Over-Voltage Protection Load Switch with Surge Protection

Features

- Highly reliable 1.3mm × 1.8mm FCQFN-12L 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
  - AW32905E: 6.8V
- OVP threshold adjustable range: 4V to 24V
- 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 AW32905E OVP load switch features surge protection, an internal clamp circuit protects the device from surge voltages up to 120V.

The AW32905E 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 6.8V, to use default OVP threshold, please NC R1, and R2=0Ω，OVLO must connect to GND. Don't float. The OVP threshold can be adjusted from 4V to 24V 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.

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Typical Application Circuit

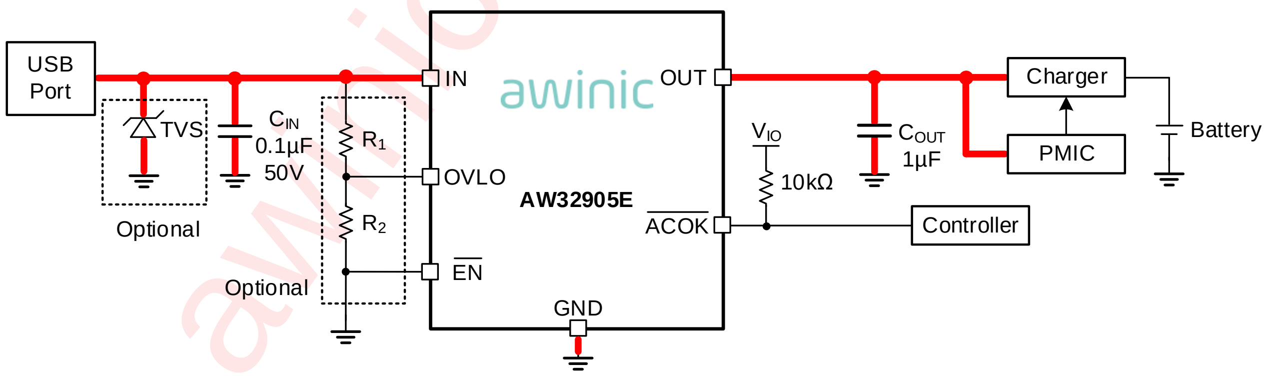

Figure 1 AW32905E typical application circuit

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

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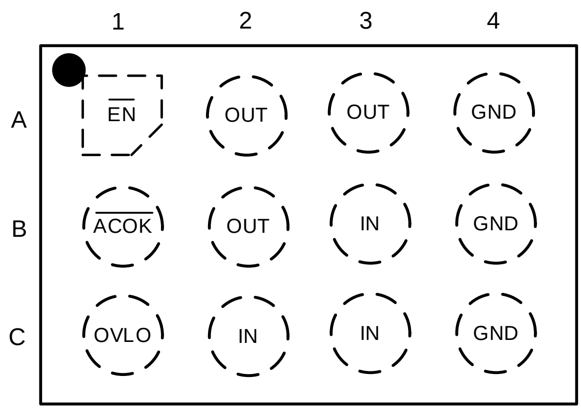
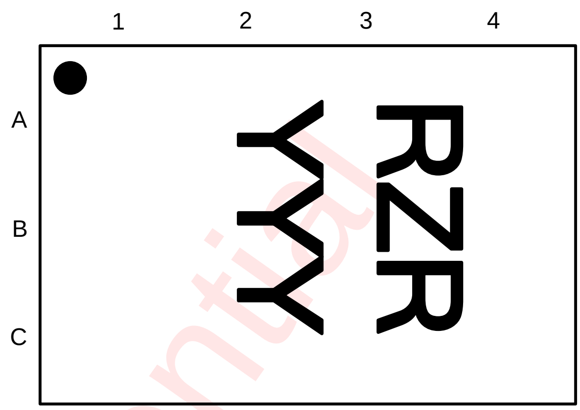
Pin Configuration and Top Mark

AW32905EFCR
(Top View)



AW32905EFCR Marking
(Top View)



RZR – AW32905EFCR
YYY – Production tracking code

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 output. When $V_{IN\_UVLO} < V_{IN} < V_{IN\_OVLO}$, $\overline{ACOK}$ is pulled low, otherwise it's hi-Z state
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

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Functional Block Diagram

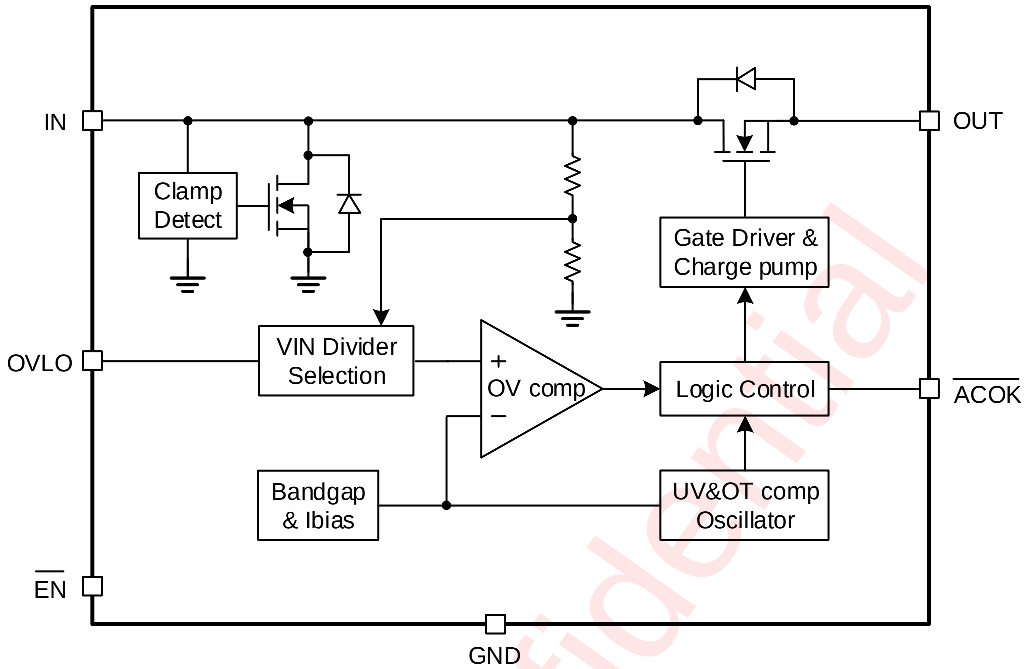

Figure 3 Functional Block Diagram

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Typical Application Circuits

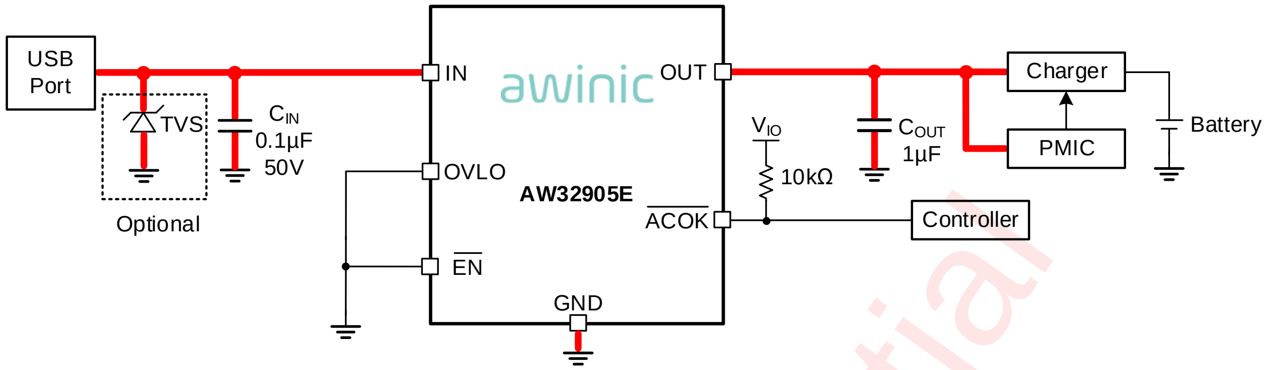

Figure 4 AW32905E typical application circuit(using default OVP threshold)

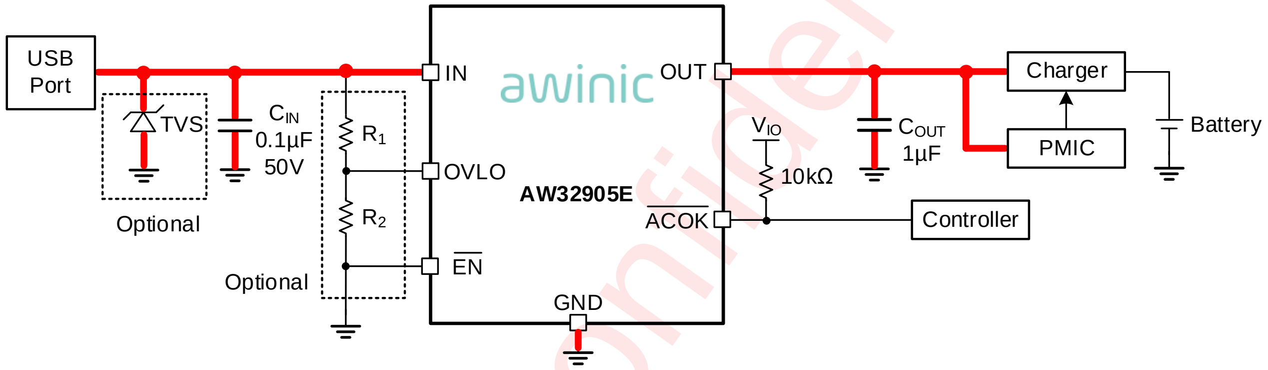

Figure 5 AW32905E typical application circuit (using external resistors set OVP threshold)

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 **29V**.
2. When the default OVP threshold is used, connect OVLO pin to GND directly or through a 0Ω resistor, R2=0Ω, R1 NC, **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 AW32905E 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.

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Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW32905EFCR	-40°C – 85°C	FCQFN 1.3mm×1.8mm -12L	RZR	MSL1	ROHS+HF	3000 units/ Tape and 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.

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Thermal Information

Symbol	Parameter	Condition	Value	Unit
$R_{\theta JA}$	Thermal resistance from junction to ambient (NOTE 4)	In free air	65	°C/W

NOTE4: 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

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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		24	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	V_{IN} rising	6.66	6.80	6.94	V
		Hysteresis		0.14		V
V_{IN_UVLO}	UVLO trip level	V_{IN} rising		2.9	3.0	V
		Hysteresis		0.1		V
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

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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
Digital Logical Interface (Continued)						
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

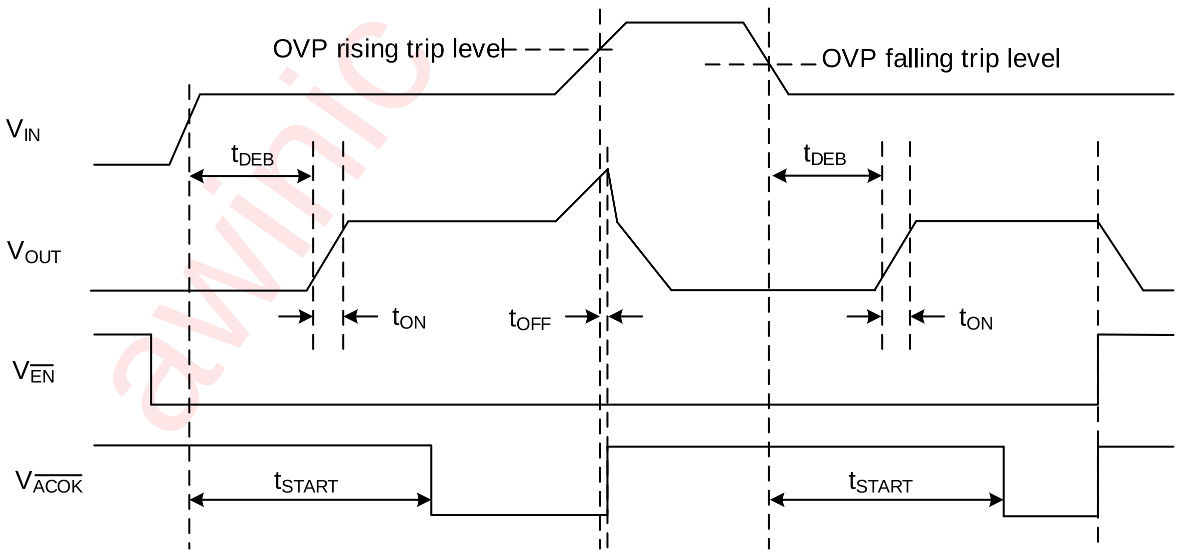

Figure 6 Timing diagram

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Typical Characteristics

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.

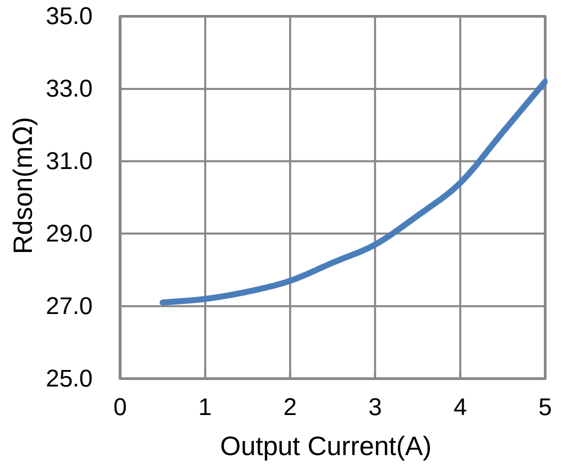

Figure 7 R_{dson} vs. Output Current

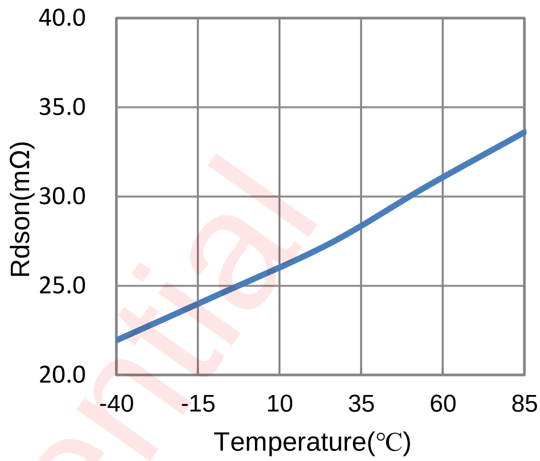

Figure 8 R_{dson} vs. Temp. (I_{OUT} = 1A)

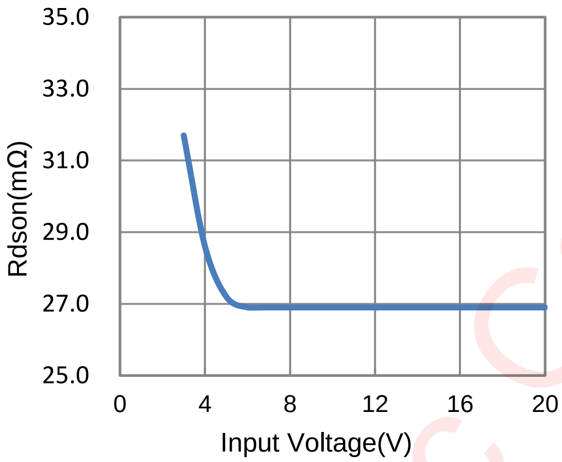

Figure 9 R_{dson} vs. Input Voltage (I_{OUT} = 1A)

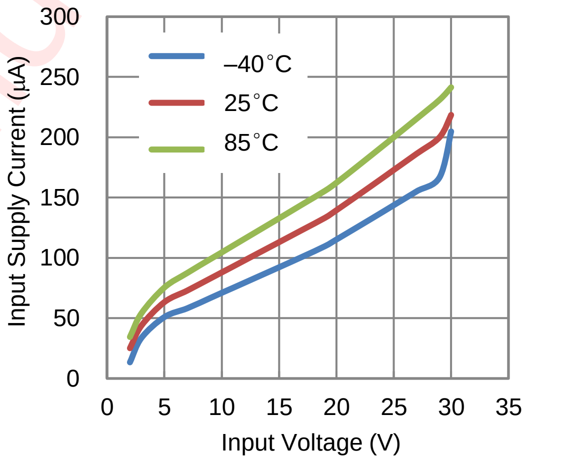

Figure 10 Input Supply Current vs. Supply Voltage

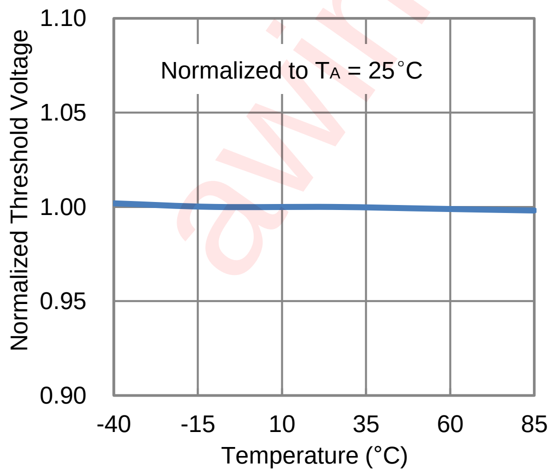

Figure 11 Normalized Internal OVP Threshold vs. Temp.

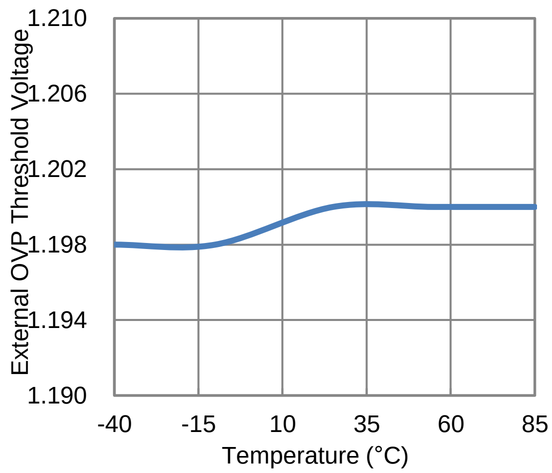

Figure 12 OVLO set threshold vs. Temp.

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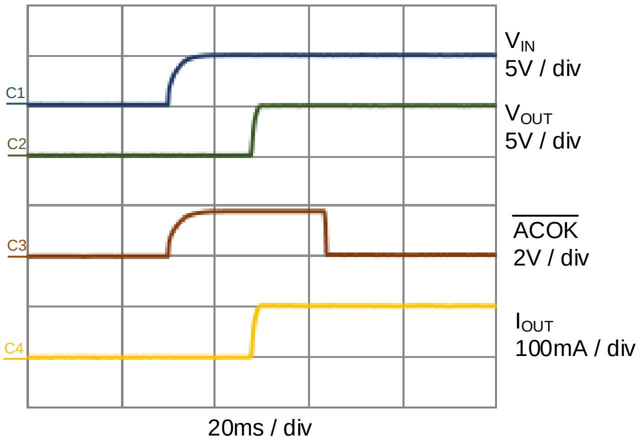
Typical Characteristics (Continued)

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.



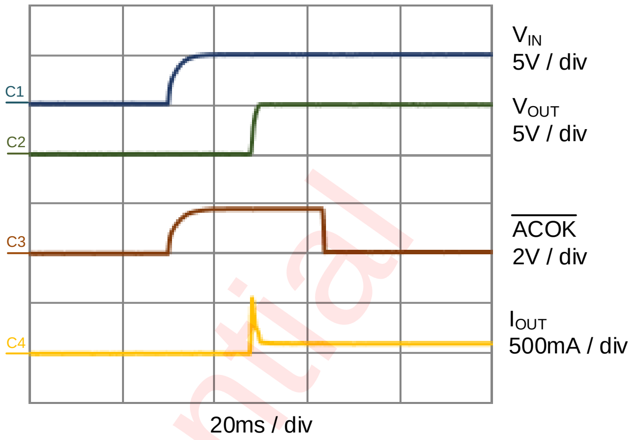


Figure 13 Power-up (C_{OUT} = 1μF, 100mA load).

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

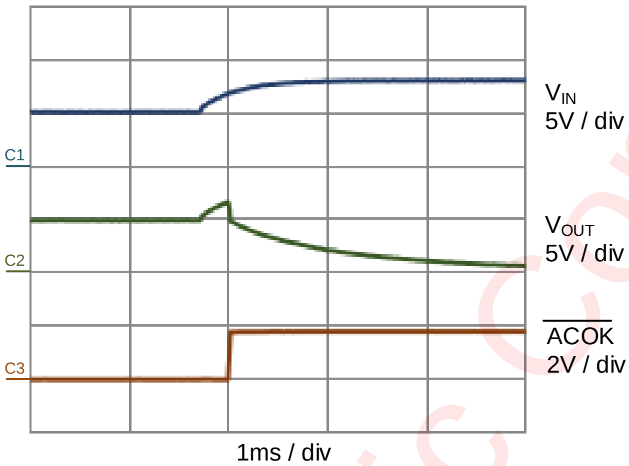


Figure 15 OVP Response (AW32905E)

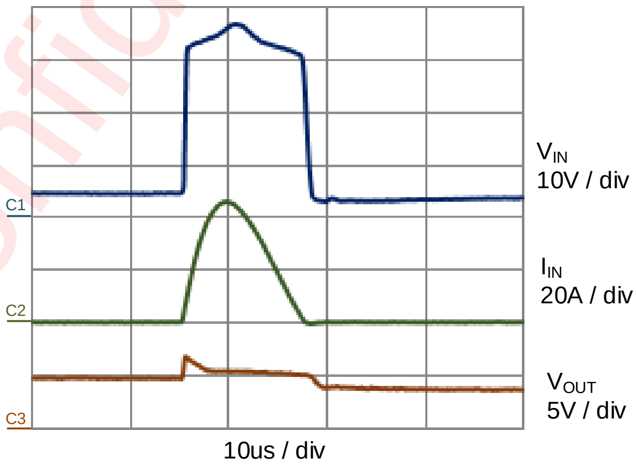


Figure 16 130V Surge Response (AW32905E)

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Functional Description

Device Operation

If the AW32905E 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. $\overline{\text{ACOK}}$ 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 $\overline{\text{EN}}$ is pulled high, or input voltage falls below UVLO threshold, or over-temperature happens, the switch will also be turned off.

Surge Protection

The AW32905E 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, please NC R1, and R2=0Ω，OVLO pin must connect to GND. Don't float. 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 24V. 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.

$\overline{\text{ACOK}}$ Output

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

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Application Information

Capacitors Selection

C_{IN} = 0.1μF, C_{OUT} = 1μF, is recommended for typical application, larger C_{IN}, C_{OUT}, 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 AW32905E is used, the rated voltage of C_{IN} should be 50V. 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 16V or higher. The recommended value of capacitors and boundary values can refer to the following table:

Capacitor	Typical Value (μF)	Boundary Value (μF)
C_{IN}	0.1	0.01~100
C_{OUT}	1	0.01~100

Resistance Selection

When using default OVP threshold, it is recommended to connect OVLO to ground or through 0Ω resistor. When 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. When (R_1+R_2) is larger, the clamping voltage of OUT is smaller. It is recommended to select R_1 = 1MΩ, R2 can calculate the value according to the required OVP threshold. The calculation formula is as follows: the typical value of V_{OVLO_TH} is 1.2V, and the adjustable range of V_{IN_OVLO} is 4V ~ 24V.

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

The recommended value of resistors and boundary values can refer to the following table:

Resistor	Typical Value (Ω)	Boundary Value (Ω)
R_1	1M	1K~10M
R_2	100K	Determined by R1

TVS (if used)

First of all, the working voltage of TVS should be determined. TVS with V_{RWM} ≥ 10V can be selected for 5V charging port, TVS with V_{RWM} ≥ 12V can be selected for 9V charging port, and TVS with V_{RWM} ≥ 15V can be selected for 12V charging port. Secondly, it is necessary to meet the requirement of surge protection capability. Assuming that the customer wants to select a TVS with a voltage of 300V, the TVS should meet the requirement of I_{PP} ≥ 300V / 2 Ω = 150A. When selecting the model of external TVS, the maximum clamping voltage of the TVS should be below **29V.** Too high clamping voltage of TVS will cause damage to OVP chip.

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PCB Layout Consideration

To make fully use of the performance of AW32905E, 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 AW32905E) and close to IN pin, and place the output capacitor C_{OUT} on the top layer (same layer as the AW32905E) and close to OUT pin.

2. If external TVS is used, IN pin routing passes through the external TVS firstly, and then connect AW32905E.

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 AW32905E 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 AW32905E to decrease EMI coupling.

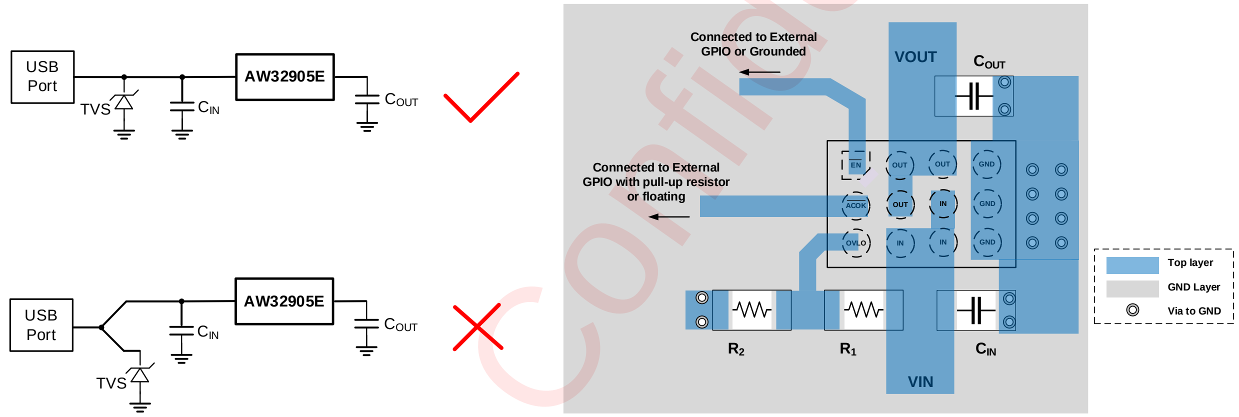

Figure 17 External Components Placements and PCB Layout Example

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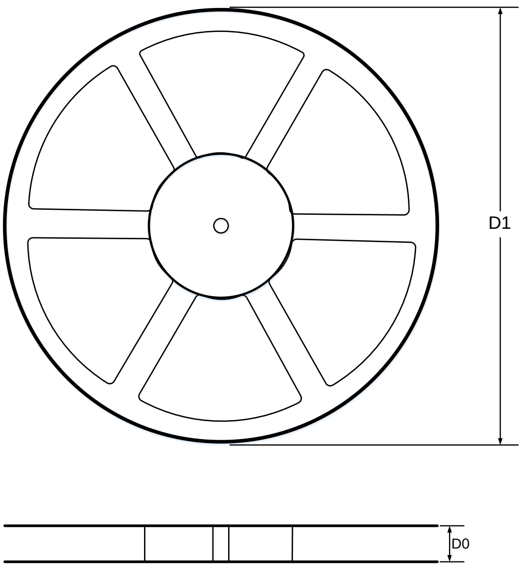
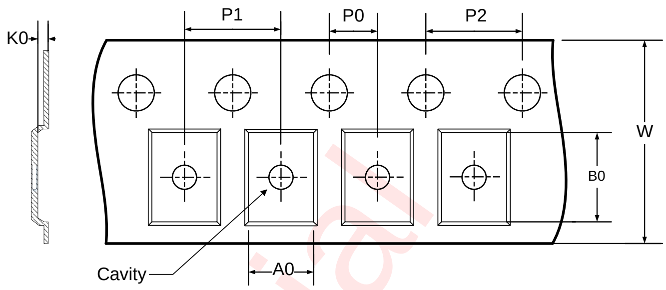
Tape and Reel Information

REEL DIMENSIONS

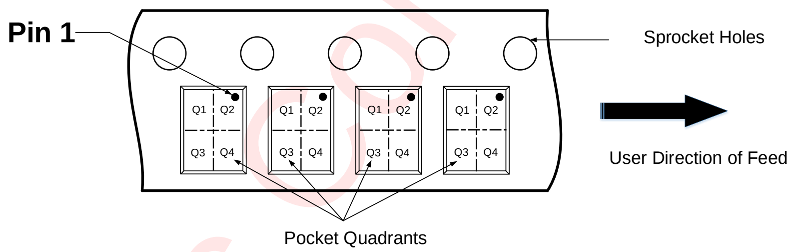


TAPE DIMENSIONS



A0：Dimension designed to accommodate the component width
B0：Dimension designed to accommodate the component length
K0：Dimension designed to accommodate the component thickness
W：Overall width of the carrier tape
P0：Pitch between successive cavity centers and sprocket hole
P1：Pitch between successive cavity centers
P2：Pitch between sprocket hole
D1：Reel Diameter
D0：Reel Width

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Note：The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
178	8.4	1.58	2.04	0.73	2	4	4	8	Q2

All dimensions are nominal

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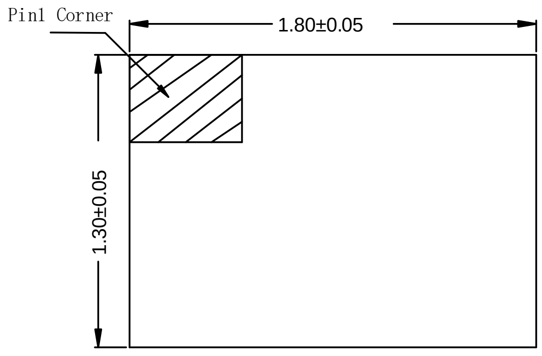
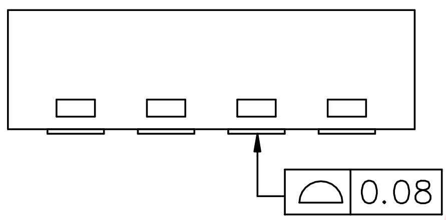
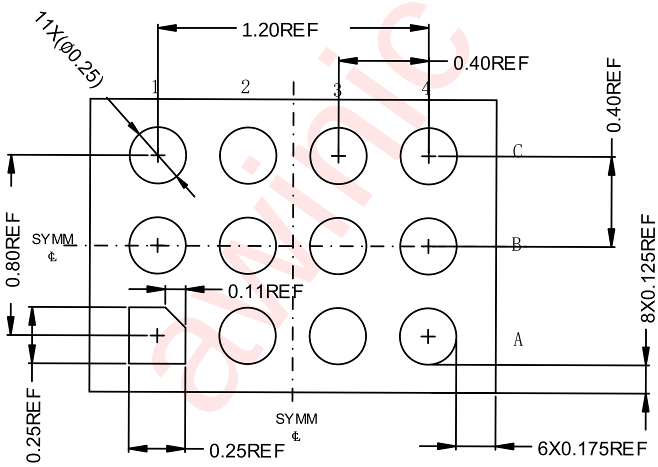
Package Description



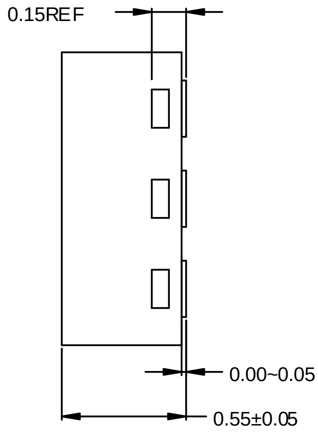
TOP VIEW



SIDE VIEW



BOTTOM VIEW



SIDE VIEW

UNIT:mm

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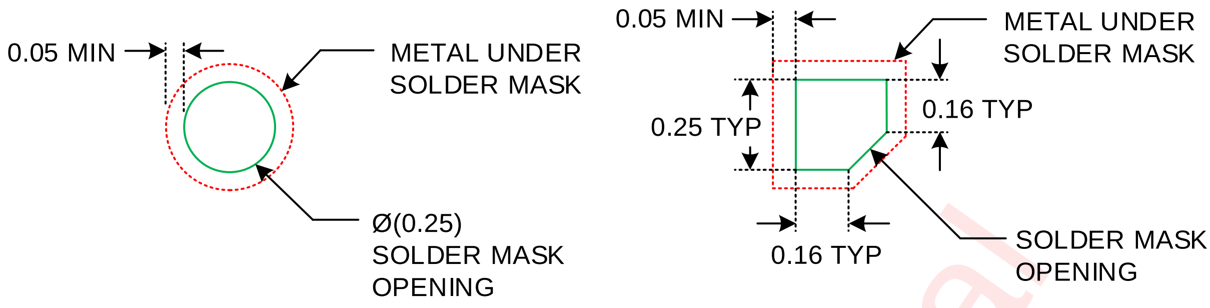
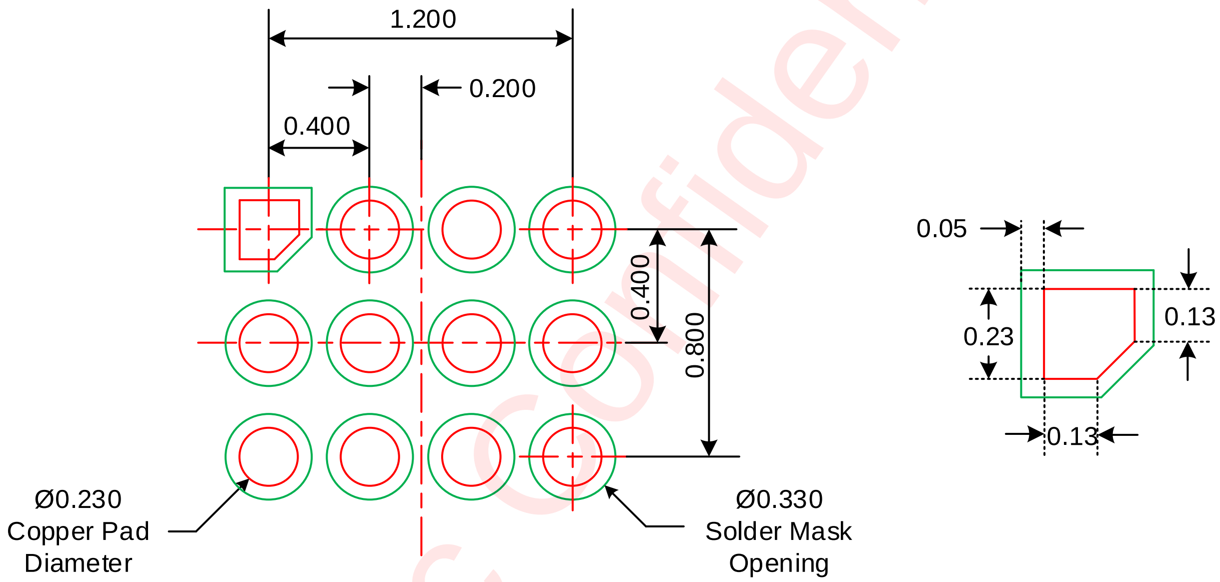
Land Pattern Data



Pad Type: Solder Mask Defined



PAD Type: Non-Solder Mask Defined

NOTE:

1. Not to scale
2. Unit: mm.

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Revision History

Version	Date	Change Record
V1.0	Mar.2023	Officially released

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