NCN2500

USB Single Channel Transceiver

The NCN2500 Integrated Circuit is a single channel transceiver designed to accommodate the physical USB Port with a microcontroller digital I/O. The part is fully USB compliant and supports the full 12 Mbps speed. On the other hand, the NCN2500 device includes the pullup resistors as defined by the USB−ECN new specifications.

Features

- Compliant to the USB Specification, Version 2.0, Low and Full Speed
- Very Small Footprint Due to the QFN−16 Package
- Integrated D+/D− Pullup Resistors
- Operates Over the Full 1.5 V to 3.6 V Supply
- Pb−Free Package is Available*

Typical Applications

- Portable Computer
- Cellular Phone

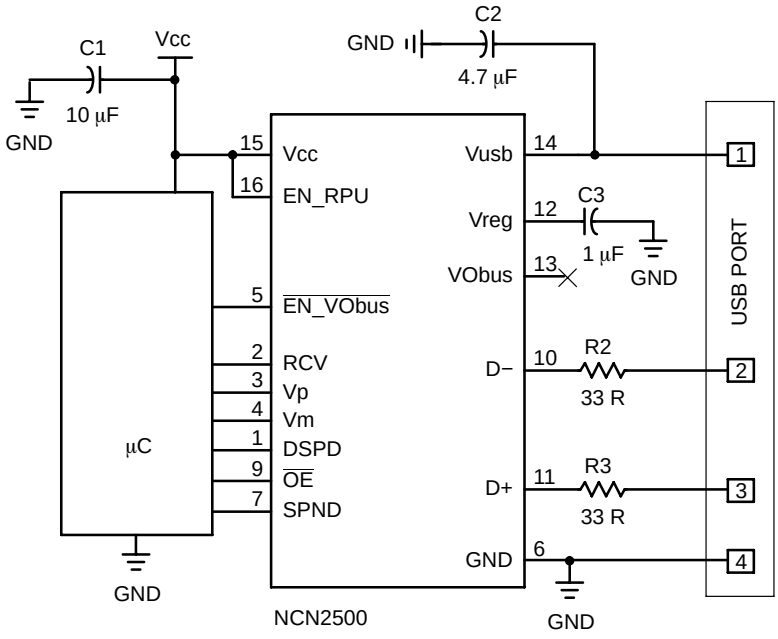

Figure 1. Typical Application

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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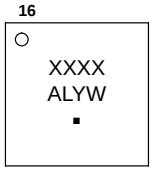
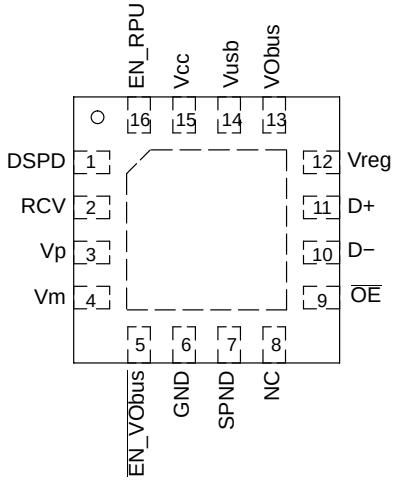
MARKING DIAGRAM

QFN−16
MNR SUFFIX
CASE 485G



A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Package	Shipping†
NCN2500MNR2	QFN−16	3000 Tape & Reel
NCN2500MNR2G	QFN−16 (Pb−Free)	3000 Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

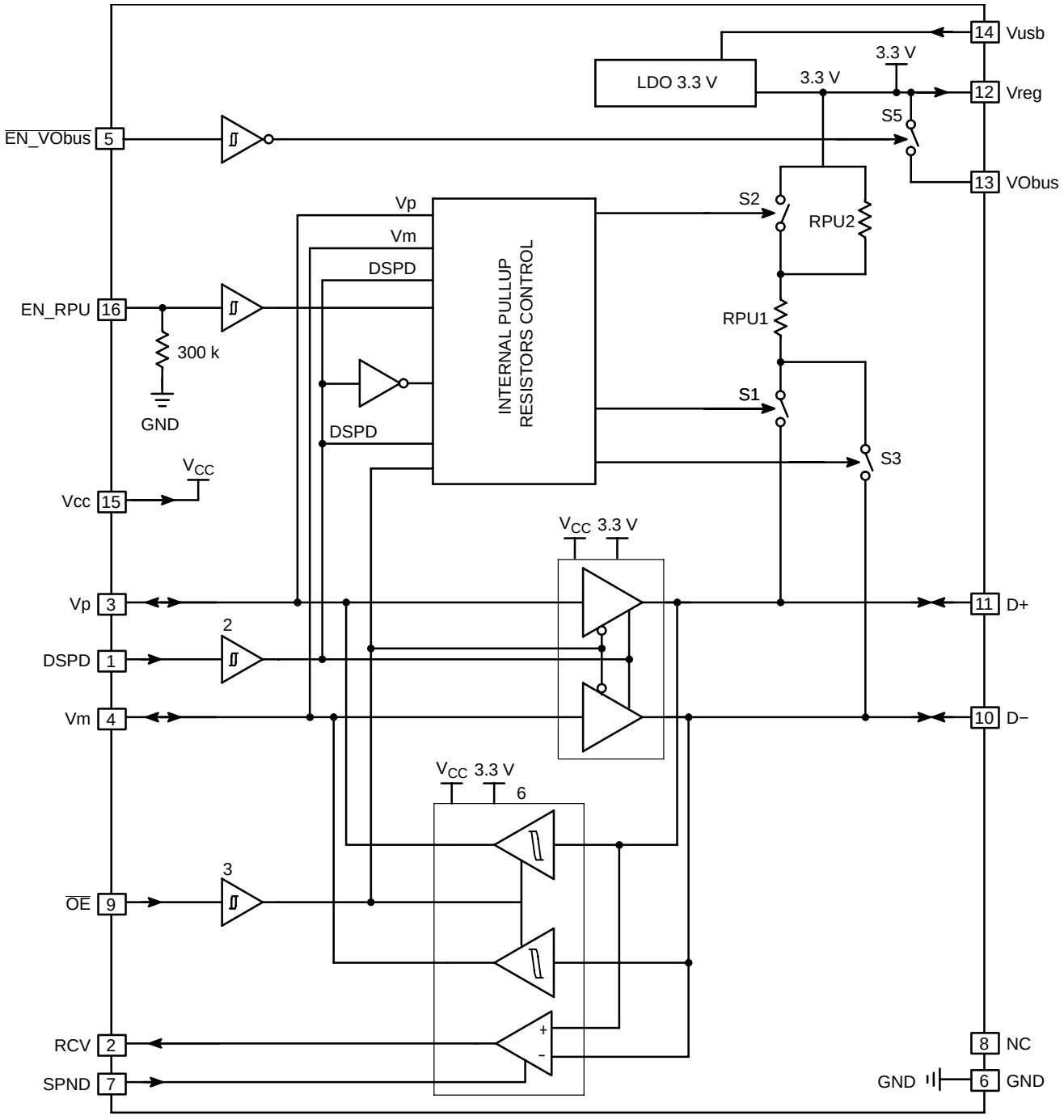


Figure 2. Block Diagram

PIN FUNCTION DESCRIPTION

Pin	Symbol	Function	Description
1	DSPD	INPUT	The DSPD logic level (Data Speed) activates the Low or the High speed operation on the USB port. DSPD = Low Low Speed, RPU1 and RPU2 connected to D− DSPD = High Full Speed, RPU1 and RPU2 connected to D+
2	RCV	OUTPUT	This pin interfaces the USB signals with the microcontroller digital line. The data present on the D+/D− pins are translated onto this signal.
3	Vp	I/O	This pin, associated with Vm, is an I/O system interface signal depending upon the $\overline{OE}$ logic state: $\overline{OE}$ = Low Vp is a Plus driver Input (from μC to USB bus) $\overline{OE}$ = High Vp is a Plus receiver Output (from USB bus to μC)
4	Vm	I/O	This pin, associated with Vp, is an I/O system interface signal depending upon the $\overline{OE}$ logic state: $\overline{OE}$ = Low Vm is a Minus driver Input (from μC to USB bus) $\overline{OE}$ = High Vm is a Minus receiver Output (from USB bus to μC)
5	$\overline{EN\_VObus}$	INPUT	Digital input to control the VObus voltage. $\overline{EN\_VObus}$ = Low VObus connected to Vreg $\overline{EN\_VObus}$ = High VObus disconnected from Vreg (Hi Z)
6	GND	PWR	This pin carries the digital and USB ground level. High Quality PCB design shall be observed to avoid uncontrolled voltage spikes.
7	SPND	INPUT	The SPND digital signal (SUSPEND) selects the operation mode to reduce the power supply current. SPND = Low Normal operation SPND = High Suspend mode, no activity takes place
8	NC	−	No Connection, shall be neither grounded, nor connected to Vcc or Vbus.
9	$\overline{OE}$	INPUT	This pin activates the operating mode of the D−/D+ signals. $\overline{OE}$ = Low logic level Data are transmitted onto the USB bus $\overline{OE}$ = High logic level Data are received from the USB bus
10	D−	I/O	This pin is connected to the USB Minus Data line I/O. The data direction depends upon the $\overline{OE}$ logic state.
11	D+	I/O	This pin is connected to the USB Plus Data line I/O The data direction depends upon the $\overline{OE}$ logic state.
12	Vreg	PWR	This pin provides a 3.3 V regulated voltage to supply the internal USB blocks and the external termination bias resistor. An external circuit can be connected to this LDO, assuming the current does not extend the maximum rating (50 mA).
13	VObus	OUTPUT, PWR	This pin connects the Vreg voltage to the 1.5 k external pullup resistor. The VObus voltage is controlled by the logic states present Pin 5. The R_{DSon} of the internal PMOS device (reference S5 in the Block Diagram) is 10 Ω typical.
14	Vusb	PWR	This pin is connected to the USB port +Vcc supply voltage.
15	Vcc	PWR	This pin provides the interface power supply. The power source can be an external supply or can be derived from the USB + Vusb voltage.
16	EN_RPU	INPUT	This pin activates or deactivate the internal RPU1 and RPU2 pullup resistors: EN_RPU = H RPU1 and RPU2 activated EN_RPU = L RPU1 and RPU2 deactivated

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	Vcc	6.0	V
Digital Input Pins	Vind	−0.5 V < Vin < Vcc + 0.5 V, but < 6.0 V	V
Digital Input Pins	Vid	−0.5 V < Vin < AGND + 0.5 V, but < 6.0 V	V
Digital Input Pins	Ibias	−35 mA < Ibias < 35 mA	mA
ESD Capability, HBM (Note 1) Vusb, D+, D−, GND Any Other Pins Machine Model, Any Pins	V_{ESD}	 10 2.0 200	 kV kV V
QFN−16 Package Power Dissipation @ Tamb = +85°C Thermal Resistance, Junction−to−Air ($R_{\theta JA}$)	 P_{DS} $R_{\theta JA}$	 470 85	 mW °C/W
Operating Ambient Temperature Range	T_A	−40 to +85	°C
Operating Junction Temperature Range	T_J	−40 to +125	°C
Maximum Junction Temperature (Note 2)	T_{Jmax}	+150	°C
Storage Temperature Range	T_{sg}	−65 to +150	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. Human Body Model, R = 1500 Ω, C = 100 pF; Machine Model.
2. Absolute Maximum Rating beyond which damage(s) to the device may occur.

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Pin	Min	Typ	Max	Unit
DIGITAL PARAMETERS SECTION @ 1.5 V < Vcc < 3.6 V (−40°C to +85°C ambient temperature, unless otherwise noted.) NOTE: Digital inputs undershoot < −0.3 V to ground, digital inputs overshoot < 0.3 V to Vcc.						
High Level Input Voltage DSPD, Vp, Vm, $\overline{EN\_VObus}$, SPND, $\overline{OE}$, EN_RPU	V_{IH}	1, 3, 4, 5, 7, 9, 16	0.80*Vcc	−	−	V
Low Level Input Voltage DSPD, Vp, Vm, $\overline{EN\_VObus}$, SPND, $\overline{OE}$, EN_RPU	V_{IL}	1, 3, 4, 5, 7, 9, 16	−	−	0.20*Vcc	V
High Level Output Voltage RCV, Vp, Vm @ I_{OH} = 1.0 mA	V_{OH}	2, 3, 4	0.80*Vcc	−	−	V
Low Level Output Voltage RCV, Vp, Vm @ I_{OL} = 1.0 mA	V_{OL}	2, 3, 4	−	−	0.20*Vcc	V
Input Leakage Current DSPD, Vp, Vm, $\overline{EN\_VObus}$, SPND, $\overline{OE}$, EN_RPU	I_{IL}	1, 3, 4, 5, 7, 9, 16	−	−	±5.0	μA
Input EN_RPU Pulldown Resistor @VCC = 3.3 V	RPU	−	−	300	−	kΩ
TRANSCEIVER SECTION @ 1.5 V < Vcc < 3.6 V (−40°C to +85°C ambient temperature, unless otherwise noted.)						
Static Output High, D−, D+ @ $\overline{OE}$ = Low, R_L = 15 kΩ to GND	V_{OH}	10, 11	2.8	−	3.6	V
Static Output Low, D−, D+ @ $\overline{OE}$ = Low, R_L = 1.5 kΩ to Vreg	V_{OL}	10, 11	−	−	0.3	V
Single Input Receiver Threshold	V_{SE}	10, 11	0.8	−	2.0	V
Single Ended Receiver Hysteresis (Note 3)	−	−	−	200	−	mV
Differential Input Sensitivity | D+ − D− | @ 0.8 V < V_{CM} < 2.5 V (Note 3)	V_{DI}	10, 11	0.2	−	−	V
Differential Common Mode Including the V_{DI}	V_{CM}	10, 11	0.8	−	2.5	V
Differential Receiver Hysteresis (Note 3)	−	10, 11	−	70	−	mV
D+ and D− Transceiver Hi−Z State Leakage Current @ $\overline{OE}$ = 1, 0 V < Vusb < 3.3 V	I_{LO}	10, 11	−	−	±10	μA
Transceiver Input Capacitance (Note 3)	Cin	10, 11	−	−	20	pF
Transceiver Output Resistance (Note 3)	Z_{DRV}	10, 11	28	−	44	Ω
Transceiver Input Impedance (Note 3)	Z_{IN}	10, 11	10	−	−	MΩ
Internal RPU1 Pull Resistor	R_{RPU-1}	10, 12	900	−	1575	Ω
Internal RPU2 Pull Up Resistor	R_{RPU-2}	10, 12	525	−	1515	Ω
LOW SPEED DRIVER OPERATION (Note 3)						
Transition Rise Time @ C_L = 50 pF @ C_L = 600 pF	tr	10, 11	 75 75	 − −	 300 300	ns
Transition Fall Time @ C_L = 50 pF @ C_L = 600 pF	tf	10, 11	 75 75	 − −	 300 300	ns
Rise and Fall Time Matching	tr, tf	10, 11	80	−	125	%
Output Signal Crossover Voltage	V_{CRS}	10, 11	1.3	−	2.0	V
Data Transaction Rate	Drate	10, 11	−	−	1.5	Mbs

3. Parameter guaranteed by design, not production tested.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Pin	Min	Typ	Max	Unit
FULL SPEED DRIVER OPERATION (Note 4)						
Transition Rise Time @ C_L = 50 pF	tr	10, 11	4.0	−	20	ns
Transition Fall Time @ C_L = 50 pF	tf	10, 11	4.0	−	20	ns
Rise and Fall Time Matching	tr, tf	10, 11	90	−	110	%
Output Signal Crossover Voltage	V_{CRS}	10, 11	1.3	−	2.0	V
Data Transaction Rate	Drate	10, 11	−	−	12	Mbs
TRANSCEIVER TIMING (Note 4)						
$\overline{OE}$ to RCVR Hi−Z Delay (see Figure 3)	t_{PVZ}	9	−	−	15	ns
Receiver Hi−Z to Transmit Delay (see Figure 3)	t_{PZD}	−	15	−	−	ns
$\overline{OE}$ to DRVR Hi−Z Delay (see Figure 3)	t_{PDZ}	−	−	−	15	ns
Driver Hi−Z to Receiver Delay (see Figure 3)	t_{PZV}	−	15	−	−	ns
Vp/Vm to D+/D− Propagation Delay (see Figure 6)	t_{PLH}	3, 4, 10, 11	−	−	15	ns
Vp/Vm to D+/D− Propagation Delay (see Figure 6)	t_{PHL}	3, 4, 10, 11	−	−	15	ns
D+/D− to RCV Propagation Delay @ 1.5 < Vcc < 5.5 V (see Figure 5) C_L = 25 pF tr = tf = 3.0 ns	t_{PLH}	11, 10, 2	−	−	15	ns
D+/D− to RCV Propagation Delay @ 1.5 < Vcc < 5.5 V (see Figure 5) C_L = 25 pF tr = tf = 3.0 ns	t_{PHL}	11, 10, 2	−	−	15	ns
D+/D− to Vp/D− Propagation Delay @ 1.5 < Vcc < 5.5 V (see Figure 5) C_L = 25 pF tr = tf = 3.0 ns	t_{PLH}	11, 10, 3	−	−	8.0	ns
D+/D− to Vm/D− Propagation Delay @ 1.5 < Vcc < 5.5 V (see Figure 5) C_L = 25 pF tr = tf = 3.0 ns	t_{PHL}	11, 10, 4	−	−	8.0	ns
POWER SUPPLY SECTION @ 1.5 V < Vcc < 3.6 V (−40°C to +85°C ambient temperature, unless otherwise noted.)						
Digital Supply Voltage	Vcc	15	1.5	−	3.6	V
USB Port Input Supply Voltage	Vusb	14	4.0	−	5.25	V
Output Regulated Voltage @ 4.0 V < Vusb < 5.25 V, Cin = 4.7 μF, Cout = 1.0 μF, Ireg = 100 mA	Vreg	12	3.0	3.3	3.6	V
Output Switched Voltage @ Io = 1.0 mA, Cin = 4.7 μF	Vobus	13	3.0	3.3	3.6	V
Line Regulation Output Voltage	Vreg	12	−	0.1	−	%
Standby Current @ Vusb = 5.25 V, $\overline{OE}$ = H, SPND = H, D+ and D− are Idle, Vcc = 3.6 V	I_{VCC}	14	−	1.0	−	μA
Standby Current @ Vusb = 5.25 V, $\overline{OE}$ = H, SPND = L, D+ and D− are Idle, Vcc = 3.6 V	I_{VCC}	14	−	1.0	−	μA
Operating Current $\overline{OE}$ = L, D− and D+ Active, SPND = L (Note 4), Transmitter Mode @ F = 6.0 MHz, C_L = 50 pF @ F = 750 kHz, C_L = 600 pF	I_{VCC}	14	−	 300 40	 − −	μA
Operating Current $\overline{OE}$ = H, D− and D+ Active, SPND = L (Note 4), Receiver Mode @ F = 6.0 MHz, C_L = 25 pF @ F = 750 kHz, C_L = 25 pF	I_{VCC}	14	−	 1.5 250	 − −	 mA μA

4. Parameter guaranteed by design, not production tested.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Pin	Min	Typ	Max	Unit
POWER SUPPLY SECTION @ 1.5 V < Vcc < 3.6 V (continued) (−40°C to +85°C ambient temperature, unless otherwise noted.)						
USB Supply Current @ D− and D+ are Idle, Vusb = 5.25 V and:	I_{BUS}	14				
@ SPND = 1, $\overline{OE}$ = 1, DSPD = 0, EN_RPU = 0			−	120	200	μA
@ SPND = 0, $\overline{OE}$ = 1, DSPD = 1, EN_RPU = 0			−	1.7	−	mA
@ SPND = 0, $\overline{OE}$ = 0, DSPD = 0, EN_RPU = 0			−	1.7	−	mA
@ SPND = 1, $\overline{OE}$ = 1, DSPD = 0, EN_RPU = 1			−	320	500	μA
@ D− and D+ are Active, C_L = 50 pF, Vusb = 5.25 V, SPND = 0, $\overline{OE}$ = 0, DSPD = 1, F = 6.0 MHz (Note 5)						
@ EN_RPU = Low			−	8.3	−	mA
@ EN_RPU = High			−	9.4	−	mA
@ D− and D+ are Active (Note 5) Vusb = 5.25 V, SPND = 0, $\overline{OE}$ = 0, DSPD = 1,						
F = 750 kHz, C_L = 600 pF			−	5.4	−	mA
F = 750 kHz, C_L = 300 pF			−	3.9	−	mA

5. Parameter guaranteed by design, not production tested.

Table 1. Internal RPU1 and RPU2 Pullup Resistors Control

EN_RPU	DSPD	S1	S2	S3	Data Line	USB	Note
0	X	X	X	X	X	X	Internal RPU Deactivated, S1 and S3 are Forced OPEN
1	1	Open	X	Open	Vbus Off	X	Internal RPU disabled
1	1	Close	Close	Open	Idle	Full Speed	Internal RPU Activated
1	1	Closed	Open	Open	Receiving	Full Speed	Internal RPU Activated
1	0	Open	X	Open	Vbus Off	X	Internal RPU disabled
1	0	Open	Close	Close	Idle	Low Speed	Internal RPU Activated
1	0	Open	Open	Close	Receiving	Low Speed	Internal RPU Activated

6. See Figure 8 and Figure 9.

Table 2. Transmit Mode Interface Control ($\overline{OE}$ = 0 → Transmit Mode)

SPND	Vp	Vm	D+	D−	RCV	STATE
0	0	0	0	0	X	SE0
0	0	1	0	1	0	Low
0	1	0	1	0	1	High
0	1	1	1	1	X	Undefined
1	0	0	0	0	0	Suspend
1	0	1	0	1	0	Suspend
1	1	0	1	0	0	Suspend
1	1	1	1	1	0	Suspend

Table 3. Receive Mode Interface Control ($\overline{OE}$ = 1 → Receive Mode)

SPND	D+	D−	Vp	Vm	RCV	STATE
0	0	0	0	0	X	SE0
0	0	1	0	1	0	Low
0	1	0	1	0	1	High
0	1	1	1	1	X	Undefined
1	0	0	0	0	0	Suspend
1	0	1	0	1	0	Suspend
1	1	0	1	0	0	Suspend
1	1	1	1	1	0	Suspend

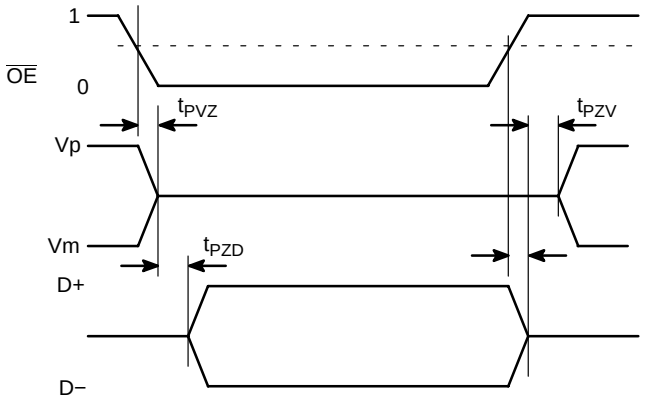


Figure 3. Enable and Disable USB Times

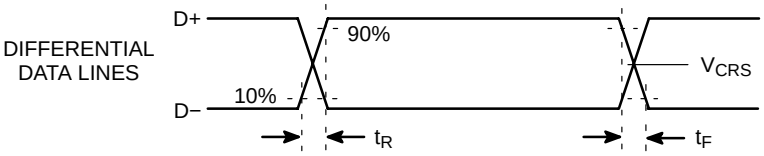


Figure 4. USB Line Rise and Fall Times

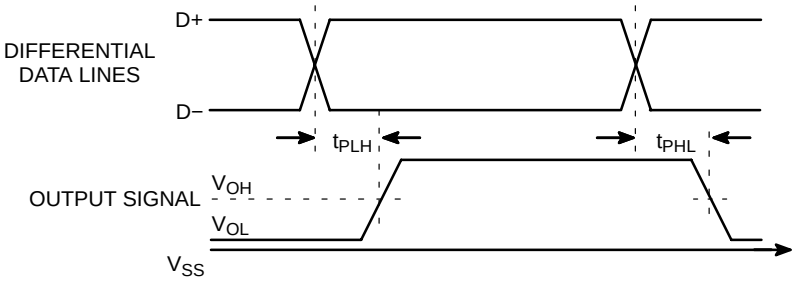


Figure 5. Receiver Propagation Delays

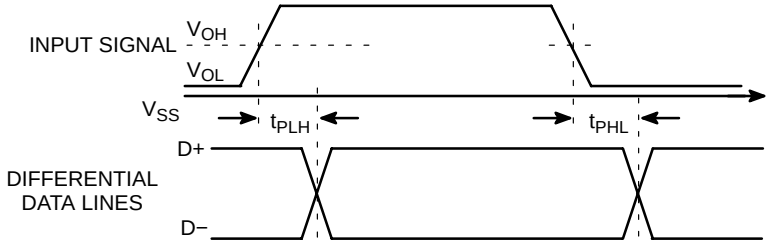


Figure 6. Driver Propagation Delays

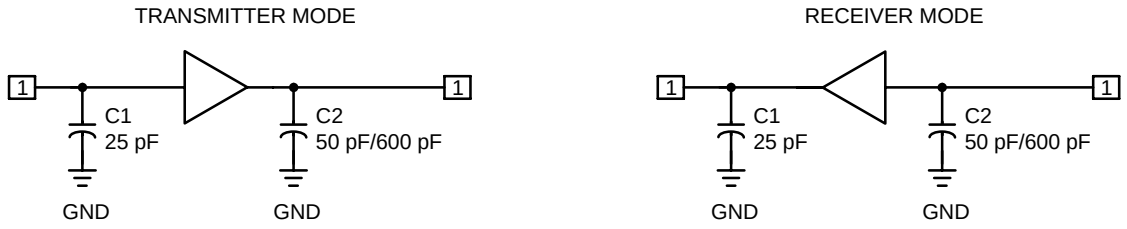


Figure 7. Input/Output Stray Capacitance Definitions

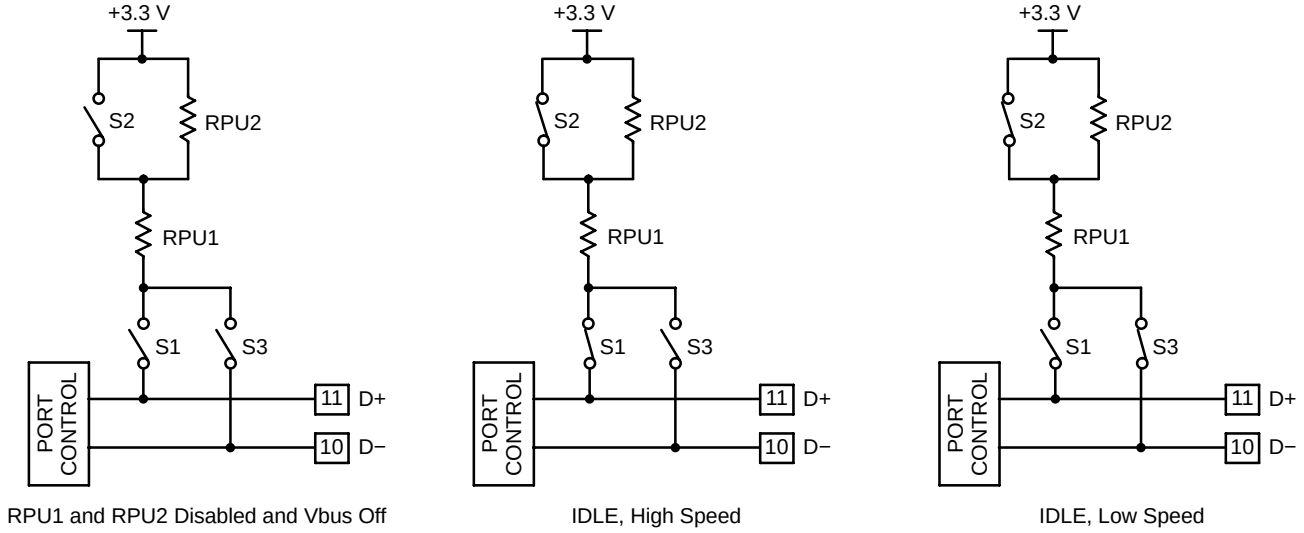
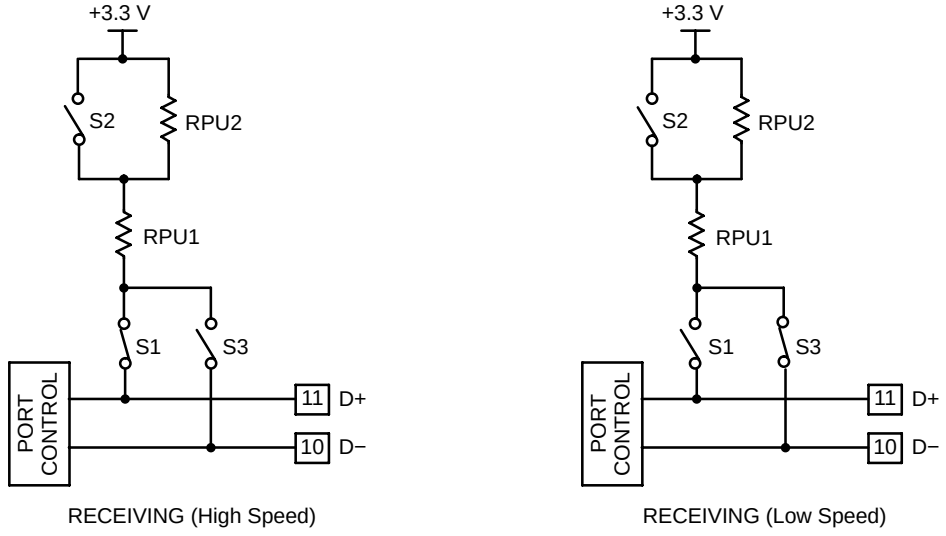


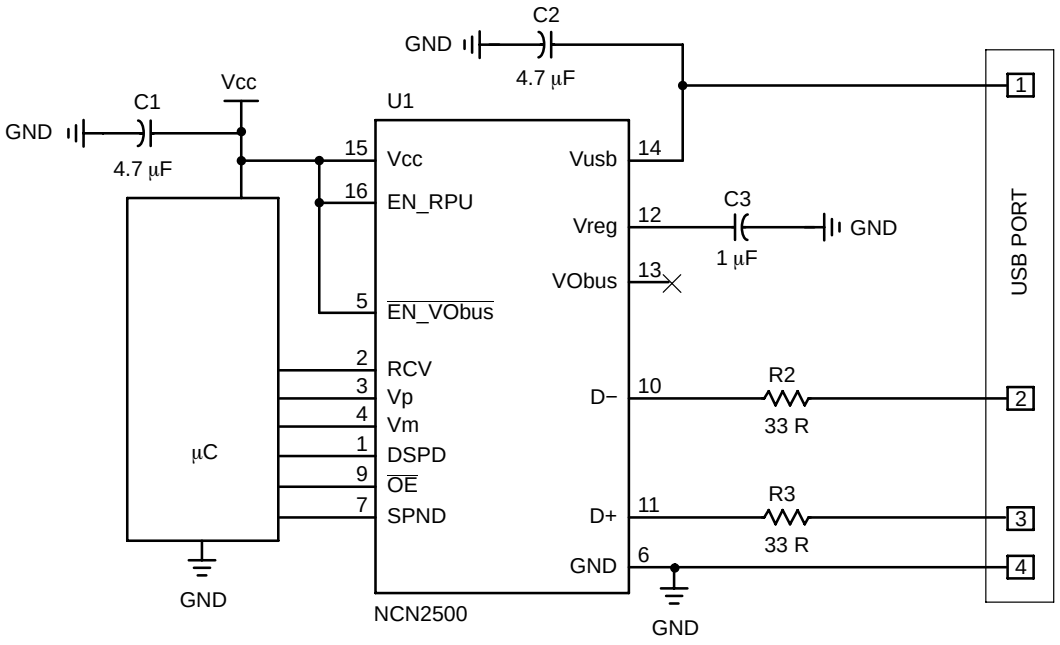
Figure 8. Internal RPU1 and RPU2 Pullup Resistors Operation, IDLE Mode



NOTE: Internal Pullup Resistor Range: RPU1: 900 Ω min−1575 Ω max, RPU2: 525 Ω min−1515 Ω max

Figure 9. Internal RPU1 and RPU2 Pullup Resistors Activated, RECEIVING Mode

TYPICAL APPLICATIONS



In this application, the two internal pullup resistors (RPU1 and RPU2) are used to bias the USB line. Consequently, the VObus voltage is deactivated (Pin 5 connected to Vcc).

Figure 10. Fully Independent Power Supplies

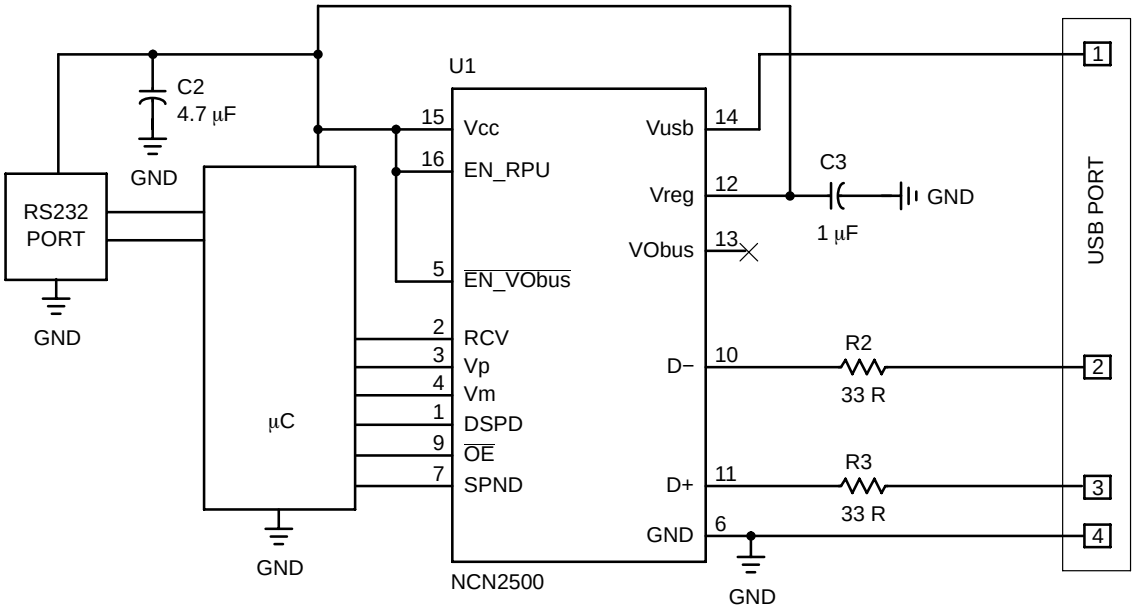
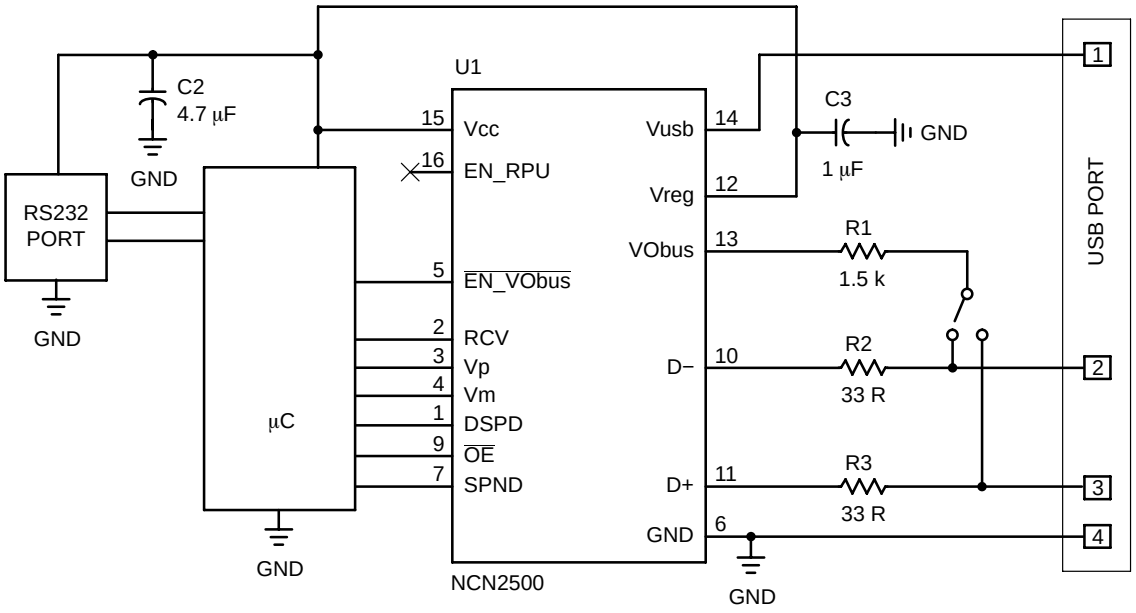


Figure 11. Peripheral are Powered by the Vreg Supply

TYPICAL APPLICATIONS



Note: Pin 16 can be left open, due to the internal pull−down resistor, or connected to ground.

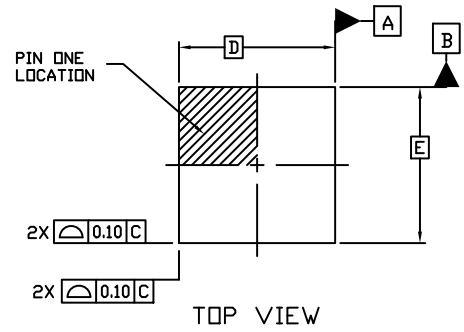
Figure 12. Using External Pullup Resistors

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

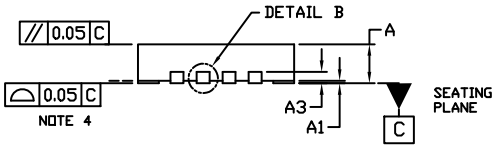
QFN16 3x3, 0.5P
CASE 485G
ISSUE G

DATE 08 OCT 2021

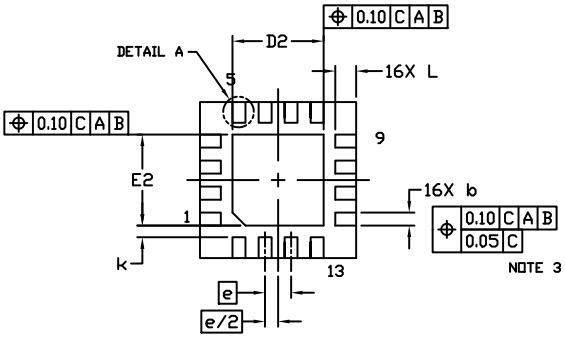
SCALE 2:1



TOP VIEW

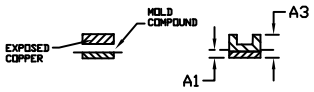


SIDE VIEW

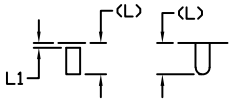


BOTTOM VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.



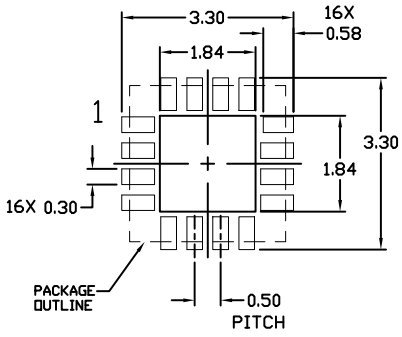
DETAIL B
ALTERNATE CONSTRUCTIONS



DETAIL A
ALTERNATE TERMINAL CONSTRUCTIONS

	MILLIMETERS		
DIM	MIN.	NOM.	MAX.
A	0.80	0.90	1.00
A1	0.00	0.03	0.05
A3		0.20 REF	
b	0.18	0.24	0.30
D		3.00 BSC	
D2	1.65	1.75	1.85
E		3.00 BSC	
E2	1.65	1.75	1.85
e		0.50 BSC	
k		0.18 TYP	
L	0.30	0.40	0.50
L1	0.00	0.08	0.15

MOUNTING FOOTPRINT



GENERIC MARKING DIAGRAM*

XXXXX = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

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