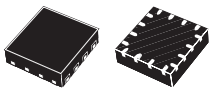
STUSB02E

USB Transceiver

Features

- Compliant to USB v2.0 for Full-speed (12Mb/s) and Low-speed (1.5Mbps) Operation
- ±14KV on D+, D– Lines; ±5KV 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



QFN16(3mmx3mm)

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

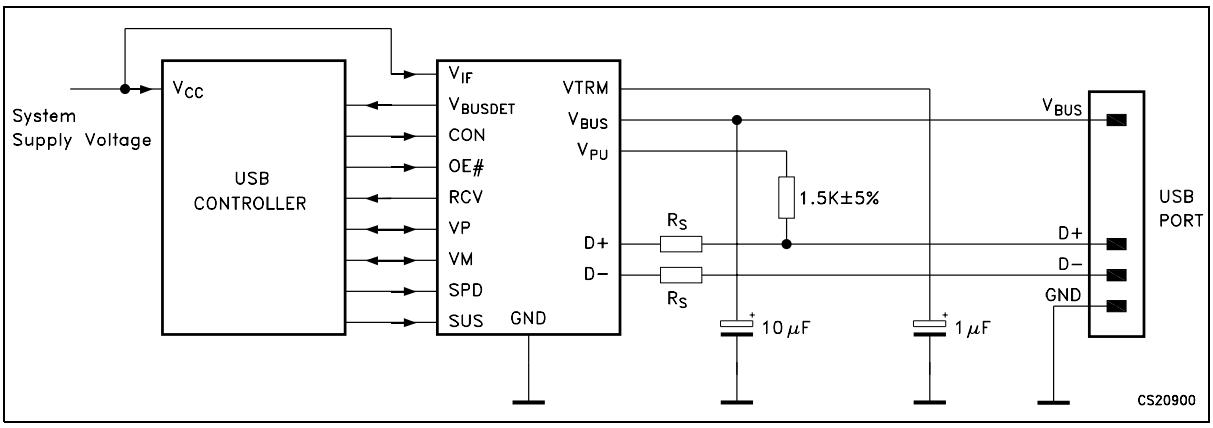
The transceiver also supports Sharing mode when VBUS is not present, which allows the D+/ D– lines to be shared with other serial protocols.

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.

Order Codes

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

Typical Application



Contents

1 Pin Configuration

Figure 1. Pin Connections (Top View)

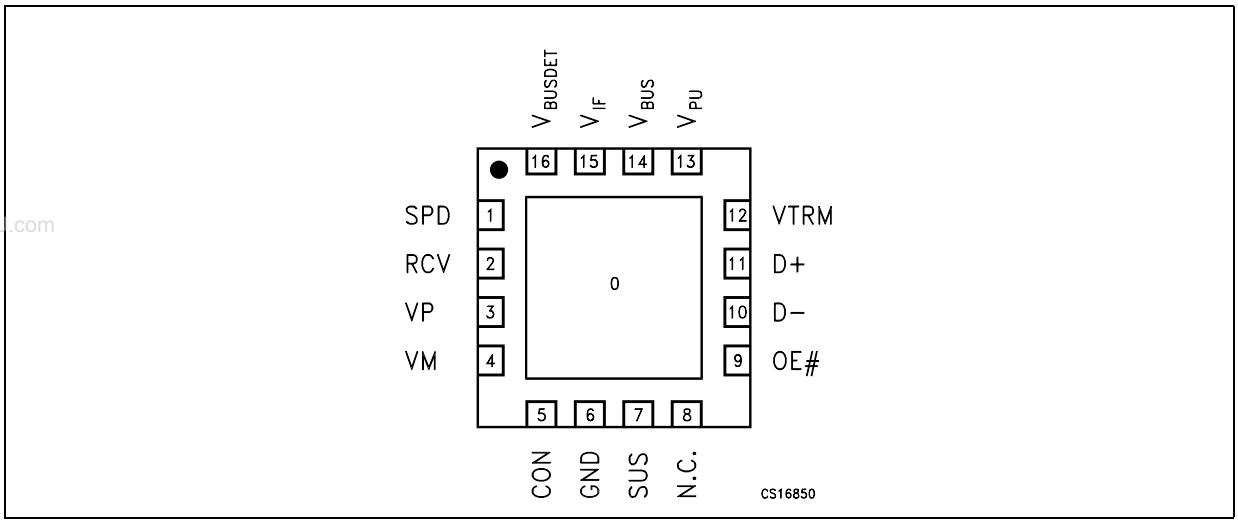


Table 1. Pin Description

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_{BUDET} = 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	°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 in series with 100pF.

Table 5. Thermal Data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal Resistance Junction-Ambient	59	°C/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°C, specifications over temperature, -40 to 85°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} = 20µA	0		100	mV
V_{OH}	High Level Output Voltage (Note 4)	I_{OH} = -20µA	VIF-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	
$I_{VPULEAK}$	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} = 200µA, 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#, 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 7. DC Electrical Characteristics (System and USB Interface)
(V_{IF} = 3.6V, V_{BUS} = 5V unless otherwise noted; T_A = 25°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} = 20µA			0.1	V
V_{OH}	High Level Output Voltage (Note 4)	I_{OH} = 20µA	$0.9V_{IF}$			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		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} = 200µA, 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

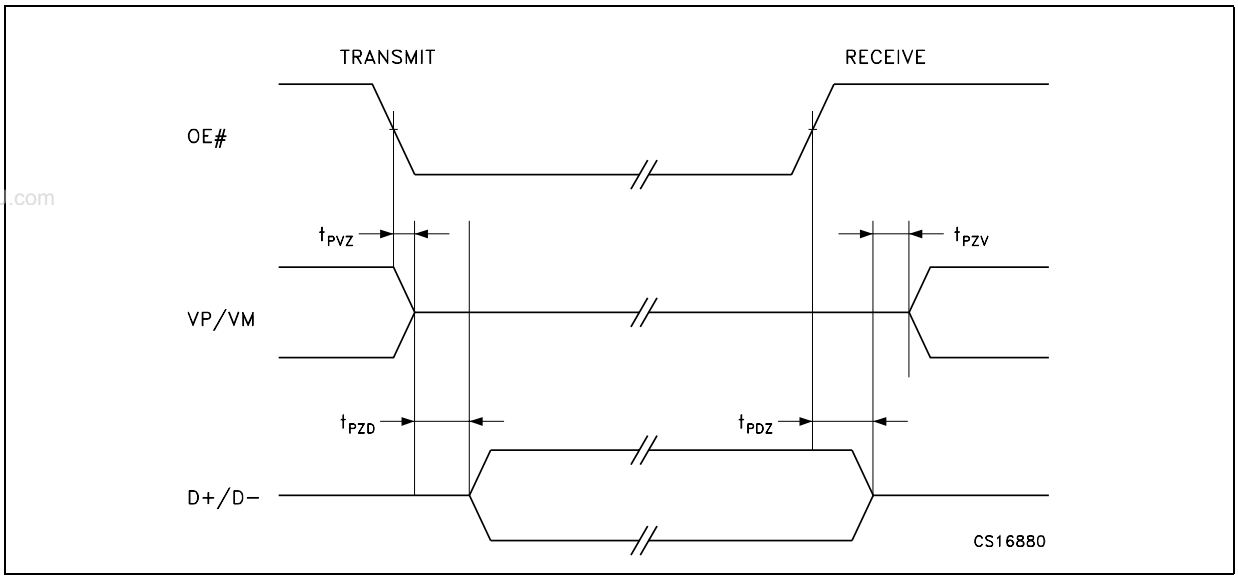


Figure 3. Rise and Fall Times

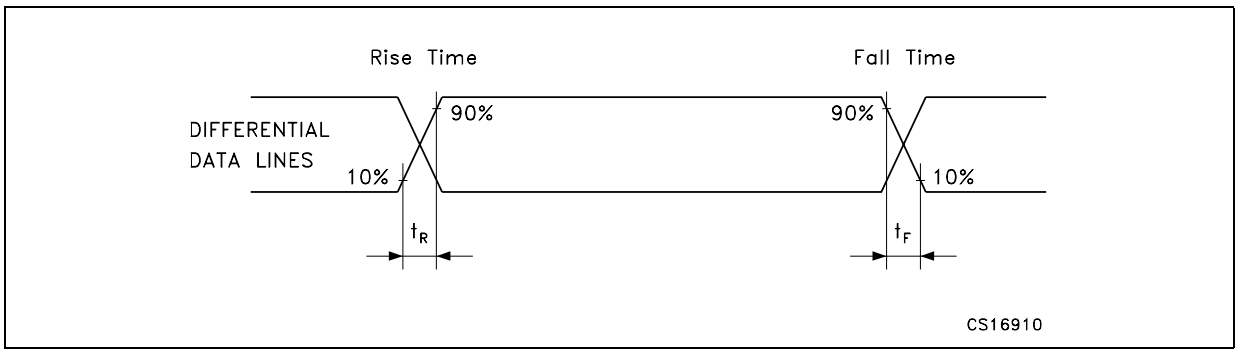


Figure 4. Receiver Propagation Delay

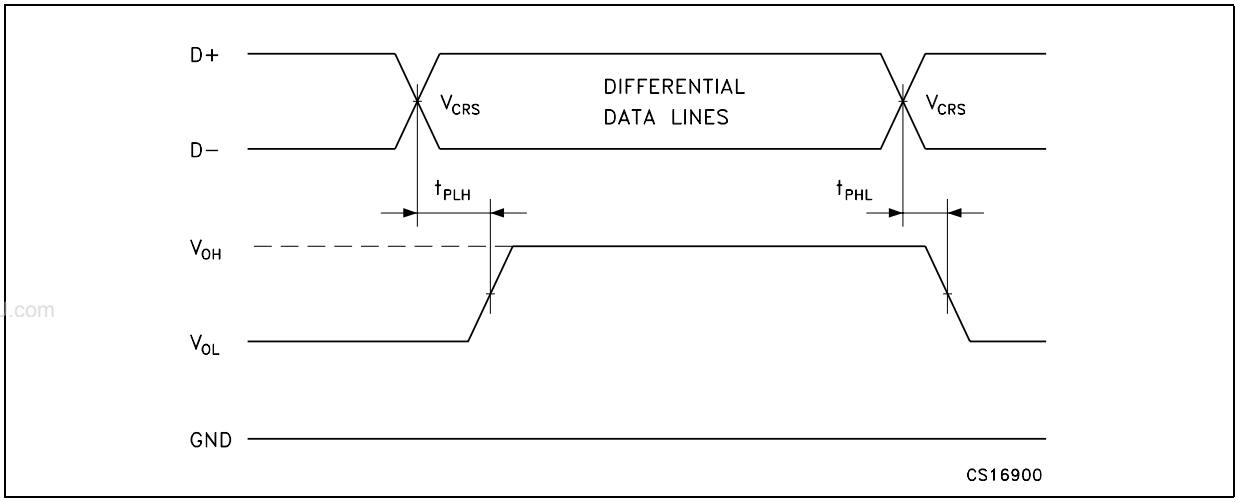
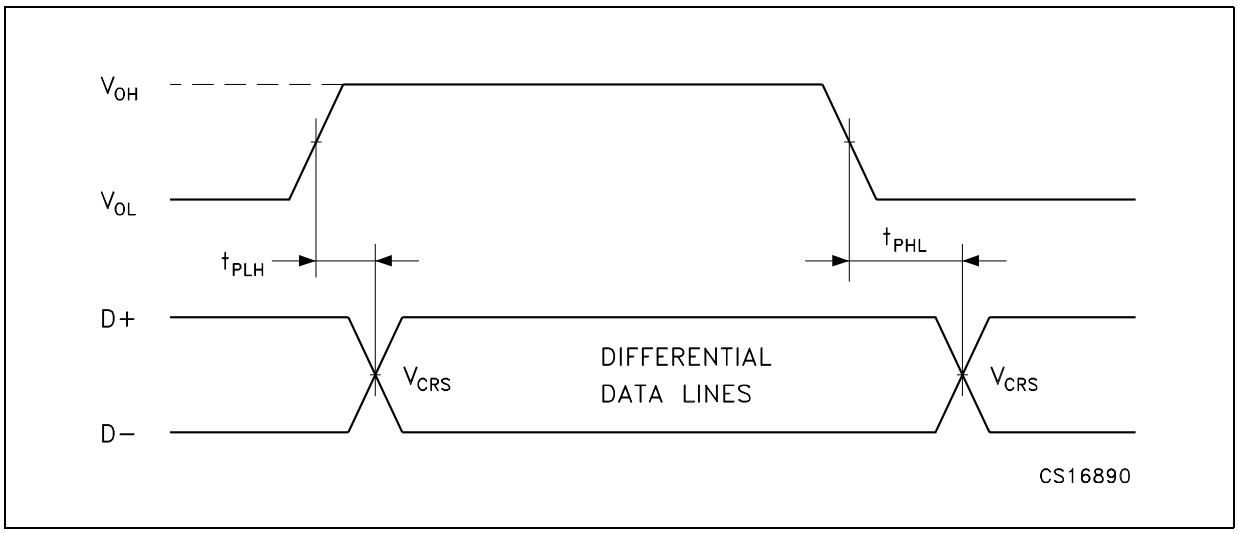
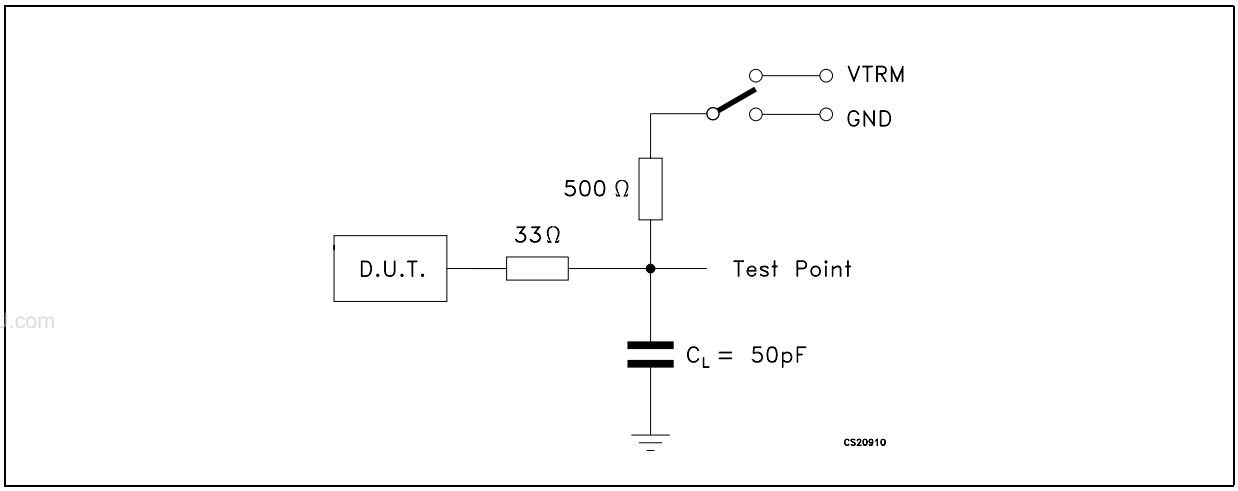


Figure 5. Driver Propagation Delay (C_L = 50pF)



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

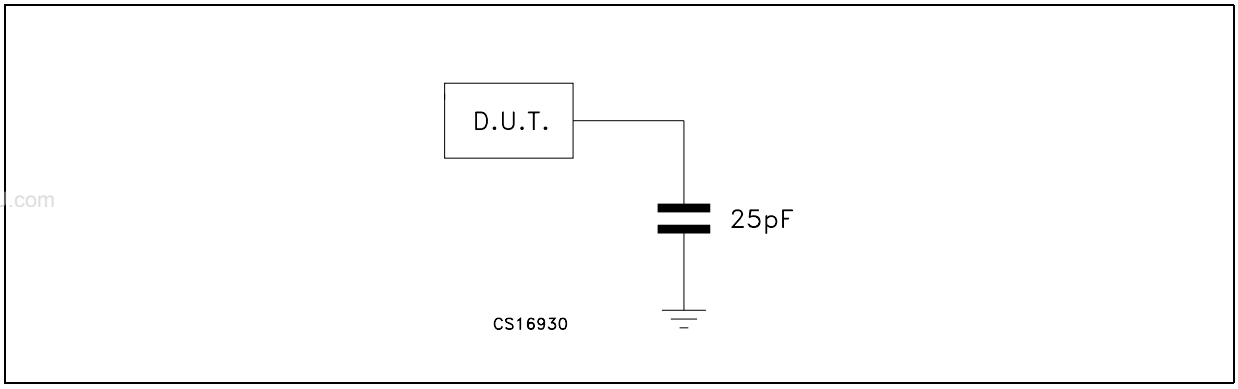


Figure 8. Load for D+, D-

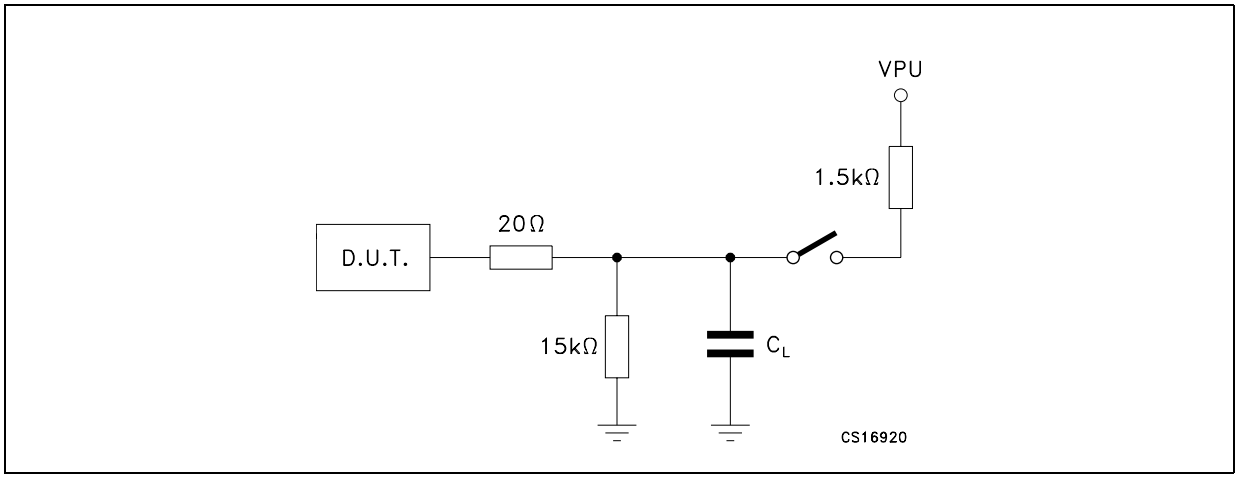
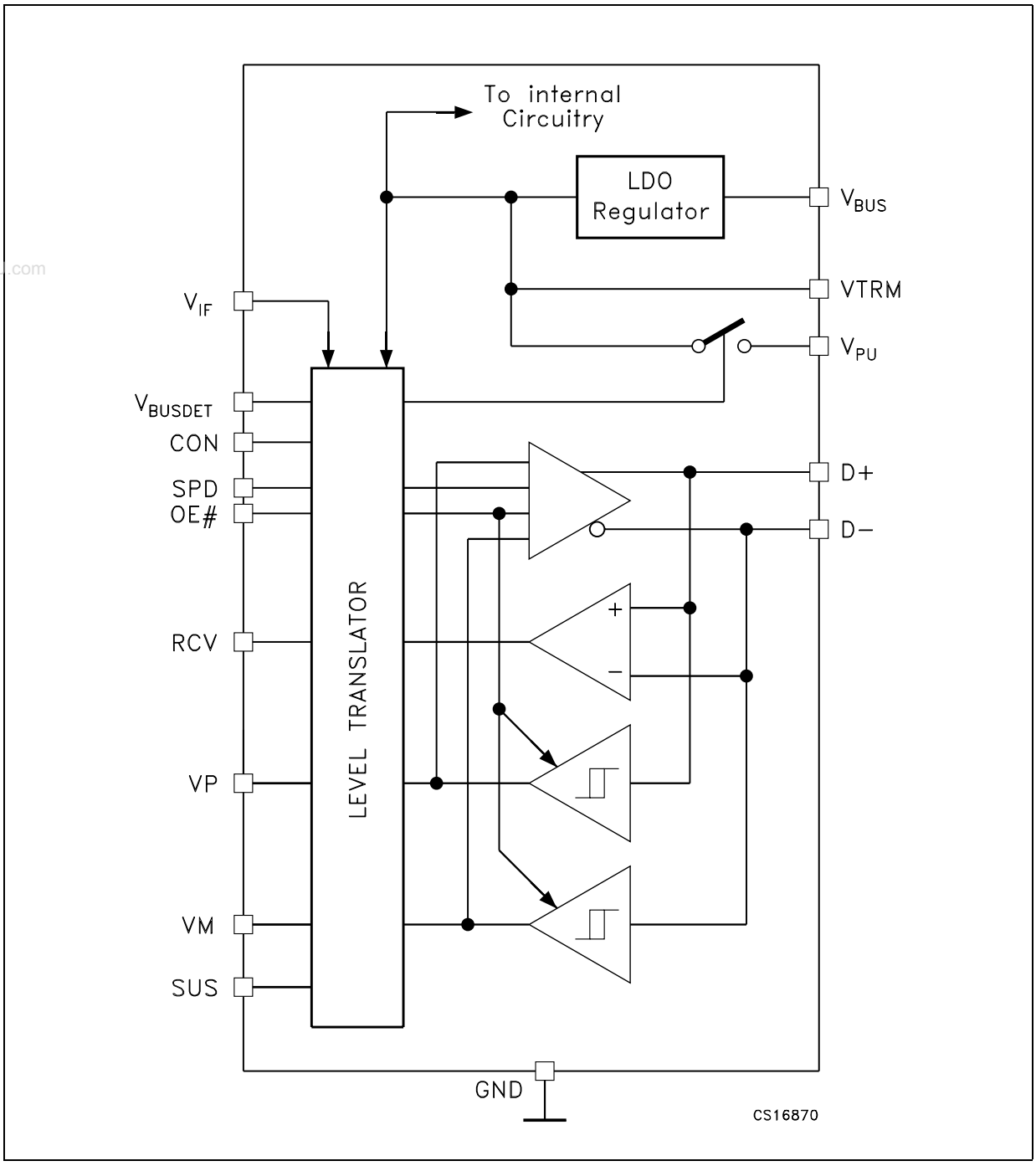


Figure 9. Functional Diagram



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.

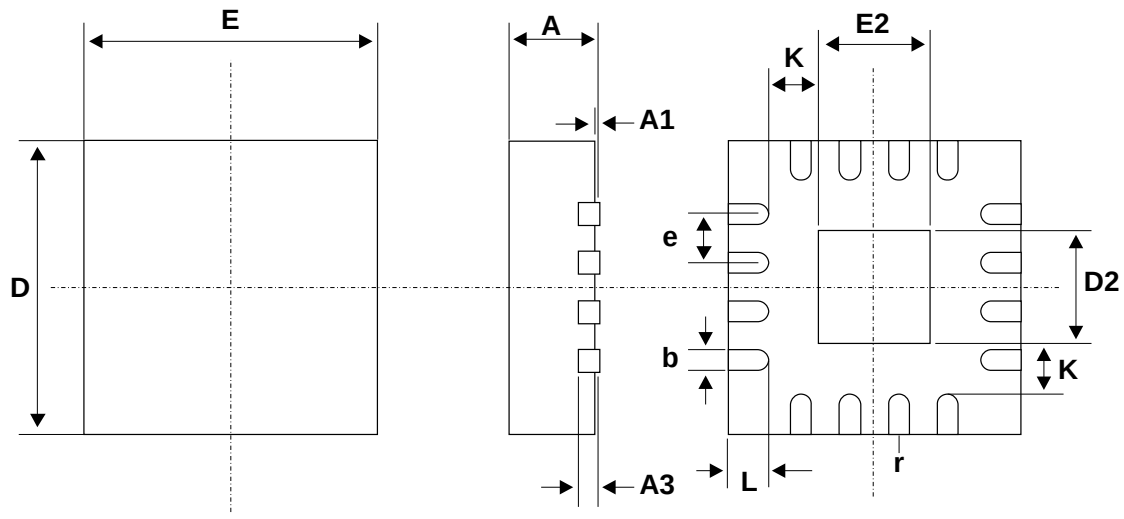
The use of ESD transient protection devices is not required for operation, but is recommended.

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

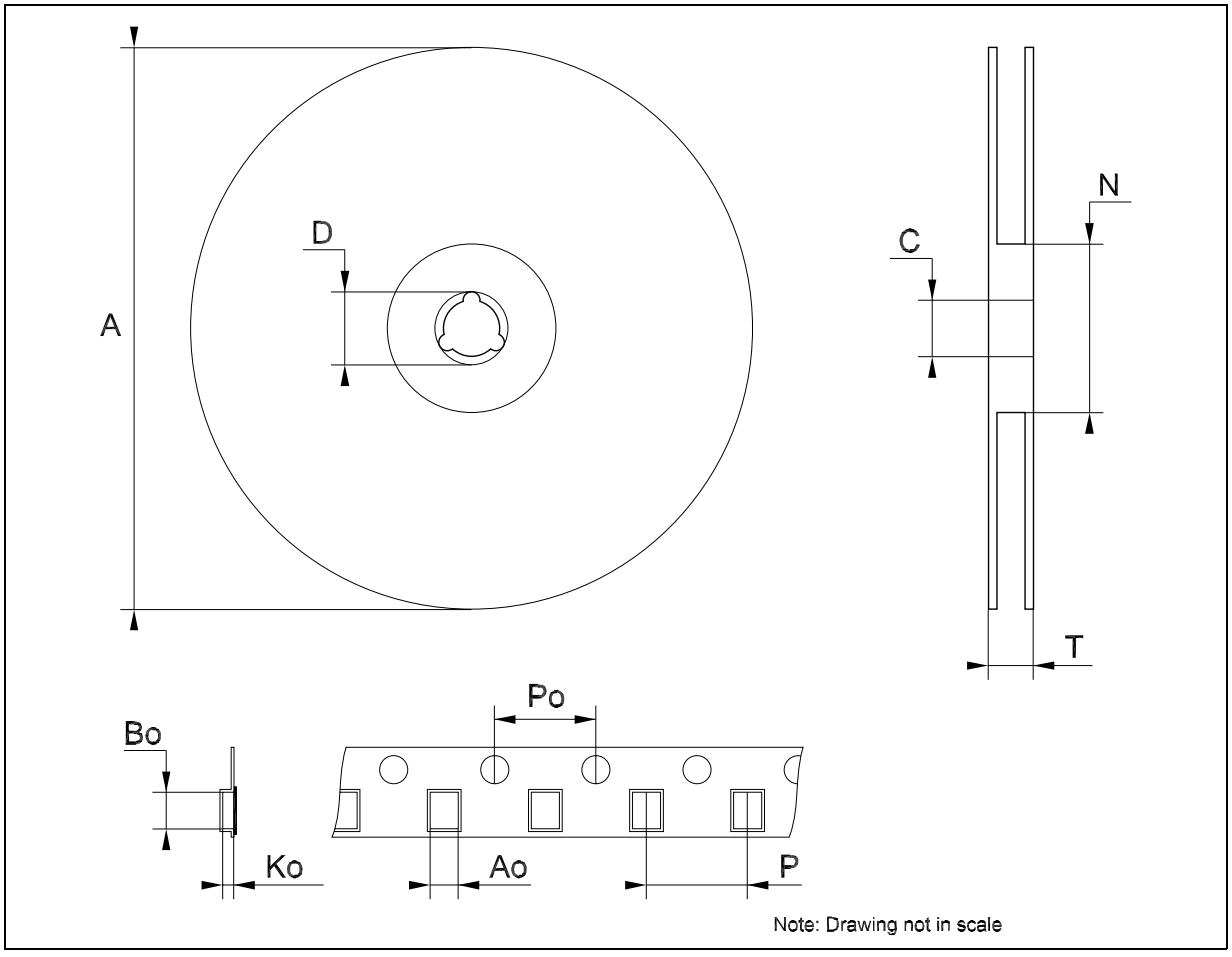
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	0.80	0.90	1.00	0.032	0.035	0.039
A1		0.02	0.05		0.001	0.002
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D		3.00			0.118	
D2	1.55	1.70	1.80	0.061	0.067	0.071
E		3.00			0.118	
E2	1.55	1.70	1.80	0.061	0.067	0.071
e		0.50			0.020	
K		0.20			0.008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



This drawing is not to scale

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	



Note: Drawing not in scale

9 Revision History

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