

# 74VHCT540AFT, 74VHCT541AFT

## 1. Functional Description

- Octal Bus Buffer
- 74VHCT540AFT: INVERTED, 3-STATE OUTPUTS  
74VHCT541AFT: NON-INVERTED, 3-STATE OUTPUTS

## 2. General

The 74VHCT540AFT and 74VHCT541AFT are advanced high speed CMOS OCTAL BUS BUFFERS fabricated with silicon gate C<sup>2</sup>MOS technology. They achieve the high speed operation similar to equivalent Bipolar Schottky TTL while maintaining the CMOS low power dissipation.

The 74VHCT540AFT is an inverting type and, the 74VHCT541AFT is a non-inverting type.

When either  $\overline{G1}$  or  $\overline{G2}$  are high, the terminal outputs are in the high-impedance state.

The input voltage are compatible with TTL output voltage.

These devices may be used as a level converter for interfacing 3.3 V to 5 V system.

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, hot board insertion, etc.

Note: Output in off-state

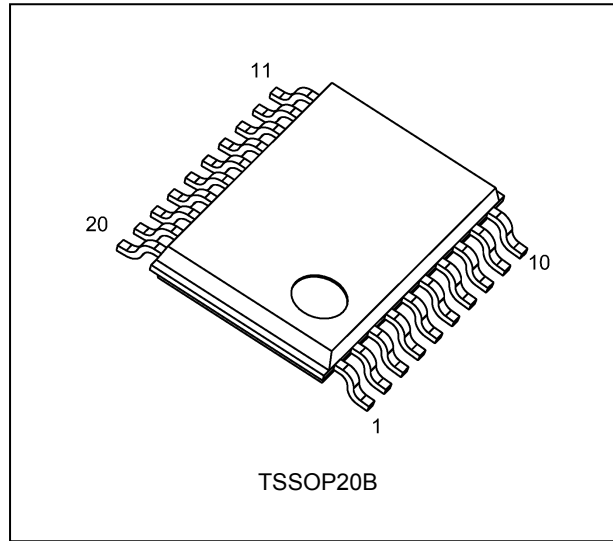
## 3. Features

- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125$  °C
- (3) High speed: Propagation delay time = 5.4 ns (typ.) at  $V_{CC} = 5.0$  V
- (4) Quiescent supply current:  $I_{CC} = 4.0$   $\mu$ A (max) at  $T_a = 25$  °C
- (5) Compatible with TTL input:  $V_{IL} = 0.8$  V (max)  
 $V_{IH} = 2.0$  V (min)
- (6) Power down protection is provided on all inputs and outputs.
- (7) Balanced propagation delays:  $t_{PLH} \approx t_{PHL}$
- (8) Low noise:  $V_{OLP} = 1.5$  V (max)
- (9) Pin and function compatible with the 74 series  
(ACT/HCT/AHCT etc.) 540/541 type.

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

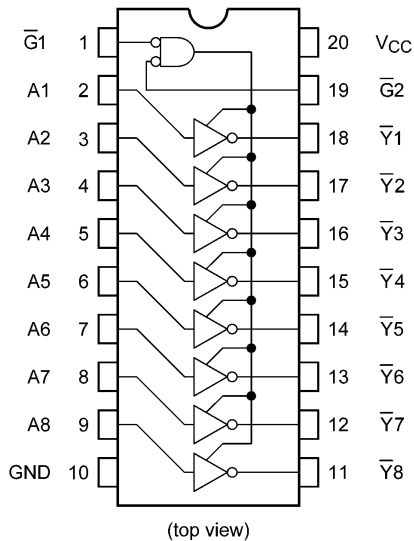
Start of commercial production  
2013-01

### 4. Packaging

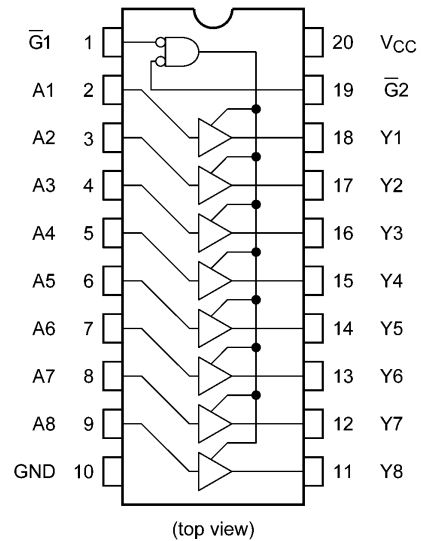


### 5. Pin Assignment

74VHCT540AFT

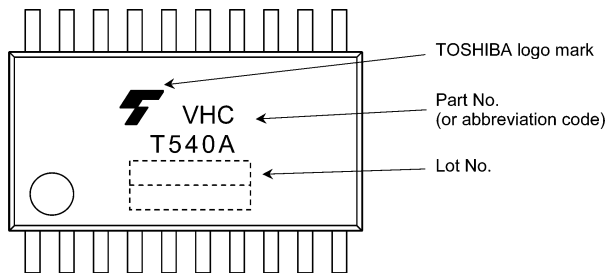


74VHCT541AFT

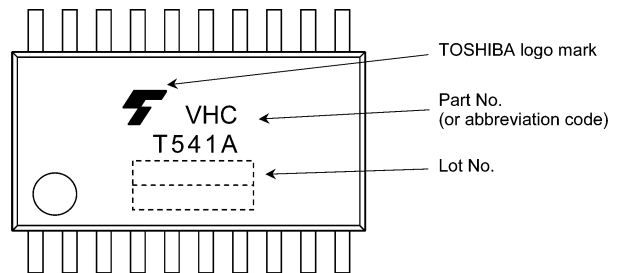


### 6. Marking

74VHCT540AFT

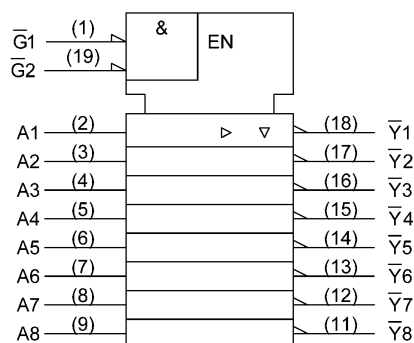


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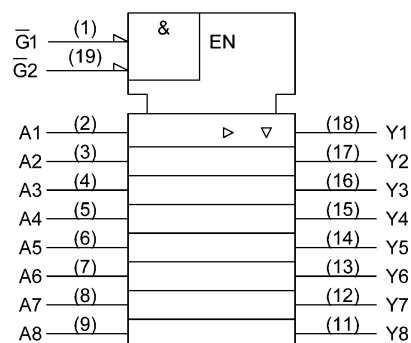


### 7. IEC Logic Symbol

74VHCT540AFT



74VHCT541AFT



### 8. Truth Table

| Input $\bar{G}1$ | Input $\bar{G}2$ | Input $A_n$ | Output $Y_n$ | Output $\bar{Y}_n$ |
|------------------|------------------|-------------|--------------|--------------------|
| H                | X                | X           | Z            | Z                  |
| X                | H                | X           | Z            | Z                  |
| L                | L                | H           | H            | L                  |
| L                | L                | L           | L            | H                  |

X: Don't care  
 Z: High impedance  
 $Y_n$ : 74VHCT541AFT  
 $\bar{Y}_n$ : 74VHCT540AFT

### 9. 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                           |             |
| Output voltage           | $V_{OUT}$ | (Note1)<br>(Note2) | -0.5 to 7.0<br>-0.5 to $V_{CC} + 0.5$ |             |
| Input diode current      | $I_{IK}$  |                    | -20                                   | mA          |
| Output diode current     | $I_{OK}$  | (Note3)            | $\pm 20$                              |             |
| Output current           | $I_{OUT}$ |                    | $\pm 25$                              |             |
| $V_{CC}$ /ground current | $I_{CC}$  |                    | $\pm 75$                              |             |
| Power dissipation        | $P_D$     | (Note4)            | 180                                   | mW          |
| Storage temperature      | $T_{stg}$ |                    | -65 to 150                            | $^{\circ}C$ |

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).

Note1: Output in OFF state.

Note2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

Note3:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

Note4: 180 mW in the range of  $T_a = -40$  to  $85^{\circ}C$ . From  $T_a = 85$  to  $125^{\circ}C$  a derating factor of  $-3.25$  mW/ $^{\circ}C$  shall be applied until 50 mW.

### 10. Operating Ranges (Note)

| Characteristics           | Symbol    | Note    | Rating        | Unit |
|---------------------------|-----------|---------|---------------|------|
| Supply voltage            | $V_{CC}$  |         | 4.5 to 5.5    | V    |
| Input voltage             | $V_{IN}$  |         | 0 to 5.5      |      |
| Output voltage            | $V_{OUT}$ | (Note1) | 0 to 5.5      |      |
|                           |           | (Note2) | 0 to $V_{CC}$ |      |
| Operating temperature     | $T_{opr}$ |         | -40 to 125    | °C   |
| Input rise and fall times | dt/dv     |         | 0 to 20       | 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.

Note1: Output in OFF state.

Note2: High (H) or Low (L) state.

### 11. Electrical Characteristics

#### 11.1. DC Characteristics (Unless otherwise specified, $T_a = 25\text{ °C}$ )

| Characteristics                          | Symbol    | Test Condition  | $V_{CC}$ (V)                | Min | Typ. | Max        | Unit          |   |
|--|-----------|---|-----------------------------|-----|------|------------|---------------|---|
| High-level input voltage                 | $V_{IH}$  | —   | 4.5 to 5.5                  | 2.0 | —    | —          | V             |   |
| Low-level input voltage                  | $V_{IL}$  | —   | 4.5 to 5.5                  | —   | —    | 0.8        | V             |   |
| High-level output voltage                | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                       | $I_{OH} = -50\ \mu\text{A}$ | 4.5 | 4.4  | 4.5        | —             | V |
|  |           |   | $I_{OH} = -8\ \text{mA}$    | 4.5 | 3.94 | —          | —             |   |
| Low-level output voltage                 | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                       | $I_{OL} = 50\ \mu\text{A}$  | 4.5 | —    | 0.0        | 0.1           | V |
|  |           |   | $I_{OL} = 8\ \text{mA}$     | 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                         | —   | —    | $\pm 0.25$ | $\mu\text{A}$ |   |
| Input leakage current                    | $I_{IN}$  | $V_{IN} = 5.5\ \text{V}$ or GND                                     | 0 to 5.5                    | —   | —    | $\pm 0.1$  | $\mu\text{A}$ |   |
| Quiescent supply current                 | $I_{CC}$  | $V_{IN} = V_{CC}$ or GND  | 5.5                         | —   | —    | 4.0        | $\mu\text{A}$ |   |
|  | $I_{CCT}$ | Per input: $V_{IN} = 3.4\ \text{V}$<br>Other input: $V_{CC}$ or GND | 5.5                         | —   | —    | 1.35       | mA            |   |
| Output leakage current (Power-OFF)       | $I_{OPD}$ | $V_{OUT} = 5.5\ \text{V}$   | 0                           | —   | —    | 0.5        | $\mu\text{A}$ |   |

#### 11.2. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $85\text{ °C}$ )

| Characteristics                          | Symbol    | Test Condition  | $V_{CC}$ (V)                | Min | Max        | Unit          |   |
|--|-----------|---|-----------------------------|-----|------------|---------------|---|
| High-level input voltage                 | $V_{IH}$  | —   | 4.5 to 5.5                  | 2.0 | —          | V             |   |
| Low-level input voltage                  | $V_{IL}$  | —   | 4.5 to 5.5                  | —   | 0.8        | V             |   |
| High-level output voltage                | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                       | $I_{OH} = -50\ \mu\text{A}$ | 4.5 | 4.4        | —             | V |
|  |           |   | $I_{OH} = -8\ \text{mA}$    | 4.5 | 3.80       | —             |   |
| Low-level output voltage                 | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                       | $I_{OL} = 50\ \mu\text{A}$  | 4.5 | —          | 0.1           | V |
|  |           |   | $I_{OL} = 8\ \text{mA}$     | 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                         | —   | $\pm 2.50$ | $\mu\text{A}$ |   |
| Input leakage current                    | $I_{IN}$  | $V_{IN} = 5.5\ \text{V}$ or GND                                     | 0 to 5.5                    | —   | $\pm 1.0$  | $\mu\text{A}$ |   |
| Quiescent supply current                 | $I_{CC}$  | $V_{IN} = V_{CC}$ or GND  | 5.5                         | —   | 40.0       | $\mu\text{A}$ |   |
| Quiescent supply current                 | $I_{CCT}$ | Per input: $V_{IN} = 3.4\ \text{V}$<br>Other input: $V_{CC}$ or GND | 5.5                         | —   | 1.50       | mA            |   |
| Output leakage current (Power-OFF)       | $I_{OPD}$ | $V_{OUT} = 5.5\ \text{V}$   | 0                           | —   | 5.0        | $\mu\text{A}$ |   |

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

| Characteristics                          | Symbol    | Test Condition  | $V_{CC}$ (V)           | Min | Max        | Unit    |   |
|--|-----------|---|------------------------|-----|------------|---------|---|
| High-level input voltage                 | $V_{IH}$  | —   | 4.5 to 5.5             | 2.0 | —          | V       |   |
| Low-level input voltage                  | $V_{IL}$  | —   | 4.5 to 5.5             | —   | 0.8        | V       |   |
| High-level output voltage                | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                               | $I_{OH} = -50$ $\mu$ A | 4.5 | 4.4        | —       | V |
|  |           |   | $I_{OH} = -8$ mA       | 4.5 | 3.70       | —       |   |
| Low-level output voltage                 | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                               | $I_{OL} = 50$ $\mu$ A  | 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                    | —   | $\pm 10.0$ | $\mu$ A |   |
| Input leakage current                    | $I_{IN}$  | $V_{IN} = 5.5$ V or GND                                     | 0 to 5.5               | —   | $\pm 2.0$  | $\mu$ A |   |
| Quiescent supply current                 | $I_{CC}$  | $V_{IN} = V_{CC}$ or GND                                    | 5.5                    | —   | 80.0       | $\mu$ A |   |
|  | $I_{CCT}$ | 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       | $\mu$ A |   |

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

| Characteristics               | Part Number  | Symbol               | Note     | Test Condition       | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Typ. | Max  | Unit |
|-------------------------------|--------------|----------------------|----------|----------------------|---------------|------------|-----|------|------|------|
| Propagation delay time        | 74VHCT540AFT | $t_{PLH}, t_{PHL}$   |          | —                    | $5.0 \pm 0.5$ | 15         | —   | 5.4  | 7.4  | ns   |
|                               |              |                      |          |                      |               | 50         | —   | 5.9  | 8.4  |      |
|                               | 74VHCT541AFT | $t_{PLH}, t_{PHL}$   |          | —                    | $5.0 \pm 0.5$ | 15         | —   | 5.0  | 6.9  | ns   |
|                               |              |                      |          |                      |               | 50         | —   | 5.5  | 7.9  |      |
| 3-state output enable time    |              | $t_{PZL}, t_{PZH}$   |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 15         | —   | 8.3  | 11.3 | ns   |
|                               |              |                      |          |                      |               | 50         | —   | 8.8  | 12.3 |      |
| 3-state output disable time   |              | $t_{PLZ}, t_{PHZ}$   |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 50         | —   | 9.4  | 11.9 | ns   |
| Output skew                   |              | $t_{osLH}, t_{osHL}$ | (Note 1) | —                    | $5.0 \pm 0.5$ | 50         | —   | —    | 1.0  | ns   |
| Input capacitance             |              | $C_{IN}$             |          | —                    |               |            | —   | 4    | 10   | pF   |
| Output capacitance            |              | $C_{OUT}$            |          | —                    |               |            | —   | 9    | —    | pF   |
| Power dissipation capacitance |              | $C_{PD}$             | (Note 2) | —                    |               |            | —   | 19   | —    | pF   |

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

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.

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

### 11.5. AC Characteristics

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

| Characteristics             | Part Number  | Symbol               | Note     | Test Condition       | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|-----------------------------|--------------|----------------------|----------|----------------------|---------------|------------|-----|------|------|
| Propagation delay time      | 74VHCT540AFT | $t_{PLH}, t_{PHL}$   |          | —                    | $5.0 \pm 0.5$ | 15         | 1.0 | 8.5  | ns   |
|                             |              |                      |          |                      |               | 50         | 1.0 | 9.5  |      |
|                             | 74VHCT541AFT | $t_{PLH}, t_{PHL}$   |          | —                    | $5.0 \pm 0.5$ | 15         | 1.0 | 8.0  | ns   |
|                             |              |                      |          |                      |               | 50         | 1.0 | 9.0  |      |
| 3-state output enable time  |              | $t_{PZL}, t_{PZH}$   |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 15         | 1.0 | 13.0 | ns   |
|                             |              |                      |          |                      |               | 50         | 1.0 | 14.0 |      |
| 3-state output disable time |              | $t_{PLZ}, t_{PHZ}$   |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 50         | 1.0 | 13.5 | ns   |
| Output skew                 |              | $t_{osLH}, t_{osHL}$ | (Note 1) | —                    | $5.0 \pm 0.5$ | 50         | —   | 1.0  | ns   |
| Input capacitance           |              | $C_{IN}$             |          | —                    |               |            | —   | 10   | pF   |

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

### 11.6. AC Characteristics

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

| Characteristics             | Part Number  | Symbol                 | Note     | Test Condition       | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|-----------------------------|--------------|------------------------|----------|----------------------|---------------|------------|-----|------|------|
| Propagation delay time      | 74VHCT540AFT | $t_{PLH}, t_{PHL}$     |          | —                    | $5.0 \pm 0.5$ | 15         | 1.0 | 9.5  | ns   |
|                             |              |                        |          |                      |               | 50         | 1.0 | 10.5 |      |
|                             | 74VHCT541AFT | $t_{PLH}, t_{PHL}$     |          | —                    | $5.0 \pm 0.5$ | 15         | 1.0 | 9.0  | ns   |
|                             |              |                        |          |                      |               | 50         | 1.0 | 10.0 |      |
| 3-state output enable time  |              | $t_{PZL}, t_{PZH}$     |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 15         | 1.0 | 14.5 | ns   |
|                             |              |                        |          |                      |               | 50         | 1.0 | 15.5 |      |
| 3-state output disable time |              | $t_{PLZ}, t_{PHZ}$     |          | $R_L = 1$ k $\Omega$ | $5.0 \pm 0.5$ | 50         | 1.0 | 15.0 | ns   |
| Output skew                 |              | $t_{oS LH}, t_{oS HL}$ | (Note 1) | —                    | $5.0 \pm 0.5$ | 50         | —   | 1.0  | ns   |
| Input capacitance           |              | $C_{IN}$               |          | —                    |               |            | —   | 10   | pF   |

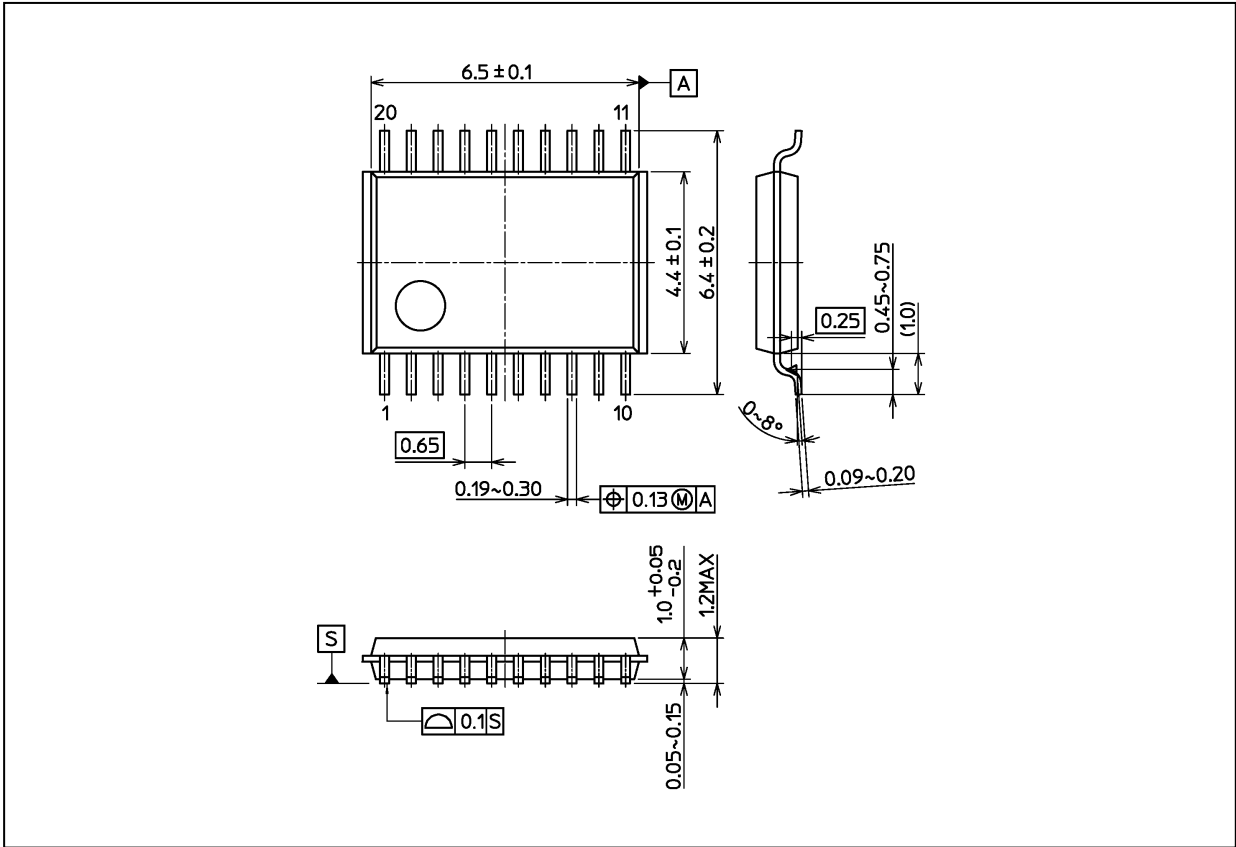
Note 1: Parameter guaranteed by design. ( $t_{oS LH} = |t_{PLHM} - t_{PLHN}|$ ,  $t_{oS HL} = |t_{PHLM} - t_{PHLN}|$ )

### 11.7. 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          | 1.1  | 1.5   | V    |
| Quiet output minimum dynamic $V_{OL}$    | $V_{OLV}$ | $C_L = 50$ pF  | 5.0          | -1.1 | -1.5  |      |
| Minimum high-level dynamic input voltage | $V_{IHD}$ | $C_L = 50$ pF  | 5.0          | —    | 2.0   |      |
| Maximum low-level dynamic input voltage  | $V_{ILD}$ | $C_L = 50$ pF  | 5.0          | —    | 0.8   |      |

**Package Dimensions**

Unit: mm



Weight: 0.071 g (typ.)

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

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