

# 7UL1G86FS

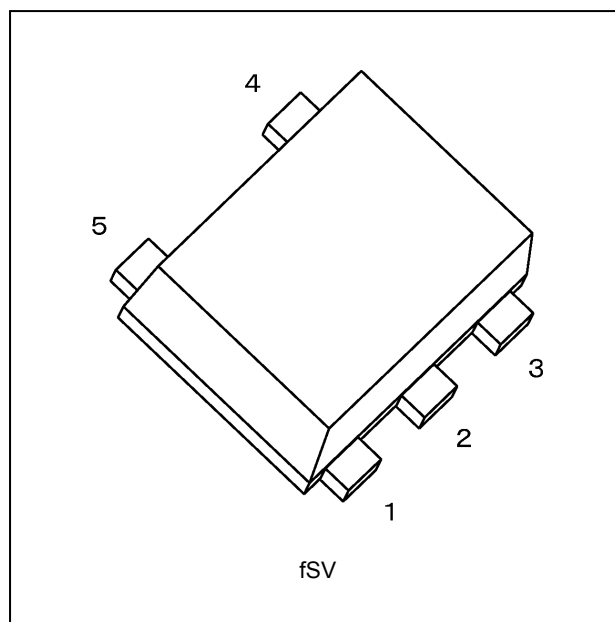
## 1. Functional Description

- 2-Input Exclusive-OR Gate

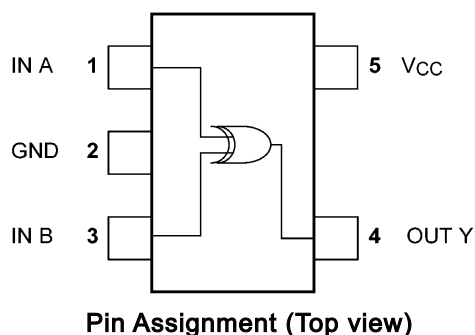
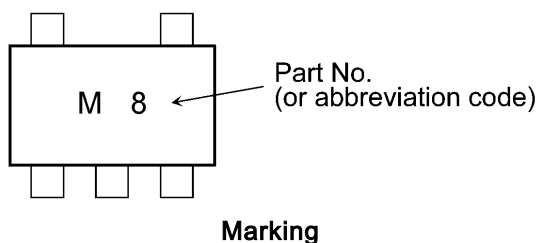
## 2. Features

- (1) Wide operating temperature range:  $T_{opr} = -40$  to  $125\text{ }^{\circ}\text{C}$
- (2) High output current:  $\pm 8.0\text{ mA}$  (min) at  $V_{CC} = 3.0\text{ V}$
- (3) Super high speed operation:  $t_{pd} = 2.5\text{ ns}$  (typ.) at  $V_{CC} = 3.3\text{ V}$ ,  $C_L = 15\text{ pF}$
- (4) Operating voltage range:  $V_{CC} = 0.9$  to  $3.6\text{ V}$
- (5)  $3.6\text{ V}$  tolerant inputs
- (6)  $3.6\text{ V}$  power down protection output

## 3. Packaging



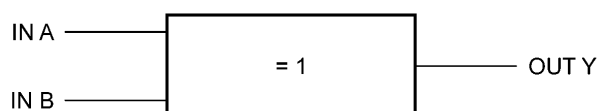
## 4. Marking and Pin Assignment



Start of commercial production

2021-06

## 5. IEC Logic Symbol



## 6. Truth Table

Input A	Input B	Output Y
L	L	L
L	H	H
H	L	H
H	H	L

## 7. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 4.6	V
Input voltage	$V_{IN}$		-0.5 to 4.6	V
DC output voltage	$V_{OUT}$	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to $V_{CC} + 0.5$	
Input diode current	$I_{IK}$		-20	mA
Output diode current	$I_{OK}$	(Note 3)	-20	mA
DC output current	$I_{OUT}$		$\pm 25$	mA
$V_{CC}$ /ground current	$I_{CC}$		$\pm 50$	mA
Power dissipation	$P_D$		50	mW
Storage temperature	$T_{stg}$		-65 to 150	$^{\circ}\text{C}$

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).

Note 1:  $V_{CC} = 0\text{ V}$

Note 2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 3:  $V_{OUT} < \text{GND}$

## 8. Operating Ranges (Note)

Characteristics	Symbol	Note	Test Condition	Rating	Unit
Supply voltage	$V_{CC}$		—	0.9 to 3.6	V
Input voltage	$V_{IN}$		—	0 to 3.6	V
Output voltage	$V_{OUT}$	(Note 1)	—	0 to 3.6	V
		(Note 2)	—	0 to $V_{CC}$	
Output current	$I_{OH}, I_{OL}$		$V_{CC} = 3.0 \text{ to } 3.6 \text{ V}$	$\pm 8.0$	mA
			$V_{CC} = 2.3 \text{ to } 2.7 \text{ V}$	$\pm 4.0$	
			$V_{CC} = 1.65 \text{ to } 1.95 \text{ V}$	$\pm 3.0$	
			$V_{CC} = 1.4 \text{ to } 1.6 \text{ V}$	$\pm 1.7$	
			$V_{CC} = 1.1 \text{ to } 1.3 \text{ V}$	$\pm 0.3$	
			$V_{CC} = 0.9 \text{ V}$	$\pm 0.02$	
Operating temperature	$T_{opr}$		—	-40 to 125	°C
Input rise and fall time	$dt/dv$		$V_{IN} = 0.8 \text{ to } 2.0 \text{ V}, V_{CC} = 3.0 \text{ V}$	0 to 10	ns/V

Note: The operating ranges must be maintained to ensure the normal operation of the device.

Unused inputs must be tied to either  $V_{CC}$  or GND.

Note 1:  $V_{CC} = 0 \text{ V}$

Note 2: High (H) or Low (L) state.

## 9. Electrical Characteristics

### 9.1. DC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Typ.	Max	Unit
High-level input voltage	$V_{IH}$	—		0.9	$V_{CC}$	—	—	V
				1.1 to 1.3	$V_{CC} \times 0.70$	—	—	
				1.4 to 1.6	$V_{CC} \times 0.65$	—	—	
				1.65 to 1.95	$V_{CC} \times 0.65$	—	—	
				2.3 to 2.7	1.7	—	—	
				3.0 to 3.6	2.0	—	—	
Low-level input voltage	$V_{IL}$	—		0.9	—	—	GND	V
				1.1 to 1.3	—	—	$V_{CC} \times 0.30$	
				1.4 to 1.6	—	—	$V_{CC} \times 0.35$	
				1.65 to 1.95	—	—	$V_{CC} \times 0.35$	
				2.3 to 2.7	—	—	0.7	
				3.0 to 3.6	—	—	0.8	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -0.02\text{ mA}$	0.9	0.75	—	—	V
			$I_{OH} = -0.3\text{ mA}$	1.1 to 1.3	$V_{CC} \times 0.75$	—	—	
			$I_{OH} = -1.7\text{ mA}$	1.4 to 1.6	$V_{CC} \times 0.75$	—	—	
			$I_{OH} = -3.0\text{ mA}$	1.65 to 1.95	$V_{CC} - 0.45$	—	—	
			$I_{OH} = -4.0\text{ mA}$	2.3 to 2.7	2.0	—	—	
			$I_{OH} = -8.0\text{ mA}$	3.0 to 3.6	2.48	—	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 0.02\text{ mA}$	0.9	—	—	0.1	V
			$I_{OL} = 0.3\text{ mA}$	1.1 to 1.3	—	—	$V_{CC} \times 0.25$	
			$I_{OL} = 1.7\text{ mA}$	1.4 to 1.6	—	—	$V_{CC} \times 0.25$	
			$I_{OL} = 3.0\text{ mA}$	1.65 to 1.95	—	—	0.45	
			$I_{OL} = 4.0\text{ mA}$	2.3 to 2.7	—	—	0.4	
			$I_{OL} = 8.0\text{ mA}$	3.0 to 3.6	—	—	0.4	
Input leakage current	$I_{IN}$	$V_{IN} = 0\text{ to }3.6\text{ V}$		0 to 3.6	—	—	$\pm 0.1$	$\mu\text{A}$
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0\text{ to }3.6\text{ V}$ , $V_{OUT} = 0\text{ to }3.6\text{ V}$		0	—	—	1.0	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		3.6	—	—	1.0	$\mu\text{A}$

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

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		0.9	$V_{CC}$	—	V
				1.1 to 1.3	$V_{CC} \times 0.70$	—	
				1.4 to 1.6	$V_{CC} \times 0.65$	—	
				1.65 to 1.95	$V_{CC} \times 0.65$	—	
				2.3 to 2.7	1.7	—	
				3.0 to 3.6	2.0	—	
Low-level input voltage	$V_{IL}$	—		0.9	—	GND	V
				1.1 to 1.3	—	$V_{CC} \times 0.30$	
				1.4 to 1.6	—	$V_{CC} \times 0.35$	
				1.65 to 1.95	—	$V_{CC} \times 0.35$	
				2.3 to 2.7	—	0.7	
				3.0 to 3.6	—	0.8	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -0.02$ mA	0.9	0.75	—	V
			$I_{OH} = -0.3$ mA	1.1 to 1.3	$V_{CC} \times 0.75$	—	
			$I_{OH} = -1.7$ mA	1.4 to 1.6	$V_{CC} \times 0.75$	—	
			$I_{OH} = -3.0$ mA	1.65 to 1.95	$V_{CC} - 0.45$	—	
			$I_{OH} = -4.0$ mA	2.3 to 2.7	2.0	—	
			$I_{OH} = -8.0$ mA	3.0 to 3.6	2.48	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 0.02$ mA	0.9	—	0.1	V
			$I_{OL} = 0.3$ mA	1.1 to 1.3	—	$V_{CC} \times 0.25$	
			$I_{OL} = 1.7$ mA	1.4 to 1.6	—	$V_{CC} \times 0.25$	
			$I_{OL} = 3.0$ mA	1.65 to 1.95	—	0.45	
			$I_{OL} = 4.0$ mA	2.3 to 2.7	—	0.4	
			$I_{OL} = 8.0$ mA	3.0 to 3.6	—	0.4	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6$ V		0 to 3.6	—	$\pm 0.5$	$\mu$ A
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0$ to $3.6$ V, $V_{OUT} = 0$ to $3.6$ V		0	—	10.0	$\mu$ A
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		3.6	—	10.0	$\mu$ A

## 9.3. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $125\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		0.9	$V_{CC}$	—	V
				1.1 to 1.3	$V_{CC} \times 0.70$	—	
				1.4 to 1.6	$V_{CC} \times 0.65$	—	
				1.65 to 1.95	$V_{CC} \times 0.65$	—	
				2.3 to 2.7	1.7	—	
				3.0 to 3.6	2.0	—	
Low-level input voltage	$V_{IL}$	—		0.9	—	GND	V
				1.1 to 1.3	—	$V_{CC} \times 0.30$	
				1.4 to 1.6	—	$V_{CC} \times 0.35$	
				1.65 to 1.95	—	$V_{CC} \times 0.35$	
				2.3 to 2.7	—	0.7	
				3.0 to 3.6	—	0.8	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -0.02\text{ mA}$	0.9	0.75	—	V
			$I_{OH} = -0.3\text{ mA}$	1.1 to 1.3	$V_{CC} \times 0.73$	—	
			$I_{OH} = -1.7\text{ mA}$	1.4 to 1.6	$V_{CC} \times 0.73$	—	
			$I_{OH} = -3.0\text{ mA}$	1.65 to 1.95	$V_{CC} - 0.5$	—	
			$I_{OH} = -4.0\text{ mA}$	2.3 to 2.7	1.95	—	
			$I_{OH} = -8.0\text{ mA}$	3.0 to 3.6	2.4	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 0.02\text{ mA}$	0.9	—	0.1	V
			$I_{OL} = 0.3\text{ mA}$	1.1 to 1.3	—	$V_{CC} \times 0.27$	
			$I_{OL} = 1.7\text{ mA}$	1.4 to 1.6	—	$V_{CC} \times 0.27$	
			$I_{OL} = 3.0\text{ mA}$	1.65 to 1.95	—	0.5	
			$I_{OL} = 4.0\text{ mA}$	2.3 to 2.7	—	0.45	
			$I_{OL} = 8.0\text{ mA}$	3.0 to 3.6	—	0.45	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6\text{ V}$		0 to 3.6	—	$\pm 2.0$	$\mu\text{A}$
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0$ to $3.6\text{ V}$ , $V_{OUT} = 0$ to $3.6\text{ V}$		0	—	80.0	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		3.6	—	80.0	$\mu\text{A}$

## 9.4. AC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$ , Input: $t_r = t_f = 3\text{ ns}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Typ.	Max	Unit
Propagation delay time	$t_{PLH}, t_{PHL}$		$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	10	—	20.7	—	ns
				1.1 to 1.3		—	10.5	18.4	
				1.4 to 1.6		—	6.1	8.5	
				1.65 to 1.95		—	4.5	6.2	
				2.3 to 2.7		—	3.0	3.9	
				3.0 to 3.6		—	2.3	3.1	
Propagation delay time	$t_{PLH}, t_{PHL}$		$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	15	—	22.9	—	ns
				1.1 to 1.3		—	11.5	21.5	
				1.4 to 1.6		—	6.7	9.3	
				1.65 to 1.95		—	4.9	6.9	
				2.3 to 2.7		—	3.2	4.4	
				3.0 to 3.6		—	2.5	3.4	
Propagation delay time	$t_{PLH}, t_{PHL}$		$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	30	—	30.6	—	ns
				1.1 to 1.3		—	14.8	29.6	
				1.4 to 1.6		—	8.5	13.1	
				1.65 to 1.95		—	6.3	9.2	
				2.3 to 2.7		—	4.3	5.7	
				3.0 to 3.6		—	3.3	4.4	
Input capacitance	$C_{IN}$		—	3.6	—	—	3	—	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)	—	0.9 to 3.6	—	—	9	—	pF

Note 1:  $C_{PD}$  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.

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

## 9.5. AC Characteristics

(Unless otherwise specified,  $T_a = -40\text{ to }85\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	10	—	—	ns
			1.1 to 1.3		1.0	34.2	
			1.4 to 1.6		1.0	10.0	
			1.65 to 1.95		1.0	6.7	
			2.3 to 2.7		1.0	4.4	
			3.0 to 3.6		1.0	3.7	
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	15	—	—	ns
			1.1 to 1.3		1.0	37.2	
			1.4 to 1.6		1.0	11.2	
			1.65 to 1.95		1.0	7.1	
			2.3 to 2.7		1.0	5.0	
			3.0 to 3.6		1.0	3.9	
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	30	—	—	ns
			1.1 to 1.3		1.0	56.0	
			1.4 to 1.6		1.0	15.9	
			1.65 to 1.95		1.0	9.6	
			2.3 to 2.7		1.0	6.1	
			3.0 to 3.6		1.0	4.8	

## 9.6. AC Characteristics

(Unless otherwise specified,  $T_a = -40$  to  $125$  °C, Input:  $t_r = t_f = 3$  ns)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	10	—	—	ns
			1.1 to 1.3		1.0	44.8	
			1.4 to 1.6		1.0	11.0	
			1.65 to 1.95		1.0	7.1	
			2.3 to 2.7		1.0	4.8	
			3.0 to 3.6		1.0	4.1	
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	15	—	—	ns
			1.1 to 1.3		1.0	47.7	
			1.4 to 1.6		1.0	12.5	
			1.65 to 1.95		1.0	7.6	
			2.3 to 2.7		1.0	5.4	
			3.0 to 3.6		1.0	4.3	
Propagation delay time	$t_{PLH}, t_{PHL}$	$R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	0.9	30	—	—	ns
			1.1 to 1.3		1.0	73.6	
			1.4 to 1.6		1.0	17.8	
			1.65 to 1.95		1.0	10.2	
			2.3 to 2.7		1.0	6.6	
			3.0 to 3.6		1.0	5.2	

## 9.7. AC Waveform

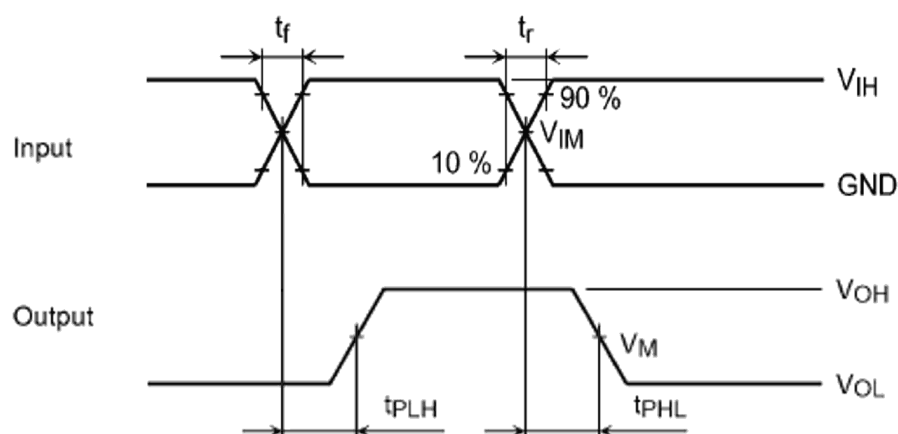


Fig. 9.7.1  $t_{PLH}$ ,  $t_{PHL}$

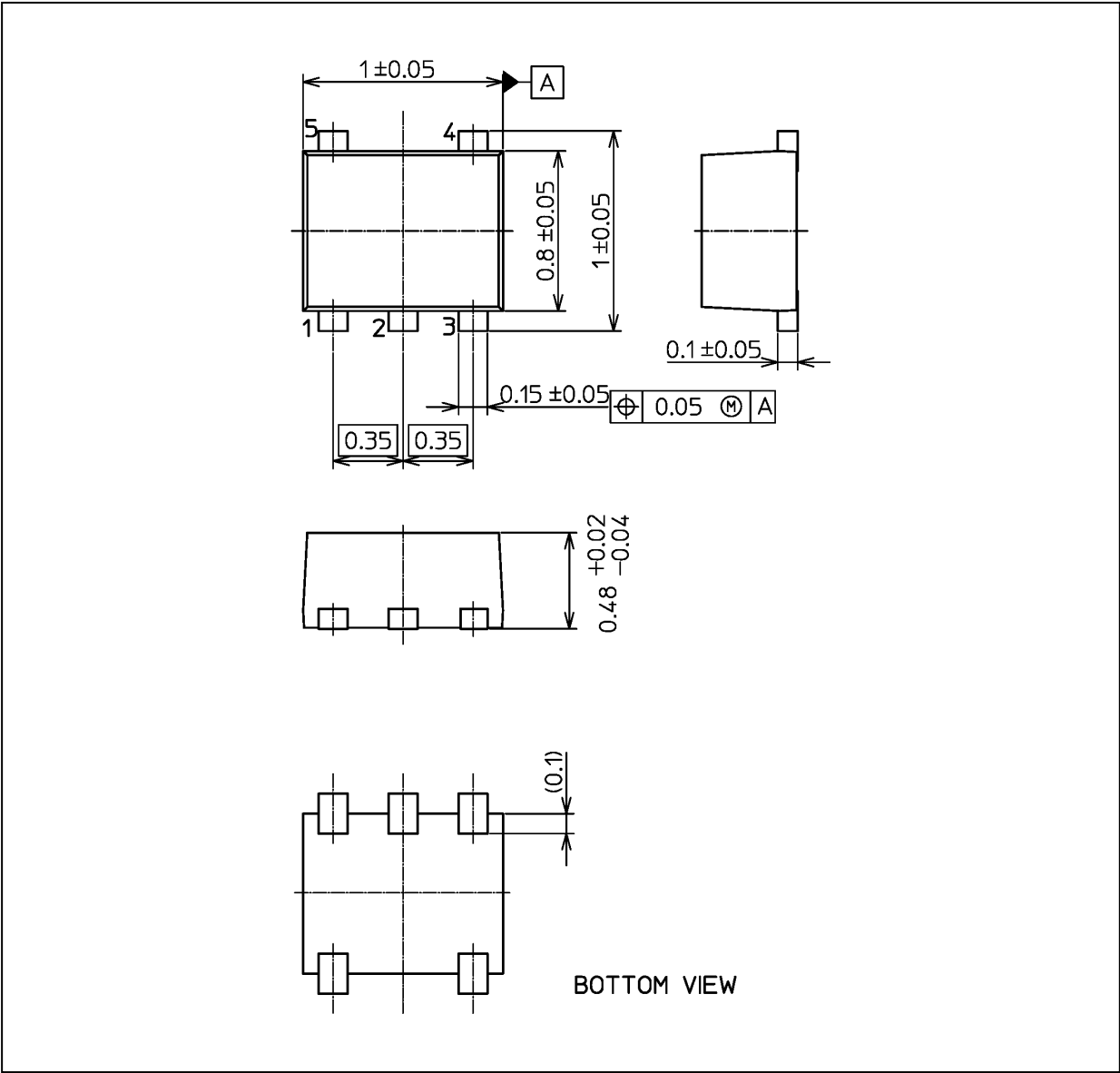
Table 9.7.1 AC Waveform Symbols

	Symbol	$V_{CC} = 3.3 \pm 0.3\text{ V}$	$V_{CC} = 2.5 \pm 0.2\text{ V}$	$V_{CC} = 1.8 \pm 0.15\text{ V}$	$V_{CC} = 1.5 \pm 0.1\text{ V}$	$V_{CC} = 1.2 \pm 0.1\text{ V}$	$V_{CC} = 0.9\text{ V}$
Input	$V_{IH}$	$V_{CC}$	$V_{CC}$	$V_{CC}$	$V_{CC}$	$V_{CC}$	$V_{CC}$
	$V_M$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$
Output	$V_M$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$



Package Dimensions

Unit: mm



Weight: 1.0 mg (typ.)

Package Name(s)
Nickname: fSV

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