USB Charging Port Controller and Load Detection Power Switch

Features

- ➔ Supports DCP Modes per USB Battery Charging Specification 1.2
- ➔ Supports Shorted Mode per Chinese Telecommunication Industry Standard YD/T1591-2009
- ➔ Supports non-BC1.2 Charging Modes by Automatic Selection
  - Divider-1A mode
  - Divider-2A mode
  - Divider-2.4A mode (with MODE_SEL='HIGH' only)
  - DCP-1.2V mode
- ➔ Integrated 65-mΩ (Typ.) High-Side MOSFET
- ➔ Programmable Current Limit up to 3A (Typ.)
- ➔ Accurate +/-7% Current Limit at 2.51A (Typ.)
- ➔ Provides /STATUS Pin for Plug-In Detection
- ➔ Operating Range:4.5V to 5.5V
- ➔ Device Package: EP-SOP8L

Description

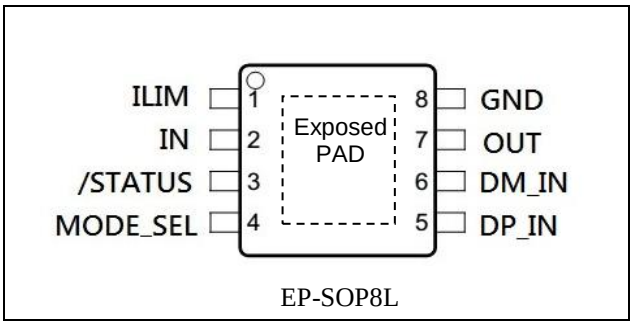
The PI5USB2549 is a USB charging port controller and current limiting power switch. PI5USB2549 provides the electrical signatures on D+/D– to support different charging schemes and is compatible with both popular BC1.2 compliant and non-BC1.2 compliant devices.

The PI5USB2549 65-mΩ power-distribution switch is intended for applications where heavy capacitive loads and short-circuits are likely to be encountered. Programmable current threshold provides flexibility for setting current limit. PI5USB2549 provides a /STATUS pin for plug-in detect indication.

Applications

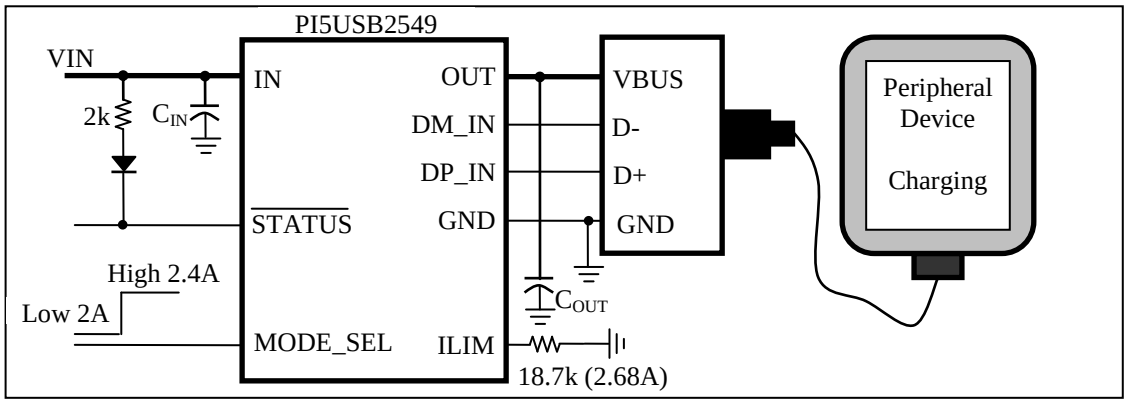
- ➔ Vehicle USB Power Charger
- ➔ AC-DC Wall Adapter with USB Port
- ➔ Other USB Charger

Pin Configuration



EP-SOP8L

Typical Application Diagram



Pin Description

Pin #	Name	Type	Description
1	ILIM	I	External resistor connection used to set the current-limit threshold.
2	IN	P	Input voltage and supply voltage; connect 0.1µF//10µF or greater ceramic capacitor from IN to GND as close to the device as possible
3	$\overline{\text{STATUS}}$	O	Active-low open-drain output as a plug-in detect indication. It is asserted when there is a load connected.
4	MODE_SEL	I	Logic-level input signal used to control the Divider-2.4A charging mode. MODE_SEL='HIGH' enables Divider-2.4A charging mode. MODE_SEL='LOW' disables Divider-2.4A charging mode.
5	DP_IN	I/O	Connected to the D+ line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
6	DM_IN	I/O	Connected to the D- line of USB connector, provide the correct voltage with attached portable equipment for DCP detection.
7	OUT	P	Power-switch output
8	GND	G	Ground connection
Exposed PAD		G	Ground connection.

** I = Input; O = Output; P = Power; G = Ground*

PI5USB2549 Charging Detection Supports Table

Part Number	MODE_SEL	Non- BC1.2 Charging Mode				Plug-in Detection
		DCP-1.2V	Divider-1A	Divider-2A	Divider-2.4A	
PI5USB2549	LOW	√	√	√	×	√
	HIGH	√	√	√	√	√

Maximum Ratings

All Input (except IN to OUT, and DP_IN, DM_IN) ..... -0.3V to +6.0V
IN to OUT ..... -6.0V to +6.0V
DP_IN, DM_IN ..... -0.3V to IN+0.3 or +5.7V
Input clamp current (DP_IN, DM_IN) ..... ±20mA
Continuous current in BC1.2 DCP mode (DP_IN to DM_IN) ..... ±50mA
Continuous output current (OUT) ..... Internally limited
Continuous output sink current (/STATUS) 25mA
Continuous output source current (ILIM) ..... internally limited
ESD: HBM Mode (All pins) 2kV
CDM Mode (All pins) 500V
HBM (USB connector pins: DP_IN, DM_IN, OUT to GND) 6kV

Note:
Stresses greater than those listed under MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage, IN	4.5	-	5.5	V
	Input Voltage, logic-level MODE_SEL input	0	-	5.5	V
V_{DP_IN}	DP_IN data line voltage	0	-	V_{IN}	V
V_{DM_IN}	DM_IN data line voltage	0	-	V_{IN}	V
V_{IH}	High-level input voltage, MODE_SEL	1.8	-	-	V
V_{IL}	Low-level input voltage, MODE_SEL	-	-	0.8	V
I_{OUT}	Continuous output current, OUT	0	-	2.5	A
	Continuous output sink current, /STATUS	0	-	10	mA
R_{ILIM}	Current-limit set resistor	16.9	-	750	kΩ
T_A	Ambient Temperature Range	-40	-	85	℃
T_J	Operating Virtual Junction Temperature Range	-40	-	125	℃

Electrical Characteristics

$4.5V \leq V_{IN} \leq 5.5V$; T_J=-40 ℃ to +125 ℃; $R_{/STATUS}$=10kΩ R_{ILIM}=20kΩ
Positive currents are into pins. Typical values are at 25 ℃. All voltages are with respect to GND. unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Power Switch						
$R_{DS(on)}$	On Resistance(1)	T_J = 25°C, I_{OUT} = 2A	-	65	-	mΩ
		-40°C ≤ T_J ≤ 85°C, I_{OUT} = 2A	-	65	105	
		-40°C ≤ T_J ≤ 125°C, I_{OUT} = 2A	-	65	120	
Discharge						
R_{DCHG}	OUT discharge resistance	V_{OUT} = 4V	-	500	-	Ω
t_{DCHG}	OUT discharge hold time	Time V_{OUT}< 0.7V	1.30	2.0	2.9	s
MODE_SEL input						
	Input pin rising logic threshold voltage	-	1	1.35	1.70	V
	Input pin falling logic threshold voltage	-	0.85	1.15	1.45	V
	Hysteresis(2)	-	-	200	-	mV
	Input current	Pin voltage= 0V to 5.5V	-0.5	-	0.5	μA

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; Thermal effects must be taken into account separately
(2) These parameters are provided for reference only and do not constitute part of Pericom's published device specifications for purposes of Pericom's product warranty

Electrical Characteristics

4.5V≤V_{IN}≤5.5V; T_J=-40 ℃ to +125 ℃; $R_{/STATUS}$=10kΩ R_{ILIM}=20kΩ
Positive currents are into pins. Typical values are at 25 ℃. All voltages are with respect to GND. unless otherwise specified.

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Unit
ILIM Current Limit						
I_{OS}	OUT Current-limit[2]	R_{ILIM}=210kΩ	205	240	275	mA
		R_{ILIM}=80.6kΩ	575	625	680	
		R_{ILIM}=22.1kΩ	2120	2275	2430	
		R_{ILIM}=20kΩ	2340	2510	2685	
		V_{IN} R_{ILIM}=16.9kΩ	2770	2970	3170	
t_{IOS}	Response time to OUT short circuit[1]	V_{IN} = 5.0V, R=0.1Ω, lead length=2”	-	1.5	-	μs
Supply Current						
I_{IN_ON}	IN supply current		-	215	270	μA
Undervoltage Lockout						
V_{UVLO}	IN rising UVLO threshold voltage	-	3.9	4.1	4.3	V
	Hysteresis[1]	-	-	100	-	mV
/STATUS						
V_{OL}	Output low voltage	$I_{/STATUS}$ = 1mA	-	-	100	mV
I_{OFF}	Off-state leakage	$V_{/STATUS}$ = 5.5V	-	-	1	μA
Thermal Shutdown						
OTSD	Thermal shutdown threshold	-		170	-	℃
	Hysteresis[1]	-	-	20	-	

Note:
(1) These parameters are provided for reference only and do not constitute part of Pericom's published device specifications for purposes of Pericom's product warranty
(2) Pulse-testing techniques maintain junction temperature close to ambient temperature; current limit value tested at 80% output voltage. Thermal effects must be taken into account separately.

Electrical Characteristics, Charging Controller

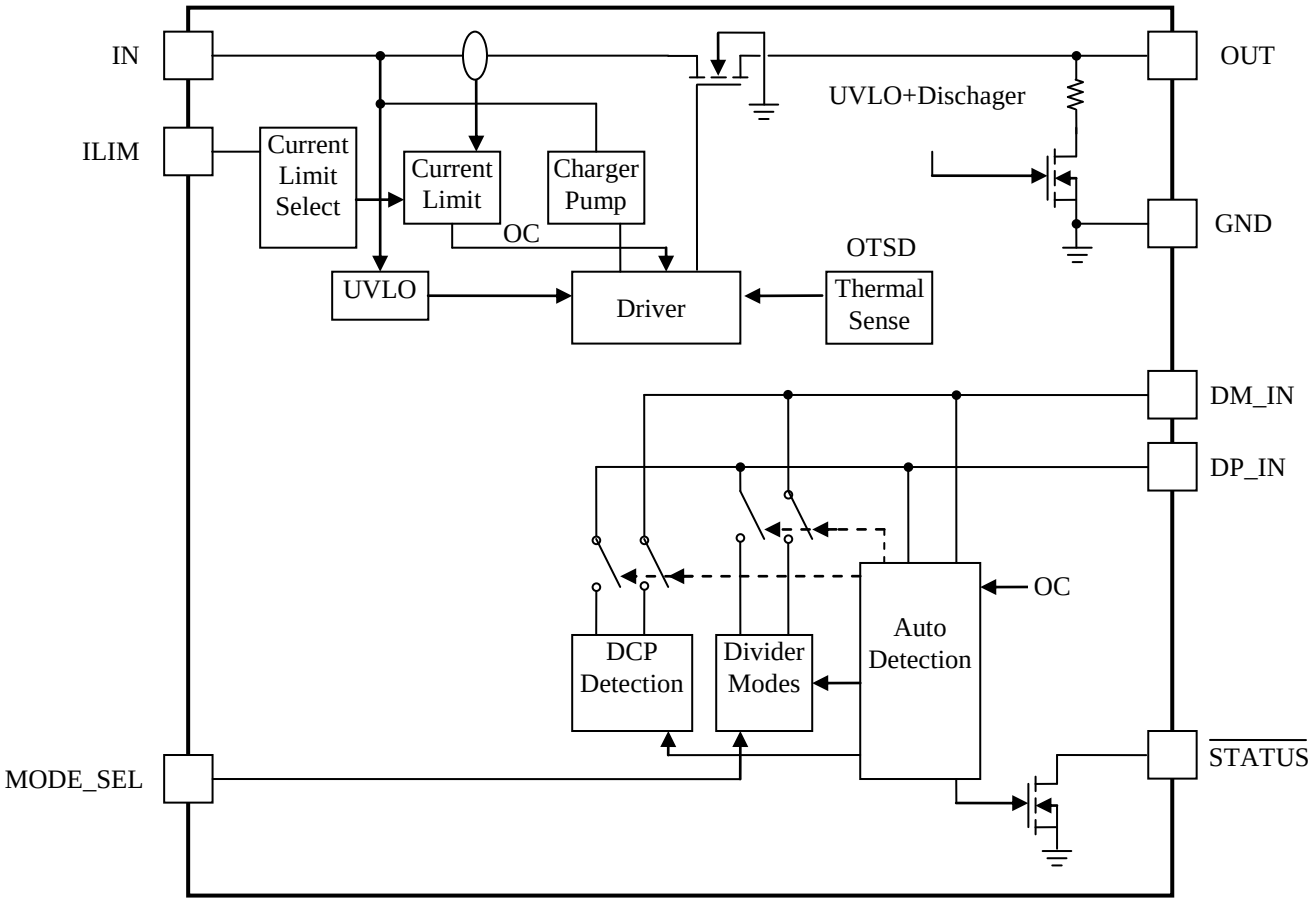
$4.5V \leq V_{IN} \leq 5.5V$; T_J=-40 ℃ to +125 ℃; $R_{/STATUS}$=10kΩ R_{ILIM}=20kΩ
Positive currents are into pins. Typical values are at 25 ℃. All voltages are with respect to GND. unless otherwise specified.

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Unit
SHORTED MODE (BC1.2 DCP)						
	DP_IN/DM_IN shorting resistance		-	125	-	Ω
DCP-1.2V MODE						
	DP_IN/DM_IN output voltage	Apply 3V on DP_IN for 0.5s and measure the D+/D- voltage within the 2s	-	1.25	-	V
	DP_IN/DM_IN output impedance		-	75	-	kΩ
DIVIDER-1A MODE						
	DP_IN Divider-1A output voltage		1.9	2.0	2.1	V
	DM_IN Divider-1A output voltage		2.57	2.7	2.84	V
	DP_IN/DM_IN output impedance		7.5	10.5	16	kΩ
DIVIDER-2A MODE						
	DP_IN Divider-2A output voltage	I_{OUT}= 1A	2.57	2.7	2.84	V
	DM_IN Divider-2A output voltage		1.9	2.0	2.1	V
	DP_IN/DM_IN output impedance		7.5	10.5	16	kΩ
DIVIDER-2.4A MODE (with MODE_SEL='HIGH')						
	DP_IN/DM_IN output voltage	I_{OUT} = 2A	2.57	2.7	2.84	V
	DP_IN/DM_IN output impedance		7.5	10.5	16	kΩ
PLUG-IN LOAD DETECT						
I_{PLUG_IN}	I_{PLUG_IN} rising set current threshold		-	55	-	mA
	I_{PLUG_IN} falling reset current threshold		-	45	-	mA
$T_{PLUG_IN_SET}$	Plug-in detect set time		140	200	275	ms
	Plug-in detect reset time		1.9	3	4.2	s

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Functional Description

PI5USB2549 Block Diagram



Overview

The following overview references various industry standards. It is always recommended to consult the most up-to-date standard to ensure the most recent and accurate information. Rechargeable portable equipment requires an external power source to charge its batteries. USB ports are a convenient location for charging because of an available 5V power source. Universally accepted standards are required to make sure host and client-side devices operate together in a system to ensure power management requirements are met. Traditionally, 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 its power allotment from the host to ensure the total current draw does not exceed 500mA. In general, each USB device is granted 100mA and may request more current in 100mA unit steps up to 500mA. The host may grant or deny based on the available current. A USB 3.0 host port not only provides higher data rate than USB 2.0 port but also raises the unit load from 100mA to 150mA. It is also required to provide a minimum current of 900mA to downstream client-side devices.

Additionally, the success of USB has made the mini-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. As USB charging has gained popularity, the 500mA minimum defined by USB 2.0 or 900mA for USB 3.0 has become insufficient for many handset and personal media players which need a higher charging rate. Wall adapters can provide much more current than 500mA/900mA. 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/900mA minimum defined by USB 2.0/3.0 while still using a single micro-USB input connector. The PI5USB2549 supports four of the most common USB charging schemes found in popular hand-held media and cellular devices:

- USB Battery Charging Specification BC1.2
- Chinese Telecommunications Industry Standard YD/T 1591-2009
- Divider-1A, Divider-2A and Divider-2.4A Mode
- DCP-1.2V Mode

YD/T 1591-2009 is a subset of BC1.2 spec. supported by vast majority of devices that implement USB charging.
Divider-1A, Divider-2A, Divider-2.4A and DCP-1.2V charging schemes are supported in devices from specific yet popular device makers.

DCP Auto Mode

PI5USB2549 integrates an auto-detect state machine that supports all the below DCP charging schemes. It starts in Divider-1A scheme, however if a BC1.2 or YD/T 1591-2009 compliant device is attached, the PI5USB2549 responds by discharging OUT, turning back on the power switch and operating in 1.2Vmode briefly and then moving to BC1.2 DCP mode. It then stays in that mode until the device is done charging or removed, in which case it goes back to Divider-1A scheme. When a Divider-1A compliant device is attached the PI5USB2549 will stay in Divider-1A state.

Also, the PI5USB2549 will automatically switch between the Divider-1A and Divider-2A (or Divider-2.4A) schemes based on charging current drawn by the connected device. Initially the device will set the DP_IN/DM_IN to Divider-1A scheme. If charging current of the device >900mA is measured by the PI5USB2549, it switches to Divider-2A scheme and test to see if the peripheral device will still charge at a high current. With MODE_SEL='HIGH', if charging current of the device >1.8A is measured by PI5USB2549 or PI5USB2549, it will switches to Divider-2.4A charging mode. If it does then it stays in Divider-2A or Divider-2.4A charging scheme otherwise it will revert to Divider-1A scheme.

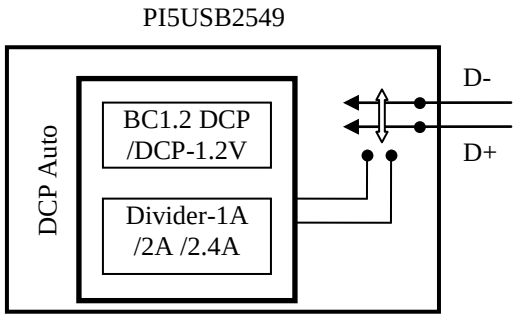


Figure 1, DCP_Auto Mode

DCP BC1.2 and YD/T 1591-2009

Both standards define that the D+ and D- data lines should be shorted together with a maximum series impedance of 200Ω. This is shown as Figure 1.

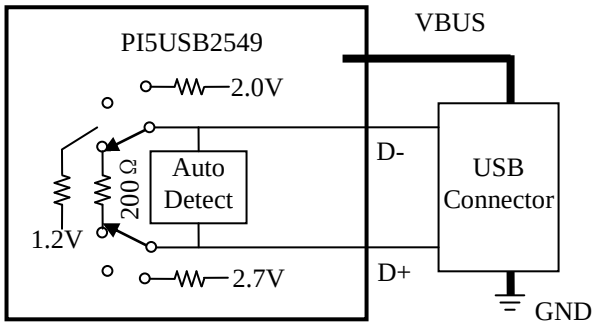


Figure 2, DCP mode

Divider-1A, Divider-2A and Divider-2.4A Charging Scheme

There is two charging mode supported by PI5USB2549 with MODE_SEL pin LOW or HIGH. PI5USB2549 supports to flag Divider-1A/Divider-2A/Divider-2.4A charging scheme as MODE_SEL pin pulls to IN (HIGH), and if MODE_SEL pin pulls to GND (LOW), the device supports to flag Divider-1A/Divider-2A charging scheme. In Divider-1A charging scheme the device applies 2.0V and 2.7V to D+ and D- data line respectively. This is reversed in Divider-2A mode. Divider-2.4A charging scheme on PI5USB2549 is applying 2.7V on both D+ and D-. The Divider-1A, Divider-2A and Divider-2.4A scheme are as shown below.

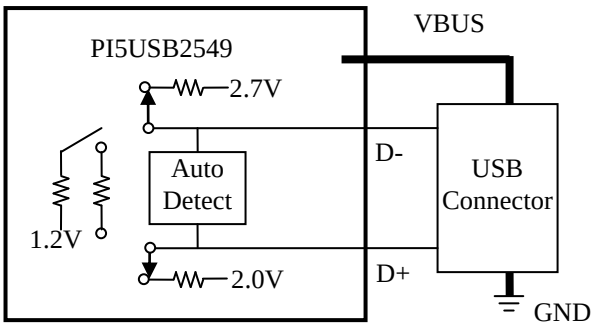


Figure 3a, Divider-1A Charging Scheme (with MODE_SEL="LOW")

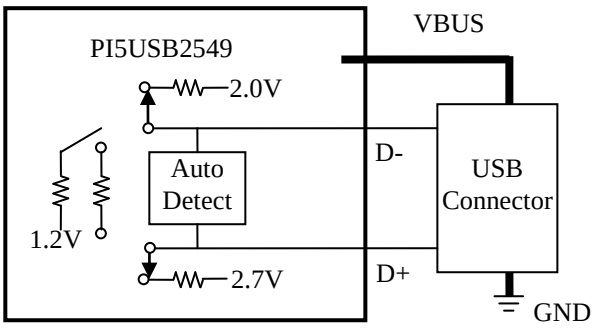


Figure 3b, Divider-2A Charging Scheme (with MODE_SEL="LOW")

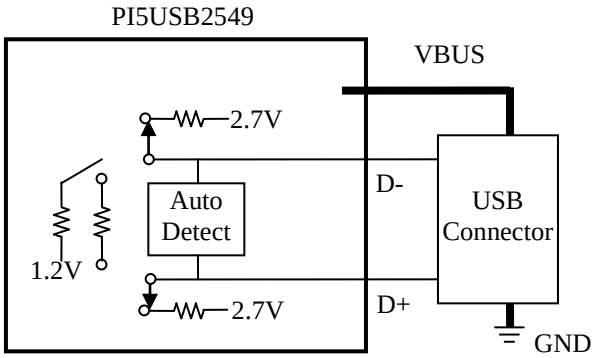


Figure 3c, Divider-2.4A Charging Scheme (with MODE_SEL="HIGH")

DCP-1.2V Charging Scheme

DCP-1.2V charging scheme is used by some handheld devices to enable fast charging at 2.0A. PI5USB2549 supports this scheme in the DCP-Auto mode before the device enters BC1.2 shorted mode. To simulate this charging scheme D+/D- lines are shorted and pulled-up to 1.2V for fixed duration then device moves to DCP shorted mode as defined in BC1.2 spec. This is shown as Figure 3.

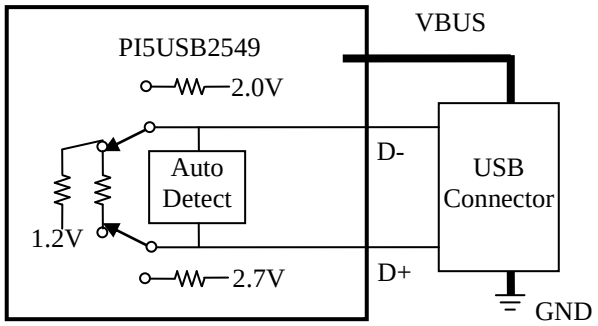


Figure 4, DCP-1.2V Charging Scheme

Output Discharge

To allow a charging port to renegotiate current with a portable device, PI5USB2549 uses the OUT discharge function. It proceeds by turning off the power switch while discharging OUT, then turning back on the power switch to reassert the OUT voltage.

Over-Current Protection

When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Two possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before VIN has been applied. The PI5USB2549 senses the short and immediately switches into a constant-current output. In the second condition, a short or an overload occurs while the device is enabled. At the instant the overload occurs, high currents may flow for nominally one to two microseconds before the current-limit circuit can react. The device operates in constant-current mode after the current-limit circuit has responded. Complete shutdown occurs only if the fault is presented long enough to activate thermal limiting. The device will remain off until the junction temperature cools approximately 20℃ and will then re-start. The device will continue to cycle on/off until the over-current condition is removed.

Current-Limit Setting

The PI5USB2549 has an independent current limit setting that is programmed externally with a resistor. The ILIM setting is programmed with R_{ILIM} connected between ILIM and GND.

The following equation programs the typical current limit:
I_{OS_TYP} (mA)=50250/R_{LIM} (kΩ)

Many applications require that the current limit meet specific tolerance limits. When designing to these tolerance limits, both the tolerance of the PI5USB2549 current limit and the tolerance of the external programming resistor must be taken into account. The following equations approximate the PI5USB2549 minimum / maximum current limits to within a few mA and are appropriate for design purposes. These equations assume an ideal – no variation - external programming resistor. To take resistor tolerance into account, first determine the minimum /maximum resistor values based on its tolerance specifications and use these values in the equations. Because of the inverse relation between the current limit and the programming resistor, use the maximum resistor value in the I_{OS_MIN} equation and the minimum resistor value in the I_{OS_MAX} equation.

I_{OS_MIN} (mA)=45271/(R_{LIM} (kΩ))$^{0.98437}$-30
I_{OS_MAX} (mA) =55325/ (R_{LIM} (kΩ))$^{1.0139}$+30

The traces routing the R_{ILIMI} resistor should be a sufficiently low resistance as to not affect the current-limit accuracy. The ground connection for the R_{ILIM} resistor is also very important. The resistors need to reference back to the PI5USB2549 GND pin. Follow normal board layout practices to ensure that current flow from other parts of the board does not impact the ground potential between the resistors and the PI5USB2549 GND pin.

Undervoltage Lockout (UVLO)

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

Thermal Sense

The PI5USB2549 protects itself with thermal sensing circuit that monitor the operating temperature of the power distribution switch and disables operation if the temperature exceeds recommended operating conditions. The device operates in constant-current mode during an over-current condition, which increases the voltage drop across power switch. The power dissipation in the package is proportional to the voltage drop across the power switch, so the junction temperature rises during an over-current condition. The thermal sensor turns off the power switch when the die temperature exceeds 135℃ regardless of whether the power switch is in current limit. Hysteresis is built into thermal sensor, and the switch turns on after the device has cooled by approximately 20℃. The switch continues to cycle off and on until the fault is removed.

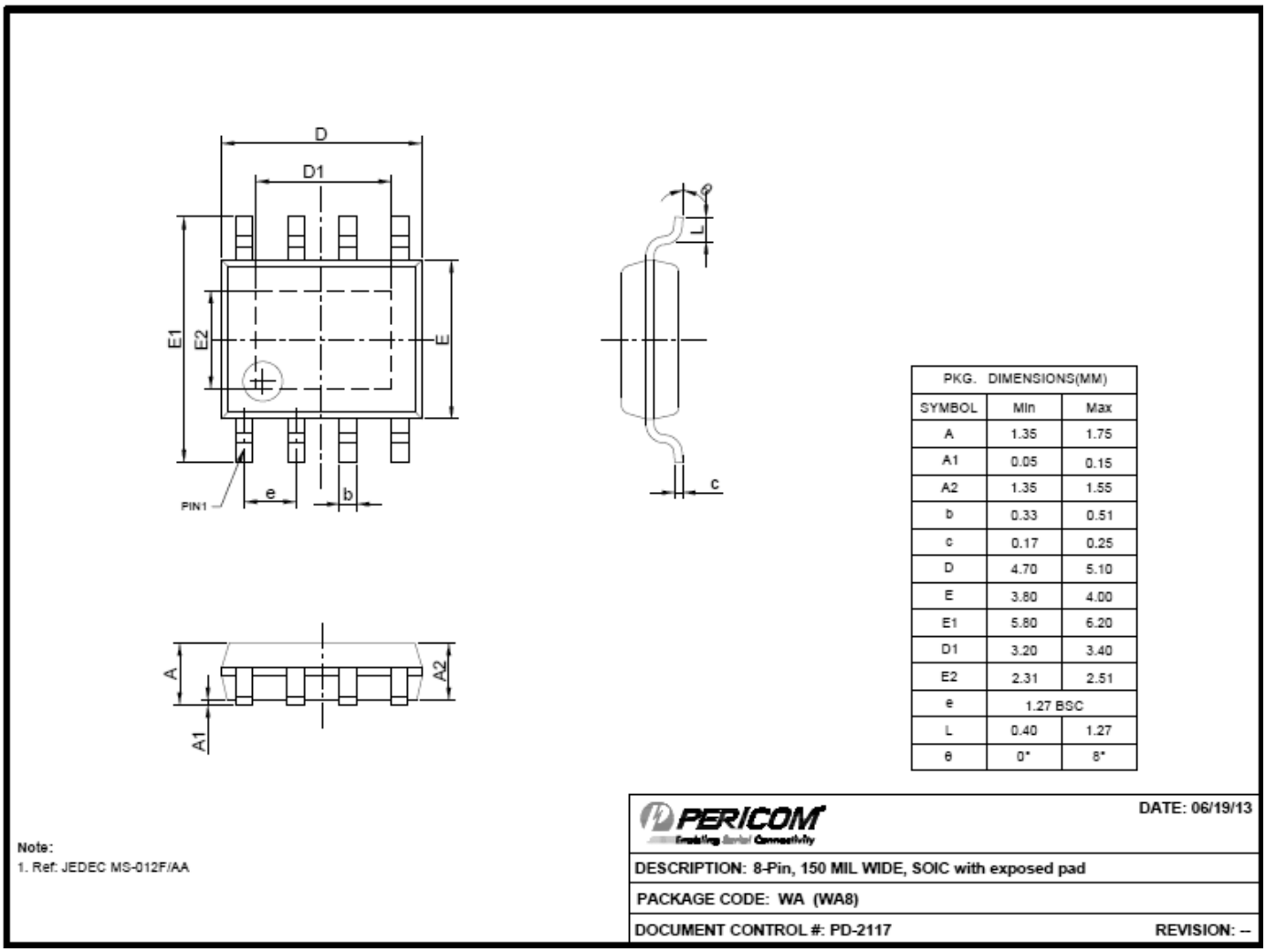
Application Information

Input and Output Capacitance

Input and output capacitance improves the performance of the device; the actual capacitance should be optimized for the particular application. For all applications, a 0.1uF or greater ceramic bypass capacitor between IN and GND is recommended as close to the device as possible for local noise decoupling. This precaution reduces ringing on the input due to power-supply transients.
Additional input capacitance 10uF or greater may be needed on the input to reduce voltage overshoot from exceeding the absolute-maximum voltage of the device during heavy transient conditions or output shorting. Normally suggested the distance between IC and DC supply is less than 15cm.
Output capacitance also needs to be close to IC as possible. When large transient currents are expected on the output, placing a high-value low ESR electrolytic capacitor 100uF or greater on the output pin is recommended.

Mechanical Information

EP-SOP8L



PKG. DIMENSIONS(MM)		
SYMBOL	Min	Max
A	1.35	1.75
A1	0.05	0.15
A2	1.35	1.55
b	0.33	0.51
c	0.17	0.25
D	4.70	5.10
E	3.80	4.00
E1	5.80	6.20
D1	3.20	3.40
E2	2.31	2.51
e	1.27 BSC	
L	0.40	1.27
θ	0°	8°

Note:
1. Ref: JEDEC MS-012F/AA

PERICOM Enabling Serial Connectivity — DATE: 06/19/13

DESCRIPTION: 8-Pin, 150 MIL WIDE, SOIC with exposed pad

PACKAGE CODE: WA (WA8)

DOCUMENT CONTROL #: PD-2117 REVISION: –

Ordering Information

Part No.	Package Code	Package
PI5USB2549WAE	WA	Lead free and Green 8-pin EP-SOP

Note:
- E = Pb-free and Green
- Adding X Suffix= Tape/Reel

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