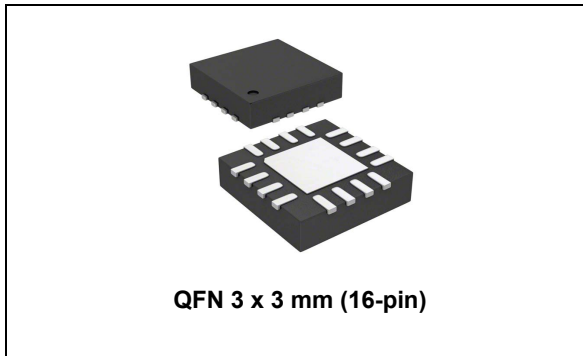


## Low voltage dual brush DC motor driver

Datasheet - production data



### Description

The STSPIN240 is a dual brush DC motor driver integrating a low  $R_{DS(ON)}$  power stage in a small QFN 3 x 3 mm package.

Both the full-bridges implement an independent PWM current controller with fixed OFF time.

The device is designed to operate in battery-powered scenarios and can be forced into a zero-consumption state allowing a significant increase in battery life.

The device offers a complete set of protection features including overcurrent, overtemperature and short-circuit protection.

### Features

- Operating voltage from 1.8 to 10 V
- Maximum output current 1.3 A<sub>rms</sub>
- $R_{DS(ON)}$  HS + LS = 0.4  $\Omega$  typ.
- Current control with programmable off-time
- Full protection set
  - Non-dissipative overcurrent protection
  - Short-circuit protection
  - Thermal shutdown
- Energy saving and long battery life with standby consumption less than 80 nA

### Applications

Battery-powered DC motor applications such as:

- Toys
- Portable printers
- Robotics
- Point of sale (POS) devices
- Portable medical equipment
- Healthcare and wellness devices (shavers and toothbrushes)

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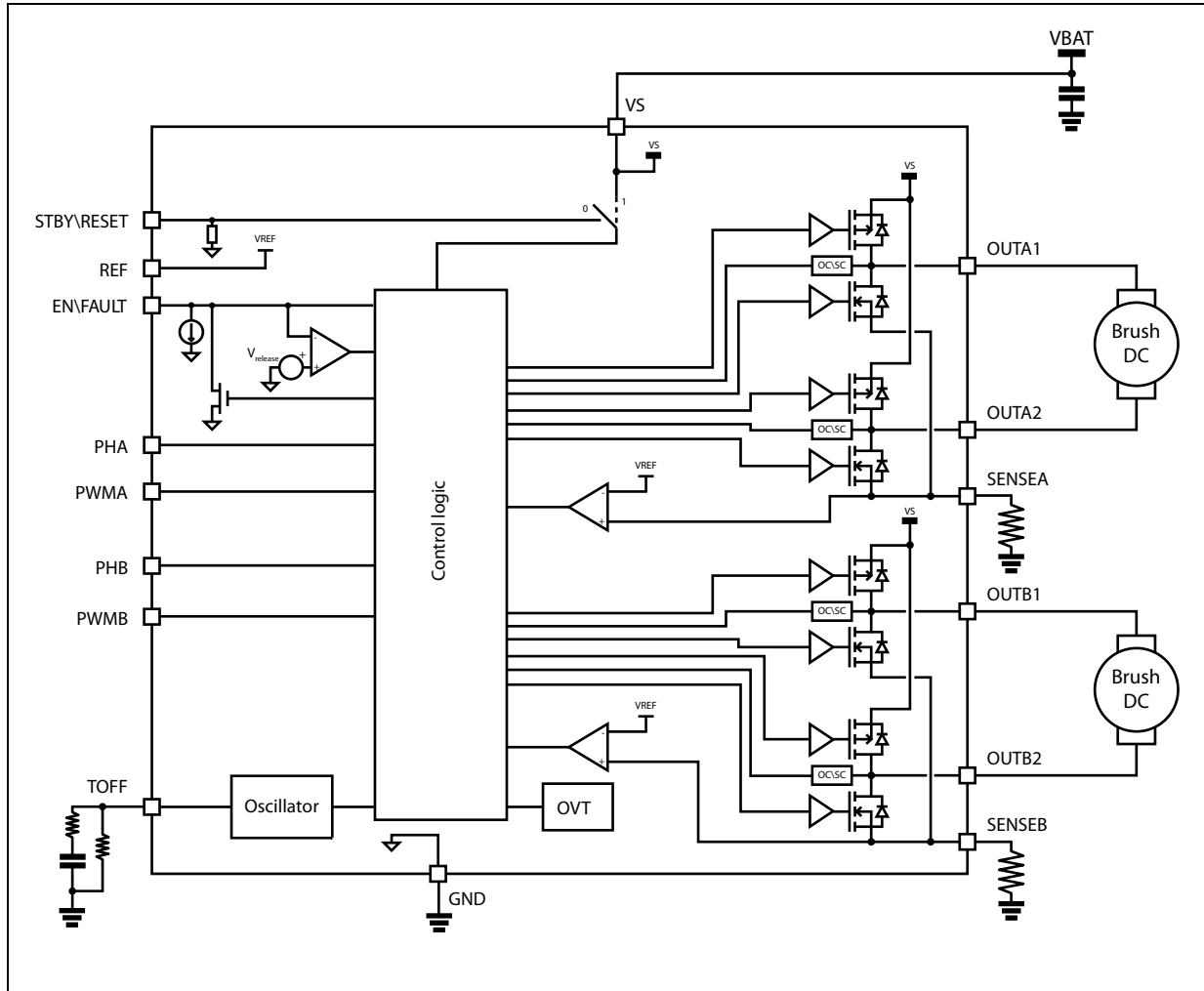
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# 1 Block diagram

Figure 1. Block diagram



## 2 Electrical data

### 2.1 Absolute maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Test condition	Value	Unit
$V_S$	Supply voltage		-0.3 to 11	V
$V_{IN}$	Logic input voltage		-0.3 to 5.5	V
$V_{OUT} - V_{SENSE}$	Output to sense voltage drop		up to 12	V
$V_S - V_{OUT}$	Supply to output voltage drop		up to 12	V
$V_{SENSE}$	Sense pins voltage		-1 to 1	V
$V_{REF}$	Reference voltage input		-0.3 to 1	V
$I_{OUT,RMS}$	Continuous power stage output current (each bridge)		1.3	$A_{RMS}$
$T_{j,OP}$	Operative junction temperature		-40 to 150	°C
$T_{j,STG}$	Storage junction temperature		-55 to 150	°C

### 2.2 Recommended operating conditions

Table 2. Recommended operating conditions

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_S$	Supply voltage		1.8		10	V
$V_{IN}$	Logic input voltage		0		5	V
$V_{REF}$	Reference voltage input		0.1		0.5	V
$t_{INw}$	Logic inputs positive/negative pulse width		300			ns

### 2.3 Thermal data

Table 3. Thermal data

Symbol	Parameter	Conditions	Value	Unit
$R_{thJA}$	Junction to ambient thermal resistance	Natural convection, according to JESD51-2a <sup>(1)</sup>	57.1	°C/W
$R_{thJTop}$	Junction to case thermal resistance (top side)	Simulation with cold plate on package top	67.3	°C/W
$R_{thJBot}$	Junction to case thermal resistance (bottom side)	Simulation with cold plate on exposed pad	9.1	°C/W
$R_{thJB}$	Junction to board thermal resistance	According to JESD51-8 <sup>(1)</sup>	23.3	°C/W
$\Psi_{JT}$	Junction to top characterization	According to JESD51-2a <sup>(1)</sup>	3.3	°C/W
$\Psi_{JB}$	Junction to board characterization	According to JESD51-2a <sup>(1)</sup>	22.6	°C/W

1. Simulated on a 21.2 x 21.2 mm board, 2s2p 1 Oz copper and four 300  $\mu$ m vias below exposed pad.

## 2.4 ESD protections

Table 4. ESD protection ratings

Symbol	Parameter	Test condition	Class	Value	Unit
HBM	Human body model	Conforming to ANSI/ESDA/JEDEC JS-001-2014	H2	2	kV
CDM	Charge device model	Conforming to ANSI/ESDA/JEDEC JS-002-2014	C2a	500	V

### 3 Electrical characteristics

Testing conditions:  $V_S = 5\text{ V}$ ,  $T_j = 25\text{ °C}$  unless otherwise specified.

**Table 5. Electrical characteristics**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Supply</b>						
$V_{Sth(ON)}$	$V_S$ turn-on voltage	$V_S$ rising from 0 V	1.45	1.65	1.79	V
$V_{Sth(OFF)}$	$V_S$ turn-off voltage	$V_S$ falling from 5 V	1.3	1.45	1.65	V
$V_{Sth(HYS)}$	$V_S$ hysteresis voltage			180		mV
$I_S$	$V_S$ supply current	No commutations, EN = 0 $R_{OFF} = 160\text{ k}\Omega$		960	1300	$\mu\text{A}$
		No commutations, EN = 1 $R_{OFF} = 160\text{ k}\Omega$		1500	1950	$\mu\text{A}$
$I_{S,STBY}$	$V_S$ standby current	STBY = 0 V		10	80	nA
$V_{STBYL}$	Standby low logic level input voltage				0.9	V
$V_{STBYH}$	Standby high logic level input voltage		1.48			V
<b>Power stage</b>						
$R_{DS(ON)HS+LS}$	Total on resistance HS + LS	$V_S = 10\text{ V}$ , $I_{OUT} = 1.3\text{ A}$		0.4	0.65	$\Omega$
		$V_S = 10\text{ V}$ , $I_{OUT} = 1.3\text{ A}$ , $T_j = 125\text{ °C}^{(1)}$		0.53	0.87	
		$V_S = 3\text{ V}$ , $I_{OUT} = 0.4\text{ A}$		0.53	0.8	
$I_{DSS}$	Leakage current	OUTx = $V_S$			1	$\mu\text{A}$
		OUTx = GND	-1			
$V_{DF}$	Freewheeling diode forward voltage	$I_D = 1.3\text{ A}$		0.9		V
$t_{rise}$	Rise time	$V_S = 10\text{ V}$ ; unloaded outputs		10		ns
$t_{fall}$	Fall time	$V_S = 10\text{ V}$ ; unloaded outputs		10		ns
$t_{DT}$	Dead time			50		ns
<b>PWM current controller</b>						
$V_{SNS,OFFSET}$	Sensing offset	$V_{REF} = 0.5\text{ V}$ ; internal reference 20% $V_{REF}$	-15		+15	mV
$t_{OFF}$	Total OFF time	$R_{OFF} = 10\text{ k}\Omega$		9		$\mu\text{s}$
		$R_{OFF} = 160\text{ k}\Omega$		125		$\mu\text{s}$
$\Delta f_{OSC}$	Internal oscillator precision ( $f_{OSC}/f_{OSC,ID}$ )	$R_{OFF} = 20\text{ k}\Omega$	-20%		+20%	
$t_{OFF,jitter}$	Total OFF time jittering	$R_{OFF} = 10\text{ k}\Omega$			2%	



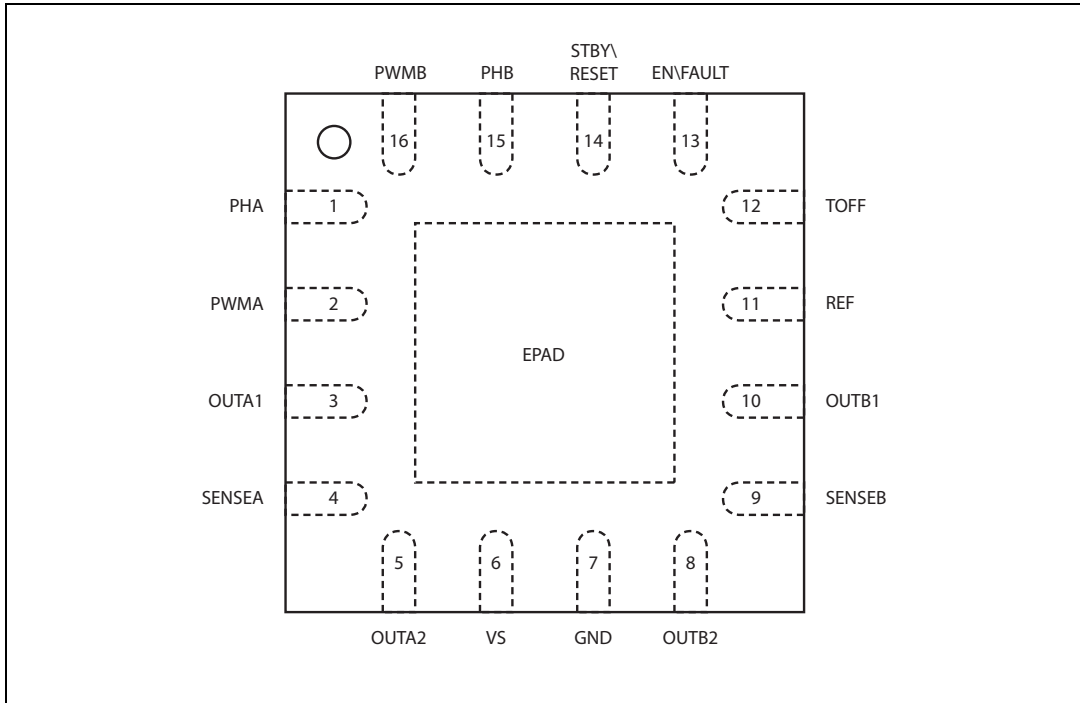
Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Logic IOs</b>						
$V_{IH}$	High logic level input voltage		1.6			V
$V_{IL}$	Low logic level input voltage				0.6	V
$V_{RELEASE}$	FAULT open drain release voltage				0.4	V
$V_{OL}$	Low logic level output voltage	$I_{OL} = 4 \text{ mA}$			0.4	V
$R_{STBY}$	STBY pull-down resistance			36		k $\Omega$
$I_{PDEN}$	EN pull-down current			10.5		$\mu\text{A}$
$t_{END}$	EN input propagation delay	From EN falling edge to OUT high impedance		55		ns
$t_{PWM,d(ON)}$	PWMX turn-on propagation delay	See <a href="#">Figure 4 on page 14</a>		125		ns
$t_{PWM,d(OFF)}$	PWMX turn-off propagation delay	See <a href="#">Figure 4</a>		140		ns
$t_{PH,d}$	PHX propagation delay	See <a href="#">Figure 4</a>		125		ns
<b>Protections</b>						
$T_{jSD}$	Thermal shutdown threshold			160		$^{\circ}\text{C}$
$T_{jSD,Hyst}$	Thermal shutdown hysteresis			40		$^{\circ}\text{C}$
$I_{OC}$	Overcurrent threshold	See <a href="#">Figure 14 on page 22</a>		2		A

1. Based on characterization data on a limited number of samples, not tested during production.

## 4 Pin description

Figure 2. Pin connection (top view)



1. The exposed pad must be connected to ground.

Table 6. Pin description

No.	Name	Type	Function
1	PHA	Logic input	Phase input for bridge A
2	PWMA	Logic input	PWM input for bridge A
3	OUTA1	Power output	Power bridge output side A1
4	SENSEA	Power output	Sense output of the bridge A
5	OUTA2	Power output	Power bridge output side A2
6	VS	Supply	Device supply voltage
7, EPAD	GND	Ground	Device ground
8	OUTB2	Power output	Power bridge output side B2
9	SENSEB	Power output	Sense output of the bridge B
10	OUTB1	Power output	Power bridge output side B1
11	REF	Analog input	Reference voltage for the current limiter circuitry
12	TOFF	Analog input	Internal oscillator frequency adjustment
13	EN\FAULT	Logic input\ open drain output	Logic input 5 V compliant with open drain output. This is the power stage enable (when low, the power stage is turned off) and is forced low through the integrated open drain MOSFET when a failure occurs.

Table 6. Pin description (continued)

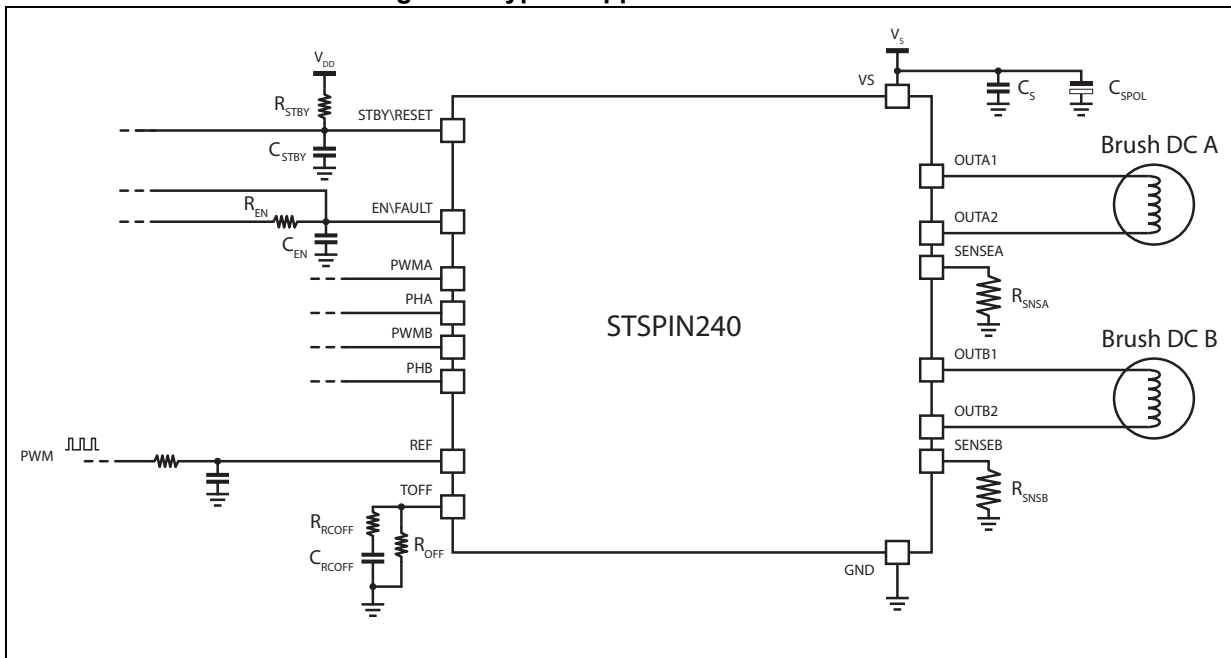
No.	Name	Type	Function
14	STBY\RESET	Logic input	Logic input 5 V compliant. When forced low, the device is forced into low consumption mode.
15	PHB	Logic input	Phase input for bridge B
16	PWMB	Logic input	PWM input for bridge B

# 5 Typical applications

Table 7. Typical application values

Name	Value
$C_S$	2.2 $\mu\text{F}$ / 16 V
$C_{SPOL}$	22 $\mu\text{F}$ / 16 V
$R_{SNSA}, R_{SNSB}$	330 $\text{m}\Omega$ / 1 W
$C_{EN}$	10 nF / 6.3 V
$R_{EN}$	18 $\text{k}\Omega$
$C_{STBY}$	1 nF / 6.3 V
$R_{STBY}$	18 $\text{k}\Omega$
$C_{RCOFF}$	22 nF
$R_{RCOFF}$	1 $\text{k}\Omega$
$R_{OFF}$	47 $\text{k}\Omega$ ( $t_{OFF} \approx 37 \mu\text{s}$ )

Figure 3. Typical application schematic



## 6 Functional description

The STSPIN240 is a dual brush DC motor driver integrating two PWM current controllers and a power stage composed by two fully-protected full-bridges.

### 6.1 Standby and power-up

The device provides a low settable consumption mode forcing the STBY\RESET input below the  $V_{STBYL}$  threshold.

When the device is in standby status, the power stage is disabled (outputs are in high impedance) and the supply to the integrated control circuitry is cut off.

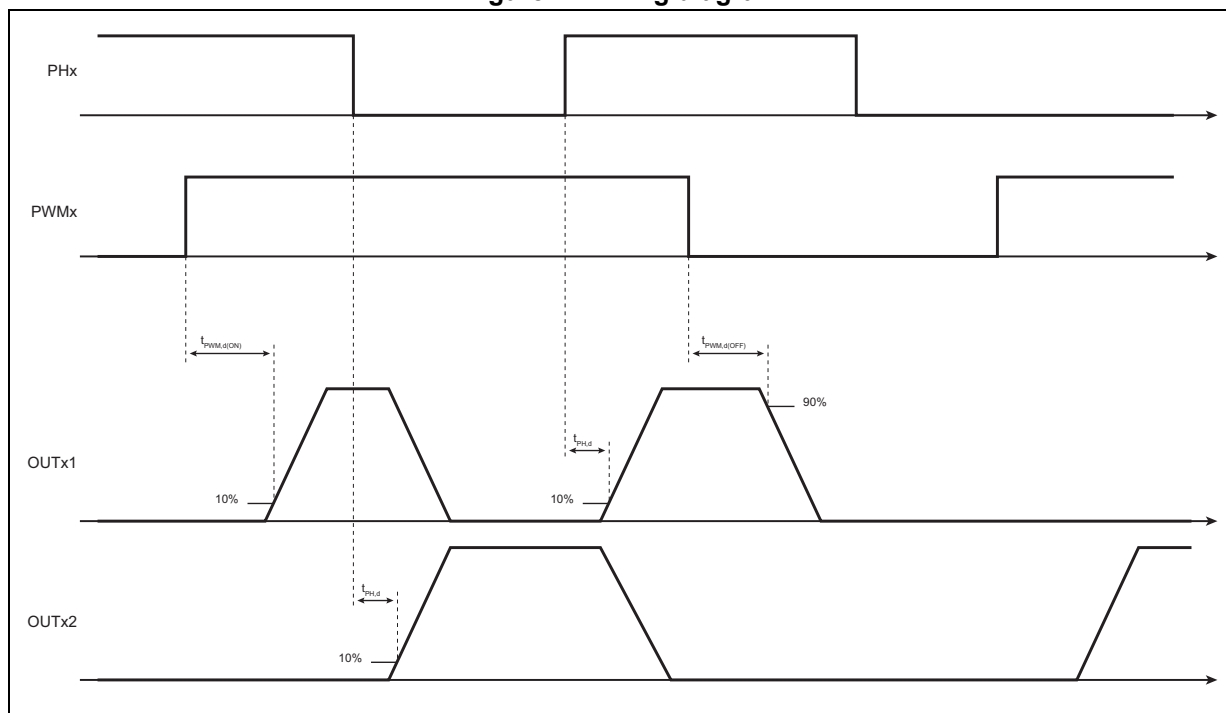
### 6.2 Motor driving

The outputs of each bridge are controlled by the respective PWMx and PHx inputs as listed in [Table 8](#).

**Table 8. Truth table**

ENFAULT	PHx	PWMx	OUTx1	OUTx2	Full-bridge condition
0	X	X	HiZ	HiZ	Disabled
1	0	0	GND	GND	Both LS on
1	0	1	GND	VS	HS2 and LS1 on (current X1 ← X2)
1	1	0	GND	GND	Both LS on
1	1	1	VS	GND	HS1 and LS2 on (current X1 → X2)

Figure 4. Timing diagram



### 6.3 PWM current control

The device implements two independent current controllers, one for each full-bridge.

The voltage on the sense pins ( $V_{SENSEA}$  and  $V_{SENSEB}$ ) is compared to the reference voltage applied on the REF pin ( $V_{REF}$ ).

When  $V_{SENSEX} > V_{REF}$ , the current limiter is triggered, the OFF time counter is started and the decay sequence is performed.

The decay sequence starts turning on both low sides of the full-bridge.

**Table 9. ON and slow decay states**

PHx	PWMx	ON	Decay
0	0	HSx1 = OFF LSx1 = ON HSx2 = OFF LSx2 = ON	N.A. <sup>(1)</sup>
0	1	HSx1 = OFF LSx1 = ON HSx2 = ON LSx2 = OFF	HSx1 = OFF LSx1 = ON HSx2 = OFF LSx2 = ON
1	0	HSx1 = OFF LSx1 = ON HSx2 = OFF LSx2 = ON	N.A. <sup>(1)</sup>
1	1	HSx1 = ON LSx1 = OFF HSx2 = OFF LSx2 = ON	HSx1 = OFF LSx1 = ON HSx2 = OFF LSx2 = ON

1. During decays the inputs values are ignored until the system returns to ON condition (decay time expired).

The reference voltage value,  $V_{REF}$ , has to be selected according to the load current target value (peak value) and sense resistors value.

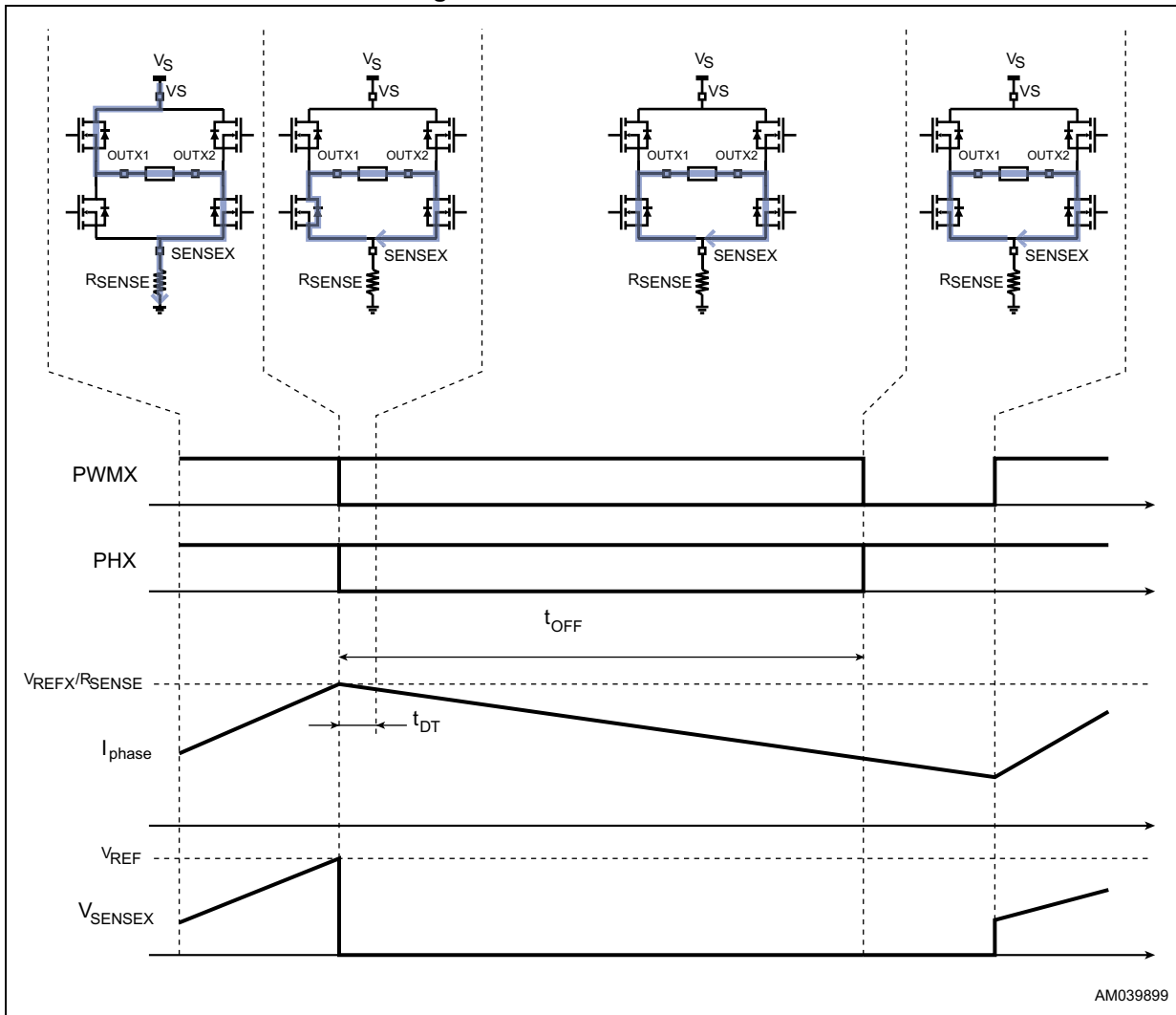
**Equation 1**

$$V_{REF} = R_{SNSx} \cdot I_{LOAD,peak}$$

In choosing the sense resistor value, two main issues must be taken into account:

- The sensing resistor dissipates energy and provides dangerous negative voltages on the SENSE pins during the current recirculation. For this reason the resistance of this component should be kept low (using multiple resistors in parallel will help to obtain the required power rating with standard resistors).
- The lower is the  $R_{SNSx}$  value, the higher is the peak current error due to noise on the  $V_{REF}$  pin and to the input offset of the current sense comparator: too low values of  $R_{SNSx}$  must be avoided.

Figure 5. PWM current control

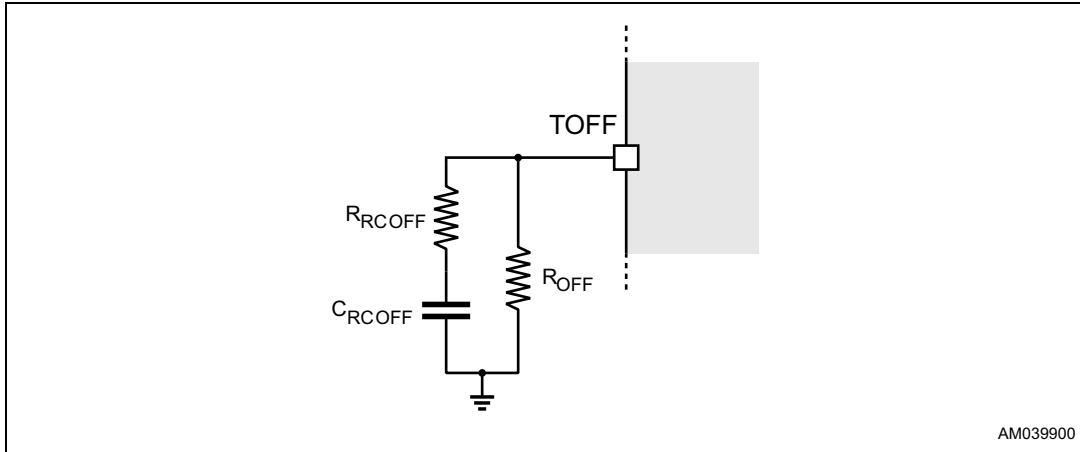




### TOFF adjustment

The decay time is adjusted through an external resistor connected between the TOFF pin and ground as shown in [Figure 6](#). A small RC series must be inserted in parallel with the regulator resistor in order to increase the stability of the regulation circuit according to indications listed in [Table 10](#).

**Figure 6. OFF time regulation circuit**

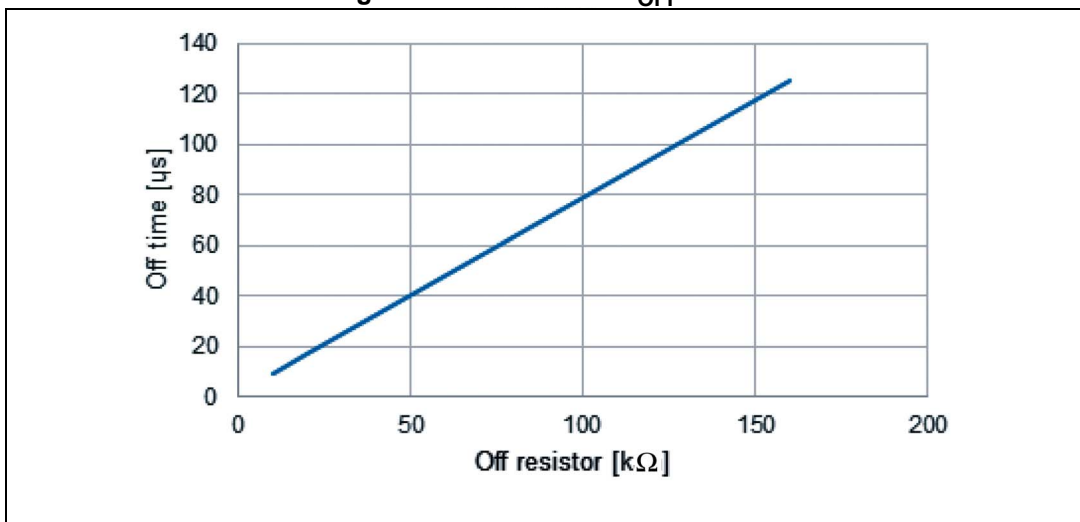


The relation between the OFF time and the external resistor value is shown in the graph of [Figure 7](#). The value typically ranges from 10  $\mu$ s to 150  $\mu$ s.

**Table 10. Recommended  $R_{RCOFF}$  and  $C_{RCOFF}$  values according to  $R_{OFF}$**

$R_{OFF}$	$R_{RCOFF}$	$C_{RCOFF}$
$10\text{ k}\Omega \leq R_{OFF} < 82\text{ k}\Omega$	1 k $\Omega$	22 nF
$82\text{ k}\Omega \leq R_{OFF} \leq 160\text{ k}\Omega$	2.2 k $\Omega$	22 nF

**Figure 7. OFF time vs.  $R_{OFF}$  value**



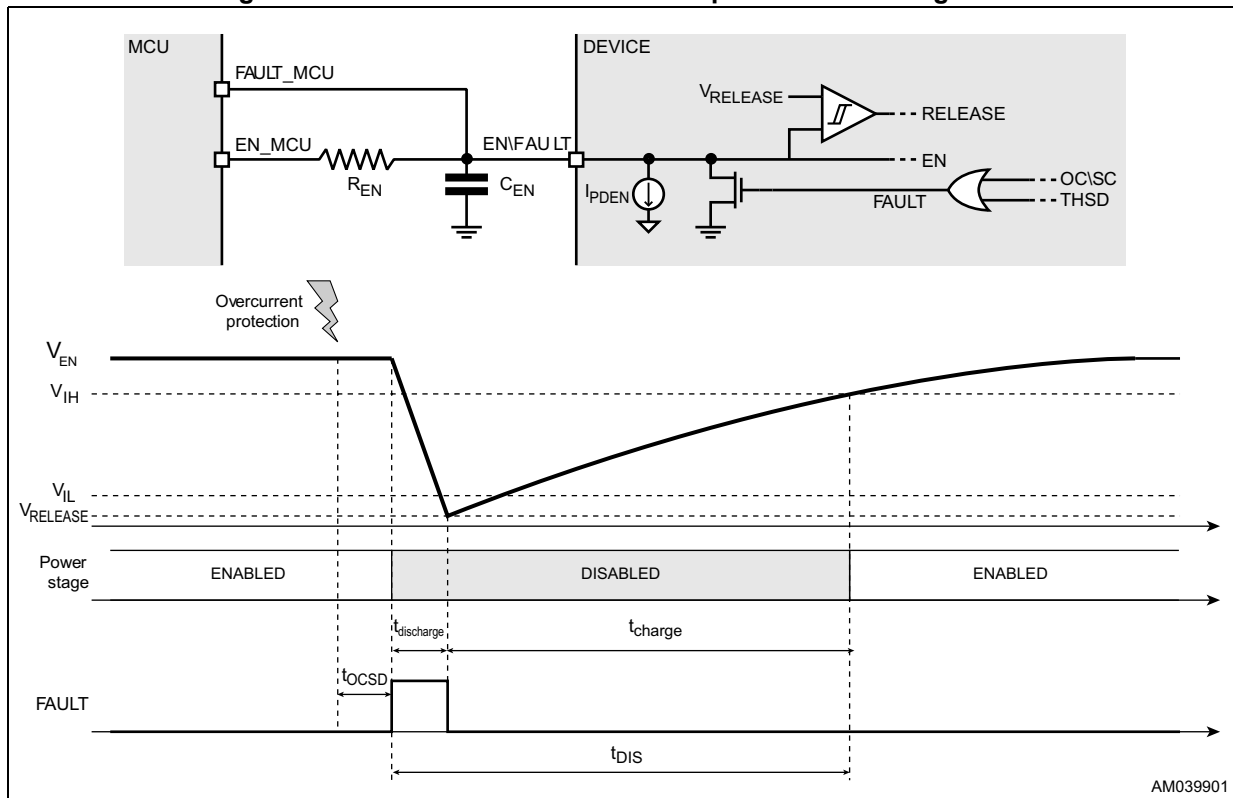
### 6.4 Overcurrent and short-circuit protections

The device embeds circuitry protecting each power output against the overload and short-circuit conditions (short to ground, short to VS and short between outputs).

When the overcurrent or the short-circuit protection is triggered, the power stage is disabled and the EN\FAULT input is forced low through the integrated open drain MOSFET discharging the external C<sub>EN</sub> capacitor.

The power stage is kept disabled and the open drain MOSFET is kept ON until the EN\FAULT input falls below the V<sub>RELEASE</sub> threshold, then the C<sub>EN</sub> capacitor is charged through the R<sub>EN</sub> resistor.

**Figure 8. Overcurrent and short-circuit protections management**



The total disable time after an overcurrent event can be set by properly sizing the external network connected to the EN\FAULT pin (refer to [Figure 9](#) and [Figure 10](#)):

**Equation 2**

$$t_{DIS} = t_{discharge} + t_{charge}$$

But t<sub>charge</sub> is normally much higher than t<sub>discharge</sub>, thus we can consider only the second one contribution:

**Equation 3**

$$t_{DIS} \cong R_{EN} \cdot C_{EN} \cdot \ln \frac{(V_{DD} - R_{EN} \cdot I_{PDEN}) - V_{RELEASE}}{(V_{DD} - R_{EN} \cdot I_{PDEN}) - V_{IH}}$$

Where V<sub>DD</sub> is the pull-up voltage of the R<sub>EN</sub> resistor.

Figure 9. Disable time versus  $R_{EN}$  and  $C_{EN}$  values ( $V_{DD} = 3.3\text{ V}$ )

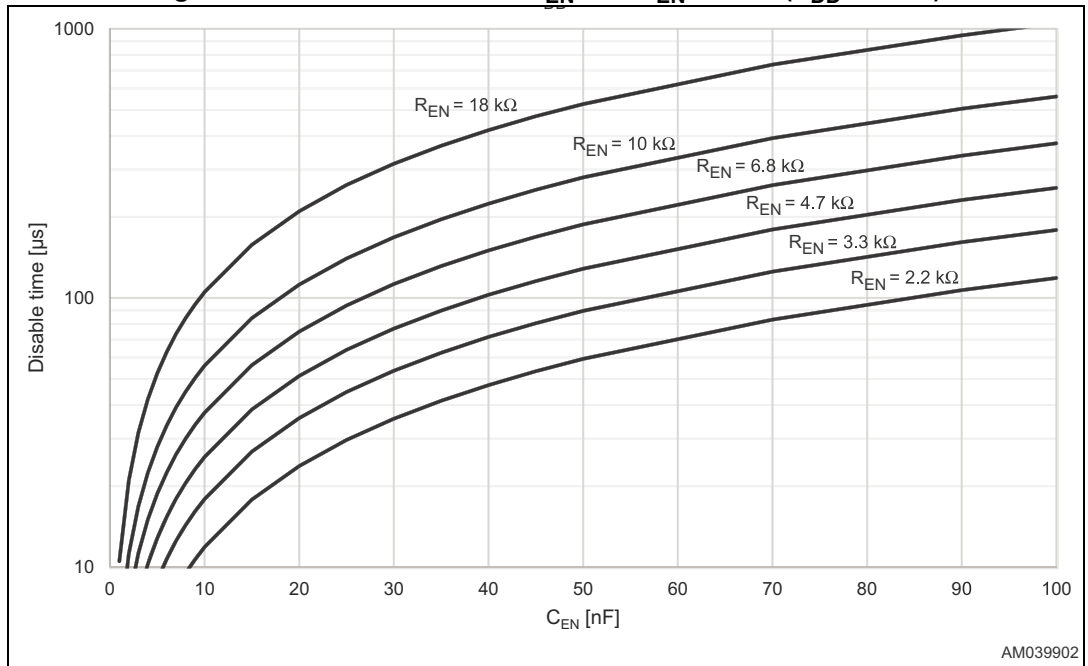
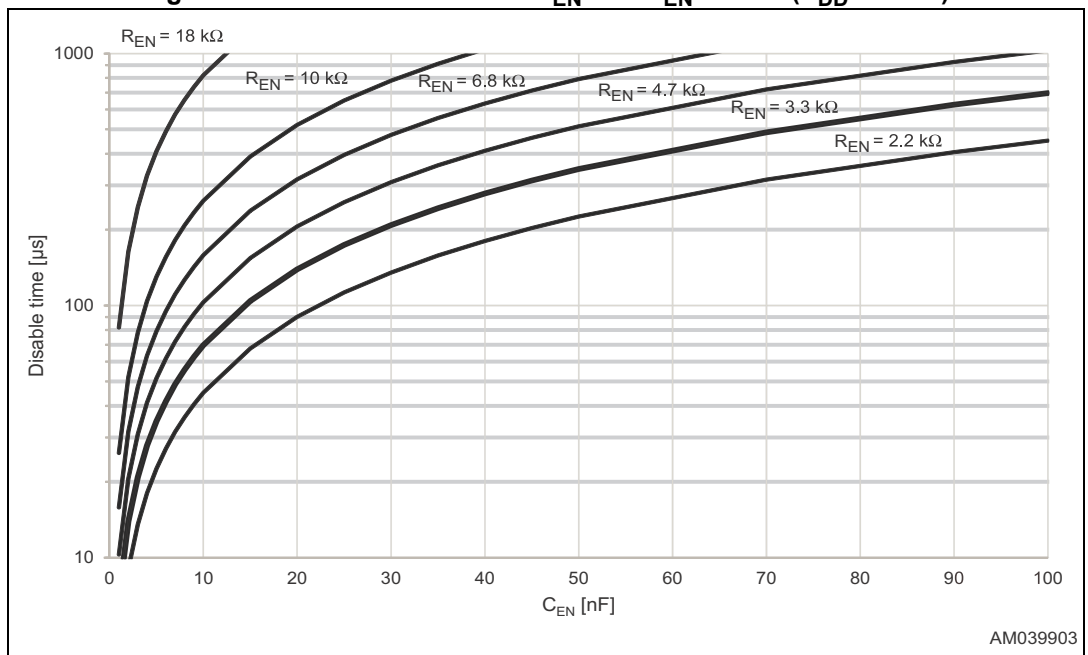


Figure 10. Disable time versus  $R_{EN}$  and  $C_{EN}$  values ( $V_{DD} = 1.8\text{ V}$ )



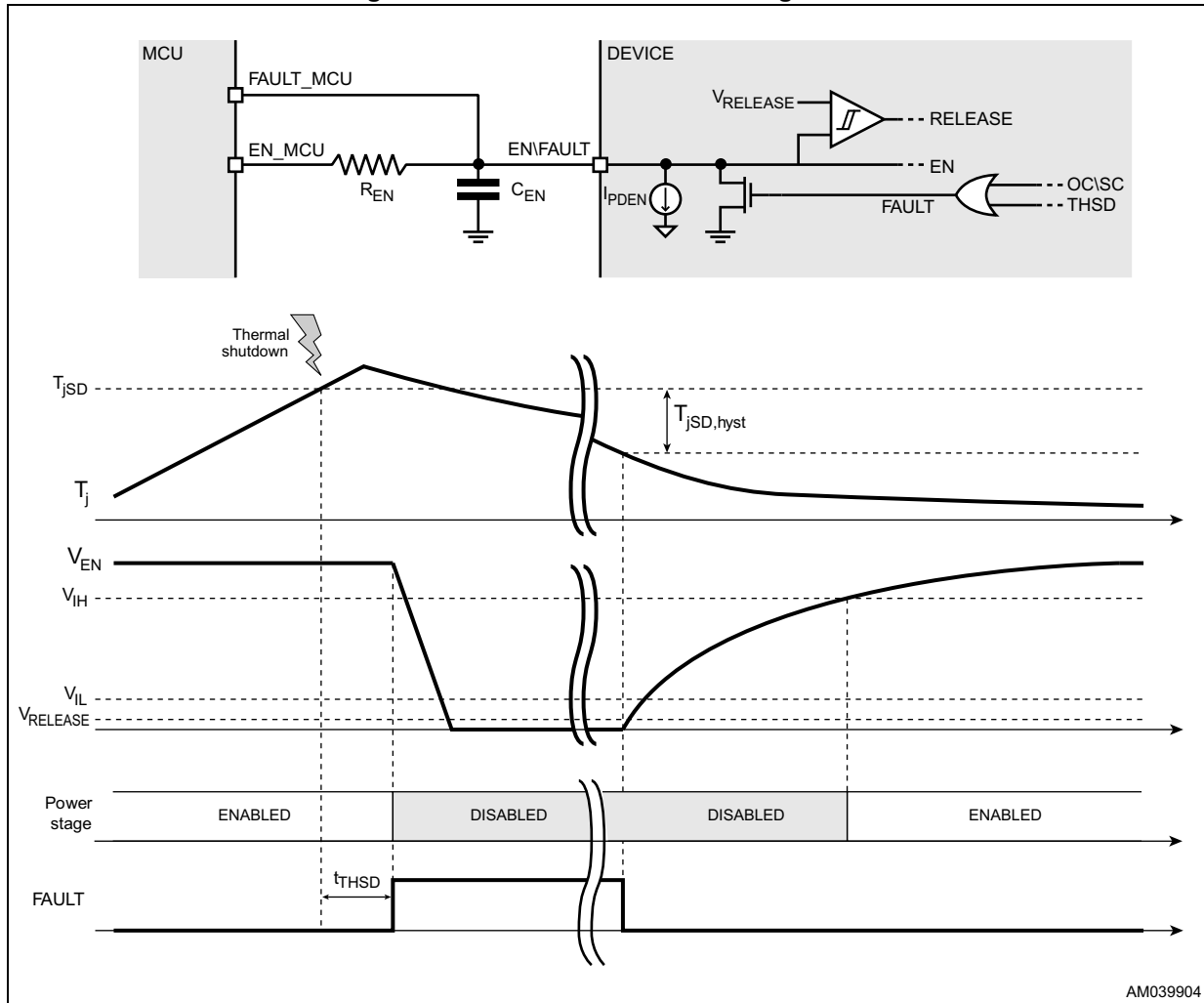
### 6.5 Thermal shutdown

The device embeds circuitry protecting it from overtemperature conditions.

When the thermal shutdown temperature is reached, the power stage is disabled and the EN\FAULT input is forced low through the integrated open drain MOSFET.

The protection and the EN\FAULT output are released when the IC temperature returns below a safe operating value ( $T_{jSD} - T_{jSD,Hyst}$ ).

Figure 11. Thermal shutdown management



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# 7 Graphs

Figure 12. Power stage resistance versus supply voltage (normalized at  $V_S = 5\text{ V}$ )

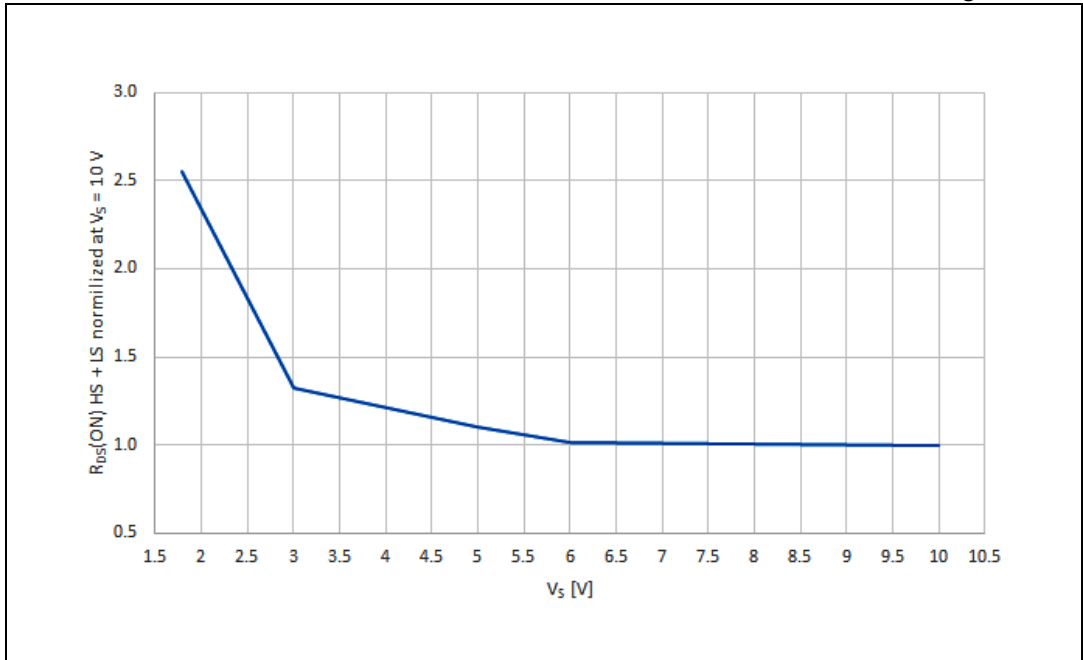
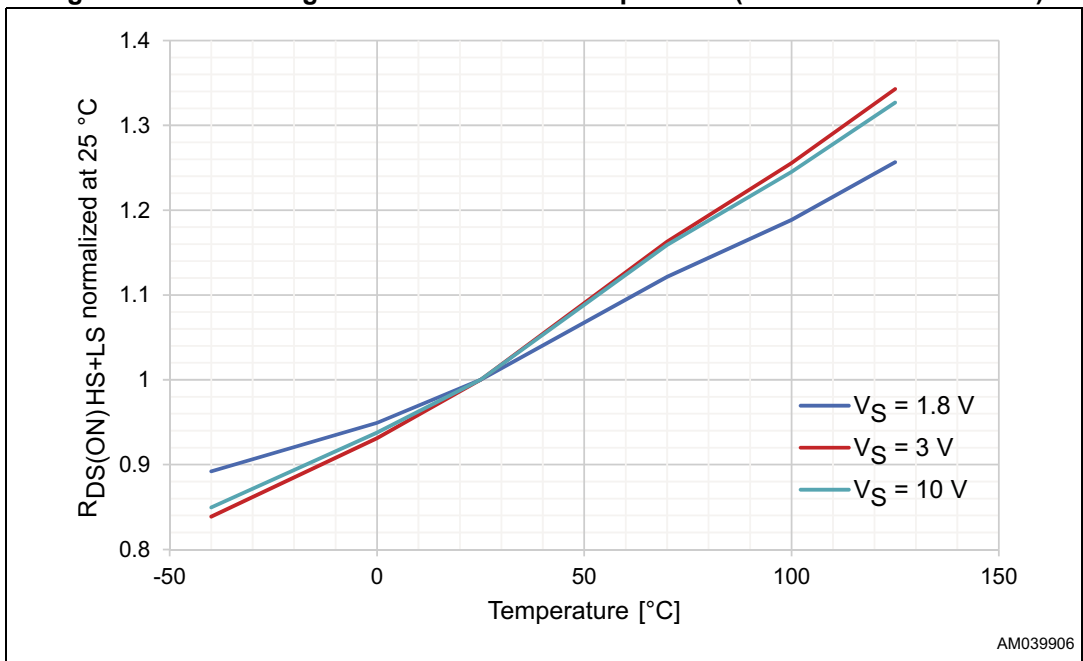
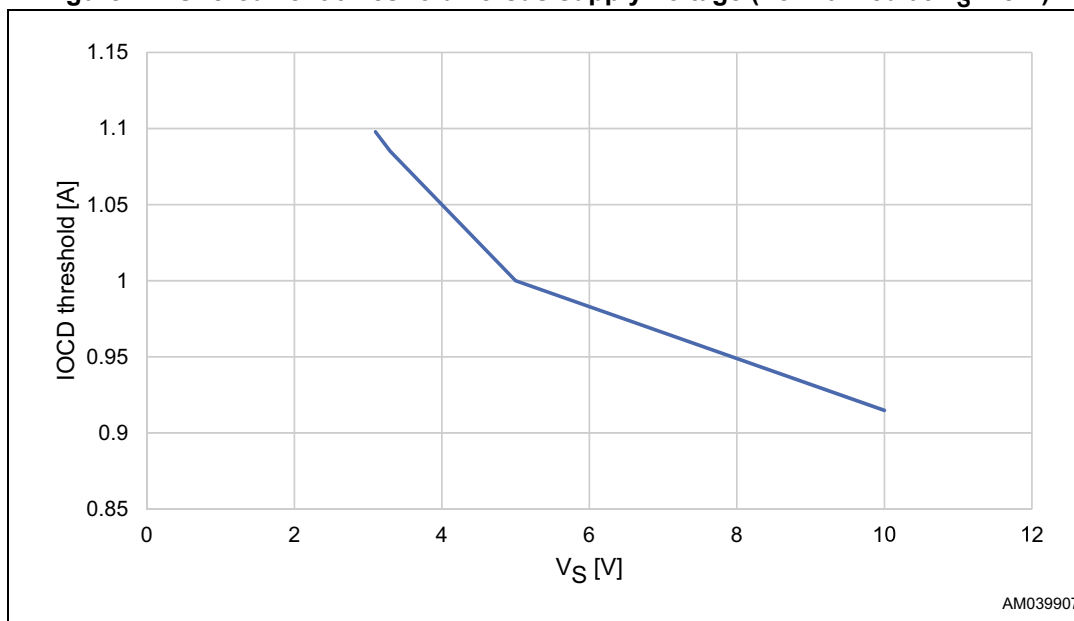


Figure 13. Power stage resistance versus temperature (normalized at  $T = 25\text{ }^\circ\text{C}$ )



AM039906

Figure 14. Overcurrent threshold versus supply voltage (normalized at  $V_S = 5\text{ V}$ )



## 8 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.

### 8.1 VFQFPN 3 x 3 x 1.0 mm - 16L package information

Figure 15. VFQFPN 3 x 3 x 1.0 mm - 16L package outline

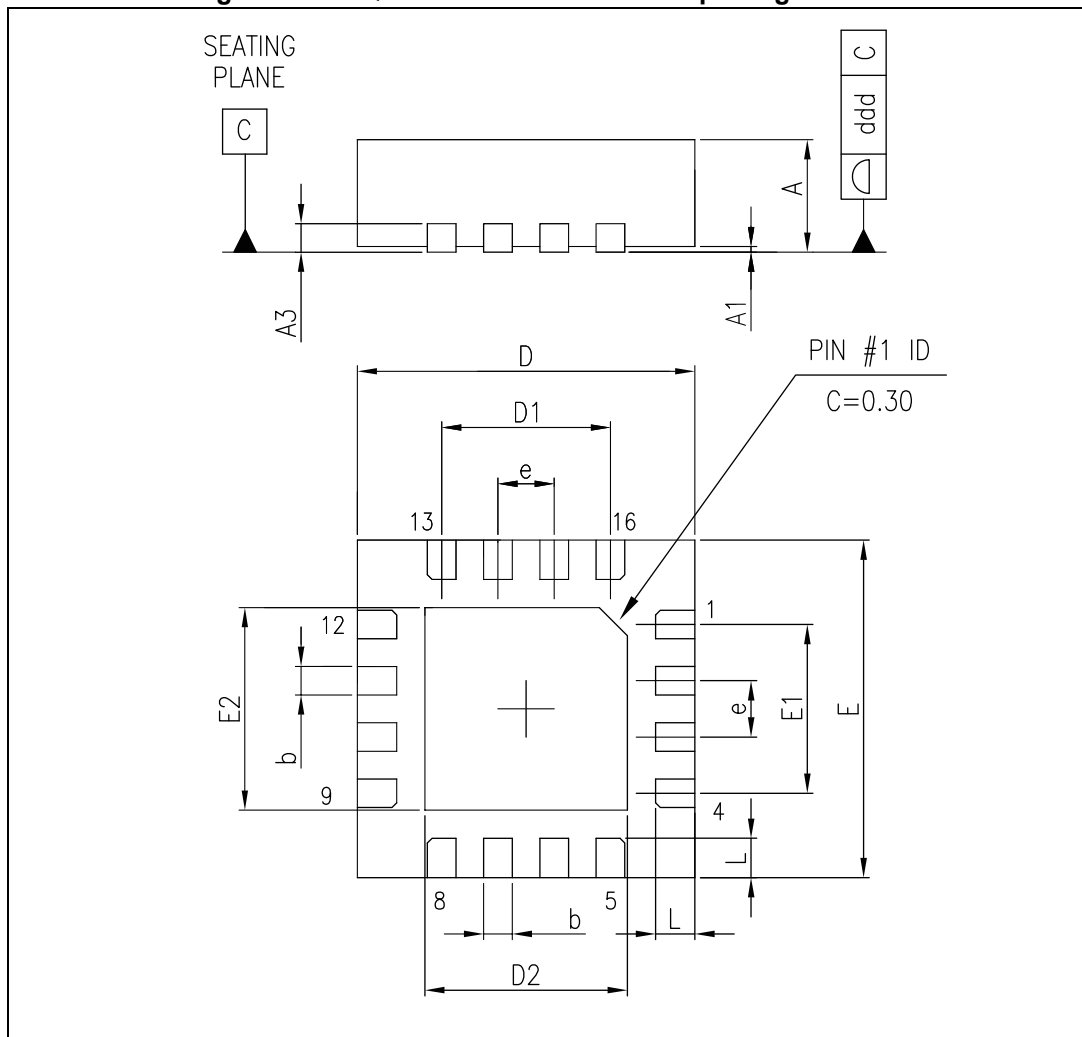
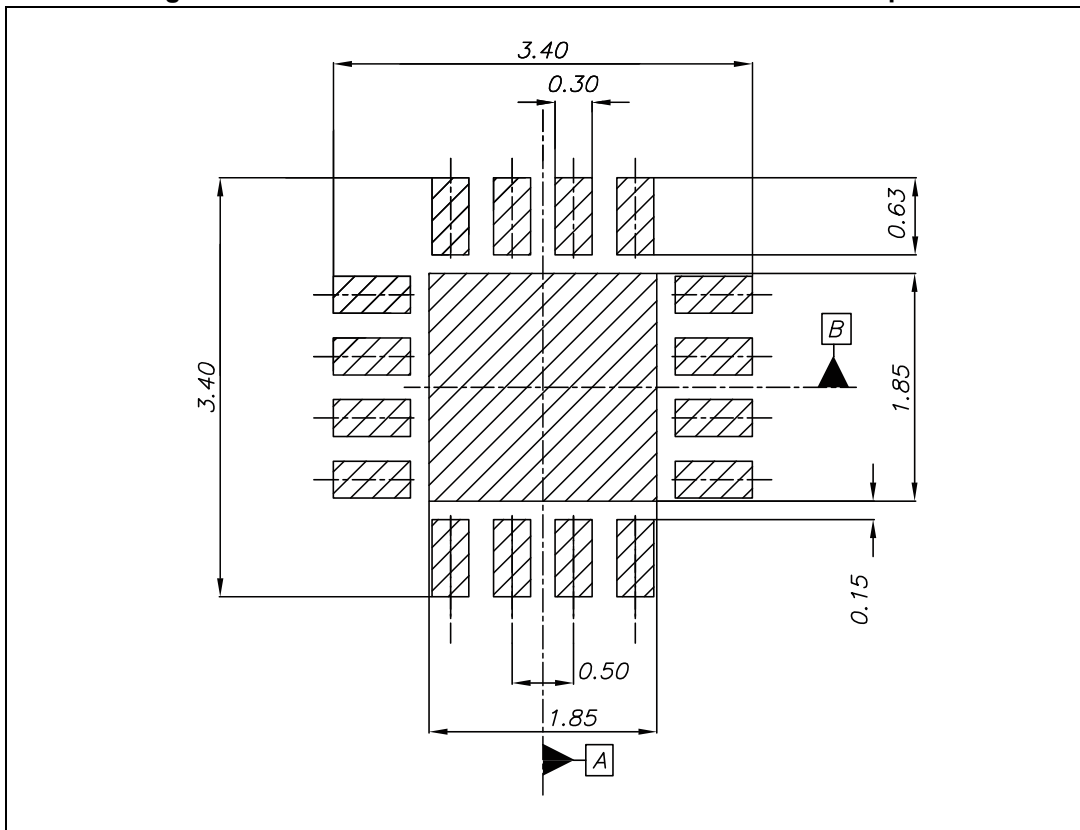


Table 11. VFQFPN 3 x 3 x 1.0 mm - 16L package mechanical data

Symbol	Dimensions (mm)			NOTES
	Min.	Typ.	Max.	
A	0.80	0.90	1.00	(1)
A1		0.02		
A3		0.20		
b	0.18	0.25	0.30	
D	2.85	3.00	3.15	
D2	1.70	1.80	1.90	
E	2.85	3.00	3.15	
E2	1.70	1.80	1.90	
e		0.50		
L	0.45	0.50	0.55	

- VFQFPN stands for "Thermally Enhanced Very thin Fine pitch Quad Packages No lead".  
 Very thin:  $0.80 < A \leq 1.00$  mm / fine pitch:  $e < 1.00$  mm.  
 The pin #1 identifier must be present on the top surface of the package by using an indentation mark or an other feature of the package body.

Figure 16. VFQFPN 3 x 3 x 1.0 mm - 16L recommended footprint





## 9 Ordering information

Table 12. Device summary

Order code	Package	Packaging
STSPIN240	VFQFPN 3x3x1.0 16L	Tape and reel

## 10 Revision history

Table 13. Document revision history

Date	Revision	Changes
06-May-2016	1	Initial release.
30-Jun-2016	2	Updated document status to <i>Datasheet - production data</i> on page 1. Updated <i>Table 1 on page 6</i> (changed Max. value of $V_S$ from 12 to 11). Updated <i>Table 7 on page 11</i> (changed value of $t_{OFF}$ from 47 $\mu$ s to 37 $\mu$ s).
04-Nov-2016	3	Updated <i>Figure 1 on page 5</i> and <i>Figure 12 on page 21</i> (replaced by new figures). Updated <i>Table 2 on page 6</i> (added $t_{INW}$ symbol). Updated <i>Table 3 on page 6</i> (replaced by new table). Minor modifications throughout document.

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