

USB Dedicated Charging Port Controller

Check for Samples: [TPS2513](#), [TPS2514](#)

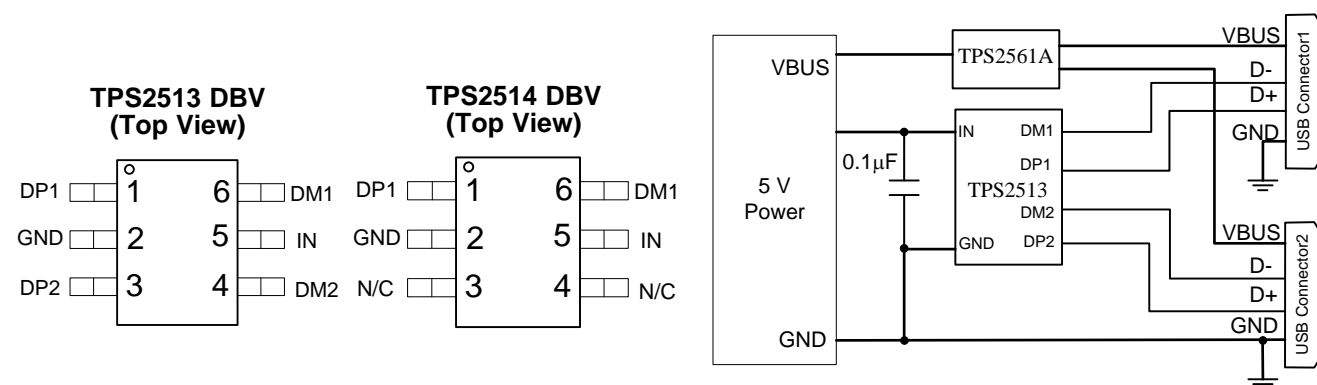
FEATURES

- Supports USB DCP Shorting D+ Line to D- Line per USB Battery Charging Specification, Revision 1.2 (BC1.2)
- Supports Shorted Mode (Shorting D+ Line to D- Line) per Chinese Telecommunication Industry Standard YD/T 1591-2009
- Supports USB DCP Applying 2.7 V on D+ Line and 2 V on D- line (or USB DCP Applying 2 V on D+ Line and 2.7 V on D- Line)
- Supports USB DCP Applying 1.2 V on D+ and D- Lines
- Automatically Switch D+ and D- Lines Connections for an Attached Device
- Dual USB Port Controller, TPS2513
- Single USB Port Controller, TPS2514
- Operating Range: 4.5 V to 5.5 V
- Available in SOT23-6 Package

APPLICATIONS

- Vehicle USB Power Charger
- AC-DC Adapter with USB Port
- Other USB Charger

TPS2513, TPS2514 DBV PACKAGE and SIMPLIFIED APPLICATION DIAGRAM



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Over recommended junction temperature range, voltages are referenced to GND (unless otherwise noted)

		MIN	MAX	UNIT
Voltage range	IN	-0.3	7	V
	DP1, DP2 output voltage, DM1, DM2 output voltage	-0.3	5.8	
	DP1, DP2 input voltage, DM1, DM2 input voltage	-0.3	5.8	
Continuous output sink current	DP1, DP2 input current, DM1, DM2 input current		35	mA
Continuous output source current	DP1, DP2 output current, DM1, DM2 output current		35	mA
ESD rating	Human Body Model (HBM)	IN	2	kV
		DP1, DP2, DM1, DM2	6	
	Charging Device Model (CDM)			500
Operating Junction Temperature	T _J	-40	125	°C
Storage Temperature Range	T _{stg}	-65	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

THERMAL INFORMATION

THERMAL METRIC ⁽¹⁾		TPS2513 TPS2514	UNITS
		DBV (6 PINS)	
θ _{JA}	Junction-to-ambient thermal resistance	179.9	°C/W
θ _{JCtop}	Junction-to-case (top) thermal resistance	117.5	
θ _{JB}	Junction-to-board thermal resistance	41.9	
ψ _{JT}	Junction-to-top characterization parameter	17.2	
ψ _{JB}	Junction-to-board characterization parameter	41.5	
θ _{JCbot}	Junction-to-case (bottom) thermal resistance	N/A	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

RECOMMENDED OPERATING CONDITIONS

Voltages are referenced to GND (unless otherwise noted), positive current are into pins.

		MIN	MAX	UNIT
V _{IN}	Input voltage of IN	4.5	5.5	V
V _{DP1}	DP1 data line input voltage	0	5.5	V
V _{DM1}	DM1 data line input voltage	0	5.5	V
I _{DP1}	Continuous sink or source current		±10	mA
I _{DM1}	Continuous sink or source current		±10	mA
V _{DP2}	DP2 data line input voltage	0	5.5	V
V _{DM2}	DM2 data line input voltage	0	5.5	V
I _{DP2}	Continuous sink or source current		±10	mA
I _{DM2}	Continuous sink or source current		±10	mA
T _J	Operating junction temperature	-40	125	°C

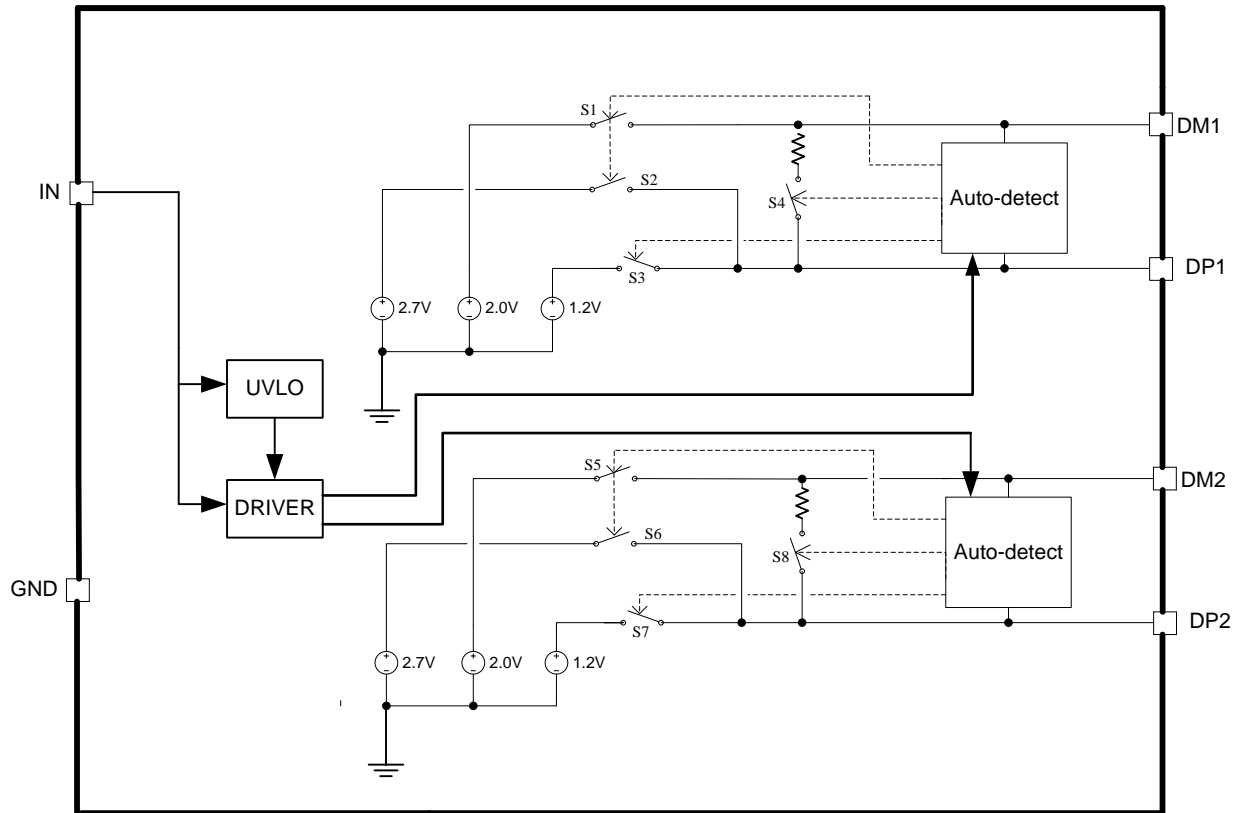
ELECTRICAL CHARACTERISTICS

Conditions are $-40^{\circ}\text{C} \leq (T_J = T_A) \leq 125^{\circ}\text{C}$, $4.5\text{ V} \leq V_{\text{IN}} \leq 5.5\text{ V}$. Positive current are into pins. Typical values are at 25°C . All voltages are with respect to GND (unless otherwise noted).

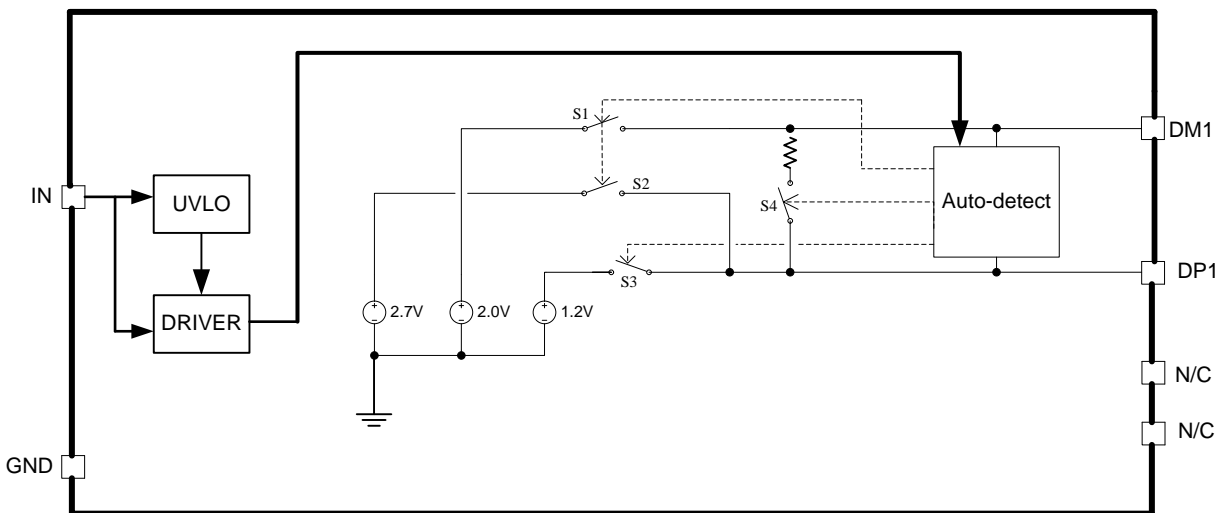
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
UNDERVOLTAGE LOCKOUT						
V_{UVLO}	IN rising UVLO threshold voltage		3.9	4.1	4.3	V
	Hysteresis ⁽¹⁾			100		mV
SUPPLY CURRENT						
I_{IN}	IN supply current	$4.5\text{ V} \leq V_{\text{IN}} \leq 5.5\text{ V}$		155	200	μA
BC 1.2 DCP MODE (SHORT MODE)						
$R_{\text{DPM_SHORT1}}$	DP1 and DM1 shorting resistance	$V_{\text{DP1}} = 0.8\text{ V}$, $I_{\text{DM1}} = 1\text{ mA}$		157	200	Ω
$R_{\text{DCHG_SHORT1}}$	Resistance between DP1/DM1 and GND	$V_{\text{DP1}} = 0.8\text{ V}$	350	656	1150	k Ω
$V_{\text{DPL_TH_DETACH1}}$	Voltage threshold on DP1 under which the device goes back to divider mode		310	330	350	mV
$V_{\text{DPL_TH_DETACH_HYS1}}$	Hysteresis ⁽¹⁾			50		mV
$R_{\text{DPM_SHORT2}}$	DP2 and DM2 shorting resistance	$V_{\text{DP2}} = 0.8\text{ V}$, $I_{\text{DM2}} = 1\text{ mA}$		157	200	Ω
$R_{\text{DCHG_SHORT2}}$	Resistance between DP2/DM2 and GND	$V_{\text{DP2}} = 0.8\text{ V}$	350	656	1150	k Ω
$V_{\text{DPL_TH_DETACH2}}$	Voltage threshold on DP2 under which the device goes back to divider mode		310	330	350	mV
$V_{\text{DPL_TH_DETACH_HYS2}}$	Hysteresis ⁽¹⁾			50		mV
DIVIDER MODE						
$V_{\text{DP1_2.7V}}$	DP1 output voltage	$V_{\text{IN}} = 5\text{ V}$	2.57	2.7	2.84	V
$V_{\text{DM1_2V}}$	DM1 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.9	2	2.1	V
$R_{\text{DP1_PAD1}}$	DP1 output impedance	$I_{\text{DP1}} = -5\ \mu\text{A}$	24	30	36	k Ω
$R_{\text{DM1_PAD1}}$	DM1 output impedance	$I_{\text{DM1}} = -5\ \mu\text{A}$	24	30	36	k Ω
$V_{\text{DP2_2.7V}}$	DP2 output voltage	$V_{\text{IN}} = 5\text{ V}$	2.57	2.7	2.84	V
$V_{\text{DM2_2V}}$	DM2 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.9	2	2.1	V
$R_{\text{DP2_PAD1}}$	DP2 output impedance	$I_{\text{DP2}} = -5\ \mu\text{A}$	24	30	36	k Ω
$R_{\text{DM2_PAD1}}$	DM2 output impedance	$I_{\text{DM2}} = -5\ \mu\text{A}$	24	30	36	k Ω
1.2 V / 1.2 V MODE						
$V_{\text{DP1_1.2V}}$	DP1 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.12	1.2	1.28	V
$V_{\text{DM1_1.2V}}$	DM1 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.12	1.2	1.28	V
$R_{\text{DM1_PAD2}}$	DP1 output impedance	$I_{\text{DP1}} = -5\ \mu\text{A}$	80	102	130	k Ω
$R_{\text{DP1_PAD2}}$	DM1 output impedance	$I_{\text{DM1}} = -5\ \mu\text{A}$	80	102	130	k Ω
$V_{\text{DP2_1.2V}}$	DP2 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.12	1.2	1.28	V
$V_{\text{DM2_1.2V}}$	DM2 output voltage	$V_{\text{IN}} = 5\text{ V}$	1.12	1.2	1.28	V
$R_{\text{DP2_PAD2}}$	DP2 output impedance	$I_{\text{DP2}} = -5\ \mu\text{A}$	80	102	130	k Ω
$R_{\text{DM2_PAD2}}$	DM2 output impedance	$I_{\text{DM2}} = -5\ \mu\text{A}$	80	102	130	k Ω

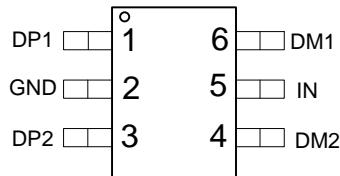
(1) Specified by design. Not production tested.

FUNCTIONAL BLOCK DIAGRAM, TPS2513



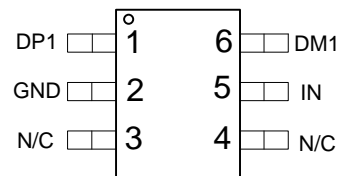
FUNCTIONAL BLOCK DIAGRAM, TPS2514



DEVICE INFORMATION
**TPS2513 DBV (SOT23-6)
(TOP VIEW)**

Table 1. PIN FUNCTIONS, TPS2513

NO.	NAME	TYPE ⁽¹⁾	DESCRIPTION
1	DP1	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
2	GND	G	Ground connection
3	DP2	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
4	DM2	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
5	IN	P	Power supply. Connect a ceramic capacitor with a value of 0.1- μ F or greater from the IN pin to GND as close to the device as possible.
6	DM1	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.

(1) G = Ground, I = Input, O = Output, P = Power

**TPS2514 DBV (SOT23-6)
(TOP VIEW)**

Table 2. PIN FUNCTIONS, TPS2514

NO.	NAME	TYPE ⁽¹⁾	DESCRIPTION
1	DP1	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
2	GND	G	Ground connection
3	N/C	–	No connect pin. Can be grounded or left floating.
4	N/C	–	No connect pin. Can be grounded or left floating.
5	IN	P	Power supply. Connect a ceramic capacitor with a value of 0.1- μ F or greater from the IN pin to GND as close to the device as possible.
6	DM1	I/O	Connected to the D+ or D– line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.

(1) G = Ground, I = Input, O = Output, P = Power

TYPICAL CHARACTERISTICS

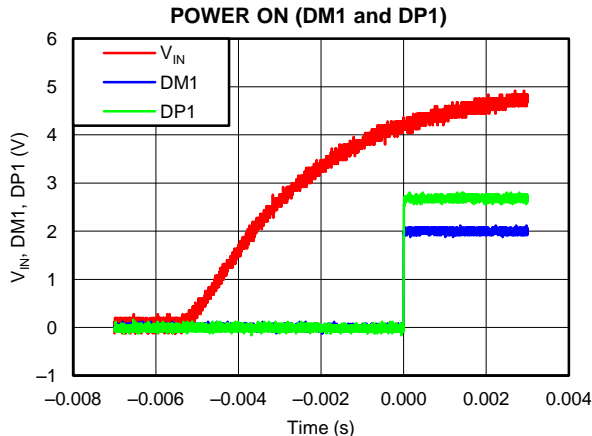


Figure 1.

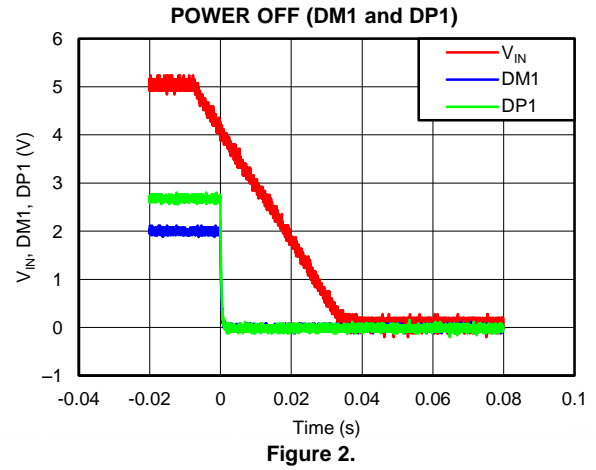


Figure 2.

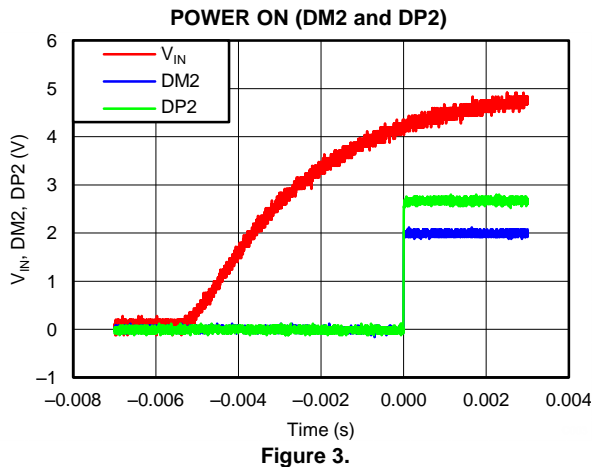


Figure 3.

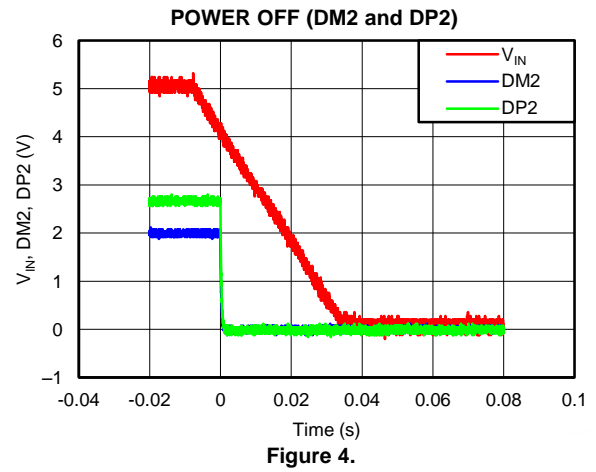


Figure 4.

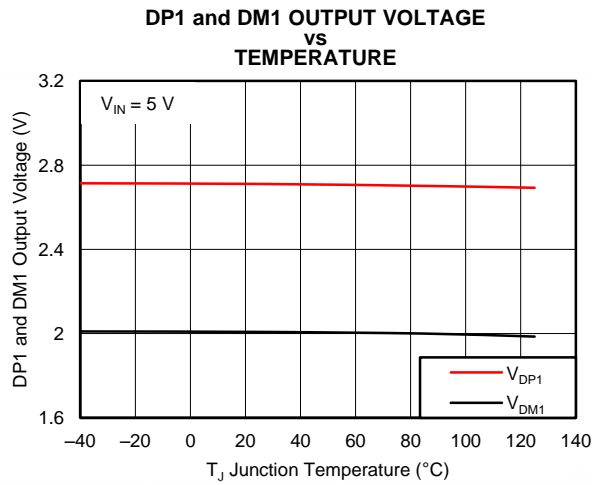


Figure 5.

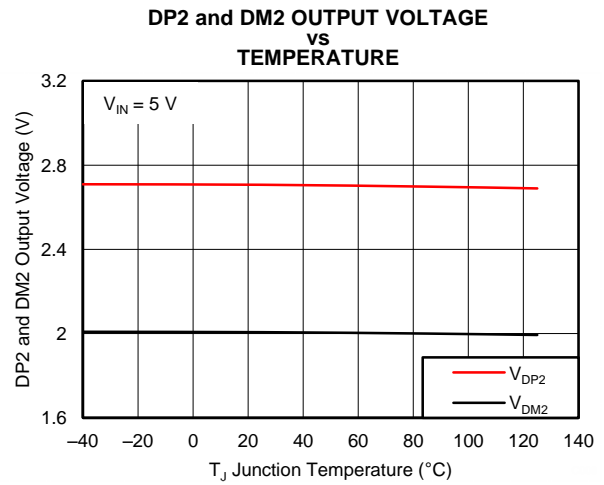


Figure 6.

TYPICAL CHARACTERISTICS (continued)

**SUPPLY CURRENT
VS
TEMPERATURE**

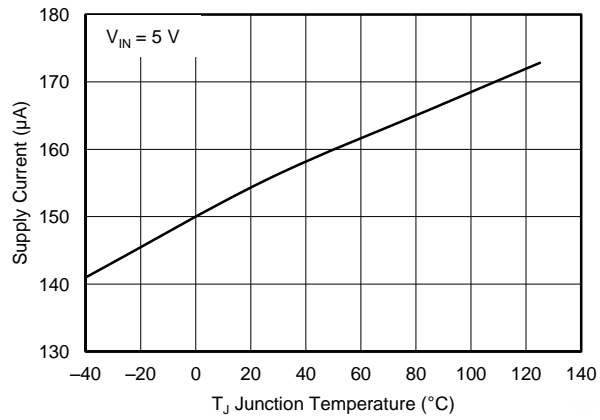


Figure 7.

DETAILED DESCRIPTION

OVERVIEW

The following overview references various industry standards. It is always recommended to consult the latest standard to ensure the most recent and accurate information.

Rechargeable portable equipment requires an external power source to charge its batteries. USB ports are convenient locations for charging because of an available 5-V power source. Universally accepted standards are required to ensure host and client-side devices meet the power management requirements. Traditionally, USB host ports following the USB 2.0 Specification must provide at least 500 mA to downstream client-side devices. Because multiple USB devices can be attached to a single USB port through a bus-powered hub, it is the responsibility of the client-side device to negotiate the power allotment from the host to guarantee the total current draw does not exceed 500 mA. In general, each USB device can subsequently request more current, which is granted in steps of 100 mA up 500 mA total. The host may grant or deny the request based on the available current.

Additionally, the success of the USB technology makes the micro-USB connector a popular choice for wall adapter cables. This allows a portable device to charge from both a wall adapter and USB port with only one connector.

One common difficulty has resulted from this. As USB charging has gained popularity, the 500-mA minimum defined by the USB 2.0 Specification or 900 mA defined in the USB 3.0 Specification, has become insufficient for many handsets, tablets and personal media players (PMP) which have a higher rated charging current. Wall adapters and car chargers can provide much more current than 500 mA or 900 mA to fast charge portable devices. Several new standards have been introduced defining protocol handshaking methods that allow host and client devices to acknowledge and draw additional current beyond the 500 mA (defined in the USB 2.0 Specification) or 900 mA (defined in the USB 3.0 Specification) minimum while using a single micro-USB input connector.

The TPS2513 and TPS2514 support four of the most common protocols:

- USB Battery Charging Specification, Revision 1.2 (BC1.2)
- Chinese Telecommunications Industry Standard YD/T 1591-2009
- Divider mode
- 1.2 V on both D+ and D– lines

YD/T 1591-2009 is a subset of the BC1.2 specification supported by the vast majority of devices that implement USB charging. Divider and 1.2-V charging schemes are supported in devices from specific yet popular device makers. BC1.2 has three different port types, listed as follows.

- Standard downstream port (SDP)
- Charging downstream port (CDP)
- Dedicated charging port (DCP)

The BC1.2 Specification defines a charging port as a downstream facing USB port that provides power for charging portable equipment.

Table 3 shows different port operating modes according to the BC1.2 Specification.

Table 3. Operating Modes Table

PORT TYPE	SUPPORTS USB2.0 COMMUNICATION	MAXIMUM ALLOWABLE CURRENT DRAWN BY PORTABLE EQUIPMENT (A)
SDP (USB 2.0)	Yes	0.5
SDP (USB 3.0)	Yes	0.9
CDP	Yes	1.5
DCP	No	1.5

The BC1.2 Specification defines the protocol necessary to allow portable equipment to determine what type of port it is connected to so that it can allot its maximum allowable current drawn. The hand-shaking process is two steps. During step one, the primary detection, the portable equipment outputs a nominal 0.6 V output on its D+ line and reads the voltage input on its D– line. The portable device concludes it is connected to a SDP if the voltage is less than the nominal data detect voltage of 0.3 V. The portable device concludes that it is connected to a Charging Port if the D– voltage is greater than the nominal data detect voltage of 0.3V and less than 0.8 V. The second step, the secondary detection, is necessary for portable equipment to determine between a CDP and a DCP. The portable device outputs a nominal 0.6 V output on its D– line and reads the voltage input on its D+ line. The portable device concludes it is connected to a CDP if the data line being remains is less than the nominal data detect voltage of 0.3 V. The portable device concludes it is connected to a DCP if the data line being read is greater than the nominal data detect voltage of 0.3 V and less than 0.8 V.

Dedicated Charging Port (DCP)

A dedicated charging port (DCP) is a downstream port on a device that outputs power through a USB connector, but is not capable of enumerating a downstream device, which generally allows portable devices to fast charge at their maximum rated current. A USB charger is a device with a DCP, such as a wall adapter or car power adapter. A DCP is identified by the electrical characteristics of its data lines. The following DCP identification circuits are usually used to meet the handshaking detections of different portable devices.

Short the D+ Line to the D– Line

The USB BC1.2 Specification and the Chinese Telecommunications Industry Standard YD/T 1591-2009 define that the D+ and D– data lines should be shorted together with a maximum series impedance of 200 Ω. This is shown in [Figure 8](#).

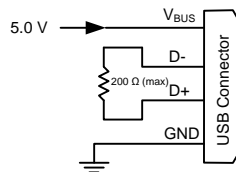


Figure 8. DCP Short Mode

Divider 1 (DCP Applying 2 V on D+ Line and 2.7 V on D– Line) or Divider 2 (DCP Applying 2.7 V on D+ Line and 2 V on D– Line)

There are two charging schemes for divider DCP. They are named after Divider 1 and Divider 2 DCPs that are shown in [Figure 9](#) and [Figure 10](#). The Divider 1 charging scheme is used for 5-W adapters, and applies 2 V to the D+ line and 2.7 V to the D– data line. The Divider 2 charging scheme is used for 10-W adapters, and applies 2.7 V on the D+ line and 2 V is applied on the D– line.

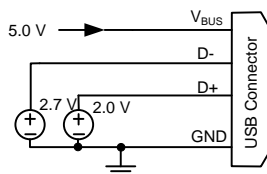


Figure 9. Divider 1 DCP

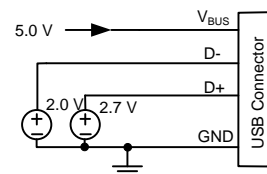


Figure 10. Divider 2 DCP

Applying 1.2 V to the D+ Line and 1.2 V to the D– Line

As shown in [Figure 11](#), some tablet USB chargers require 1.2 V on the shorted data lines of the USB connector. The maximum resistance between the D+ line and the D– line is 200 Ω.

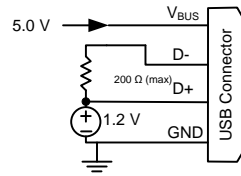


Figure 11. DCP Applying 1.2 V to the D+ Line and 1.2 V to the D- Line

The TPS2513 and TPS2514 are USB dedicated charging port (DCP) controllers. Applications include vehicle power charger, wall adapters with USB DCP and other USB chargers. The TPS2513 and TPS2514 DCP controllers have the auto-detect feature that monitors the D+ and D- line voltages of the USB connector, providing the correct electrical signatures on the DP and DM pins for the correct detections of compliant portable devices to fast charge. These portable devices include smart phones, 5-V tablets and personal media players.

DCP Auto-Detect

The TPS2513 and TPS2514 integrate an auto-detect feature to support divider mode, short mode and 1.2 V / 1.2 V modes. If a divider device is attached, 2.7 V is applied to the DP pin and 2 V is applied to the DM pin. If a BC1.2-compliant device is attached, the TPS2513 and TPS2514 automatically switches into short mode. If a device compliant with the 1.2 V / 1.2 V charging scheme is attached, 1.2 V is applied on both the DP pin and the DM pin. The functional diagram of DCP auto-detect feature (DM1 and DP1) is shown in Figure 12. DCP auto-detect feature (DM2 and DP2 of TPS2513) has the same functional configuration.

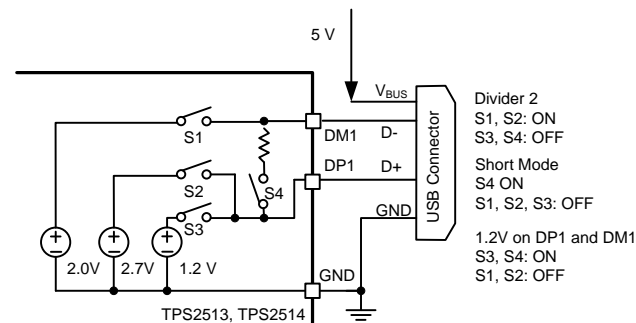


Figure 12. TPS2513 and TPS2514 DCP Auto-Detect Functional Diagram

Undervoltage Lockout (UVLO)

The undervoltage lockout (UVLO) circuit disables DP1, DM1, DP2 and DM2 output voltage until the input voltage reaches the UVLO turn-on threshold. Built-in hysteresis prevents unwanted oscillations due to input voltage drop from large current surges.

APPLICATION INFORMATION

The TPS2513 and TPS2514 only provide the correct electrical signatures on the data line of USB charger port and do not provide any power for the VBUS.

Divide Mode Selection of 5-W and 10-W USB Chargers

The TPS2513 and TPS2514 provide two types of connections between the DP pin and the DM pin and between the D+ data line and the D– data line of the USB connector for a 5-W USB charger and a 10-W USB charger with a single USB port. For 5-W USB charger, the DP1 pin is connected to the D– line and the DM1 pin is connected to the D+ line. This is shown in Figure 13. For 10-W USB charger, the DP1 pin is connected to the D+ line and the DM1 pin is connected to the D– line. This is shown in Figure 14. Table 4 shows different charging schemes for both 5-W and 10-W USB charger solutions. DP2 and DM2 of TPS2513 also provides this two types of connections.

Table 4. Charging Schemes for 5-W and 10-W USB Chargers

USB CHARGER TYPE	CONTAINING CHARGING SCHEMES		
5-W	Divider 1	1.2 V on both D+ and D– Lines	BC1.2 DCP
10 -W	Divider 2	1.2 V on both D+ and D– Lines	BC1.2 DCP

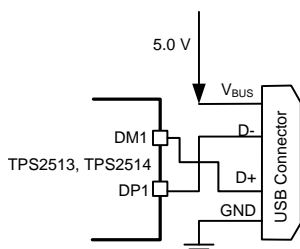


Figure 13. 5-W USB Charger Application

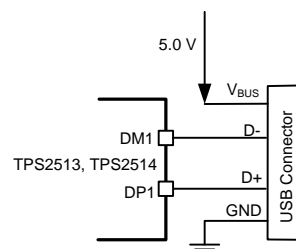


Figure 14. 10-W USB Charger Application

Layout Guidelines

Place the TPS2513 and TPS2514 near the USB output connector and place the 0.1-μF bypass capacitor near the IN pin.

REVISION HISTORY

Changes from Original (May 2013) to Revision A

Page

- Changed the device From: Product Preview To: Production 1

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS2513DBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2513	Samples
TPS2513DBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2513	Samples
TPS2514DBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2514	Samples
TPS2514DBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	2514	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS2513DBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TPS2513DBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TPS2514DBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TPS2514DBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS2513DBVR	SOT-23	DBV	6	3000	180.0	180.0	18.0
TPS2513DBVT	SOT-23	DBV	6	250	180.0	180.0	18.0
TPS2514DBVR	SOT-23	DBV	6	3000	180.0	180.0	18.0
TPS2514DBVT	SOT-23	DBV	6	250	180.0	180.0	18.0

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