Adjustable Current-Limit Load Switch with OVP

Features

- V_{IN}: 2.7~5.5V
- 28V Absolute Rating at V_{OUT}
- 4A Continuous Current Capability
- Adjustable Current Limit:0.1A~4A (Typ.)
  - 0.5A~4A with 7% Accuracy
  - <0.5A with 10% Accuracy
  - <0.3A with 15% Accuracy
- Ron: 35mΩ (Typ.)
- Soft-start
- Output OVP: Typ.=5.8V
- No Output Discharge During Off State
- Open-Drain over-current fault flag
- Thermal Shutdown
- Under-Voltage Lockout (UVLO)
- True Reverse-Current Blocking (TRCB)
- Shut-Down Supply Current: 0.5μA
- FCQFN 1.3mm×1.8mm-12L package

Applications

- Type C Power Source Switch
- Computing, Monitor
- Portable Devices

General Description

AW35065 is a current-limiting protection switch, 35mΩ(Typ.), low resistance MOSFET switch intended to be inserted between a power source and a load to isolate and protect against abnormal voltage and current conditions. The input operating voltage range is between 2.7V to 5.5V. The output terminal is rated 28V absolute maximum.

The internal soft-start circuit controls inrush current due to highly capacitive loads. The device features very low quiescent current. The supply current reduces to 0.5μA in shut-down state.

The AW35065 has True Reverse-Current Blocking (TRCB) protection to avoid undesired reverse current from output to its input in either enabled or disabled states.

The AW35065 also features several additional protection functions, such as output over-voltage (OVP) and input under-voltage protection (UVLO), plus over-current (with Fault-flag) and thermal protection.

Typical Application Circuit

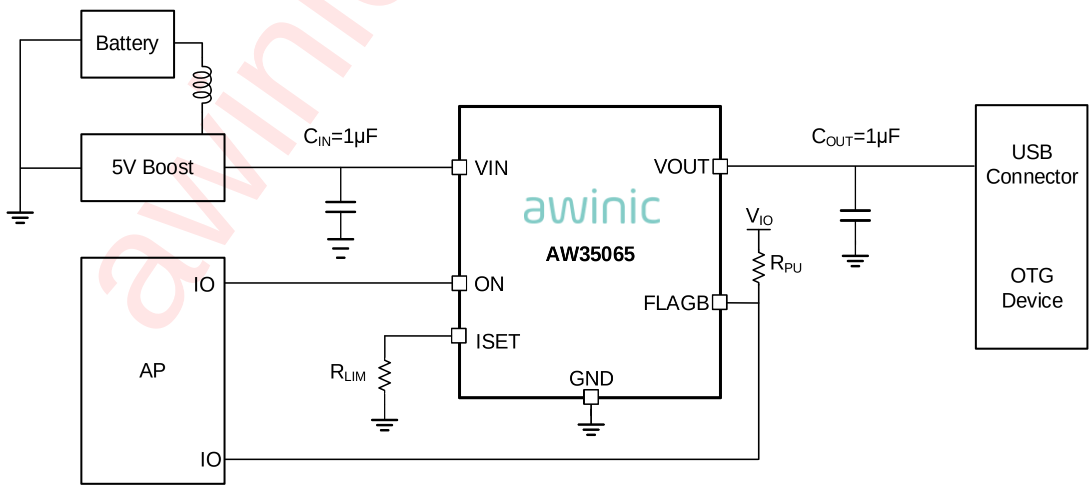


Figure 1 AW35065 Typical Application Circuit

Pin Configuration and Top Mark

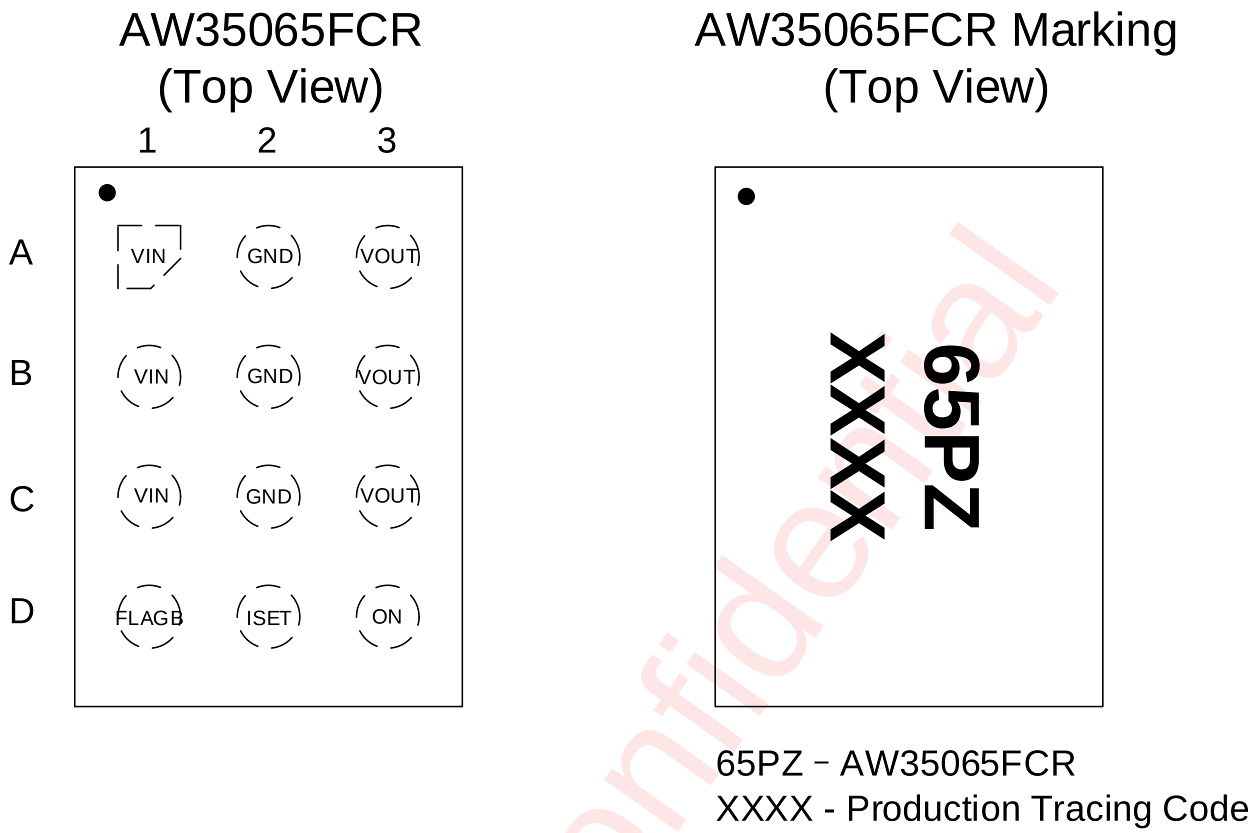


Figure 2 Pin Configuration and Top Mark

Pin Definition

<table>
<tr><th>Pin</th><th>Name</th><th colspan="3">Description</th></tr>
<tr><td>A3, B3, C3</td><td>VOUT</td><td colspan="3">Switch output</td></tr>
<tr><td>A1, B1, C1</td><td>VIN</td><td colspan="3">Supply Input: Input to the power switch</td></tr>
<tr><td>A2, B2, C2</td><td>GND</td><td colspan="3">Device ground</td></tr>
<tr><td rowspan="2">D3</td><td rowspan="2">ON</td><td rowspan="2">Logic Enable Control: Active HIGH-GPIO compatible</td><td>Logic HIGH</td><td>Enable Operation</td></tr>
<tr><td>Logic LOW</td><td>Disable Operation</td></tr>
<tr><td>D1</td><td>FLAGB</td><td colspan="3">Fault Output: Active Low, open-drain output that indicates an input over current. External pull-up resistor of greater than 10k is recommended.</td></tr>
<tr><td>D2</td><td>ISET</td><td colspan="3">Current Limit Set Input: A resistor from ISET to ground sets the current limit for the switch.</td></tr>
</table>

Functional Block Diagram

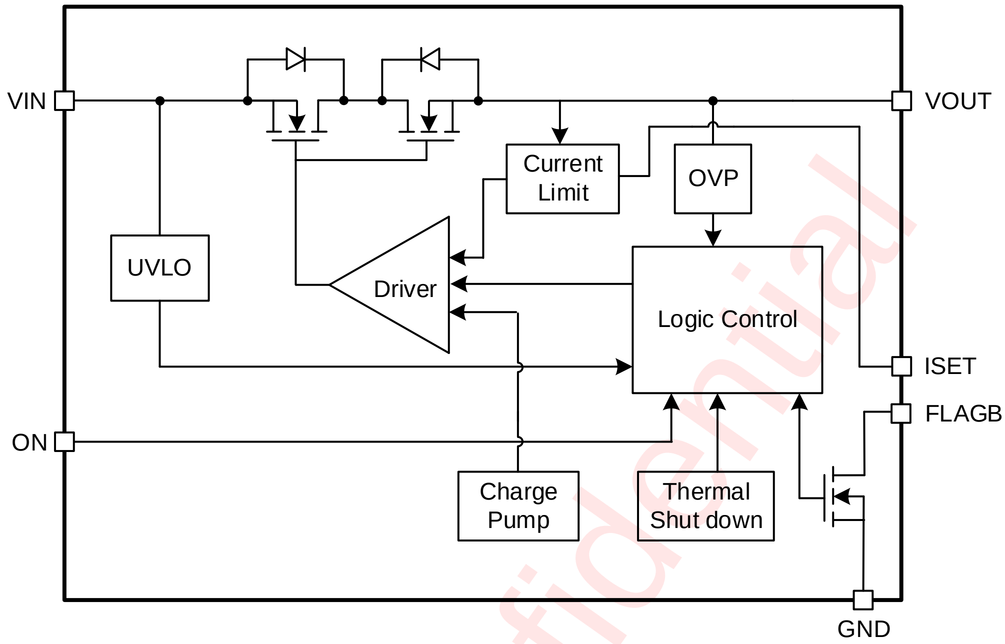


Figure 3 AW35065 Functional Block Diagram

Typical Application Circuits

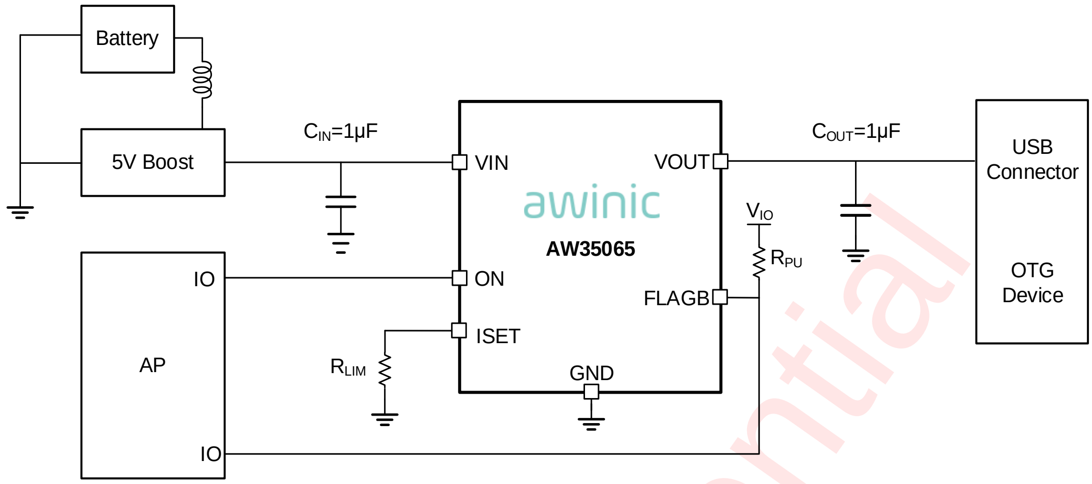


Figure 4 AW35065 Application circuit

Notice for Typical Application Circuits:

1. If VOUT is required external TVS, the maximum clamping voltage of the TVS should be below 28V.
2. If R_{LIM} is used to adjust the OCP threshold, connected between the ISET and GND pins. it is better to use 1% precision resistors to improve the OCP threshold precision. **ISET pin cannot be left floating.**
3. If FLAGB is used, R_{PU} is more than 10KΩ， If FLAGB is not used, it can be left floating, or short to GND.
4. C_{IN} = 1μF is recommended for typical application, larger C_{IN} is also acceptable.
5. The input PCB traces as short and wide as possible to reduce the unwanted effect of long wire.
6. C_{OUT} minimum is recommended to be 1μF. The rated voltage of C_{OUT} should be larger than the TVS clamping voltage. For example, the rated voltage of C_{OUT} is 50V.

Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW35065FCR	-40°C ~ 85°C	FCQFN 1.3mm×1.8mm -12L	65PZ	MSL1	ROHS+HF	4500 units/ Tape and Reel

Absolute Maximum Ratings (NOTE 1)

PARAMETERS	RANGE
V_{IN}	-0.3V to 6.0V
ON	-0.3V to 6.0V
I_{SET}	-0.3V to 6.0V
FLAGB	-0.3V to 6.0V
V_{OUT}	-0.3V to 28.0V
I_{SW}	4A
t_{PD}	2.3W
$R_{\theta JA}$	53.4°C/W
Operating free-air temperature range	-40°C to 85°C
Maximum operating junction temperature T_{JMAX}	150°C
Storage temperature T_{STG}	-65°C to 150°C
Lead temperature (soldering 10 seconds)	260°C

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

ESD Rating and Latch Up

PARAMETERS	VALUE	UNIT
HBM (Human Body Model) (NOTE 3)	±2	kV
CDM(NOTE 4)	±1.5	kV
Latch-Up(NOTE 5)	+IT: 200 -IT: -200	mA

NOTE3: The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. Test method: ESDA/JEDEC JS-001-2017

NOTE4: Test method: ESDA/JEDEC JS-002-2018

NOTE5: Test method: JESD78E

Electrical Characteristics

Unless otherwise noted, V_{IN}=2.7 to 5.5V, T_A = -40°C to 85°C, Typical values are at V_{IN} = 5V and T_A = 25℃.

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
BASIC OPERATION						
V_{IN}	Input Voltage		2.7		5.5	V
$I_{Q(OFF)}$	Off Supply Current	V_{IN}=5V, V_{OUT}=Open V_{ON}=GND		0.5	3.0	μA
$I_{SD(OFF)}$	Shutdown Current	V_{IN}=5V, V_{OUT}=0V, V_{ON}=GND		0.5	4.0	μA
I_Q	Quiescent current into V_{IN} pin	I_{OUT}=0, T_A = 25°C		182	250	μA
$R_{DS(ON)}$	On resistance	V_{IN}=5V, I_{OUT}=1A, T_A = 25°C		35	50	mΩ
		V_{IN}=3.7V, I_{OUT}=1A, T_A = 25°C		36	55	mΩ
V_{IH}	ON Input Logic HIGH Voltage	V_{IN}=2.7V to 5.5V	0.9			V
V_{IL}	ON Input Logic LOW Voltage	V_{IN}=2.7V to 5.5V			0.4	V
V_{IL_FLAG}	FLAGB Output Logic LOW Voltage	V_{IN}=5V, I_{SINK}=1mA		0.05	0.1	V
		V_{IN}=2.7V, I_{SINK}=1mA		0.06	0.15	V
I_{FLAGB_LK}	FLAGB Output Logic HIGH Leakage Voltage	V_{IN}=5V, Switch On			1.0	μA
I_{ON}	ON Input Leakage	V_{ON} =0V to VIN			1.0	μA
R_{ON_PD}	Pull-Down Resistance at ON Pin			14		MΩ
OVER-VOLTAGE PROTECTION						
V_{OVP_TRIP}	Output OVP Lockout	Rising Threshold		5.8		V
		Falling Threshold		5.5		V
OUT_{HYS}	Output OVP Hysteresis			0.3		V
t_{OVP}	OVP Response	I_{OUT}=0.5A, C_L=1uF, T_A=25°C, V_{OUT} from 5.5V to 6.0V		300		ns
UNDER-VOLTAGE LOCK OUT						
V_{UVLO}	Under voltage lock out	V_{IN} Increasing		2.5		V
		V_{IN} Decreasing		2.3		V
V_{UVLO_HYS}	UVLO Hysteresis			200		mV

Electrical Characteristics (Continued)

Unless otherwise noted, V_{IN}=2.7 to 5.5V, T_A = -40°C to 85°C, Typical values are at V_{IN} = 5V and T_A = 25℃.

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
OVER-CURRENT PROTECTION						
I_{LIM}	Current Limit	V_{IN}=5V, R_{LIM}=1KΩ V_{OUT} from 5V to 4.6V	0.93	1.0	1.07	A
		V_{IN}=5V, R_{LIM}=2KΩ V_{OUT} from 5V to 4.6V	465	500	535	mA
		V_{IN}=5V, R_{LIM}=5KΩ V_{OUT} from 5V to 4.6V	170	200	230	mA
		V_{IN}=5V, R_{LIM}=10KΩ V_{OUT} from 5V to 4.6V	85	100	115	mA
t_{HOCP}	Hard Over-Current Response Time	Moderate Over-Current Condition, I_{OUT}≥I_{LIM}, V_{OUT} =0		1		μs
t_{OCP}	Over-Current Response Time	Moderate Over-Current Condition, I_{OUT}≥ILIM, V_{OUT}≤V_{IN}		6		μs
t_{OC_FLAG}	Over-Current Flag Response Time	When Over-Current Occurs to Flag Pulling LOW		7		ms
TURE REVERSE CURRENT PROTECTION						
I_{RCB}	RCB Current	V_{ON}=0V, V_{OUT}=5.5V, T_A = 25°C		12		μA
V_{T_RCB}	RCB Protection Trip Point	V_{OUT}-V_{IN}, T_A = 25°C		50		mV
V_{R_RCB}	RCB Protection Release Trip Point	V_{IN}-V_{OUT}, T_A = 25°C		50		mV
t_{RCB}	Default RCB Response Time	V_{IN}=5V, V_{ON}=High, From V_{OUT} > V_{IN} + 100mV to $I_{OUT\ MAX}$		10		μs
		V_{IN}=5V, V_{ON}=High, From V_{OUT} > V_{IN} + 50mV to $I_{OUT\ MAX}$		3.0		ms
THERMAL SHUTDOWN						
t_{SD}	Thermal shutdown	Shutdown		155		°C
		Return from Shutdown		135		
		Hysteresis		20		
DYNAMIC CHARACTERISTICS						
t_{DON}	Turn-On Delay	V_{IN}=5V, R_{LOAD}=100Ω, C_L=1μF, T_A=25°C, R_{LIM}=2040Ω		0.78		ms
t_R	V_{OUT} Rise Time			0.52		ms
t_{ON}	Turn-On Time			1.30		ms
t_{DOFF}	Turn-Off Delay			22		μs
t_F	V_{OUT} Fall Time			0.23		ms
t_{OFF}	Turn-Off Time			0.25		ms

Timing Diagrams

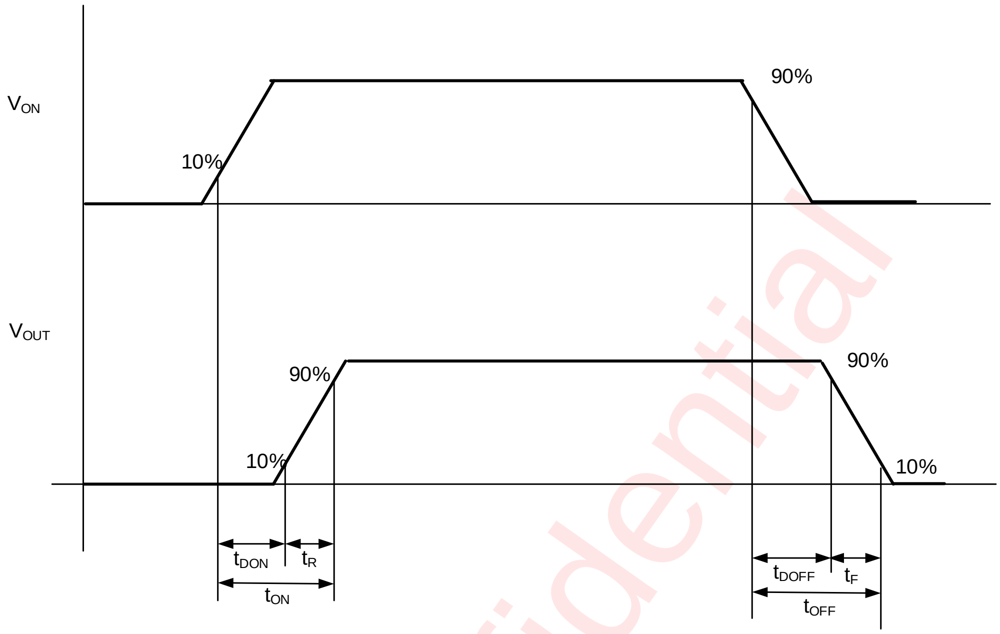


Figure 5 AW35065 Timing Diagrams

Typical Characteristics

Unless otherwise noted, V_{IN}=2.7 to 5.5V, T_A = -40°C to 85°C, Typical values are at V_{IN} = 5V and T_A = 25℃.

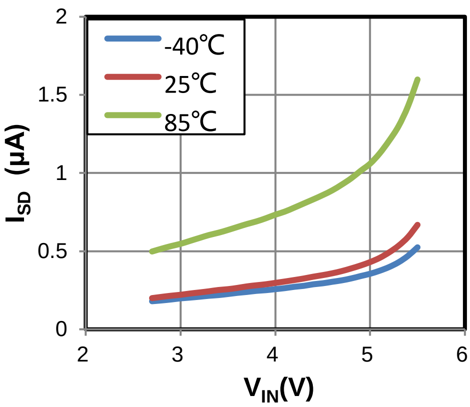


Figure 6 Shutdown Current vs. VIN

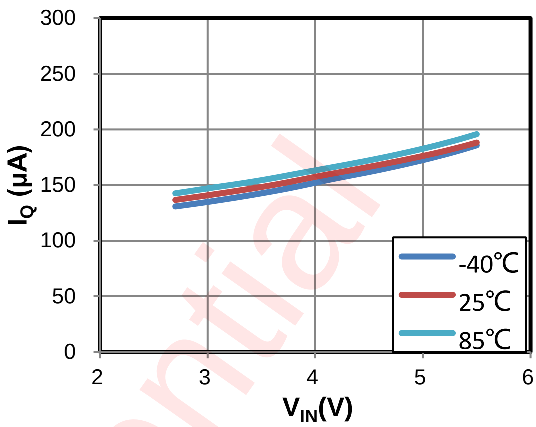


Figure 7 Quiescent Current vs. VIN

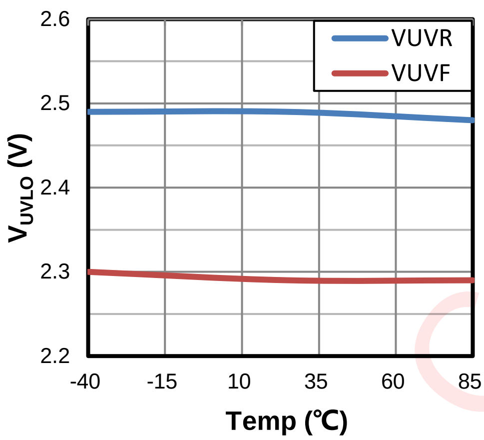


Figure 8 UVLO Threshold Voltage vs. Temperature

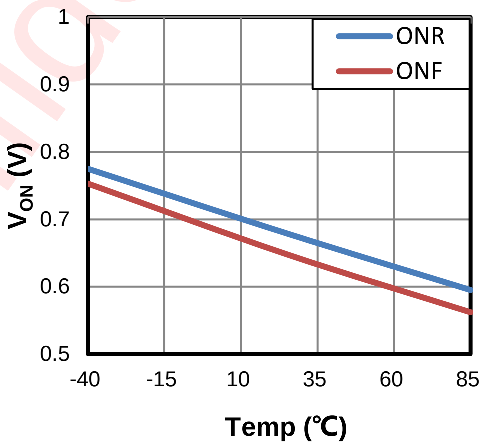


Figure 9 ON Threshold Voltage vs. Temperature

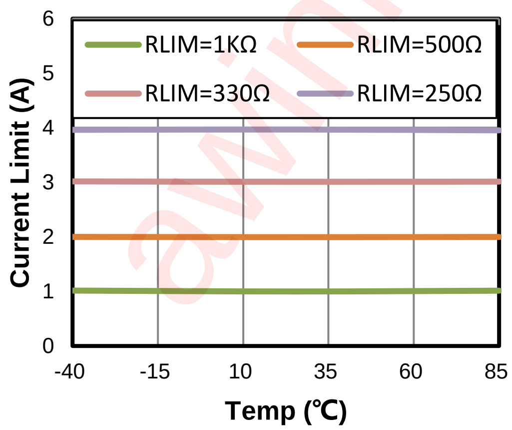


Figure 10 Current Limit Threshold vs. Temperature

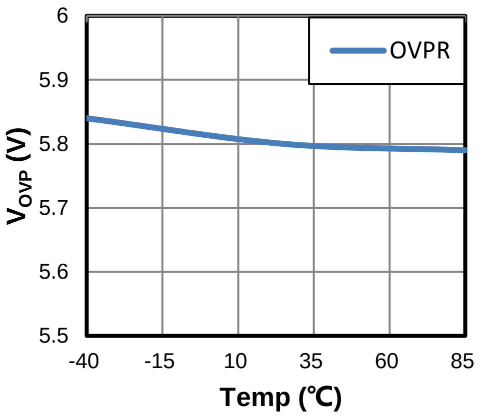


Figure 11 OVP Threshold Voltage vs. Temperature

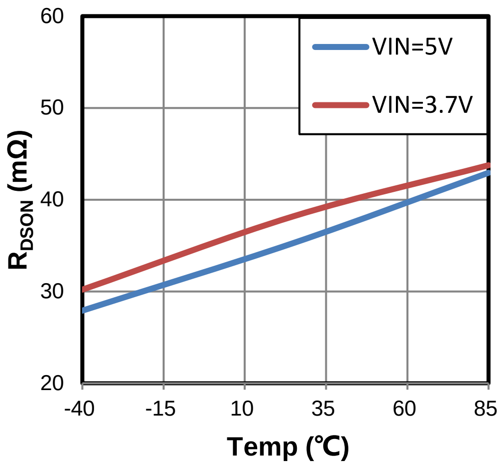


Figure 12 R_{DSON} vs. Temperature

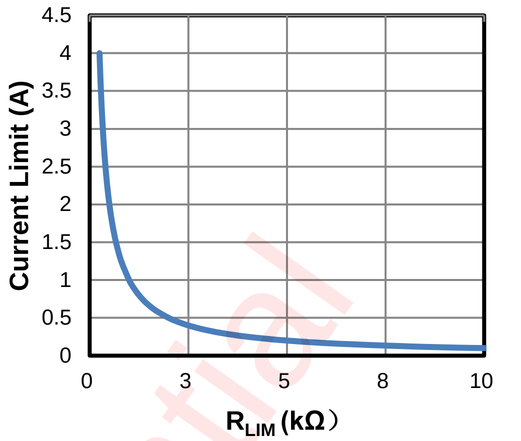


Figure 13 Current Limit Threshold vs. R_{LIM}

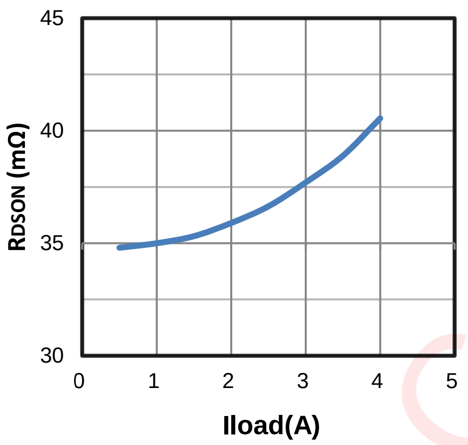


Figure 14 R_{DSON} vs. Iload

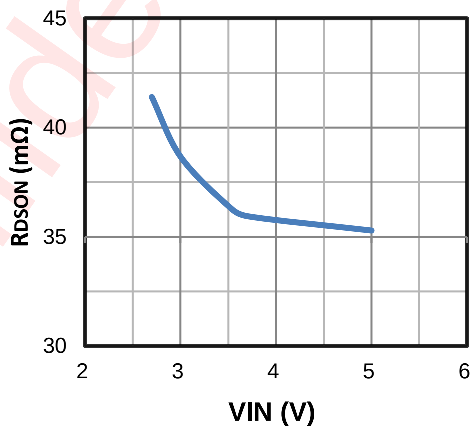


Figure 15 R_{DSON} vs. VIN

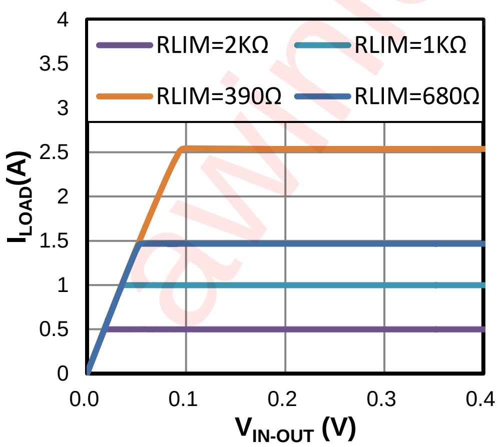


Figure 16 ILOAD vs. VIN-OUT

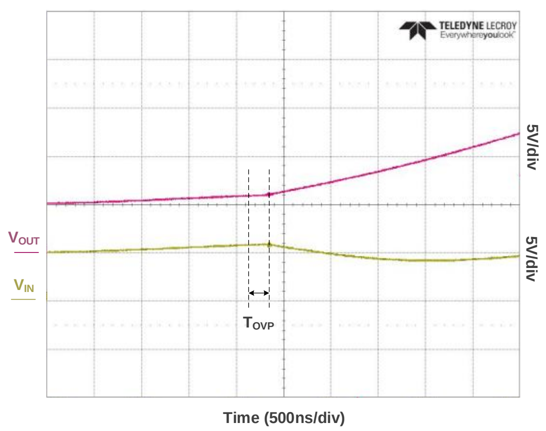


Figure 17 Over Voltage Protection

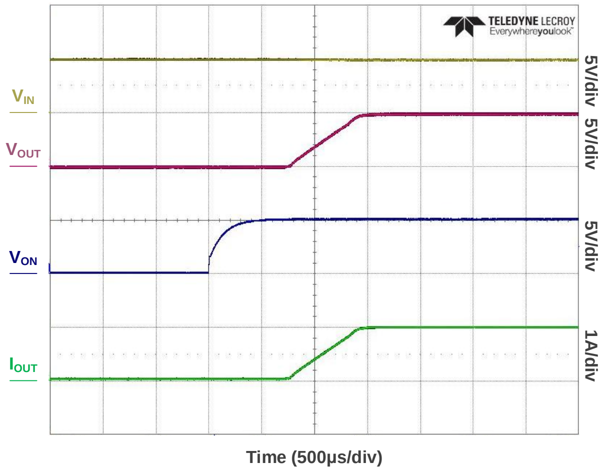


Figure 18 Turn-On By ON

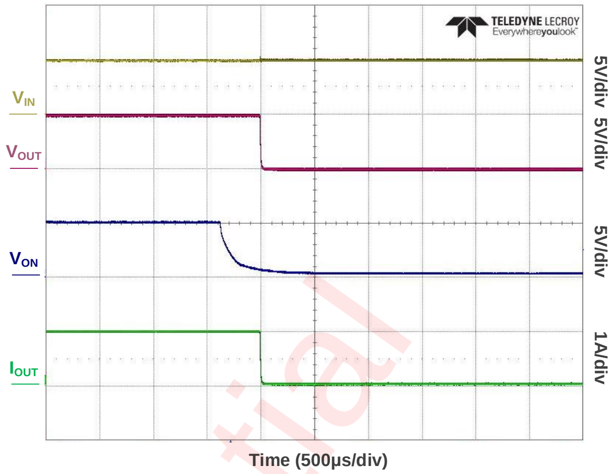


Figure 19 Turn-Off By ON

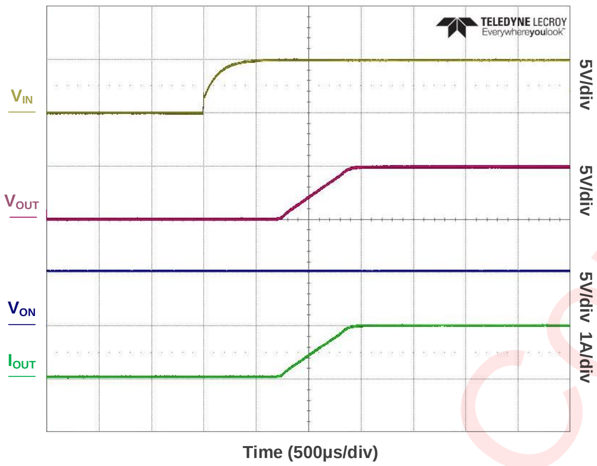


Figure 20 Turn-On By Toggling VIN

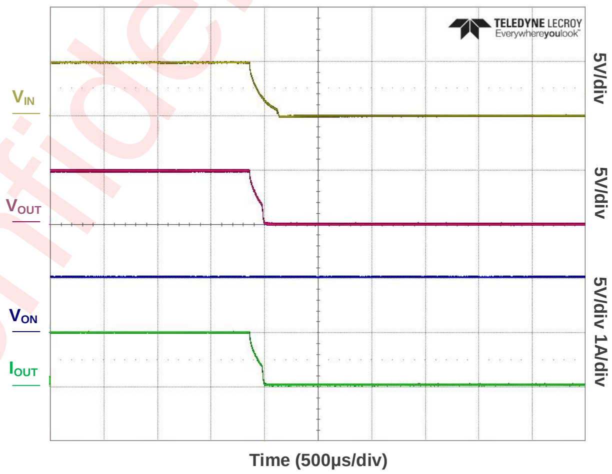


Figure 21 Turn-Off By Toggling VIN

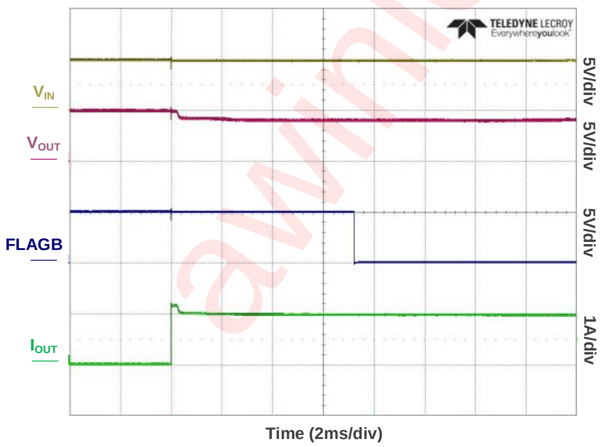


Figure 22 Over Current Protection

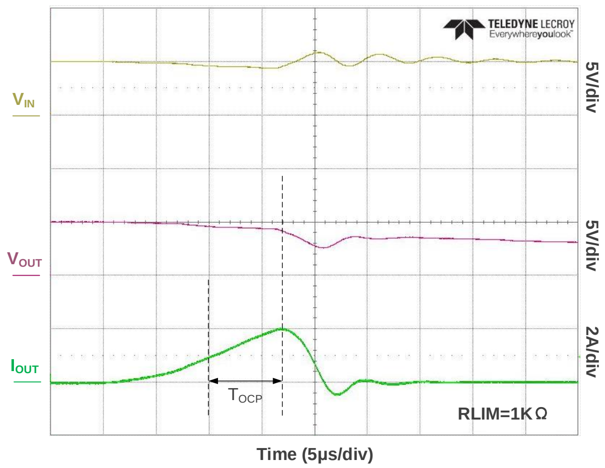


Figure 23 Tocp Response Time

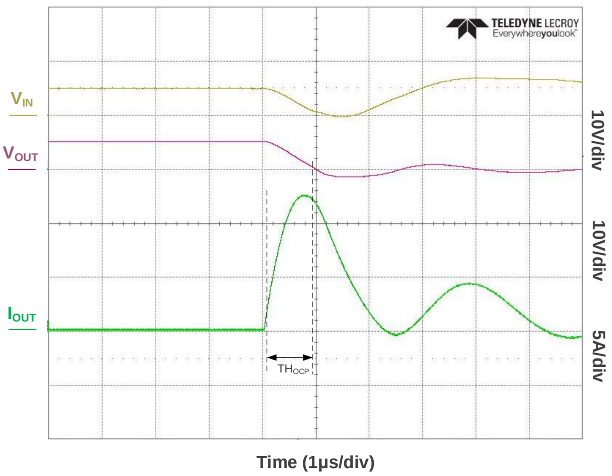


Figure 24 THocp Response Time

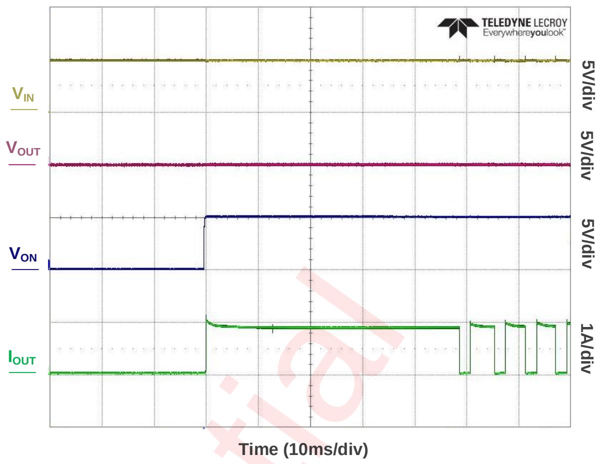


Figure 25 Starting up into shorted output

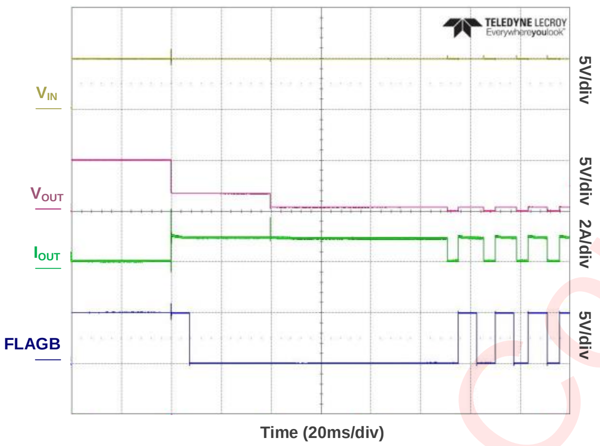


Figure 26 Output Short Circuit Protection

Figure 27 Output Short Circuit Recovery

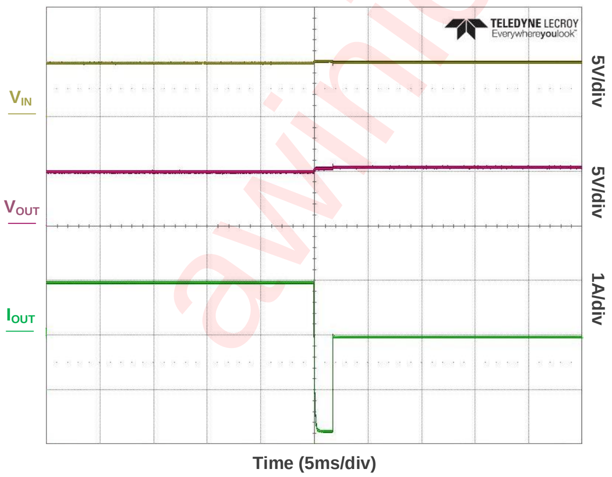


Figure 28 Reverse Current Blocking

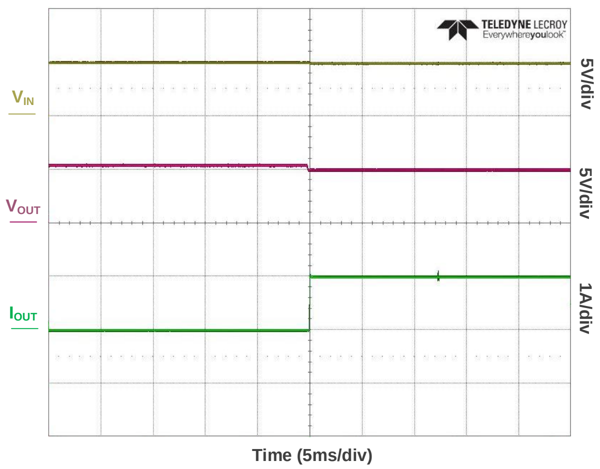


Figure 29 Recovery from Reverse Current Blocking

Detailed Functional Description

The AW35065 is a current limited power switch with over-voltage, over-current, reverse-current and thermal shutdown protections. The VOUT pin is rated 28V. The switch current is rated up to 4A.

The device has true reverse-current blocking features that will prevent undesired current flow from output to its input in either enabled or disabled state.

Enable

The ON pin is the ON/OFF control for the power switch. The device is enabled when ON pin is high and not in under-voltage lockout state. The ON pin must be driven to a logic high or logic low state to guarantee operation. While disabled, the AW35065 draws 0.5μA from supply.

Soft Start

The AW35065 has internal soft-start circuitry to limit inrush current due to large capacitive load.

Fault Reporting

The FLAGB pin is an open drain output. It is asserted low when either an over-current, or over-temperature condition occurs. The FLAGB pin becomes high impedance when the fault conditions are removed. It is recommended to be pulled up by a 10kΩ pull-up resistor (R_{PU}) connected between FLAGB to 5V to provide a logic signal.

When thermal shutdown is activated, FLAGB is pulled low immediately to report fault condition to host. FLAGB become impedance again once fault is removed. In case of output overload, FLAGB pin is pulled low about 7ms (t_{OC_FLAG}) after device is in current-limiting.

The is no fault reporting for UVLO, OVP, and RCB event.

Under-Voltage Lockout

Under-voltage lockout protection turns off the switch if the input voltage drops below the under-voltage lockout threshold (V_{UVLO}). With the ON pin active, the input voltage rising above V_{UVLO_R}, the switch will return to the ON state.

Over-Voltage Protection

The voltages at V_{OUT} terminal is constantly monitored once the device is enabled. In case output voltage exceeds the over-voltage protection threshold (V_{OVP}), the device is turned off immediately. AW35065 can restart when V_{OUT} drops below V_{OVP_F}.

True Reverse-Current Blocking

True Reverse-Current Blocking (TRCB) protection to avoid undesired reverse current from output to its input in either enabled or disabled states. When device is enabled, device is turned off whenever output voltage is higher than input voltage 50 mV. The device is turned on again when output voltage falls below input by 50mV.

Thermal Shutdown

The thermal shutdown protects the device from internally or externally generated excessive temperature. The power switch is turned off when the die temperature reaches thermal shutdown threshold of 155°C. There is a 20°C hysteresis. The switch automatically turns on again if the temperature of the die drops below approximately 135°C.

Over Current Protection and Programmable Current Limit

The device continuously monitors the load current and ensure that the current through the switch does not exceed current limit threshold. The current limit value is set with an external resistor connected between the ISET and GND pins. when the switch current reaches the maximum value set by the switch, the switch acts as constant current source until the power dissipation and die temperature to increase and trigger thermal shutdown. The switch recovers if the device temperature drops below the threshold temperature.

During a transient short circuit event, the current through the switch increases very rapidly. The current limit amplifier cannot respond to this event due to its limited bandwidth. Therefore, the AW35065 incorporates a fast-trip comparator, which shuts down the pass switch when $I_{OUT}>I_{FASTRIP}$, and terminates the rapid short circuit peak current. The fast-trip comparator threshold $I_{FASTRIP}$ is $1.6I_{LIM}$ and shuts down power switch for 6μs. After the transient short-circuit peak current has been terminated by the fast-trip comparator, the current limit amplifier regulates the output current to I_{LIM}.

Application Information

Current limit Programming

An external resistor (R_{LIM}) placed between the ISET pin and GND sets the switch current limit threshold (I_{LIM}). The ISET pin voltage is regulated by an internal control loop. The current limit threshold is proportional to the current pulled from the ISET pin by the resistor. Use short trace routes for the R_{LIM} on the PCB to minimize the impact of parasitic and noise on the accuracy of the current limit setting.

The current limit threshold can be estimated using the equation below:

$$I_{LIM} = 2500 * 0.4V / R_{LIM} \ (A)$$

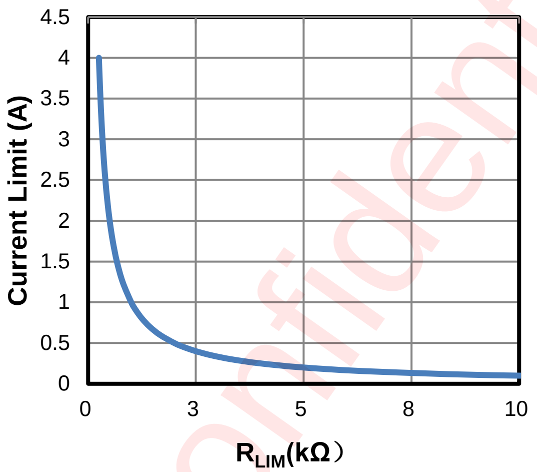


Figure 30 Current Limit Threshold (I_{LIM}) vs. Current Limit Programming Resistor (R_{LIM})

For example, for 1A current limit threshold, a 1kΩ R_{LIM} resistor should be selected.

The current limit resistor setting is shown below in Table 1. The recommended 1% resist range for R_{LIM} is $250\Omega \leq R_{LIM} \leq 10K\Omega$.

Table 1. Current Limit Settings by R_{LIM}

R_{LIM}(Ω)	MIN. Current Limit(A)	TYP. Current Limit(A)	MAX. Current Limit(A)
250	3.72	4	4.28
267	3.4875	3.75	4.0125
285	3.255	3.5	3.745
308	3.0225	3.25	3.4775
333	2.790	3	3.21
364	2.5575	2.75	2.9425
400	2.325	2.5	2.675
444	2.0925	2.25	2.4075
500	1.860	2	2.14
571	1.6275	1.75	1.872.5

R_{LIM}(Ω)	MIN. Current Limit(A)	TYP. Current Limit(A)	MAX. Current Limit(A)
667	1.395	1.5	1.605
800	1.1625	1.25	1.3375
1000	0.93	1	1.07
1111	0.837	0.9	0.963
1250	0.744	0.8	0.856
1429	0.651	0.7	0.749
1667	0.558	0.6	0.642
2000	0.465	0.5	0.535
2222	0.405	0.45	0.495
2500	0.36	0.4	0.44
2857	0.315	0.35	0.385
3333	0.27	0.3	0.33
4000	0.2125	0.25	0.2875
5000	0.17	0.2	0.23
6667	0.1275	0.150	0.1725
10000	0.085	0.100	0.115

Power Dissipation Calculation

Calculate the power dissipation for normal load condition using the following equation:

Power Dissipated = $R_{ON} \times (I_{OUT})^2$

The worst cases power dissipation occurs when the load current hits the current limit due to over-current. The power dissipation can be calculated using the following equation:

Power Dissipated = $(V_{IN} - V_{OUT}) \times I_{LIM}$

Assuming a given ambient temperature and an output current, the maximum allowable power dissipation is calculated by:

$P_{D(MAX)}=T_{J(MAX)}-T_A/\theta_{JA}$

where:

$P_{D(MAX)}$ is the maximum power dissipation.

$T_{J(MAX)}$ is the maximum operating junction temperature.

T_A is the operating ambient temperature.

θ_{JA} is junction to air thermal impedance.

Please note that the thermal vias are placed under the exposed pad of the device, thus allowing for thermal dissipation away from the device.

Input Capacitor Selection

The input capacitor prevents large voltage transients from appearing at the input, and provides the instantaneous current needed each time the switch turns on to charge output capacitors and to limit input voltage drop. It also prevents high-frequency noise on the power line from passing through to the output. The input capacitor should be located as close to the pin as possible. A minimum of 1μF ceramic capacitor should be used. However, higher capacitor value is strongly recommended to further reduce the transient voltage drop at the input. It is recommended to use a 1μF capacitor between VIN and GND close to the device pins. It can limit the voltage drop of the input supply. Larger CIN can reduce voltage dip in high current applications. Without or smaller an input capacitor, short-circuit and surge at the output will cause the input voltage to ring, which may destroy the chip's internal circuitry when the input transient voltage exceeds the absolute maximum supply voltage (6V).

Output Capacitor Selection

To reduce EMI, improve the transient performance, and minimize negative effects of resistance and inductance between the bypass capacitor and the downstream connector, a low-ESR 1μF ceramic capacitor between VOUT and GND standard bypass methods are recommended. The output capacitor has to supply enough current for a large load that it may encounter during system transient. This bulk capacitor must be large enough to supply fast transient load in order to prevent the output from dropping. There is an upper limit for output capacitor for AW35065 to ensure the output capacitor can be charged fully during start-up.

PCB Layout Guidelines

Reasonable PCB layout is important for improving the thermal and overall performance of AW35065. For best results, follow the guidelines below:

1、 It is recommended to bypass VIN to GND with a 1μF or greater ceramic capacitor as close as possible to the VIN pin;

2、 It is recommended to bypass VOUT to GND with a 1μF or greater ceramic capacitor as close as possible to the VOUT pin. The internal soft-start function allows the AW35065 to charge an output capacitor up to 100μF without turning off due to overcurrent;

3、 To optimize the switch response time to output short-circuit conditions, the traces routing the R_{LIM} to the AW35065 must be as short as possible to reduce the effect of unwanted parasitic capacitor;

4、 The input and output PCB traces as short and wide as possible to reduce the unwanted effect of long wire; For 1 ounces of copper and use at least 4mm wire width; For 2 ounces of copper and use at least 2mm wire width;

5、 Placing a ground plane under all circuits to reduce resistance and inductance will improve DC and transient performances.

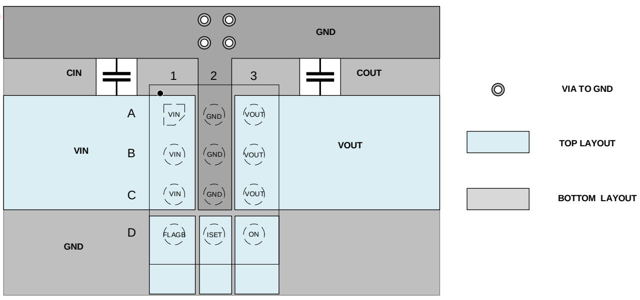
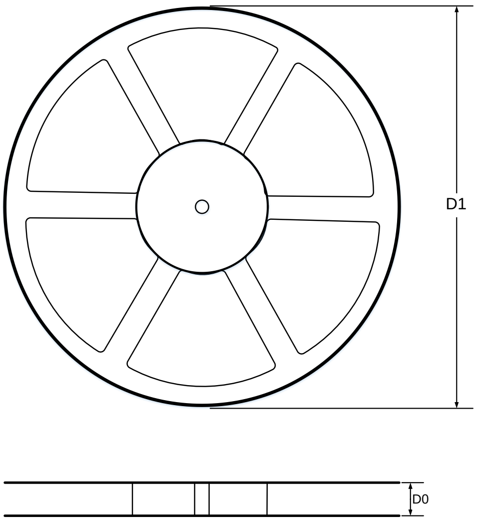


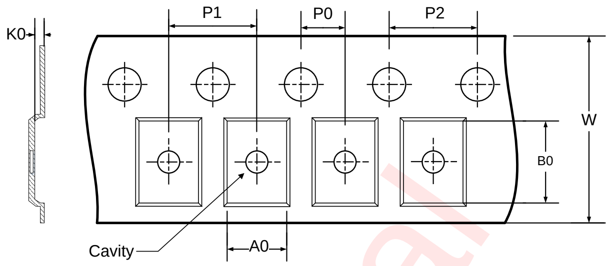
Figure 31 AW35065 PCB Layout Example

Tape And Reel Information

REEL DIMENSIONS

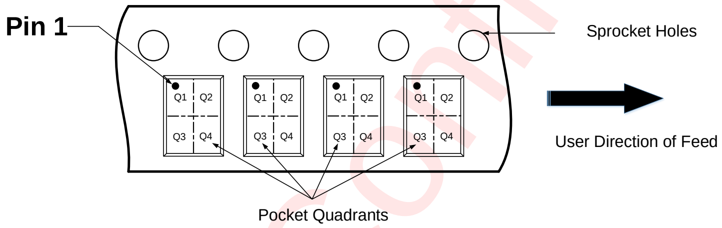


TAPE DIMENSIONS



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



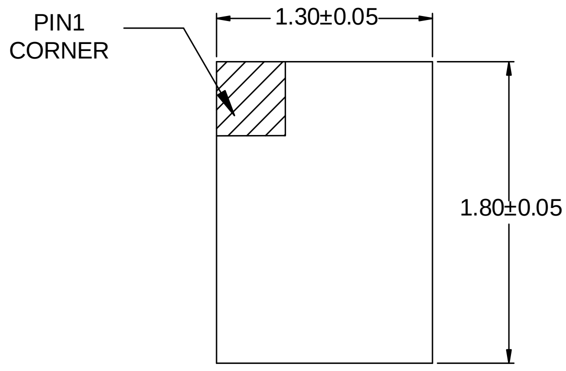
Note：The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

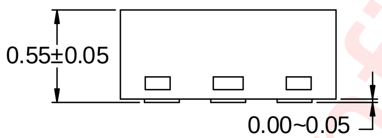
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
178	8.4	1.58	2.04	0.73	2	4	4	8	Q1

All dimensions are nominal

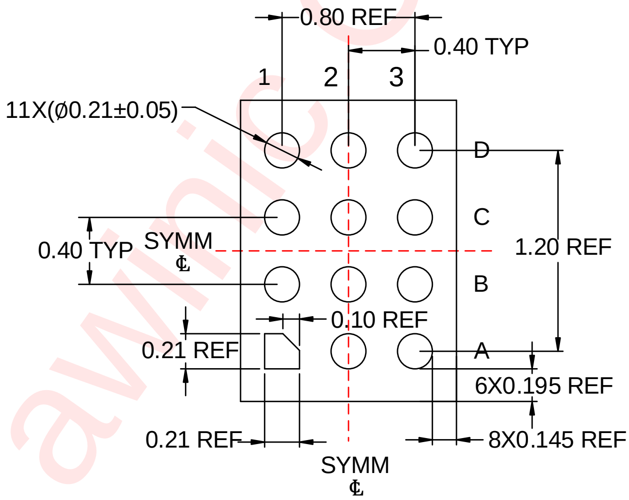
Package Description



Top View



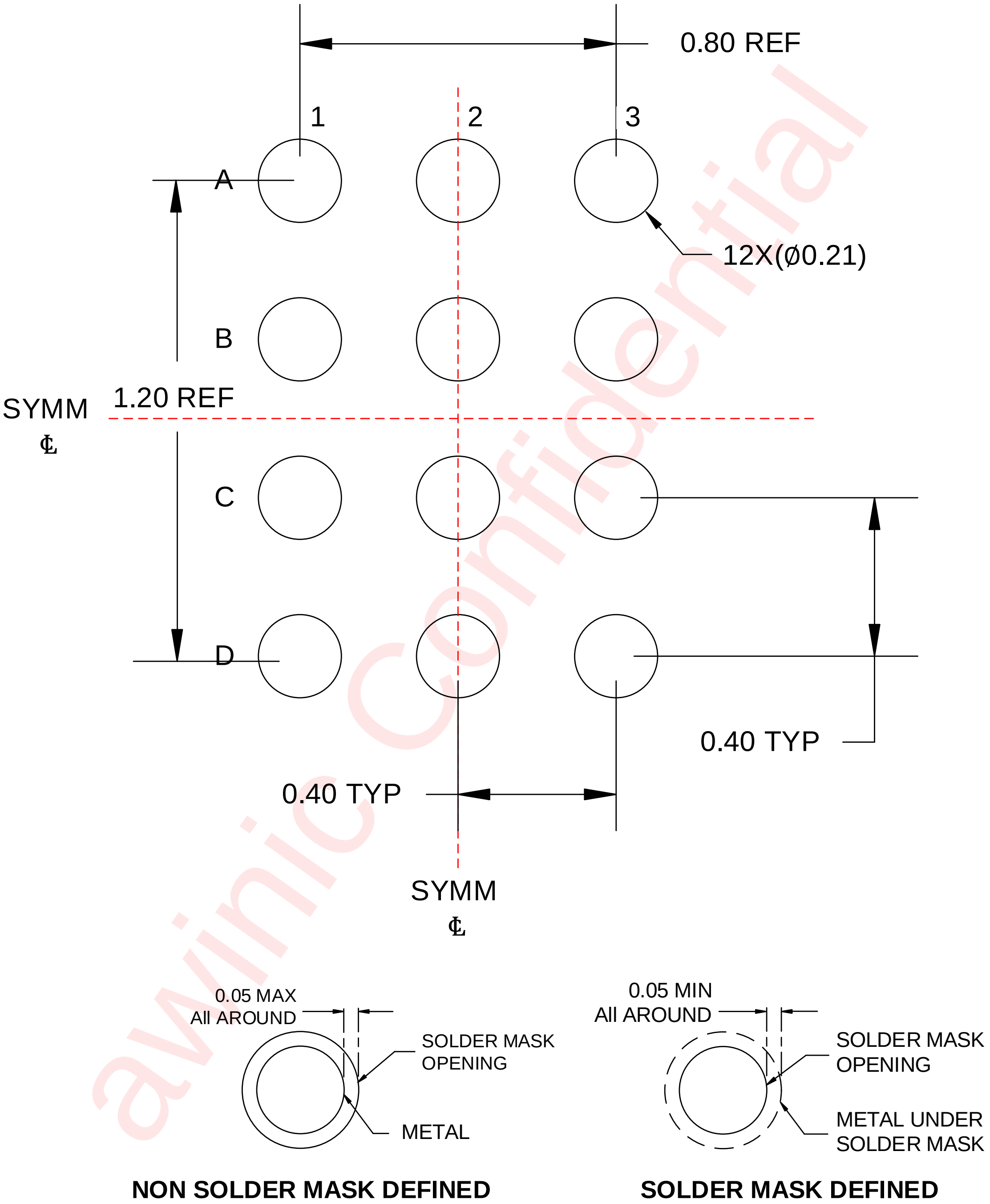
Side View



Bottom View

Unit:mm

Land Pattern Data



Unit: mm

Revision History

Version	Date	Change Record
V1.0	Mar. 2023	The preliminary datasheet V1.0 released.

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