



### General features

- Supports 1.5Mbps and 12Mbps serial data transmission
- ESD HBM:  $\pm 14\text{kV}$  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

### Description

The STUSB02E is a single chip USB transceiver that supports both full-speed (12Mbps) and low-speed (1.5Mbps) operation. It has an integrated 5V to 3.3V regulator which allows direct powering from the  $V_{\text{BUS}}$ . The transceiver has an integrated voltage detector to detect the presence of the  $V_{\text{BUS}}$  voltage.



The transceiver also supports Sharing mode when  $V_{\text{BUS}}$  is not present, which allows the D+/D- lines to be shared with other serial protocols.

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.

### Order code

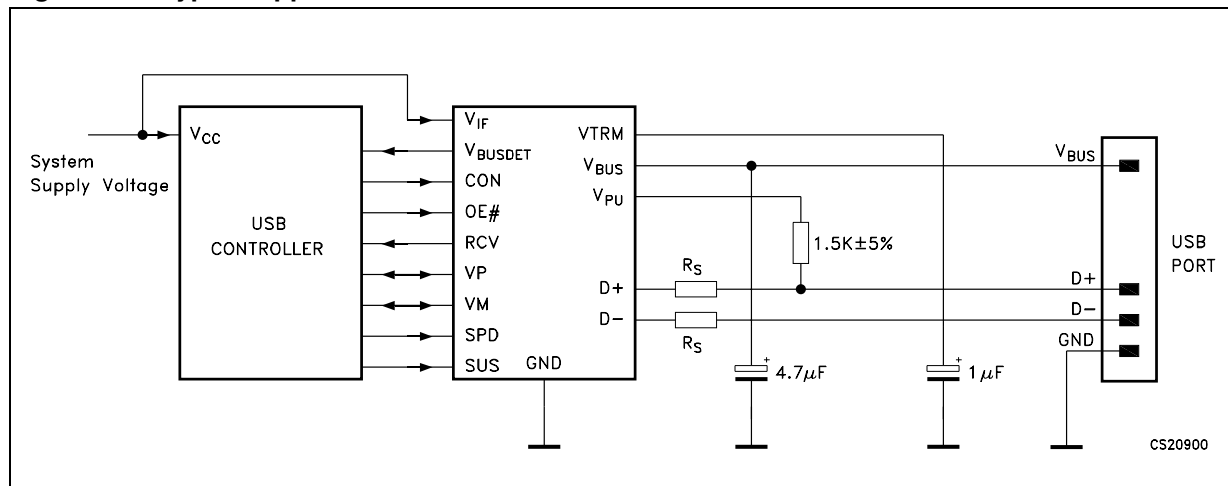
Part number	Package	Packaging
STUSB02EQR	QFN16 (3mm x 3mm)	3000 parts per reel

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# 1 Typical application

Figure 1. Typical application



## 2 Pin configuration

Figure 2. Pin connections (top view)

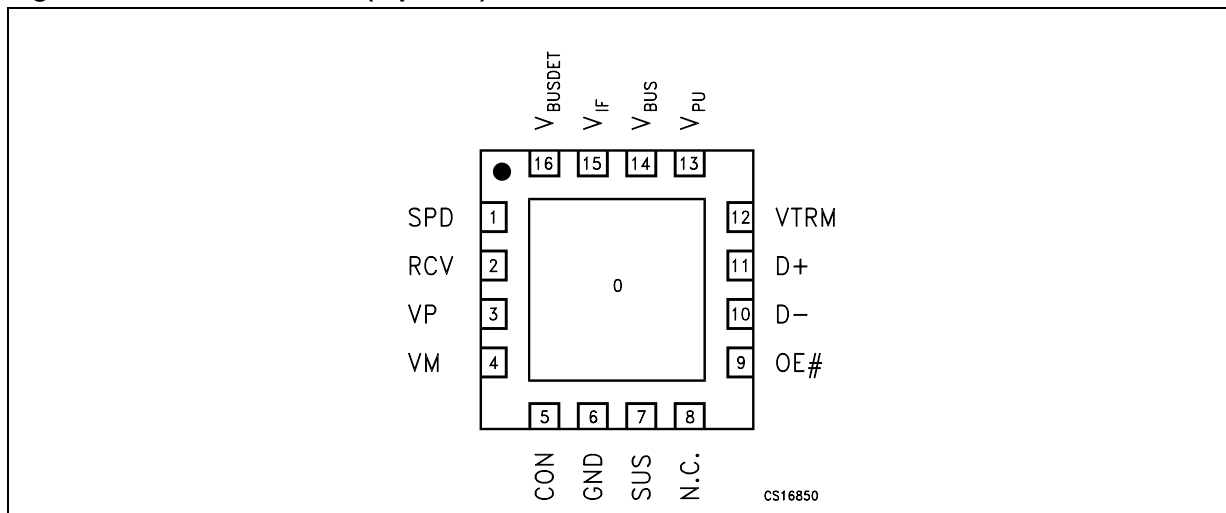


Table 1. Pin description

PIN N°	SYMBOL	I/O	NAME AND FUNCTION
0	N.C.		Not Connected.
15	V <sub>IF</sub>	I	System Interface Supply Voltage (1.6V to 3.6V). 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 <a href="#">Table 2</a> )
3	VP	I/O	If OE# = H, VP = Receiver output (+) If OE# = L, VP = Driver input (+) (see <a href="#">Table 2</a> )
4	VM	I/O	If OE# = H, VM = Receiver output (-) If OE# = L, VM = Driver input (-) (see <a href="#">Table 2</a> )
5	CON	I	CONNECT (input). Controls state of V <sub>PU</sub> . Refer to V <sub>PU</sub> 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 <a href="#">Table 2</a> )
10, 11	D-, D+	I/O	Differential data lines. (see <a href="#">Table 2</a> )
12	VTRM	O	3.3V Reference Supply Output. Requires a 1.0µF decoupling capacitor for stability.
13	V <sub>PU</sub>	O	Pull-up Supply Voltage Output. Used to connect 1.5kΩ pull-up speed detect resistor. If CON = 0, V <sub>PU</sub> is high impedance. If CON = 1, V <sub>PU</sub> = 3.3V ±10%.
14	V <sub>BUS</sub>	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 <sub>BUSDET</sub>	O	V <sub>BUS</sub> indicator output. When V <sub>BUS</sub> > 2.9V, V <sub>BUSDET</sub> = High and when < 2.2V, V <sub>BUSDET</sub> = Low.

### 3 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) <sup>(1)</sup>

(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

## 4 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-)	$\pm 50$	mA
$I_O$	Output current (all others)	$\pm 15$	mA
$I_I$	Input current	$\pm 50$	mA
ESD	D+, D-, HBM (Note 3)	$\pm 14$	kV
	$V_{BUS}$ (Note 3)	$\pm 5$	
	All other pins (Note 3)	$\pm 2$	
$T_{STG}$	Storage temperature range	-65 to + 150	°C
$T_{OPR}$	Operating temperature range	-40 to + 85	°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 $\Omega$  in series with 100pF.

**Table 5. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	59	°C/W

## 5 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	$\mu A$
$I_{IF}$	$V_{IF}$ Supply current (Note 7)	D+, D- are idle, OE# = SUS = 0			5	$\mu A$
		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	$\mu A$
		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	$\mu A$
		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	
$I_{VPULEAK}$	$V_{PU}$ Leakage current	CON = 0, $V_{PU} = 0V$	-5		5	$\mu A$
$I_{VIFLEAK}$	$V_{IF}$ Leakage current	$V_{IF} = 3.6V$ , $V_{BUS} = 0V$	-5		5	$\mu A$
$V_{PU}$	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	$\Omega$

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 $\Omega$  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 NOT 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	$\mu A$
$I_{IF}$	$V_{IF}$ Supply current (Note 7)	D+, D- are idle, OE# = SUS = 0			5	$\mu A$
		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	$\mu A$
		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		$\mu A$
		D+, D- are idle, $V_{BUS} = 5.25V$ OE# = 1, SUS = SPD = 0		150		$\mu A$
		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		mA
$I_{VPULEAK}$	$V_{PU}$ Leakage current	CON = 1, $V_{PU} = 0V$	-5		5	$\mu A$
$I_{VIFLEAK}$	$V_{IF}$ Leakage current	$V_{IF} = 3.6V$ , $V_{BUS} = 0V$	-5		5	$\mu A$
$V_{PU}$	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		$\Omega$

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,  $1.5k\Omega$  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 NOT LOADED

**Table 8. ESD Performance**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
ESD	IEC-1000-4-2 (D+, D-)	Air discharge (10 pulses)		$\pm 8$		kV
		Contact discharge (10 pulses)		$\pm 6$		
	IEC-1000-4-2 ( $V_{BUS}$ only)	Air discharge (10 pulses)		$\pm 5$		
		Contact discharge (10 pulses)		$\pm 5$		



**Table 9. DC electrical characteristics (Transceiver)**

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

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{LO}$	Hi-Z State data line leakage (suspend mode)	$V_I = 0$ to 3.3 V, SUS = 1	-10		10	$\mu A$
$V_{DI}$	Differential input sensitivity	$ I(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	$R_L = 1.5$ K $\Omega$ at 3.6V (see test circuit)			0.3	V
$V_{OH}$	Static output high	$R_L = 15$ K $\Omega$ 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	$\Omega$

**Table 10. DC electrical characteristics (Transceiver)**

( $V_{IF} = 3.6V$ ,  $V_{BUS} = 5V$  unless otherwise noted;  $T_A = 25^\circ C$ )

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	$\mu A$
$V_{DI}$	Differential input sensitivity	$ I(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	$R_L = 1.5$ K $\Omega$ at 3.6V (see <a href="#">Test circuits</a> )			0.3	V
$V_{OH}$	Static output high	$R_L = 15$ K $\Omega$ at GND (see <a href="#">Test circuits</a> )	2.8		3.6	V
$C_I$	Transceiver Capacitance <sup>(3)</sup>	Pin to GND		25		pF
$Z_{DRV}$	Driver Output Resistance	Steady state drive		16		$\Omega$

(3) Pins D+, D-

**Table 11. AC electrical characteristics**(V<sub>IF</sub> = 3.6V, V<sub>BUS</sub> = 5V unless otherwise noted; T<sub>A</sub> = 25°C.) (Note 6)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T <sub>R</sub>	Transition Rise Time (LOW SPEED)	C <sub>L</sub> = 50pF ( <i>Figure 4</i> )	75			ns
		C <sub>L</sub> = 600pF			300	
T <sub>F</sub>	Transition Fall Time (LOW SPEED)	C <sub>L</sub> = 50pF ( <i>Figure 4</i> )	75			ns
		C <sub>L</sub> = 600pF			300	
T <sub>R</sub> , T <sub>F</sub>	Rise/Fall Time Matching (LOW SPEED)	(T <sub>R</sub> , T <sub>F</sub> )	80		125	%
V <sub>CRS</sub>	Output Signal Crossover Voltage (LOW SPEED)		1.3		2	V
T <sub>R</sub>	Transition Rise Time (FULL SPEED)	C <sub>L</sub> = 50pF ( <i>Figure 4</i> )	4		20	ns
T <sub>F</sub>	Transition Fall Time (FULL SPEED)	C <sub>L</sub> = 50pF ( <i>Figure 4</i> )	4		20	ns
T <sub>R</sub> , T <sub>F</sub>	Rise/Fall Time Matching (FULL SPEED)	(T <sub>R</sub> , T <sub>F</sub> )	90		111.11	%
V <sub>CRS</sub>	Output Signal Crossover Voltage (FULL SPEED)		1.3		2	V
t <sub>PVZ</sub>	OE# TO RCVR Tri-State Delay	<i>Figure 3</i>		3		ns
t <sub>PZD</sub>	Receiver Tri-State to Transmit Delay	LOW SPEED ( <i>Figure 3</i> )	13			ns
		FULL SPEED ( <i>Figure 3</i> )	32			
t <sub>PDZ</sub>	OE# TO RCVR Tri-State Delay	<i>Figure 3</i>		6		ns
t <sub>PZV</sub>	Driver Tri-State to Receive Delay	<i>Figure 3</i>		27		ns
t <sub>PLH</sub> t <sub>PHL</sub>	VP, VM to D+, D- Propagation Delay	<i>Figure 6</i>		16	20	ns
t <sub>PLH</sub> t <sub>PHL</sub>	D+, D- to RCV Propagation Delay	<i>Figure 5</i>		13	20	ns
t <sub>PLH</sub> t <sub>PHL</sub>	D+, D- to VP, VM Propagation Delay	<i>Figure 5</i>		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, 1.5kΩ 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.

## 6 Timing diagram

Figure 3. Enable and disable times

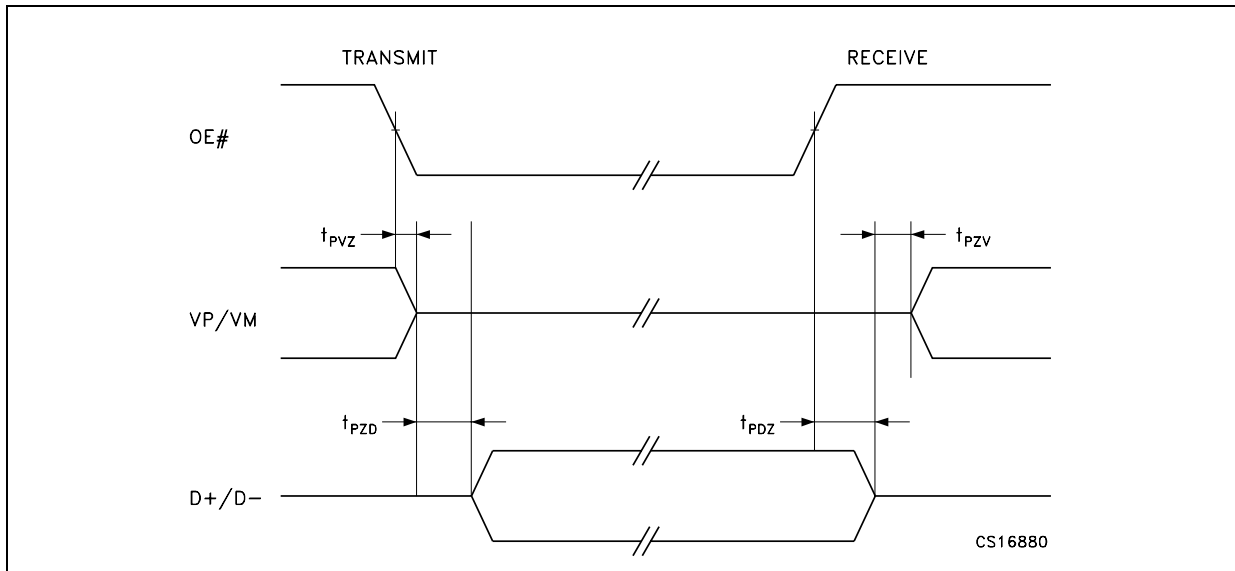
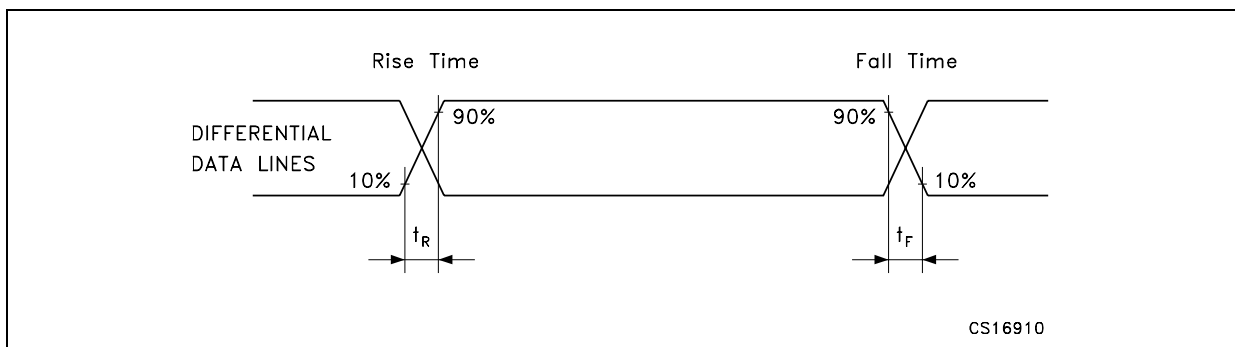
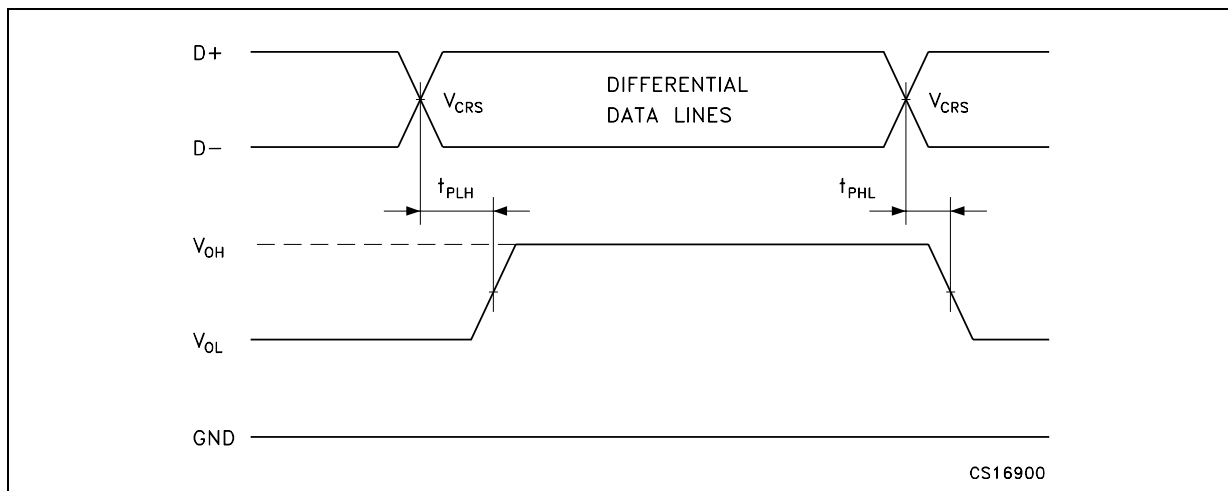


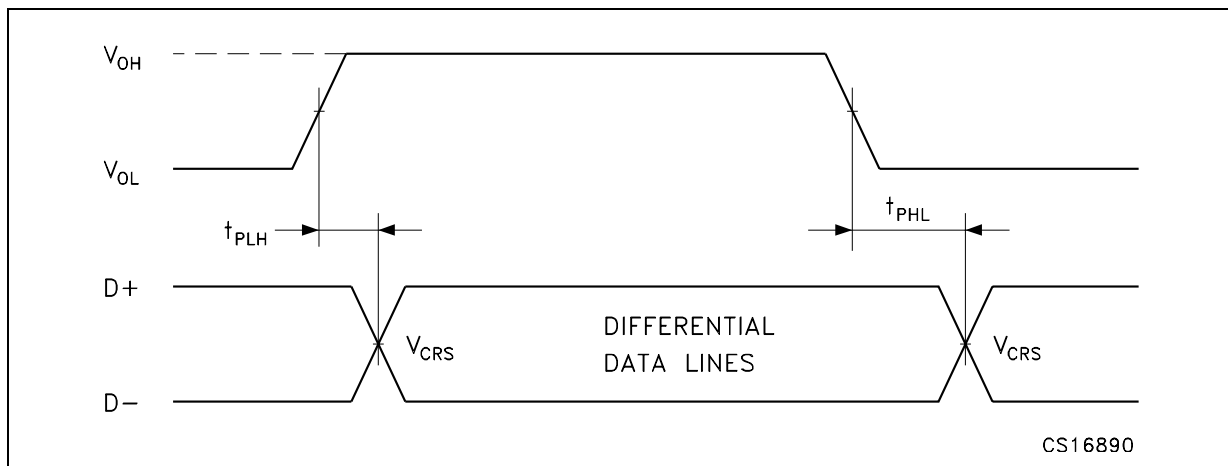
Figure 4. Rise and fall times



**Figure 5. Receiver propagation delay**

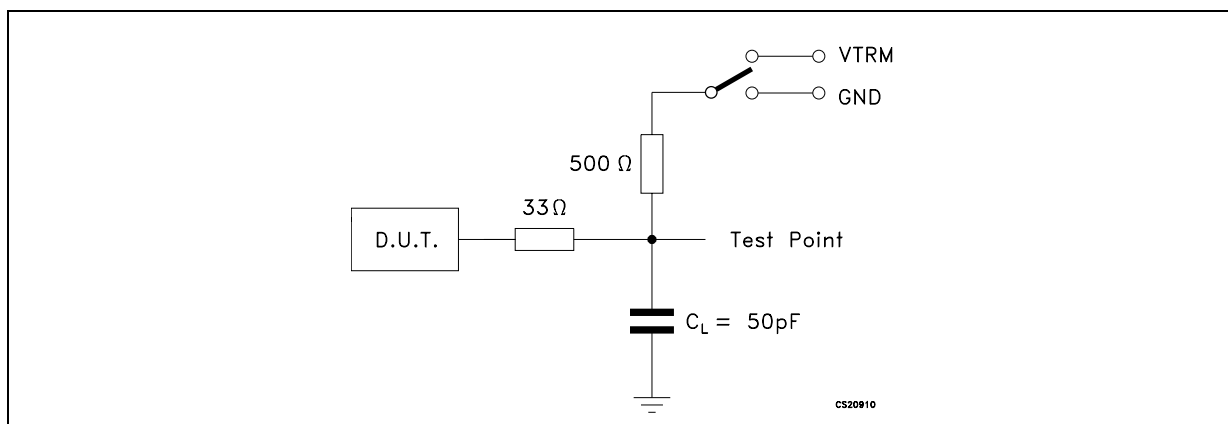


**Figure 6. Driver propagation delay (CL = 50pF)**



Minimum Timing LS and maximum timing FS

**Figure 7. Enable and disable time circuit**



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

## 7 Test circuits

Figure 8. Load for VP, VM, RCV

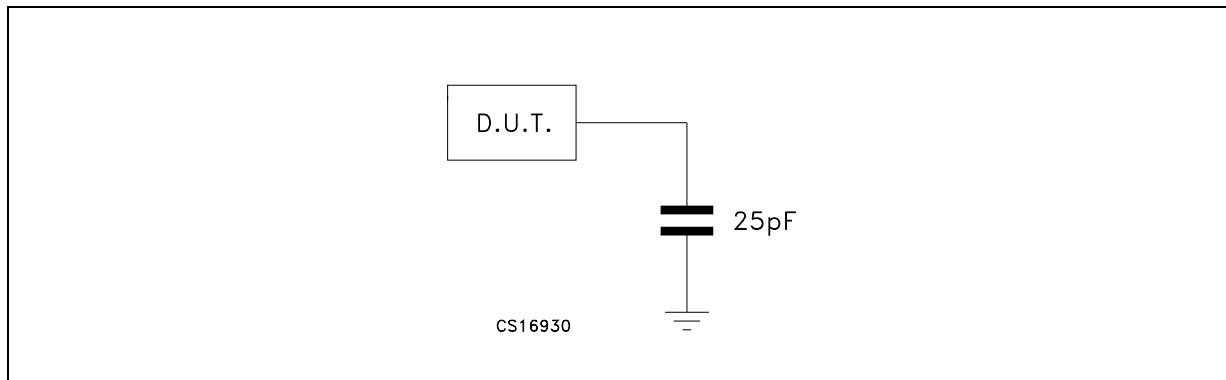


Figure 9. Load for D+, D-

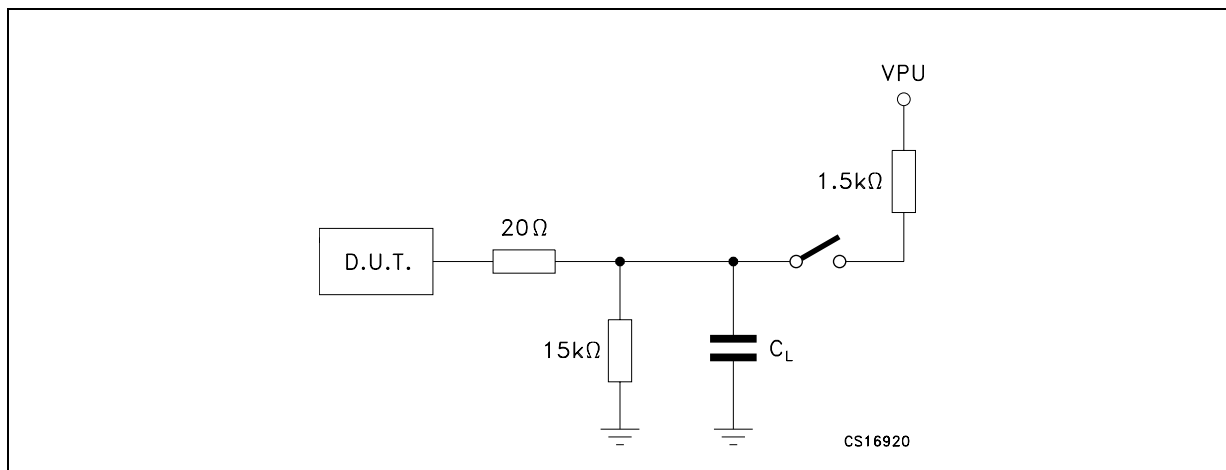
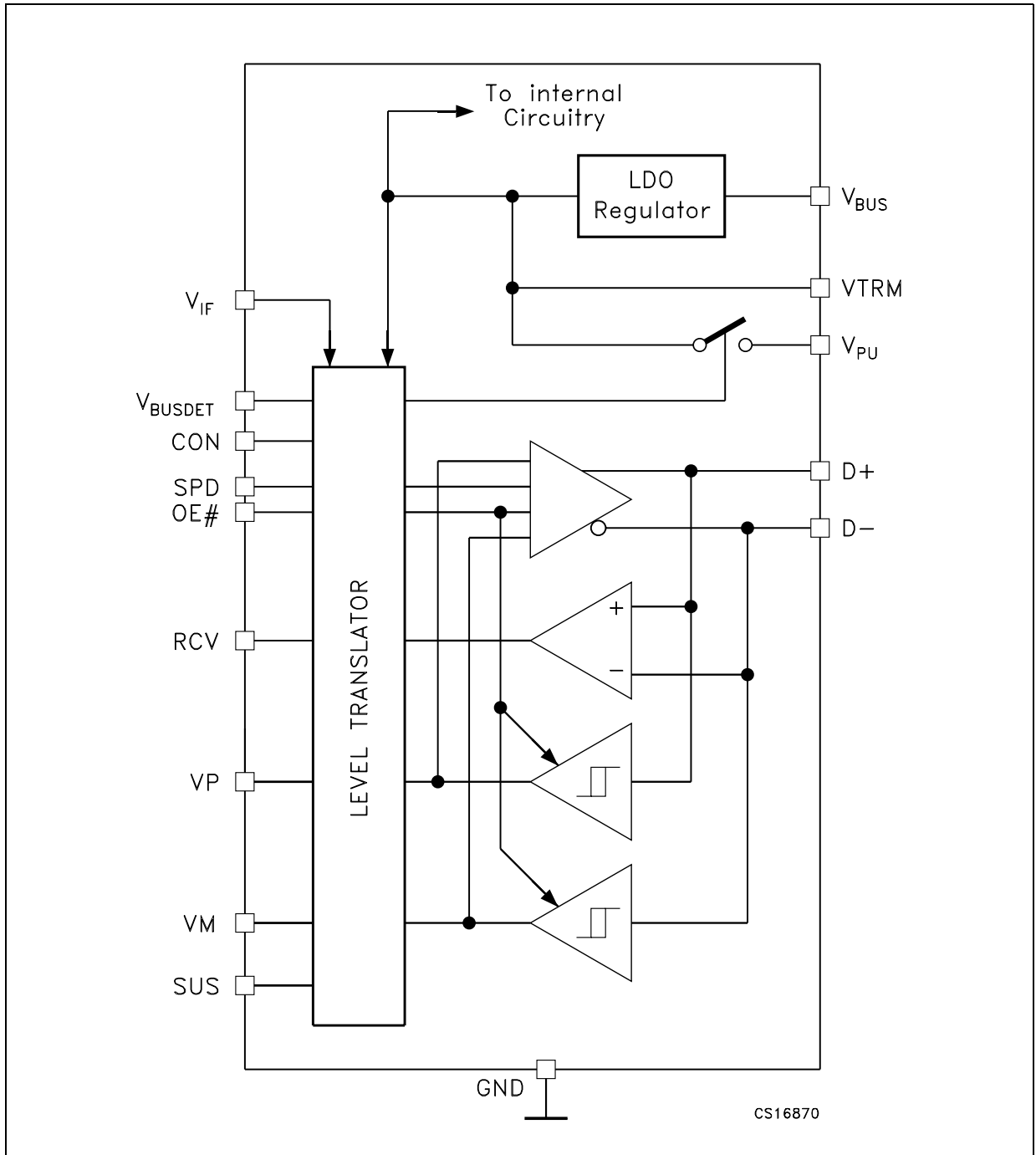


Figure 10. Functional diagram



## 8 Functional description

The STUSB02E is designed to provide USB connectivity in mobile systems where available system supply voltages are not able to satisfy USB requirements. The STUSB02E can operate down to supply voltages of 1.6V. 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 $\Omega$  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.

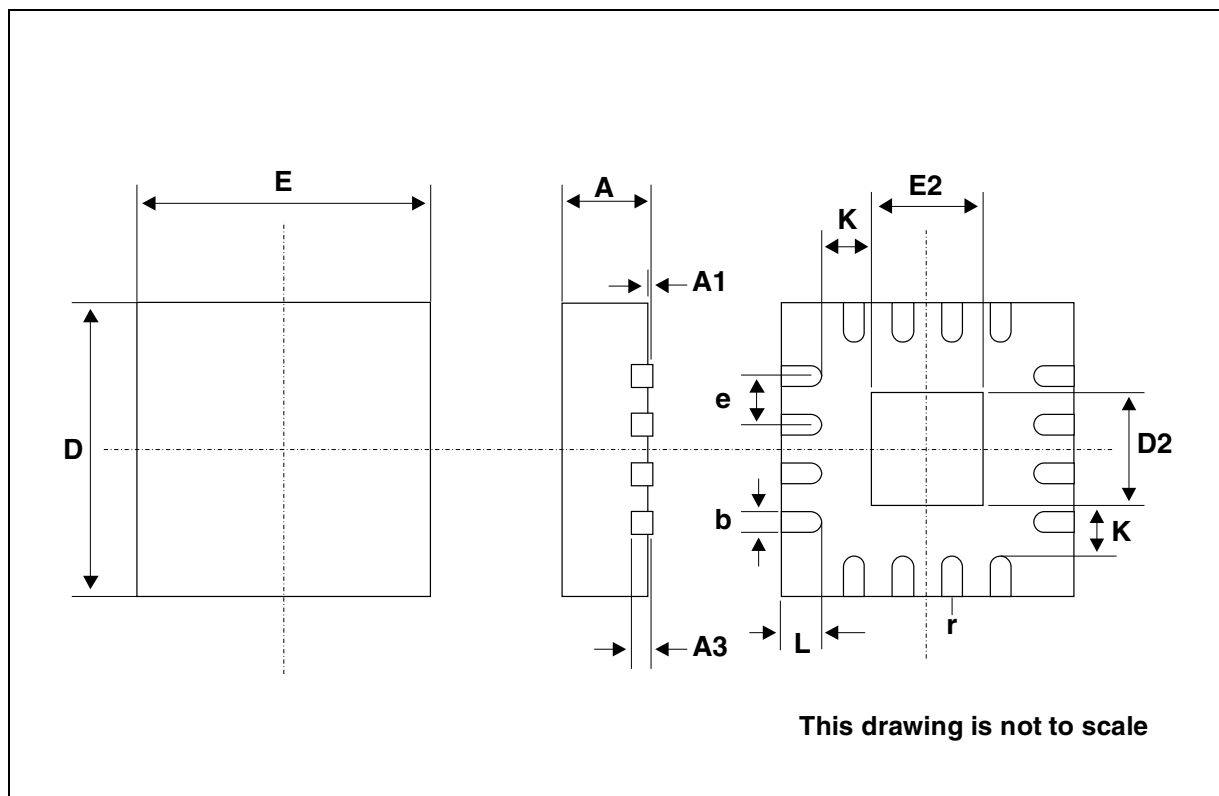
## 9 Package mechanical data

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](http://www.st.com).



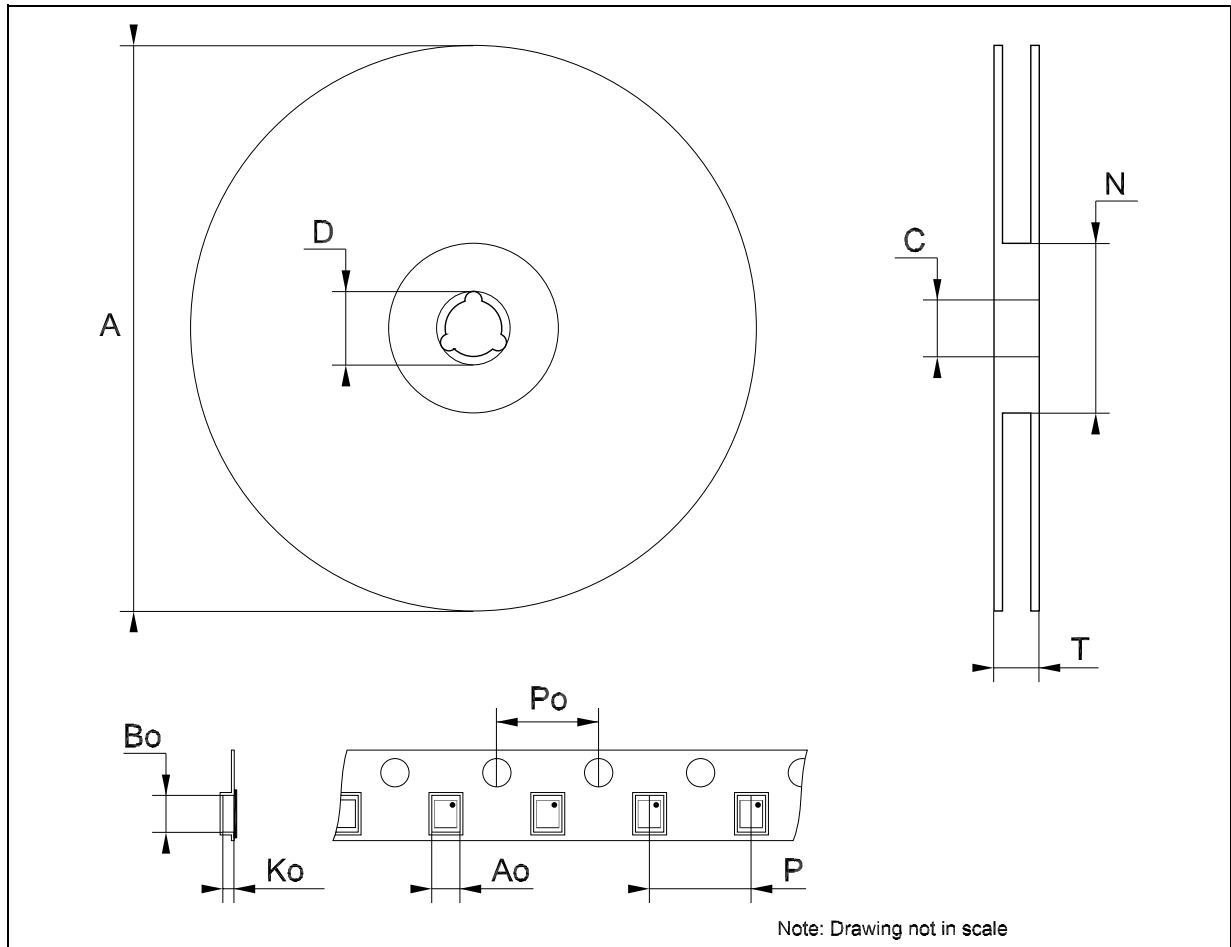
**QFN16 (3mmx3mm) MECHANICAL DATA**

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	



## 10 Revision history

**Table 12. Revision history**

<b>Date</b>	<b>Revision</b>	<b>Changes</b>
19-Oct-2005	1	First Release.
21-Feb-2006	2	Declaration of conformity with USB 2.0 specification removed.
07-Apr-2006	3	Corrected wrong links to figures in table 11.
14-Mar-2007	4	Update tape & reel.

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