CMOS Digital Integrated Circuits Silicon Monolithic

74VHC9164FT

1. Functional Description

- 8-Bit Shift Register (P-IN, S-OUT/S-IN, P-OUT)

2. General

The 74VHC9164FT is an ultra-high-speed 8-Bit Shift Register fabricated using silicon-gate CMOS technology. The 74VHC9164FT combines low power consumption of CMOS with Schottky TTL speeds.

The 74VHC9164FT has parallel data inputs/outputs, a serial input and a serial output. It converts parallel data into serial data or vice versa.

When P/S CONT is Low, Q/D1 to Q/D8 are configured as parallel data outputs. At this time, the SI input is serially loaded on the rising edges of CK and unloaded from the Q/D1 to Q/D8 outputs in parallel. When $\overline{\text{CLR/LOAD}}$ input is Low, all flip-flops are asynchronously reset, irrespective of the CK state.

When P/S CONT is High, Q/D1 to Q/D8 are configured as parallel data inputs. At this time, when $\overline{\text{CLR/LOAD}}$ is Low, Q/D1 to Q/D8 latch data in parallel asynchronously from the CK input.

All the inputs have hysteresis between the positive-going and negative-going thresholds. Thus the 74VHC9164FT is capable of squaring up transitions of slowly changing input signals and provides an improved noise immunity.

Additionally, all the inputs have a newly developed protection circuit without a diode returned to V_{CC}. This enables the inputs to be tolerant of up to 5.5 volts even when power supply is down.

The input power-down protection capability makes the 74VHC9164FT ideal for a wide range of applications, such as interfacing between different voltages, voltage translation from 5 V to 3 V and battery back-up circuits.

3. Features

(1) AEC-Q100 (Rev. H) (Note 1)

(2) Wide operating temperature range: T_{opr} = -40 to 125 °C

(3) High speed: f_{MAX} = 149 MHz (typ.) at V_{CC} = 5.0 V

(4) Low power dissipation: I_{CC} = 4.0 μA (max) at T_a = 25 °C

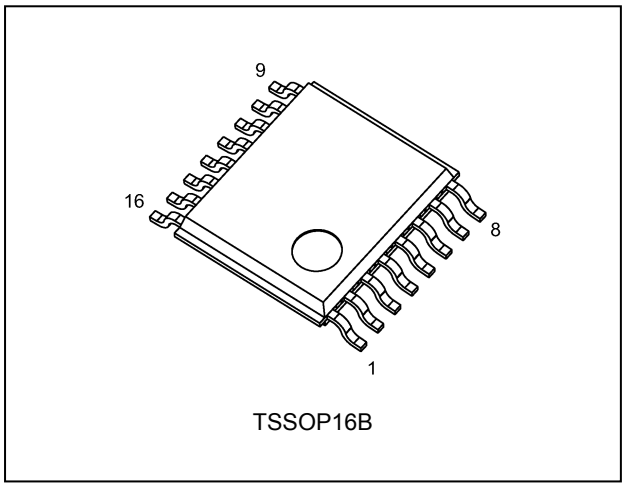
(5) Power-down protection is provided on all inputs.

(6) Balanced propagation delays: $t_{PLH} \approx t_{PHL}$

(7) Wide operating voltage range: $V_{CC(opr)}$ = 2.0 V to 5.5 V

Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.

4. Packaging

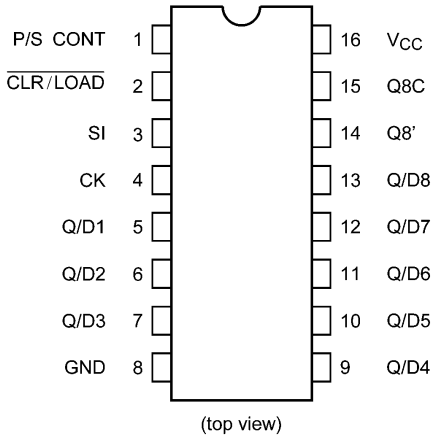


TSSOP16B

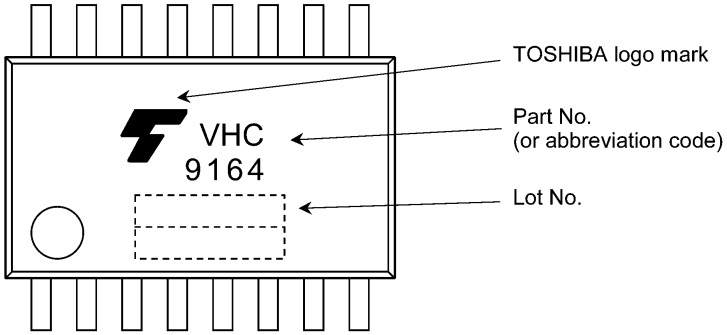
Start of commercial production

2014-06

5. Pin Assignment



6. Marking

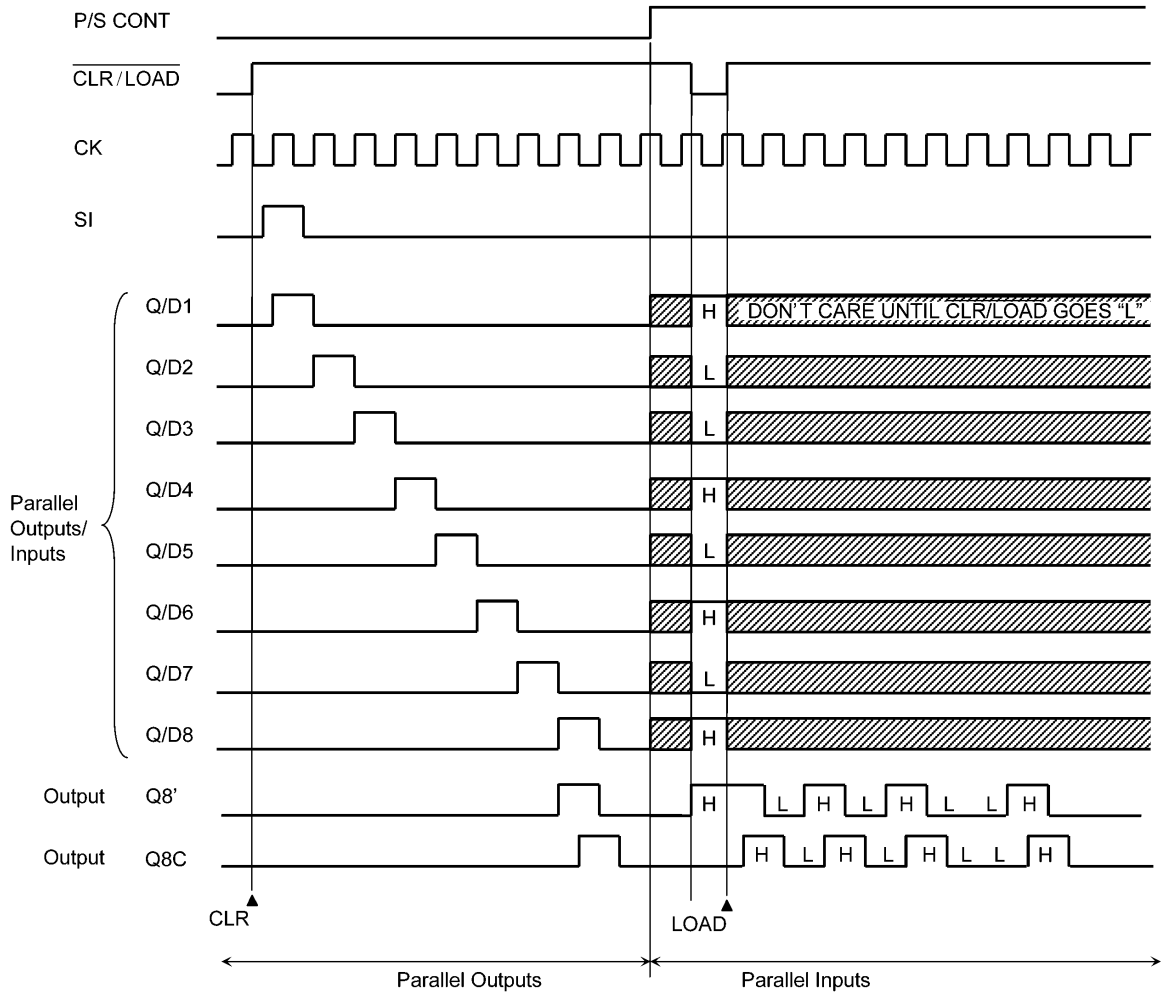


7. Truth Table

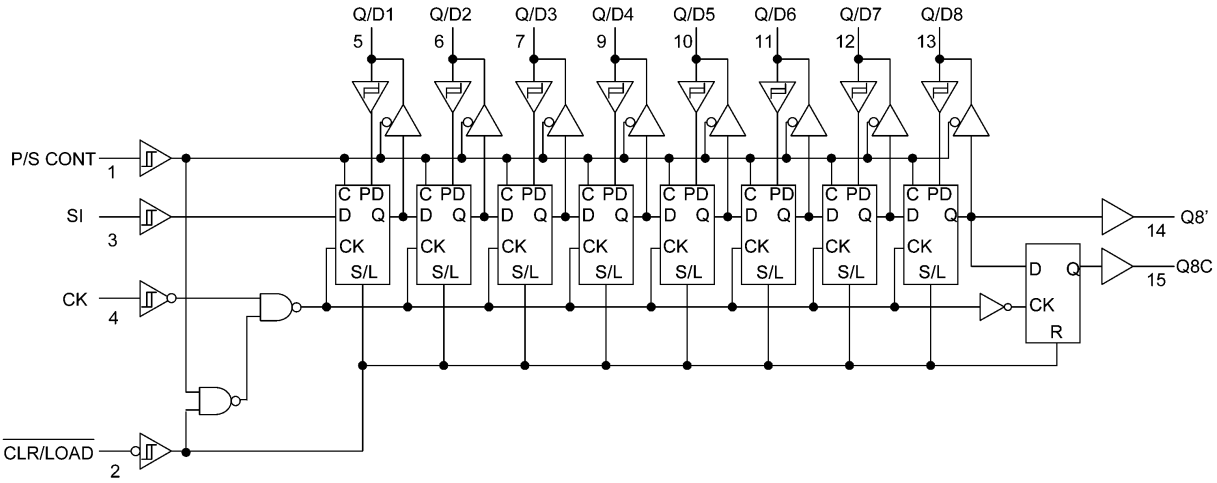
Inputs				Parallel Outputs/Inputs	Function
P/S CONT	$\overline{\text{CLR}}$/LOAD	SI	CK	Q/D1·····Q/D8	
L	X	X	X	Output- state Parallel Outputs	Q/D1 to Q/D8 are configured as parallel outputs.
L	L	X	X		Shift register is cleared.
L	H	L	↑		First stage of S.R. becomes "L". Other stages store the data of previous stage, respectively.
L	H	H	↑		First stage of S.R. becomes "H". Other stages store the data of previous stage, respectively.
L	H	X	↓		The shift register remains unchanged. The Q8C output keeps the value of the previous flip-flop.
H	X	X	X	Input- state Parallel Inputs	Q/D1 to Q/D8 are configured as parallel inputs.
H	L	X	X		Q/D1 to Q/D8 are latched into the shift register.
H	H	L	↑		First stage of S.R. becomes "L". Other stages store the data of previous stage, respectively.
H	H	H	↑		First stage of S.R. becomes "H". Other stages store the data of previous stage, respectively.
H	H	X	↓		The shift register remains unchanged. The Q8C output keeps the value of the previous flip-flop.

X: Don't care

8. Timing Diagrams



9. System Diagram



10. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		-0.5 to 7.0	V
Input voltage	V_{IN}		-0.5 to 7.0	V
Output voltage	V_{OUT}		-0.5 to V_{CC} + 0.5	V
Bus I/O voltage (Q/D1 to Q/D8)	$V_{I/O}$	(Note 1)	-0.5 to 7.0	V
		(Note 2)	-0.5 to V_{CC} + 0.5	
Input diode current	I_{IK}		-20	mA
Output diode current	I_{OK}		±20	mA
Output current	I_{OUT}		±25	mA
V_{CC}/ground current	I_{CC}		±75	mA
Power dissipation	P_D	(Note 3)	180	mW
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).

Note 1: Output in OFF state.

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

Note 3: 180 mW in the range of T_a = -40 to 85 °C. From T_a = 85 to 125 °C a derating factor of -3.25 mW/°C shall be applied until 50 mW.

11. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		2.0 to 5.5	V
Input voltage	V_{IN}		0 to 5.5	V
Output voltage	V_{OUT}		0 to V_{CC}	V
Bus I/O voltage (Q/D1 to Q/D8)	$V_{I/O}$	(Note 1)	0 to 5.5	V
		(Note 2)	0 to V_{CC}	
Operating temperature	T_{opr}		-40 to 125	°C

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: Output in OFF state.

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

12. Electrical Characteristics

12.1. DC Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Typ.	Max	Unit
Positive threshold voltage	V_P	—		3.0	—	—	2.20	V
				4.5	—	—	3.15	
				5.5	—	—	3.85	
Negative threshold voltage	V_N	—		3.0	0.90	—	—	V
				4.5	1.35	—	—	
				5.5	1.65	—	—	
Hysteresis voltage	V_H	—		3.0	0.30	—	1.20	V
				4.5	0.40	—	1.40	
				5.5	0.50	—	1.60	
High-level output voltage	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = -50 μA	2.0	1.9	2.0	—	V
				3.0	2.9	3.0	—	
				4.5	4.4	4.5	—	
			I_{OH} = -4 mA	3.0	2.58	—	—	
			I_{OH} = -8 mA	4.5	3.94	—	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 50 μA	2.0	—	0.0	0.1	V
				3.0	—	0.0	0.1	
				4.5	—	0.0	0.1	
			I_{OL} = 4 mA	3.0	—	—	0.36	
			I_{OL} = 8 mA	4.5	—	—	0.36	
3-state output OFF-state leakage current (Q/D1 to Q/D8)	I_{OZ}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = 5.5 V or GND		0 to 5.5	—	—	±0.25	μA
Input leakage current	I_{IN}	V_{IN} = 5.5 V or GND		0 to 5.5	—	—	±0.1	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND		5.5	—	—	4.0	μA

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

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Positive threshold voltage	V_P	—		3.0	—	2.20	V
				4.5	—	3.15	
				5.5	—	3.85	
Negative threshold voltage	V_N	—		3.0	0.90	—	V
				4.5	1.35	—	
				5.5	1.65	—	
Hysteresis voltage	V_H	—		3.0	0.30	1.20	V
				4.5	0.40	1.40	
				5.5	0.50	1.60	
High-level output voltage	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = -50 μA	2.0	1.9	—	V
				3.0	2.9	—	
				4.5	4.4	—	
			I_{OH} = -4 mA	3.0	2.48	—	
			I_{OH} = -8 mA	4.5	3.80	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 50 μA	2.0	—	0.1	V
				3.0	—	0.1	
				4.5	—	0.1	
			I_{OL} = 4 mA	3.0	—	0.44	
			I_{OL} = 8 mA	4.5	—	0.44	
3-state output OFF-state leakage current (Q/D1 to Q/D8)	I_{OZ}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = 5.5 V or GND		0 to 5.5	—	±2.5	μA
Input leakage current	I_{IN}	V_{IN} = 5.5 V or GND		0 to 5.5	—	±1.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND		5.5	—	40.0	μA

12.3. DC Characteristics (Unless otherwise specified, T_a = -40 to 125 °C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Positive threshold voltage	V_P	—		3.0	—	2.20	V
				4.5	—	3.15	
				5.5	—	3.85	
Negative threshold voltage	V_N	—		3.0	0.90	—	V
				4.5	1.35	—	
				5.5	1.65	—	
Hysteresis voltage	V_H	—		3.0	0.30	1.20	V
				4.5	0.40	1.40	
				5.5	0.50	1.60	
High-level output voltage	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = -50 μA	2.0	1.9	—	V
				3.0	2.9	—	
				4.5	4.4	—	
			I_{OH} = -4 mA	3.0	2.40	—	
			I_{OH} = -8 mA	4.5	3.70	—	
Low-level output voltage	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 50 μA	2.0	—	0.1	V
				3.0	—	0.1	
				4.5	—	0.1	
			I_{OL} = 4 mA	3.0	—	0.55	
			I_{OL} = 8 mA	4.5	—	0.55	
3-state output OFF-state leakage current (Q/D1 to Q/D8)	I_{OZ}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = 5.5 V or GND		0 to 5.5	—	±10.0	μA
Input leakage current	I_{IN}	V_{IN} = 5.5 V or GND		0 to 5.5	—	±2.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND		5.5	—	80.0	μA

12.4. Timing Requirements (Unless otherwise specified, T_a = 25 °C, Input: $t_r = t_f$ = 3 ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Limit	Unit
Minimum pulse width (CK)	$t_{w(L)}$,$t_{w(H)}$	—	3.3 ± 0.3	7.0	ns
			5.0 ± 0.5	5.0	
Minimum pulse width ($\overline{CLR}$/LOAD)	$t_{w(L)}$	—	3.3 ± 0.3	6.0	ns
			5.0 ± 0.5	5.0	
Minimum setup time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_S	—	3.3 ± 0.3	6.0	ns
			5.0 ± 0.5	5.0	
Minimum setup time (SI-CK)	t_S	—	3.3 ± 0.3	6.0	ns
			5.0 ± 0.5	5.0	
Minimum hold time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.0	
Minimum hold time (SI-CK)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.5	
Minimum removal time ($\overline{CLR}$/LOAD-CK)	t_{rem}	—	3.3 ± 0.3	5.0	ns
			5.0 ± 0.5	3.0	

12.5. Timing Requirements (Unless otherwise specified, T_a = -40 to 85 °C, Input: $t_r = t_f$ = 3 ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Limit	Unit
Minimum pulse width (CK)	$t_{w(L)}$,$t_{w(H)}$	—	3.3 ± 0.3	8.0	ns
			5.0 ± 0.5	6.0	
Minimum pulse width ($\overline{CLR}$/LOAD)	$t_{w(L)}$	—	3.3 ± 0.3	7.0	ns
			5.0 ± 0.5	6.0	
Minimum setup time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_S	—	3.3 ± 0.3	7.0	ns
			5.0 ± 0.5	6.0	
Minimum setup time (SI-CK)	t_S	—	3.3 ± 0.3	7.0	ns
			5.0 ± 0.5	5.0	
Minimum hold time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.0	
Minimum hold time (SI-CK)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.5	
Minimum removal time ($\overline{CLR}$/LOAD-CK)	t_{rem}	—	3.3 ± 0.3	5.0	ns
			5.0 ± 0.5	3.0	

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

Characteristics	Symbol	Test Condition	V_{CC} (V)	Limit	Unit
Minimum pulse width (CK)	$t_{w(L)}$,$t_{w(H)}$	—	3.3 ± 0.3	8.0	ns
			5.0 ± 0.5	6.0	
Minimum pulse width ($\overline{CLR}$/LOAD)	$t_{w(L)}$	—	3.3 ± 0.3	7.0	ns
			5.0 ± 0.5	6.0	
Minimum setup time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_s	—	3.3 ± 0.3	8.0	ns
			5.0 ± 0.5	7.0	
Minimum setup time (SI-CK)	t_s	—	3.3 ± 0.3	8.0	ns
			5.0 ± 0.5	5.0	
Minimum hold time (Q/D1 to Q/D8 -$\overline{CLR}$/LOAD)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.0	
Minimum hold time (SI-CK)	t_h	—	3.3 ± 0.3	1.0	ns
			5.0 ± 0.5	1.5	
Minimum removal time ($\overline{CLR}$/LOAD-CK)	t_{rem}	—	3.3 ± 0.3	5.0	ns
			5.0 ± 0.5	3.0	

12.7. AC Characteristics (Unless otherwise specified, T_a = 25 °C, Input: $t_r = t_f$ = 3 ns)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	C_L (pF)	Min	Typ.	Max	Unit
Propagation delay time (CK-Q/D1 to Q/D8)	t_{PLH},t_{PHL}		—	3.3 ± 0.3	15	—	9.3	14.7	ns
					50	—	12.1	19.0	
				5.0 ± 0.5	15	—	6.7	9.7	
					50	—	9.1	13.1	
Propagation delay time (CK-Q8',Q8C)	t_{PLH},t_{PHL}		—	3.3 ± 0.3	15	—	9.0	14.4	ns
					50	—	11.8	18.6	
				5.0 ± 0.5	15	—	6.4	9.4	
					50	—	8.7	12.7	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q/D1 to Q/D8)	t_{PLH},t_{PHL}		—	3.3 ± 0.3	15	—	7.9	11.7	ns
					50	—	10.2	15.1	
				5.0 ± 0.5	15	—	6.2	8.4	
					50	—	8.0	11.1	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q8',Q8C)	t_{PLH},t_{PHL}		—	3.3 ± 0.3	15	—	8.0	11.8	ns
					50	—	10.3	15.3	
				5.0 ± 0.5	15	—	6.2	8.5	
					50	—	8.1	11.2	
Propagation delay time (Q/D8-Q8')	t_{PLH},t_{PHL}		—	3.3 ± 0.3	15	—	9.5	15.2	ns
					50	—	11.8	18.9	
				5.0 ± 0.5	15	—	6.7	9.6	
					50	—	8.4	12.2	
3-state output enable time (P/S CONT-Q/D1 to Q/D8)	t_{PZL},t_{PZH}		R_L = 1 kΩ	3.3 ± 0.3	15	—	6.7	10.4	ns
					50	—	9.9	15.4	
				5.0 ± 0.5	15	—	5.0	7.3	
					50	—	7.6	11.0	
3-state output disable time (P/S CONT-Q/D1 to Q/D8)	t_{PLZ},t_{PHZ}		R_L = 1 kΩ	3.3 ± 0.3	50	—	10.1	12.8	ns
				5.0 ± 0.5	50	—	7.8	9.8	
Maximum clock frequency	f_{MAX}		—	3.3 ± 0.3	15	68	107	—	MHz
					50	52	82	—	
				5.0 ± 0.5	15	103	149	—	
					50	76	109	—	
Input capacitance	C_{IN}		—			—	4	10	pF
Bus I/O capacitance	$C_{I/O}$		Q/D1 to Q/D8			—	8	—	pF
Power dissipation capacitance	C_{PD}	(Note 1)	P/S CONT = L (Parallel Outputs)			—	102	—	pF
			P/S CONT = H (Parallel Inputs)			—	34	—	

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.

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

12.8. AC Characteristics
(Unless otherwise specified, T_a = -40 to 85 °C, Input: $t_r = t_f$ = 3 ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	C_L (pF)	Min	Max	Unit
Propagation delay time (CK-Q/D1 to Q/D8)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	16.7	ns
				50	1.0	21.6	
			5.0 ± 0.5	15	1.0	11.1	
				50	1.0	14.9	
Propagation delay time (CK-Q8',Q8C)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	16.4	ns
				50	1.0	21.2	
			5.0 ± 0.5	15	1.0	10.7	
				50	1.0	14.5	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q/D1 to Q/D8)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	13.4	ns
				50	1.0	17.2	
			5.0 ± 0.5	15	1.0	9.6	
				50	1.0	12.6	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q8',Q8C)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	13.5	ns
				50	1.0	17.5	
			5.0 ± 0.5	15	1.0	9.7	
				50	1.0	12.8	
Propagation delay time (Q/D8-Q8')	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	17.3	ns
				50	1.0	21.6	
			5.0 ± 0.5	15	1.0	10.9	
				50	1.0	13.9	
3-state output enable time (P/S CONT-Q/D1 to Q/D8)	t_{PZL},t_{PZH}	R_L = 1 kΩ	3.3 ± 0.3	15	1.0	11.9	ns
				50	1.0	17.6	
			5.0 ± 0.5	15	1.0	8.3	
				50	1.0	12.5	
3-state output disable time (P/S CONT-Q/D1 to Q/D8)	t_{PLZ},t_{PHZ}	R_L = 1 kΩ	3.3 ± 0.3	50	1.0	13.7	ns
			5.0 ± 0.5	50	1.0	10.6	
Maximum clock frequency	f_{MAX}	—	3.3 ± 0.3	15	59	—	MHz
				50	46	—	
			5.0 ± 0.5	15	90	—	
				50	67	—	
Input capacitance	C_{IN}	—			—	10	pF

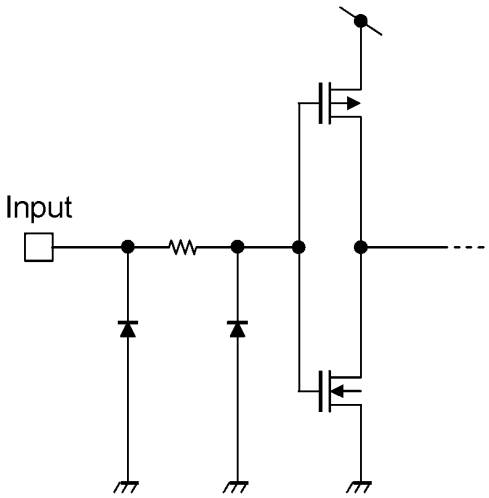
12.9. AC Characteristics (Unless otherwise specified, T_a = -40 to 125 °C, Input: $t_r = t_f$ = 3 ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	C_L (pF)	Min	Max	Unit
Propagation delay time (CK-Q/D1 to Q/D8)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	18.5	ns
				50	1.0	23.5	
			5.0 ± 0.5	15	1.0	12.5	
				50	1.0	16.5	
Propagation delay time (CK-Q8',Q8C)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	18.0	ns
				50	1.0	23.0	
			5.0 ± 0.5	15	1.0	12.0	
				50	1.0	16.0	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q/D1 to Q/D8)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	15.0	ns
				50	1.0	19.0	
			5.0 ± 0.5	15	1.0	10.5	
				50	1.0	14.0	
Propagation delay time ($\overline{\text{CLR}}$/LOAD-Q8',Q8C)	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	15.0	ns
				50	1.0	19.0	
			5.0 ± 0.5	15	1.0	10.5	
				50	1.0	14.0	
Propagation delay time (Q/D8-Q8')	t_{PLH},t_{PHL}	—	3.3 ± 0.3	15	1.0	19.0	ns
				50	1.0	23.5	
			5.0 ± 0.5	15	1.0	12.0	
				50	1.0	15.5	
3-state output enable time (P/S CONT-Q/D1 to Q/D8)	t_{PZL},t_{PZH}	R_L = 1 kΩ	3.3 ± 0.3	15	1.0	13.0	ns
				50	1.0	19.5	
			5.0 ± 0.5	15	1.0	9.0	
				50	1.0	13.5	
3-state output disable time (P/S CONT-Q/D1 to Q/D8)	t_{PLZ},t_{PHZ}	R_L = 1 kΩ	3.3 ± 0.3	50	1.0	14.5	ns
			5.0 ± 0.5	50	1.0	11.5	
Maximum clock frequency	f_{MAX}	—	3.3 ± 0.3	15	50	—	MHz
				50	40	—	
			5.0 ± 0.5	15	80	—	
				50	60	—	
Input capacitance	C_{IN}	—			—	10	pF

12.10. Noise Characteristics (Unless otherwise specified, T_a = 25 °C, Input: $t_r = t_f$ = 3 ns)

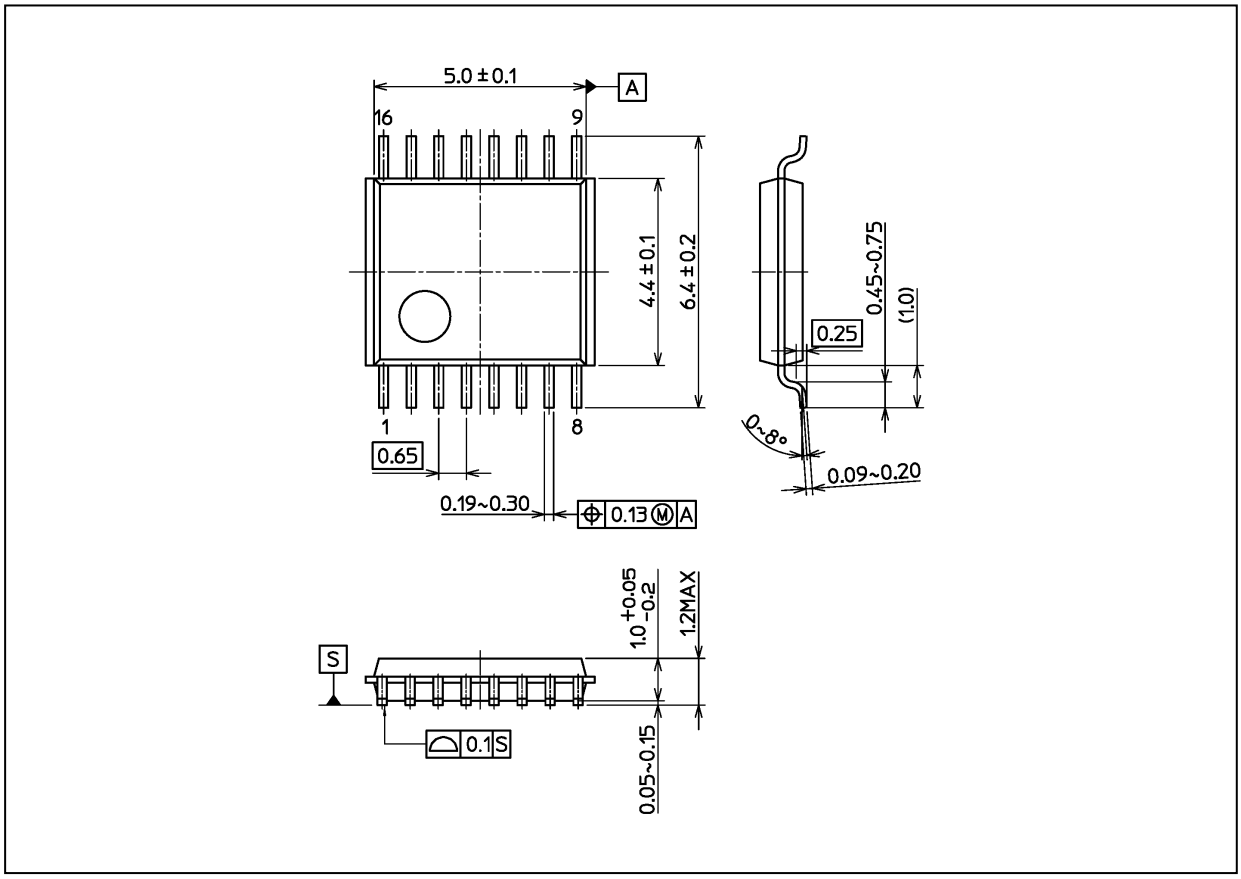
Characteristics	Symbol	Test Condition	V_{CC} (V)	Typ.	Limit	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	C_L = 50 pF	5.0	0.6	1.0	V
Quiet output minimum dynamic V_{OL}	V_{OLV}	C_L = 50 pF	5.0	-0.5	-1.0	V
Minimum high-level dynamic input voltage	V_{IHD}	C_L = 50 pF	5.0	—	3.5	V
Maximum low-level dynamic input voltage	V_{ILD}	C_L = 50 pF	5.0	—	1.5	V

13. Internal Equivalent Circuit



Package Dimensions

Unit: mm



Weight: 0.055 g (typ.)

Package Name(s)
Nickname: TSSOP16B

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