CMOS Digital Integrated Circuits Silicon Monolithic

# 74VHCT9541AFT

## 1. Functional Description

- Octal Universal Schmitt Buffer with 3-State Outputs

## 2. General

The 74VHCT9541AFT is an ultra-high-speed octal Schmitt buffer fabricated using silicon-gate CMOS technology.
The 74VHCT9541AFT combines low power consumption of CMOS with Schottky TTL speeds.
The input voltage are compatible with TTL output voltage.
This device may be used as a level converter for interfacing 3.3 V to 5 V system.
The outputs can be put in the high-impedance state by placing a logic HIGH on the Enable ($\overline{G}$) input. The CONT input determines the logical inversion of data. A logic LOW on the CONT input configures the 74VHCT9541AFT as an inverter; a logic HIGH on the CONT input configures the 74VHCT9541AFT as a buffer.
All the inputs have hysteresis between the positive-going and negative-going thresholds. Thus the 74VHCT9541AFT is capable of squaring up transitions of slowly changing input signals and provides an improved noise immunity.
Input protection and output circuit ensure that 0 to 5.5 V can be applied to the input and output (Note) pins without regard to the supply voltage. These structure prevents device destruction due to mismatched supply and input/output voltages such as battery back up, etc.
Note: Output in off-state

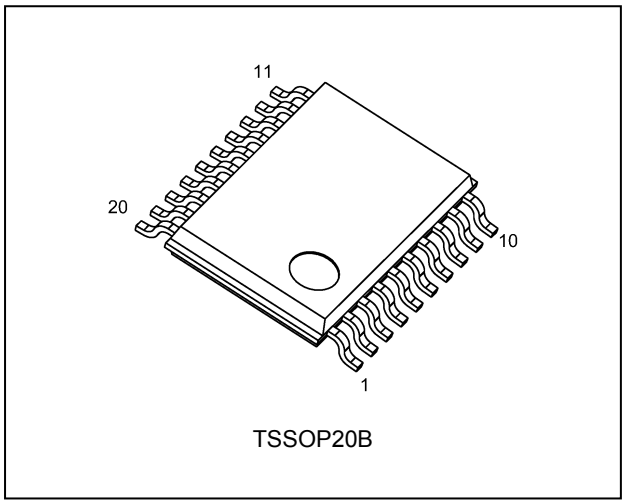
## 3. Features

(1) AEC-Q100 (Rev. H) (Note 1)
(2) Wide operating temperature range: $T_{opr}$ = -40 to 125 °C
(3) High speed: $t_{pd}$ = 6.5 ns (typ.) at $V_{CC}$ = 5.0 V
(4) Low power dissipation: $I_{CC}$ = 4.0 μA (max) ($T_a$ = 25 °C)
(5) Compatible with TTL inputs: $V_{IL}$ = 0.5 V (max)
$V_{IH}$ = 2.1 V (min)
(6) Power down protection is provided on all inputs.
(7) Balanced propagation delays: $t_{PLH} \approx t_{PHL}$
(8) Input terminals are at the opposite side of Output terminals

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

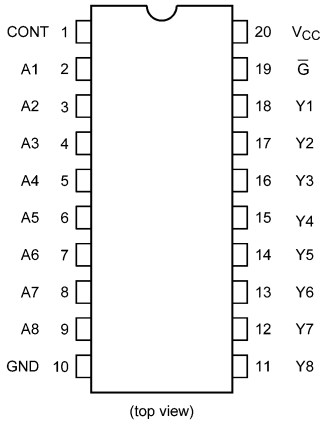
Start of commercial production
2014-12

## 4. Packaging

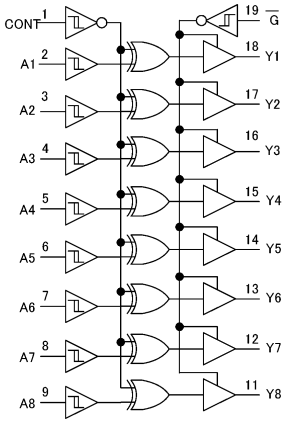



TSSOP20B

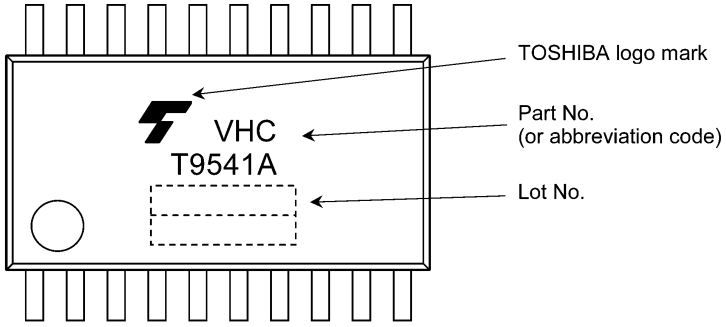
## 5. Pin Assignment




(top view)




## 6. Marking




## 7. Truth Table

| Input $\overline{G}$ | Input CONT | Input An | Output Yn |
|---|---|---|---|
| H | X | X | Z |
| L | L | L | H |
| L | L | H | L |
| L | H | L | L |
| L | H | H | H |

X: Don't care
Z: High impedance

## 8. 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 | $V_{OUT}$ | (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 | $I_{OK}$ | (Note 3) | ±20 | mA |
| Output current | $I_{OUT}$ | | ±25 | mA |
| $V_{CC}$/ground current | $I_{CC}$ | | ±75 | mA |
| Power dissipation | $P_D$ | (Note 4) | 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: $V_{OUT}$ < GND, $V_{OUT}$ > $V_{CC}$

Note 4: 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.

## 9. Operating Ranges (Note)

| Characteristics | Symbol | Note | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | 4.0 to 5.5 | V |
| Input voltage | $V_{IN}$ | | 0 to 5.5 | V |
| Output voltage | $V_{OUT}$ | (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.

## 10. Electrical Characteristics

### 10.1. DC Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Positive threshold voltage | $V_P$ | — | | 4.5 | — | — | 1.90 | V |
| | | | | 5.5 | — | — | 2.10 | |
| Negative threshold voltage | $V_N$ | — | | 4.5 | 0.50 | — | — | V |
| | | | | 5.5 | 0.60 | — | — | |
| Hysteresis voltage | $V_H$ | — | | 4.5 | 0.40 | — | 1.40 | V |
| | | | | 5.5 | 0.40 | — | 1.50 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -50 μA | 4.5 | 4.4 | 4.5 | — | V |
| | | | $I_{OH}$ = -8 mA | 4.5 | 3.94 | — | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50 μA | 4.5 | — | 0.0 | 0.1 | V |
| | | | $I_{OL}$ = 8 mA | 4.5 | — | — | 0.36 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 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 |
| | $I_{CCT}$ | Per input: $V_{IN}$ = 3.4 V<br>Other input: $V_{CC}$ or GND | | 5.5 | — | — | 1.35 | mA |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT}$ = 5.5 V | | 0 | — | — | 0.5 | μA |

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

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Positive threshold voltage | $V_P$ | — | | 4.5 | — | 1.90 | V |
| | | | | 5.5 | — | 2.10 | |
| Negative threshold voltage | $V_N$ | — | | 4.5 | 0.50 | — | V |
| | | | | 5.5 | 0.60 | — | |
| Hysteresis voltage | $V_H$ | — | | 4.5 | 0.40 | 1.40 | V |
| | | | | 5.5 | 0.40 | 1.50 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -50 μA | 4.5 | 4.4 | — | V |
| | | | $I_{OH}$ = -8 mA | 4.5 | 3.80 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50 μA | 4.5 | — | 0.1 | V |
| | | | $I_{OL}$ = 8 mA | 4.5 | — | 0.44 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 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 |
| | $I_{CCT}$ | Per input: $V_{IN}$ = 3.4 V<br>Other input: $V_{CC}$ or GND | | 5.5 | — | 1.50 | mA |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT}$ = 5.5 V | | 0 | — | 5.0 | μA |

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

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Positive threshold voltage | $V_P$ | — | | 4.5 | — | 1.90 | V |
| | | | | 5.5 | — | 2.10 | |
| Negative threshold voltage | $V_N$ | — | | 4.5 | 0.50 | — | V |
| | | | | 5.5 | 0.60 | — | |
| Hysteresis voltage | $V_H$ | — | | 4.5 | 0.40 | 1.40 | V |
| | | | | 5.5 | 0.40 | 1.50 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -50 μA | 4.5 | 4.4 | — | V |
| | | | $I_{OH}$ = -8 mA | 4.5 | 3.70 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50 μA | 4.5 | — | 0.1 | V |
| | | | $I_{OL}$ = 8 mA | 4.5 | — | 0.55 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 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 |
| Quiescent supply current | $I_{CCT}$ | Per input: $V_{IN}$ = 3.4 V<br>Other input: $V_{CC}$ or GND | | 5.5 | — | 1.50 | mA |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT}$ = 5.5 V | | 0 | — | 20.0 | μA |

## 10.4. 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 (An - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | — | 6.5 | 8.5 | ns |
| | | | | | 50 | — | 8.6 | 11.5 | |
| Propagation delay time (CONT - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | — | 8.2 | 10.5 | ns |
| | | | | | 50 | — | 10.8 | 14.5 | |
| 3-state output enable time | $t_{PZL}$,$t_{PZH}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 15 | — | 6.9 | 8.5 | ns |
| | | | | | 50 | — | 9.1 | 12.5 | |
| 3-state output disable time | $t_{PLZ}$,$t_{PHZ}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 50 | — | 7.4 | 11.5 | ns |
| Output skew | $t_{osLH}$,$t_{osHL}$ | (Note 1) | — | 5.0 ± 0.5 | 50 | — | — | 1.0 | ns |
| Input capacitance | $C_{IN}$ | | — | | | — | 4 | 10 | pF |
| Output capacitance | $C_{OUT}$ | | — | | | — | 9 | — | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note 2) | $f_{IN}$ = 1 MHz | | | — | 16 | — | pF |

Note 1: Parameter guaranteed by design. ($t_{osLH}$ = $|t_{PLH}m-t_{PLH}n|$, $t_{osHL}$ = $|t_{PHL}m-t_{PHL}n|$)

Note 2: $C_{PD}$ 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.

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

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

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | $C_L$ (pF) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Propagation delay time (An - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | 1.0 | 10.0 | ns |
| | | | | | 50 | 1.0 | 13.0 | |
| Propagation delay time (CONT - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | 1.0 | 12.0 | ns |
| | | | | | 50 | 1.0 | 17.0 | |
| 3-state output enable time | $t_{PZL}$,$t_{PZH}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 15 | 1.0 | 10.0 | ns |
| | | | | | 50 | 1.0 | 14.5 | |
| 3-state output disable time | $t_{PLZ}$,$t_{PHZ}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 50 | 1.0 | 13.0 | ns |
| Output skew | $t_{osLH}$,$t_{osHL}$ | (Note 1) | — | 5.0 ± 0.5 | 50 | — | 1.0 | ns |
| Input capacitance | $C_{IN}$ | | — | | | — | 10 | pF |

Note 1: Parameter guaranteed by design. ($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

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

| Characteristics | Symbol | Note | Test Condition | $V_{CC}$ (V) | $C_L$ (pF) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Propagation delay time (An - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | 1.0 | 11.0 | ns |
| | | | | | 50 | 1.0 | 14.0 | |
| Propagation delay time (CONT - Yn) | $t_{PLH}$,$t_{PHL}$ | | — | 5.0 ± 0.5 | 15 | 1.0 | 13.0 | ns |
| | | | | | 50 | 1.0 | 19.0 | |
| 3-state output enable time | $t_{PZL}$,$t_{PZH}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 15 | 1.0 | 11.0 | ns |
| | | | | | 50 | 1.0 | 16.0 | |
| 3-state output disable time | $t_{PLZ}$,$t_{PHZ}$ | | $R_L$ = 1 kΩ | 5.0 ± 0.5 | 50 | 1.0 | 14.0 | ns |
| Output skew | $t_{osLH}$,$t_{osHL}$ | (Note 1) | — | 5.0 ± 0.5 | 50 | — | 1.0 | ns |
| Input capacitance | $C_{IN}$ | | — | | | — | 10 | pF |

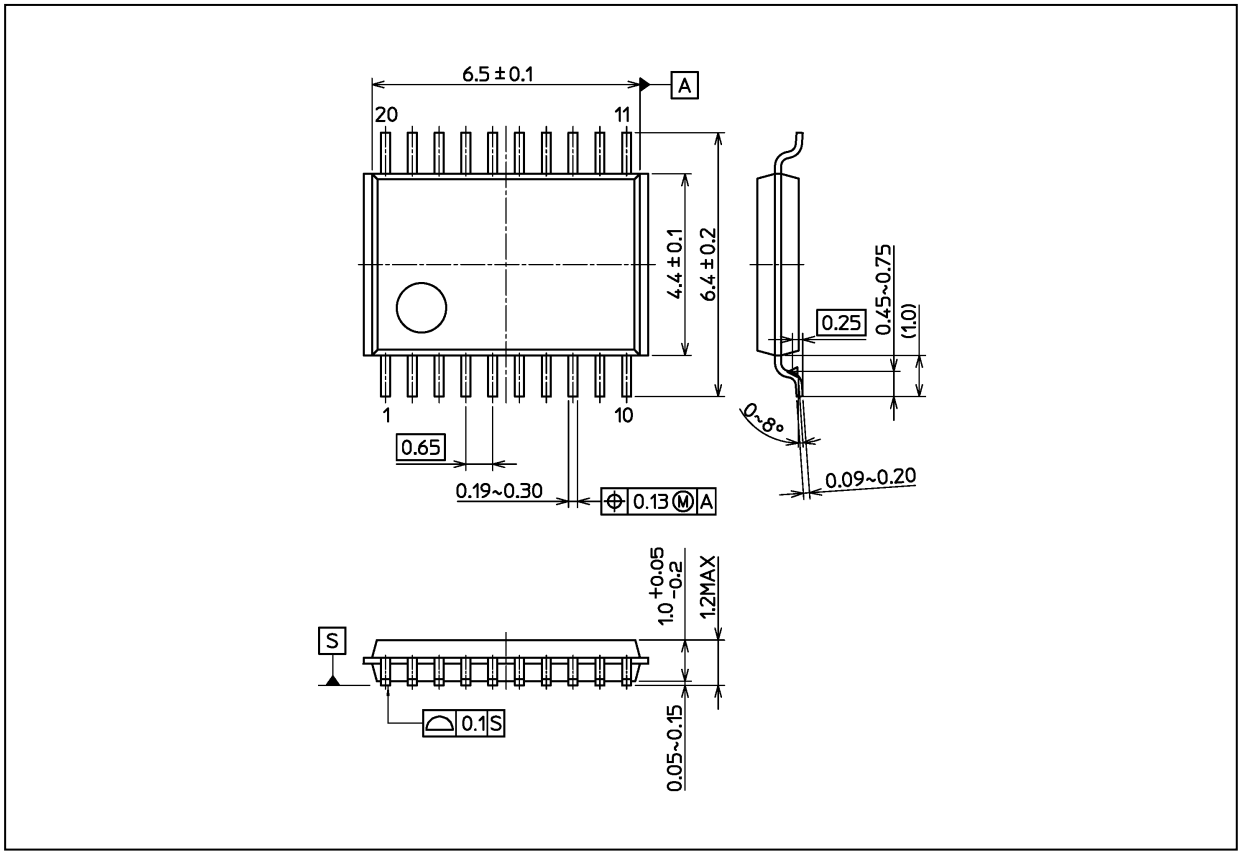
Note 1: Parameter guaranteed by design. ($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

### 11. 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 | 1.0 | 1.5 | V |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $C_L$ = 50 pF | 5.0 | -0.3 | -1.5 | V |
| Minimum high-level dynamic input voltage | $V_{IHD}$ | $C_L$ = 50 pF | 5.0 | — | 2.1 | V |
| Maximum low-level dynamic input voltage | $V_{ILD}$ | $C_L$ = 50 pF | 5.0 | — | 0.5 | V |

## Package Dimensions

Unit: mm




Weight: 0.071 g (typ.)

| Package Name(s) |
| --- |
| Nickname: TSSOP20B |

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