AC/DC Secondary-Side Controller for Qualcomm® Quick Charge™ 2.0 USB Interface with Soft-Short Protection

1.0 Features

- Supports Qualcomm® Quick Charge™ 2.0 (QC2.0) technology High Voltage Dedicated Charging Port (HVDCP)
- Double-layer cable protection:
  - » Secondary side (iW629): Proprietary D+/D- over-voltage protection (OVP) addresses V_{BUS} D+/D- soft shorts
  - » Primary side (iW1780): SmartDefender™ smart hiccup technology reduces average output power at fault conditions without latch
- Proprietary secondary-to-primary digital communication eliminates discrete decoders in the primary side and simplifies system designs
- Single opto-coupler transmits all information for rapid charge: output voltage requests, output current limits, output voltage undershoot, over-voltage protection, and fault and reset signals
- Backward compatible with USB Battery Charging Specification Revision 1.2 (USB BC1.2) Dedicated Charging Port (DCP)
- Pin-to-pin compatible with iW626
- Programmable active fast discharge from 9V to 5V at mobile device (MD) unplug or upon request with built-in switch or external switch
- Normally OFF state with <120µA cut-off current during 5V steady-state operation to achieve <10mW power consumption at no load
- Wide operating voltage range from 3V to 25V
- Built-in opto-coupler LED driver with minimum driving current of 2mA
- 6-lead SOT-23 package

2.0 Description

The iW629 is an AC/DC secondary-side controller compatible with the Qualcomm Quick Charge 2.0 USB interface and secondary-to-primary communication protocol, allowing rapid charging of QC2.0-enabled mobile devices. The iW629 resides on the secondary side of an AC/DC power supply and allows the adapter to be configured for multi-level output such as 5V and 9V, depending on the voltage requested by the mobile device. It can be used in Dialog's primary-side controlled AC/DC systems to achieve fast voltage transition, low no-load power consumption, and fast dynamic load response.

The iW629 implements Dialog's proprietary secondary-to-primary digital communication technique. When paired with Dialog's primary-side iW1780 controller, the iW629 eliminates the discrete decoders in the primary side, simplifying system designs. It uses one opto-coupler to transmit all necessary information for rapid charging, including output voltage requests, output current limits, output voltage undershoot, output over-voltage, and fault and reset signals. It also has a built-in opto-coupler LED driver to minimize the bill of material cost.

The iW629 and iW1780 provide double-layer cable protection. On the secondary side, the iW629 incorporates Dialog's proprietary D+/D- over-voltage protection to address V_{BUS} D+/D- soft shorts. On the primary side, the iW1780 uses Dialog's SmartDefender advanced hiccup technology to reduce the average output power during soft shorts without latch.

Dialog's innovative, proprietary technology ensures that power supplies designed with the iW629 and iW1780 can provide multi-level output voltage configuration, with user-selected various output current limit combinations. Furthermore, the chipset can achieve <10mW no-load power consumption at 5V, 2A output setting and fast dynamic load response in typical AC/DC rapid charge adapter designs.

Qualcomm® Quick Charge™ 2.0 is a product of Qualcomm Technologies, Inc.

3.0 Applications

- Rapid-charging AC/DC adapters for smart phones, tablets, and other portable devices

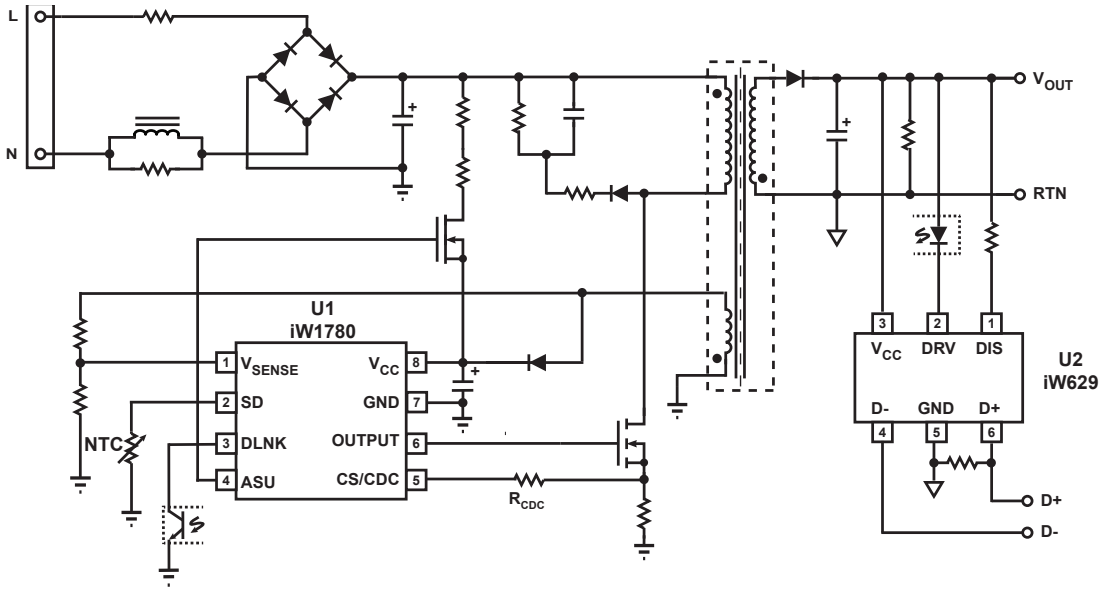


Figure 3.1: iW629 Typical Application Circuit for Multi-Level Output Voltage and Current (Using iW1780 as Primary-Side Controller. Achieving <10mW No-Load Power Consumption)

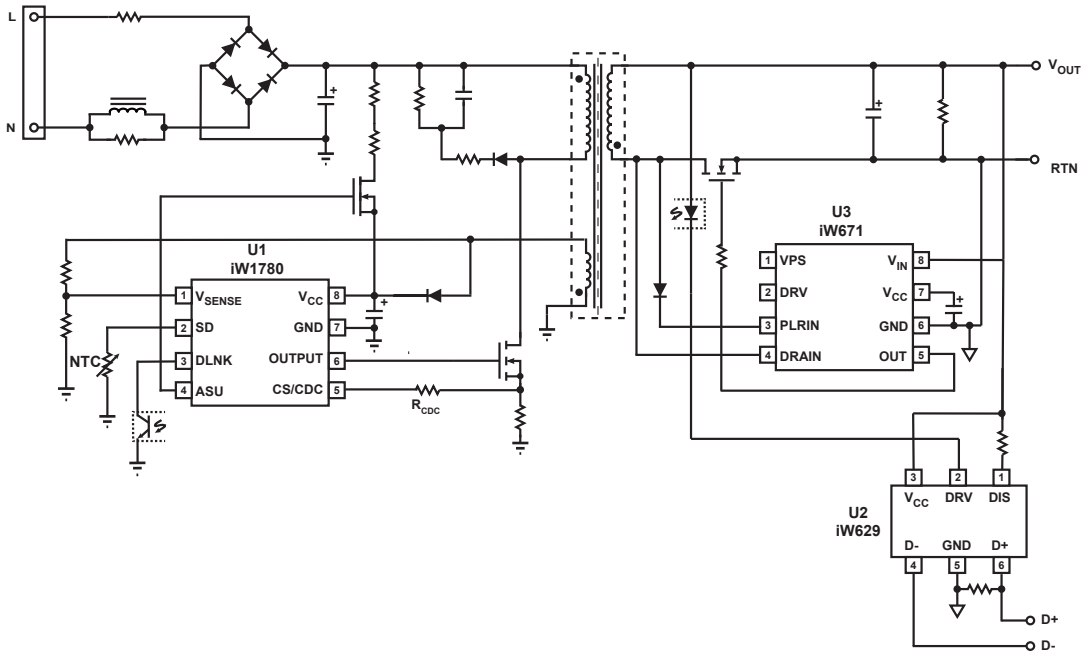


Figure 3.2: iW629 Typical Application Circuit for Multi-Level Output Voltage and Current (Using iW1780 as Primary-Side Controller and iW671 as Synchronous Rectifier Controller. Achieving < 20mW No-Load Power Consumption)

4.0 Pinout Description

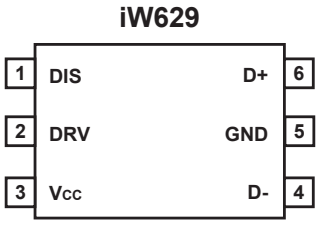


Figure 4.1: 6 Lead SOT-23 Package

Pin #	Name	Type	Pin Description
1	DIS	Analog Output	Discharging circuit and external FET drive. Used for fast discharging of output capacitor. Also can be used for driving external FET.
2	DRV	Analog Output	External circuit drive. Can be used for opto-coupler LED drive with automatic current limiting for transmitting signals to primary side.
3	V_{CC}	Power Supply	IC power supply.
4	D-	Analog Input/ Output	USB D- signal.
5	GND	Ground	Ground.
6	D+	Analog Input	USB D+ signal.

5.0 Absolute Maximum Ratings

Absolute maximum ratings are the parameter values or ranges which can cause permanent damage if exceeded.

Parameter	Symbol	Value	Units
DIS (pin 1) voltage	V_{DIS}	30	V
DRV (pin 2) voltage	V_{DRV}	30	V
V_{CC} (pin 3) voltage	V_{CC}	30	V
D- (pin 4) voltage	V_{D-}	-0.3 to 7	V
D+ (pin 6) voltage	V_{D+}	-0.3 to 7	V
Continuous DC current at DRV pin (V_{DRV}= 11V)	I_{DRV}	25	mA
Continuous DC supply current at V_{CC} pin (V_{CC}= 12V)	I_{VCC}	25	mA
Peak current at DIS pin (V_{DIS}= 12V)	I_{DIS}	600	mA
Maximum junction temperature	T_{JMAX}	150	°C
Operating junction temperature	T_{JOPT}	-40 to 150	°C
Storage temperature	T_{STG}	-65 to 150	°C
ESD rating per JEDEC JESD22-A114 (D+ and D- pins)		4,000	V
ESD rating per JEDEC JESD22-A114 (all other pins)		2,000	V

6.0 Electrical Characteristics

V_{CC} = 12V, -40°C ≤ T_A ≤ 85°C, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V_{CC} SECTION (Pin 3)						
Standby operating current (Note 1)	I_{CC}	No preload, V_{CC} = 5V			120	µA
Operating voltage (Note 1)	V_{CC}				25	V
Start-up threshold (Note 1)	$V_{CC(ST)}$			3.3		V
Undervoltage lockout threshold (Note 1)	$V_{CC(UVL)}$			3.0		V
Active fast discharge threshold (Note 1)	$V_{CC(DIS)}$		+7	+8.5	+10	%
Under-voltage threshold	$V_{CC(UV)}$		-6	-5	-4	%
Over-voltage threshold	$V_{CC(OV)}$		+20	+23	+26	%
DRV SECTION (Pin 2)						
DRV pin sink current	I_{DRV}		2		10	mA
DIS SECTION (Pin 1)						
DIS pin sink current (Note 1)	I_{DIS}	ON state			500	mA
D+ and D- SECTION (Pin 6 and Pin 4)						
Data detect voltage	V_{DAT_REF}		0.25	0.325	0.4	V
V_{OUT} selection reference	V_{SEL_REF}		1.8	2	2.2	V
D+ to D- resistance when shorted	R_{DCP_DAT}	D+=D-=0.6V			40	Ω
D- pull-down resistance	R_{DM_DWN}		14.25	19.53	24.80	kΩ
D+ OVP threshold	V_{DP_OVP}		4.3	4.5	4.7	V
D- OVP threshold	V_{DM_OVP}		4.3	4.5	4.7	V
TIMING SECTION (Pin 4)						
QC2.0 voltage change de-glitch filter (Note 1)	$T_{GLITCH\_V\_CHANGE}$		20	40	60	ms
New voltage request interval (Note 1)	$T_{V\_NEW\_REQUEST}$		200			ms

Notes:

Note 1. These parameters are not 100% tested. They are guaranteed by design and characterization.

7.0 Typical Performance Characteristics

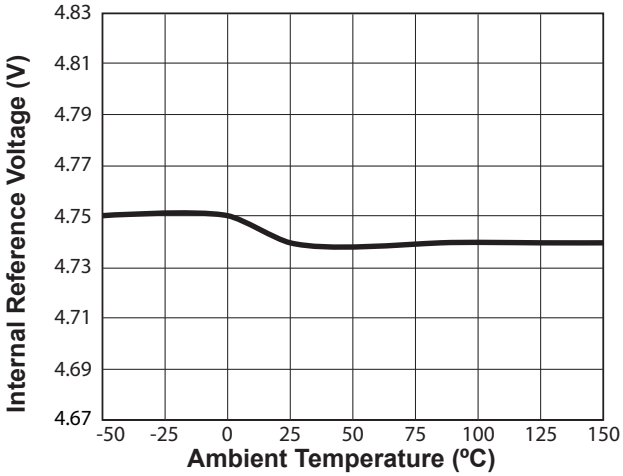


Figure 7.1 : Internal Reference Voltage vs. Ambient Temperature

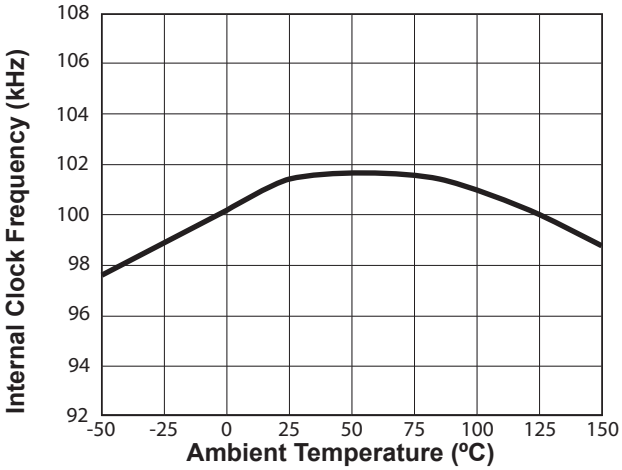


Figure 7.2 : Internal Clock Frequency vs. Ambient Temperature

8.0 Functional Block Diagram

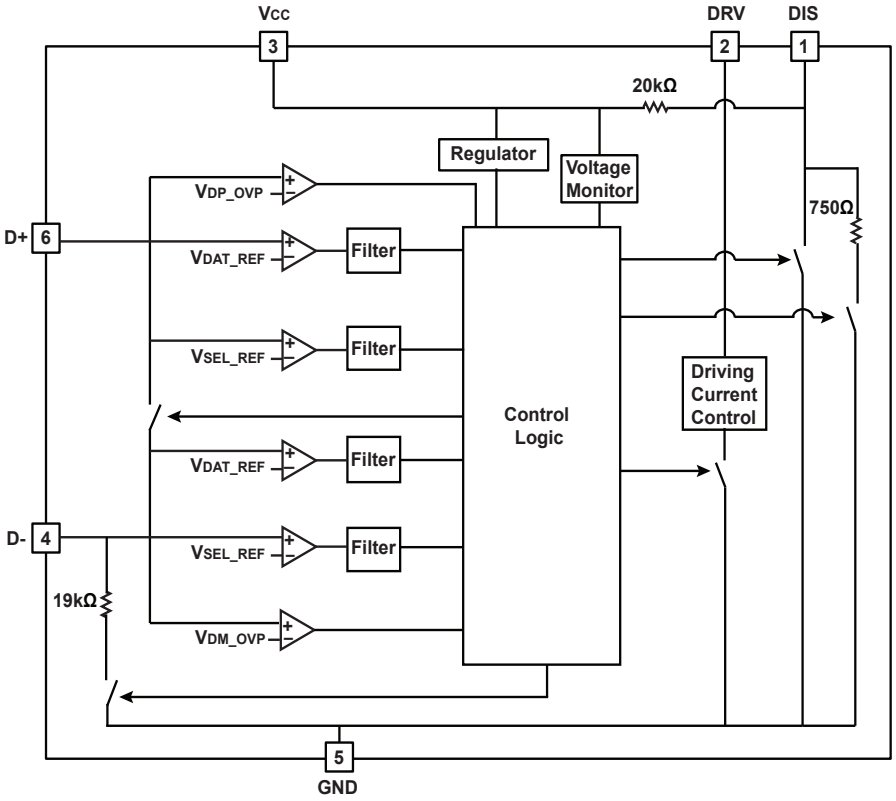


Figure 8.1: iW629 Functional Block Diagram

9.0 Theory of Operation

The iW629 is an AC/DC secondary-side controller for QC2.0 protocol and secondary-primary communication interfacing with MDs equipped with QC2.0 technology to configure the adapter output voltage to 5V/9V levels for rapid charging. The iW629 is also backward compatible with USB BC1.2 compliant MDs and other MDs to provide 5V output voltage by default setting. The iW629 can be detected as a DCP if a QC2.0-equipped MD is connected. After the initial detection stage, the iW629 interprets the D+/D- signal voltage to QC2.0 mode and its associated output voltage/current requests. A valid request is encoded to certain pulse patterns and sent to the primary side through an opto-coupler. The constant current (CC) limit setting is also sent together with the voltage request. Besides the voltage and current information, the iW629 also monitors the adapter output voltage and sends over-voltage or under-voltage information to primary side through the same opto-coupler with Dialog's proprietary secondary side to primary side digital communication protocol. An internal circuit is designed for limiting the driving current to typical operating forward current range of the opto-coupler LED so that the driving current is independent of output voltage. The iW629 should be paired with Dialog's primary-side controller, iW1780, for dynamic multi-level voltage and current configuration and control. The iW1780 has a built-in circuit to decode the different pulse patterns for voltage configuration, current limit setting, V_{OUT} under-voltage and over-voltage detection, and based on the decoded information, the iW1780 responses accordingly. The iW629 also features a programmable fast/slow active discharging function to discharge the output capacitor in a short time after a request for a lower voltage or unplug of QC2.0-equipped MDs.

9.1 Pin Detail

Pin 1 – DIS

Programmable active discharge. This pin provides fast and slow discharge paths for the external circuit, such as an output capacitor. It can also drive an external P-channel FET. When there is a request for a lower voltage or the USB MD is unplugged at a high voltage, the internal active discharge switches are turned on.

Pin 2 – DRV

External circuit drive. This pin drives the external circuit, such as the opto-coupler, to send out all the information for rapid charge. The DRV pin sink current at ON state is limited to a range such that a low-cost opto-coupler can be used.

Pin 3 – V_{cc}

IC power supply. This pin provides the IC supply voltage.

Pin 4 – D-

USB D- signal.

Pin 5 – GND

Ground.

Pin 6 – D+

USB D+ signal.

9.2 Initialization and Handshaking

An AC/DC power adaptor designed with the iW1780 and iW629 starts up initially at default 5V output voltage. When the output voltage of the AC/DC adapter, which is also the V_{CC} voltage for the iW629, rises above $V_{CC(ST)}$, the iW629 begins to work at 5V state and the D+/D- short switch is turned on. The USB BC1.2 or QC2.0 compliant MD detects the D- voltage while applying a voltage on D+ and vice versa. The iW629 is designed such that the impedance between D+ and D- is low enough to meet the specifications of USB BC1.2 and QC2.0 during the initial detection when the D+/D- short switch is on. The iW629 ensures that D+ stays between V_{DAT_REF} and V_{SEL_REF} for at least 1.25 second without any glitch before it turns off the D+/D- short switch and turns on the D- pull-down switch. The handshaking between the iW629 and QC2.0-equipped MD finishes and the iW629 starts to take voltage requests from the MD after D- is pulled down for 20ms.

9.3 D+/D- OVP

The iW629 features a proprietary D+/D- OVP, which addresses V_{BUS} to D+/D- soft short issues in the output cables and connectors and provides protection against damages.

When iW629 detects D+/D- OVP, it sends out a signal to iW1780 to shut down the TA.

9.4 Voltage and Current Request Interpretation and Encoding

After initialization and handshaking with MD, if there is a D+/D- combination change and D+/D- voltage combination is a valid QC2.0 request and passes 40ms deglitch filter. The iW629 enters QC2.0 mode.

The iW629 interprets the D+/D- combination according to QC2.0 specification. The interpretation of D+/D- combination and the voltage requests are listed in Table 9.1.

Please note that a voltage at D+ or D- is detected as:

a) 0V, if it is lower than V_{DAT_REF};

b) 0.6V, if it is between V_{DAT_REF} and V_{SEL_REF};

c) 3.3V, if it is higher than V_{SEL_REF}.

The iW1780 uses the patented primary-feedback control to achieve the multi-level constant-voltage and multi-level constant-current (CC) regulations. The CC limit is given by

$$I_{CC\_LIMIT} = \frac{k}{2} \times \frac{N}{R_S} \times \eta_x$$

where N is the transformer primary to secondary side winding turns ratio, R_S is the current sense resistor, η_X is the transformer conversion efficiency, and k is a coefficient set by the iW629 (see Section 11 for pre-defined k information).

D+	D-	V_{OUT}
3.3V	0.6V	9V
0.6V	0V	5V
0V	0/0.6/3.3V	5V
All other combinations		Stays unchanged

Table 9.1: D+/D- Signals and Adapter V_{OUT} (aka V_{BUS}, V_{CC})

The iW629 has a built-in encoder to generate different pulse patterns and to drive the internal switch of DRV pin so that the different voltage information together with the associated current limit setting can be sent to the primary side through an opto-coupler.

9.5 Programmable Active Discharge

Discharge of output capacitor is necessary for quick voltage transition from a higher level to a lower level when there is a lower voltage request. It is even more important to discharge the output capacitor quickly from a high level to 5V after the MD is unplugged in order to ensure the safety of other non-QC2.0 compliant MDs. An internal switch between the DIS pin and GND pin is turned on to provide a path from the output voltage through an external resistor, the DIS pin, and the internal switch to ground. The discharging time is programmable with the external resistor. The resistance of 47Ω or higher is recommended for the external resistor to prevent over-current or over-heat inside the IC. If certain application uses a larger output capacitor or requires faster discharging, an external P-channel FET can be used and the iW629 DIS pin can be used to drive the FET. When the MD is unplugged, the iW629 resets to its initial setting. The active fast discharge starts after a confirmed lower voltage request or after 40ms de-glitch of D+ voltage drop; it stops when the active discharge threshold of target voltage is reached or a 200ms timer (including de-glitch time) expires to avoid excess load current and high power dissipation inside the IC. After the active fast discharge stops, a slow discharge path continues to discharge the output capacitor until the 200ms timer expires.

9.6 Dynamic Preload

Flyback converter with primary-side sensing usually has a preload resistor in order to balance the power at no-load condition. If the preload resistor is sufficient for power balance at 5V output, it consumes the excessive power at 9V standby mode. An 11kΩ internal dynamic preload resistor is implemented in the iW629 between V_{CC} and GND at 5V state only. On the other hand, a fixed external preload resistor can be used in addition to the internal dynamic preload resistor for fine-tuning the preload at 5V state, and for the preload at 9V state for low standby power consumption, while the internal dynamic preload resistor is disconnected.

9.7 V_{BUS} Monitoring

In addition to encoding and transmitting the output voltage and current request, the iW629 monitors the V_{BUS} for both under-voltage and over-voltage. The V_{BUS} under-voltage or voltage undershoot is usually caused by a sudden load current increase. The iW629 also monitors the V_{BUS} over-voltage, especially the over-voltage caused by the output voltage setting mismatch between the iW1780 and iW629.

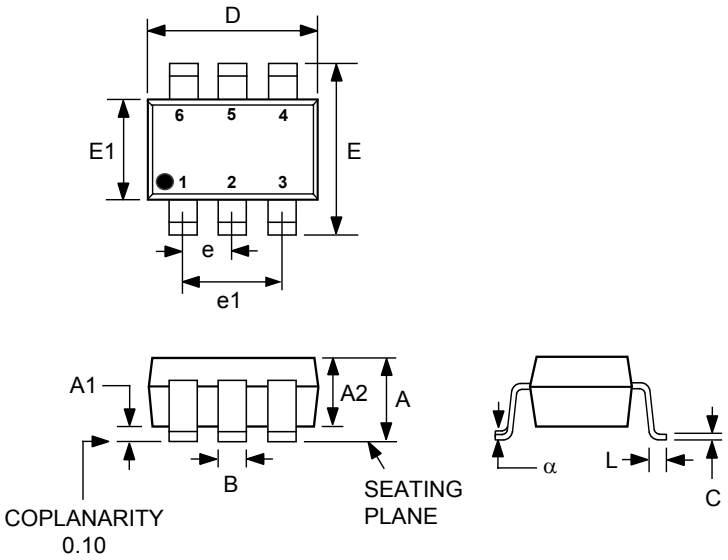
When a load transient event from light load to heavy load happens, the output voltage drops. If the output voltage drops to the voltage undershoot threshold, the iW629 turns on the LED of the opto-coupler by controlling the DRV pin sink current, and the DLNK pin of the iW1780 is pulled down by the transistor of the opto-coupler. After the iW1780 receives this DLNK pin signal, it can intelligently confirm if this signal is caused by an undershoot event and distinguish it from a voltage and current request, and then it promptly increases the switching frequency and the t_{ON} to delivery more power to the secondary side in order to bring the output voltage back to regulation. The undershoot detection signal of the iW629 is backward compatible with Dialog's secondary-side voltage position monitor, the iW628.

The iW1780/iW629 chipset added one more layer of OVP. When the V_{BUS} rises to above the over-voltage threshold of the iW629's present setting, the iW629 drives the DRV pin in a special switching pattern serving as a OVP signal and turns on both the fast and slow discharge. After the iW1780 receives this OVP signal, it shuts down the power supply promptly.

In this way, through the single opto-coupler and proprietary digital communication the iW629 transmits to the iW1780 all the necessary information for a high-performance rapid-charge AC/DC system design including output voltage requests, output current limits, output voltage undershoot and output over-voltage.

10.0 Physical Dimensions

6-Lead SOT Package



Symbol	Millimeters	
	MIN	MAX
A	-	1.45
A1	0.00	0.15
A2	0.90	1.30
B	0.30	0.50
C	0.08	0.22
D	2.90 BSC	
E	2.80 BSC	
E1	1.60 BSC	
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
α	0°	8°

Compliant to JEDEC Standard MO-178AB

Controlling dimensions are in millimeters

This package is RoHS compliant and Halide free.

Soldering Temperature Resistance:

[a] Package is IPC/JEDEC Std 020D Moisture Sensitivity Level 1

[b] Package exceeds JEDEC Std No. 22-A111 for Solder Immersion Resistance; packages can withstand 10 s immersion < 260ºC

Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.25 mm per side.

The package top may be smaller than the package bottom. Dimensions D and E1 are are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs and interlead flash, but including any mismatch between top and bottom of the plastic body.

11.0 Ordering Information

Part Number	Options	Package	Description
iW629-20[1]	Supports QC2.0 5V/9V, k = 0.411 for 5V/9V CC limits, 4.75V undershoot threshold for 5V, 11kΩ dynamic preload at 5V	SOT-23	Tape & Reel[2]

Note 1: The iW629-20 is a customized product option with 12V disabled. Adapters designed with this product option may not pass QC2.0 HVDCP compliancy test.

Note 2: Tape & Reel packing quantity is 3,000/reel. Minimum ordering quantity is 3,000.

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Contacting Dialog Semiconductor

United Kingdom
Dialog Semiconductor (UK) Ltd
Phone: +44 1793 757700

Germany
Dialog Semiconductor GmbH
Phone: +49 7021 805-0

The Netherlands
Dialog Semiconductor B.V.
Phone: +31 73 640 88 22

Email
info_pcbg@diasemi.com

North America
Dialog Semiconductor Inc.
Phone: +1 408 845 8500

Japan
Dialog Semiconductor K. K.
Phone: +81 3 5425 4567

Taiwan
Dialog Semiconductor Taiwan
Phone: +886 281 786 222

Web site:
www.dialog-semiconductor.com

Singapore
Dialog Semiconductor Singapore
Phone: +65 648 499 29

Hong Kong
Dialog Semiconductor Hong Kong
Phone: +852 2607 4271

Korea
Dialog Semiconductor Korea
Phone: +82 2 3469 8200

China
Dialog Semiconductor (Shenzhen)
Phone: +86 755 2981 3669

Dialog Semiconductor (Shanghai)
Phone: +86 21 5424 9058