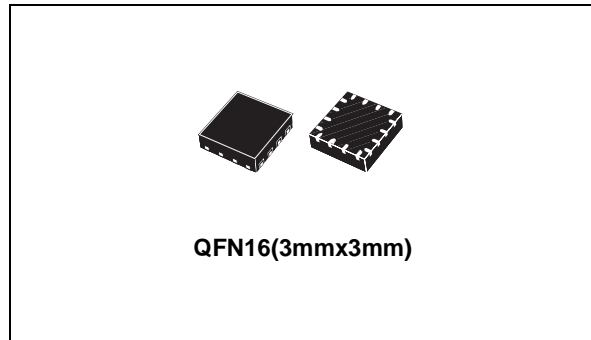


USB Transceiver

Features

- Compliant to USB v2.0 for Full-speed (12Mb/s) and Low-speed (1.5Mbps) Operation
- $\pm 14\text{KV}$ on D+, D- Lines; $\pm 5\text{KV}$ on VBUS
- ESD Compliant To IEC-61000-4.2 (Level 3)
- Separate I/o Supply With Operation Down To 1.6V
- Integrated Speed Select Termination Supply
- Very Low Power Consumption To Meet USB 'suspend' Current Requirements
- Small QFN16 Lead Free Package
- No Power Supply Sequencing Requirements
- Software Controlled Re-enumeration



transceiver has an integrated voltage detector to detect the presence of the VBUS voltage.

The transceiver also supports Sharing mode when VBUS is not present, which allows the D+/D- lines to be shared with other serial protocols.

It supports both full-speed (12Mbps) and low-speed (1.5Mbps) operation. It is also designed to operate down to 1.6V so that it is compatible with lower system voltages of most portable systems, which include PDAs, MP3 Player and Cell phones to mention few.

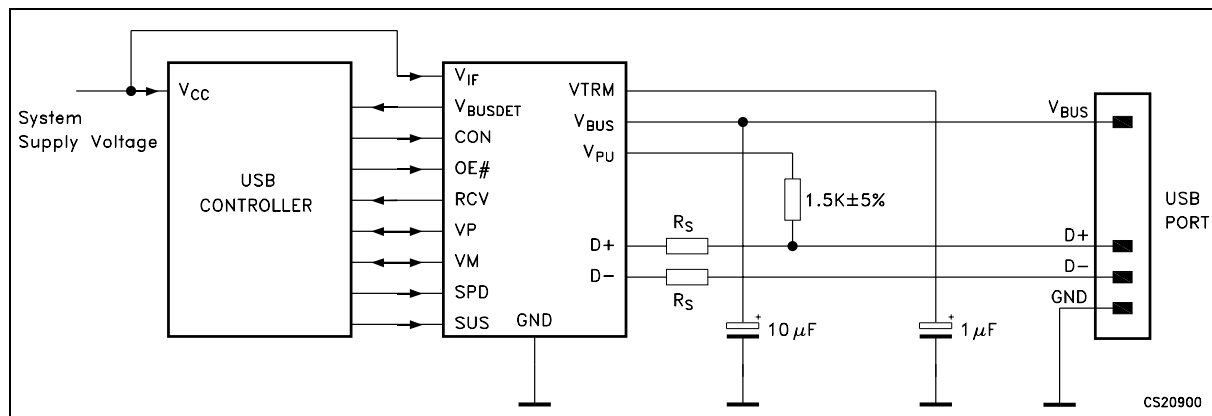
Description

The STUSB02E is a single chip transceiver that complies with the physical layer specifications of the Universal Serial Bus (USB) v2.0 standard. It has an integrated 5V to 3.3V regulator which allows direct powering from the VBUS. The

Order Codes

| Type | Package | Comments |
|------------|-------------------|---------------------|
| STUSB02EQR | QFN16 (3mm x 3mm) | 3000 parts per reel |

Typical Application



Contents

| | | |
|---|----------------------------------|----|
| 1 | Pin Configuration | 3 |
| 2 | Functional Tables | 4 |
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1 Pin Configuration

Figure 1. Pin Connections (Top View)

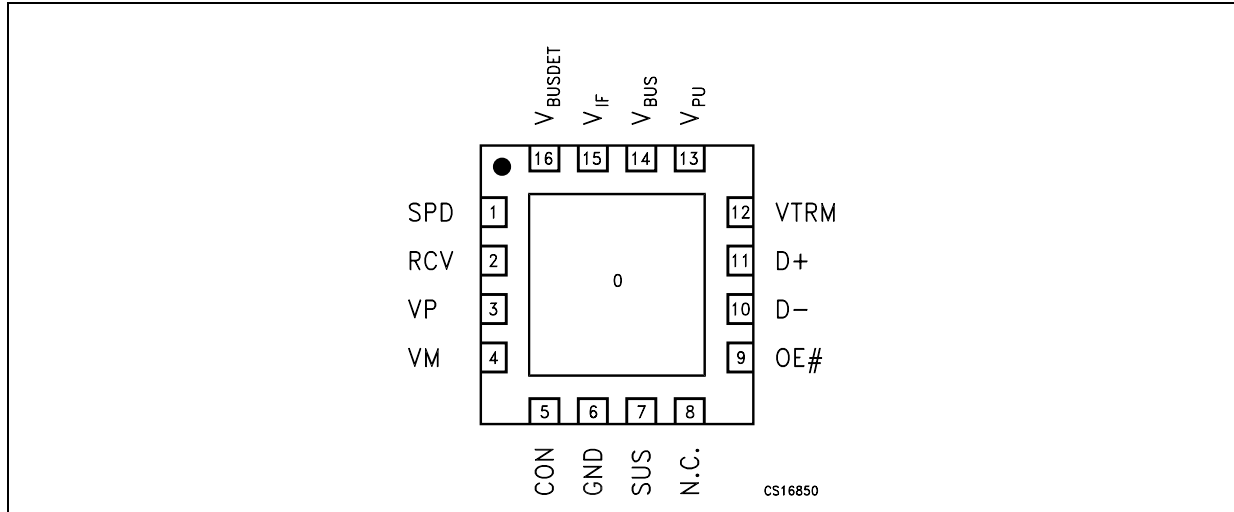


Table 1. Pin Description

| PIN N° | SYMBOL | I/O | NAME AND FUNCTION |
|--------|---------------------|-----|--|
| 0 | N.C. | | Not Connected. |
| 15 | V _{IF} | I | System Interface Supply Voltage (1.6V to 3.6V). (return) Provides reference supply voltage for system I/O interface signals. |
| 1 | SPD | I | Edge Rate Control. A logic HIGH operates at edge rates for “fullspeed” operation. A logic LOW operates edge rates for “lowspeed” operation. |
| 2 | RCV | O | Receive Data. Output for USB differential data. (see Table 2) |
| 3 | VP | I/O | If OE# = H, VP = Receiver output (+) If OE# = L, VP = Driver input (+) (see Table 2) |
| 4 | VM | I/O | If OE# = H, VM = Receiver output (-) If OE# = L, VM = Driver input (-) (see Table 2) |
| 5 | CON | I | CONNECT (input). Controls state of V _{PU} . Refer to V _{PU} pin description for detail. |
| 6 | GND | | Ground Reference |
| 7 | SUS | I | Suspend (active-high). Turns off internal circuits to reduce supply current. |
| 9 | OE# | I | Output Enable (active-low). Enables transceiver data transmission onto the bus. When not active, the transceiver is in the receive mode. (see Table 2) |
| 10, 11 | D-, D+ | I/O | Differential data lines that conform to the USB v2.0 standard. (see Table 2) |
| 12 | VTRM | O | 3.3V Reference Supply Output. Requires a 1.0µF decoupling capacitor for stability. |
| 13 | V _{PU} | O | Pull-up Supply Voltage Output. Used to connect 1.5K pull-up speed detect resistor. If CON = 0, V _{PU} is high impedance. If CON = 1, V _{PU} = 3.3V ±10%. |
| 14 | V _{BUS} | I | USB Bus Supply Voltage (4V to 5.5V). Supplies power to the USB transceiver and internal circuitry. |
| 8 | N.C. | | Not connected. |
| 16 | V _{BUSDET} | O | V _{BUS} indicator output. When V _{BUS} > 2.9V, V _{BUSDET} = High and when < 2.2V, V _{BUSDET} = Low. |

2 Functional Tables

Table 2. Function Selection

| SUS | OE# | D+, D- | RCV | VP/VM | FUNCTION |
|-----|-----|-----------|--------|------------|---|
| L | L | Driving | Active | Active | Normal transmit mode |
| L | H | Receiving | Active | Active | Normal receive mode |
| H | L | Hi-Z | L | Not Active | Low power state |
| H | H | Hi-Z | L | Active | Receiving during suspend (low power state) ⁽¹⁾ |

(1) During suspend VP and VM are active in order to detect out of band signalling conditions

Table 3. Truth Table During Normal Mode

| OE# = L | | | | | |
|---------|----|--------|----|-----|------------|
| INPUT | | OUTPUT | | | RESULT |
| VP | VM | D+ | D- | RCV | |
| L | L | L | L | X | SE0 |
| L | H | L | H | L | Logic Low |
| H | L | H | L | H | Logic High |
| H | H | X | X | X | Undefined |
| OE# = H | | | | | |
| INPUT | | OUTPUT | | | RESULT |
| D+ | D- | VP | VM | RCV | |
| L | L | L | L | X | SE0 |
| L | H | L | H | L | Logic Low |
| H | L | H | L | H | Logic High |
| H | H | X | X | X | Undefined |

X = Undefined

3 Maximum Ratings

Table 4. Absolute Maximum Ratings

| Symbol | Parameter | Value | Unit |
|-----------|-----------------------------|--------------|--------------------|
| V_{BUS} | Supply Voltage | 6 | V |
| V+ | All other Inputs | -0.5 to 4.6 | V |
| I_O | Output Current (D+, D-) | ± 50 | mA |
| I_O | Output Current (all others) | ± 15 | mA |
| I_I | Input Current | ± 50 | mA |
| ESD | D+, D-, HBM (Note 3) | ± 14 | KV |
| | V_{BUS} (Note 3) | ± 5 | |
| | All other pins (Note 3) | ± 2 | |
| T_{STG} | Storage Temperature Range | -65 to + 150 | $^{\circ}\text{C}$ |
| T_{OPR} | Operating Temperature Range | -40 to + 85 | $^{\circ}\text{C}$ |

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional Operation under these conditions is not implied.

Note 3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

Table 5. Thermal Data

| Symbol | Parameter | Value | Unit |
|------------|-------------------------------------|-------|-----------------------------|
| R_{thJA} | Thermal Resistance Junction-Ambient | 59 | $^{\circ}\text{C}/\text{W}$ |

4 Electrical Characteristics

Table 6. DC Electrical Characteristics (System and USB Interface)

($V_{IF} = 3.6V$, $V_{BUS} = 5V$ unless otherwise noted; $T_A = 25^\circ C$, specifications over temperature, -40 to $85^\circ C$)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|----------------|-------------------------------------|---|--------------|------|--------------|---------|
| V_{BUS} | USB Supply Voltage | | 4 | | 5.5 | V |
| V_{IF} | System I/F Supply Voltage | | 1.6 | | 3.6 | V |
| V_{IL} | Low Level Input Voltage (Note 4) | | | | $0.15V_{IF}$ | V |
| V_{IH} | High Level Input Voltage (Note 4) | | $0.85V_{IF}$ | | | V |
| V_{OL} | Low Level Output Voltage (Note 4) | $I_{OL} = 20\mu A$ | 0 | | 100 | mV |
| V_{OH} | High Level Output Voltage (Note 4) | $I_{OH} = -20\mu A$ | $V_{IF}-100$ | | V_{IF} | mV |
| I_{IL} | Input Leakage Current (Note 4) | | -5 | | 5 | μA |
| I_{IF} | V_{IF} Supply Current (Note 7) | D+, D- are idle, OE# = SUS = 0 | | | 5 | μA |
| | | D+, D- are idle, OE# = SUS = 1 | | | 5 | |
| | | D+, D- active, $C_{LOAD} = 50pF$, SPD = 1, f = 6MHz, (Note 5) | | | 650 | |
| | | D+, D- active, $C_{LOAD} = 600pF$, SPD = 0, f = 750KHz, (Note 5) | | | 75 | |
| I_{BUS} | V_{BUS} Supply Current | D+, D- are idle, $V_{BUS} = 5.25V$ Suspend Mode (SUS = 1), OE# = 1, SPD = 1 | | | 200 | μA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ SPD = 1, OE# = SUS = 0 | | | 5 | mA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ OE# = SUS = SPD = 0 | | | 700 | μA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ OE# = 1, SUS = SPD = 0 | | | 350 | |
| | | D+, D- active, $V_{BUS} = 5.25V$ $C_{LOAD} = 50pF$, SPD = 1, f = 6 MHz OE# = SUS = 0 (Note 5) | | | 10 | mA |
| | | D+, D- active, $V_{BUS} = 5.25V$ $C_{LOAD} = 600pF$, f = 750 KHz, OE# = SUS = SPD = 0 (Note 5) | | | 5 | |
| $I_{VPULLEAK}$ | V_{PU} Leakage Current | CON = 0, $V_{PU} = 0V$ | -5 | | 5 | μA |
| $I_{VIFLEAK}$ | V_{IF} Leakage Current | $V_{IF} = 3.6V$, $V_{BUS} = 0V$ | -5 | | 5 | μA |
| V_{PU} | Pull-Up Output Voltage | $I_{TERM} = 200\mu A$, $V_{BUS} = 4$ to $5.25V$ | 3 | | 3.6 | V |
| R_{SW} | V_{PU} Internal Switch Resistance | $I_{TERM} = 10mA$, $V_{BUS} = 4$ to $5.25V$ | 7 | 9 | 11 | W |

Note 1. Exceeding the absolute maximum rating may damage the device.

Note 2. The device is not guaranteed to function outside its operating rating.

Note 3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

Note 4. Specification applies to the following pins: SUS, SPD, RCV, CON, VP, VM, OE#, VBUSDDET.

Note 5. Characterized specification(s), but not production tested.

Note 6. All AC parameters guaranteed by design but not production tested.

Note 7. RCV = NO LOADED

Table 7. DC Electrical Characteristics (System and USB Interface)
 ($V_{IF} = 3.6V$, $V_{BUS} = 5V$ unless otherwise noted; $T_A = 25^\circ C$)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---------------|-------------------------------------|---|--------------------------|------------------------|--------------|---------|
| V_{BUS} | USB Supply Voltage | | 4 | | 5.5 | V |
| V_{IF} | System I/F Supply Voltage | | 1.6 | | 3.6 | V |
| V_{IL} | Low Level Input Voltage (Note 4) | | | | $0.15V_{IF}$ | V |
| V_{IH} | High Level Input Voltage (Note 4) | | $0.85V_{IF}$ | | | V |
| V_{OL} | Low Level Output Voltage (Note 4) | $I_{OL} = 20\mu A$ | | | 0.1 | V |
| V_{OH} | High Level Output Voltage (Note 4) | $I_{OH} = 20\mu A$ | $0.9V_{IF}$ | | | V |
| I_{IL} | Input Leakage Current (Note 4) | | -5 | | 5 | μA |
| I_{IF} | V_{IF} Supply Current (Note 7) | D+, D- are idle, OE# = SUS = 0 | | | 5 | μA |
| | | D+, D- active, $C_{LOAD} = 50pF$, SPD = 1, f = 6MHz, (Note 5) | | 450 | | |
| | | D+, D- active, $C_{LOAD} = 50pF$, SPD = 0, f = 750KHz, (Note 5) | | 50 | | |
| I_{BUS} | V_{BUS} Supply Current | D+, D- are idle, $V_{BUS} = 5.25V$ Suspend Mode (SUS = 1) | | 70 | 150 | μA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ SPD = 1, OE# = SUS = 0 | | 3.0 | | mA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ OE# = SUS = SPD = 0 | | 300 | | μA |
| | | D+, D- are idle, $V_{BUS} = 5.25V$ OE# = 1, SUS = SPD = 0 | | 150 | | |
| | | D+, D- active, $V_{BUS} = 5.25V$ $C_{LOAD} = 50pF$, SPD = 1, f = 6 MHz OE# = SUS = 0 (Note 5) | | 7.3 | | mA |
| | | D+, D- active, $V_{BUS} = 5.25V$ $C_{LOAD} = 600pF$, f = 750 KHz, OE# = SUS = SPD = 0 (Note 5) | | 3.6 | | |
| | | $I_{VPULEAK}$ | V_{PU} Leakage Current | CON = 1, $V_{PU} = 0V$ | -5 | |
| $I_{VIFLEAK}$ | V_{IF} Leakage Current | $V_{IF} = 3.6V$, $V_{BUS} = 0V$ | -5 | | 5 | μA |
| V_{PU} | Pull-Up Output Voltage | $I_{TERM} = 200\mu A$, $V_{BUS} = 4$ to $5.25V$ | | 3.3 | | V |
| R_{SW} | V_{PU} Internal Switch Resistance | $I_{TERM} = 10mA$, $V_{BUS} = 4$ to $5.25V$ | | 9 | | W |

Note 1. Exceeding the absolute maximum rating may damage the device.

Note 2. The device is not guaranteed to function outside its operating rating.

Note 3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

Note 4. Specification applies to the following pins: SUS, SPD, RCV, CON, VP, VM, OE#, VBUSDET.

Note 5. Characterized specification(s), but not production tested.

Note 6. All AC parameters guaranteed by design but not production tested.

Note 7. RCV = NO LOADED

Table 8. ESD Performance

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|--------------------------------------|-------------------------------|------|------|------|------|
| ESD | IEC-1000-4-2 (D+, D-) | Air Discharge (10 pulses) | | ± 8 | | KV |
| | | Contact Discharge (10 pulses) | | ± 6 | | |
| | IEC-1000-4-2 (V _{BUS} only) | Air Discharge (10 pulses) | | ± 5 | | |
| | | Contact Discharge (10 pulses) | | ± 5 | | |

Table 9. DC Electrical Characteristics (Transceiver)

(V_{IF} = 3.6V, V_{BUS} = 5V unless otherwise noted; T_A = 25°C, specifications over temperature, -40 to 85°C)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-------------------|---|--|------|------|------|------|
| I _{LO} | Hi-Z State Data Line Leakage (Suspend Mode) | V _I = 0 to 3.3 V, SUS = 1 | -10 | | 10 | μA |
| V _{DI} | Differential Input Sensitivity | {(D+) - (D-)} | 0.2 | | | V |
| V _{CM} | Differential Common Mode Range | Includes V _{DI} range | 0.8 | | 2.5 | V |
| V _{SE} | Single Ended Receiver Threshold | | 0.8 | | 2.0 | V |
| V _{RHYS} | Receiver Hysteresis | V _{CM} = 0.8 V | | 100 | | mV |
| V _{OL} | Static Output Low | R _L = 1.5 KΩ at 3.6V (see test circuit) | | | 0.3 | V |
| V _{OH} | Static Output High | R _L = 15 KΩ at GND (see test circuit) | 2.8 | | 3.6 | V |
| C _I | Transceiver Capacitance | Pin to GND | | 25 | | pF |
| Z _{DRV} | Driver Output Resistance | Steady state drive | 9 | | 22 | W |

Table 10. DC Electrical Characteristics (Transceiver)

(V_{IF} = 3.6V, V_{BUS} = 5V unless otherwise noted; T_A = 25°C)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-------------------|---|--|------|------|------|------|
| I _{LO} | Hi-Z State Data Line Leakage (Suspend Mode) | V _I = 0 to 3.3 V, SUS = 1 | -2 | | 2 | μA |
| V _{DI} | Differential Input Sensitivity | {(D+) - (D-)} | 0.2 | | | V |
| V _{CM} | Differential Common Mode Range | Includes V _{DI} range | 0.8 | | 2.5 | V |
| V _{SE} | Single Ended Receiver Threshold | | 0.8 | | 2 | V |
| V _{RHYS} | Receiver Hysteresis | V _{CM} = 0.8 V | | 50 | | mV |
| V _{OL} | Static Output Low | R _L = 1.5 KΩ at 3.6V (see Test Circuits) | | | 0.3 | V |
| V _{OH} | Static Output High | R _L = 15 KΩ at GND (see Test Circuits) | 2.8 | | 3.6 | V |
| C _I | Transceiver Capacitance ⁽³⁾ | Pin to GND | | 25 | | pF |
| Z _{DRV} | Driver Output Resistance | Steady state drive | | 16 | | W |

(3) Pins D+, D-

Table 11. AC Electrical Characteristics(V_{IF} = 3.6V, V_{BUS} = 5V unless otherwise noted; T_A = 25°C.) (Note 6)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------------------------|--|--|------|------|--------|------|
| T _R | Transition Rise Time (LOW SPEED) | C _L = 50pF (Figure 3) | 75 | | | ns |
| | | C _L = 600pF | | | 300 | |
| T _F | Transition Fall Time (LOW SPEED) | C _L = 50pF (Figure 3) | 75 | | | ns |
| | | C _L = 600pF | | | 300 | |
| T _R , T _F | Rise/Fall Time Matching (LOW SPEED) | (T _R , T _F) | 80 | | 125 | % |
| V _{CRS} | Output Signal Crossover Voltage (LOW SPEED) | | 1.3 | | 2 | V |
| T _R | Transition Rise Time (FULL SPEED) | C _L = 50pF (Figure 3) | 4 | | 20 | ns |
| T _F | Transition Fall Time (FULL SPEED) | C _L = 50pF (Figure 3) | 4 | | 20 | ns |
| T _R , T _F | Rise/Fall Time Matching (FULL SPEED) | (T _R , T _F) | 90 | | 111.11 | % |
| V _{CRS} | Output Signal Crossover Voltage (FULL SPEED) | | 1.3 | | 2 | V |
| t _{PVZ} | OE# TO RCVR Tri-State Delay | Figure 2 | | 3 | | ns |
| t _{PZD} | Receiver Tri-State to Transmit Delay | LOW SPEED (Figure 2) | 13 | | | ns |
| | | FULL SPEED (Figure 2) | 32 | | | |
| t _{PDZ} | OE# TO RCVR Tri-State Delay | Figure 2 | | 6 | | ns |
| t _{PZV} | Driver Tri-State to Receive Delay | Figure 2 | | 27 | | ns |
| t _{PLH} t _{PHL} | VP, VM to D+, D- Propagation Delay | Figure 5 | | 16 | 20 | ns |
| t _{PLH} t _{PHL} | D+, D- to RCV Propagation Delay | Figure 4 | | 13 | 20 | ns |
| t _{PLH} t _{PHL} | D+, D- to VP, VM Propagation Delay | Figure 4 | | 8 | 20 | ns |

Note 1. Exceeding the absolute maximum rating may damage the device.

Note 2. The device is not guaranteed to function outside its operating rating.

Note 3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

Note 4. Specification applies to the following pins: SUS, SPD, RCV, CON, RCV, VP, VM, OE#.

Note 5. Characterized specification(s), but not production tested.

Note 6. All AC parameters guaranteed by design but not production tested.

5 Timing Diagram

Figure 2. Enable and Disable Times

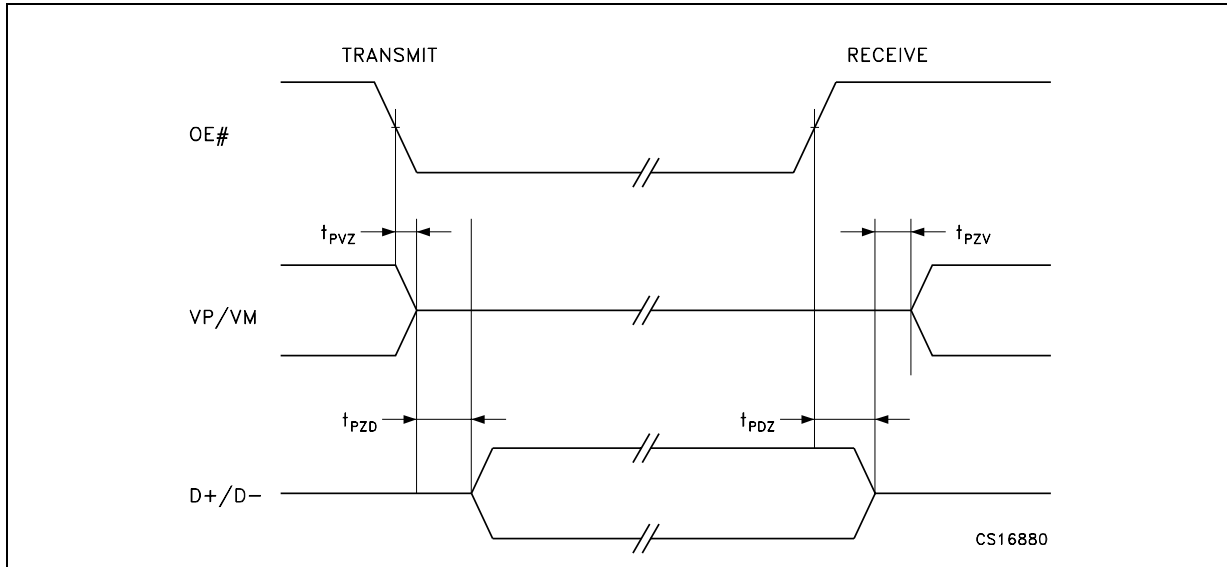


Figure 3. Rise and Fall Times

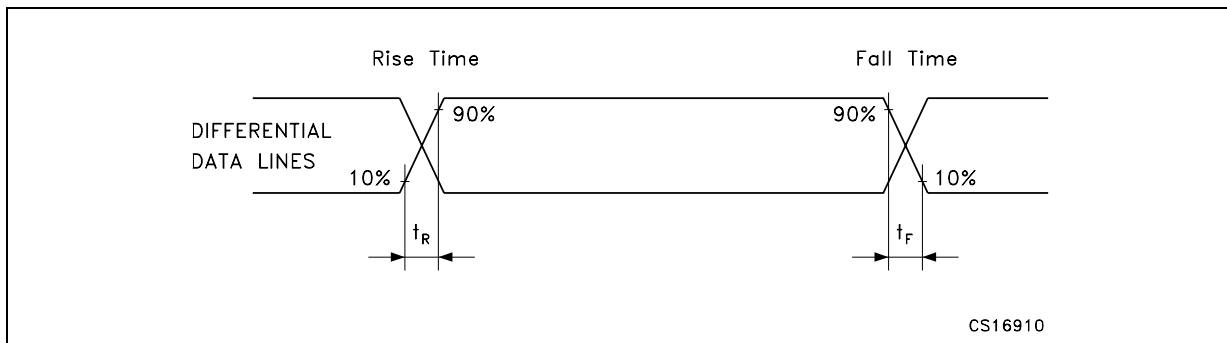


Figure 4. Receiver Propagation Delay

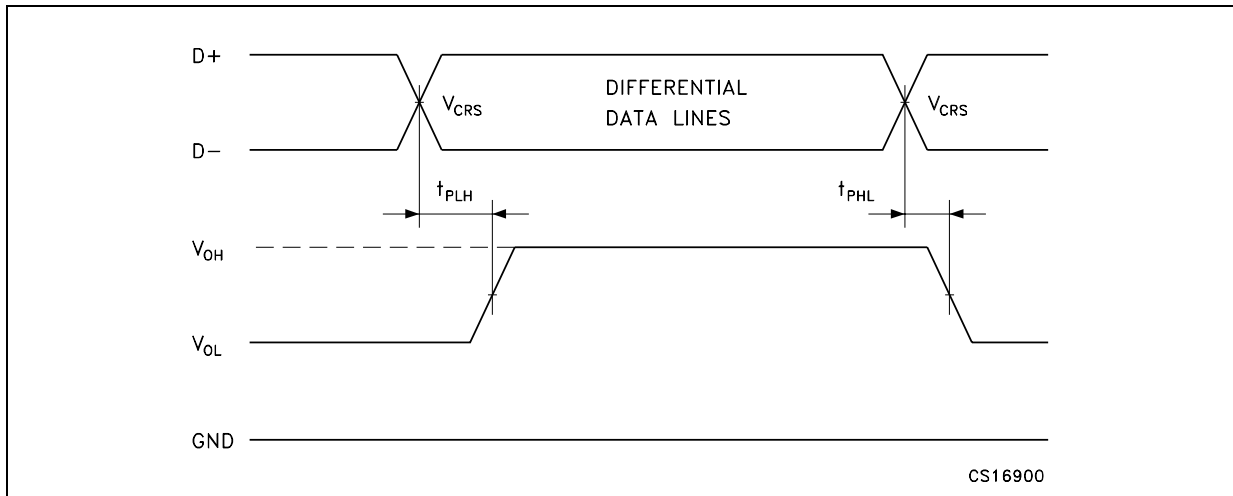
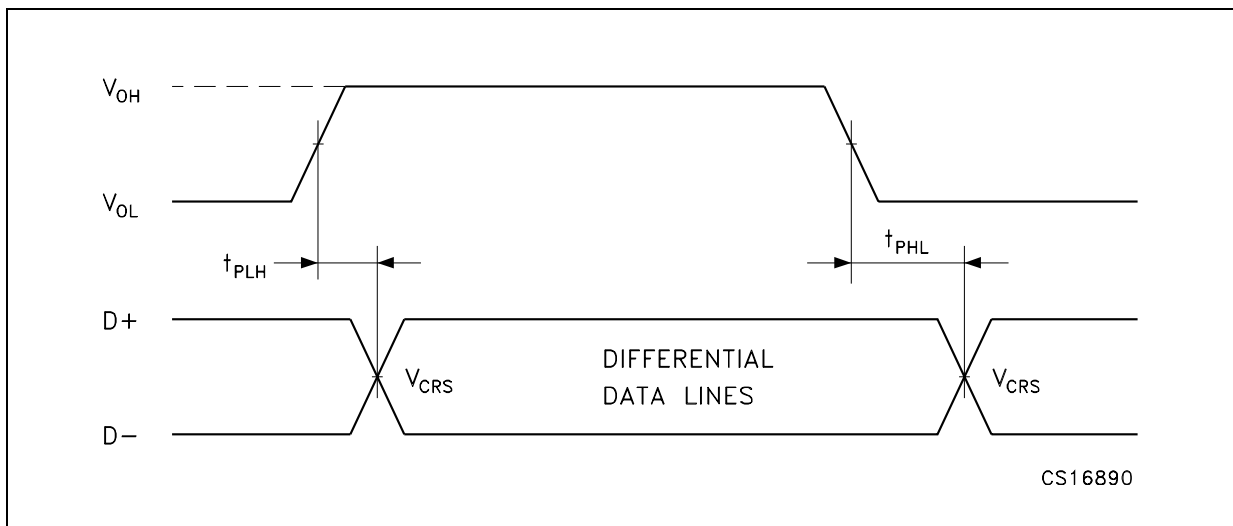
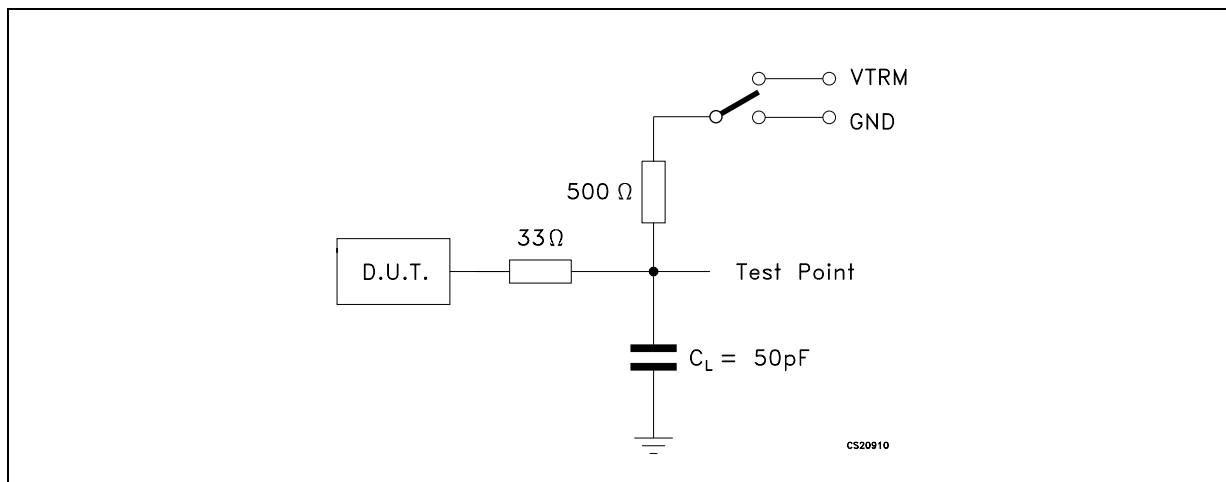


Figure 5. Driver Propagation Delay ($C_L = 50pF$)



Minimum Timing LS and maximum timing FS

Figure 6. Enable and Disable Time Circuit

Switch = GND for t_{pZH} and t_{pHZ} ; V = VTRM for t_{pZL} and t_{pLZ}

6 Test Circuits

Figure 7. Load for VP, VM, RCV

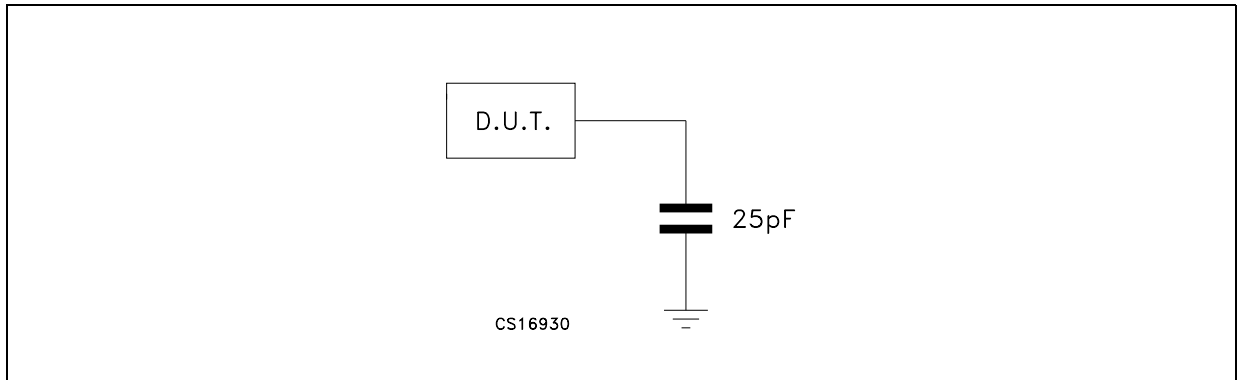


Figure 8. Load for D+, D-

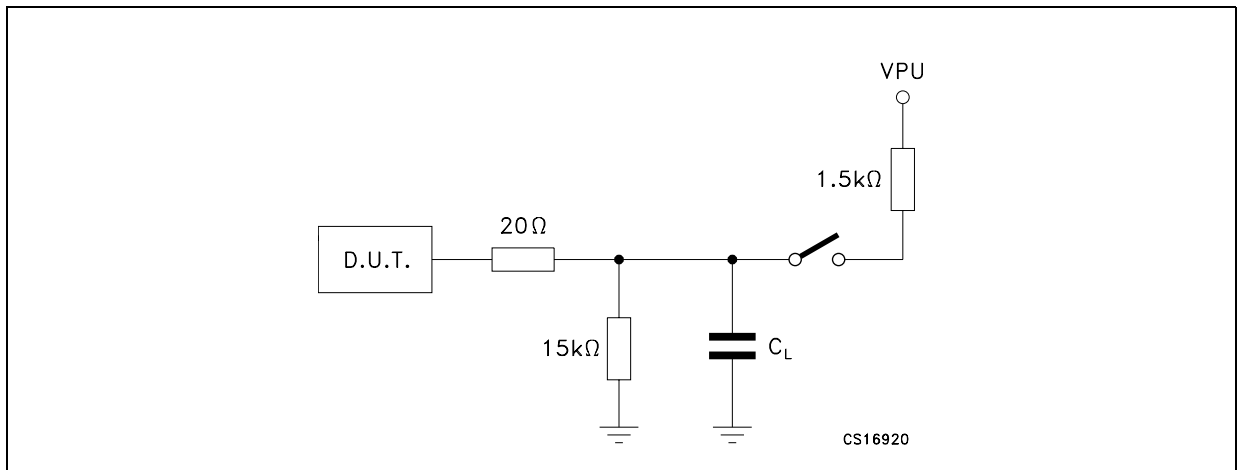
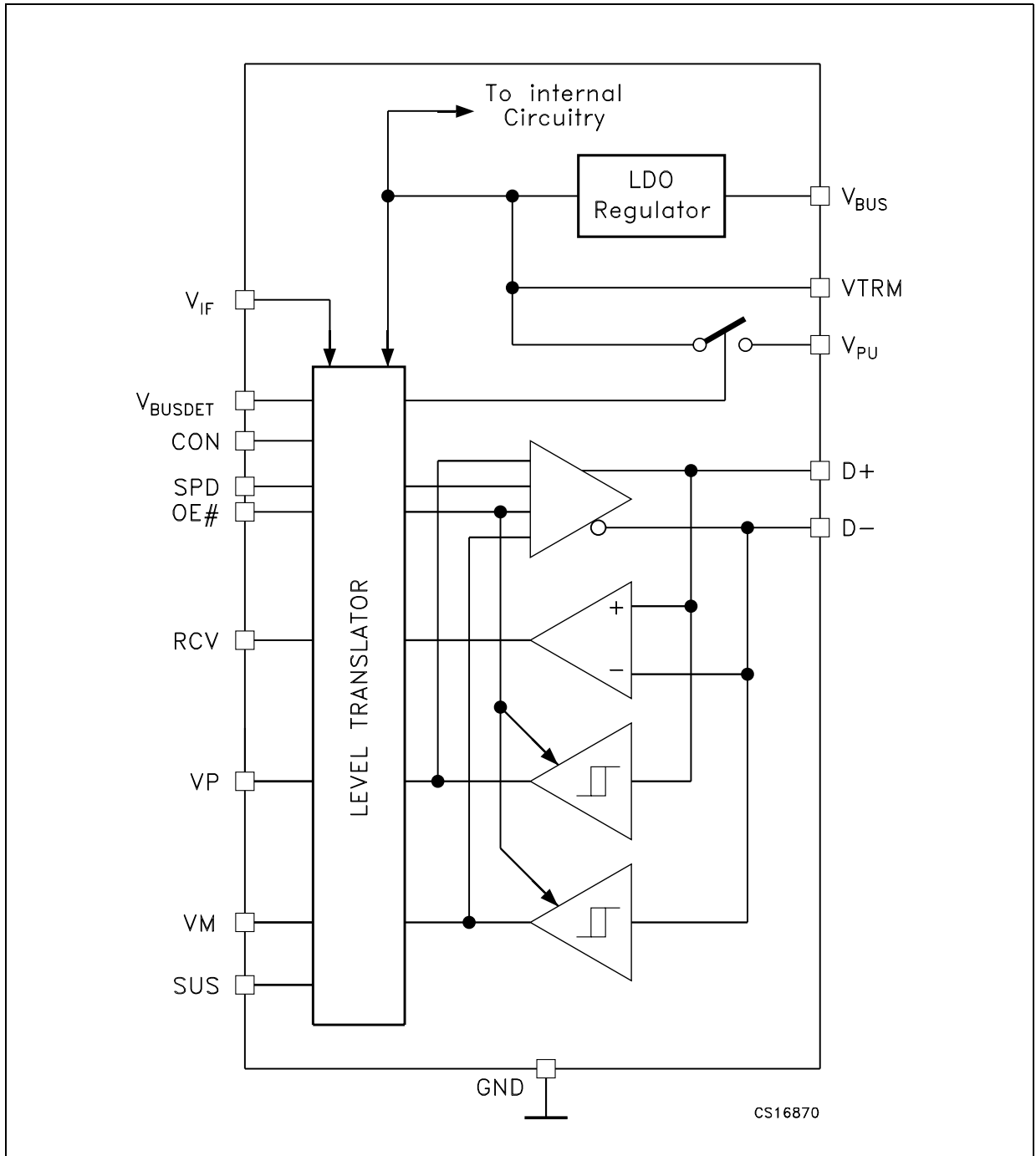


Figure 9. Functional Diagram



7 Functional Description

The STUSB02E is designed to provide USB connectivity in portable systems where available system supply voltages are not able to satisfy USB requirements. The STUSB02E can operate down to supply voltages of 1.6V and still meet USB physical layer specifications. As shown in the circuit above, the STUSB02E takes advantage of the USB supply voltage, V_{BUS} , to operate the transceiver. The system voltage, V_{IF} , is used to set the reference voltage used by the digital I/O lines interfacing to the system controller. Internal circuitry provides translation between the USB and system voltage domains. V_{IF} will typically be the main supply voltage rail for the controller.

In addition, a 3.3V, 10% termination supply voltage, V_{PU} , is provided to support speed selection. V_{PU} can be disabled or enabled under software control via the CON input. This allows for software-controlled connect or disconnect states. A 1.5K resistor is required to be connected between this pin and the D+ or D- lines to respectively specify full speed or low speed operation.

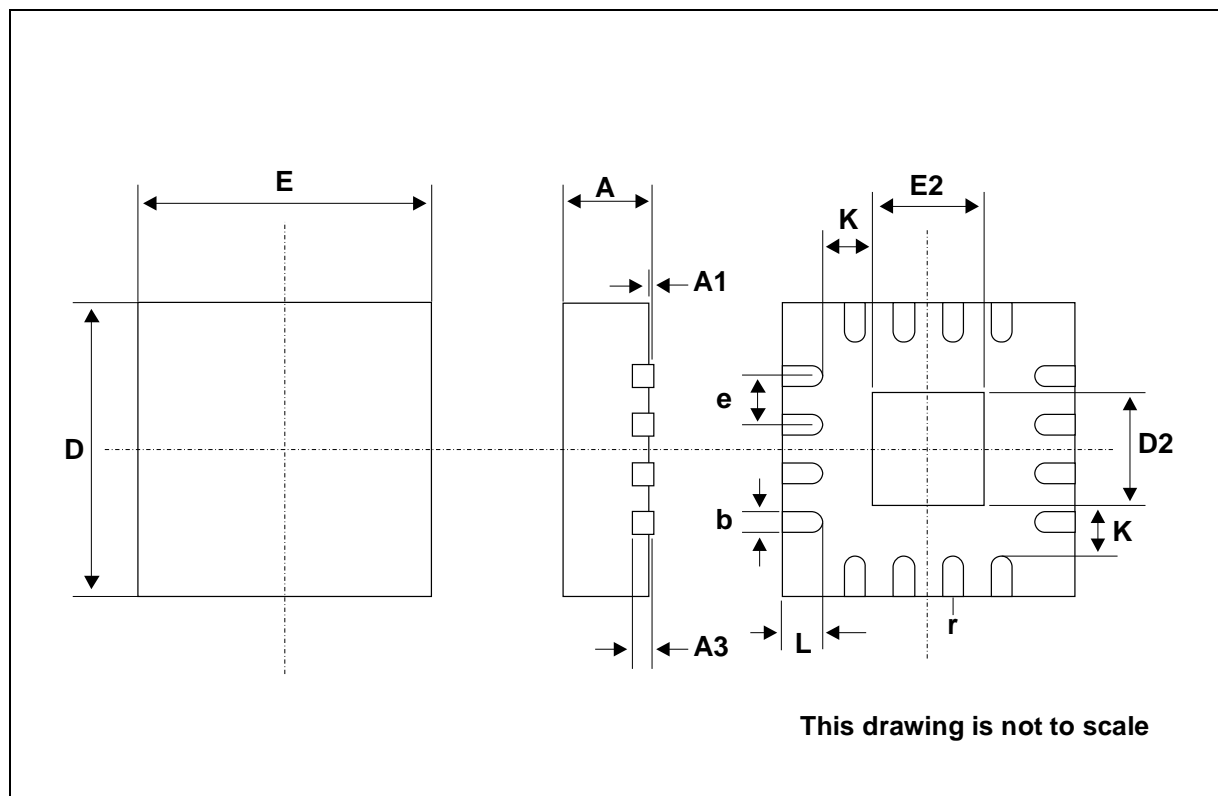
The use of ESD transient protection devices is not required for operation, but is recommended.

8 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.

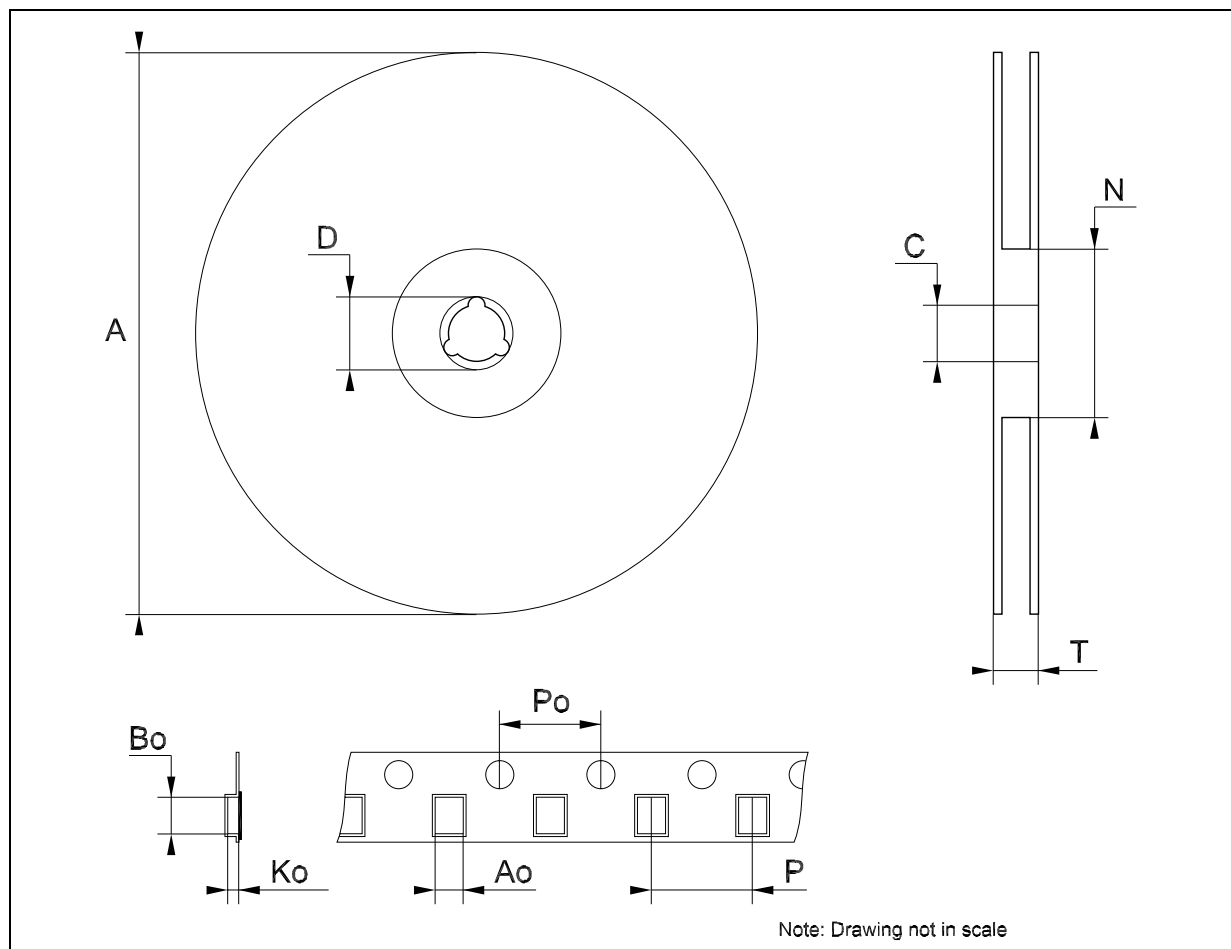
QFN16 (3mmx3mm) MECHANICAL DATA

| DIM. | mm. | | | inch | | |
|------|------|------|------|-------|-------|-------|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | 0.80 | 0.90 | 1.00 | 0.032 | 0.035 | 0.039 |
| A1 | | 0.02 | 0.05 | | 0.001 | 0.002 |
| A3 | | 0.20 | | | 0.008 | |
| b | 0.18 | 0.25 | 0.30 | 0.007 | 0.010 | 0.012 |
| D | | 3.00 | | | 0.118 | |
| D2 | 1.55 | 1.70 | 1.80 | 0.061 | 0.067 | 0.071 |
| E | | 3.00 | | | 0.118 | |
| E2 | 1.55 | 1.70 | 1.80 | 0.061 | 0.067 | 0.071 |
| e | | 0.50 | | | 0.020 | |
| K | | 0.20 | | | 0.008 | |
| L | 0.30 | 0.40 | 0.50 | 0.012 | 0.016 | 0.020 |
| r | 0.09 | | | 0.006 | | |



Tape & Reel QFNxx/DFNxx (3x3) 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 | | | 18.4 | | | 0.724 |
| Ao | | 3.3 | | | 0.130 | |
| Bo | | 3.3 | | | 0.130 | |
| Ko | | 1.1 | | | 0.043 | |
| Po | | 4 | | | 0.157 | |
| P | | 8 | | | 0.315 | |



9 Revision History

| Date | Revision | Description of Change |
|-------------|----------|-----------------------|
| 19-Oct-2005 | 1 | First Release. |

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