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USB Dedicated Charging Port Controller

CE250X Series

■ INTRODUCTION:

The devices are USB dedicated charging port (DCP) controllers. A Smart-detect feature monitors USB data line voltage, and automatically provides the correct electrical signatures on the data line to charge compliant devices among the following dedicated charging schemes:

1. Divider1 DCP, required to apply 2.0V and 2.7V on the D+ and D- Lines respectively (CE2501, CE2502)
2. Divider 2 DCP, required to apply 2.7V and 2.0V on the D+ and D- Lines respectively (CE2501, CE2502)
3. Divider 3 DCP, required to apply 2.7V and 2.7V on the D+ and D- Lines respectively (CE2503, CE2504)
4. BC1.2 DCP, required to short the D+ Line to the D- Line
5. Chinese Telecom Standard YD/T 1591-2009 Short Mode, required to short the D+ Line to the D- Line
6. 1.2V on both D+ and D-Lines

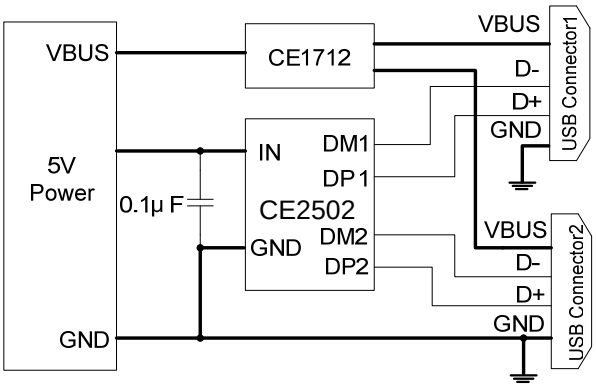
■ FEATURES:

- Supports USB DCP Shorting D+ Line to D- Line per USB Battery Charging Specification, Revision 1.2(BC1.2)
- Supports Short Mode(Shorting)D+ Line to D- Line) per Chinese Telecommunication Industry Standard YD/T 1591-2009
- Support USB DCP Applying 2.7V on D+ Line and 2.0V on D- Line(or USB DCP Applying 2.0V on D+ line and 2.7V on D- Line) (CE2501, CE2502)
- Support USB DCP Applying 2.7V on D+ Line and 2.7V on D- Lines(CE2503, CE2504)
- Supports USB DCP Applying 1.2 V on D+ and D– Lines
- Automatically switch D+ and D- Lines Connections for an Attached Device
- Single USB Port Controller(CE2501, CE2503)
- Dual USB Port Controller(CE2502, CE2504)
- Operating Range: 4.5V to 5.5V
- Input Over Voltage Protection
- Available in SOT23-5 and SOT23-6 Packages

■ APPLICATIONS：

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

■ TYPICAL APPLICATION CIRCUIT



■ ORDER INFORMATION(1)

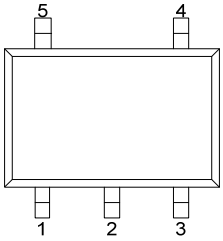
Table 1. Product Information

DEVICE	NUMBER OF CONTROLLER	CHARGING SCHEMES (DCP_AUTO)			1.2V mode (D+/D- shorted and bias to 1.2V)	BC1.2 and YD/T 1591-2009 mode (D+/D- shorted)
		Divider 1 (D+/D- = 2.0V/2.7V)	Divider 2 (D+/D- = 2.7V/2.0V)	Divider 3 (D+/D- = 2.7V/2.7V)		
CE2501AE	Single	Yes (1)	Yes	No	Yes	Yes
CE2501AM	Single	Yes (1)	Yes	No		
CE2502AE	Dual	Yes (1)	Yes	No		
CE2503AE	Single	No	No	Yes		
CE2503AM	Single	No	No	Yes		
CE2504AE	Dual	No	No	Yes		

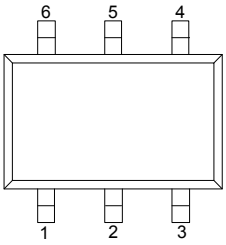
(1) See to Figure 14.

■ PIN CONFIGURATION

CE2501, CE2503
TOP VIEW



SOT23-5



SOT23-6

Table 2. SOT23-5, Pin Functions, CE2501/CE2503

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

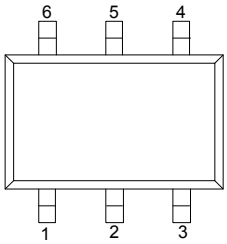
(1) G=Ground, I=Input, O=Output, P=Power

Table 3. SOT23-6. Pin Functions, CE2501/CE2503

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 0.1μF 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

CE2502, CE2504
TOP VIEW



SOT23-6

Table 4. SOT23-6，Pin Functions, CE2502/CE2504

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 0.1μF 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

■ ABSOLUTE MAXIMUM RATINGS(1)

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

PARAMETER	SYMBOL		MIN.	MAX.	UNITS
Voltage range	V_{IN}		-0.3	20	V
	DP1, DP2 output voltage, DM1, DM2 output voltage		-0.3	6	V
	DP1, DP2 input voltage, DM1, DM2 input voltage		-0.3	6	V
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		8	kV
		DP1,DP2,DM1,DM2		6	kV
	Charging Device Model (CDM)			500	V
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.

■ RECOMMENDED OPERATING CONDITIONS

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

PARAMETER	SYMBOLE	MIN.	MAX.	UNITS
Supply voltage at IN	V_{IN}	4.5	5.5	V
DP1 data line input voltage	V_{DP1}	0	5.5	V
DM1 data line input voltage	V_{DM1}	0	5.5	V
Continuous sink or source current	I_{DP1}		±10	mA
Continuous sink or source current	I_{DM1}		±10	mA
DP2 data line input voltage	V_{DP2}	0	5.5	V
DM2 data line input voltage	V_{DM2}	0	5.5	V
Continuous sink or source current	I_{DP2}		±10	mA
Continuous sink or source current	I_{DM2}		±10	mA
Operating junction temperature	T_J	-40	125	°C

■ ELECTRICAL CHARACTERISTICS

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

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
UNDERVOLTAGE LOCKOUT						
UVLO threshold voltage	V_{UVLO}	V_{IN} Rising	3.9	4.1	4.3	V
Hysteresis				100		mV
OVERVOLTAGE LOCKOUT						
Input Voltage Over Voltage Protection	V_{INOVP}	V_{IN} Rising		7.3		V
Input Voltage OVP Hysteresis				30		mV
SUPPLY CURRENT						
IN supply current	I_{IN}	4.5V≤V_{IN}≤5.5V		150	200	μA
BC 1.2 DCP MODE(SHORT MODE)						
DP1 and DM1 shorting resistance	R_{DPM_SHORT1}	V_{DP1}=0.8V, I_{DM1}=1mA		150	200	Ω
Resistance between DP1/DM1 and GND	R_{DCHG_SHORT1}	V_{DP1}=0.8V	350	650	1150	kΩ
Voltage threshold on DP1 under which the device goes back to divider mode	$V_{DPL\_TH\_DETACH1}$		310	330	350	mV
Hysteresis(1)	$V_{DPL\_TH\_DETACH\_HYS1}$			50		mV
DP2 and DM2 shorting resistance	R_{DPM_SHORT2}	V_{DP2}=0.8V, I_{DM2}=1mA		150	200	Ω
Resistance between DP2/DM2 and GND	R_{DCHG_SHORT2}	V_{DP2}=0.8V	350	650	1150	kΩ
Voltage threshold on DP2 under which the device goes back to divider mode	$V_{DPL\_TH\_DETACH2}$		310	330	350	mV
Hysteresis(1)	$V_{DPL\_TH\_DETACH\_HYS2}$			50		mV
DIVIDER MODE(CE2501, CE2502)						
DP1 output voltage	$V_{DP1\_2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DM1 output voltage	$V_{DM1\text{-}2.0V}$	V_{IN}=5V	1.9	2.0	2.1	V
DP1 output impedance	R_{DP1_PAD1}	I_{DP1}=-5μA	24	30	36	kΩ
DM1 output impedance	R_{DM1_PAD1}	I_{DM1}=-5μA	24	30	36	kΩ
DP2 output voltage	$V_{DP2\_2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DM2 output voltage	$V_{DM2\_2.0V}$	V_{IN}=5V	1.9	2.0	2.1	V
DP2 output impedance	R_{DP2_PAD1}	I_{DP2}=-5μA	24	30	36	kΩ
DM2 output impedance	R_{DM2_PAD1}	I_{DM2}=-5μA	24	30	36	kΩ

(1) Parameters provided for reference only, and do not constitute part of CHIPOWER's published device specifications for purposes of CHIPOWER 's product warranty

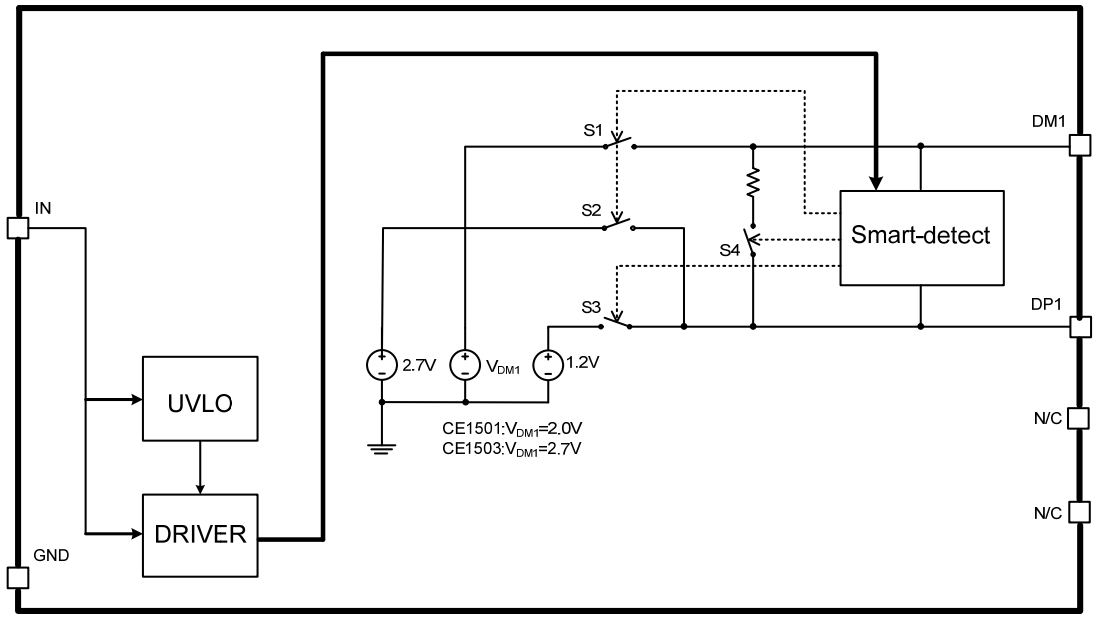
■ ELECTRICAL CHARACTERISTICS(CONTINUED)

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

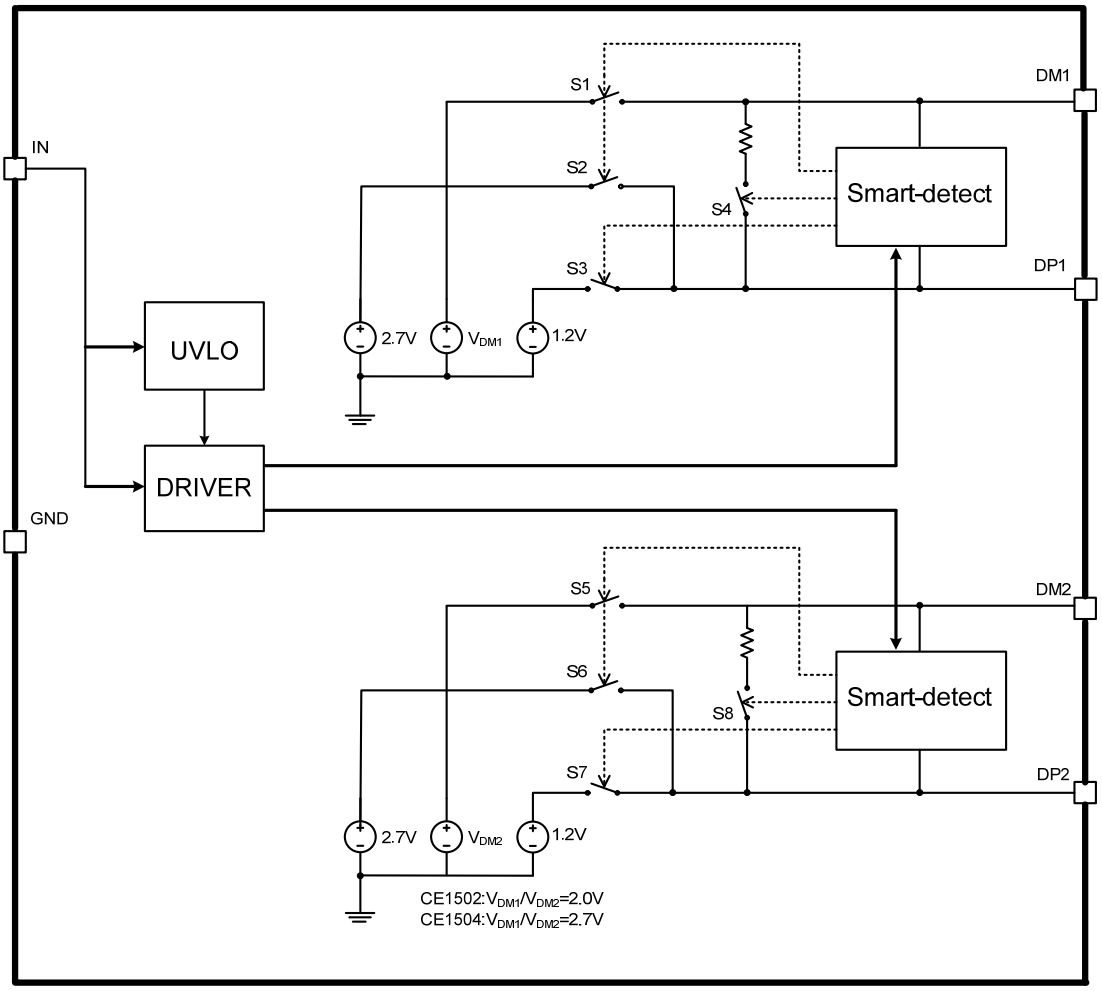
DIVIDER MODE(CE2503, CE2504)						
DP1 output voltage	$V_{DP1\_2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DM1 output voltage	$V_{DM1-2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DP1 output impedance	R_{DP1_PAD1}	I_{DP1}=-5μA	24	30	36	kΩ
DM1 output impedance	R_{DM1_PAD1}	I_{DM1}=-5μA	24	30	36	kΩ
DP2 output voltage	$V_{DP2\_2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DM2 output voltage	$V_{DM2\_2.7V}$	V_{IN}=5V	2.57	2.7	2.84	V
DP2 output impedance	R_{DP2_PAD1}	I_{DP2}=-5μA	24	30	36	kΩ
DM2 output impedance	R_{DM2_PAD1}	I_{DM2}=-5μA	24	30	36	kΩ
1.2V/1.2V MODE						
DP1 output voltage	$V_{DP1\_1.2V}$	V_{IN}=5V	1.12	1.2	1.28	V
DM1 output voltage	$V_{DM1-1.2V}$	V_{IN}=5V	1.12	1.2	1.28	V
DP1 output impedance	R_{DP1_PAD2}	I_{DP1}=-5μA	80	100	130	kΩ
DM1 output impedance	R_{DM1_PAD2}	I_{DM1}=-5μA	80	100	130	kΩ
DP2 output voltage	$V_{DP2\_1.2V}$	V_{IN}=5V	1.12	1.2	1.28	V
DM2 output voltage	$V_{DM2\_1.2V}$	V_{IN}=5V	1.12	1.2	1.28	V
DP2 output impedance	R_{DP2_PAD2}	I_{DP2}=-5μA	80	100	130	kΩ
DM2 output impedance	R_{DM2_PAD2}	I_{DM2}=-5μA	80	100	130	kΩ

■ BLOCK DIAGRAM

FUNCTIONNAL BLOCK DIAGRAM, CE2501, CE2503



FUNCTIONNAL BLOCK DIAGRAM, CE2502, CE2504



■ TYPICAL CHARACTERISTICS

POWER ON (DM1 and DP1)

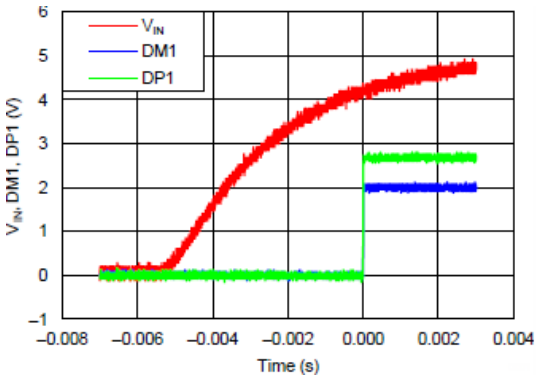


Figure 1.

POWER OFF (DM1 and DP1)

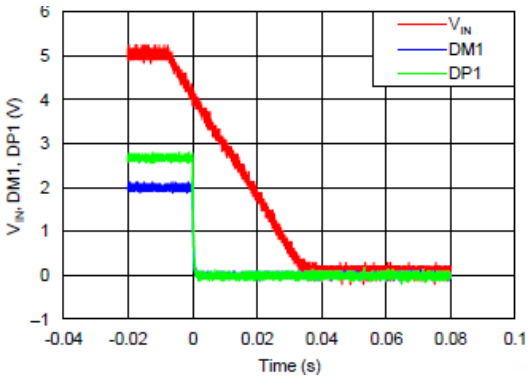


Figure 2.

POWER ON (DM2 and DP2)

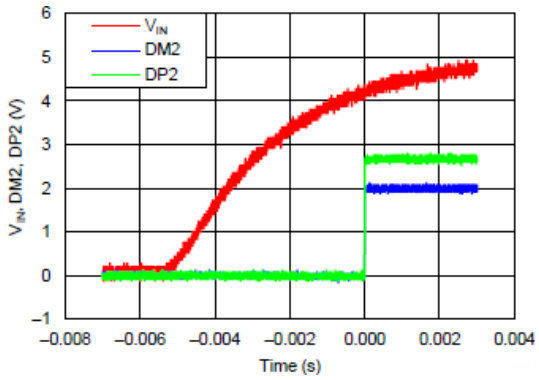


Figure 3.

POWER OFF (DM2 and DP2)

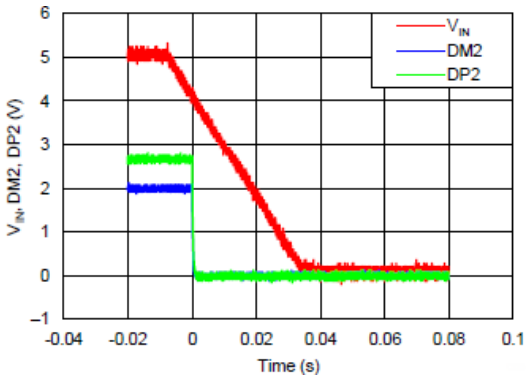


Figure 4.

DP1 and DM1 OUTPUT VOLTAGE vs TEMPERATURE

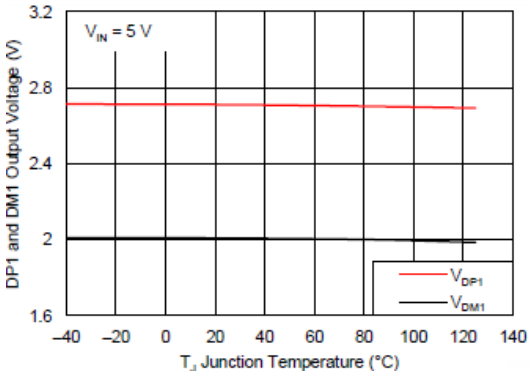


Figure 5.

DP2 and DM2 OUTPUT VOLTAGE vs TEMPERATURE

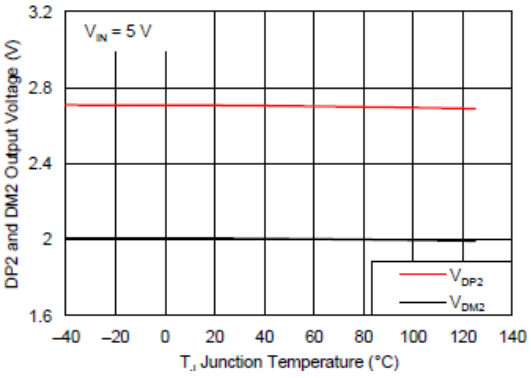


Figure 6.

■ TYPICAL CHARACTERISTICS (continued)

SUPPLY CURRENT

vs

TEMPERATURE

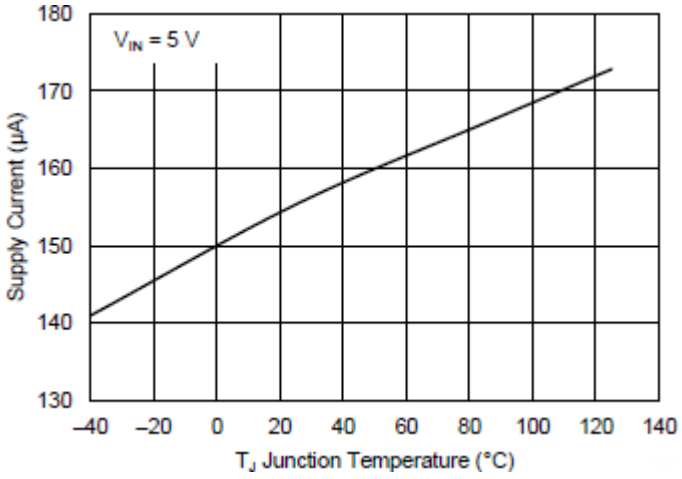


Figure 7.

■ 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 5V 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 500mA 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 500mA. In general, each USB device can subsequently request more current, which is granted in steps of 100mA up 500mA 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 500mA minimum defined by the USB 2.0 Specification or 900mA 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 500mA or 900mA 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 500mA (defined in the USB 2.0 Specification) or 900mA (defined in the USB 3.0 Specification) minimum while using a single micro-USB input connector.

The devices 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 1.2V 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 5 shows different port operating modes according to the BC1.2 Specification.

Table 5. Operating Modes Table

PORT TYPE	SUPPORTS USB2.0 COMMUNICATION	MAXIMUM ALLOWABLE CURRENT DRAWN BY PORTABLE EQUIPMENT (A)
SDP(USB2.0)	Yes	0.5
SDP(USB3.0)	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 0.6V 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 0.3V. 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 0.8V. 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 0.6V 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 0.3V. 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 0.3V and less than 0.8V.

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.

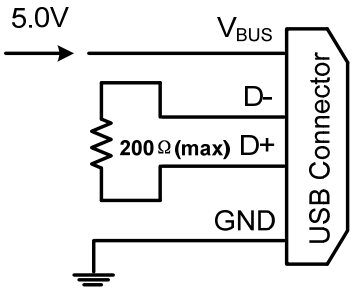


Figure 8. DCP Short Mode

Divider DCP

There are three charging schemes for divider DCP. They are named after Divider 1, Divider 2, and Divider 3 DCPs that are shown in Figure 9, Figure 10, and Figure11. The Divider 1 charging scheme is used for 5W adapters, and applies 2V to the D+ line and 2.7V to the D– data line. The Divider 2 charging scheme is used for 10W adapters, and applies 2.7V on the D+ line and 2V is applied on the D– line. The Divider 3 charging scheme is used for 12W adapters, and applies 2.7V on D+ and D- lines.

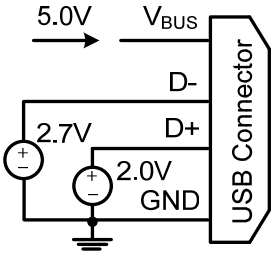


Figure 9. Divider 1 DCP

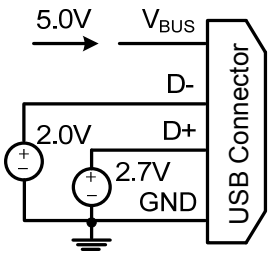


Figure 10. Divider 2 DCP

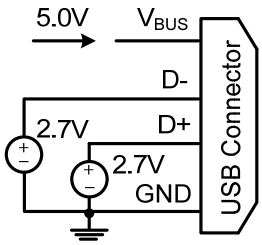


Figure 11. Divider3 DCP

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

As shown in Figure 12, some tablet USB chargers require 1.2V on the shorted data lines of the USB connector. The maximum resistance between the D+ line and the D- line is 200Ω.

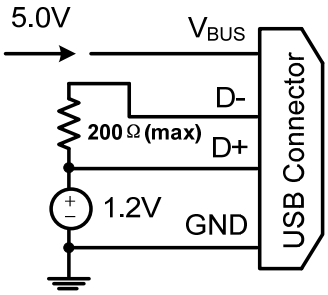


Figure 12. DCP Applying 1.2V to the D+ Line and 1.2V to the D-Line

The devices are USB dedicated charging port (DCP) controllers. Applications include vehicle power charger, wall adapters with USB DCP and other USB chargers. The device DCP controllers have the Smart-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, 5V tablets and personal media players.

DCP Smart-detect

The devices integrate an Smart-detect feature to support divider mode, short mode and 1.2 V/1.2V modes. If a divider device is attached, 2.7V is applied to the DP pin and 2V is applied to the DM pin. If a BC1.2-compliant device is attached, the CE2501 and CE2502 automatically switches into short mode. If a device compliant with the 1.2V/1.2V charging scheme is attached, 1.2V is applied on both the DP pin and the DM pin. The functional diagram of DCP Smart-detect feature (DM1 and DP1) is shown in Figure 13. DCP Smart-detect feature (DM2 and DP2 of CE2502) has the same functional configuration. For CE2503 and CE2504, the devices also have DCP Smart-detect feature and the Smart-detect have the same functional configuration expect for the default mode is Divider 3 (D+/D- = 2.7V/2.7V).

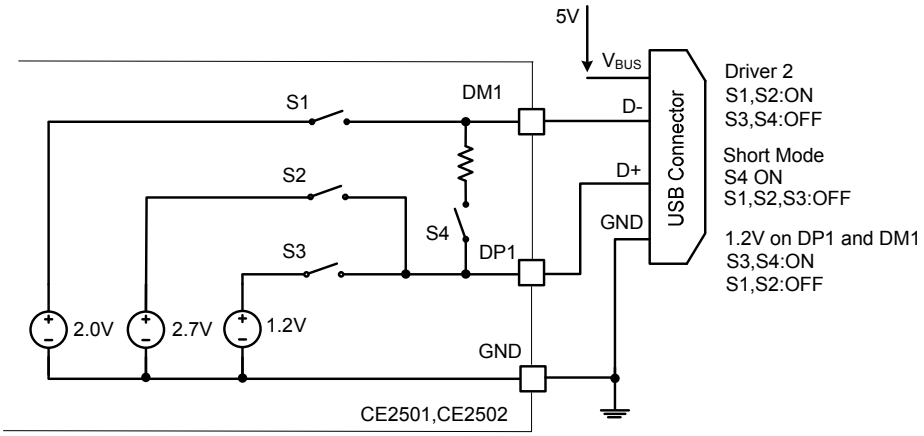


Figure 13. CE2501 and CE2502 DCP Smart-detect Function Diagram

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 devices 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 5W and 10W USB Chargers

The CE2501 and CE2502 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 5W USB charger and a 10W USB charger with a single USB port. For 5W 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. For 10W 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 15. Table 6 shows different charging schemes for both 5W and 10W USB charger solutions. DP2 and DM2 of CE2502 also provides this two types of connections.

Table 6. Charging Schemes for 5W and 10W USB Chargers

USB CHARGER TYPE	CONTAINING CHARGING SHCEMES		
5W	Divider1	1.2V on both D+ and D-Lines	BC1.2 DCP
10W	Divider2	1.2V on both D+ and D-Lines	BC1.2 DCP

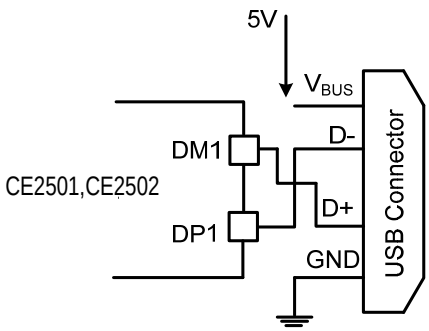


Figure14 5W USB Charger Application

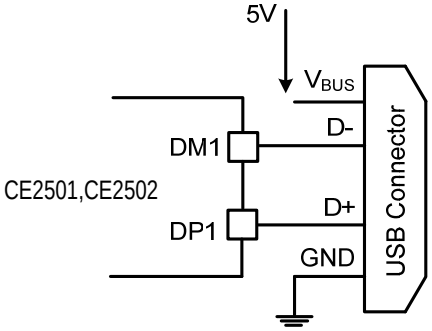


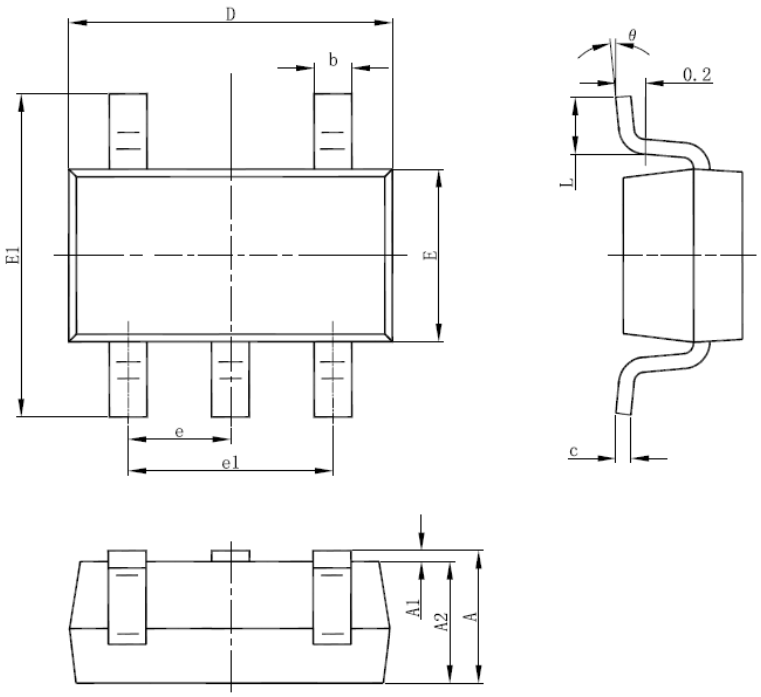
Figure15 10W USB Charger Application

Layout Guidelines

Place the devices near the USB output connector and place the 0.1μF bypass capacitor near the IN pin.

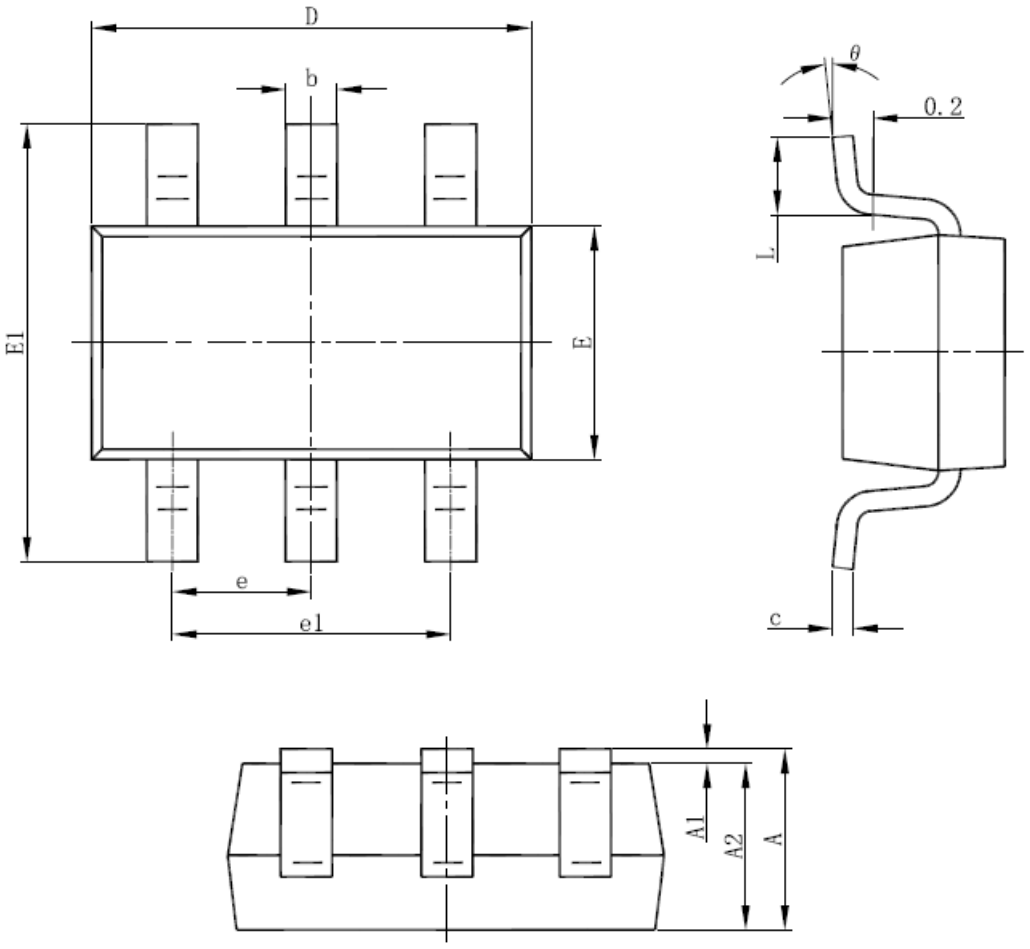
■ PACKAGING INFORMATION

● SOT23-5 Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

- **SOT23-6 Package Outline Dimensions**



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L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°