Over-Voltage Protection Load Switch with Surge Protection

FEATURES

- Highly reliable 1.3mm × 1.8mm FCQFN-12 package
- Surge protection
  - IEC 61000-4-5: > 120V
- Integrated low R_{dson} nFET switch: typical 27mΩ
- 5A continuous current capability
- Default Over-Voltage Protection (OVP) threshold
  - AW32901: 5.95V
  - AW32902: 6.2V
  - AW32905: 6.8V
  - AW32909: 9.98V
  - AW32910: 10.5V
  - AW32912: 14V
- OVP threshold adjustable range: 4V to 20V
- Input system ESD protection
  - IEC 61000-4-2 Contact discharge: ±8kV
  - IEC 61000-4-2 Air gap discharge: ±15kV
- Input maximum voltage rating: $29V_{DC}$
- Fast turn-off response: typical 50ns
- Over-Temperature Protection (OTP)
- Under-Voltage Lockout (UVLO)

APPLICATIONS

- Smartphones
- Tablets
- Charging Ports

GENERAL DESCRIPTION

The AW329xx family OVP load switch features surge protection, an internal clamp circuit protects the device from surge voltages up to 120V.

The AW329xx features an ultra-low 27mΩ (typ.) R_{dson} nFET load switch. When input voltage exceeds the OVP threshold, the switch is turned off very fast to prevent damage to the protected downstream devices. The IN pin is capable of withstanding fault voltages up to $29V_{DC}$.

The default OVP threshold is 5.95V (AW32901), 6.2V (AW32902), 6.8V (AW32905), 9.98V (AW32909), 10.5V (AW32910) and 14V (AW32912), the OVP threshold can be adjusted from 4V to 20V through external OVLO pin.

The device features an open-drain output $\overline{ACOK}$, when $V_{IN\_UVLO} < V_{IN} < V_{IN\_OVLO}$ and the switch is on, $\overline{ACOK}$ will be driven low to indicate a good power input, otherwise it is high impedance.

This device features over-temperature protection that prevents itself from thermal damaging.

The AW329xx is available in a RoHS compliant 1.3mm × 1.8mm FCQFN-12 package.

TYPICAL APPLICATION CIRCUIT

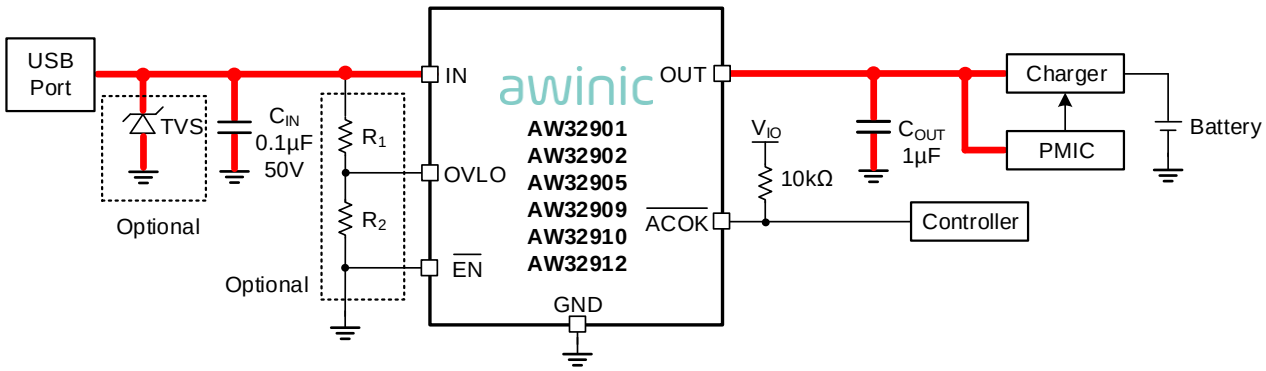

Figure 1 AW329XX typical application circuit

R_1 and R_2 are used for OVP threshold adjustment, to use default OVP threshold, connect OVLO to ground.

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DEVICE COMPARISON TABLE

Device	V_{IN_OVLO} (V)				V_{IN_OVLO} hysteresis (mV)
	Condition	Min.	Typ.	Max.	
AW32901	V_{IN} rising	5.83	5.95	6.07	130
AW32902	V_{IN} rising	6.08	6.20	6.32	130
AW32905	V_{IN} rising	6.66	6.80	6.94	140
AW32909	V_{IN} rising	9.78	9.98	10.18	210
AW32910	V_{IN} rising	10.29	10.50	10.71	210
AW32912	V_{IN} rising	13.7	14.0	14.3	280

PIN CONFIGURATION AND TOP MARK

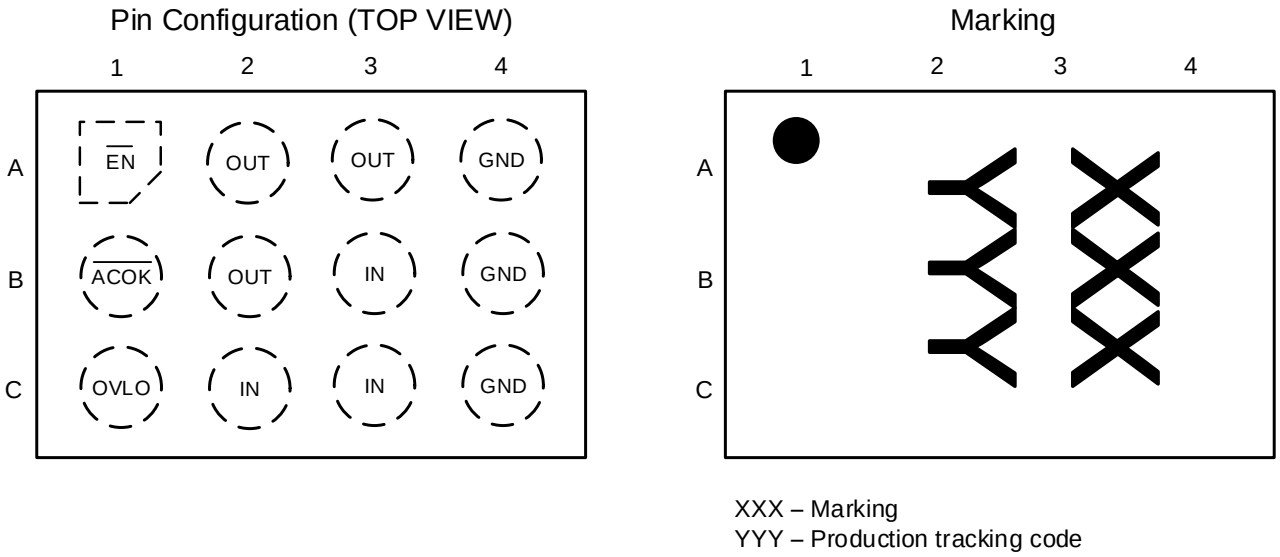


Figure 2 Pin Configuration and Top Mark

PIN DEFINITION

Pin	Name	Description
A1	$\overline{EN}$	Enable pin, active low
B1	$\overline{ACOK}$	Power good flag, active-low, open-drain
C1	OVLO	OVP threshold adjustment pin
C2, C3, B3	IN	Switch input and device power supply
A2, A3, B2	OUT	Switch output
A4, B4, C4	GND	Device ground

FUNCTIONAL BLOCK DIAGRAM

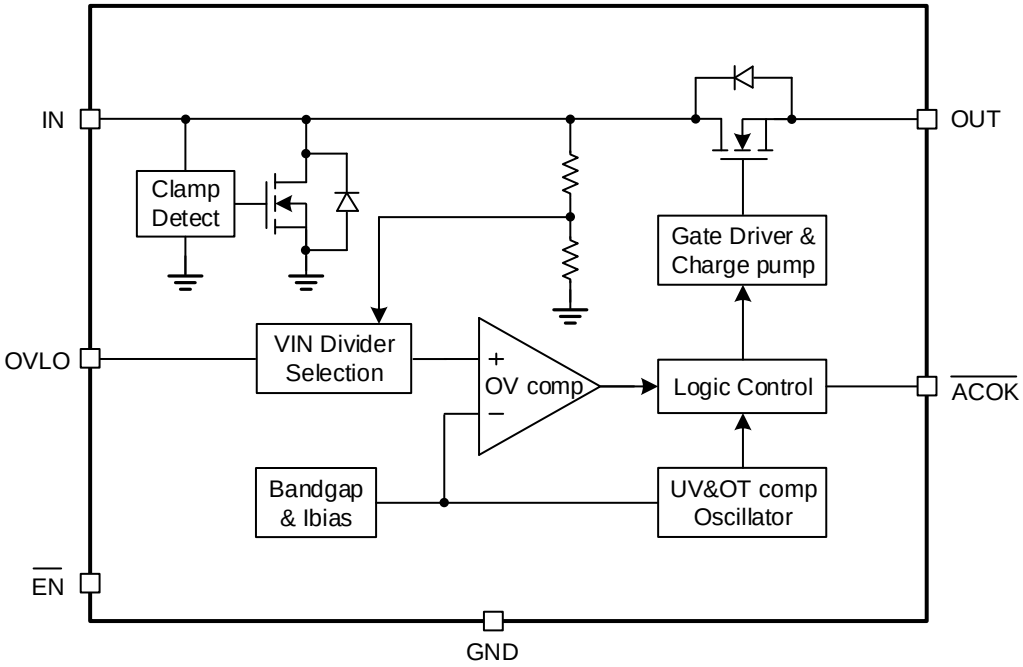


Figure 3 Functional Block Diagram

TYPICAL APPLICATION CIRCUITS

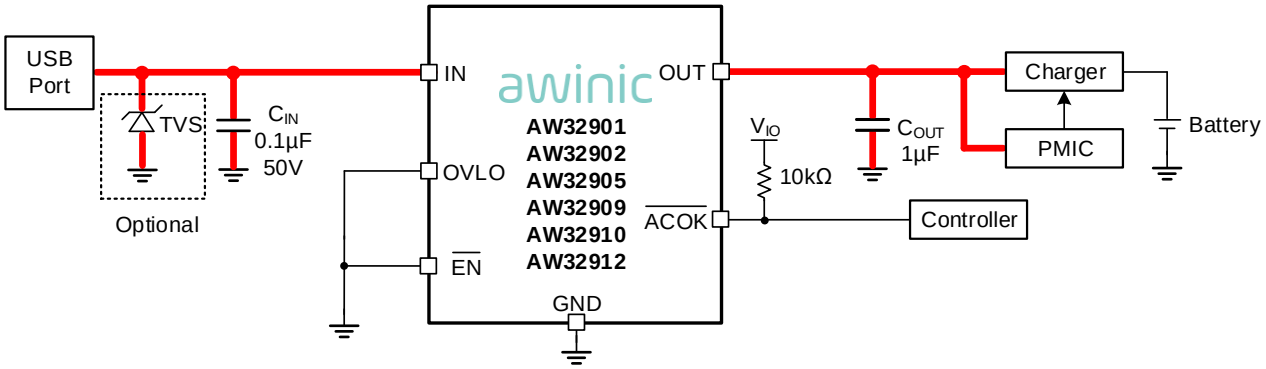


Figure 4 AW329XX typical application circuit(using default OVP threshold)

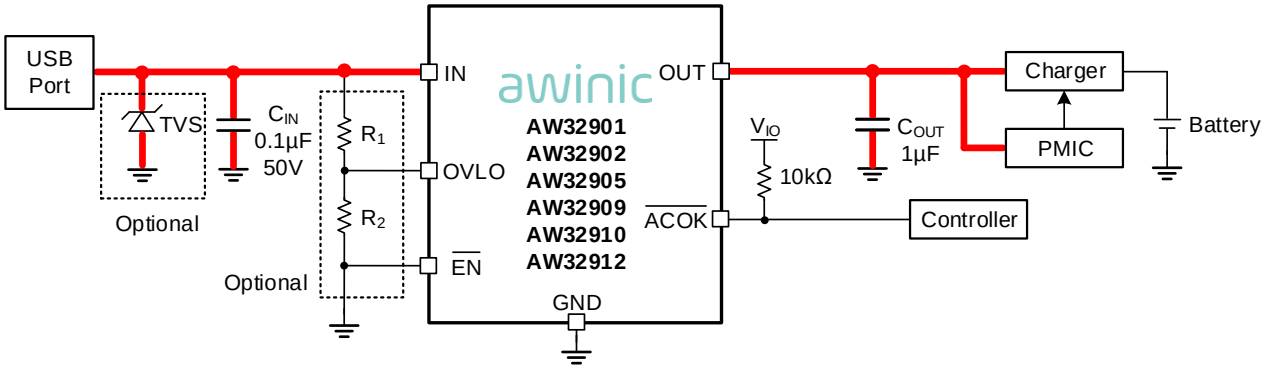


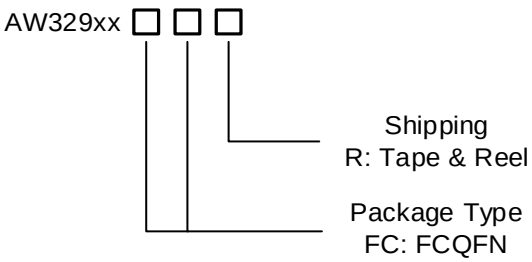
Figure 5 AW329XX typical application circuit(using external resistors set OVP threshold)

Notice for Typical Application Circuits:

1. If VBUS is required to pass surge voltage greater than 120V, external TVS is needed, the maximum clamping voltage of the TVS should be below 34V.
2. When the default OVP threshold is used, connect OVLO pin to GND directly or through a 0Ω resistor. OVLO pin cannot be left floating.
3. If R_1 and R_2 are used to adjust the OVP threshold, it is better to use 1% precision resistors to improve the OVP threshold precision.
4. If $\overline{ACOK}$ is not used, it can be left floating, or short to GND.
5. C_{IN} = 0.1μF is recommended for typical application, larger C_{IN} is also acceptable. The rated voltage of C_{IN} should be larger than the TVS maximum clamping voltage, if no TVS is applied and only AW329XX is used, the rated voltage of C_{IN} should be 50V.
6. C_{OUT} = 1μF is recommended for typical application, larger C_{OUT} is also acceptable. The rated voltage of C_{OUT} should be larger than the OVP threshold. For example, if the OVP threshold is 6.8V, the rated voltage of C_{OUT} should be 10V or higher.

ORDERING INFORMATION

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW32901FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	NV9	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel
AW32902FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	OWM	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel
AW32905FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	RZR	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel
AW32909FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	V5B	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel
AW32910FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	N9V	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel
AW32912FCR	-40°C – 85°C	1.3mm × 1.8mm × 0.55mm FCQFN-12	PBN	MSL1	ROHS+HF	Tape and Reel 3000pcs/Reel



ABSOLUTE MAXIMUM RATINGS (NOTE 1)

Symbol	Parameter	Condition	Min.	Max.	Unit
V_{IN}	Input voltage		-0.3	29	V
V_{OUT}	Output voltage		-0.3	See(NOTE 2)	V
V_{OVLO}	OVLO voltage		-0.3	6	V
$V_{\overline{ACOK}}$	$\overline{ACOK}$ voltage		-0.3	6	V
$V_{\overline{EN}}$	$\overline{EN}$ voltage		-0.3	6	V
I_{SW}	Continuous current of switch IN-OUT(NOTE 3)	Continuous current on IN and OUT pin		5	A
I_{PEAK}	Peak current	Peak input and output current on IN and OUT pin(10ms)		8	A
I_{DIODE}	Continuous diode current	Continuous forward current through the nFET body diode		1.5	A
T_A	Ambient temperature		-40	85	°C
T_J	Junction temperature		-40	150	°C
T_{STG}	Storage temperature		-65	150	°C
T_{LEAD}	Soldering temperature	At leads, 10 seconds		260	°C
Surge	Input surge protection	IEC61000-4-5 test with 2Ω equivalent series resistance	120		V

NOTE1: Conditions out of those ranges listed in "absolute maximum ratings" may cause permanent damages to the device. In spite of the limits above, functional operation conditions of the device should within the ranges listed in "recommended operating conditions". Exposure to absolute-maximum-rated conditions for prolonged periods may affect device reliability.

NOTE2: *29V or V_{IN}+0.3V, whichever is smaller.*

NOTE3: *Limited by thermal design.*

THERMAL INFORMATION

Symbol	Parameter	Condition	Value	Unit
$R_{\theta JA}$	Thermal resistance from junction to ambient (NOTE 1)	In free air	65	°C/W

NOTE1: Thermal resistance from junction to ambient is highly dependent on PCB layout.

ESD AND LATCH-UP RATINGS

Symbol	Parameter	Condition	Value	Unit
V_{ESD}	IEC61000-4-2 system ESD on IN pin	Contact discharge	±8	kV
		Air gap discharge	±15	kV
	Human Body Model	All pins, per MIL-STD-883J Method 3015.9	±2	kV
	Charged Device Model	All pins, per ESDA/JEDEC JS-002-2014	±1	kV
	Machine Model	All pins, per JESD22-A115C	±200	V
$I_{Latch-up}$	Latch-up	All pins, per JESD78D, I Trigger	±800	mA

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IN}	Input DC voltage	3		28	V
C_{IN}	Input capacitance		0.1		μF
C_{OUT}	Output load capacitance		1		μF

ELECTRICAL CHARACTERISTICS

T_A = -40°C to 85°C unless otherwise noted. Typical values are guaranteed for V_{IN} = 5V, C_{IN} = 0.1μF, I_{IN}≤ 5A and T_A = 25℃.

Symbol	Description	Test Conditions		Min.	Typ.	Max.	Units
V_{IN_CLAMP}	Input clamp voltage	I_{IN} = 10mA			30.8		V
R_{dson}	Switch on resistance	V_{IN} = 5V, I_{OUT} = 1A, T_A = 25°C			27	37	mΩ
I_Q	Input quiescent current	V_{IN} = 5V, V_{OVLO}=0V,I_{OUT} = 0A			65	130	μA
I_{IN_OVLO}	Input current at over-voltage condition	V_{IN} = 5V, V_{OVLO}=3V,V_{OUT} = 0V			60	120	μA
V_{OVLO_TH}	OVLO set threshold			1.16	1.20	1.24	V
V_{OVLO_RNG}	OVP threshold adjustable range			4		20	V
V_{OVLO_SEL}	External OVLO select threshold	OVLO rising		0.19	0.26	0.33	V
		Hysteresis			0.06		V
I_{OVLO}	OVLO pin leakage current	V_{OVLO}=V_{OVLO_TH}		-0.2		0.2	μA
Protection							
V_{IN_OVLO}	OVP trip level	AW32901	V_{IN} rising	5.83	5.95	6.07	V
			Hysteresis		0.13		
		AW32902	V_{IN} rising	6.08	6.20	6.32	
			Hysteresis		0.13		
		AW32905	V_{IN} rising	6.66	6.80	6.94	
			Hysteresis		0.14		
		AW32909	V_{IN} rising	9.78	9.98	10.18	
			Hysteresis		0.21		
		AW32910	V_{IN} rising	10.29	10.50	10.71	
			Hysteresis		0.21		
		AW32912	V_{IN} rising	13.7	14.0	14.3	
			Hysteresis		0.28		

ELECTRICAL CHARACTERISTICS (CONTINUED)

T_A = -40°C to 85°C unless otherwise noted. Typical values are guaranteed for V_{IN} = 5V, C_{IN} = 0.1μF, I_{IN}≤ 5A and T_A = 25℃.

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
Protection(continued)						
V_{IN_UVLO}	UVLO trip level	V_{IN} rising		2.9	3.0	V
		Hysteresis		0.1		
T_{SDN}	Shutdown temperature			150		°C
T_{SDN_HYS}	Shutdown temperature hysteresis			20		°C
R_{DCHG}	Output discharge resistance	V_{OUT}=7V,V_{OVLO}=3V		50		Ω
Digital Logical Interface						
V_{OL}	$\overline{ACOK}$ output low voltage	I_{SINK}=1mA			0.4	V
$I_{LEAK\_\overline{ACOK}}$	$\overline{ACOK}$ leakage current	V_{IO}=5V, $\overline{ACOK}$ de-asserted	-0.5		0.5	μA
V_{IH}	$\overline{EN}$ input high voltage		1.2			V
V_{IL}	$\overline{EN}$ input low voltage				0.5	V
$I_{LEAK\_\overline{EN}}$	$\overline{EN}$ leakage current	$V_{\overline{EN}}$ = 5V	0		2	μA
Timing Characteristics (Figure 6)						
t_{DEB}	Debounce time	From V_{IN} > V_{IN_UVLO} to 10% V_{OUT}		15		ms
t_{START}	Start-up time	From V_{IN} > V_{IN_UVLO} to $\overline{ACOK}$ low		30		ms
t_{ON}	Switch turn-on time	R_L = 100Ω, C_L = 22μF, V_{OUT} from 10% V_{IN} to 90% V_{IN}		2		ms
t_{OFF}	Switch turn-off time	C_L = 0μF, R_L = 100Ω, V_{IN} > V_{IN_OVLO} to V_{OUT} stop rising, V_{IN} rise at 10V/μs		50		ns

TIMING DIAGRAM

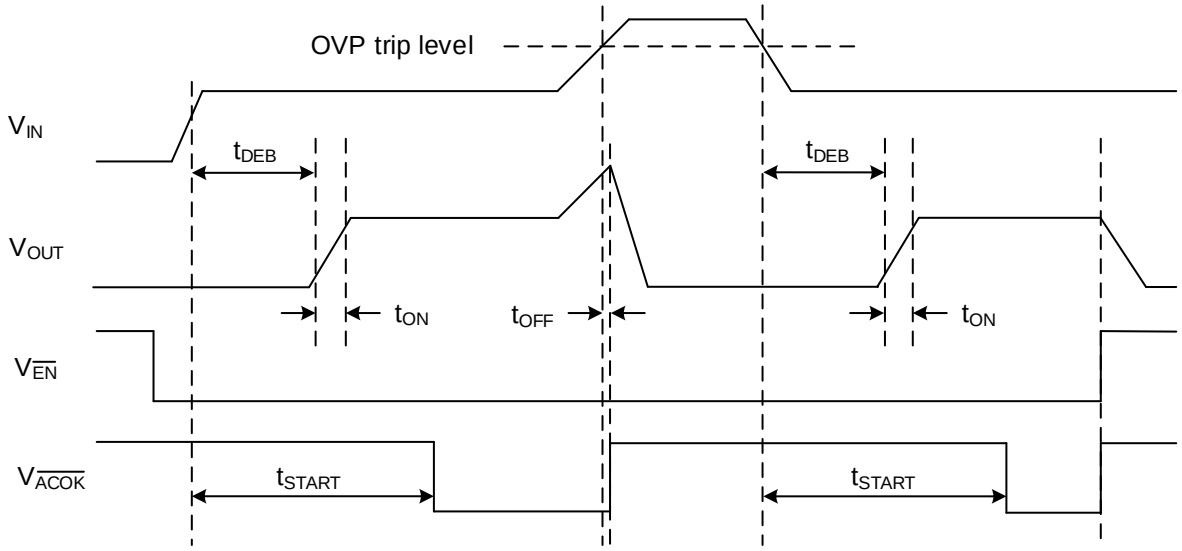


Figure 6 Timing diagram

TYPICAL CHARACTERISTICS

Table 1 Table of Figures

V_{IN} = 5V, $V_{\overline{EN}}$ = 0V, V_{OVLO} = 0V, C_{IN} = 0.1μF, C_{OUT} = 1μF, and T_A = 25°C unless otherwise specified.

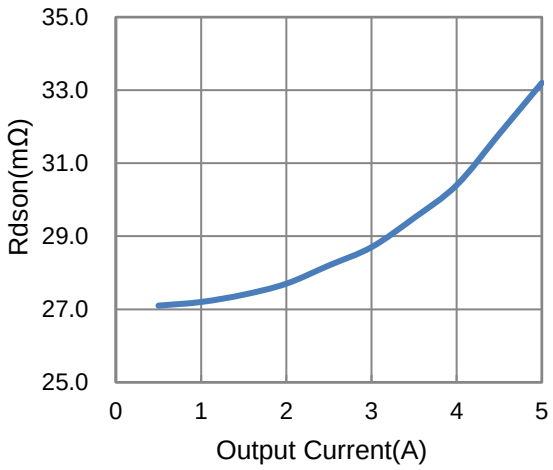


Figure 7 R_{dson} vs. Output Current

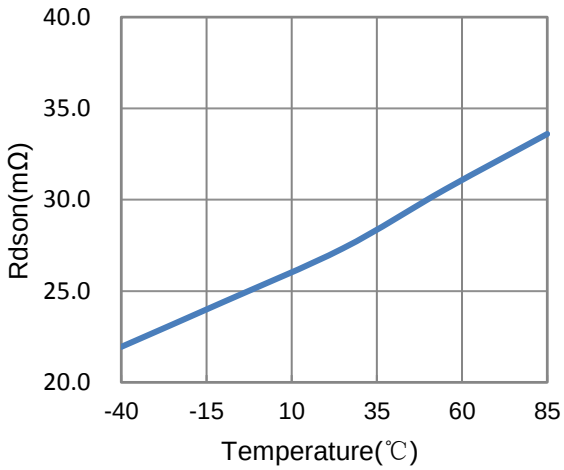


Figure 8 R_{dson} vs. Temp. (I_{OUT} = 1A)

TYPICAL CHARACTERISTICS (CONTINUED)

V_{IN} = 5V, $V_{\overline{EN}}$ = 0V, V_{OVLO} = 0V, C_{IN} = 0.1μF, C_{OUT} = 1μF, and T_A = 25°C unless otherwise specified.

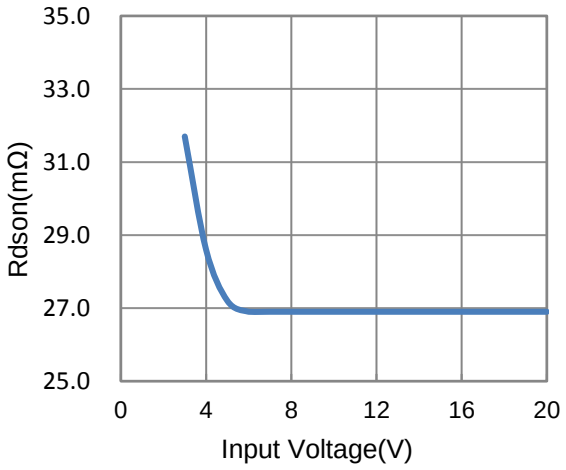


Figure 9 R_{dson} vs. Input Voltage (I_{OUT} = 1A)

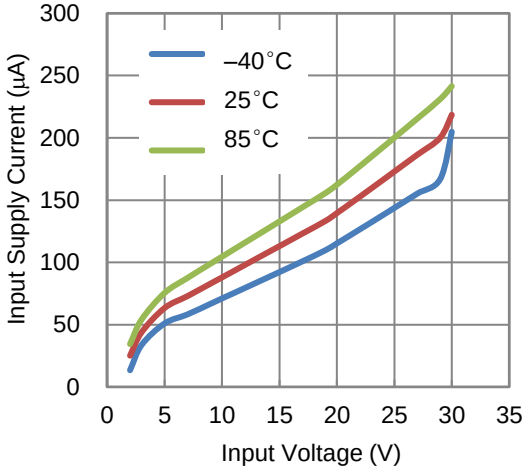


Figure 10 Input Supply Current vs. Supply Voltage

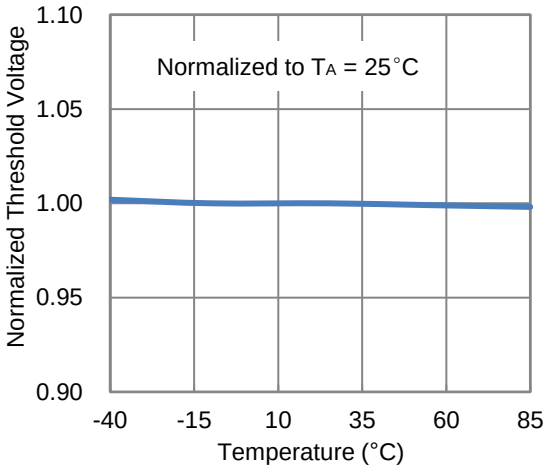


Figure 11 Normalized Internal OVP Threshold vs. Temp.

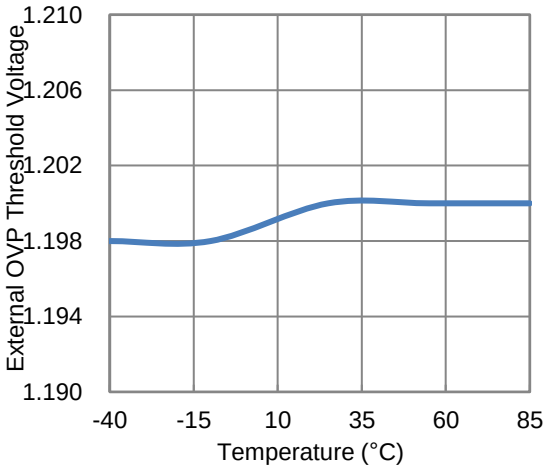


Figure 12 OVLO set threshold vs. Temp.

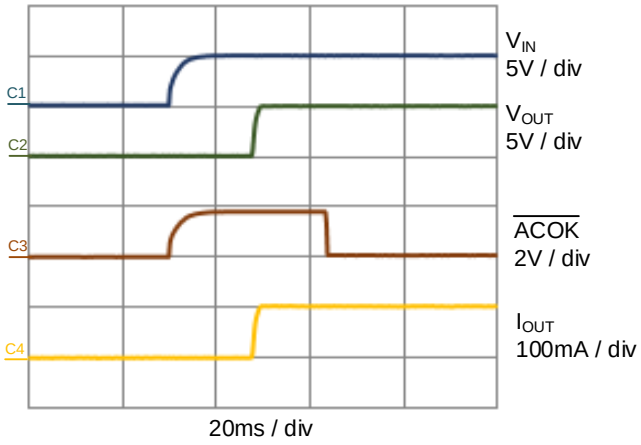


Figure 13 Power-up (C_{OUT} = 1μF, 100mA load).

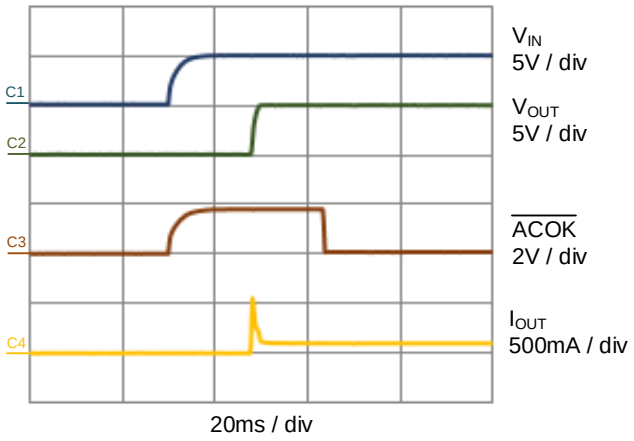


Figure 14 Power-up (C_{OUT} = 100μF, 100mA load)

TYPICAL CHARACTERISTICS (CONTINUED)

V_{IN} = 5V, $V_{\overline{EN}}$ = 0V, V_{OVLO} = 0V, C_{IN} = 0.1μF, C_{OUT} = 1μF, and T_A = 25°C unless otherwise specified.

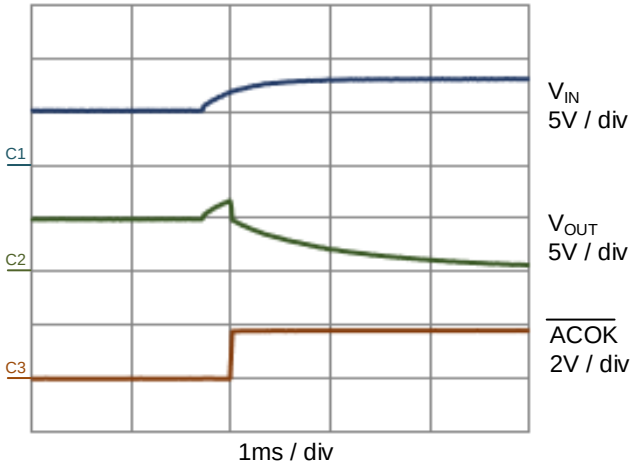


Figure 15 OVP Response (AW32905)

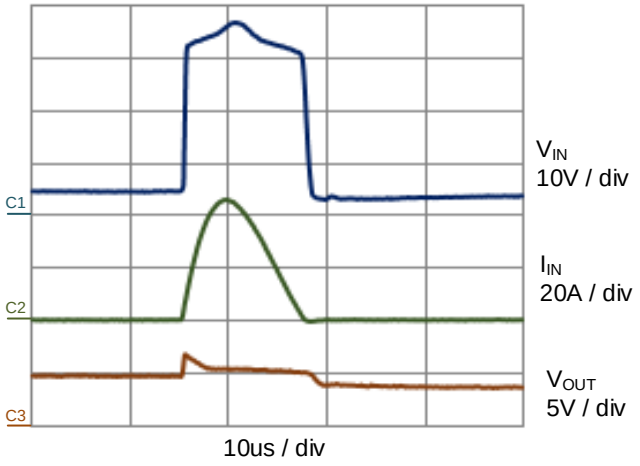


Figure 16 130V Surge Response (AW32905)

FUNCTIONAL DESCRIPTION

Device Operation

If the AW329xx is enabled and the input voltage is between UVLO and OVP threshold, the internal charge pump begins to work after debounce time, the gate of the nFET switch will be slowly charged high till the switch is fully on. $\overline{ACOK}$ will be driven low about 30ms after V_{IN} valid, indicating the switch is on with a good power input. If the input voltage exceeds the OVP trip level, the switch will be turned off in about 50ns. If $\overline{EN}$ is pulled high, or input voltage falls below UVLO threshold, or over-temperature happens, the switch will also be turned off.

Surge Protection

The AW329xx integrates a clamp circuit to suppress input surge voltage. For surge voltages between V_{IN_OVLO} and V_{IN_CLAMP}, the switch will be turned off but the clamp circuit will not work. For surge voltages greater than V_{IN_CLAMP}, the internal clamp circuit will detect surge voltage level and discharge the surge energy to ground. The device can suppress surge voltages up to 120V.

Over-Voltage Protection

If the input voltage exceeds the OVP rising trip level, the switch will be turned off in about 50ns. The switch will remain off until V_{IN} falls below the OVP falling trip level.

OVP Threshold Adjustment

If the default OVP threshold is used, OVLO pin must be grounded. If OVLO pin is not grounded, and by connecting external resistor divider to OVLO pin as shown in the typical application circuit, between IN and GND, the OVP threshold can be adjusted as following:

$$V_{IN\_OVLO} = \frac{R_1+R_2}{R_2} V_{OVLO\_TH}$$

For example, if we select R_1 = 1MΩ and R_2 = 100kΩ, then the new OVP threshold calculated from the above formula is 13.2V. The OVP threshold adjustment range is from 4V to 20V. When the OVLO pin voltage V_{OVLO} exceeds V_{OVLO_SEL} (0.26V typical), V_{OVLO} is compared with the reference voltage V_{OVLO_TH} (1.2V typical) to judge whether input supply is over-voltage.

$\overline{ACOK}$ Output

The device features an open-drain output $\overline{ACOK}$, it should be connected to the system I/O rail through a pull-up resistor. If the device is enabled and $V_{IN\_UVLO} < V_{IN} < V_{IN\_OVLO}$, $\overline{ACOK}$ will be driven low indicating the switch is on with a good power input. If OVP, UVLO, or OT occurs, or $\overline{EN}$ is pulled high, the switch will be turned off and $\overline{ACOK}$ will be pulled high.

USB On-The-Go (OTG) Operation

If V_{IN} = 0V and OUT is supplied by OTG voltage, the body diode of the load switch conducts current from OUT to IN and the voltage drop from OUT to IN is approximately 0.7V. When $V_{IN} > V_{IN\_UVLO}$, internal charge pump begins to open the load switch after debounce time (about 15ms). After switch is fully on, current is supplied through switch channel and the voltage drop from OUT to IN is minimum.

PCB LAYOUT CONSIDERATION

To make fully use of the performance of AW329XX, the guidelines below should be followed.

1. All the peripherals should be placed as close to the device as possible. Place the input capacitor C_{IN} on the top layer (same layer as the AW329XX) and close to IN pin, and place the output capacitor C_{OUT} on the top layer (same layer as the AW329XX) and close to OUT pin.

2. If external TVS is used, IN pin routing passes through the external TVS firstly, and then connect AW329XX.

3. Red bold paths on figure 4 and 5 are power lines that will flow large current, please route them on PCB as straight, wide and short as possible.

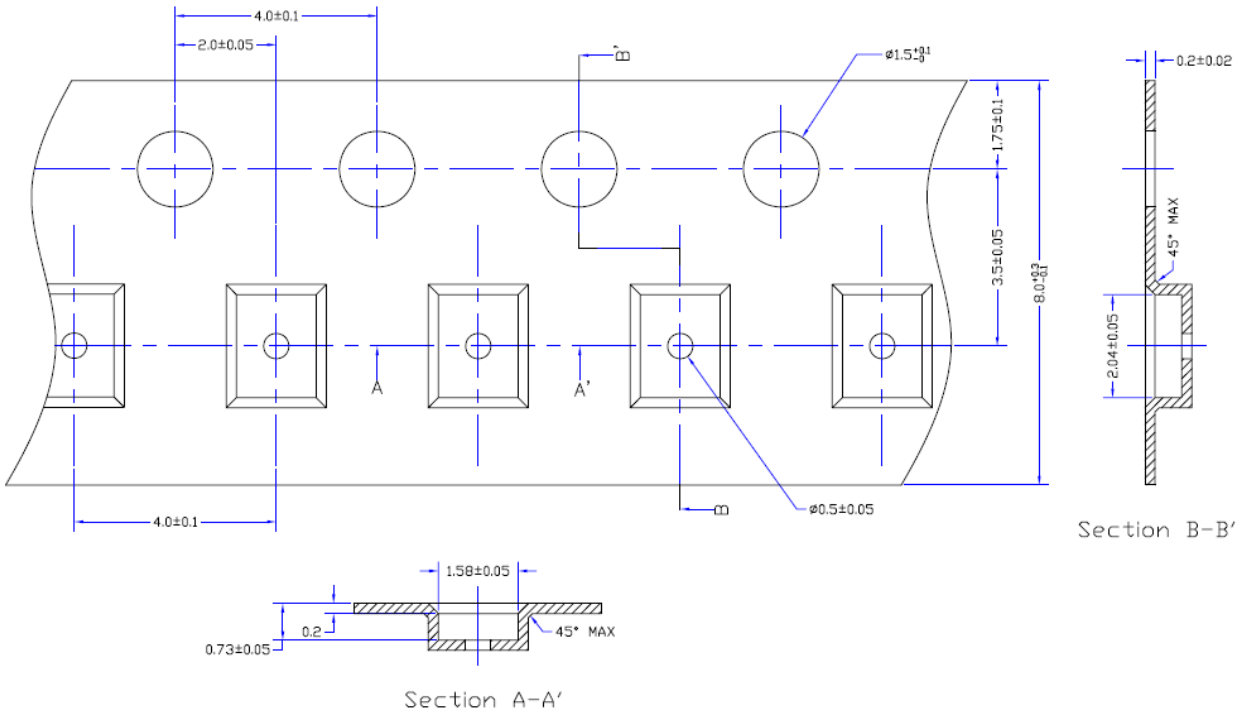
4. If R_1 and R_2 are used, route OVLO line on PCB as short as possible to reduce parasitic capacitance.

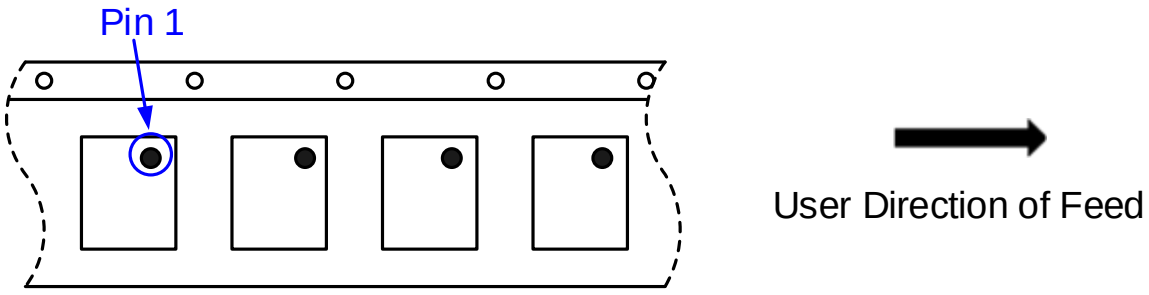
5. The power trace from USB connector to AW329XX may suffer from ESD event, keep other traces away from it to minimize possible EMI and ESD coupling.

6. Use rounded corners on the power trace from USB connector to AW329XX to decrease EMI coupling.

TAPE AND REEL INFORMATION

CARRIER TAPE

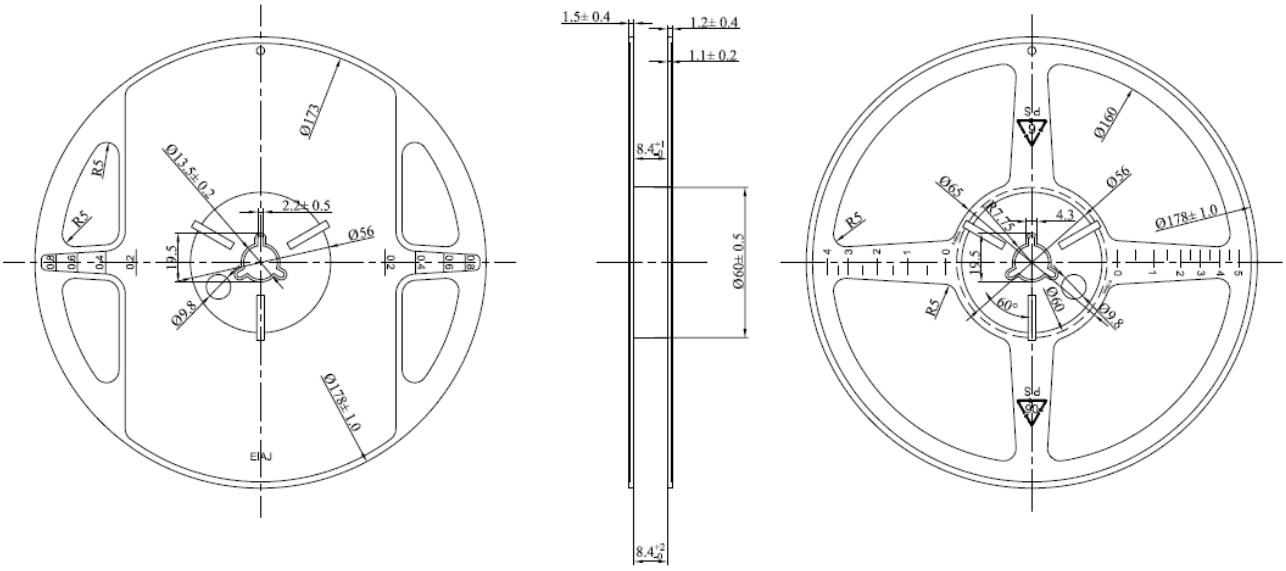




NOTE:

1. Unit: mm;
2. Material: 3000(carbon filled polycarbonate);
3. A permissible difference of the accumulation pitch of the sending hole is assumed to be ±0.2 up to 10 pitches;
4. Surface resistance: 10^5 to 10^{11} ohms/sq.

REEL

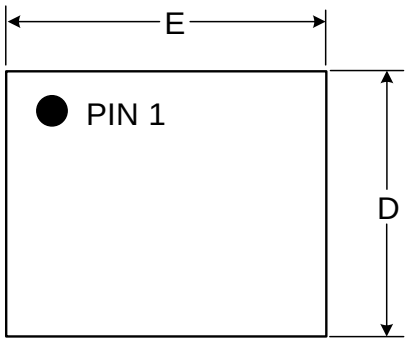


NOTE:

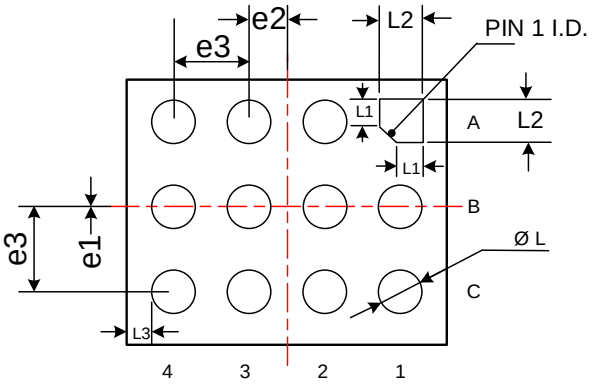
1. Units: mm;
2. Material: polystyrene;
3. Planeness: max 3mm;
4. Surface resistance: 10^5 to 10^{11} ohms/sq;
5. All outstanding tolerance: ±0.25mm.

PACKAGE DESCRIPTION

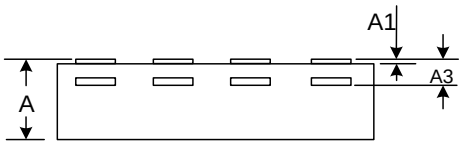
TOP VIEW



BOTTOM VIEW



SIDE VIEW



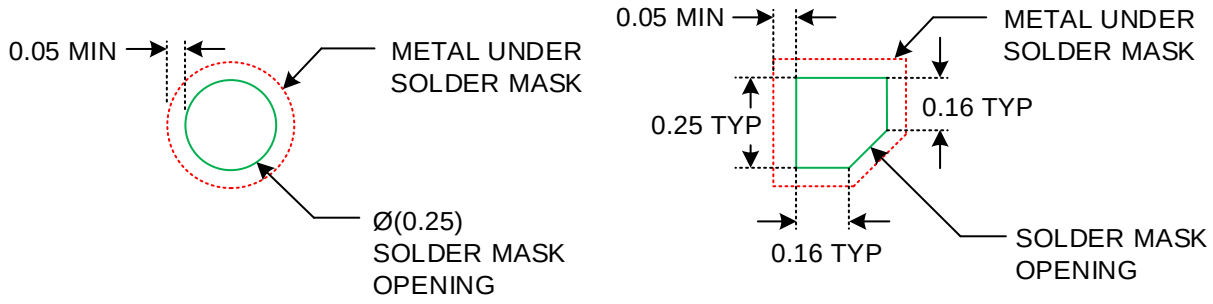
SYMBOL	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.15REF.	
D	1.20	1.30	1.40
E	1.70	1.80	1.90
e1		0 REF.	
e2		0.200REF.	
e3		0.400REF.	
L	0.18	0.25	0.30
L1		0.16REF.	
L2		0.25REF.	
L3		0.175REF.	

Unit: mm

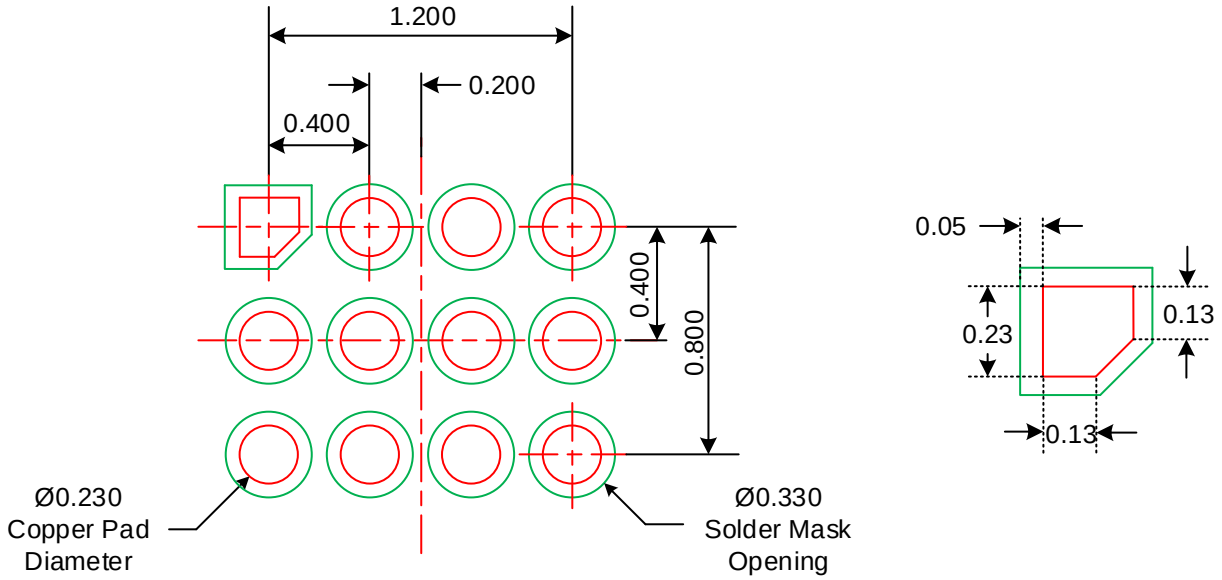
NOTE:

All dimensions do not include mold flash or protrusions.

SOLDER MASK DETAILS



Pad Type: Solder Mask Defined



PAD Type: Non-Solder Mask Defined

NOTE:

1. Not to scale
2. Unit: mm.

REFLOW

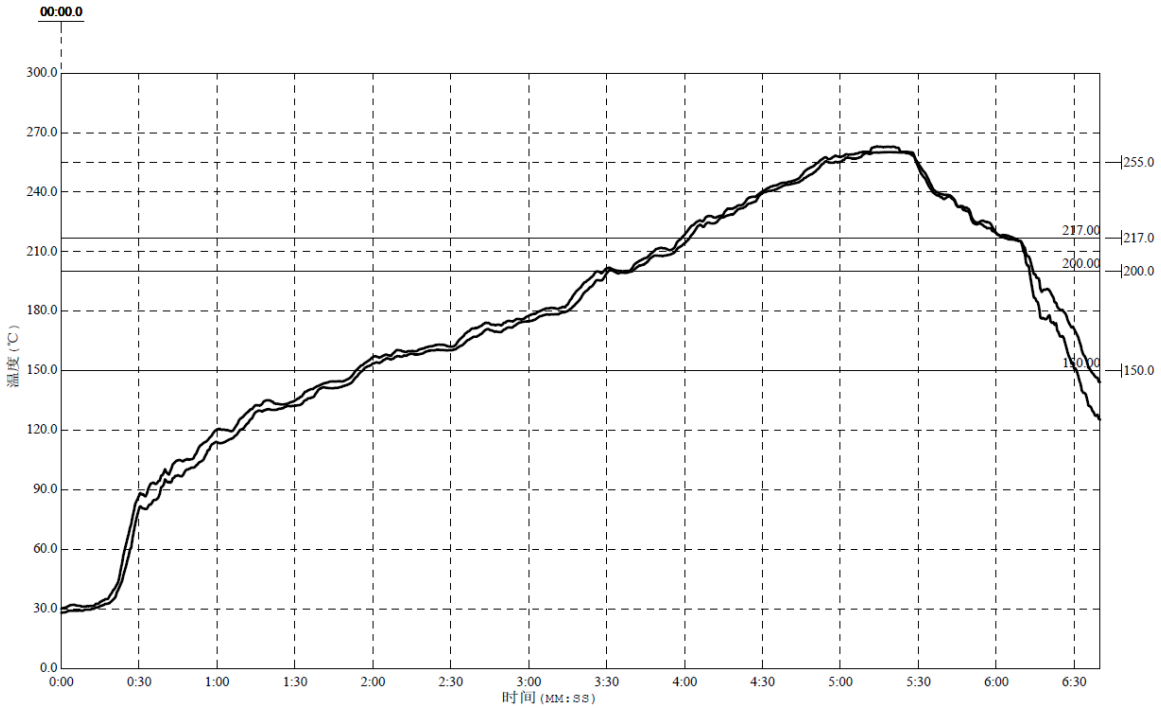


Figure 17 Package Reflow Oven Thermal Profile

Table 2 Package Reflow Standard

Reflow Note	Spec
Average ramp-up rate (217°C to Peak)	Max. 3°C /sec
Time of Preheat temp.(from 150°C to 200°C)	60-120 sec
Time to be maintained above 217°C	60-150 sec
Peak Temperature	250-260°C
Time within 5°C of actual peak temp	20-40 sec
Ramp-down rate	Max. 6°C /sec
Time from 25°C to peak temp	Max. 8min

NOTE:

1. All data are compared with the package-top temperature, measured on the package surface;
2. AW329XX adopted the Pb-Free assembly.

REVISION HISTORY

Vision	Date	Change Record
V0.9	February 2018	Datasheet V0.9 released
V1.0	April 2018	1. Added Typical Characteristics. 2. Added Tape and Reel Information. 3. Added Solder Mask Details. 4. Added Reflow Information.
V1.1	September, 2018	Storage Temperature Modified

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