LPW5212

High-Side Load Switch with Over-Current Protection

Features

- Input voltage range: 2.4V to 6.0V
- Low on-state resistance: 70mΩ
- 38μA low current consumption
- Ultra-low shutdown current (<100nA)
- Fixed or adjustable current limit with foldback
  - Fixed: 0.65A, 1.35A, 1.6A, 2.3A
  - Adjustable: 200mA to 2.5A
- Under-voltage lockout
- Blocking reverse current when power off
- Output reverse-voltage protection
- Thermal shutdown protection
- Fast current limit response
- Logic active-high enable
- Available with or without output discharge
- Open-drain flag output
- ESD protection:
  - Human body model: 4kV
  - Charged device model: 0.5kV
- SOT23-5 Package
- RoHS Compliant and 100% Lead (Pb)-Free

Applications

- Notebook and PC
- Cell phone and PDAs
- USB or other peripheral ports
- Camera

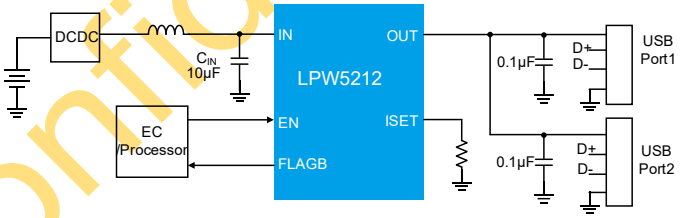
General Description

The LPW5212 is a series of load switches which provide full protection to systems and loads which may encounter large current conditions.

The device contains a 70mΩ current-limited P-channel MOSFET which can operate over an input voltage range from 2.4V to 6V. The current limit is fixed or could be settable using an external resistor. When the current reaches the threshold, the device will limit the current to constant value to prohibit excessive currents from causing damage. Internally, current is prevented from flowing when the MOSFET is off and the output voltage is higher than the input voltage. Switch is controlled by an active-high/low logic pin. Thermal shutdown protection is integrated which shuts off the switch to prevent damage to the part when a continuous over-current condition causes excessive heating.

These parts are available in a space-saving 5 pin SOT23 package.

Typical Application Circuit



Order Information

LPW5212 □□□□ □ □□

- Fixed current limiting:
  - 06: 0.7A
  - 11: 1.35A
  - 15: 1.6A
  - 21: 2.3A
- F: Pb Free
- B5: SOT23-5 Package
- D: With discharge function
- F: With Flag indicator
- A: Current limiting is adjustable
- S: Fixed current limiting and without Flag

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Device Information

Part Number	Top Marking	Current limiting	Output Discharge	Flag Indicator	Moisture Sensitivity Level	Package	Shipping
LPW5212ADB5F	LPS D0YWX	Adjustable	Yes	No	MSL3	SOT23-5	3K/REEL
LPW5212FDB5F11	LPS D2YWX	1.35A	Yes	Yes	MSL3	SOT23-5	3K/REEL
LPW5212FDB5F21	LPS D3YWX	2.3A	Yes	Yes	MSL3	SOT23-5	3K/REEL
Marking indication: Y: Year code. W: Week code. X: Batch numbers.							

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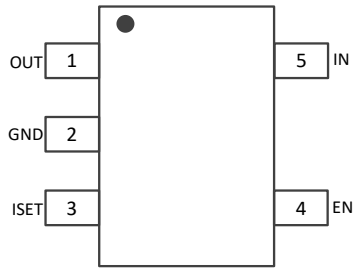
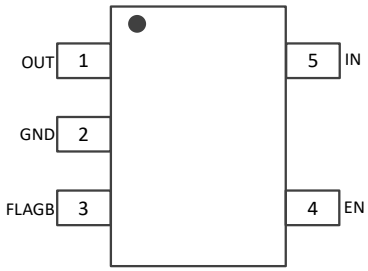
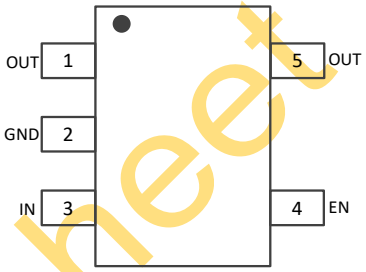
Pin Diagram



SOT23-5（top view）
LPW5212A



SOT23-5（top view）
LPW5212F



SOT23-5（top view）
LPW5202S

Pin Description

Name	Description
OUT	Output of the power switch.
GND	Ground.
ISET	Current limiting setting pin. Connect a resistor to GND.
EN	Enable pin. Active high.
IN	Power supply and input of power switch.
FLAGB	Open-drain active low flag pin to indicate fault condition.

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Absolute Maximum Ratings (Note 1)

IN to GND ---------- -0.3~7V
OUT, EN, ISET to GND ---------- -0.3~V_{IN}
FLAG to GND ---------- -0.3~7V
Maximum Junction Temperature (T_J) ---------- 150℃
Maximum Soldering Temperature (at leads, 10 sec) ---------- 260℃
Storage Temperature Range ---------- -65℃ to 125℃

Note 1. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information (Note 2)

Thermal Resistance (from junction to ambient, θ_{JA}) ---------- 203°C/W
Thermal Resistance (from junction to case, θ_{JC}) ---------- 120°C/W

Note 2. It is based on 2S2P JEDEC standard PCB.

ESD Susceptibility

HBM (Human Body Model) ---------- 4kV
CDM (Charged Device Model) ---------- 500V

Recommended Operating Conditions

Input Voltage ---------- 2.4 V to 6.0V
EN Voltage ---------- 0 V to 6.0V
Limited Current Setting ---------- 200mA to 2.5A
Ambient Temperature Range ---------- -40℃ to 85℃

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Electrical Characteristics

(The specifications are at T_A=25℃, V_{IN} = 5V, unless otherwise noted.)

Parameters		Symbol	Test conditions	Min	Typ	Max	Unit
On-resistance		$R_{DS(ON)}$	V_{IN} = 5V, I_{OUT}=500mA, T_A=25°C		70	100	mΩ
Input quiescent current		I_Q	V_{IN} = 5V, OUT floating, V_{EN} = 5V		38	60	μA
Input shutdown current		I_{SD}	V_{IN} = 5V, OUT grounded, V_{EN} = 0V			200	nA
Under voltage lockout level		V_{UVLO_F}	IN voltage falling	2.05	2.3	2.55	V
		V_{UVLO_R}	IN voltage rising	2.15	2.4	2.65	V
Current limit level	LPW5212xxx21	I_{LIM}	V_{IN} = 5V, V_{OUT} = 4.5V	2.10	2.30	2.50	A
	LPW5212xxx15		V_{IN} = 5V, V_{OUT} = 4.5V	1.4	1.6	1.8	
	LPW5212xxx11		V_{IN} = 5V, V_{OUT} = 4.5V	1.20	1.35	1.50	
	LPW5212xxx06		V_{IN} = 5V, V_{OUT} = 4.5V	0.55	0.65	0.75	
	LPW5212Axxx		Refer to **Figure8** and **Equation(1)**				
Fold-back Current	LPW5212xxx21	I_{FDB}	VIN>3.5V and VOUT<1V		1.53		A
	LPW5212xxx15		VIN>3.5V and VOUT<1V		1.06		
	LPW5212xxx11		VIN>3.5V and VOUT<1V		0.90		
	LPW5212xxx06		VIN>3.5V and VOUT<1V,		0.43		
	LPW5212Axxx		VIN>3.5V and VOUT<1V		2/3*I_{LIM}		
Current limit level accuracy (LPW5212Axxx)		ACC_{LIM}	V_{IN} = 5V, 500mA < ILIM < 3.3A		10		%
			V_{IN} = 5V, 200mA < ILIM < 500mA		15		
Short circuit protection level (4)		I_{SHORT}	V_{IN} = 5V, T_A=25°C		4.5	6.5	A
Enable pull-down resistor		R_{PD}	V_{IN} = 5V, T_A=25°C		1.4		MΩ
Output auto discharge		R_{DIS}	V_{IN} = 5V, EN flip from high to low	90	110	130	Ω
Reverse voltage protection (4)		V_{RVP}	V_{IN} = 5V, V_{OUT} - V_{IN} level to trigger off		80		mV
Enable logic high voltage level		V_{IH}	V_{IN} = 2.4V to 6V	1.4			V
Enable logic low voltage level		V_{IL}	V_{IN} = 2.4V to 6V			0.4	V
Enable hold time for discharge		t_{HOLD}	V_{IN} = 2.4V to 6V, time for EN hold high level before switching to low. Only for part with output discharge.	30			μs
Leakage current on EN pin		I_{LKG_EN}	V_{EN} = V_{IN} = 5V		3.5		μA
Output logic low voltage level		V_{OL}	V_{IN} = 2.4V to 6V, I_{FLAGB} = 10mA			0.1	V
Leakage on FLAG pin		I_{LKG_FLAGB}	V_{IN} = 5V, V_{FLAGB} = 5V			0.1	μA

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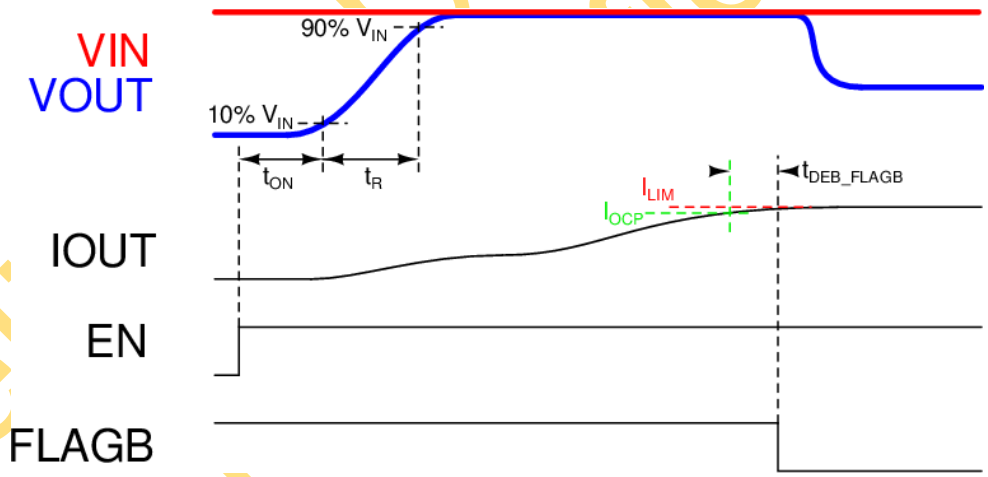
Parameters	Symbol	Test conditions	Min	Typ	Max	Unit
FLAGB de-bounce time	t_{DEB_FLAGB}	V_{IN} = 5V, R_{FLAG_PU} = 10kΩ, T_A = 25°C, time from I_{OUT} hits I_{OCP} to V_{FLAGB} = 0.1V		10		ms
Short circuit protection time	t_{SHORT}	V_{IN} = 5V, T_A = 25°C, time from I_{OUT} hits I_{SHORT} to switch turned off		300		ns
Load switch turned on delay	t_{DON}	V_{IN} = 5V, R_{OUT} = 10Ω, C_{OUT} = 1μF, time from enabled to V_{OUT} = 0.5		500		μs
Output rising time	t_R	V_{IN} = 5V, R_{OUT} = 10Ω, C_{OUT} = 1μF, time from V_{OUT} = 0.1×V_{IN} to 0.9×		500		μs
Load switch turned off delay	t_{OFF}	V_{IN} = 5V, R_{OUT} = 10Ω, C_{OUT} = 1μF, time from disabled to V_{OUT} = 0.9×		1.2		μs
Output discharge time	t_{DIS}	V_{IN} = 5V, R_{OUT} = 10Ω, C_{OUT} = 1μF, time from V_{OUT} = 0.9×V_{IN} to 0.1×		25		μs
Thermal shutdown trigger	T_{SD}	Temperature rising		150		°C
Thermal shutdown release	T_{SD_REL}	Temperature falling		130		°C

Typical Timing Diagram



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Typical Characteristics

(T_J = 25℃, V_{IN} = 5V, C_{IN} = C_{OUT} = 1.0μF, unless otherwise noted.)

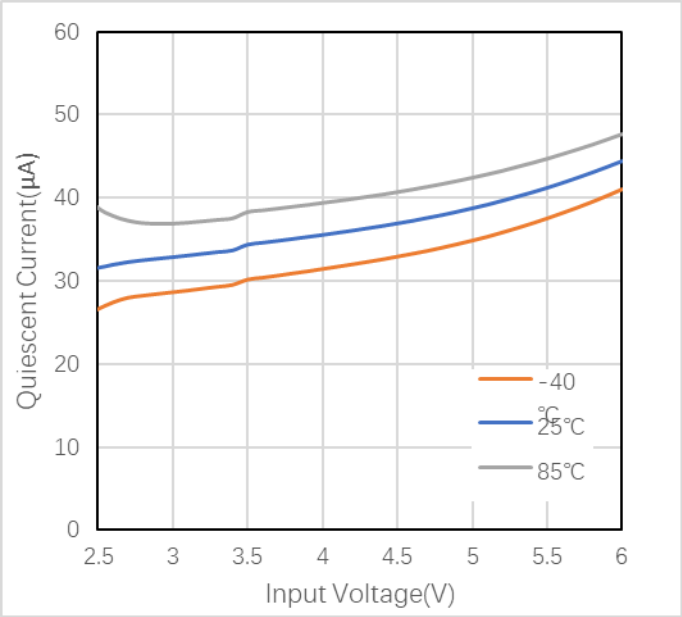

Figure 1. Quiescent Current vs Input Voltage, (VEN=VIN, no load)

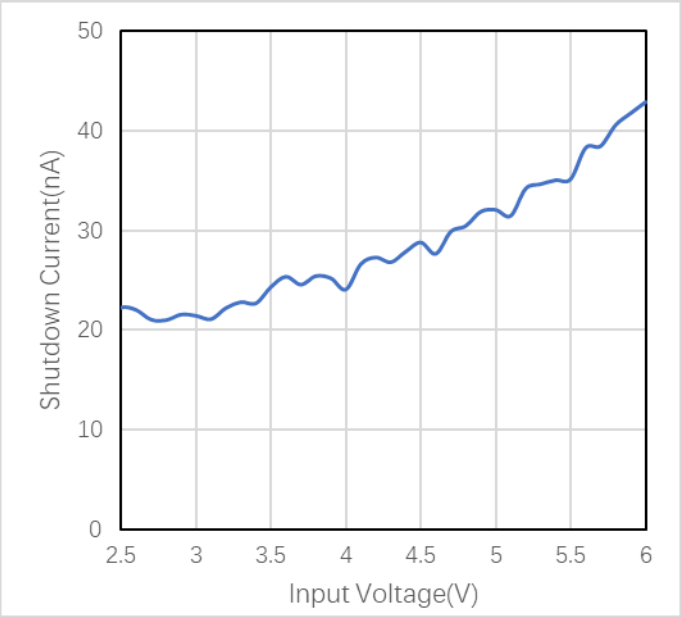

Figure 2. Shutdown Current vs Input Voltage (VEN=VIN, no load)

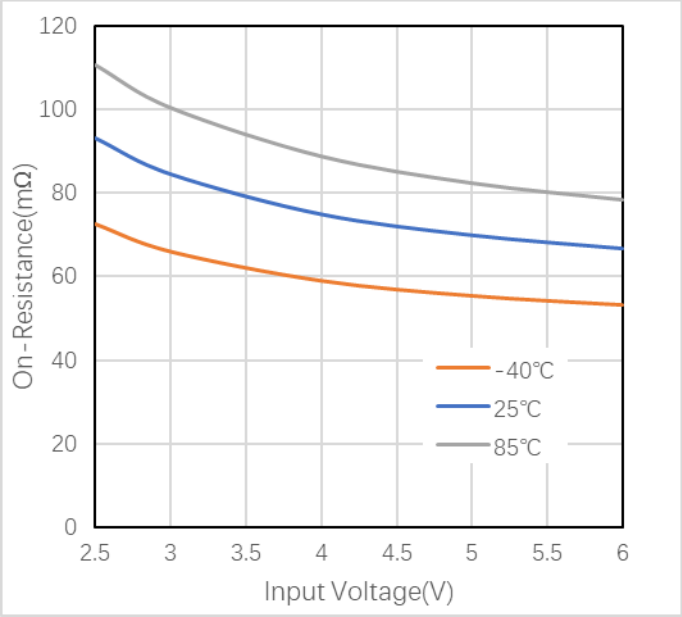

Figure 3 On-Resistance vs Input Voltage (VEN=VIN, no load)

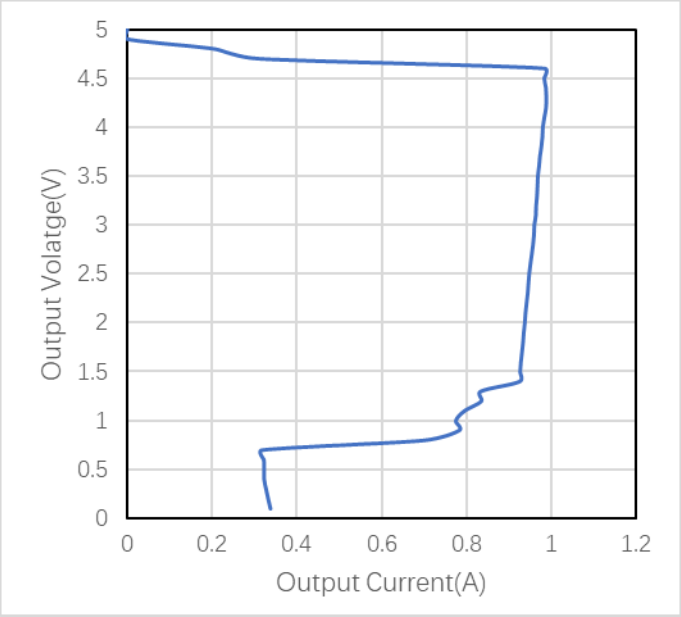

Figure 4 Output V-I curve (VEN=VIN，RISET=8.2kΩ)

Functional Block Diagram

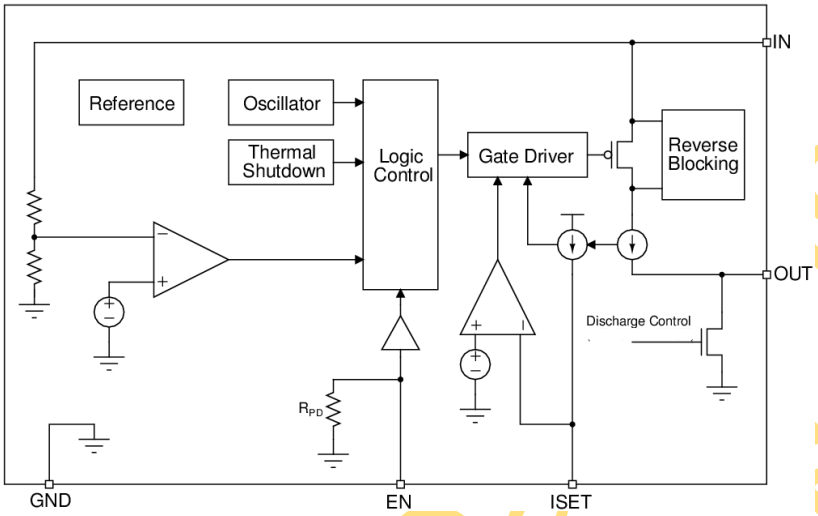

Figure 5. LPW5212A Block Diagram

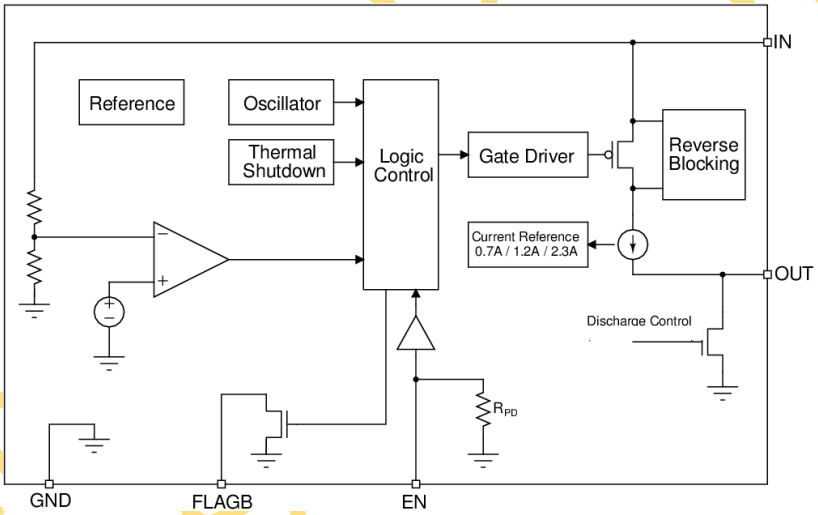

Figure 6. LPW5212F Block Diagram

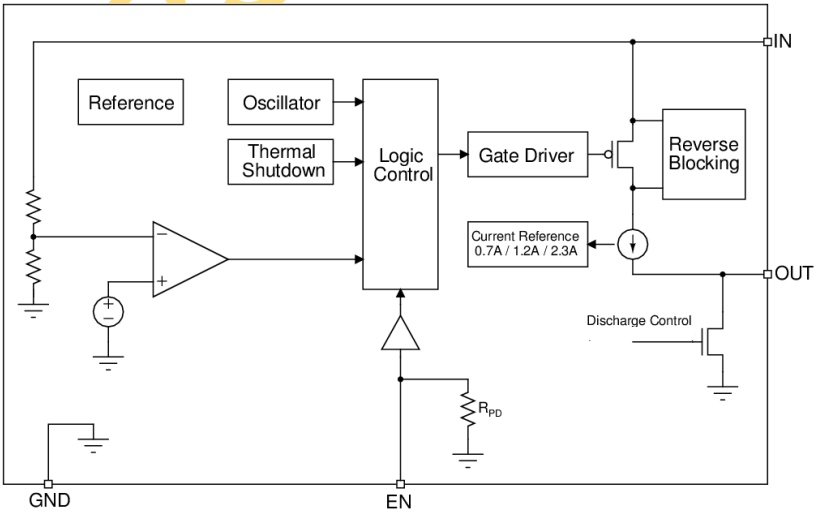

Figure 7. LPW5212S Block Diagram

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Detailed Description

Overview

LPW5212 series are current limited switches that protect systems and loads which can be damaged or disrupted by the application of high currents. The devices all contain a 70mΩ P-channel MOSFET and a controller capable of working over a wide input operating range of 2.4V to 6V. The controller protects against system malfunctions through current limiting, under-voltage lockout and thermal shutdown. The current limit is adjustable from 200mA to 2.5A through an external resistor, or fixed value typical 1.35A, 1.6A or 2.35A to allow 1.1A, 1.5A or 2.1A applications.

Enable control

The EN pin controls the state of the switch. When EN is pulled high, the load switch is turned on. Activating EN continuously holds the switch in the on state so long as there is no fault. For all versions, an under-voltage on IN or a junction temperature in excess of 150°C overrides the EN control to turn off the switch. The LPW5212 does not turn off in response to an over current condition but instead remains operating in a constant current mode as long as EN is active and the thermal shutdown or under-voltage lockout have not activated.

The enable pin EN's control voltage and IN pin have independent recommended operating ranges. The EN pin voltage can be driven by a voltage level higher than the input voltage.

Reverse Voltage Protection

The LPW5212 has a reverse voltage protection feature that protects the input when output voltage is higher than the input. For a standard USB power design, this is an important feature to protect the USB host from being damaged due to the current flow from VBUS.

When the load switch is OFF, no current flows from the output to the input. If the switch is turned on and V_{OUT} - V_{IN} is higher than V_{RVP}, this feature is activated and turns off the switch. This prevents any current flow from output to input. The reverse voltage protection feature will be deactivated if the V_{OUT} is smaller than V_{IN}. FLAGB operation is independent of the reverse voltage protection and does not report a fault condition if this feature is activated

Current Limit

The current limit ensures that the current through the switch doesn't exceed a maximum value while not limiting at less than a minimum value. The current at which the parts will limit is fixed or adjustable through the selection of an external resistor connected to ISET. The LPW5212F have a debounce time of 10ms, nominally, for indicator pin. At the end of this time, the FLAGB will be internally pulled down. As long as the heavy load condition continued, the LPW5212 will remain in a constant current state until the EN pin is deactivated or the thermal shutdown turns-off the switch.

There is foldback of current limit when VIN>3.5V and VOUT<1V. The foldback function is always active even in start-up phase.

Under-Voltage Lockout

The under-voltage lockout turns-off the switch if the input voltage drops below the under-voltage lockout threshold. With the EN pin active, the input voltage rising above the under-voltage lockout threshold will cause a controlled turn-on of the switch which limits current over-shoots.

Thermal Shutdown

The thermal shutdown protects the die from internally or externally generated excessive temperatures. During an over temperature condition, the switch is turned off. The switch automatically turns on again if the temperature of the die drops below the threshold temperature.

FLAGB Function

The FLAGB open-drain output is asserted (active low) when an over current condition is encountered after a 10-ms deglitch timeout. The output remains asserted until the overcurrent condition is removed for 10-ms deglitch timeout. Over temperature condition is also reported by FLAGB open-drain output. The deglitch circuitry delays asserting and de-asserting current limit induce FLAGB reports. The FLAGB signal is deglitched both an over-temperature happened and after the device has cooled and begins to turn on.

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Application Description

The LPW5212A current limit is set with an external resistor connected between ISET pin and GND. This resistor is selected using the following equation:

$$R_{SET} = \frac{7900}{I_{LIM}} \quad (1)$$

Where, R_{SET}, united as kΩ, is the resistor connected to ISET. I_{LIM} is the expected current limit value in mA. Resistor tolerance of 1% or less is recommended.
The relationship between R_{SET} and I_{LIM} could also be found as below diagram:

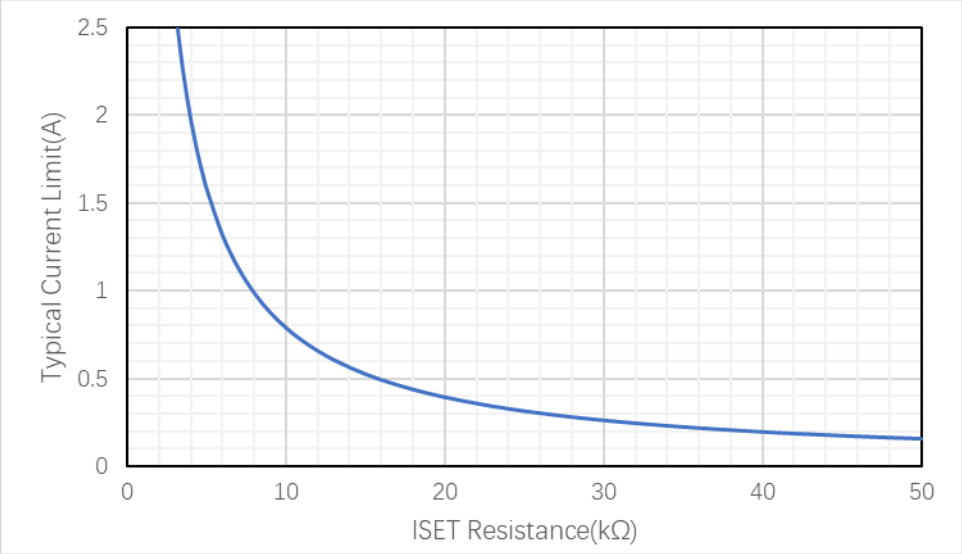

Figure 8. Current limit level of LPW5212A

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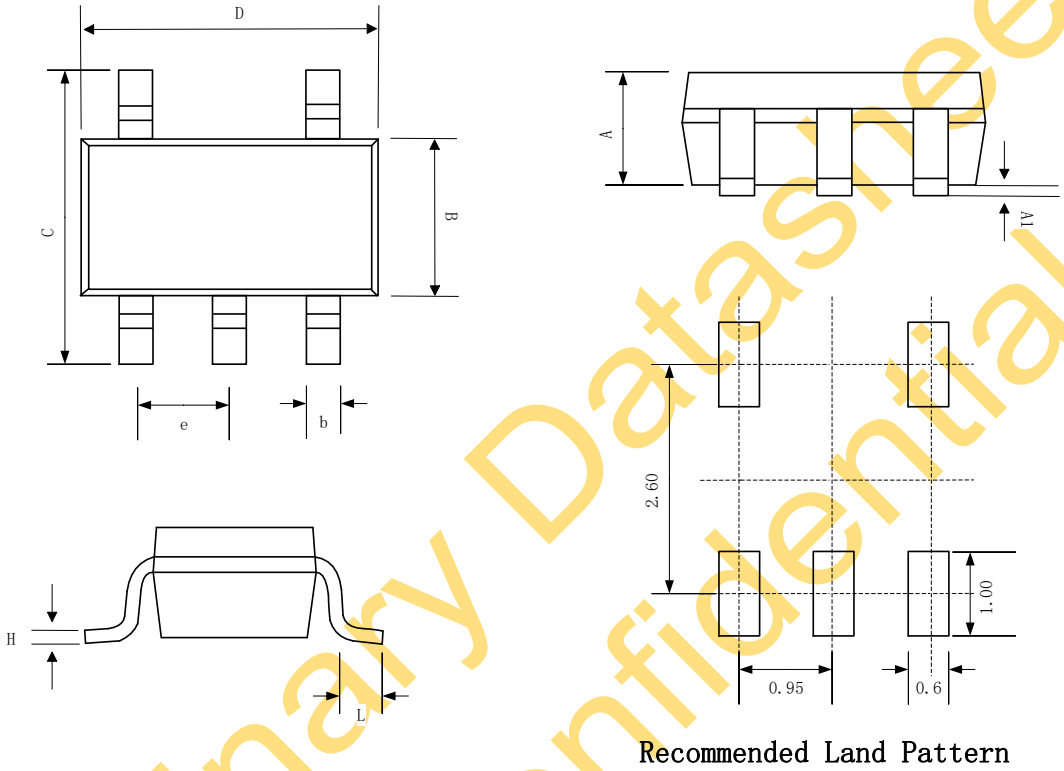
Packaging Information

SOT23-5



Recommended Land Pattern

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.889	1.100	1.295
A1	0.000	0.050	0.152
B	1.397	1.600	1.803
b	0.28	0.35	0.559
C	2.591	2.800	3.000
D	2.692	2.920	3.120
e	0.95BSC		
H	0.080	0.152	0.254
L	0.300	0.450	0.610

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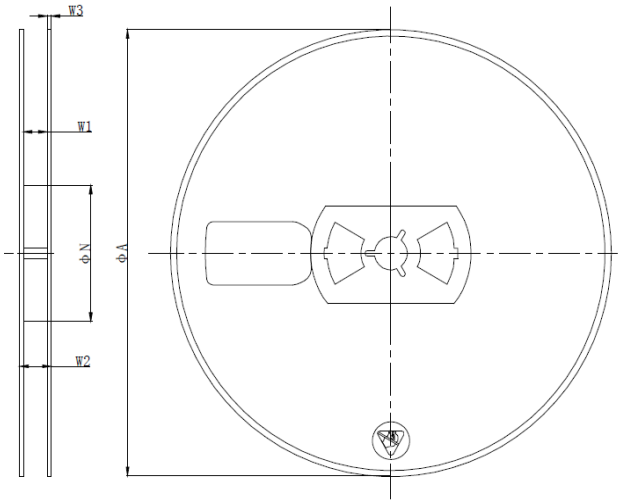
Tape and Reel Information

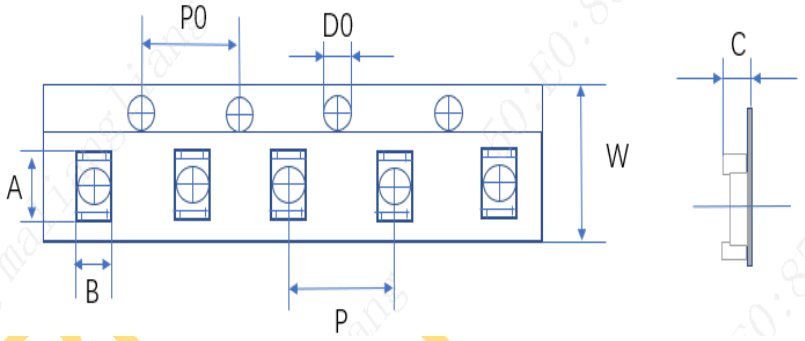
SOT23-5

REEL DIMENSIONS



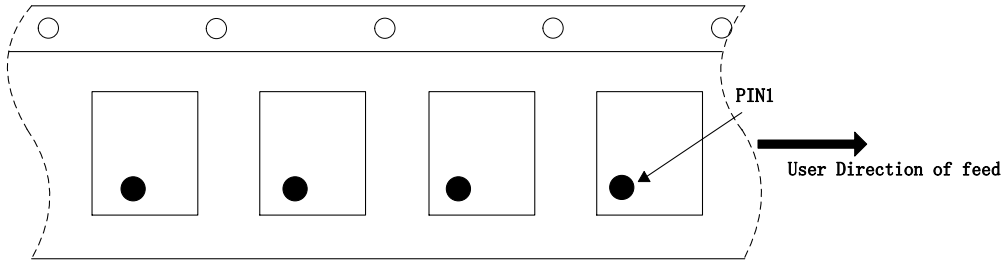
SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
ΦA	176.00	180.00	184.00
W2	10.00	12.00	14.00

TAPE DIMENSIONS



SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
A	3.00	3.20	3.40
B	3.06	3.26	3.46
P0	3.90	4.00	4.10
P	3.90	4.00	4.10
D0	1.35	1.50	1.65
W	7.70	8.00	8.30
C	1.20	1.40	1.60

PIN1 AND TAPE FEEDING DIRECTION



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Classification of IR Reflow Profile

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat/Soak		
Temperature Min(T_{SMIN})	100℃	150℃
Temperature Max(T_{SMAX})	150℃	200℃
Time(T_S) from (T_{SMIN} to T_{SMAX})	60~120 seconds	60~120 seconds
Ramp-up rate (T_L to T_P)	3℃/second max	3℃/second max
Liquidous temperature(T_L)	183℃	217℃
Time(t_L) maintained above T_L	60~150 seconds	60~150 seconds
Peak package body temperature (T_P)	For users T_P must not exceed the Classification temp in Table 1. For suppliers T_P must equal or exceed the Classification temp in Table 1.	For users T_P must not exceed the Classification temp in Table 2. For suppliers T_P must equal or exceed the Classification temp in Table 2.
Time(t_P)* within 5℃ of the specified classification temperature(T_C), see Figure1	20* seconds	30* seconds
Ramp-down rate (T_P to T_L)	6℃/second max	6℃/second max
Time 25℃ to peak temperature	6 minutes max	8minutes max
* Tolerance for peak profile temperature (T_P) is defined as a supplier minimum and a user maximum.		

Table 1Sn-Pb Eutectic Process - Classification Temperatures (T_C)

Package Thickness	Volume mm³ <350	Volume mm³ ≥350
<2.5mm	235℃	220℃
≥2.5mm	220℃	220℃

Table 2 Pb-Free Process - Classification Temperatures (T_C)

Package Thickness	Volume mm³ <350	Volume mm³ 350~2000	Volume mm³ ≥350
<1.6mm	260℃	260℃	260℃
1.6mm~2.5mm	260℃	250℃	245℃
>2.5mm	250℃	245℃	245℃

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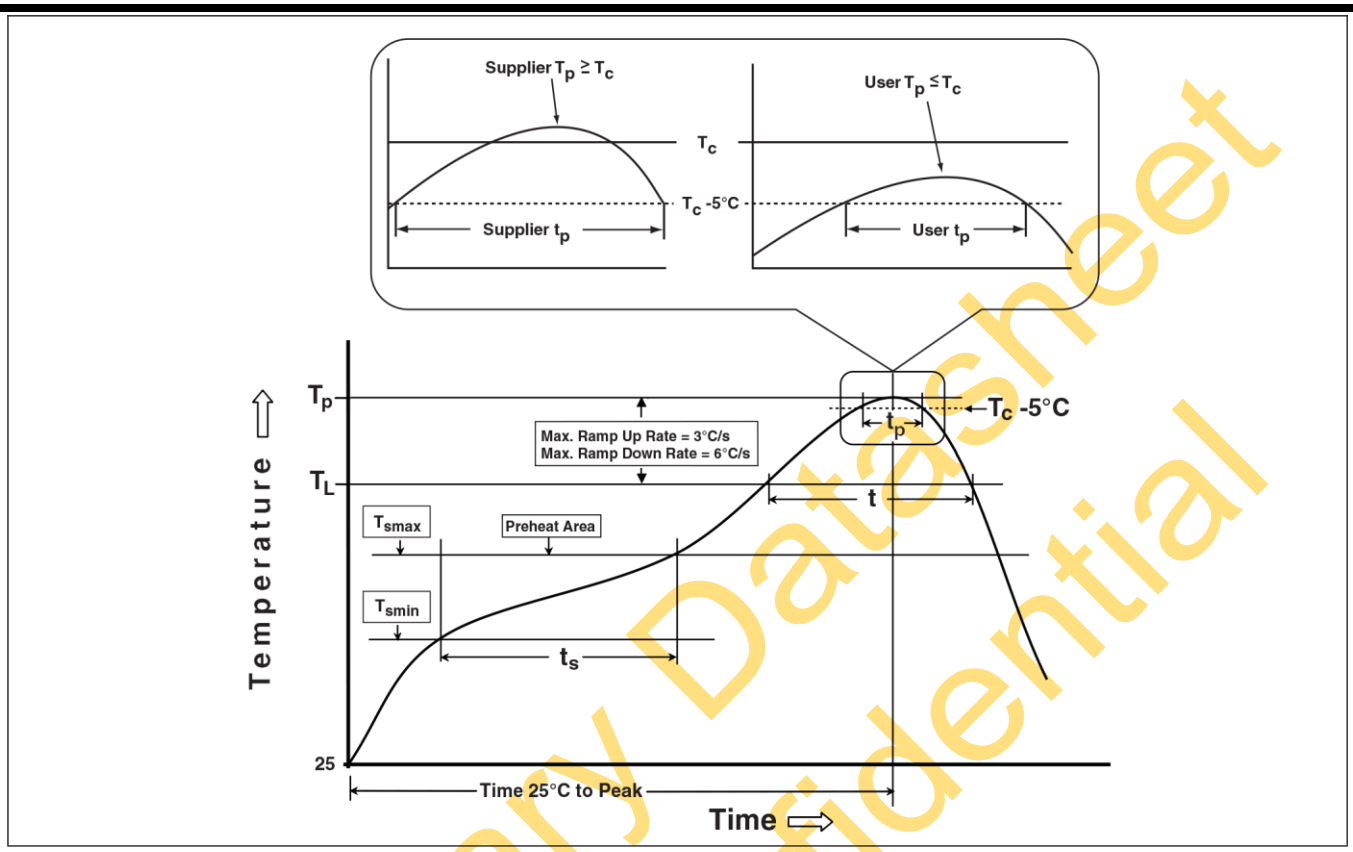

Figure1Classification Profile (Not to scale)

Products conform to "JEDEC J-STD-020C" standards;

Products shipped conform to "Rohs" standards;

Moisture Sensitivity Level：MSL3（CONDITION：≦30 °C/60%RH、Time control:168 hours）;

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