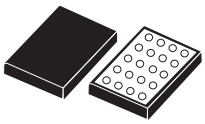
# ST2378E

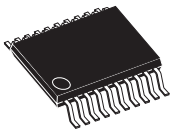
## 8-bit dual supply 1.71V to 5.5V level translator with I/O $V_{CC}$ ± 15KV ESD protection

## General features

- High speed:
  - $t_{PD}$ = 15ns (Max.) at $T_A$ = 85°C
  - $V_L$ = 1.8V
  - $V_{CC}$ = 5.5V
- Guaranteed data rate:
  - 13Mbps (1.8V ≤ $V_L$ ≤ $V_{CC}$ ≤ 5.5V)
- Low power dissipation:
  - $I_{TS-VL}$ = $I_{TS-VCC}$ = 1µA (Max.) at $T_A$ = 85°C
  - $I_{QVL}$ = 100µA (Max.) at $T_A$ = 85°C
  - $I_{QCC}$ = 10µA (Max.) at $T_A$ = 85°C
- Output impedance:
  - $|I_{OHA}|$ = 20µA(Min.) at $V_L$=1.8V; $V_{CC}$ = 5.5V
  - $I_{OLA}$ = 1.0µA(Min.) at $V_L$=1.8V $V_{CC}$ = 5.5V
- Bi-directional level translation
- Totem pole and open drain driving for $I^2C$ communications
- 5V tolerant on enable pin
- Wide operating voltage range:
  - $V_L$(Opr) = 1.71V to $V_{CC}$
  - $V_{CC}$(Opr) = 1.71V to 5.5V
- ESD performance
- HBM > 15KV ESD protection on I/O$V_{CC}$ lines
- Leadfree Flip-Chip and TSSOP packages



Flip-Chip20



TSSOP20

## Description

The ST2378E is an 8-bit, dual supply, bi-directional level translator with ±15kV ESD-protection on I/Os at $V_{CC}$ side. It is designed to interface data transfer between low-voltage ASICs/PLDs and higher voltage systems. Externally applied voltage, $V_{CC}$ and $V_L$, set logic levels at both sides with range specified as 1.71V ≤ $V_L$ ≤ 5.5V and $V_L$ ≤ $V_{CC}$ ≤ 5.5V. For proper operation, $V_{CC}$ should be set higher than VL.

Utilizing a transmission-gate-based design, this device allows bi-directional asynchronous data transfer, which means each channel is allowed to have either $V_{CC}$ to $V_L$ or $V_L$ to $V_{CC}$ data transfer direction independently and no direction pin is required. ST2378E operates at guaranteed data rate of 13Mbps over the entire specified operating voltage range.

Among the other features is included the OE pin which allows disable-mode operation whereby current consumption is reduced to less than 1µA.

## Order codes

| Part number | Temperature range | Package | Comments |
|---|---|---|---|
| ST2378EBJR | -40 to 85 °C | Flip-Chip20 (Tape and Reel) | 3000 parts per reel |
| ST2378ETTR | -40 to 85 °C | TSSOP20 (Tape and Reel) | 2500 parts per reel |

# Contents

# 1 Block diagram

**Figure 1. Block diagram**

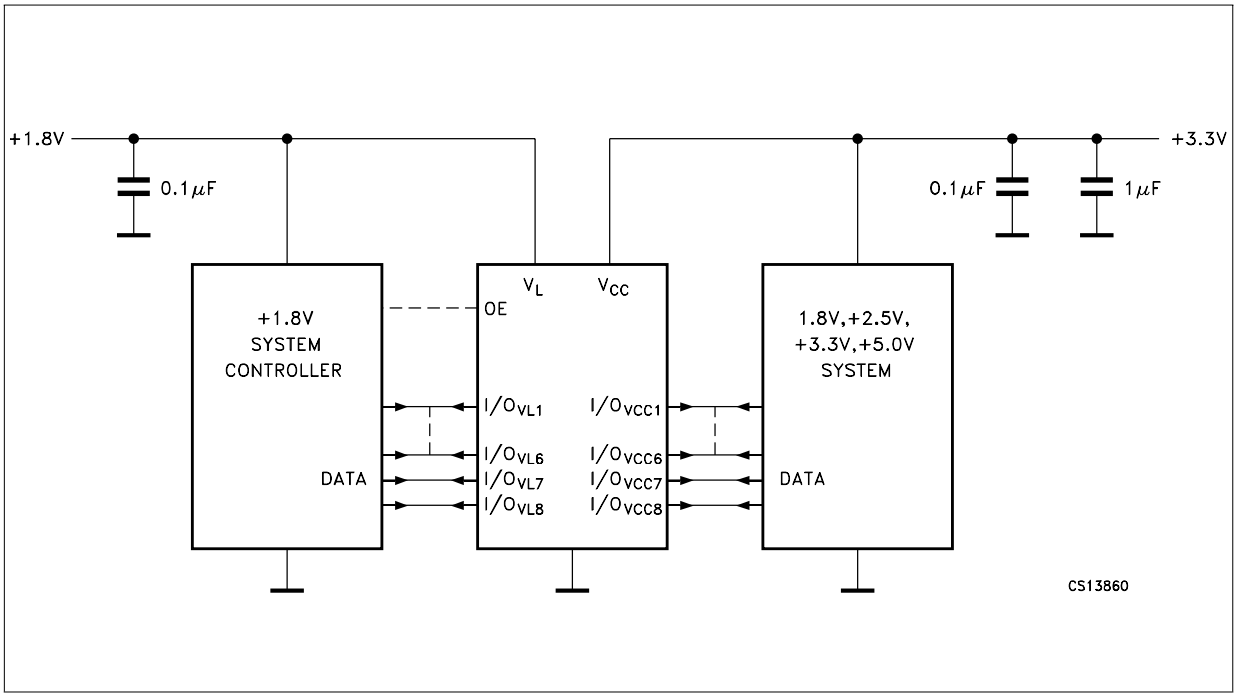
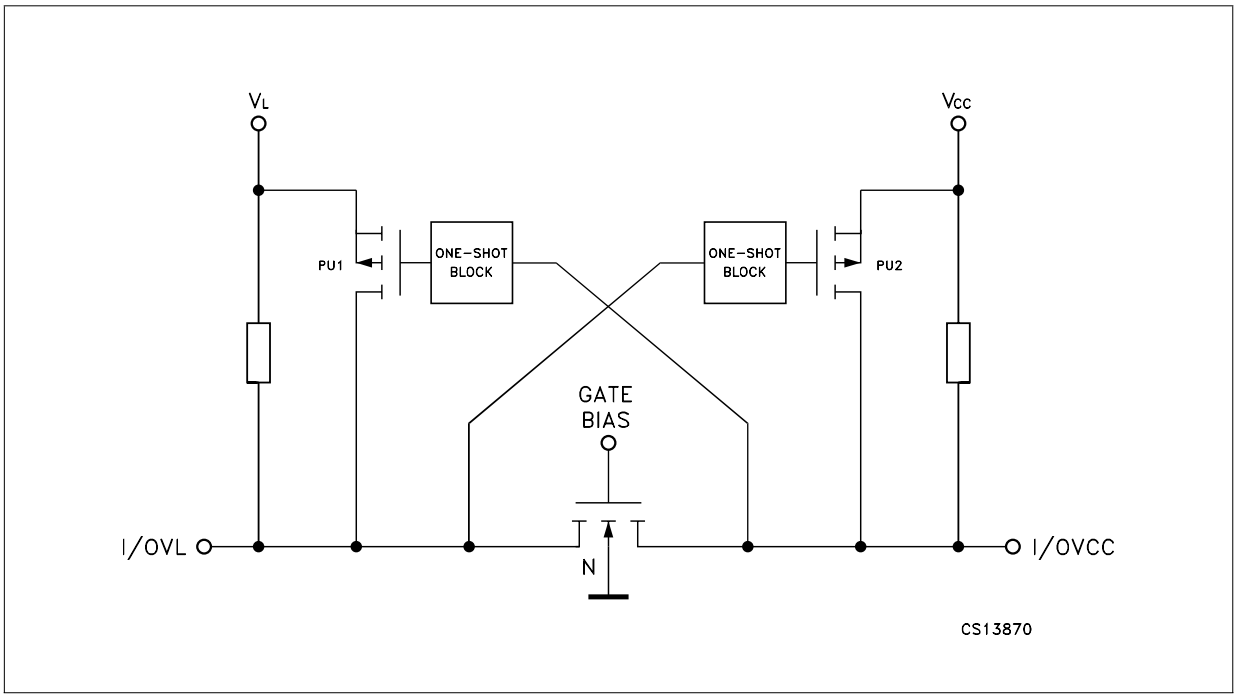


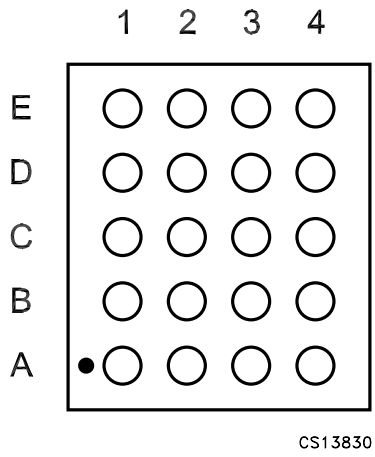

**Figure 2. Functional diagram (1 I/O line)**



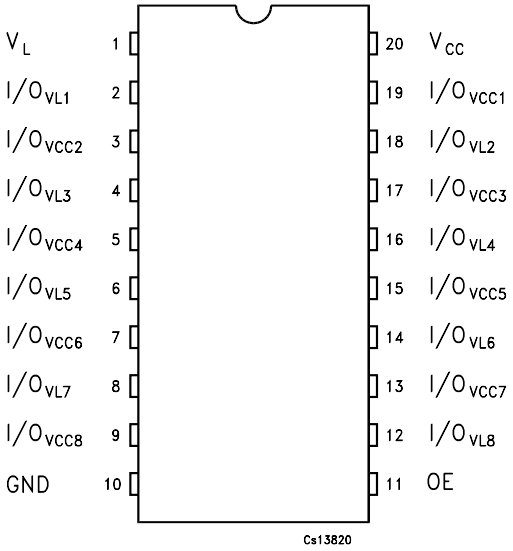
# 2 Pin settings

## 2.1 Pin connection

**Figure 3. Pin connection**




Flip-Chip20
(Bottom view) Bump side




TSSOP20 (Top view)

## 2.2 Pin description

**Table 1. Pin description**

| Flip-Chip20 Pin N° | TSSOP20 Pin N° | Symbol | Name and function |
|---|---|---|---|
| E2, D1, D2, C1, C2, B1, B2, A1 | 2, 18, 4, 16, 6, 14, 8, 12 | $I/O_{VL1}$ to $I/O_{VL8}$ | Data Inputs/Outputs |
| E3, D4, D3, C4, C3, B4, B3, A4 | 19, 3, 17, 5, 15, 7, 13, 9 | $I/O_{VCC1}$ to $I/O_{VCC8}$ | Data Inputs/Outputs |
| A2 | 11 | OE | Output Enable Inputs |
| A3 | 10 | GND | Ground (0V) |
| E1 | 1 | $V_L$ | Positive Supply Voltage |
| E4 | 20 | $V_{CC}$ | Positive Supply Voltage |

# 3 Electrical data

## 3.1 Maximum ratings

**Table 2. Absolute maximum rating**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_L$ | Supply Voltage | -0.3 to $V_{CC}$ | V |
| $V_{CC}$ | Supply Voltage | -0.3 to +7.0 | V |
| $V_{OE}$ | DC Control Input Voltage | -0.3 to +7.0 | V |
| $V_{I/OVL}$ | DC $I/O_{VL}$ Input Voltage (OE = Gnd or $V_L$) | -0.3 to $V_L$ + 0.3 | V |
| $V_{I/OVCC}$ | DC $I/O_{VCC}$ Input Voltage (OE = Gnd or $V_L$) | -0.3 to $V_{CC}$ + 0.3 | V |
| $I_{IK}$ | DC Input Diode Current (OE Control Pin) | – 20 | mA |
| $I_{IOVL}$ | DC Output Current | ± 25 | mA |
| $I_{IOVCC}$ | DC Output Current | ± 25 | mA |
| $I_{SCTOUT}$ | Short Circuit Duration $I/O_{VL}$, $I/O_{VCC}$ Driven from 40mA Source | Continuous | mA |
| $I_{CCB}$ | DC $V_{CC}$ or Ground Current | ± 100 | mA |
| $P_d$ | Power Dissipation (1) | 500 | mW |
| $T_{stg}$ | Storage Temperature | -65 to +150 | °C |
| $T_L$ | Lead Temperature (10 sec) | 300 | °C |

1. 500mW: ≅ 65°C derated to 300mW by 10mW/°C: 65°C to 85°C

## 3.2 Recommended operating conditions

**Table 3. Recommended operating conditions**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_L$ | Supply Voltage | | 1.71 to $V_{CC}$ | V |
| $V_{CC}$ | Supply Voltage | | 1.71 to 5.5 | V |
| $V_I$ | Input Voltage (OE Output Enable Pin, $V_L$ Power Supply referred) | | 0 to 5.5 | V |
| $V_{I/OVL}$ | $I/O_{VL}$ Voltage | | 0 to $V_L$ | V |
| $V_{I/OVCC}$ | $I/O_{VCC}$ Voltage | | 0 to $V_{CC}$ | V |
| $T_{op}$ | Operating Temperature | | -40 to 85 | °C |
| dt/dv | Input Rise and Fall Time (OE Control Pin) (1) | | 0 to 10 | ns/V |
| dt/dv | Input Rise and Fall Time (2) | $1.71 < V_L < V_{CC} < 5V$ | 0 to 10 | ns/V |
| | | $V_{CC} = V_L = 5V$ | 0 to 3 | ns/V |

1. $V_{OE}$ from 10% $V_L$ to 90%$V_L$
2. $V_{IOVL}$ from 10%$V_L$ to 90%$V_L$; $V_{IOVCC}$ from 10%$V_{CC}$ to 90%$V_{CC}$

# 4 Electrical characteristics

**Table 4. DC Specification**

| Symbol | Parameter | Test Condition | | | Value | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $V_{L(*)}$ (V) | $V_{CC(*)}$ (V) | | $T_A$ = 25 °C | | | -40 to 85 °C | | |
| | | | | | Min. | Typ | Max. | Min. | Max. | |
| $V_{IHL}$ | High Level Input Voltage ($I/O_{VL}$) | 1.8 | $V_L$ to 5.5 | | $V_L$-0.2 | | | $V_L$-0.2 | | V |
| | | 2.5 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| | | 3.3 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| | | 5.0 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| $V_{ILL}$ | Low Level Input Voltage ($I/O_{VL}$) | 1.8 | $V_L$ to 5.5 | | | | 0.15 | | 0.15 | V |
| | | 2.5 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |
| | | 3.3 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |
| | | 5.0 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |
| $V_{IHC}$ | High Level Input Voltage ($I/O_{VCC}$) | 1.8 | $V_L$ to 5.5 | | $V_L$-0.2 | | | $V_L$-0.2 | | V |
| | | 2.5 | $V_L$ to 5.5 | | 0.75$V_{CC}$ | | | 0.75$V_{CC}$ | | |
| | | 3.3 | $V_L$ to 5.5 | | 0.75$V_{CC}$ | | | 0.75$V_{CC}$ | | |
| | | 5.0 | $V_L$ to 5.5 | | 0.75$V_{CC}$ | | | 0.75$V_{CC}$ | | |
| $V_{ILC}$ | Low Level Input Voltage ($I/O_{VCC}$) | 1.8 | $V_L$ to 5.5 | | | | 0.15 | | 0.15 | V |
| | | 2.5 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |
| | | 3.3 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |
| | | 5.0 | $V_L$ to 5.5 | | | | 0.30 | | 0.30 | |

**Table 4. DC Specification**

| Symbol | Parameter | Test Condition | | | Value | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $V_{L(*)}$ (V) | $V_{CC(*)}$ (V) | | $T_A$ = 25 °C | | | -40 to 85 °C | | |
| | | | | | Min. | Typ | Max. | Min. | Max. | |
| $V_{IH-TS}$ | High Level Input Voltage (OE) | 1.8 | $V_L$ to 5.5 | | $V_L$-0.2 | | | $V_L$-0.2 | | V |
| | | 2.5 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| | | 3.3 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| | | 5.0 | $V_L$ to 5.5 | | 0.75$V_L$ | | | 0.75$V_L$ | | |
| $V_{IL-TS}$ | Low Level Input Voltage (OE) | 1.8 | $V_L$ to 5.5 | | | | 0.15 | | 0.15 | V |
| | | 2.5 | $V_L$ to 5.5 | | | | 0.25$V_L$ | | 0.25$V_L$ | |
| | | 3.3 | $V_L$ to 5.5 | | | | 0.25$V_L$ | | 0.25$V_L$ | |
| | | 5.0 | $V_L$ to 5.5 | | | | 0.25$V_L$ | | 0.25$V_L$ | |
| $V_{OHL}$ | High Level Output Voltage $I/O_{VL}$ | 1.8 to 5.5 | $V_L$ to 5.5 | $I_O$=-20 µA $I/O_{VCC} \geq V_{CC}$-0.2 | 0.67$V_L$ | | | 0.67$V_L$ | | V |
| $V_{OLL}$ | Low Level Output Voltage $I/O_{VL}$ | | | $I_O$=1.0 mA $I/O_{VCC} \leq$0.15V | | | 0.40 | | 0.40 | |
| $V_{OHC}$ | High Level Output Voltage $I/O_{VCC}$ | 1.8 to 5.5 | $V_L$ to 5.5 | $I_O$=-20 µA $I/O_{VL} \geq V_L$-0.2 | 0.67$V_{CC}$ | | | 0.67$V_{CC}$ | | V |
| $V_{OLC}$ | Low Level Output Voltage $I/O_{VCC}$ | | | $I_O$=1.0 mA $I/O_{VL} \leq$0.15V | | | 0.40 | | 0.40 | |
| $I_{TSL}$ | Control Input Leakage Current (OE) | 1.8 to 5.5 | $V_L$ to 5.5 | $V_I$=GNDor5.5 | | | 1 | | 1 | µA |
| $I_{TS-LKG}$ | High Impedance Input Leakage Current ($IO_{VL}$, $I/O_{VCC}$) | 1.8 to 5.5 | $V_L$ to 5.5 | OE = GND | | | 1 | | 1 | µA |
| $I_{QVCC}$ | Quiescent Supply Current $V_{CC}$ | 1.8 to 5.5 | $V_L$ to 5.5 | $I/O_{VL}$, $I/O_{VCC}$ unconnected | | 0.1 | 1 | | 10 | µA |

**Table 4. DC Specification**

| Symbol | Parameter | Test Condition | | | Value | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $V_{L(*)}$ (V) | $V_{CC(*)}$ (V) | | $T_A$ = 25 °C | | | -40 to 85 °C | | |
| | | | | | Min. | Typ | Max. | Min. | Max. | |
| $I_{QVL}$ | Quiescent Supply Current $V_L$ | 1.8 to 5.5 | $V_L$ to 5.5 | $I/O_{VL}$, $I/O_{VCC}$ unconnected | | 13 | 20 | | 100 | µA |
| $I_{TS-VCC}$ | High Impedance Mode Quiescent Supply Current $V_{CC}$ | 1.8 to 5.5 | $V_L$ to 5.5 | OE= GND | | | 1 | | 1 | µA |
| $I_{TS-VL}$ | High Impedance Mode Quiescent Supply Current $V_L$ | 1.8 to 5.5 | $V_L$ to 5.5 | OE= GND $I/O_{VL}$=GND to $V_L$ $I/O_{VCC}$ = GND to $V_{CC}$ | | | 1 | | 1 | µA |

*Note: 1 Typical values are referred to $T_A$ = 25°C*

*2 Power Supply Range: $V_L$, $V_{CC}$ 1.8V ± 5%, 2.5 ± 0.2V, 3.3 ± 0.3V, 5.0 ± 0.5V*

*3 For normal operation, ensure $V_L < (V_{CC} + 0.3V)$. During power-up, $V_L > (V_{CC} + 0.3V)$ will not damage the device*

**Table 5. AC Electrical characteristics (totem pole driving)**

| Symbol | Parameter | | Test Condition (1) $C_L$=15pF $t_r$=$t_f$ ≤ 6ns Driver output $R_T$ ≤ 50Ω (2) | | Value -40 to +85 °C | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | $V_L$ (V) (3) | $V_{CC}$ (V) (3) | Min. | Typ. (4) | Max. | |
| $t_{RVCC}$ | Rise Time I/$O_{VCC}$(3)(8) | | 1.8 | 1.8 | | 11 | 15 | ns |
| | | | 1.8 | 2.5 | | 11 | 15 | |
| | | | 1.8 | 3.3 | | 10 | 15 | |
| | | | 1.8 | 5.0 | | 9 | 15 | |
| | | | 2.5 | 3.3 | | 8 | 15 | |
| $t_{FCC}$ | Fall Time I/$O_{VCC}$(3)(8) | | 1.8 | 1.8 | | 6 | 15 | ns |
| | | | 1.8 | 2.5 | | 7 | 15 | |
| | | | 1.8 | 3.3 | | 8 | 15 | |
| | | | 1.8 | 5.0 | | 10 | 15 | |
| | | | 2.5 | 3.3 | | 6 | 15 | |
| $t_{RVL}$ | Rise Time I/$O_{VL}$(3)(8) | | 1.8 | 1.8 | | 12 | 15 | ns |
| | | | 1.8 | 2.5 | | 10 | 15 | |
| | | | 1.8 | 3.3 | | 9 | 15 | |
| | | | 1.8 | 5.0 | | 10 | 15 | |
| | | | 2.5 | 3.3 | | 7 | 15 | |
| $t_{FVL}$ | Fall Time I/$O_{VL}$(3)(8) | | 1.8 | 1.8 | | 7 | 15 | ns |
| | | | 1.8 | 2.5 | | 6 | 15 | |
| | | | 1.8 | 3.3 | | 6 | 15 | |
| | | | 1.8 | 5.0 | | 7 | 15 | |
| | | | 2.5 | 3.3 | | 4 | 15 | |
| $t_{IOVL-VCC}$ | Propagation Delay Time(4) I/$O_{VL-LH}$ to I/$O_{VCC-LH}$ I/$O_{VL-HL}$ to I/$O_{VCC-HL}$ | $t_{PLH}$ | 1.8 | 1.8 | | 6 | 15 | ns |
| | | | 1.8 | 2.5 | | 7 | 15 | |
| | | | 1.8 | 3.3 | | 7 | 15 | |
| | | | 1.8 | 5.0 | | 7 | 15 | |
| | | | 2.5 | 3.3 | | 4 | 15 | |
| | | $t_{PHL}$ | 1.8 | 1.8 | | 5 | 15 | |
| | | | 1.8 | 2.5 | | 5 | 15 | |
| | | | 1.8 | 3.3 | | 6 | 15 | |
| | | | 1.8 | 5.0 | | 8 | 15 | |
| | | | 2.5 | 3.3 | | 4 | 15 | |

**Table 5. AC Electrical characteristics (totem pole driving)**

| Symbol | Parameter | | Test Condition | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | $C_L$=15pF $t_r$=$t_f$ ≤ 6ns Driver output $R_T$ ≤ 50Ω | | -40 to +85 °C | | | |
| | | | $V_L$ (V) | $V_{CC}$ (V) | Min. | Typ. | Max. | |
| $t_{IOVCC-VL}$ | Propagation Delay Time(4) $I/O_{VCC-LH}$ to $I/O_{VL-LH}$ $I/O_{VCC-HL}$ to $I/O_{VL-HL}$ | $t_{PLH}$ | 1.8 | 1.8 | | 2 | 15 | ns |
| | | | 1.8 | 2.5 | | 2 | 15 | |
| | | | 1.8 | 3.3 | | 2 | 15 | |
| | | | 1.8 | 5.0 | | 2 | 15 | |
| | | | 2.5 | 3.3 | | 2 | 15 | |
| | | $t_{PHL}$ | 1.8 | 1.8 | | 5 | 15 | |
| | | | 1.8 | 2.5 | | 5 | 15 | |
| | | | 1.8 | 3.3 | | 5 | 15 | |
| | | | 1.8 | 5.0 | | 6 | 15 | |
| | | | 2.5 | 3.3 | | 4 | 15 | |
| $t_{PZL}$ $t_{PZH}$ $t_{PLZ}$ $t_{PZL}$ | Output Enable and Disable Time | | 1.8 | 1.8 | | 60 | 80 | ns |
| | | | 1.8 | 5.0 | | 150 | 200 | |
| $t_{OSLH}$ $t_{OSHL}$ | Channel to channel Skew Time (6)(7) | | 1.8 | 1.8 | | 0.1 | 1 | ns |
| | | | 1.8 | 5.0 | | 0.5 | 1 | |
| DR | Maximum Data Rate | | 1.8 to 5.0 | $V_L$ to 5.0 | 13 | | | Mbps |

1. For normal operation, ensure $V_L$ < ($V_{CC}$ + 0.3V). During power-up, $V_L$ > ($V_{CC}$ + 0.3V) will not damage the device
2. For $V_{CC}$ = $V_L$ = 1.8V, tr = tf ≤ 4ns
3. Power Supply Range: $V_L$, $V_{CC}$ 1.8V ± 5%, 2.5 ± 0.2V, 3.3 ± 0.3V, 5.0 ± 0.5V.
4. Typical values are referred to $T_A$=25°CTypical values are referred to $T_A$=25°C
5. Rise Time:10% to 90%, Fall Time 90% to 10%
6. tpd: 50% to 50%
7. Skew is defined as the absolute value of the difference between the actual propagation delay for any two outputs of the same device switching in the same direction, either HIGH or LOW ($t_{OSLH}$ = | $t_{PLHm}$ - $t_{PLHn}$|, $t_{OSHL}$ = | $t_{PHLm}$ - $t_{PHLn}$|
8. Each translator equally loaded; parameter guaranteed by design

**Table 6. AC characteristic (open drain driving)**

| Symbol | Parameter | | Test Condition (1) | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | $C_L$=15pF $t_r$=$t_f$ ≤ 6ns Driver output $R_T$ ≤ 50Ω (2) | | -40 to +85 °C | | | |
| | | | $V_L$ (V) (3) | $V_{CC}$ (V) (3) | Min. | Typ. (4) | Max. | |
| $t_{RVCC}$ | Rise Time $I/O_{VCC}$ (3)(8) | | 1.8 | 1.8 | | 210 | 300 | ns |
| | | | 1.8 | 5.0 | | 59 | 150 | |
| $t_{FCC}$ | Fall Time $I/O_{VCC}$ (3)(8) | | 1.8 | 1.8 | | 12 | 30 | ns |
| | | | 1.8 | 5.0 | | 20 | 30 | |
| $t_{RVL}$ | Rise Time $I/O_{VL}$ (3)(8) | | 1.8 | 1.8 | | 210 | 300 | ns |
| | | | 1.8 | 5.0 | | 96 | 150 | |
| $t_{FVL}$ | Fall Time $I/O_{VL}$ (3)(8) | | 1.8 | 1.8 | | 11 | 30 | ns |
| | | | 1.8 | 5.0 | | 11 | 30 | |
| $t_{IOVL-VCC}$ | Propagation Delay Time(4) $I/O_{VL-LH}$ to $I/O_{VCC-LH}$ $I/O_{VL-HL}$ to $I/O_{VCC-HL}$ | $t_{PLH}$ | 1.8 | 1.8 | | 210 | 300 | ns |
| | | | 1.8 | 5.0 | | 100 | 150 | |
| | | $t_{PHL}$ | 1.8 | 1.8 | | 7 | 20 | |
| | | | 1.8 | 5.0 | | 14 | 20 | |
| $t_{IOVCC-VL}$ | Propagation Delay Time(4) $I/O_{VCC-LH}$ to $I/O_{VL-LH}$ $I/O_{VCC-HL}$ to $I/O_{VL-HL}$ | $t_{PLH}$ | 1.8 | 1.8 | | 210 | 300 | ns |
| | | | 1.8 | 5.0 | | 57 | 150 | |
| | | $t_{PHL}$ | 1.8 | 1.8 | | 7 | 20 | |
| | | | 1.8 | 5.0 | | 8 | 20 | |
| $t_{PZL}$ $t_{PZH}$ $t_{PLZ}$ $t_{PZL}$ | Output Enable and Disable Time | | 1.8 | 1.8 | | 60 | 80 | ns |
| | | | 1.8 | 5.0 | | 150 | 200 | |
| $t_{OSLH}$ $t_{OSHL}$ | Channel to channel Skew Time (6)(7) | | 1.8 | 1.8 | | 10 | 20 | ns |
| | | | 1.8 | 5.0 | | 2 | 10 | |
| DR | Maximum Data Rate | | 1.8 to 5.0 | $V_L$ to 5.0 | 800 | | | kbps |

1. For normal operation, ensure $V_L$ < ($V_{CC}$ + 0.3V). During power-up, $V_L$ > ($V_{CC}$ + 0.3V) will not damage the device
2. For $V_{CC}$ = $V_L$ = 1.8V, tr = tf ≤ 4ns
3. Power Supply Range: $V_L$, $V_{CC}$ 1.8V ± 5%, 2.5 ± 0.2V, 3.3 ± 0.3V, 5.0 ± 0.5V.
4. Typical values are referred to $T_A$=25°C
5. Rise Time:10% to 90%, Fall Time 90% to 10%
6. tpd: 50% to 50%
7. Skew is defined as the absolute value of the difference between the actual propagation delay for any two outputs of the same device switching in the same direction, either HIGH or LOW ($t_{OSLH}$ = | $t_{PLHm}$ - $t_{PLHn}$|, $t_{OSHL}$ = | $t_{PHLm}$ - $t_{PHLn}$|
8. Each translator equally loaded; parameter guaranteed by desig

# 5 Test circuit

**Figure 4. Test circuit**

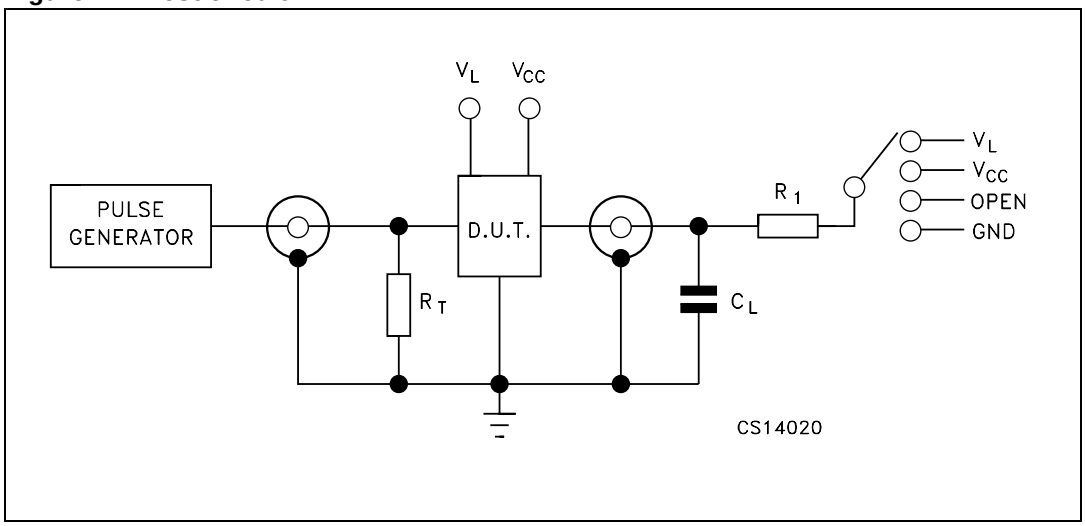



**Table 7. Test circuit switches**

| Test | Switch | | |
|---|---|---|---|
| | Driving $I/O_{VL}$ | Driving $I/O_{VCC}$ | Open Drain Driving |
| $t_{PLH}$, $t_{PHL}$ | Open | Open | Open |
| $t_{PZL}$, $t_{PLZ}$ | $V_{CC}$ | $V_L$ | - |
| $t_{PZH}$, $t_{PHZ}$ | Gnd | Gnd | - |

*Note:* *$C_L$ = 15/50pF or equivalent (includes jig and probe capacitance)*

*$R_1$ = 1KΩ or equivalent*

*$R_T$ = $Z_{OUT}$ of pulse generator (typically 50Ω)*

**Table 8. Truth table**

| Control Pin | Bidirectional Input/Outputs | |
|---|---|---|
| OE | $I/O_{VL}$ | $I/O_{VCC}$ |
| H (1) | H (1) | H (2) |
| H (1) | L | L |
| L | Z | Z |

1. High Level $V_L$ Power Supply referred
2. High Level $V_{CC}$ Power Supply referred

*Note:* *X= Do not care; Z = High Impedance;*

# 6 Waveforms

**Table 9. Waveform symbol value**

| Symbol | Driving $I/O_{VL}$ | | Driving $I/O_{VCC}$ | |
|---|---|---|---|---|
| | $1.8V \le V_L \le V_{CC} \le 2.5V$ | $3.3V \le V_L \le V_{CC} \le 5.0V$ | $1.8V \le V_L \le V_{CC} \le 2.5V$ | $3.3V \le V_L \le V_{CC} \le 5.0V$ |
| $V_{IH}$ | $V_L$ | $V_L$ | $V_{CC}$ | $V_{CC}$ |
| $V_{IM}$ | 50% $V_L$ | 50% $V_L$ | 50% $V_{CC}$ | 50% $V_{CC}$ |
| $V_{OM}$ | 50% $V_{CC}$ | 50% $V_{CC}$ | 50% $V_{CC}$ | 50% $V_{CC}$ |
| $V_X$ | $V_{OL}$ +0.15V | $V_{OL}$ +0.3V | $V_{OL}$ +0.15V | $V_{OL}$ +0.3V |
| $V_Y$ | $V_{OH}$ -0.15V | $V_{OH}$ -0.3V | $V_{OH}$ -0.15V | $V_{OH}$ -0.3V |

**Figure 5. Waveform - propagation delay (f = 1MHz; 50% duty cycle)**

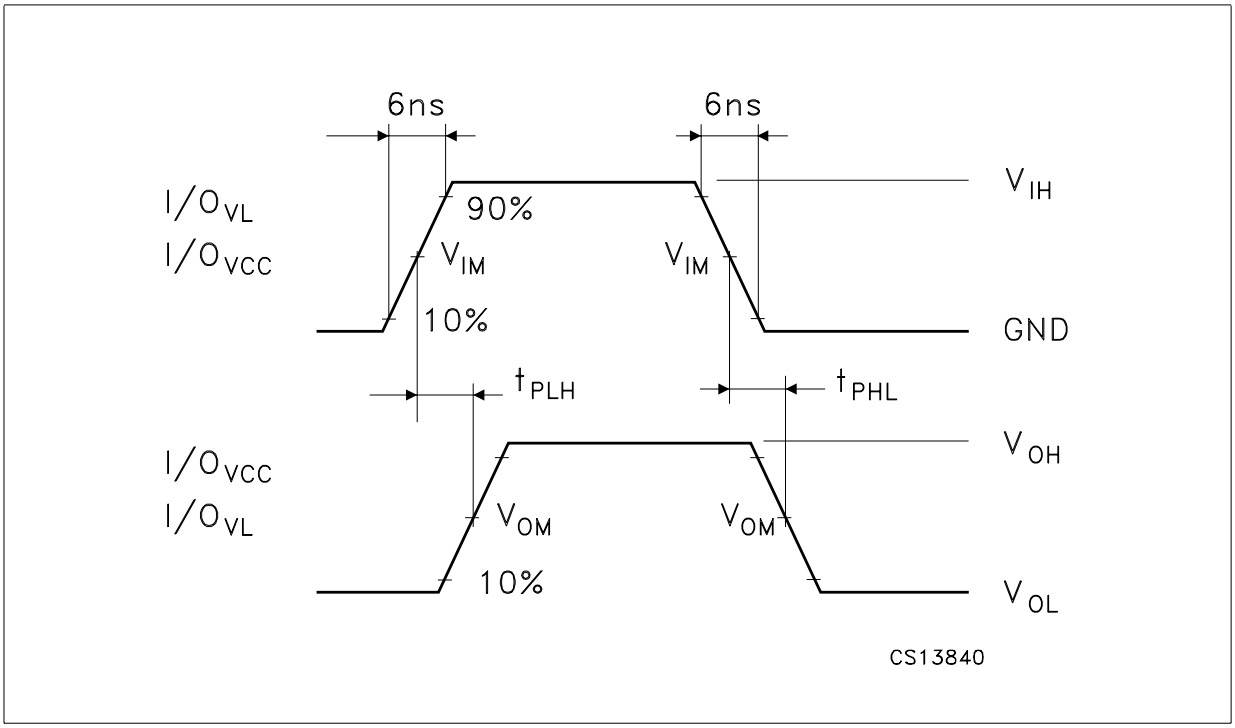
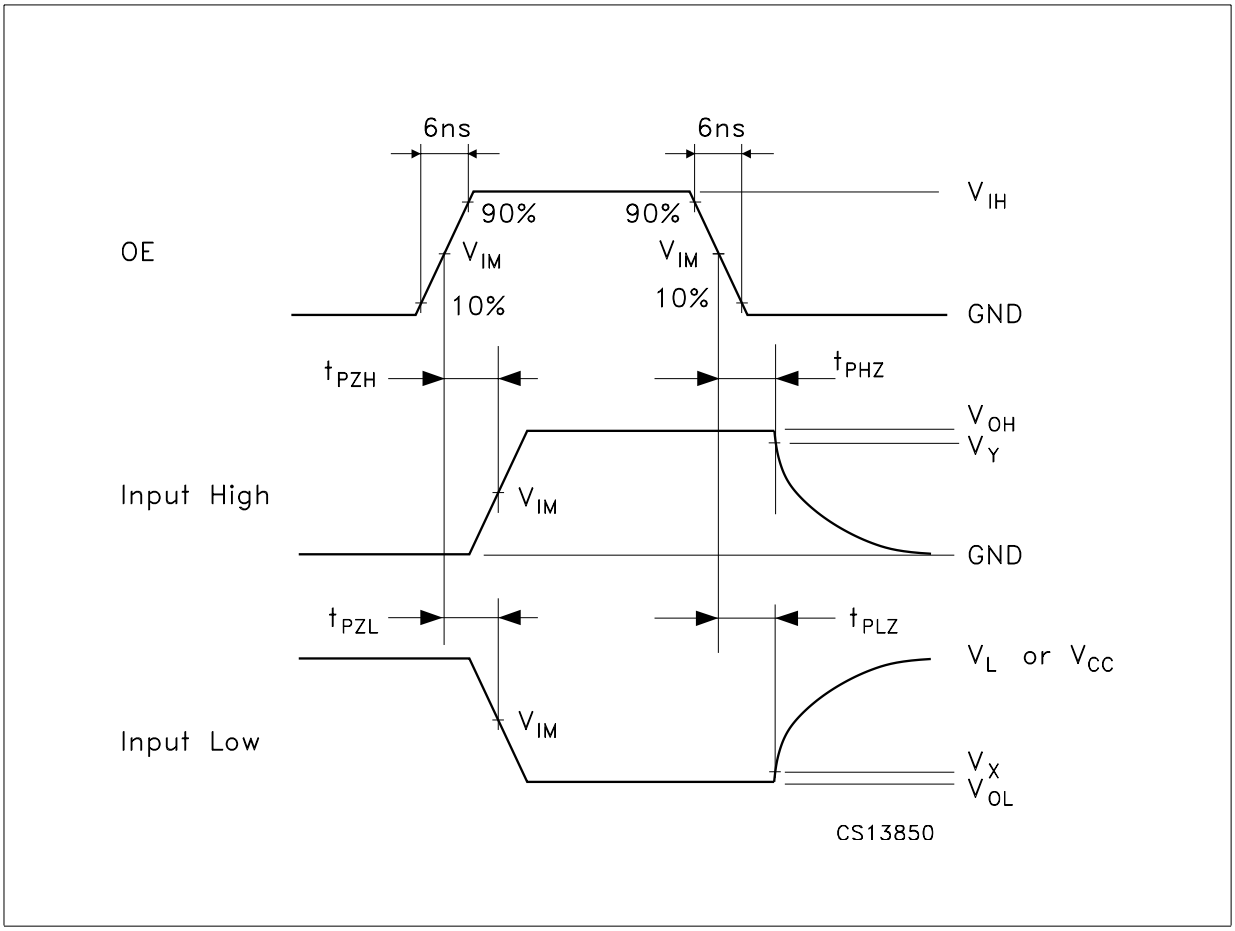


**Figure 6. Waveform - output enable and disable time (f = 1MHz; 50% duty cycle)**



# 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com

**Figure 7. TSSOP20 Mechanical data**

**TSSOP20 MECHANICAL DATA**

| DIM. | mm. | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | | | 1.2 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | 0.004 | 0.006 |
| A2 | 0.8 | 1 | 1.05 | 0.031 | 0.039 | 0.041 |
| b | 0.19 | | 0.30 | 0.007 | | 0.012 |
| c | 0.09 | | 0.20 | 0.004 | | 0.0079 |
| D | 6.4 | 6.5 | 6.6 | 0.252 | 0.256 | 0.260 |
| E | 6.2 | 6.4 | 6.6 | 0.244 | 0.252 | 0.260 |
| E1 | 4.3 | 4.4 | 4.48 | 0.169 | 0.173 | 0.176 |
| e | | 0.65 BSC | | | 0.0256 BSC | |
| K | 0° | | 8° | 0° | | 8° |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |

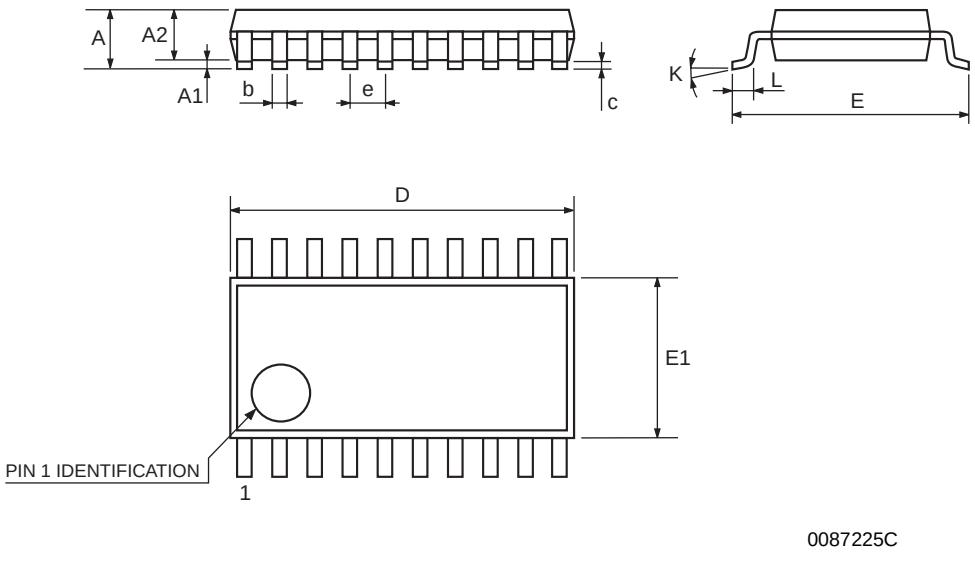


**Figure 8. Flip-Chip20 Mechanical data**

**Flip-Chip20 MECHANICAL DATA**

| DIM. | mm. | | | mils | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | 0.81 | 0.89 | 1.00 | 31.9 | 35.0 | 39.4 |
| A1 | 0.15 | 0.24 | 0.35 | 5.9 | 9.4 | 13.8 |
| A2 | | 0.65 | | | 25.6 | |
| b | 0.25 | 0.30 | 0.35 | 9.8 | 11.8 | 13.8 |
| D | 2.41 | 2.46 | 2.51 | 94.9 | 96.9 | 98.8 |
| D1 | | 2.00 | | | 78.7 | |
| E | 1.93 | 1.98 | 2.03 | 76.0 | 78.0 | 79.9 |
| E1 | | 1.5 | | | 59.1 | |
| e | | 0.50 | | | 19.7 | |
| SE | | 0.25 | | | 9.8 | |

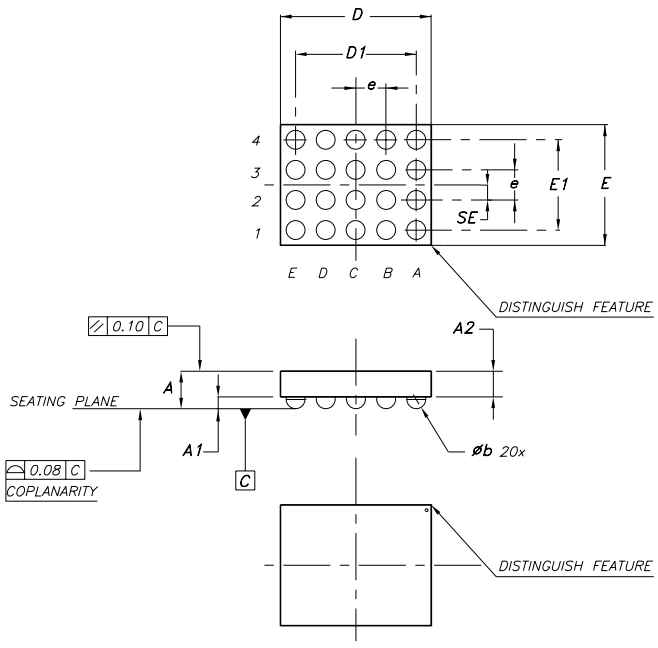
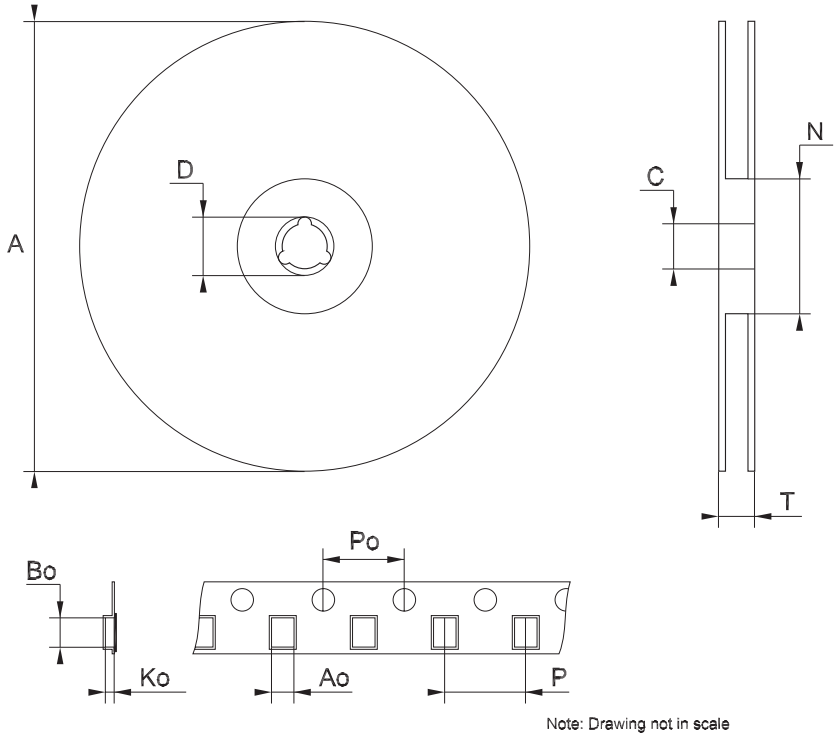


**Figure 9. TSSOP20 Tape and reel**

**Tape & Reel TSSOP20 MECHANICAL DATA**

| DIM. | mm. | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | | | 330 | | | 12.992 |
| C | 12.8 | | 13.2 | 0.504 | | 0.519 |
| D | 20.2 | | | 0.795 | | |
| N | 60 | | | 2.362 | | |
| T | | | 22.4 | | | 0.882 |
| Ao | 6.8 | | 7 | 0.268 | | 0.276 |
| Bo | 6.9 | | 7.1 | 0.272 | | 0.280 |
| Ko | 1.7 | | 1.9 | 0.067 | | 0.075 |
| Po | 3.9 | | 4.1 | 0.153 | | 0.161 |
| P | 11.9 | | 12.1 | 0.468 | | 0.476 |

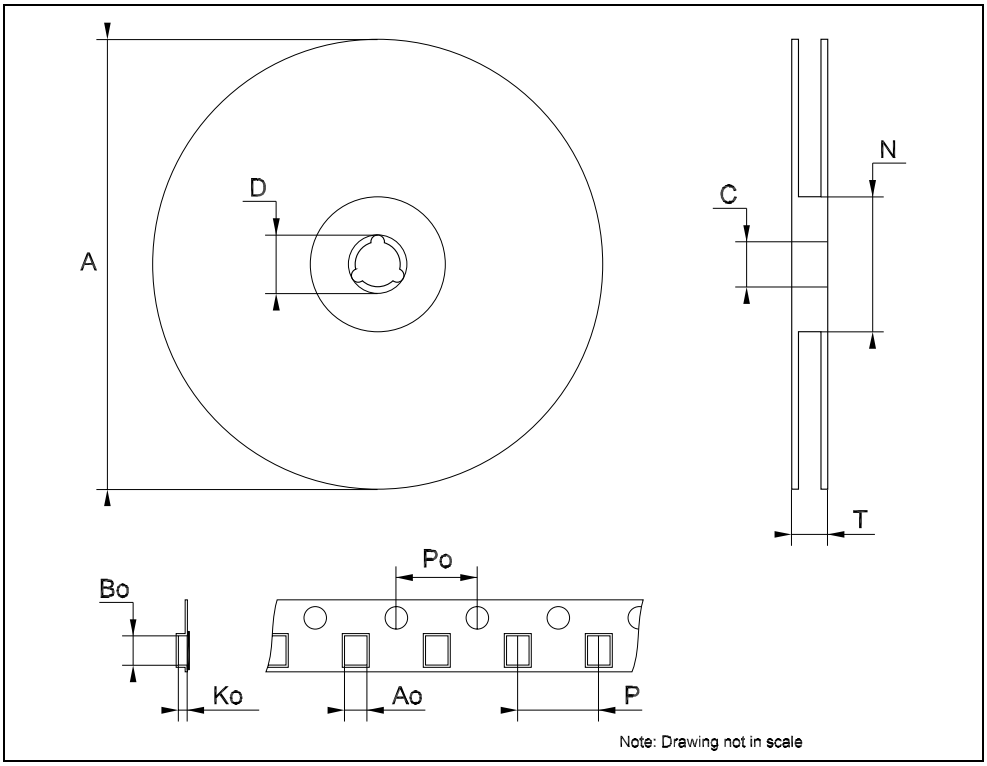



Note: Drawing not in scale

**Figure 10. Flip-Chip20 Tape and reel**

**Tape & Reel Flip-Chip20 MECHANICAL DATA**

| DIM. | mm. | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | | | 180 | | | 7.086 |
| C | 12.8 | | 13.2 | 0.504 | | 0.519 |
| D | 20.2 | | | 0.795 | | |
| N | 60 | | | 2.362 | | |
| T | | | 14.4 | | | 0.567 |
| Ao | 2.13 | 2.23 | 2.33 | 0.084 | 0.088 | 0.092 |
| Bo | 2.62 | 2.72 | 2.82 | 0.103 | 0.107 | 0.111 |
| Ko | 1.05 | 1.15 | 1.25 | 0.041 | 0.045 | 0.049 |
| Po | 3.9 | | 4.1 | 0.153 | | 0.161 |
| P | 3.9 | | 4.1 | 0.153 | | 0.161 |



# 8 Revision history

**Table 10. Revision history**

| Date | Revision | Changes |
|---|---|---|
| 10-Apr-2006 | 1 | Initial release. |

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