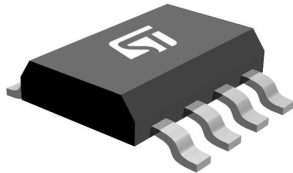


## Programmable electronic power breaker for 12 V bus



Power SO8

### Features

- Real-time input power sensing
- Input voltage range: from 10.5 V to 18 V
- Continuous current typ.: 1.5 A
- P-channel on resistance typ.: 50 mΩ
- Power limit accuracy typ.: 3%
- Undervoltage lockout
- Adjustable power limitation
- PWM mode
- Programmable power limit masking time
- Programmable auto-retry delay
- Thermal shutdown
- Enable function
- Short-circuit current limit
- Operative junction temp. - 40 °C to 125 °C
- Available in power SO8 package
- Simplifies UL compliance and certification

### Applications

- White goods
- Consumer electronics
- Industrial applications
- Air conditioner
- User interface
- Fan motor control

### Description

The **STPW12** is an integrated electronic power breaker, optimized to monitor the input power.

Connected in series to the power rail, it is able to disconnect the electronic circuitry on its output if the power consumption overcomes the programmed limit. When this happens, the device automatically opens the integrated power switch and disconnects the load.

The intervention of the protection is communicated to the board monitoring circuits through a signal on the fault pin.

After a certain delay time, programmable by the user, the device automatically tries again to close the internal switch and re-connect the load.

A dedicated monitor pin provides the user with continuous information on the monitored power.

The device can be enabled/disabled through a dedicated pin, and a direct PWM mode can be implemented providing PWM pin with an external signal.

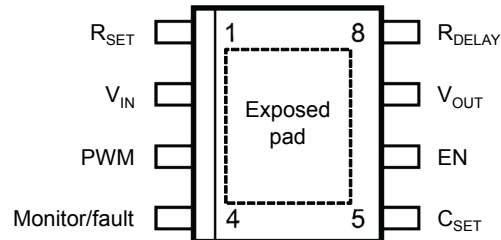
Maturity status link	
<a href="#">STPW12</a>	
Device summary	
<b>Order code</b>	STPW12PHR
<b>Package</b>	Power SO8

This approach allows the user to optimize the design power distribution system, in terms of accurate power control, choice of isolation material, safety improvement, such as: reduced risk of flammability and easier qualification and certification flow.



## 2 Pin configuration

**Figure 3. Pin connection (top view)**



**Table 1. Pin description**

Pin n°	Symbol	Note
1	$R_{SET}$	An $R_S$ resistor between this pin and GND fixes the power limiting threshold
2	$V_{IN}$	Input voltage
3	PWM	A PWM signal can be provided through this pin to turn-ON/OFF the power switch If PWM function is not used it is suggested to connect this pin to EN or $V_{IN}$
4	Monitor/fault	Power monitor signal, fault signal
5	$C_{SET}$	A $C_S$ capacitor between this pin and GND sets the auto-retry delay
6	Enable	Enable pin (device active when EN=high)
7	$V_{OUT}$	Output pin
8	$R_{delay}$	An $R_D$ resistor connected between this pin and GND sets the power limit masking time. Do not connect this pin directly to GND
Exp.pad	GND	Device GND connection

### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{IN}$	Positive power supply voltage	-0.3 to 25	V
$V_{OUT}$	Output voltage	-0.3 to $V_{IN} + 0.3$	V
$R_{set}$	$R_{set}$ pin voltage	-0.3 to 7	V
$C_{set}$	$C_{set}$ pinvoltage	-0.3 to 7	V
$R_{delay}$	$R_{delay}$ pin voltage	-0.3 to 7	V
Monitor/fault	Monitor/fault pin voltage	-0.3 to 7	V
$I_D$	Continuous current	Internally limited	A
$T_J$	Operating junction temperature range <sup>(1)</sup>	-40 to 125	°C
$T_{STG}$	Storage temperature range	-65 to 150	°C
$T_{LEAD}$	Lead temperature (soldering) 10 s	260	°C

1. The thermal shutdown limit is set above the maximum thermal ratings. It is not recommended to operate the device at temperatures greater than the maximum ratings for extended periods of time.

**Note:** Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	40	°C/W
$R_{thJC}$	Thermal resistance junction-case	12	°C/W

## 4 Electrical characteristics

$V_{IN} = 12\text{ V}$ ,  $V_{EN} = V_{PWM} = 5\text{ V}$ ,  $C_I = 10\text{ }\mu\text{F}$ ,  $C_O = 10\text{ }\mu\text{F}$ ,  $T_J = 25\text{ }^\circ\text{C}$  (unless otherwise specified).

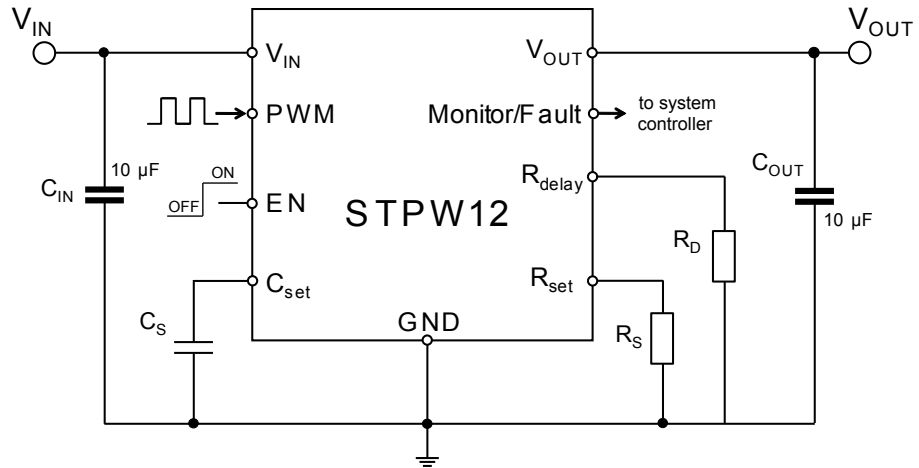
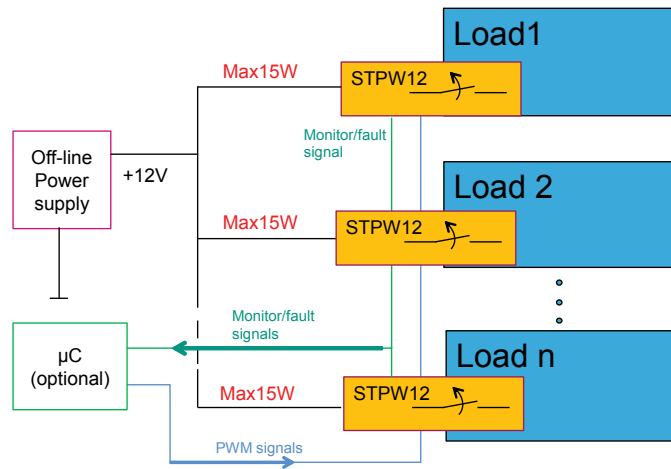
**Table 4. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IN}$	Operating input voltage range	$V_{PWM} = V_{IN}$	10.5		18	V
<b>Under/overvoltage protection</b>						
$V_{UVLO}$	Undervoltage lockout	Turn-on, voltage going up, $I_{LOAD} = 5\text{ mA}$		8.1		V
$V_{Hyst}$	UVLO hysteresis	$I_{LOAD} = 5\text{ mA}$		2.2		V
<b>Power MOSFET</b>						
$R_{DSon}$	ON-resistance	<i>Note:</i> Pulsed test.		50	70	m $\Omega$
<b>Power limit circuit</b>						
$\Delta P$	Power limit accuracy	Limit set to 15 W, $R_S = 2.7\text{ k}\Omega$ $V_{IN} = 12\text{ V}$ , $T_J = 25\text{ }^\circ\text{C}$		$\pm 3$		%
		Limit set to 15 W, $V_{IN} = 12\text{ V}$ , $T_J = 0\text{ to }75\text{ }^\circ\text{C}$ <sup>(1)</sup>	-7.5		+7.5	
P	Power limit range		10		16	W
<b>Enable</b>						
$V_{IL}$	Low level input voltage	Output disabled			0.8	V
$V_{IH}$	High level input voltage	Output enabled	2			V
$I_{EN}$	Enable pin current	$V_{EN} = 12\text{ V}$		0.1	1	$\mu\text{A}$
<b>PWM input logic</b>						
$V_{SPL}$	Low level input voltage	Turn-off			0.8	V
$V_{SPH}$	High level input voltage	Turn-on	2			V
$I_{PWM}$	PWM pin current	$V_{PWM} = 12\text{ V}$		0.1	1	$\mu\text{A}$
$f_{PWM}$	PWM signal frequency	No $C_{OUT}$		2		kHz
D	PWM signal duty cycle	No $C_{OUT}$	20		100	%
<b>Auto-retry circuit</b>						
$I_{SET}$	$C_S$ capacitor charging current	During fault condition		0.16		$\mu\text{A}$
<b>Power limit masking circuit</b>						
$t_{mask}$	Masking time in PWM mode	$R_D = 1\text{ k}\Omega$		45		$\mu\text{s}$
<b>Total device</b>						
$I_{Bias}$	Bias current	$R_S = 2.7\text{ k}\Omega$ device operational		4		mA
		Shutdown mode		40	100	$\mu\text{A}$
<b>Thermal shutdown</b>						
TSD	Shutdown temperature	<sup>(2)</sup>		160		$^\circ\text{C}$
	Hysteresis			15		

1. Values over the temperature range are guaranteed by design/correlation and tested in production only at ambient temperature.

2. Guaranteed by design, but not tested in production.

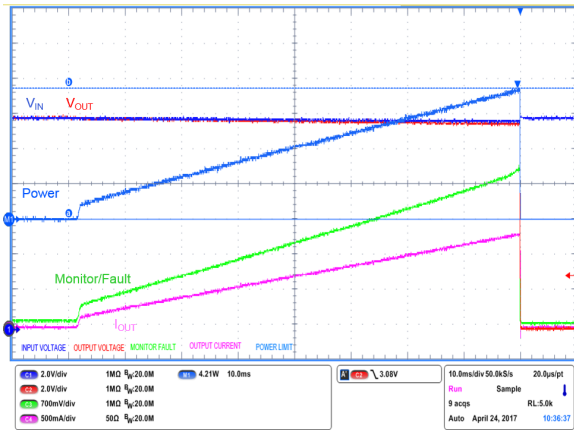
## 5 Typical application diagram

**Figure 4. Application circuit**

**Figure 5. Application diagram**


## 6 Typical characteristics

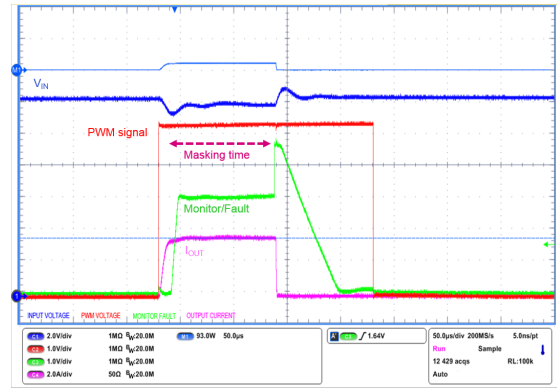
$V_{IN} = 12\text{ V}$ ,  $I_{LOAD} = 1\text{ A}$ ,  $V_{EN} = V_{PWM} = 5\text{ V}$ ,  $C_I = 10\text{ }\mu\text{F}$ ,  $C_O = 10\text{ }\mu\text{F}$ ,  $T_J = 25\text{ }^\circ\text{C}$  (unless otherwise specified).

Figure 6. Monitor signal vs. power



$V_{IN} = 12\text{ V}$ ,  $C_{IN} = 22\text{ }\mu\text{F}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$ ,  $I_{OUT}$  = from 0 to power limit

Figure 7. Masking time, fault signal



$V_{IN} = 12\text{ V}$ ,  $C_{IN} = 10\text{ }\mu\text{F}$ ,  $C_{OUT} = 68\text{ nF}$ ,  $V_{EN} = V_{IN}$ ,  $R_{DELAY} = 10\text{ k}\Omega$ , PWM from 0 to 5 V

Figure 8. On resistance vs. temperature

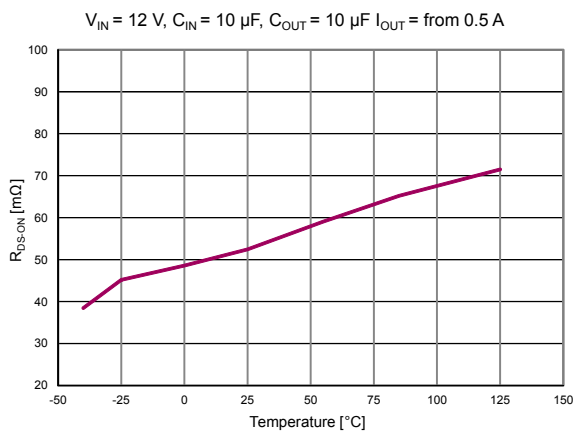


Figure 9. UVLO thresholds vs. temperature

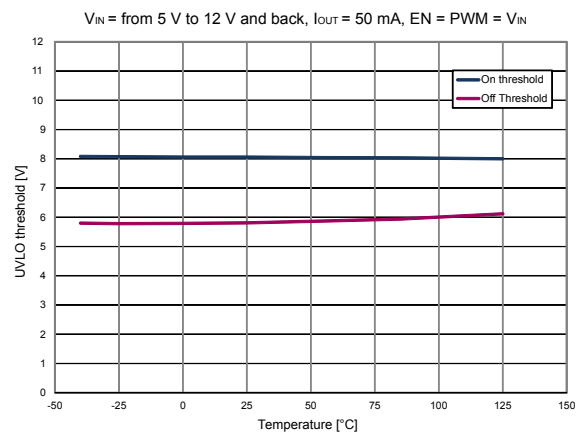




Figure 10. Enable thresholds vs. temperature

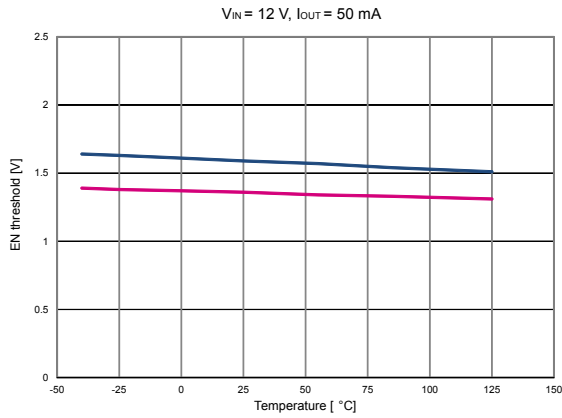


Figure 11. PWM thresholds vs. temperature

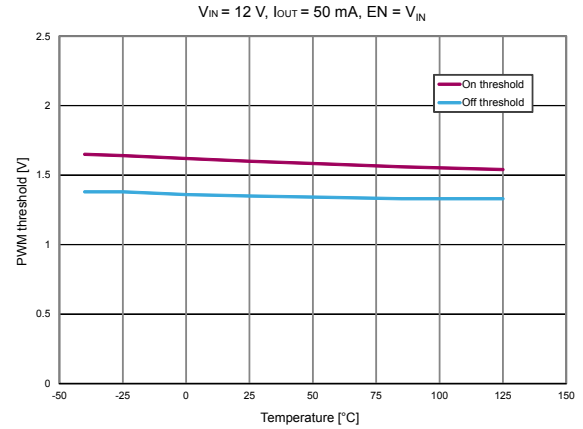


Figure 12. Bias current vs. temperature

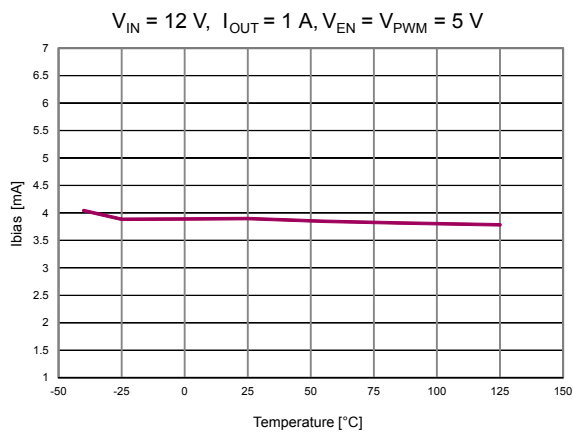


Figure 13. Off-state current vs. temperature

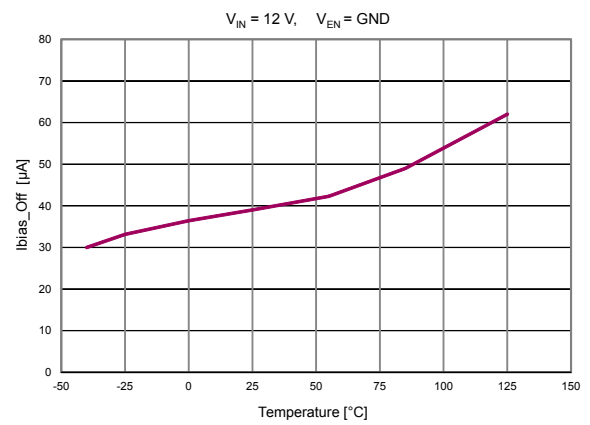


Figure 14. Power limit accuracy vs. temperature

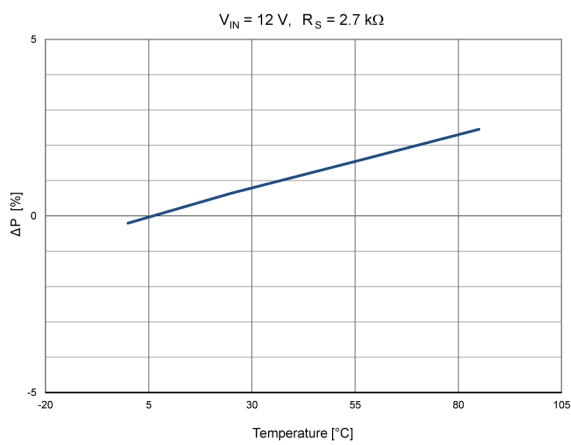


Figure 15. Power limit threshold vs.  $R_S$

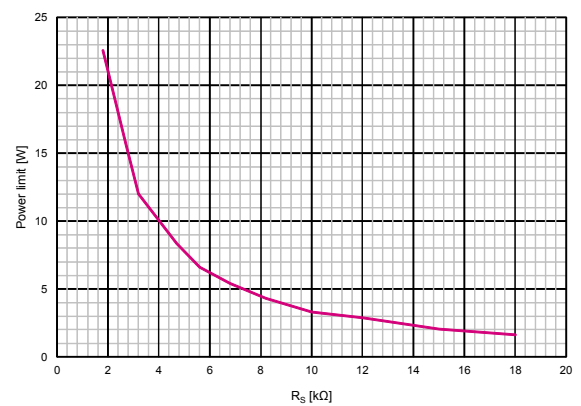


Figure 16. Auto-retry delay time vs.  $C_S$

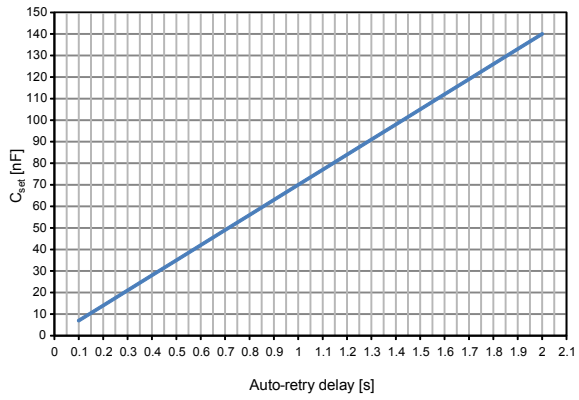
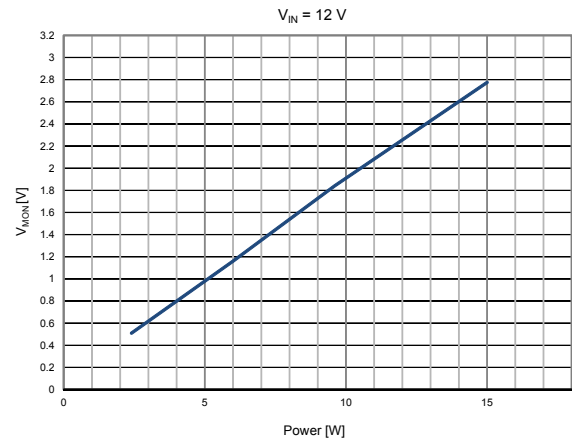


Figure 17. Monitor voltage vs. power



## 7 The STPW12 detailed description

### 7.1 Power breaker intervention and thermal shutdown

The device disconnects the load if the power overcomes the pre-set threshold.

The intervention threshold is programmed by the  $R_S$  resistor, connected by the  $R_{set}$  pin and GND. The  $R_S$  resistor can be chosen with the help of the [Figure 15. Power limit threshold vs.  \$R\_S\$](#)  graph and can be rated for  $\frac{1}{4}$  W.

The accuracy level of the limiting circuit is achieved by using high precision resistor (0.1%) for the  $R_S$ . The lower precision resistors, the lower precision of the power limit.

The overcoming of the power limit threshold is signalled on the monitor/fault pin (see [Figure 7. Masking time, fault signal](#) and [Section 7.3 Monitor/fault pin description](#)).

After a programmable delay time, the device attempts again to reconnect the load, by the auto-retry circuit. Each auto-retry cycle starts with the defined masking time.

### 7.2 Current limit and thermal protections

The STPW12 is equipped with internal self-protections, such as: current limit and thermal shutdown.

Thermal shutdown is always active and occurs if the die temperature reaches the thermal shutdown threshold. If this happens, the device switches off and the load is disconnected. The monitor/fault pin signal goes to low level (power-off).

Once the die temperature decreases to the hysteresis value, the device automatically attempts to restart.

Current limit protection is always active and intervenes in case of strong overload or short-circuit on the output. In such occurrence, the device internal power switch is immediately turned off and the load is disconnected.

Therefore the device immediately tries to activate the output. This on-off cycle is repeated until the overload is removed or if thermal protection or power limit are activated.

During current limit events the monitor/fault pin is set to high logic level (4.5 V typ.).

### 7.3 Monitor/fault pin description

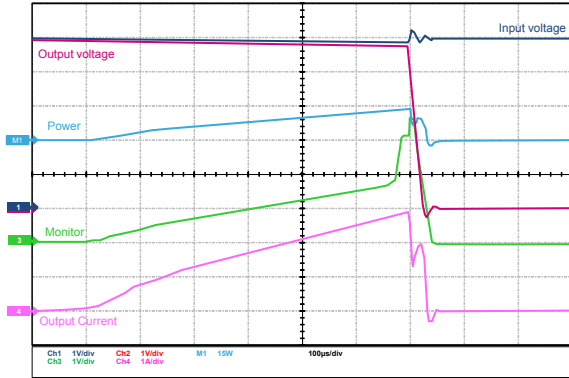
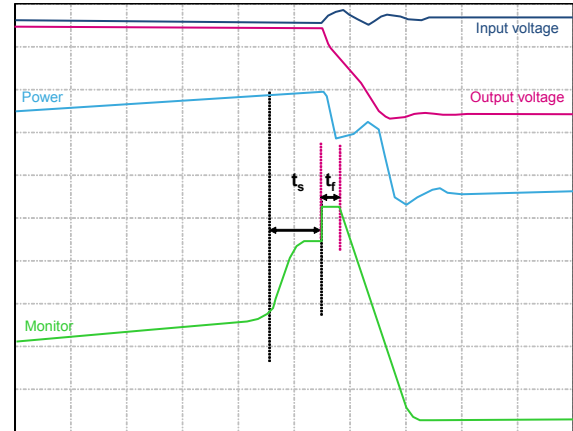
The monitor/fault pin provides two useful signals for the real-time control of the device and application status. A monitor signal proportional to the power is continuously present on the pin. The relation between this signal and the input power is almost linear and it is shown in [Figure 6. Monitor signal vs. power](#) and [Figure 17. Monitor voltage vs. power](#).

The target accuracy of monitor signal in relation to the input power is  $\pm 15\%$ , in the typical operating condition ( $V_{IN} = 12$  V,  $I_{LOAD} = 1$  A).

When the power limit threshold is reached, after a settling time  $t_s$  of about 30  $\mu$ s, the monitor/fault pin voltage goes to high logic level for about 10  $\mu$ s ( $t_f$ ), so that the user can detect the fault.

Therefore the signal goes to low logic level, the output is turned off and the auto-retry cycle starts.

The same happens if the power limit overcomes during the PWM masking time. See the following pictures and [Table 5. Monitor signal truth table](#) for more details.

**Figure 18. Monitor signal vs. power**

**Figure 19. Monitor signal vs. power (zoom)**

**Table 5. Monitor signal truth table**

Device status	Mon / fault
Normal operation	$I_{MON}$
Power limit triggered	High (for 10 $\mu$ s)
Thermal shutdown	Low
Off-state	Low
Current limit triggered	High

The voltage at high logic level is typically 4.5 V, therefore the pin can be directly interfaced to a 5 V compliant microcontroller or ADC device.

## 7.4 Auto-retry delay time setting

The auto-retry delay time, defined as the time between a power interruption event and the device restart, can be set by choosing the appropriate value for the  $C_S$  capacitor, according to the graph in [Figure 16. Auto-retry delay time vs.  \$C\_S\$](#) .

## 7.5 PWM mode description, masking time

In this mode the device internal power switch can be driven on/off by an external PWM signal, provided to the PWM pin (square wave, maximum 2 kHz, duty cycle 20% - 100%). It is important to notice that in this mode the power limit protection is kept inactive for a delay time (masking time) selected by an external  $R_D$  resistor (see [Table 6. Masking time vs.  \$R\_D\$](#) ), so to avoid false triggering during in-rush power events at each PWM signal rising edge.

Eleven discrete steps are available for the PWM masking time. They can be selected by choosing an appropriate value of the  $R_D$  resistor, as shown in the following table, where the standard 1% resistors are used.

For a correct operation of the device, the  $R_{Delay}$  pin must not be directly connected to GND, and the minimum masking time (45  $\mu$ s) is achieved by using  $R_D = 1$  k $\Omega$ .

The masking time is measured starting from when the PWM rising edge overcomes the  $V_{SPH}$  threshold till the monitor signal starts increasing (see [Figure 7. Masking time, fault signal](#)).

PWM masking time is active also during each start-up cycle (including auto-retry), in order to avoid that inrush current flowing to the output capacitor triggers the power limit, which would cause a premature shutdown.

## 7.6 Details about the start-up sequence

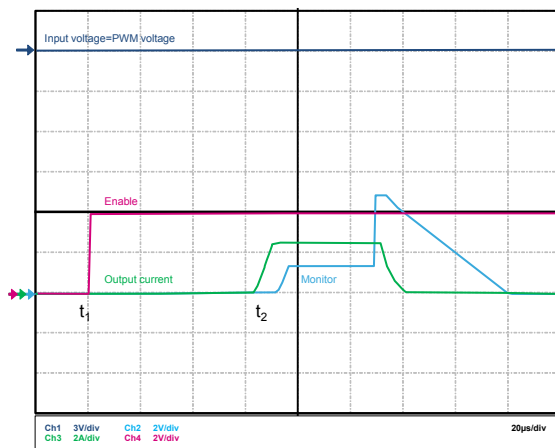
The device is not equipped with a soft-start control, in order to comply with the maximum PWM frequency, therefore in certain applications, featuring high output capacitance after the device and depending on the load characteristics, the current limit protection could occur during the start-up. The device is immediately turned off and restarted as described in [Section 7.2 Current limit and thermal protections](#). This kind of on-off cycle can happen several times until the  $C_{OUT}$  is fully charged and as a result, the start-up is prolonged.

When  $V_{OUT}$  reaches the target value, if power limit threshold is overcome and PWM is still high, due to a short masking time the device could turn off. The device then starts again after the auto-retry delay time has elapsed. For all of the above reasons,  $R_D$  and  $C_S$  have to be selected carefully in order to achieve the start-up sequence and time that satisfies the needs of the application.

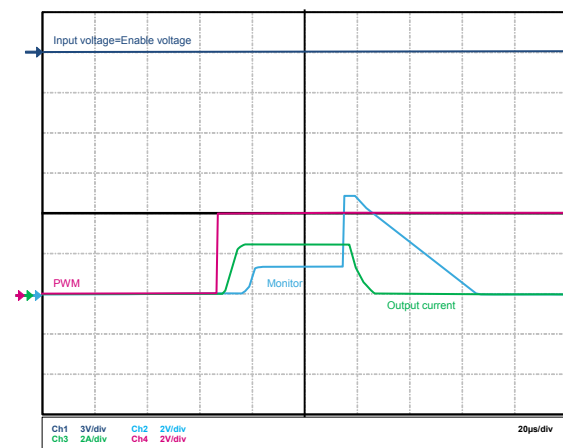
The UVLO internal signal is deglitched by a delay of 60  $\mu\text{s}$  (typ.) after EN assertion, in order to ensure that all the circuit functions are ready for the start-up. UVLO, EN, and PWM signals need being correctly asserted so that the masking time is activated.

During the start-up, attention must be paid in case a specific sequence/connection of  $V_{IN}$ , EN and PWM is needed. The following diagrams show two examples of start-up with masking time activation. [Figure 20. Start-up with PWM tied to  \$V\_{IN}\$](#)  shows a start-up with PWM pin connected directly to  $V_{IN}$  (PWM function is not used in the application), whereas [Figure 21. Start-up with EN tied to  \$V\_{IN}\$](#)  shows a start-up with EN pin tied to  $V_{IN}$  (EN function is not used in the application).

**Figure 20. Start-up with PWM tied to  $V_{IN}$**



**Figure 21. Start-up with EN tied to  $V_{IN}$**



With reference to [Figure 20. Start-up with PWM tied to  \$V\_{IN}\$](#) , at time  $t_1$  the EN signal activates the UVLO comparator and the UVLO deglitch time starts. At deglitch time expiration ( $t_2$ ) all signals are high, the device is activated and the masking time starts.

Instead, in the case described in [Figure 21. Start-up with EN tied to  \$V\_{IN}\$](#) , the enable is applied to  $V_{IN}$  connection, so the UVLO deglitch time has already expired when PWM signal is asserted. The masking time starts together with PWM.

**Table 6. Masking time vs.  $R_D$** 

$R_D$ [k $\Omega$ ]	$T_{MASK}$
1	45 $\mu$ s
12.7	100 $\mu$ s
17.8	500 $\mu$ s
23.2	1 ms
29.4	5 ms
36.5	10 ms
44.2	50 ms
53.6	200 ms
65.5	500 ms
84.5	1000 ms
105 or higher	2000 ms

## 8 Application guidelines

### 8.1 Power supply voltage

The device is designed and optimized to work on 12 V power rails, even if the operating supply voltage can range from 10.5 V to 18 V.

The maximum accuracy of the main operating features is reached for an input voltage of 12 V, therefore the operation at lower or higher voltages implies some small variations in the characteristic performance.

### 8.2 Input and output capacitors

Input and output capacitors are mandatory to guarantee the device control loop stability and reduce the transient effects of stray inductances present in the input and output power paths. In fact when the STPW12 quickly interrupts the current flow due to power limit or thermal shutdown events, input inductance generates a positive voltage spike on the input pin and, at the same way, the output inductance generates a negative voltage spike on the output. Such spikes might overcome the absolute maximum voltage ratings of the device and damage the device itself.

To reduce the effects of such transients,  $C_{IN}$  capacitor with a minimum value of 10  $\mu\text{F}$  must be connected between the input pin and GND and placed as close as possible to the device. For the same reason,  $C_{OUT}$  capacitor has to be connected on the output port. The recommended value is 10  $\mu\text{F}$ , if this is compatible with the required PWM operating frequency.

When the device is supplied via a power line made of very long wires, where input inductance is higher than 3-4  $\mu\text{H}$ , the input capacitance should be increased to 47  $\mu\text{F}$  or more. See also next paragraph for additional information about protection.

### 8.3 Additional protections and layout guidelines

Recommended additional protections and methods to address the input/output voltage spikes are the following:

- Minimizing inductance of the input and output tracks, by making short and well dimensioned power traces.
- Using TVS diodes on the input to absorb inductive spikes.
- Schottky diode on the output to absorb negative spikes (for instance the STPS2L30).
- Using a ground plane to connect the GND terminal of the IC (exposed pad) to the system GND.

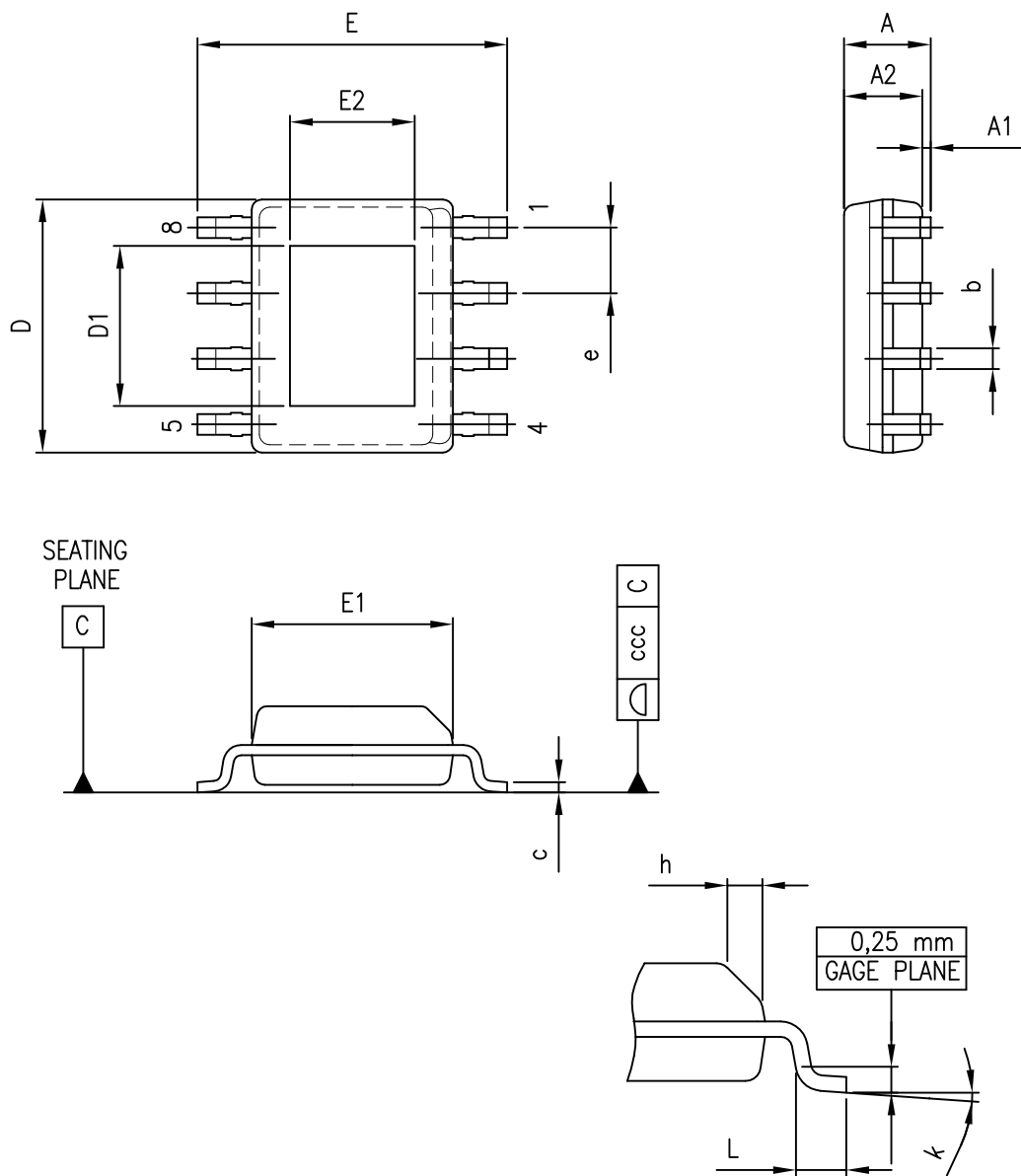
The  $C_S$  capacitor, used for the selection of the auto-retry delay time, is charged by a low 160 nA (typ.) current. To minimize the effect of noisy signals present on this PCB on the  $C_{set}$  pin, resulting in incorrect delay time, the capacitor should be placed as close as possible to the IC pin and GND.

## 9 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 9.1 Power SO8 package information

Figure 22. Power SO8 package outline





**Table 7. Power SO8 mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A			1.70
A1	0.00		0.15
A2	1.25		
b	0.38		0.51
c	0.17		0.25
D	4.80	4.90	5.00
D1	3.10	3.30	3.50
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
E2	2.20	2.40	2.60
e		1.27	
h	0.30		0.50
L	0.45	0.60	0.80
k	0		8
ccc			0.10

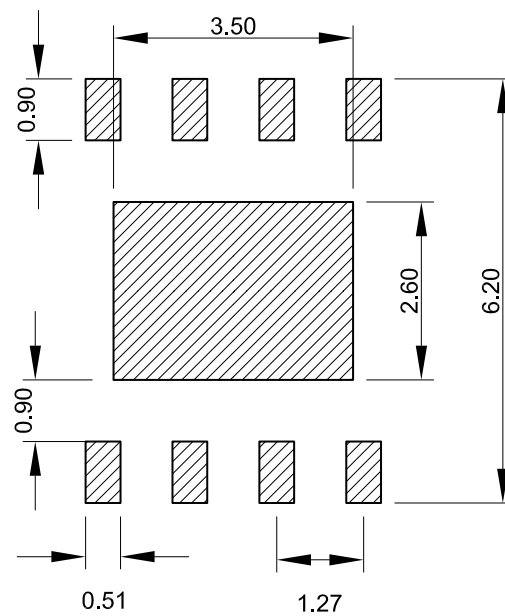
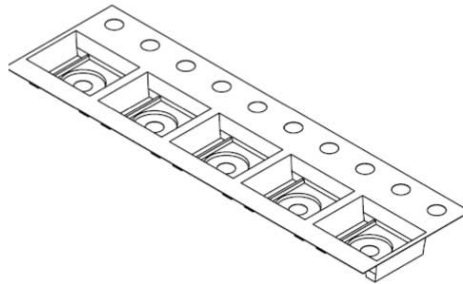
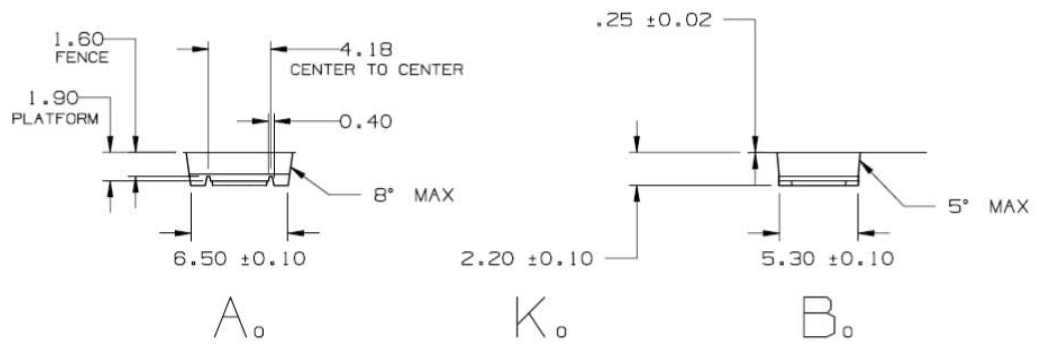
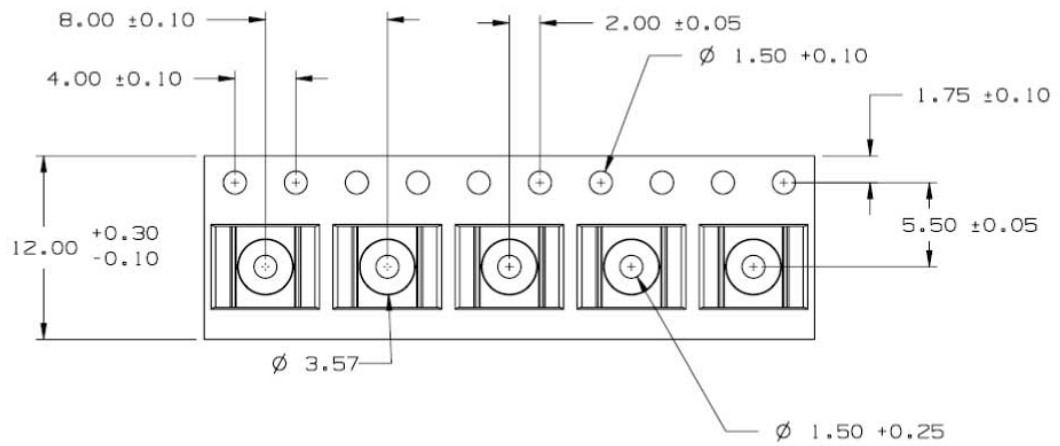
**Figure 23. Power SO8 recommended footprint**


Figure 24. Power SO8 tape and reel



## Revision history

**Table 8. Document revision history**

Date	Revision	Changes
20-Mar-2018	1	Initial release.

## Contents

<b>1</b>	<b>Diagram</b> .....	<b>3</b>
<b>2</b>	<b>Pin configuration</b> .....	<b>4</b>
<b>3</b>	<b>Maximum ratings</b> .....	<b>5</b>
<b>4</b>	<b>Electrical characteristics</b> .....	<b>6</b>
<b>5</b>	<b>Typical application diagram</b> .....	<b>7</b>
<b>6</b>	<b>Typical characteristics</b> .....	<b>8</b>
<b>7</b>	<b>The STPW12 detailed description</b> .....	<b>11</b>
7.1	Power breaker intervention and thermal shutdown .....	11
7.2	Current limit and thermal protections .....	11
7.3	Monitor/fault pin description .....	11
7.4	Auto-retry delay time setting .....	12
7.5	PWM mode description, masking time .....	12
7.6	Details about the start-up sequence .....	12
<b>8</b>	<b>Application guidelines</b> .....	<b>15</b>
8.1	Power supply voltage .....	15
8.2	Input and output capacitors .....	15
8.3	Additional protections and layout guidelines .....	15
<b>9</b>	<b>Package information</b> .....	<b>16</b>
9.1	Power SO8 package information .....	16
	<b>Revision history</b> .....	<b>19</b>

## List of tables

<b>Table 1.</b>	Pin description . . . . .	4
<b>Table 2.</b>	Absolute maximum ratings . . . . .	5
<b>Table 3.</b>	Thermal data . . . . .	5
<b>Table 4.</b>	Electrical characteristics . . . . .	6
<b>Table 5.</b>	Monitor signal truth table . . . . .	12
<b>Table 6.</b>	Masking time vs. $R_D$ . . . . .	14
<b>Table 7.</b>	Power SO8 mechanical data . . . . .	17
<b>Table 8.</b>	Document revision history . . . . .	19

## List of figures

Figure 2.	Block diagram . . . . .	3
Figure 3.	Pin connection (top view) . . . . .	4
Figure 4.	Application circuit . . . . .	7
Figure 5.	Application diagram. . . . .	7
Figure 6.	Monitor signal vs. power . . . . .	8
Figure 7.	Masking time, fault signal . . . . .	8
Figure 8.	On resistance vs. temperature . . . . .	8
Figure 9.	UVLO thresholds vs. temperature . . . . .	8
Figure 10.	Enable thresholds vs. temperature . . . . .	9
Figure 11.	PWM thresholds vs. temperature . . . . .	9
Figure 12.	Bias current vs. temperature. . . . .	9
Figure 13.	Off-state current vs. temperature. . . . .	9
Figure 14.	Power limit accuracy vs. temperature . . . . .	9
Figure 15.	Power limit threshold vs. $R_S$ . . . . .	9
Figure 16.	Auto-retry delay time vs. $C_S$ . . . . .	10
Figure 17.	Monitor voltage vs. power . . . . .	10
Figure 18.	Monitor signal vs. power . . . . .	12
Figure 19.	Monitor signal vs. power (zoom) . . . . .	12
Figure 20.	Start-up with PWM tied to $V_{IN}$ . . . . .	13
Figure 21.	Start-up with EN tied to $V_{IN}$ . . . . .	13
Figure 22.	Power SO8 package outline . . . . .	16
Figure 23.	Power SO8 recommended footprint. . . . .	17
Figure 24.	Power SO8 tape and reel. . . . .	18

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