STUSB06E

3.3 V USB transceiver

Features

- Compliant to USB v2.0 for full-speed (12 Mb/s) and low-speed (1.5 Mbps) operation
- HBM = ± 9 kV on D+, D- lines, ± 7 kV on V_{REG}
- ± 6 kV ESD compliant to IEC-61000-4-2 on D+, D-, V_{REG} lines
- Separate I/O supply with operation down to 1.6 V
- Integrated 150 kΩ switchable pull-up from D+ to V_{REG}
- Supports host negotiation protocol (DP pull-up auto-connection after SE0)
- SEO active low interrupt in HNP mode (INT, VCC_IO referred)
- Very low power consumption to meet USB 'suspend' current requirements
- No power supply sequencing requirements
- Software controlled re-enumeration (SOFTCON)
- Available in small BCC++16L package 3 mm x 3 mm max thickness 0.80 mm halogen free RoHS compliant package

Applications

- Mobile phones
- PDAs
- MP3 players
- Digital still cameras

**BCC++16L
(3 mm x 3 mm)**

Description

The STUSB06E is a single chip transceiver that complies with the physical layer specifications of the Universal Serial Bus (USB) v2.0 standard. It is powered by external 3.3 V supply and has an integrated 150 kΩ resistor to implement charger detection with weak pull-up method.

The STUSB06E also supports sharing mode when V_{REG} is not present, which allows the D+/D- lines to be shared with other serial protocols.

It supports both full-speed (12 Mbps) and low-speed (1.5 Mbps) operation. It is also designed to operate down to 1.6 V so that it is compatible with lower system voltages of most portable systems, which include cell phones, PDAs and MP3 players.
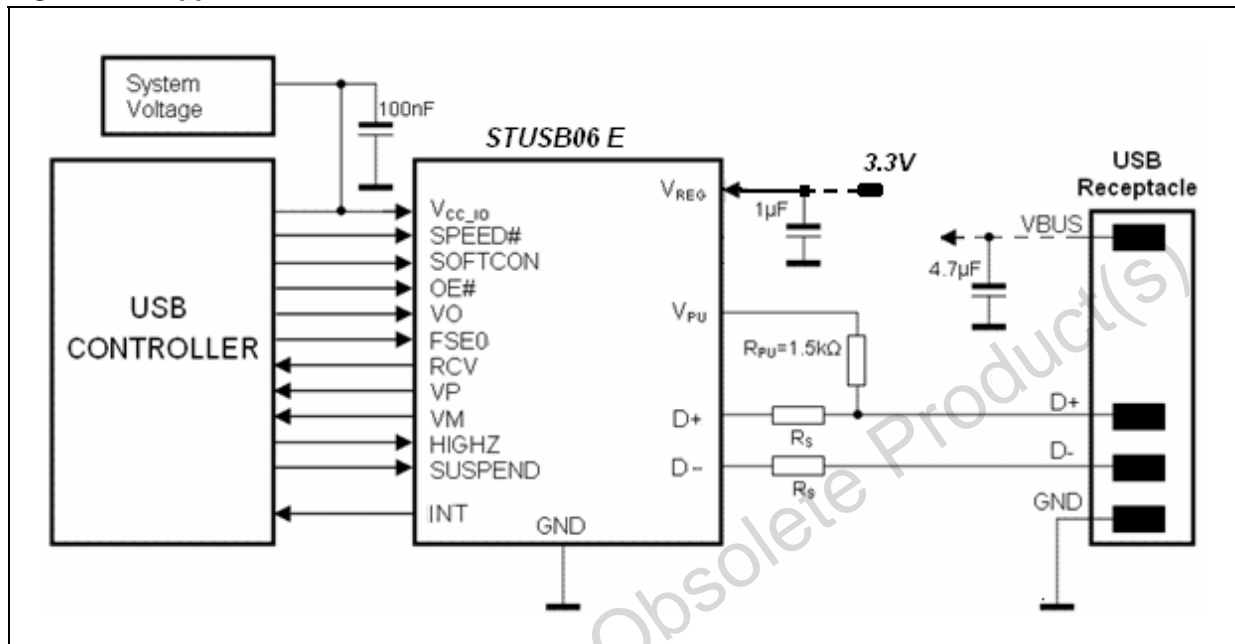
Table 1.   Device summary

Order code	Package	Packaging
STUSB06EHTR	BCC++16L (3 mm x 3 mm)	3000 parts per reel

Contents

1   Application

Figure 1.   Application circuit

$R_S = 33\ \Omega \pm 10\ \%$

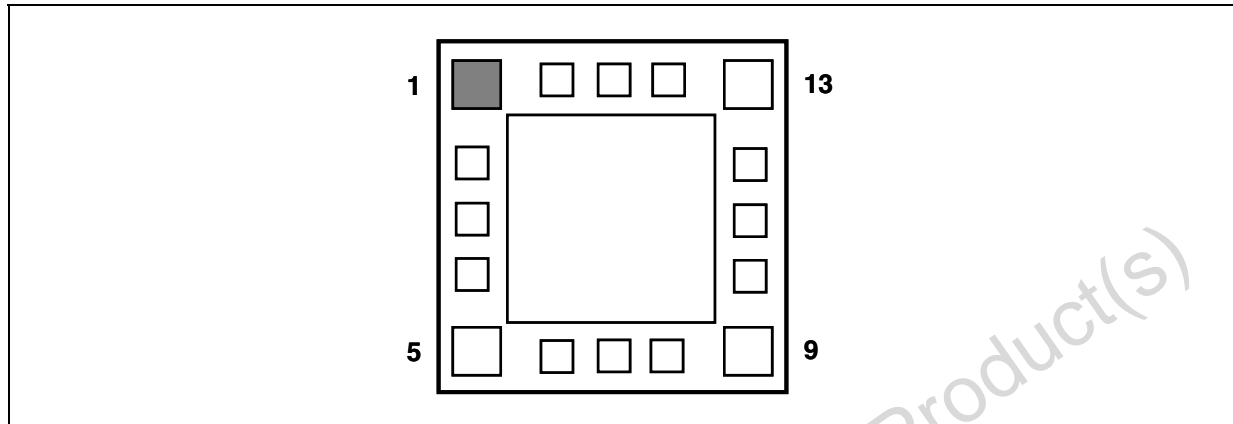# 2   Pin configuration

Figure 2.   Pin connections (top view)

Table 2.   Pin description

Pin°	Symbol	Type	Description
1	OE#	I	Active low output enable signal
2	RCV	O	Differential receiver output. Stable output during SE0. This pin has an internal 220 kΩ pull-down to ground when HIGHZ="H" only.
3	VP	O	Standard Mode: USB D+ receiver output. This pin has an internal 220 kΩ pull-down to ground when HIGHZ="H" only.
4	VM	O	Standard Mode: USB D- receiver output. This pin has an internal 220 kΩ pull-down to ground when HIGHZ="H" only.
5	SUSPEND	I	Normally used as Suspend input (active high). Puts the transceiver in low power consumption mode. Functionality can change depending on status of SPEED# and SOFTCON pins. See *Table 12* for more details.
6	HIGHZ	I	Sets to high impedance for production flash. This pin has an internal 220 kΩ pull-down to ground always connected.
7	V_{CC_IO}	PWR	Supply voltage for digital I/O pins (1.6 V to 3.6 V)
8	SPEED#	I	Normally used as Speed selection input. A logic LOW adjusts the slew rate of D+/D- USB differential signals for Full-speed operation. Set to HIGH for Low-speed operation. Functionality can change depending on status of SUSPEND and SOFTCON pins. See *Table 12* for more details.
9	D-	AI/O	USB Mode: Negative USB data line
10	D+	AI/O	USB Mode: Positive USB data line
11	VO	I	USB differential driver data input
12	FSE0	I	Standard Mode: Force single-ended zero data input. This pin has an internal 220 kΩ pull-down to ground when HIGHZ="H" only.
13	V_{REG}	PWR	Analog supply voltage input (3.0 V to 3.6 V). Left floating brings the device into sharing mode.

Table 2. Pin description (continued)

Pin°	Symbol	Type	Description
14	INT	O	Active Low output interrupt signal. Active when a SE0 is detected while in HNP mode. This pin has an internal 220 kΩ pull-down to ground when HIGHZ="H" only.
15	V_{PU}	PWR	Data line pull-up supply voltage. Connect an external 1.5 kΩ resistor to D+ (full-speed) or D- (low-speed). Pin output is controlled by SUSPEND, SPEED# and SOFTCON inputs.
16	SOFTCON	I	Normally used as Software controlled enumeration pin: controls the status of VPU pin and the connection of internal weak pull-up resistor. LOW: VPU floating (SUSPEND="0" or "1"). HIGH: VPU = 3.3 V. Functionality can change depending on status of SPEED# and SUSPEND pins. See *Table 12* for more details.
Exp	GND	PWR	Ground reference

3 Maximum ratings

Table 3. Absolute maximum ratings [1]

Symbol	Parameter	Value	Unit
V_{REG}	Supply voltage	-0.5 to 4.6	V
V_+	All other input	-0.5 to 4.6	V
I_O	Output current (D+, D-)	± 50	mA
I_O	Output current (all others)	± 15	mA
T_{STG}	Storage temperature range	-65 to +150	°C
ESD	Electrostatic discharge voltage (according to HBM JESD22-A114) (D+,D-)	± 9	kV
	Electrostatic discharge voltage (according to HBM JESD22-A114) (V_{REG})	± 7	kV
	Electrostatic discharge voltage (according to HBM JESD22- A114) (all other pins)	± 2	kV
	Electrostatic discharge voltage (according to CDM JESD22-C101C) (all pins)	± 500	V
	Electrostatic discharge voltage (according to MM JESD22-A115A) (all pins)	± 200	V

1. Absolute maximum ratings are those values above which damage to the device may occur. Functional operation under these conditions is not implied. All voltages are referenced to GND.

4   Electrical characteristics

Table 4.   **DC electrical characteristics (power supply, digital I/O pins)** (V_{CC_IO} = 1.8 V, V_{REG} = 3.3V unless otherwise noted; T_A = 25 °C, specifications over temperature, -40 to 85 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{REG}	Analog supply voltage		3.0		3.6	V
V_{CC_IO}	System I/F supply voltage		1.6		3.6	V
V_{IL}	Low level input voltage [1]				0.15 V_{CC_IO}	V
V_{IH}	High level input voltage [1]		0.85 V_{CC_IO}			V
I_{IOLZ}	Low level input leakage (RCV, VP, VM, FSE0, INT)	V_{CC_IO}=1.8V, HIGHZ=1.8V, all inputs at GND.			± 10	µA
I_{IOHZ}	High level input leakage (RCV, VP, VM, FSE0, INT)	V_{CC_IO}=1.8V, HIGHZ=1.8V all inputs at 1.8V.			± 10	µA
I_{IL}	Low level input leakage (Speed#, OE#, VO, FSE0, SUSPEND)	V_{CC_IO}=1.65 to 3.6V, HIGHZ=GND or floating			± 5	µA
I_{IH}	High level input leakage (Speed#, OE#, VO, FSE0, SUSPEND)	V_{CC_IO}=1.65 to 3.6V, HIGHZ=GND or floating			± 5	µA
V_{OL}	Low level output voltage [2]	I_{OL}= +20µA	0		100	mV
V_{OH}	High level output voltage [2]	I_{OH}= -20µA	V_{CC_IO}-100		V_{CC_IO}	mV
I_{IF}	V_{CC_IO} supply current	D+, D- are idle, SUSPEND = 1			5	µA
		D+, D- active, C_{LOAD} = 25pF, SPEED#=0, f=6MHz [3]		1.3	2	mA
		D+, D- active, C_{LOAD} = 25pF, SPEED#=1, f=750kHz [3]		180	220	µA

1.   Specification applies to the following pins: OE#, SUSPEND, HIGHZ, SPEED#, VO, FSE0, SOFTCON.

2.   Specification applies to the following pins: RCV, VP, VM, INT.

3.   Characterized specification(s), but not production tested.

Note: *1   The device is not guaranteed to function outside its operating rating.*

   2   Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5 kΩ in series with 100 pF.

   3   All AC parameters guaranteed by design but not production tested.

Table 5. DC electrical characteristics (power supply, digital I/O pins)
(V_{CC_IO} = 1.8 V, V_{REG} = 3.3 V unless otherwise noted; T_A = 25 °C, specifications over temperature, -40 to 85 °C)

Symbol	Parameter	Test conditions		Min.	Typ.	Max.	Unit
I_{REG}	V_{REG} supply current (suspend mode)	D+, D- are idle, V_{REG}=3.0-3.6V, V_{CC_IO}=1.6-3.6V. Suspend Mode (See *Table 6*)				10	µA
	V_{REG} supply current (disable mode)	D+, D- are idle, V_{REG}=3.0-3.6V, V_{CC_IO}=GND or floating				5	µA
	V_{REG} supply current (HighZ Mode)	D+, D- are idle, V_{REG}=3.0-3.6V, V_{CC_IO}=1.8V, HIGHZ="1"				5	µA
	V_{REG} supply current (FS receiving mode)	D+, D- are idle, V_{REG}=3.0-3.6V SPEED# = 0, SUSPEND = 0	OE#=1			6.0	mA
	V_{REG} supply current (FS transmit mode)		OE#=0			6.0	mA
	V_{REG} supply current (LS receiving mode)	D+, D- are idle, V_{REG}=3.0-3.6V, SPEED# = 1, SUSPEND = 0	OE#=1			4.0	mA
	V_{REG} supply current (LS transmit mode)		OE#=0			4.0	mA
	V_{REG} supply current (receiving mode 12 Mbps)	D+, D- are active, V_{REG}=3.0-3.6V, C_{LOAD} = 50pF, SPEED# = 0, SUSPEND = 0	OE#=1			5.5	mA
	V_{REG} supply current (transmit mode 12 Mbps)		OE#=0			8.5	mA
	V_{REG} supply current (receiving mode 1.5 Mbps)	D+, D- are active, V_{REG}=3.0-3.6V, C_{LOAD} = 600pF, SPEED# = 1, SUSPEND = 0	OE#=1			4	mA
	V_{REG} supply current (transmit mode 1.5 Mbps)		OE#=0			7	mA
$I_{VPULEAK}$	V_{PU} leakage current	V_{PU} = 0V		-5		5	µA
I_{VCC_IOLEAK}	V_{CC_IO} leakage current	V_{CC_IO} = 3.6V, V_{REG} = 0V		-5		5	µA
V_{PU}	Pull-Up output voltage	I_{TERM} = 200µA, V_{REG}=3.0-3.6V		V_{REG}-5.0mV			V
RSW	V_{PU} internal switch resistance	I_{TERM} = 10mA, V_{REG} = 3.0-3.6V		6	9	11	Ω
V_{THREG}	V_{REG} comparator threshold	Supply present		2.4			V
		Supply lost				0.8	V
V_{THIF}	V_{CC_IO} comparator threshold	Supply present		1.4			V
		Supply lost				0.25	V
V_{HYS}	V_{CC_IO} and V_{REG} supply voltage detection hysteresis	V_{CC_IO} = 1.8V, V_{REG} = 3.0-3.6V			100		mV

Table 6.   DC electrical characteristics (D+, D- pins; USB standard mode)
(V_{CC_IO} = 1.8 V, V_{REG} = 3.3 V unless otherwise noted; T_A = 25 °C, specifications over temperature, -40 to 85 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{LO}	HighZ state data line leakage	V_{CC_IO} = 1.8V; SUSPEND = 1	-10		10	µA
V_{DI}	Differential input sensitivity	I(D+)-(D-)I	0.2			V
V_{CM}	Differential common mode range	Includes V_{DI} range (VDI=200mV)	0.8		2.5	V
V_{SE}	Single ended receiver threshold	Low to high transition	0.8	1.6	2.0	V
		High to low transition	0.8	1.1	2.0	V
V_{RHYS}	Receiver hysteresis	V_{CM} = 0.8V		100		mV
V_{OL}	Static output low	R_L = 1.5kΩ to 3.6V			0.3	V
V_{OH}	Static output high	R_L = 15kΩ to GND	2.8		3.6	V
C_I	Transceiver input capacitance	Pin to GND		25		pF
Z_{DRV}	Driver output impedance [1]	Steady state drive	28		44	Ω
Z_{IN}	Input impedance		1			MΩ
$Z_{IN\ CD}$	D+ input impedance vs V_{REG} (During weak pull-up charger detection method)		105	150	195	kΩ

1. It includes external resistor. We recommend 33 Ω ± 10 % series external resistor to match USB compliance spec range (28-44 Ω)

Table 7. AC electrical characteristics (V_{CC_IO} = 1.8 V, V_{REG} = 3.3 V unless otherwise noted; T_A = 25 °C, specifications over temperature, -40 to 85 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t_R	Transition rise time (LOW SPEED)	CL = 50pF	75			ns
		CL = 600pF			300	
t_F	Transition fall time (LOW SPEED)	CL = 50pF	75			ns
		CL = 600pF			300	
t_{RFM}	Rise/Fall time matching (LOW SPEED)	(t_R, t_F)	80		125	%
V_{CRS_LS}	Output signal crossover voltage (LS)		1.3		2	V
t_R	Transition Rise time (FULL SPEED)	CL = 50pF *Figure 5*	4		20	ns
t_F	Transition Fall time (FULL SPEED)	CL = 50pF *Figure 5*	4		20	ns
t_{RFM}	Rise/Fall time matching (FULL SPEED)	(t_R, t_F)	90		111.11	%
V_{CRS_FS}	Output signal crossover voltage (FS)		1.3		2	V
t_{TA_OI}	Output to input turnaround time		0		5	ns
t_{TA_IO}	Turnaround time		0		5	ns
t_{PZH}, t_{PZL}	Driver enable delay time			8		ns
t_{PHZ}, t_{PLZ}	Driver disable delay time			17		ns
t_{PLH}, t_{PHL}	VP, VM to D+, D- propagation delay time	FS, CL=50pF			55	ns
		LS, CL=600pF			300	ns
t_{PLH}, t_{PHL}	D+, D- to RCV propagation delay time	FS, input slope = 15 ns			18	ns
t_{PLH}, t_{PHL}	D+, D- to VP, VM propagation delay time	FS, input slope = 15 ns			24	ns
t_{DET_SE0}	SE0 detection delay time D+, D- to INT ("0", "0" to INT="0")	Suspend="0", Softcon= Speed#="1"			40	ns
$t_{DET\#\_SE0}$	No SE0 detection delay time D+, D- to INT ("1", "X" to INT= "1") or ("x", "1" to "1")	Suspend="0", Softcon= Speed#="1"			40	ns

5   Functional description

The STUSB06E is designed to provide USB connectivity in mobile systems. The STUSB06E can operate down to digital I/O supply voltages of 1.6 V and still meet USB physical layer specifications. The STUSB06E takes typical 3.3 V supply voltage, V_{REG}, to operate the transceiver. The system voltage, V_{CC_IO}, is used to set the reference voltage required by the digital I/O lines interfacing to the system controller. Internal circuitry provides translation between the USB and system voltage domains. V_{CC_IO} will typically be the main supply voltage rail for the controller.

In addition, a termination supply voltage, V_{PU}, is provided to support speed selection. V_{PU} can be disabled or enabled under software control via the SOFTCON input. This allows for software-controlled connect or disconnect states. A 1.5 kΩ resistor is required to be connected between this pin and the D+ (full-speed) or D- (low-speed) line; according to *Table 6* behavior, sometimes, an internal weak pull-up resistor is connected instead.

The V_{REG} Input voltage ranging form 3 V to 3.6 V must be provided as main power supply.

The STUSB06E also supports sharing mode in which some pins are made 3-state to allow data lines sharing.

5.1   Power supply configurations

The STUSB06E supports four power supply configurations.

Operating mode: Both V_{CC_IO} and V_{REG} are present. This is the standard configuration for normal operation.

Disable mode: V_{REG} is connected while V_{CC_IO} is disconnected. D+ and D- pins are three-stated and the power consumption is reduced.

Sharing mode: V_{CC_IO} is connected while V_{REG} is disconnected. HIGHZ input is left floating or driven low. D+ and D- pins are three-stated and the differential data lines can be shared with signals of up to 3.6 V. Power consumption is reduced in this mode. The pins VP and VM are driven high and pin RCV is driven low.

High-Z mode: V_{CC_IO} is connected while V_{REG} is disconnected. High-Z input must be driven High. Every output pin is three-stated and the differential data lines can be shared with signals of up to 3.6 V. Power consumption is reduced in this mode. Refer to the functional tables for more details regarding pin's status in these power modes.

Charger detection mode: An embedded weak pull-up resistor of 150 kΩ is used to implement a resistive detection mechanism. According to USB Battery Charger Specification rel.1.1, this method will reliably detect:

– Rechargeable Portable Device attached to Dedicated Charger Port or
– Rechargeable Portable Device attached to Standard Host Port.

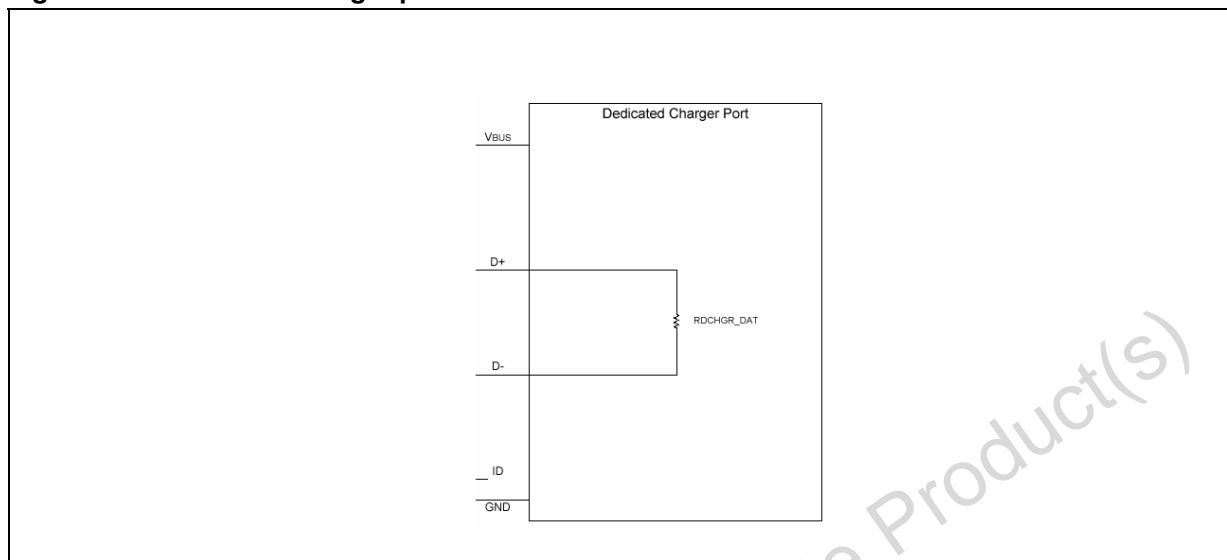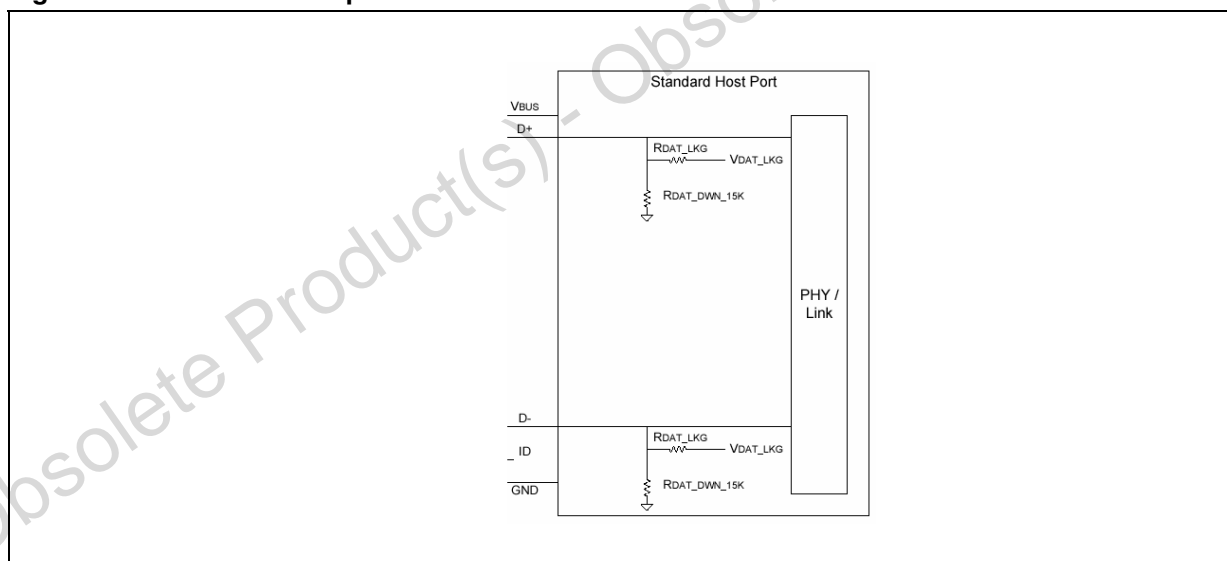**Figure 3. Dedicated charger port**


Figure 4. Standard host port

First charger (*Figure 3*) will have a 200 Ω Max resistor (RDCHGR_DAT) between D+ and D- and its connection will held both the D+ and D- lines at high level. Second charger (Charging Host Port *Figure 4*) connection will held both the D+ and D- lines to logic low level.

Table 8. USB lines status during charger detection

USB lines status	USB PHY with resistive detection method ON		
	Disconnected	**Dedicated charger port**	**Standard host port**
D+	"1"	"1"	"0"
D-	"0"	"1"	"0"

6   Block diagram

Figure 5.   Functional diagram
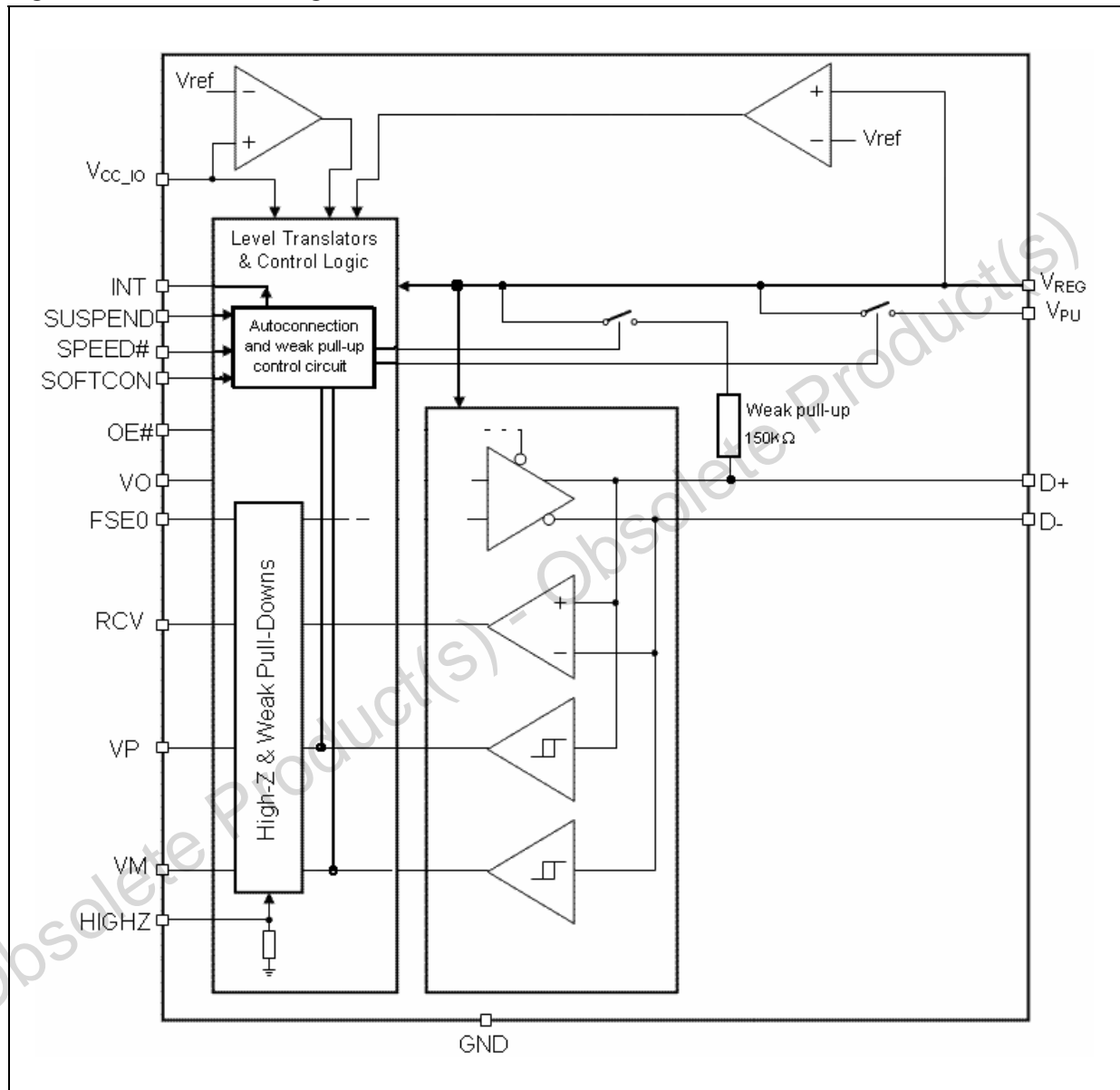
7 Functional tables

Table 9. Standard mode (see *Table 12*)

SUSPEND	OE#	D+, D-	RCV	VP, VM	Function
L	L	Driving	Active	Active	Normal driving
L	H	Receiving	Active	Active	Receiving
H	L	Driving	Inactive [1]	Active	Driving during suspend (Differential receiver inactive)
H	H	High-Z	Inactive [1]	Active	Low-power state

1. In suspend mode the differential receiver is inactive and RCV is LOW.

Table 10. Standard mode driving (OE#=LOW)

FSE0	VO	D+, D-
L	L	Differential logic 0
L	H	Differential logic 1
H	L	SE0
H	H	SE0

Table 11. Standard mode receiving (OE#=HIGH)

D+,D-	RCV	VP	VM
Differential logic 0	L	L	H
Differential logic 1	H	H	L
SE0	RCV [1]	L	L

1. RCV holds the status it had just before SE0.

Table 12. Pull-up setting mode (speed selection and charger detection)

Suspend	Softcon	Speed#	Function		
0	0	0	No 1.5 kΩ pull-up	FS	USB standard mode, default state
0	1	0	1.5 kΩ pull-up	FS	USB standard mode
0	0	1	No 1.5 kΩ pull-up	LS	USB standard mode
0	1	1	Pull-up ON (1.5 kΩ) after detecting SE0 RCV="0"	FS	Suspend, conditional pull-up
1	0	0	No 1.5 kΩ pull-up	FS	Suspend standard mode
1	1	0	1.5 kΩ Pull-up	FS	Suspend standard mode
1	0	1	No 1.5 kΩ pull-up	LS	Suspend standard mode
1	1	1	No 1.5 kΩ pull-up, RCV="0"	FS/X	USB mode & Rwpu ON (150 kΩ)

Table 13.   Pin states in power modes

Pins	Disable mode	Sharing mode	High-Z mode
V_{REG}	3.3 V	Not Present	-
V_{CC_IO}	Not present	1.6 V to 3.6 V input	1.6 V to 3.6 V input
V_{PU}	High impedance	High impedance	High impedance
D+, D-	High impedance	High impedance	High impedance
VP, VM	Invalid	H	High impedance [1]
RCV	Invalid	L	High impedance [1]
INT	Invalid	H	High impedance [1]
FSE0	High impedance [1]	High impedance [1]	High impedance [1]
Inputs (VO, SPEED#, SUSPEND, OE#, SOFTCON)	High impedance	High impedance	High impedance
HIGHZ	Floating [2]	Floating [2]	H

1. A 220 kΩ pull down is connected when HIGHZ="1".

2. HIGHZ input has an internal pull down resistor in order to disable HIGH-Z mode if left floating.

Table 14.   Power supply configurations

Mode	V_{REG}	V_{CC_IO}
Operating mode	3.0 V to 3.6 V	1.6 V to 3.6 V
Disable mode	X [1]	GND
Charger detection mode [2]	3.0 V to 3.6 V	1.6 V to 3.6 V

1. X: don't care.

2. weak 150 kΩ pull-up is connected between D+ to V_{REG} below some conditions.

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.

BCC++16L (3x3) Mechanical Data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		0.725	0.80		0.029	0.031
A1	0.05	0.075	0.10	0.002	0.003	0.004
b	0.27	0.30	0.33	0.011	0.012	0.013
b1	0.32	0.35	0.38	0.013	0.014	0.015
D	2.90	3	3.10	0.114	0.118	0.122
D2	1.73	1.80	1.87	0.068	0.071	0.074
D3	1.35	1.40	1.45	0.053	0.055	0.057
E	2.90	3	3.10	0.114	0.118	0.122
E2	1.73	1.80	1.87	0.068	0.071	0.074
E3	1.35	1.40	1.45	0.053	0.055	0.057
e		0.50			0.020	
e1		2.45			0.096	
e2		2.50			0.098	

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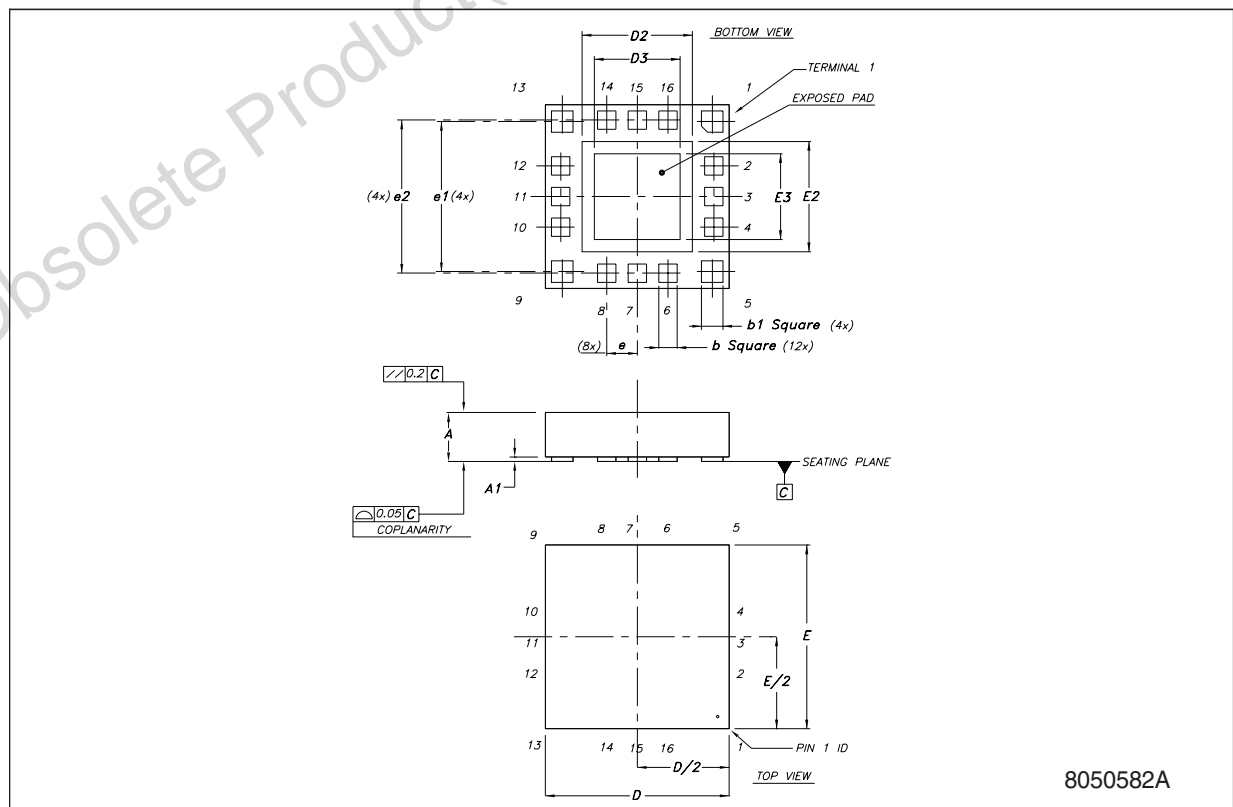
Tape & Reel BCC++16L (3x3) Mechanical Data

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			14.4			0.567
Ao	3.2	3.3	3.4	0.126	0.130	0.134
Bo	3.2	3.3	3.4	0.126	0.130	0.134
Ko	1.0	1.1	1.2	0.039	0.043	0.047
Po	3.9	4	4.1	0.154	0.157	0.161
P	7.9	8	8.1	0.311	0.315	0.319

Note: Drawing not in scale
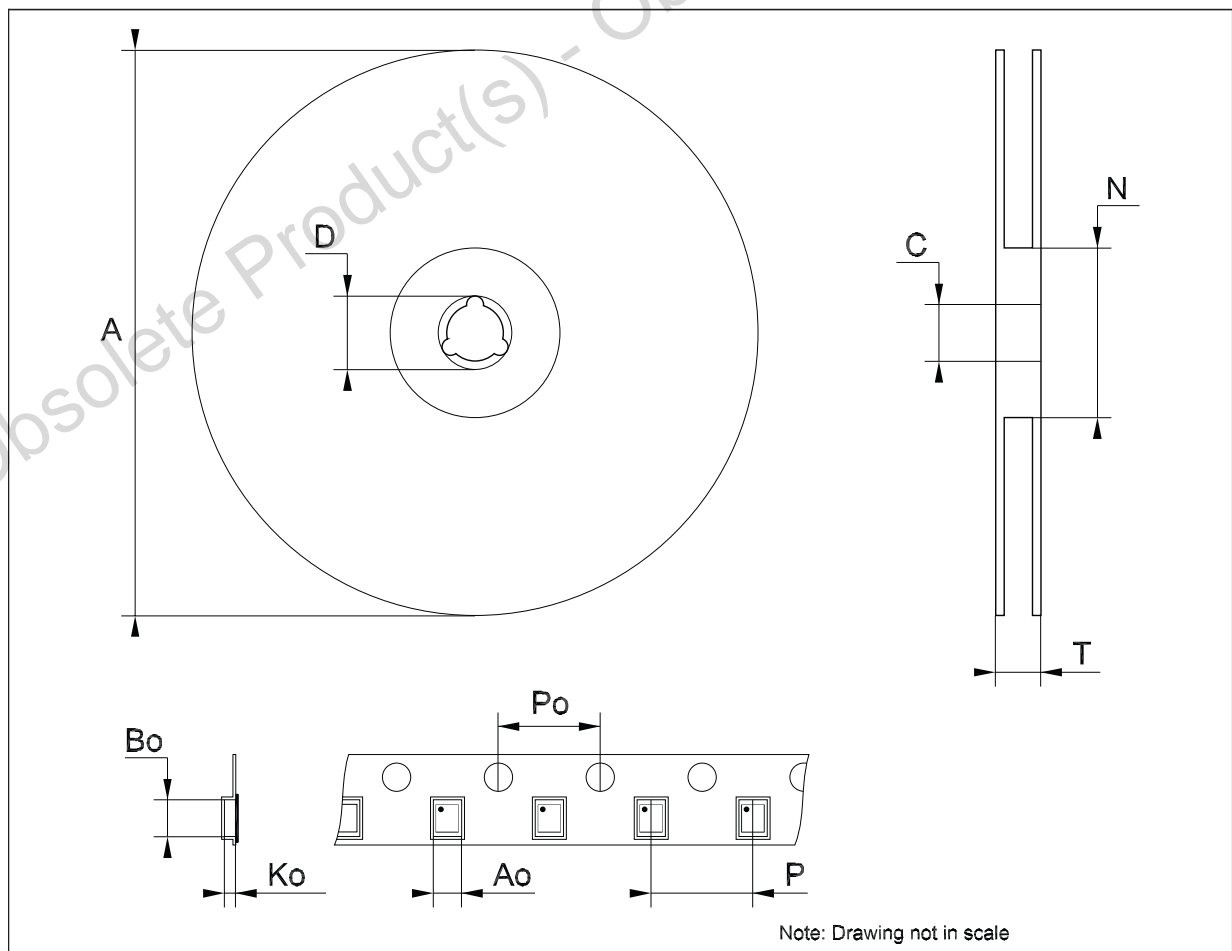
9 Revision history

Table 15.   Document revision history

Date	Revision	Changes
04-Dec-2008	1	Initial release.

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