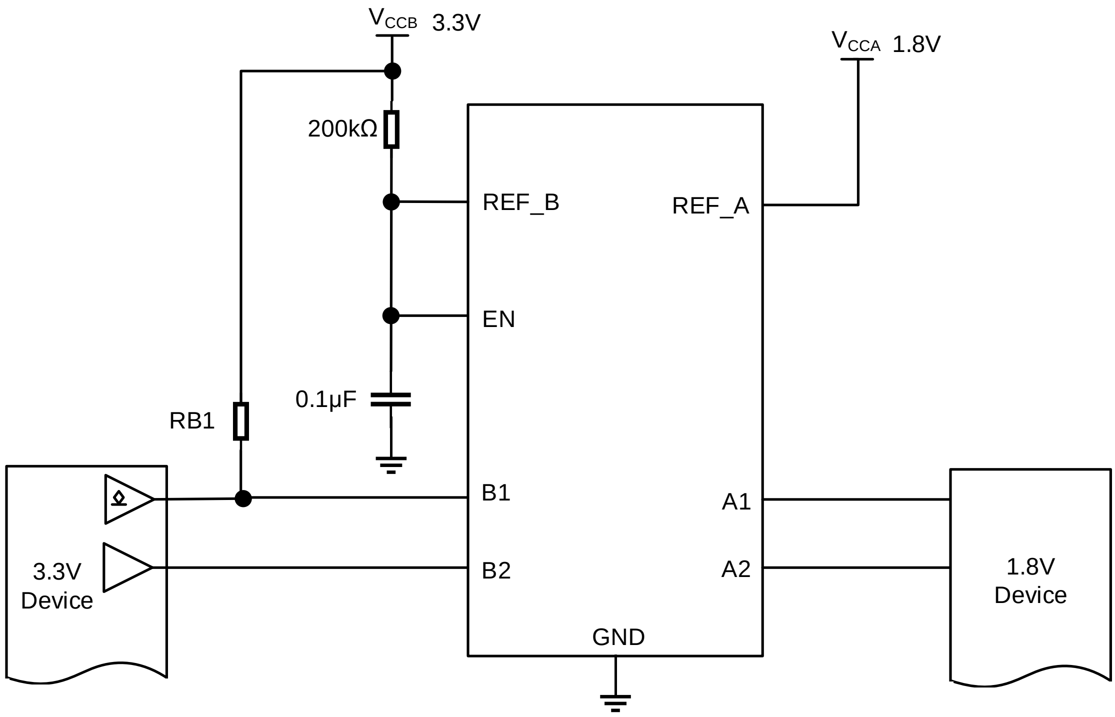


Figure 4. Up Translation Example Schematic with Push-Pull and Open Drain Configuration

Up translation with the ETF0102 requires attention to two important factors: maximum data rate and sink current. Maximum data rate is directly related to the rising edge of the output signal. Sink current depends on supply values and the chosen pull-up resistor values. Equation 1 shows the maximum data rate formula and Equation 2 shows the maximum sink current formula, both of which are estimations. A low RC value is needed to reach high speeds, which also require strong drivers.

$$\frac{1}{3\times 2R_{B1}C_{B1}} \equiv \frac{1}{6R_{B1}C_{B1}}\left(\frac{\text{bits}}{\text{second}}\right) \tag{1}$$

$$I_{OL} \cong \frac{VCCA}{R_{A1}} + \frac{VCCB}{R_{B1}}(A) \tag{2}$$

Down Translation

When the signal is being driven HIGH from the Bn port to An port, the switch will be OFF, clamping the voltage on the An port to the voltage set by V_{REF_A}. A pull-up resistor can be added on either side of the device. There are special circumstances that allow the removal of one or both of the pull-up resistors. If the signal is always going to be down translated from a push-pull transmitter, then the resistor on the B-side can be removed. If the leakage current into the receiver on the A-side is less than 1µA, then the resistor on the A-side can also be removed. This arrangement with no external pull-up resistors can be used when down translating from a push-pull output to a low-leakage input. For an open drain transmitter, the pull-up resistor on the B-side is necessary because an open drain output can't drive high by itself.

Absolute Maximum Ratings

Symbol	Parameters (Items)	Value	Unit
V_I	Input Voltage (REF_A, REF_B, OE)	-0.3 to 6.0	V
$V_{I/O}$	Input/output Voltage	-0.3 to 6.0	V
I_O	Continuous Channel Current	0 to 128	mA
I_{IK}	Input Clamp Current	-50	mA
T_{STG}	Storage Temperature Range	-65 to +150	ºC
T_J	Operating Junction Temperature	-40 to +150	ºC
$R_{\theta JA}$	Junction-to-ambient Thermal Resistance	250	°C/W
V_{ESD}	Human Body Model (JEDEC JS-001)	±2000	V
	Charged Device Model (JEDEC JS-002)	±1000	V
I_{LU}	Latch Up Current (JEDEC JESD78F)	±100	mA

Recommended Operating Conditions

Symbol	Parameters	Rating	Unit
$V_{I/O}$	Input/Output Voltage	0 to 5.5	V
V_{CCB}	V_{REF_B} Supply Voltage	0 to 5.5	V
V_{REF_A} (V_{CCA})	Reference Voltage	0 to 5.5	V
V_{EN}	EN Pin Voltage	0 to 5.5	V
I_{PASS}	Pass Transistor Current	64	mA
T_A	Operating Ambient Temperature	-40 to +85	ºC

Electrical Characteristics

T_A=-40ºC~85ºC, from A to B or B to A (unless otherwise noted, all typical values are at T_A = 25°C.)

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
V_{IK}	I/O Input Clamp Voltage	I_I = -18mA, V_{EN} = 0V			-1.2	V
I_{IH}	Input Leakage Current	V_I = 5V, V_{EN} = 0V			5.0	uA
I_{CC}	Input Current	V_{CCB} = V_{EN} = 5.5V, V_{CCA} = 4.5V, I_O = 0mA, V_I = V_{CC} or GND		0.1	1	uA
$C_{I(REF\_A/B/EN)}$ (3)	Input Capacitance	V_I = 3V or 0V， T_A = 25°C.		11		pF
$C_{IO(off)}$ (3)	Off Capacitance	V_I = 3V or 0V, V_{EN} = 0V, T_A = 25°C.		4.0	6.0	pF
$C_{IO(on)}$ (3)	On Capacitance	V_I = 3V or 0V, V_{EN} = 3V, T_A = 25°C.		12	17	pF
R_{ON}(4)	On-state Resistance	V_I = 0V, I_O=64mA; V_{CCA} = 3.3V; V_{CCB}=V_{EN}=5V		3.0	7.0	Ω
		V_I = 0V, I_O=64mA; V_{CCA} = 1.8V; V_{CCB} = V_{EN} = 5V		4.0	10	
		V_I = 0V, I_O=64mA; V_{CCA} = 1.0V; V_{CCB} =V_{EN} = 5V		5.0	25	
		V_I = 0V, I_O=32mA; V_{REF_A}= 1.8V; V_{CCB} = V_{EN} =5V		4.0	9.0	
		V_I = 0V, I_O=32mA; V_{CCA}= 2.5V; V_{CCB} = V_{EN}= 5V		3.0	8.0	
		V_I = 1.8V, I_O=15mA; V_{CCA} = 3.3V; V_{CCB} = V_{EN} = 5V		4.0	13	
		V_I = 1.0V, I_O=10mA; V_{CCA} = 1.8V; V_{CCB} = V_{EN} =3.3V		7.0	24	
		V_I = 0V, I_O=10mA; V_{CCA} = 1.0V; V_{CCB} = V_{EN} = 3.3V		5.0	18	
		V_I = 0V, I_O=10mA; V_{CCA} = 1.0V; V_{CCB} = V_{EN} = 1.8V		6.0	19	

Note3: Guaranteed by design and characterization, not a FT item.

Note4: Measured by the voltage drop between the A and B pins at the indicated current through the switch. On-state resistance is determined by the lowest voltage of the two (A or B) pins.

AC Performance (Translating Down) Switching Characteristics

T_A=-40ºC~85ºC, from B to A, R_L=1KΩ (unless otherwise noted, all typical values are at T_A = 25°C.)

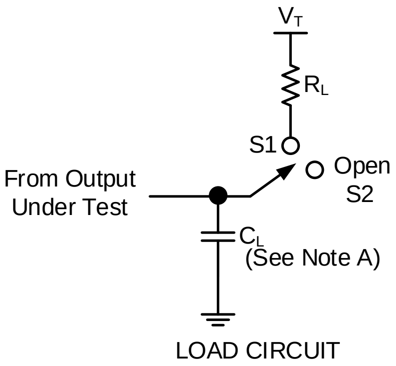
Symbol	Parameters	Conditions		Min	Typ	Max	Unit
t_{PLH}	Low-to-High Propagation Delay	V_{CCB} = V_{IH} =1.8V, V_{CCA} = 0.95V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.6	1.5	ns
			C_L = 30pF		0.8	2.0	
			C_L = 50pF		1.0	2.5	
		V_{CCB} = V_{IH} =1.8V, V_{CCA} = 1.2V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.8	1.5	
			C_L = 30pF		1.4	2.5	
			C_L = 50pF		3.0	4.0	
		V_{CCB} = V_{IH} =3.3V, V_{CCA} = 1.8V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.3	1.2	
			C_L = 30pF		0.5	2.0	
			C_L = 50pF		0.9	2.5	
		V_{CCB} = V_{IH} =5V, V_{CCA} = 3.3V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.8	1.2	
			C_L = 30pF		1.0	1.5	
			C_L = 50pF		1.2	2.0	
t_{PHL}	High-to-Low Propagation Delay	V_{CCB} = V_{IH} =1.8V, V_{CCA} = 0.95V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.4	2.5	
			C_L = 30pF		1.0	3.0	
			C_L = 50pF		2.0	4.0	
		V_{CCB} = V_{IH} =1.8V, V_{CCA} = 1.2V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.7	2.0	
			C_L = 30pF		1.3	3.0	
			C_L = 50pF		2.0	4.0	
		V_{CCB} = V_{IH} =3.3V, V_{CCA} = 1.8V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.4	2.0	
			C_L = 30pF		0.9	2.5	
			C_L = 50pF		1.5	3.0	
		V_{CCB} = V_{IH} =5V, V_{CCA} = 3.3V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.4	1.5	
			C_L = 30pF		1.0	2.5	
			C_L = 50pF		1.4	3.0	

AC Performance (Translating Up) Switching Characteristics

T_A=-40ºC~85ºC, from A to B, R_L=1KΩ (unless otherwise noted, all typical values are at T_A = 25°C.)

Symbol	Parameters	Conditions		Min	Typ	Max	Unit
t_{PLH}	Low-to-High Propagation Delay	V_{CCB} =1.8V, V_{CCA} = V_{IH} = 0.95V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.8	1.5	ns
			C_L = 30pF		1.0	2.0	
			C_L = 50pF		1.2	3.0	
		V_{CCB} = 1.8V, V_{CCA} = V_{IH} = 1.2V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		1.1	1.5	
			C_L = 30pF		1.3	2.0	
			C_L = 50pF		1.9	3.0	
		V_{CCB} = 3.3V, V_{CCA} = V_{IH} = 1.8V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.6	1.0	
			C_L = 30pF		0.8	1.5	
			C_L = 50pF		1.0	2.0	
		V_{CCB} = 5V, V_{CCA} = V_{IH} = 3.3V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.6	1.5	
			C_L = 30pF		0.8	2.5	
			C_L = 50pF		1.2	3.0	
t_{PHL}	High-to-Low Propagation Delay	V_{CCB} =1.8V, V_{CCA} = V_{IH} = 0.95V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		2.0	3.5	
			C_L = 30pF		2.8	4.5	
			C_L = 50pF		4.2	6.5	
		V_{CCB} = 1.8V, V_{CCA} = V_{IH} = 1.2V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		1.7	3.0	
			C_L = 30pF		2.6	3.5	
			C_L = 50pF		4.2	4.5	
		V_{CCB} = 3.3V, V_{CCA} = V_{IH} = 1.8V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		1.2	3.0	
			C_L = 30pF		1.8	4.0	
			C_L = 50pF		2.6	5.0	
		V_{CCB} = 5V, V_{CCA} = V_{IH} = 3.3V, V_{IL} = 0V, and V_M = 0.5 V_{CCA}	C_L = 20pF		0.8	2.0	
			C_L = 30pF		1.2	3.0	
			C_L = 50pF		1.8	4.0	

AC Performance Test Circuit



Usage	Switch
Translating Up	S1
Translating Down	S2

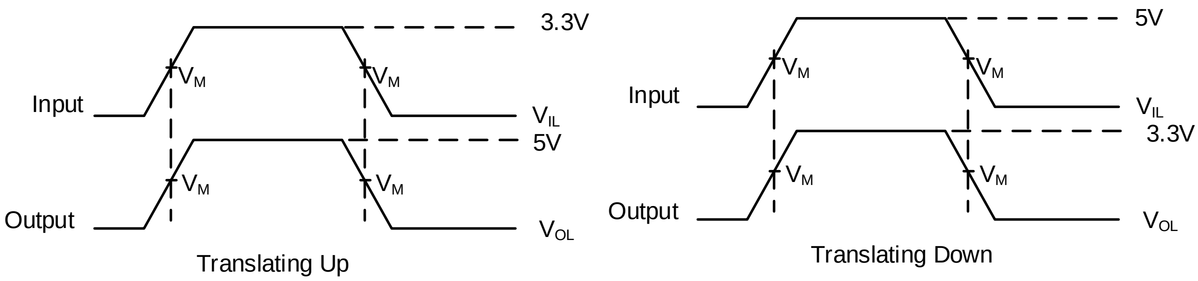


Figure 5. AC Performance Load Circuit for Outputs

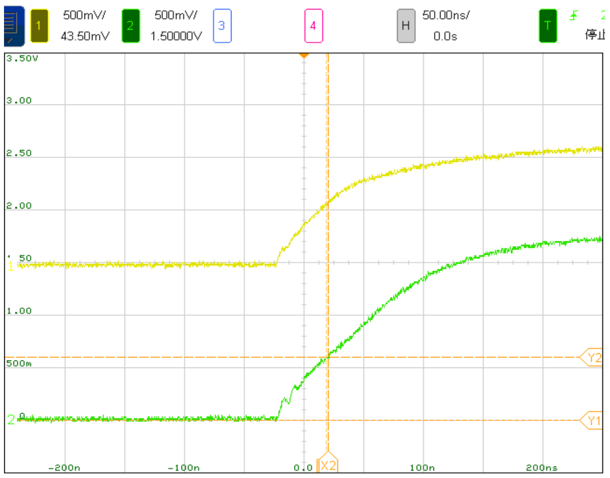
Note A: C_L includes probe and jig capacitance.

Note B: Generators that have the following characteristics generate all input pulses: PRR ≤ 10MHz, Zo = 50Ω, tr ≤ 2ns, tf ≤ 2ns.

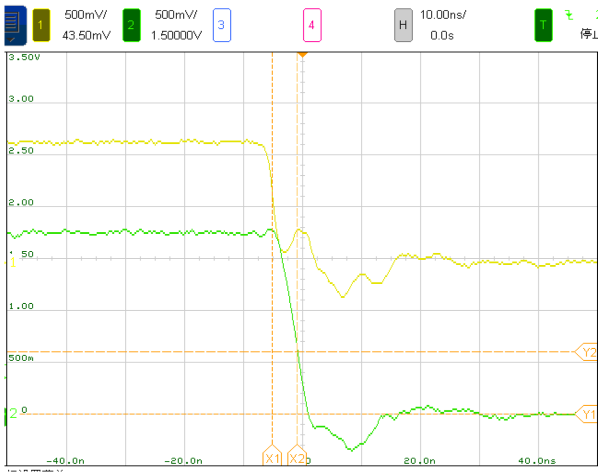
Note C: The outputs are measured one at a time, with one transition per measurement.

Typical Characteristics

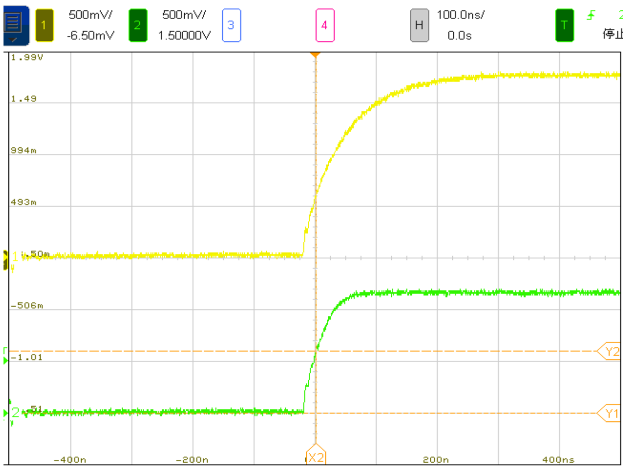
(V_{CCB}=1.8V, V_{CCA}=1.2V, C_L=50pF, R_{PU} =1KΩ，C_L = 50pF unless otherwise noted T_A=25°C.)



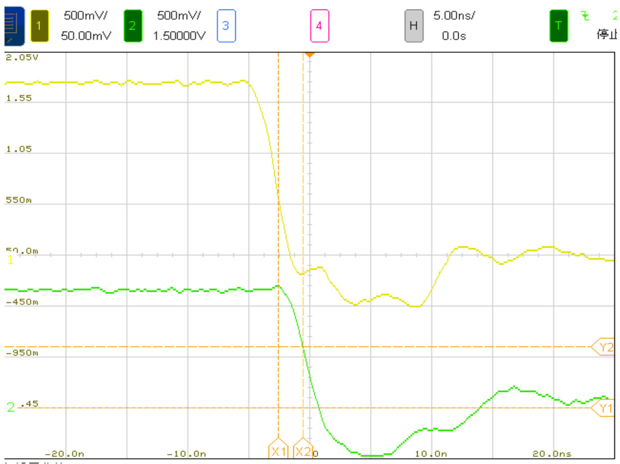
AC Performance t_{PLH} 1.2V to 1.8V



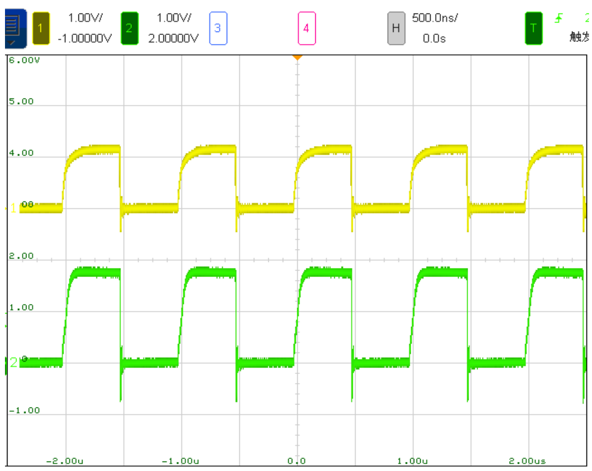
AC Performance t_{PHL} 1.2V to 1.8V



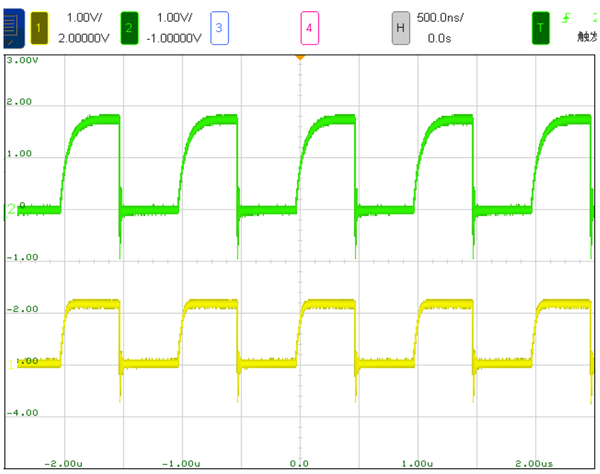
AC Performance t_{PLH} 1.8V to 1.2V



AC Performance t_{PHL} 1.8V to 1.2V



Voltage Translation, 1.2V to 1.8V, f=1MHz



Voltage Translation, 1.8V to 1.2V, f=1MHz

Application Circuits

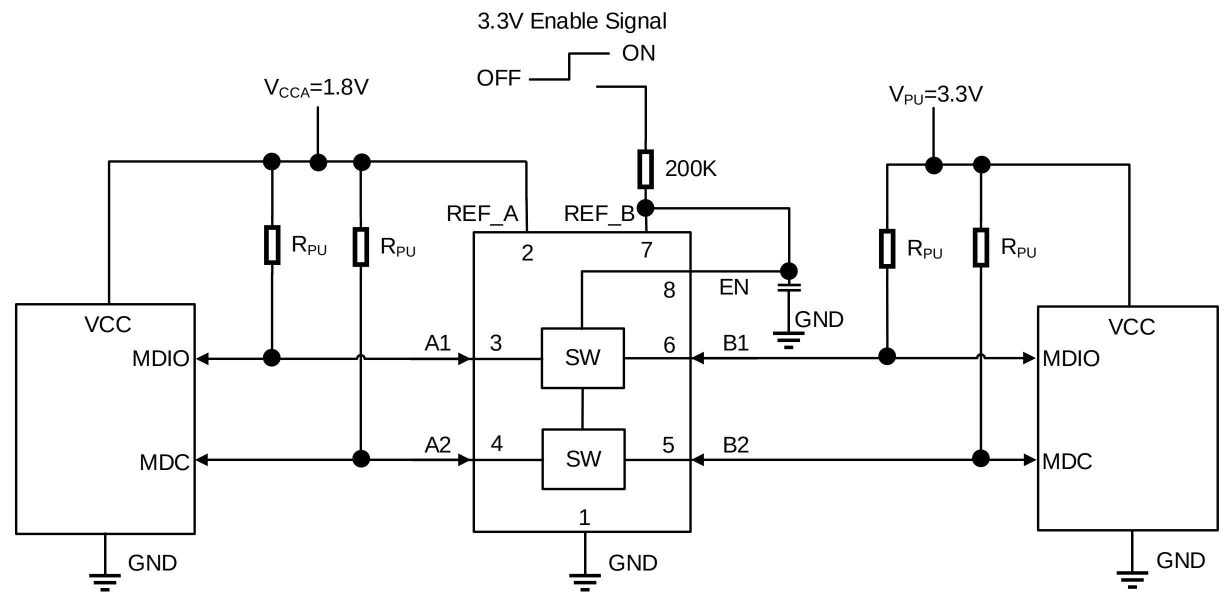


Figure 6. Typical Application Circuit for Open-Drain Translation (MDIO Shown as an Example)

In the previous figure, V_{CCB} is connected through a 200kΩ resistor to a 3.3V power supply and V_{REF_A} is set to 1.8V. The A1 and A2 channels have a maximum output voltage equal to V_{REF_A} and the B1 and B2 channels have has a maximum output voltage equal to V_{PU}.

The ETF0102 has an EN input that is used to disable the device by setting EN LOW, placing all I/Os in the high-impedance state. Since the ETF0102 of devices are switch-type voltage translators, the power consumption is very low.

Table 3. Application Operating Condition

Symbol	Parameters	Min	Typ	Max	Unit
$V_{CCA}(V_{REF\_A})$ (5)	Reference Voltage (A)	0.9		5.5	V
V_{CCB}	V_{REF_B} Supply Voltage (B)	V_{CCA} + 0.8		5.5	V
V_{EN}	Input Voltage on EN Pin	V_{CCA} + 0.8		5.5	V
V_{PU}	Pull-up Supply Voltage	0		V_{CCB}	V

Note5: $V_{CCA}(V_{REF\_A})$ is required to be the lowest voltage level across all inputs and outputs. The 200kΩ, bias resistor is required to allow V_{CCB} to regulate the EN input and properly bias the device for translation.

PCB Layout Guide

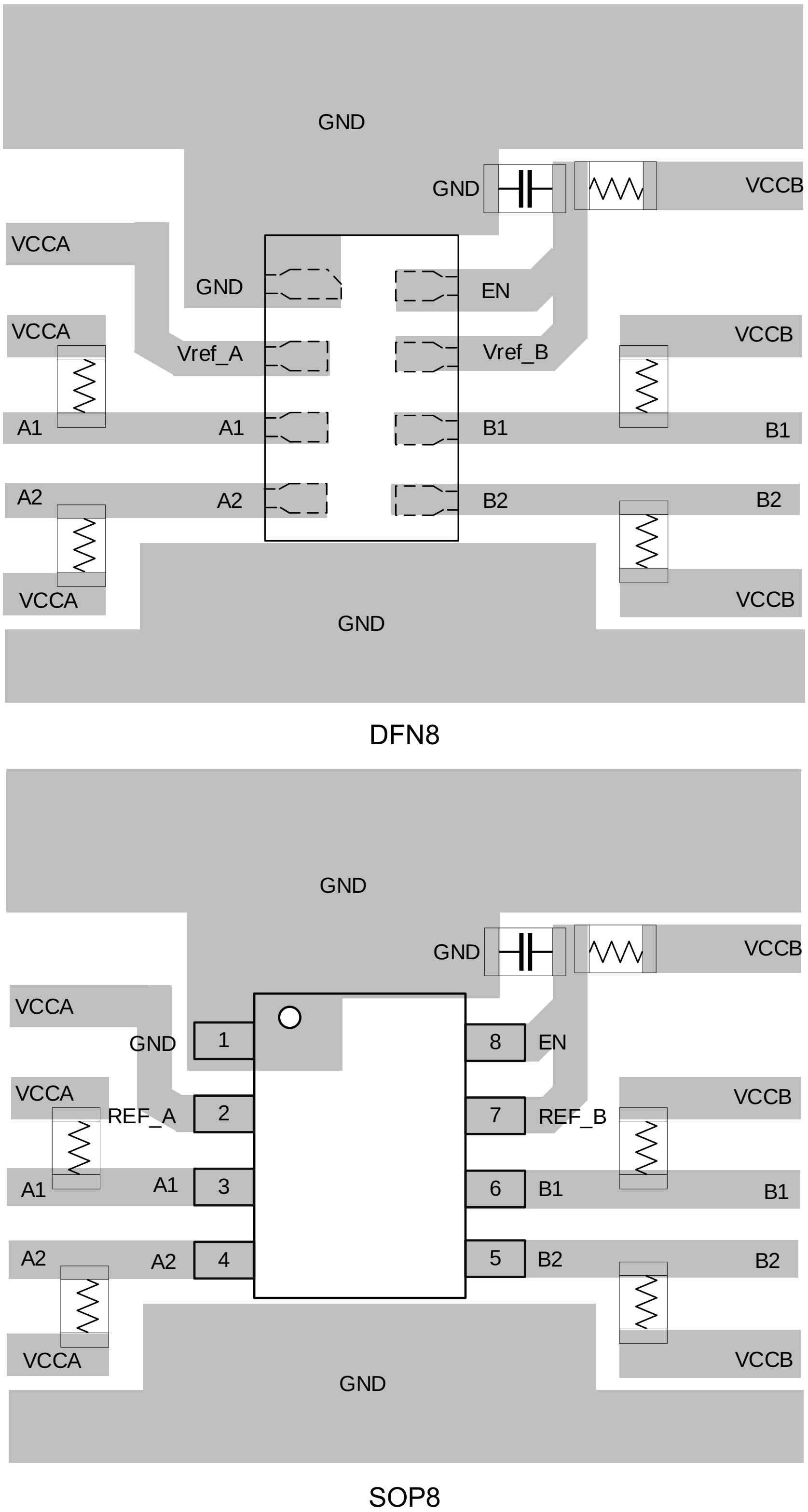
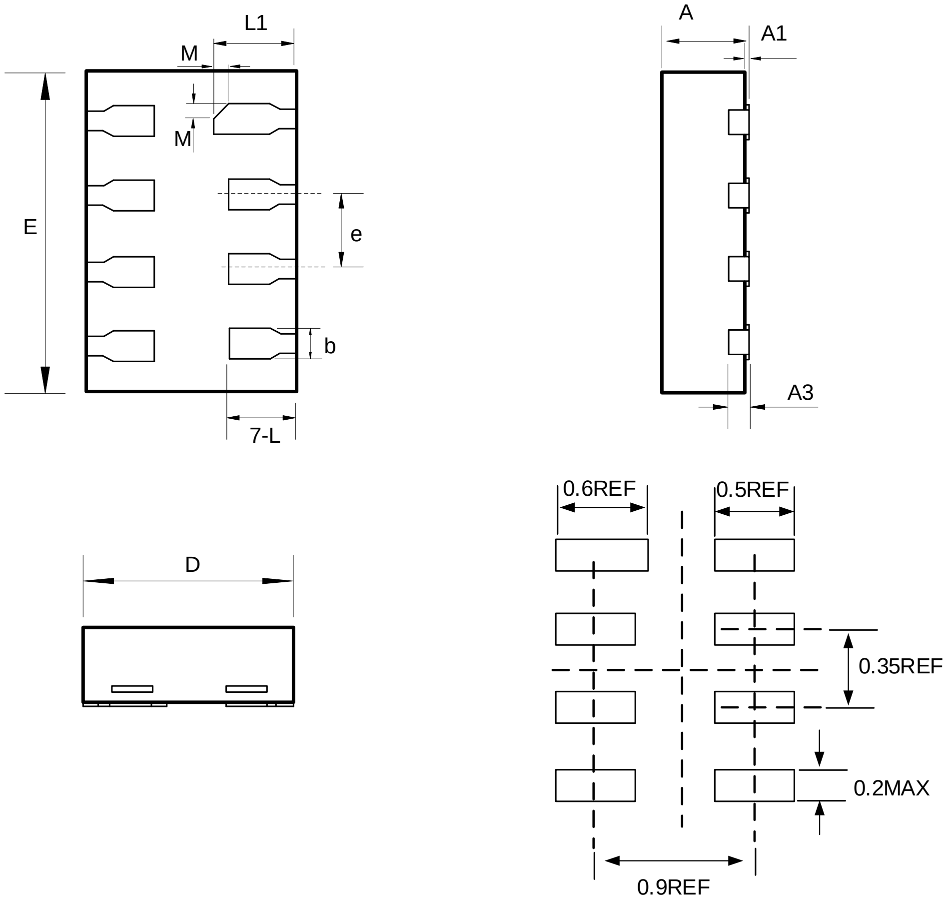


Figure 6. PCB Layout Guide

Package Dimension

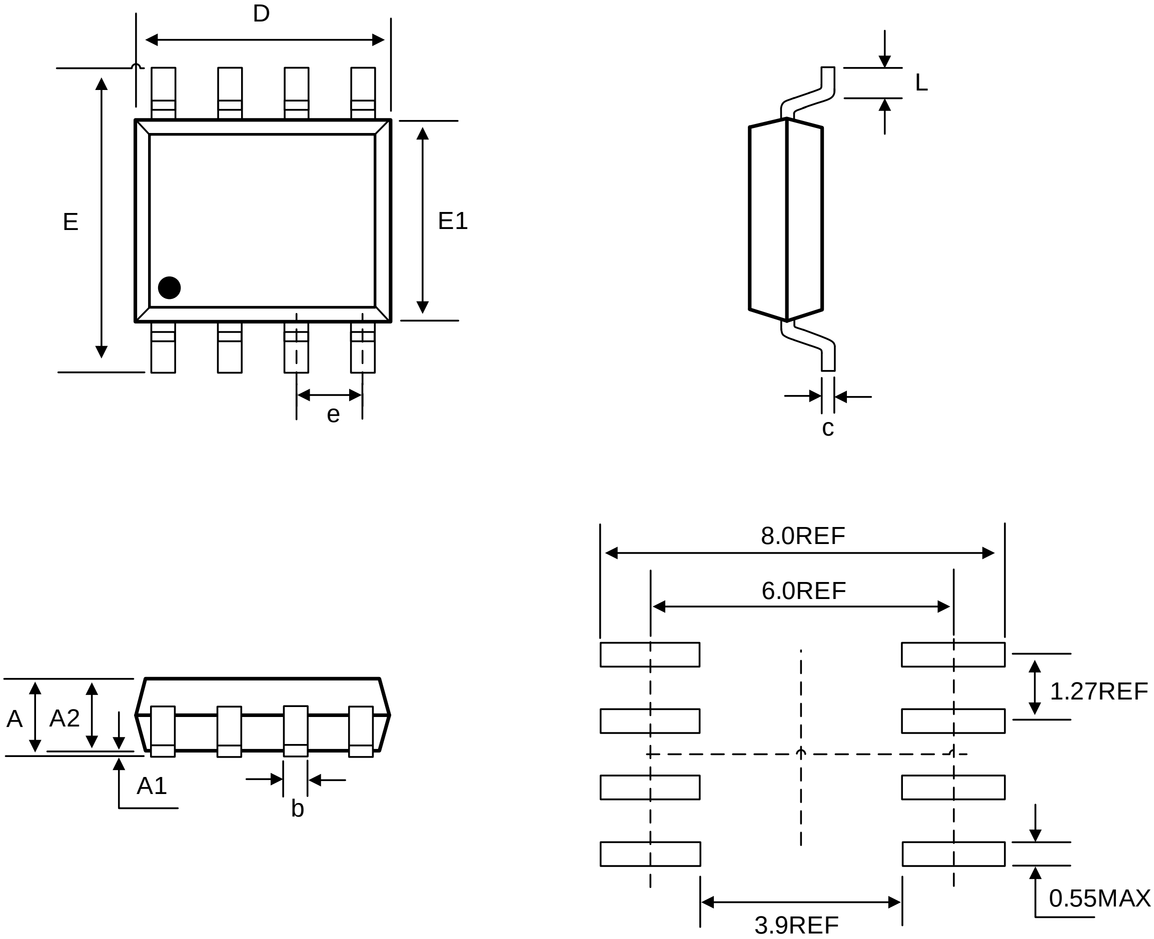
DFN8(1.4mm × 1.0mm)



COMMON DIMENSIONS
(Unit: mm)

SYMBOL	MIN	NOM	MAX
A	0.34	0.37	0.40
A1	0.00	0.02	0.05
A3		0.10REF	
b	0.125	0.175	0.225
D	0.90	1.00	1.10
E	1.30	1.40	1.50
e	0.30	0.35	0.40
L	0.25	0.30	0.35
L1	0.35	0.40	0.45
M		0.10REF	

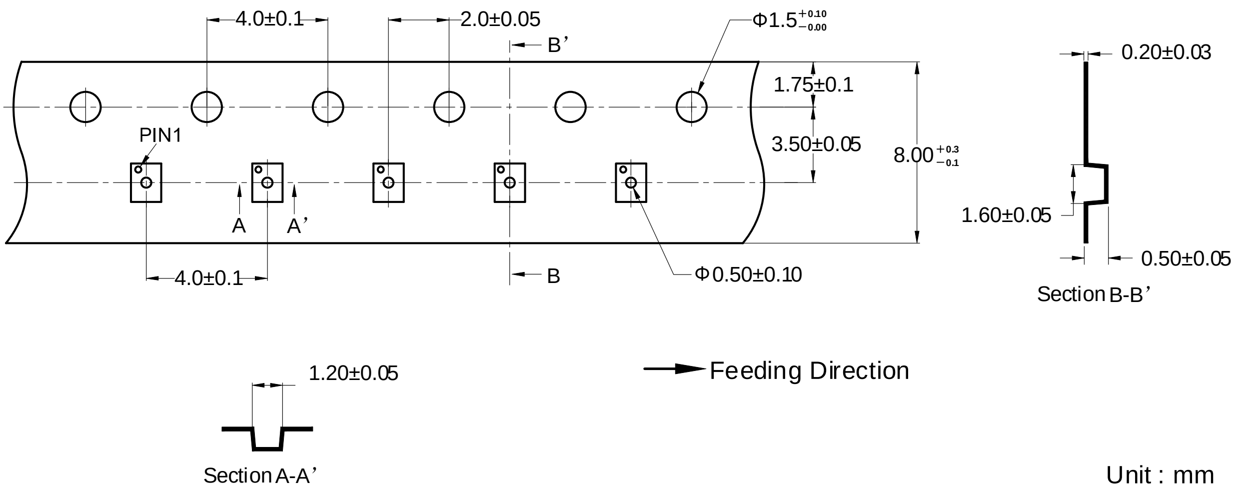
SOP8(3.9mm × 4.9mm)



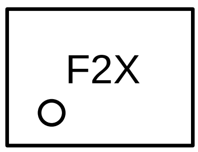
COMMON DIMENSIONS
(Unit: mm)

SYMBOL	MIN	NOM	MAX
A	-	-	1.90
A1	0.00	-	0.30
A2	1.20	1.40	1.60
b	0.35	-	0.47
c	0.15	-	0.27
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.35	0.60	0.85

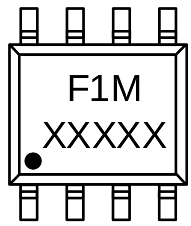
Tape Information (DFN8,1.4mm × 1mm)



Marking Information



F = Part Number
2X = Tracking Number
DFN8(1.4mm × 1mm)



F1M = Part Number
XXXXX = Tracking Number
SOP8(3.9mm × 4.9mm)

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2025-04-17	Initial Version	Zhang Wang	Liu Yi Guo	Liu Jia Ying
1.1	2025-10-10	Update Package Dimension	Zhang Wang	Liu Yi Guo	Liu Jia Ying
1.1.a	2025-10-13	Words correction	Shib		