WS3225C

USB TYPE-C Port Protection Switch With Short-to-V_{BUS} Overvoltage and IEC ESD Protection

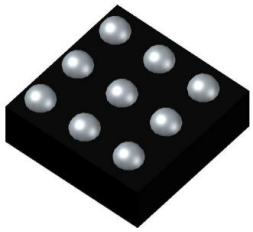
Http//:www.sh-willsemi.com

Descriptions

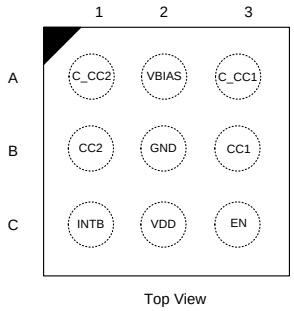
The WS3225C is a single chip USB Type-C port protection solution that provides 24-V Short-to-VBUS overvoltage and IEC ESD protection. The chip also integrates IEC 61000-4-2 system level ESD protection for external pins (C_CC1, C_CC2), removing the need to place high voltage TVS diodes externally on the connector.

The WS3225C enables the CC pins to be 24V tolerant without interfering with normal operation by providing overvoltage protection on the CC lines. When a voltage above the OVP threshold is detected on these lines, the high voltage switches will be off, isolating the rest of the system from the high voltage condition present on the connector.

The WS3225C is available in CSP-9L package. Standard product is Pb-Free and halogen-Free.



CSP-9L (Bottom View)



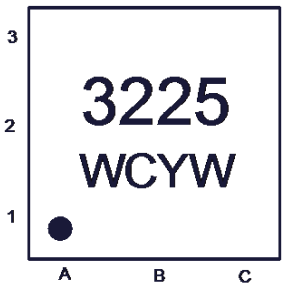
Pin configuration (TOP View)

Features

- Supply voltage : 2.7 ~ 5.5V
- Maximum short-to-Vbus voltage : 24V @ CCX
- Ultra-low On Resistance : 0.3Ω @ CCX
- Ultra-fast OVP response time : 100ns
- -3dB Bandwidth : 100MHz
- OVP threshold voltage : 5.65V
- System ESD: IEC61000-4-2
  - Contect : ±8KV
  - Air Discharge : ±15KV

Applications

- Mobile Handsets and Tables
- Laptop PC
- Monitors and TVs
- Docking Stations



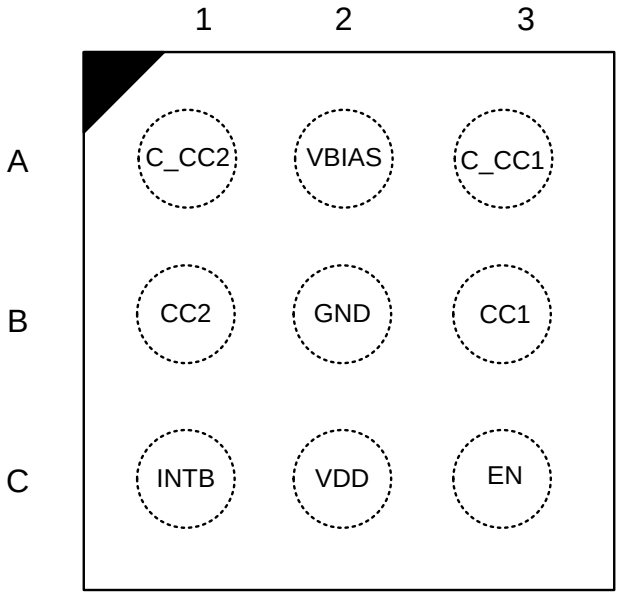
Marking

3225 = Device code
WC= Special code
Y = Year code
W = Week code

Order information

Device	Package	Shipping
WS3225C-9/TR	CSP-9L	3000/Reel&Tape

Pin configuration (Top view)



WS3225C

Pin descriptions

Symbol	Pin NO.	I/O	Description
C_CC1	A3	IO	Connector side of the CC1 OVP FET. Connect to either CC pin of the USB Type-C connector
VBIAS	A2	Power	Pin for ESD support capacitor. Place a 0.1-uF capacitor on the pin to ground.
GND	B2	Ground	Ground
C_CC2	A1	IO	Connector side of the CC2 OVP FET. Connect to either CC pin of the USB Type-C connector
CC2	B1	IO	System side of the CC2 OVP FET. Connect to either CC pin of the CC/PD controller
EN	C3	DI	Switch Enable，High active
VDD	C2	Power	2.7V~5.5V power supply
INTB	C1	OD	Open drain for OVP/OTP reporting
CC1	B3	IO	System side of the CC1 OVP FET. Connect to either CC pin of the CC/PD controller

Function descriptions

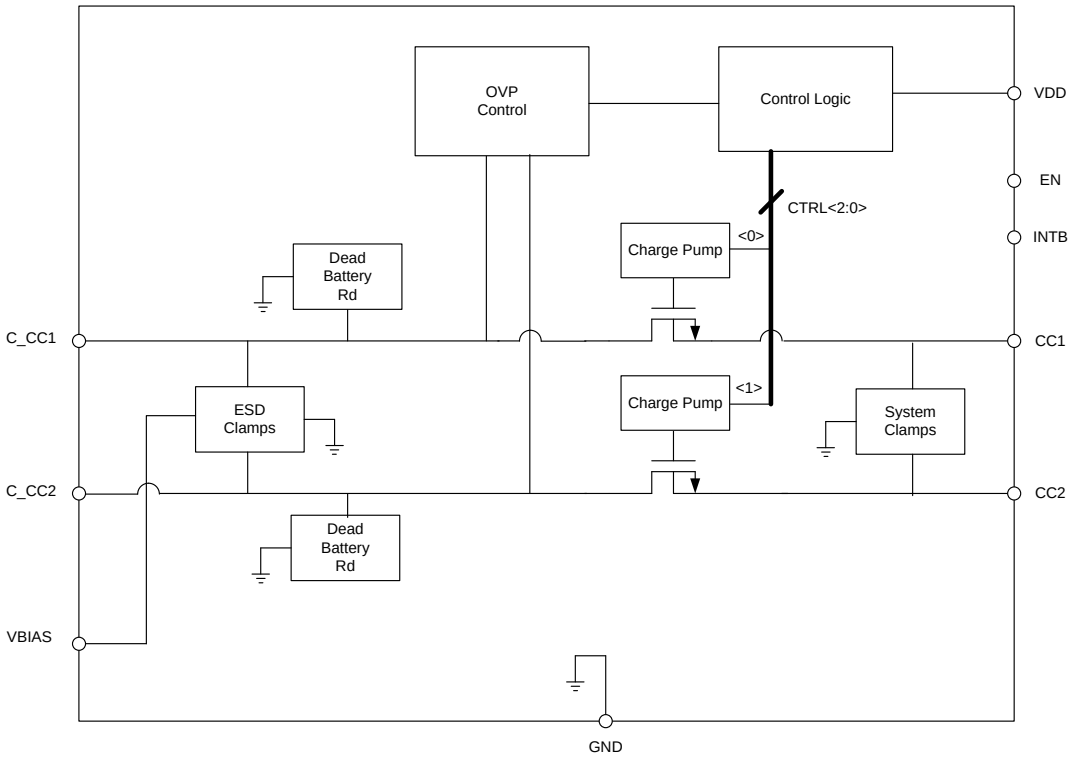
EN=High or Floating

Device Mode Table		Inputs				Outputs		
MODE		VDD	C_CC1	C_CC2	TJ	INTB	CC1 FETs	CC2 FETs
Normal Operating	Unpowered	<UVLO	X	X	X	High-Z	OFF	OFF
	Powered on	>UVLO	<OVP	<OVP	<TSD	High-Z	ON	ON
Fault Conditions	TSD	>UVLO	X	X	>TSD	Low	OFF	OFF
	CC1 OVP	>UVLO	>OVP	<OVP	X	Low	OFF	OFF
	CC2 OVP	>UVLO	<OVP	>OVP	X	Low	OFF	OFF

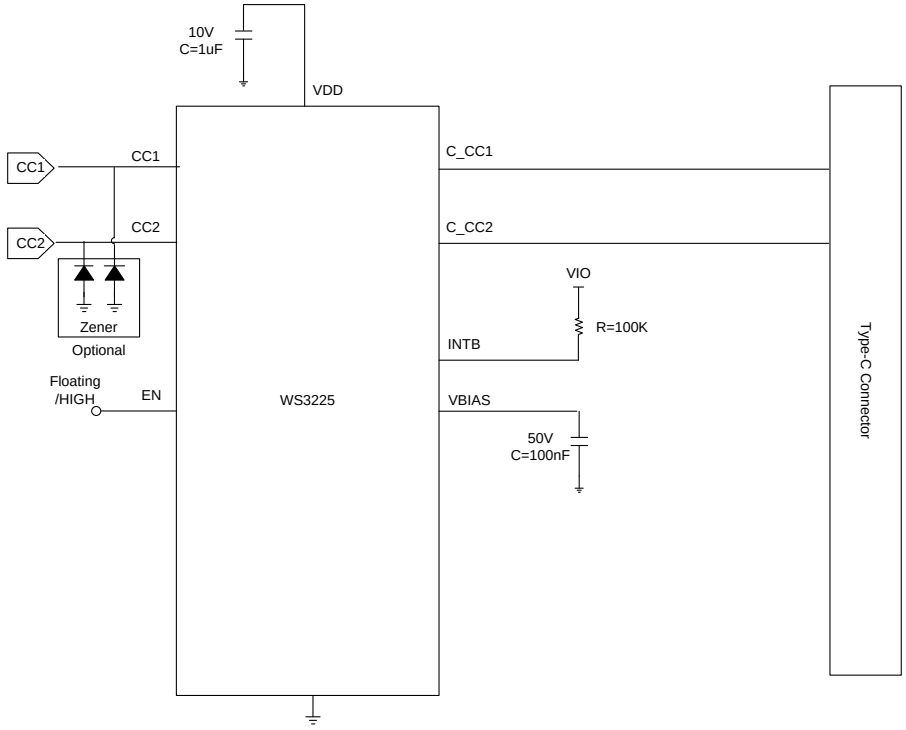
EN=Low or tied to Ground (CCx Switches are always off)

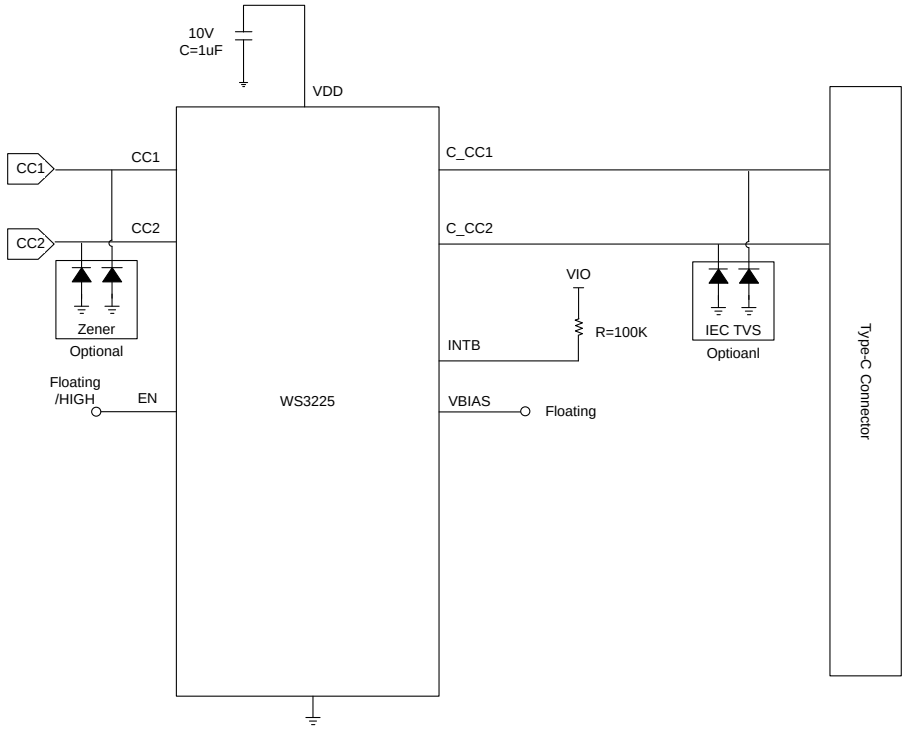
Device Mode Table		Inputs				Outputs		
MODE		VDD	C_CC1	C_CC2	TJ	INTB	CC1 FETs	CC2 FETs
Normal Operating	Unpowered	<UVLO	X	X	X	High-Z	OFF	OFF
	Powered on	>UVLO	<OVP	<OVP	<TSD	High-Z	OFF	OFF
Fault Conditions	TSD	>UVLO	X	X	>TSD	High-Z	OFF	OFF
	CC1 OVP	>UVLO	>OVP	<OVP	X	High-Z	OFF	OFF
	CC2 OVP	>UVLO	<OVP	>OVP	X	High-Z	OFF	OFF

Functional Block Diagram



Application Block Diagram





Note: For the WS3225C, If TVS are all used in the C_CCx pins, the VBIAS pin can be floating without 100nF capacitor.

Absolute Maximum Ratings (1)

Symbol	Parameter		Min.	Max.	Unit
V_{VDD}	Supply Voltage from VDD		-0.3	6	V
V_{IO}	CC1,CC2		-0.3	6	V
	C_CC1,C_CC2,VBIAS		-0.3	24	V
	EN		-0.3	12	V
$T_{STORAGE}$	Storage temperature Range		-65	150	˚C
$T_{JUNCTION}$	Maximum Junction temperature			150	˚C
T_{LEAD}	Lead temperature(Soldering, 10 Seconds)			260	˚C
ESD	Human Body Model	VDD to GND;	6.5	-	kV
		External Pins to GND (C_CC1,C_CC2)			
		EN to GND;	6.5	-	kV
		System Pins to GND (CC1,CC2)			
	Charged Device Model	All Pins	2	-	kV
	IEC 61000-4-2 Air Discharge	Connector Pins ($V_{C\_CCx,}$)	15	-	kV
	IEC 61000-4-2 Contact	Connector Pins ($V_{C\_CCx,}$)	8	-	kV
Surge	IEC 61000-4-5,Surge Protection	Connector Pins ($V_{C\_CCx,}$)	24		V

Recommend operating ratings (2)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{VDD}	Supply Voltage from VDD	2.7	4.2	5.5	V
V_{CCx}	CC pins in system side	0		5.5	V
V_{C_CCx}	CC pins in connector side	0		5.5	V
T_A	Operating free air temperature	-40		85	˚C

Note:

1. “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied.
2. The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance. ON does not recommend exceeding them or designing to Absolute Maximum Ratings.

Electronics Characteristics (Ta=-25°C~85 °C, VCC=3.6V, unless otherwise noted)

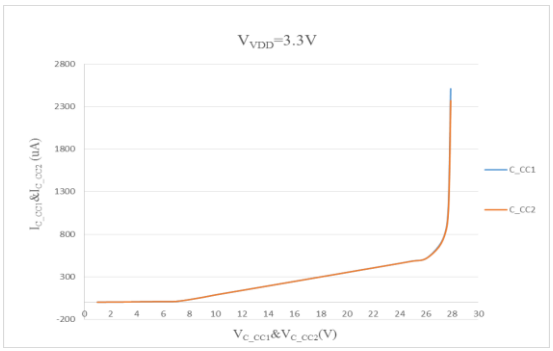
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Basic Operation Device (Power Supply an Leakage Currents)						
V_{UVLO}	VDD under voltage lockout	VDD Rising from 1V to 3V		2.5		V
V_{UVLO_HYS}	VDD UVLO hysteresis	VDD Falling from 3V to 1V		200		mV
I_{DD}	VDD supply Current	VDD=3.3V		20		uA
I_{CC_LEAK}	Leakage current for CC pins when device is powered	VDD=3.3V, V_{C_CCx}=3.6V,CCx floating, measure leakage into C_CCx			6	uA
$I_{C\_CC\_LEAK\_OVP}$	Leakage current for CC pins when device is in OVP	VDD=3.3V, V_{C_CCx}=24V,CCx are sets to 0, measure leakage into C_CCx			1200	uA
$I_{CC\_LEAK\_OVP}$	Leakage current for CC pins when device is in OVP	VDD=3.3V, V_{C_CCx}=24V,CCx are sets to 0, measure leakage out of CCx			30	uA
Basic Operation CC Switch						
R_{ON}	On resistance of CC OVP FETs	CCx=0 to 5.5V		300	500	mΩ
$R_{ON(FLAT)}$	On resistance flatness	Sweep CCx from 0 to 1.2V			20	mΩ
C_{ON_CC}	Equivalent on capacitance	Capacitance from C_CCx or CCx to GND when device is powered. VC-CCx/VCCx=0V to 1.2V, f=400kHz		100	120	pF
R_D	Dead battery pull-down resistance	VC_CCx=2.6V	4.1	5.1	6.1	KΩ
V_{TH_DB}	Threshold voltage of the pull-down FET in series with R_D during dead battery	I_CC=80uA	0.5	0.9	1.2	V
V_{OVP_CC}	OVP threshold on C_CCx pins	C_CCx Rising from 5.0V to 6.5V		5.65	6.20	V
$V_{OVP\_CC\_HYS}$	Hysteresis on C_CCx OVP	C_CCx Falling from 6.5V to 5.0V		300		mV
BW_{ON}	On bandwidth single ended(-3 dB)	R_L=50Ω, C_L=0pF		100		MHz
		R_L=50Ω, C_L=200pF		25		
$V_{ST\_VBUS\_CC}$	Short-to-VBUS tolerance on the C_CCx pins	Hot-Plug C_CCx with 1 meter USB TypeC Cable			24	V

$V_{ST\_VBUS\_CC\_CLAMP}$	Short-to-VBUS clamp voltage on the CCx pins	Hot-Plug C_CCx with 1 meter USB TypeC Cable; Hot-Plug C_CCx=24V		8		V
Thermal Shutdown						
TSD	Thermal shutdown	Enter the shutdown state	-	150	-	°C
	Thermal hysteresis	Exit the shutdown state	-	15	-	°C
Digital Interface Pins						
V_{IL}	Digital Input low level		-	-	0.4	V
V_{IH}	Digital Input high level		1.4	-	-	V
V_{OL}	Digital Output low level	I_{SINK}=2mA	-	-	0.2	V
I_{LEAK}	Digital Input leakage current: EN	VDD=5V	-	-	1	uA

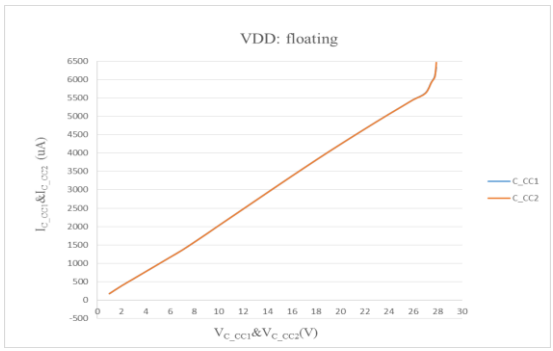
Timing Requirement

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Power On Timings						
t_{ON_1}	Time from crossing rising Power UVLO until CC OVP FETs are on	VDD Rising from 1V to 3V		2		mS
t_{ON_2}	Time from EN 0->1 until CC OVP FETs are on	EN from Low to High		2		mS
Over Voltage Protection						
t_{OVP_CC}	OVP response time on CC pins. Time from OVP asserted until OVP FETs turnoff	VDD=3.3V		100		nS
$t_{OVP\_RE\_CC\_1}$	OVP recovery time on CC pins. Once an OVP occurred, the minimum time duration until the CC FETs turn back on			30		mS
$t_{OVP\_RE\_CC\_2}$	OVP recovery time on CC pins. Time from OVP removal until the CC FETs turn back on, if device has been in OVP > 30mS			0.5		mS
$t_{OVP\_INTB\_TRIG}$	Time from OVP asserted to INTB assertion			20		uS
$t_{OVP\_INTB\_RELEASE}$	Time from OVP FETs turn on after an OVP to INTB desertion			5		mS

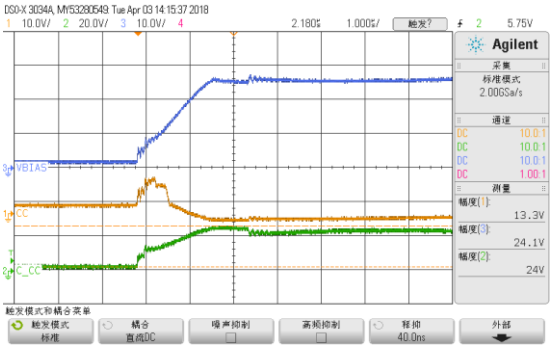
Typical Characteristics (VDD: 3.3V; Temp: 27°C; VBIAS-GND: 100nF)



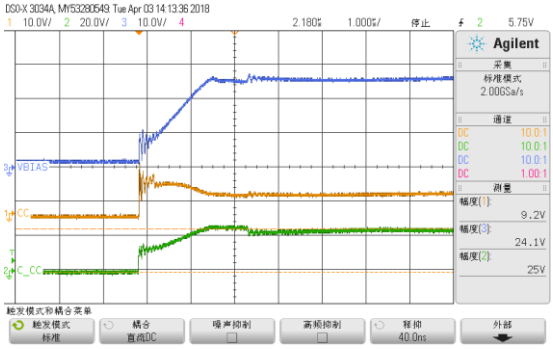
V_{C_CC1}&V_{C_CC2} vs I_{C_CC1}&I_{C_CC2} (V_{DD} = 3.3V)



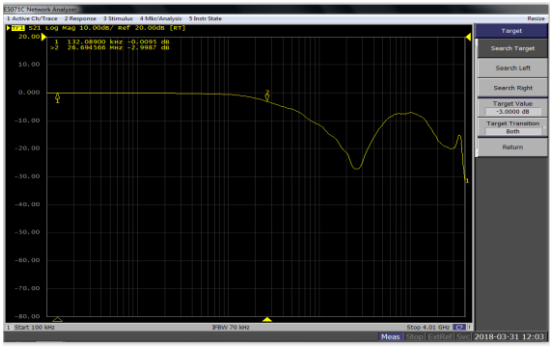
V_{C_CC1}&V_{C_CC2} vs I_{C_CC1}&I_{C_CC2} (V_{DD} : floating)



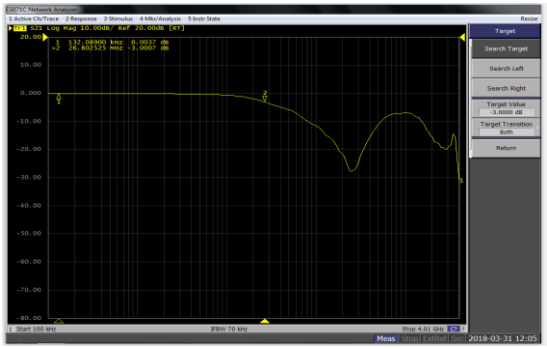
C_CC1 Voltage: 24V



C_CC2 Voltage: 24V



CC1 Bandwidth @ loading=200pf`



CC2 Bandwidth @ loading=200pf

Detailed Description

The WS3225 is a single chip USB Type-C port protection solution that provides 24-V Short-to-VBUS overvoltage and IEC ESD protection. Due to the small pin pitch of the USB Type-C connector and non-compliant USB Type-C cables and accessories, the VBUS pins can get shorted to the CC pins inside the USB Type-C connector. Because of this short-to-VBUS event, the CC pins need to be 20-V tolerant, to support protection on the full USB PD voltage range. Even if a device does not support 20-V operation on VBUS, non- complaint adaptors can start out with 20-V VBUS condition, making it necessary for any USB Type-C device to support 20 V protection. The WS3225 integrates two channels of 24-V Short-to-VBUS overvoltage protection for the CC1, CC2 pins of the USB Type-C connector.

Additionally, IEC 61000-4-2 system level ESD protection is required in order to protect a USB Type-C port from ESD strikes generated by end product users. The WS3225 integrates two channels of IEC61000-4-2 ESD protection for the CC1/CC2 pins of the USB Type-C connector. This means IEC ESD protection is provided for all of the low-speed pins on the USB Type-C connector in a single chip in the WS3225. Additionally, high voltage IEC ESD protection that is 22-V DC tolerant is required for the CC lines in order to simultaneously support IEC ESD and Short-to-VBUS protection

Feature Description

2-Channels of Short-to-VBUS Overvoltage Protection (CC1, CC2 Pins): 24-VDC Tolerant

The WS3225 provides 2-channels of Short-to-VBUS Overvoltage Protection for the CC1, CC2 pins of the USB Type-C connector. The WS3225 is able to handle 24-VDC on its C_CC1, C_CC2 pins. This is necessary because according to the USB PD specification, with VBUS set for 20 V operation, the VBUS voltage is allowed to legally swing up to 21 V, and 21.5 V on voltage transitions from a different USB PD VBUS voltage. The WS3225 builds in tolerance up to 24-VBUS to provide margin above this 21.5 V specification to be able to support USB PD adaptors that may break the USB PD specification.

When a short-to-VBUS event occurs, ringing happens due to the RLC elements in the hot-plug event. With very low resistance in this RLC circuit, ringing up to twice the settling voltage can appear on the connector. More than 2x ringing can be generated if any capacitor on the line derates in capacitance value during the short-to-VBUS event. This means that more than 44 V could be seen on a USB Type-C pin during a Short-to-VBUS event. The WS3225 has built in circuit protection to handle this ringing. The diode clamps used for IEC ESD protection also clamp the ringing voltage during the short-to-VBUS event to limit the peak ringing to around 30V. Additionally, the overvoltage protection FETs integrated inside the WS3225 are 30-V tolerant, therefore being capable of supporting the high-voltage ringing waveform that is experienced during the short-to-VBUS event. The well designed combination of voltage clamps and 30-V tolerant OVP FETs insures the WS3225 can handle Short-to-VBUS hot-plug events with hot-plug voltages as high as 24-VDC.

2-Channels of IEC 61000-4-2 ESD Protection (CC1, CC2 Pins)

The WS3225 integrates 2-Channels of IEC 61000-4-2 system level ESD protection for the CC1, CC2 pins. USB Type-C ports on end-products need system level IEC ESD protection in order to provide adequate protection for the ESD events that the connector can be exposed to from end users. The WS3225 integrates

IEC ESD protection for two of the low-speed pins on the USB Type-C connector in a single chip. Additionally, high-voltage IEC ESD protection that is 24-V DC tolerant is required for the CC lines in order to simultaneously support IEC ESD and Short-to-VBUS protection. The WS3225 integrates this type of high-voltage ESD protection so a system designer can meet both IEC ESD and Short-to-VBUS protection requirements in a single device.

CC1, CC2 Overvoltage Protection FETs 600 mA Capable for Passing VCONN Power

When CC is configured to provide power, it is called VCONN. VCONN is a DC voltage source in the range of 3 V-5.5V. If supporting VCONN, a VCONN provider must be able to provide 1 W of power to a cable; this translates into a current range of 200 mA to 333 mA (depending on your VCONN voltage level). Additionally, if operating in a USB PD alternate mode, greater power levels are allowed on the VCONN line.

When a USB Type-C port is configured for VCONN and using the WS3225, this VCONN current flows through the OVP FETs of the WS3225. Therefore, the WS3225 has been designed to handle these currents and have an RON low enough to provide a specification compliant VCONN voltage to the active cable. The WS3225 is designed to handle up to 600 mA of DC current to allow for alternate mode support in addition to the standard 1 W required by the USB Type-C specification.

CC Dead Battery Function

An important feature of USB Type-C and USB PD is the ability for this connector to serve as the sole power source to mobile devices. With support up to 100 W, the USB Type-C connector supporting USB PD can be used to power a whole new range of mobile devices not previously possible with legacy USB connectors.

When the USB Type-C connector is the sole power supply for a battery powered device, the device must be able to charge from the USB Type-C connector even when its battery is dead. In order for a USB Type-C power adapter to supply power on VBUS, RD pull-down resistors must be exposed on the CC pins. These RD resistors are typically included inside a USB Type-C CC/PD controller. However, when the WS3225 is used to protect the USB Type-C port, the OVP FETs inside the device isolate these RD resistors in the CC/PD controller when the mobile device has no power. This is because when the WS3225 has no power, the OVP FETs are turned off to guarantee overvoltage protection in a dead battery condition. Therefore, the WS3225 integrates high voltage, dead battery RD pull-down resistors to allow dead battery charging simultaneously with high-voltage OVP protection.

When the WS3225 is unpowered, and the RP pull-up resistor is connected from a power adaptor, this RP pull-up resistor activates the RD resistor inside the WS3225. This enables VBUS to be applied from the power adaptor even in a dead battery condition. Once power is restored back to the system and back to the WS3225 on its VPWR pin, after about 2mS the WS3225 removes its RD pull-down resistor and turn on its OVP FETs to guarantee the RD pull-down resistor inside the CC/PD Controller is exposed within 10 mS. This is by design, because if the RD pull-down resistor is not exposed within 10 mS, the power adaptor can legally interpret this behavior as a port disconnect and remove VBUS.

If desiring to power the CC/PD controller during dead battery mode and if the CC/PD Controller is configured as a DRP, it is critical that the WS3225 be powered before or at the same time that the CC/PD controller is powered. It is also critical that when unpowered, the CC/PD controller also expose its dead battery resistors. When the WS3225 gets powered, it exposes the CC pins of the CC/PD controller within 3.5 mS. Once the

WS3225 turns on, the RD pull-down resistors of the CC/PD controller must be present immediately, in order to guarantee the power adaptor connected to power the dead battery device keeps its VBUS turned on. If the power adaptor sees any change to its CC voltage for more than 10 mS, it can disconnect VBUS. This removes power from the device with its battery still not sufficiently charged, which consequently removes power from the CC/PD controller and the WS3225. Then the RD resistors of the WS3225 are exposed again, connect the power adaptor's VBUS to start the cycle over. This creates an infinite loop, never or very slowly charging the mobile device.

If the CC/PD Controller is configured for DRP and has started its DRP toggle before the WS3225 turns on, this DRP toggle is unable to guarantee that the power adaptor does not disconnect from the port. Therefore, it is recommended if the CC/PD controller is configured for DRP, that its dead battery resistors be exposed as well, and that they remain exposed until the WS3225 turns on. This is typically accomplished by powering the WS3225 at the same time as the CC/PD controller when powering the CC/PD controller in dead battery operation.

Over-Voltage Protection

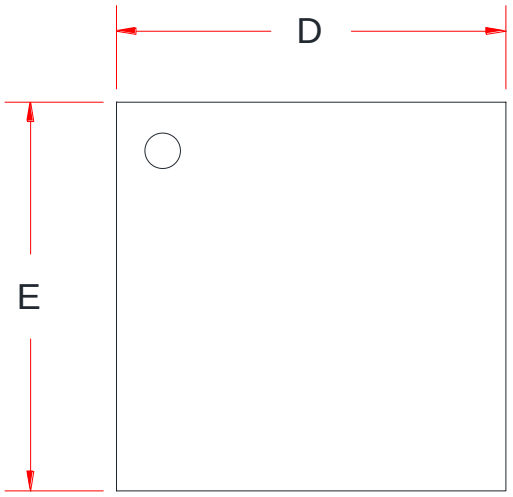
When over-voltage event is detected， device will activate OVP to shut down the switch MOSFET within tOVP，as well as signal the INTB to indicate there is over-voltage event to system.

Fault Report

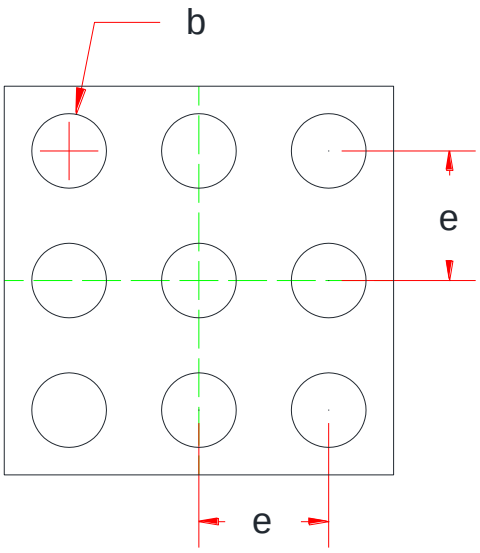
Upon the detection of an over-voltage/over-temperature event, the INTB signal signals the fault by activating low.

PACKAGE OUTLINE DIMENSIONS

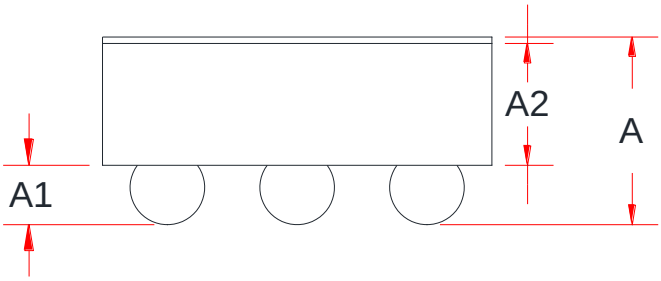
1.2mmx1.2mm CSP-9L



TOP VIEW



BOTTOM VIEW

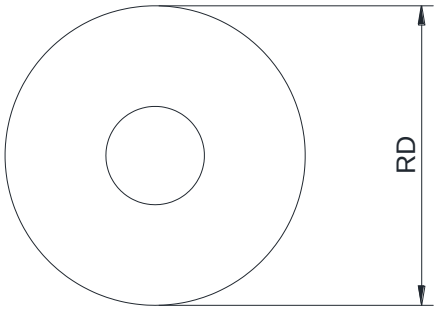


SIDE VIEW

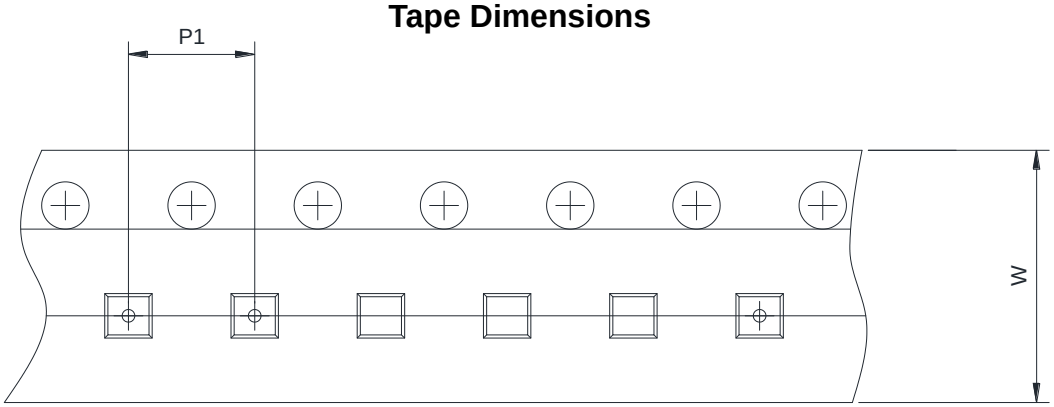
Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.55	-	0.62
A1	0.02	-	0.03
A2	0.36	-	0.39
D	1.17	1.20	1.23
E	1.17	1.20	1.23
B	0.21	0.23	0.25
E	0.40 BSC		

TAPE AND REEL INFORMATION

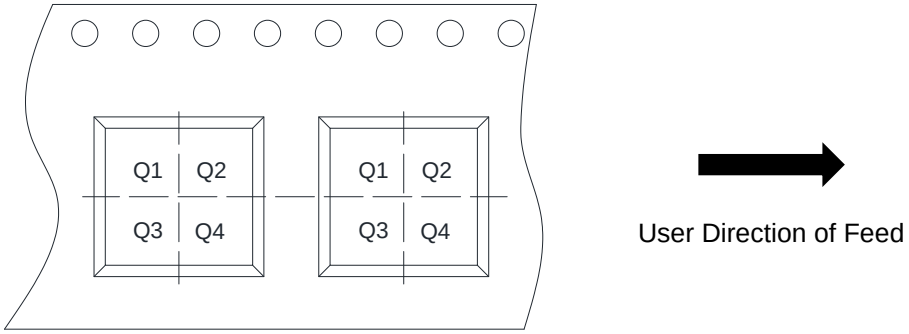
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	☑ 7inch	☐ 13inch		
W	Overall width of the carrier tape	☑ 8mm	☐ 12mm		
P1	Pitch between successive cavity centers	☐ 2mm	☑ 4mm	☐ 8mm	
Pin1	Pin1 Quadrant	☑ Q1	☐ Q2	☐ Q3	☐ Q4

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