

## Low voltage stepper motor driver



VFQFPN 3 X 3 X 1.0 (16-pin)

## Features

- Operating voltage: from 1.8 to 10 V
- Maximum output current: 1.3 A<sub>rms</sub>
- R<sub>DS(ON)</sub> HS + LS = 0.4 Ω typ.
- Microstepping up to 1/256<sup>th</sup> of a step
- 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 stepper motor applications such as:

- Pop-up camera control for smartphones
- Point of sale (POS) devices
- Portable printers
- PC peripherals and accessories
- Robotics
- Toys
- Reflex cameras

Product status link	
STSPIN220	
Product summary	
Order code	STSPIN220
Package	VFQFPN 3x3x1.0 16L
Packing	Tape & reel

## Description

The STSPIN220 is a stepper motor driver which integrates, in a small VFQFPN 3 x 3 x 1.0 mm package, both control logic and a low R<sub>DS (on)</sub> power stage.

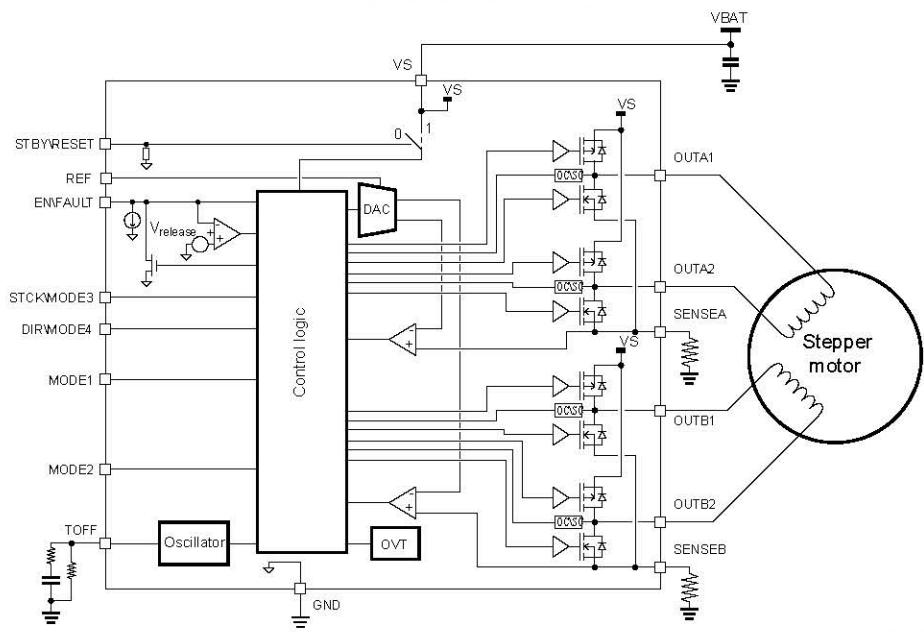
The integrated controller implements PWM current control with fixed OFF time and a microstepping resolution up to 1/256<sup>th</sup> of a step.

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.

## 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 pin 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 <sub>rms</sub>
$T_{J,OP}$	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
$R_{th}(JA)$	Junction to ambient thermal resistance	Natural convection, according to JESD51-2a <sup>(1)</sup>	57.1	°C/W
$R_{thJCtop}$	Junction to case thermal resistance (top side)	Simulation with cold plate on package top	67.3	°C/W
$R_{thJCbot}$	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 21.2x21.2 mm board, 2s2p 1 Oz copper and four 300 µm vias below exposed pad.

## 2.4 ESD protection

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

Test conditions:  $V_S = 5 \text{ V}$ ,  $T_J = 25^\circ\text{C}$  unless otherwise specified.

**Table 5. Electrical characteristics**

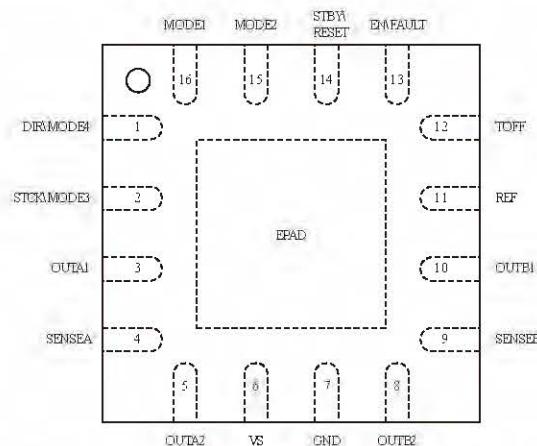
Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Supply</b>						
$V_{Sth}(\text{ON})$	$V_S$ turn-on voltage	$V_S$ rising from 0 V	1.45	1.65	1.79	V
$V_{Sth}(\text{OFF})$	$V_S$ turn-off voltage	$V_S$ falling from 5 V	1.3	1.45	1.65	V
$V_{Sth}(\text{HYS})$	$V_S$ hysteresis voltage			180		mV
$I_S$	$V_S$ 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	$\mu\text{A}$
$I_{S,SBY}$	$V_S$ standby current	$STBY = 0 \text{ V}$		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>						
$R_{DS(\text{ON}) HS+LS}$	Total ON resistance HS + LS	$V_S = 10 \text{ V}$ , $I_{OUT} = 1.3 \text{ A}$		0.4	0.65	$\Omega$
		$V_S = 10 \text{ V}$ , $I_{OUT} = 1.3 \text{ A}$ , $T_J = 125^\circ\text{C}$ (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
$t_{DT}$	Deadtime			50		ns
<b>Current control</b>						

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{SNS,OF}$ FSET	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 ( $f_{OSC}/f_{OSC,10}$ )	$R_{OFF} = 20 \text{ k}\Omega$	-20%		+20%	
$t_{OFF,jitter}$	Total OFF time jittering	$R_{OFF} = 10 \text{ k}\Omega$			2%	
$t_{OFF,SLOW}$	Slow decay time			$5/8 \times t_{OFF}$		$\mu\text{s}$
$t_{OFF,FAST}$	Fast decay time			$3/8 \times t_{OFF}$		$\mu\text{s}$
<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
$V_{OL}$	EN Low logic level output voltage	$I_{EN} = 4 \text{ mA}$			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
$t_{MODEho}$	MODEx input hold time	From STBY edge, see Figure 5	100			$\mu\text{s}$
$t_{MODEsu}$	MODEx input setup time	From STBY edge, see Figure 5	1			$\mu\text{s}$
$t_{DIRh}$	DIR input hold time	From STCK rising edge, see Figure 4	100			ns
$t_{DIRsu}$	DIR input setup time	From STCK rising edge, see Figure 4	100			ns
$t_{STCKH}$	STCK high time	See Figure 4	100			ns
$t_{STCKL}$	STCK low time	See Figure 4	100			ns
$f_{STCK}$	STCK inputs frequency	See Figure 4			1	MHz
<b>Protections</b>						
$T_{jSD}$	Thermal shutdown threshold			160		°C
$T_{jSD,Hyst}$	Thermal shutdown hysteresis			40		°C
$I_{OC}$	Overcurrent threshold	See Figure 14. Power stage resistance versus temperature		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)



**Note:** The exposed pad must be connected to ground.

Table 6. Pin description

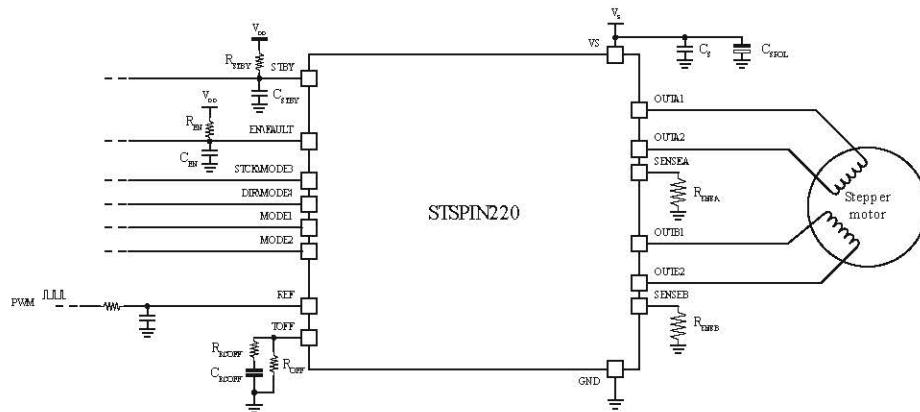
N.	Name	Type	Function
1	DIRMODE4	Logic input	Direction input, Step mode selection input 4.
2	STCKMODE3	Logic input	Step clock input, Step mode selection input 3.
3	OUTA1	Power output	Power bridge output side A1.
4	SENSEA	Power output	Sense output of the bridge A.
5	OUTA2	Power output	Power bridge output 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 PWM current control circuitry.
12	TOFF	Analog input	Internal oscillator frequency adjustment.
13	ENFAULT	Logic input\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.
14	STBY\RESET	Logic input	When forced low, the device is forced into low consumption mode.
15	MODE2	Logic input	Step mode selection input 2.
16	MODE1	Logic input	Step mode selection input 1.

## 5 Typical application

**Table 7. Typical application values**

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

**Figure 3. Typical application schematic**



## 6 Functional description

The STSPIN220 is a stepper motor driver integrating a microstepping sequencer (up to 1/256<sup>th</sup> of a step), two PWM current controllers and a power stage composed of two fully-protected full-bridges.

### 6.1 Standby and power-up

The device provides a low consumption mode which is set forcing the STBY\RESET input below the V<sub>STBYL</sub> 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. When the device exits the standby status, all of the control circuitry is reset to power-up condition.

At power-up, power-down and when leaving the standby condition, the EN/FAULT pin is forced low until the internal circuitry stabilize.

### 6.2 Microstepping sequencer

The value of the MODEx inputs is latched at power-up and when the device exits the STBY condition. After this, the input value is unimportant and the MODE3 and MODE4 inputs start operating as step-clock and direction input.

The only exception is the MODE1 = MODE2 = LOW condition; in this case the system is forced into full-step mode. The previous condition is restored as soon as the MODE1 and MODE2 inputs switch to a different combination.

An example of mode selection is shown in [Figure 4. STCK and DIR timing](#).

At each STCK rising edge, the sequencer of the device is increased (DIR input high) or decreased (DIR input low) of a module selected through the MODEx inputs as listed in [Table 8. Step mode selection through MODEx inputs](#).

The sequencer is a 10-bit counter that sets the reference value of the PWM current controller and the direction of the current for both of the H bridges.

**Table 8. Step mode selection through MODEx inputs**

MODE3 (STCK)	MODE4 (DIR)	MODE1	MODE2	Step mode
0	0	0	0	Full-step
0	0	0	1	1/32 <sup>nd</sup> step
0	0	1	0	1/128 <sup>th</sup> step
0	0	1	1	1/256 <sup>th</sup> step
0	1	0	0	Full-step - 1/32 <sup>nd</sup> step <sup>(1)</sup>
0	1	0	1	1/4 <sup>th</sup> step
0	1	1	0	1/256 <sup>th</sup> step
0	1	1	1	1/64 <sup>th</sup> step
1	0	0	0	Full-step - 1/128 <sup>nd</sup> step <sup>(1)</sup>
1	0	0	1	1/256 <sup>th</sup> step
1	0	1	0	1/2 step
1	0	1	1	1/8 <sup>th</sup> step
1	1	0	0	Full-step - 1/256 <sup>th</sup> step <sup>(1)</sup>
1	1	0	1	1/64 <sup>th</sup> step

MODE3 (STCK)	MODE4 (DIR)	MODE1	MODE2	Step mode
1	1	1	0	1/8 <sup>th</sup> step
1	1	1	1	1/16 <sup>th</sup> step

1. This driving mode is automatically bypassed by the MODE1 = MODE2 = 0 if it is kept after the device quit the standby condition.

Figure 4. STCK and DIR timing

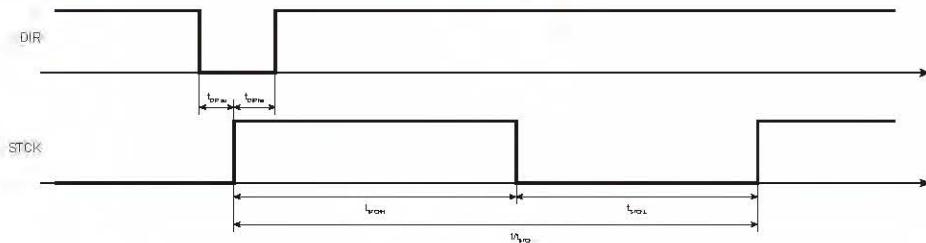
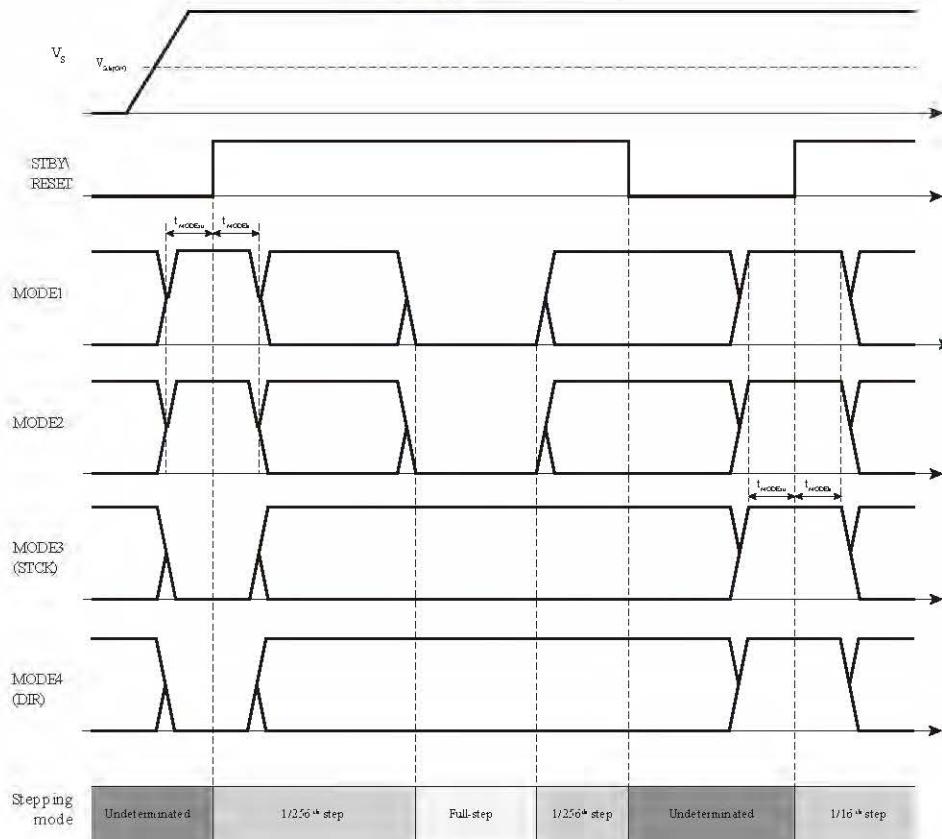


Figure 5. Mode selection example



When the full-step mode is set, the reference value of the PWM current controller and the direction of the current for both H bridges as listed in Table 8. Step mode selection through MODEx inputs.

**Table 9.** Target reference and current direction according to sequencer value (full-step mode)

Sequencer value												Phase A		Phase B	
												Reference voltage		Current direction	
0	0	X	X	X	X	X	X	X	X	X	X	100% × V <sub>REF</sub>	A1 → A2	100% × V <sub>REF</sub>	B1 → B2
0	1	X	X	X	X	X	X	X	X	X	X	100% × V <sub>REF</sub>	A1 → A2	100% × V <sub>REF</sub>	B1 ← B2
1	0	X	X	X	X	X	X	X	X	X	X	100% × V <sub>REF</sub>	A1 ← A2	100% × V <sub>REF</sub>	B1 ← B2
1	1	X	X	X	X	X	X	X	X	X	X	100% × V <sub>REF</sub>	A1 ← A2	100% × V <sub>REF</sub>	B1 → B2

When the step mode is different from the full-step mode the values listed in **Table 10.** Target reference and current direction according to sequencer value (not full-step mode) are used.

**Table 10.** Target reference and current direction according to sequencer value (not full-step mode)

Sequencer value												Phase A		Phase B	
												Reference voltage		Current direction	
0	0	0	0	0	0	0	0	0	0	0	0	Zero (power bridge disabled)	-	100% × V <sub>REF</sub>	B1 → B2
0	0	N										Sin(N/256 × π/2) × V <sub>REF</sub>	A1 → A2	Cos(N/256 × π/2) × V <sub>REF</sub>	B1 → B2
0	1	0	0	0	0	0	0	0	0	0	0	100% × V <sub>REF</sub>	A1 → A2	Zero (power bridge disabled)	-
0	1	N										Sin(π/2 + N/256 × π/2) × V <sub>REF</sub>	A1 → A2	Cos(π/2 + N/256 × π/2) × V <sub>REF</sub>	B1 ← B2
1	0	0	0	0	0	0	0	0	0	0	0	Zero (power bridge disabled)	-	100% × V <sub>REF</sub>	B1 ← B2
1	0	N										Sin(N/256 × π/2) × V <sub>REF</sub>	A1 ← A2	Cos(N/256 × π/2) × V <sub>REF</sub>	B1 ← B2
1	1	0	0	0	0	0	0	0	0	0	0	100% × V <sub>REF</sub>	A1 ← A2	Zero (power bridge disabled)	-
1	1	N										Sin(π/2 + N/256 × π/2) × V <sub>REF</sub>	A1 ← A2	Cos(π/2 + N/256 × π/2) × V <sub>REF</sub>	B1 → B2

The following table shows the target reference and sequencer values for 1/2-, 1/4- and 1/8-step operation. Higher microstepping resolutions follow the same pattern. The reset state (home state) for all stepping mode is entered at power-up or when the device exits the standby status.

**Table 11. Example**

1/2 step	1/4 step	1/8 step	VREF phase A	VREF phase B	Sequencer value
1	1	1	0%	100%	0000000000 home state
		2	19.509%	98.079%	0000100000
	2	3	38.268%	92.388%	0001000000
		4	55.557%	83.147%	0001100000
2	3	5	70.711%	70.711%	0010000000
		6	83.147%	55.557%	0010100000
	4	7	92.388%	19.509%	0011100000
		8	98.079%	19.509%	0011100000
3	5	9	100%	0%	0100000000
		10	98.079%	-19.509%	0100100000
	6	11	92.388%	-38.268%	0101000000
		12	83.147%	-55.557%	0101100000
4	7	13	70.711%	-70.711%	0110000000
		14	55.557%	-83.147%	0110100000
	8	15	38.268%	-92.388%	0111000000
		16	19.509%	-98.079%	1000100000
5	9	17	0%	100%	1000000000
		18	-19.509%	-98.079%	1000100000
	10	19	-38.268%	-92.388%	1001000000
		20	-55.557%	-83.147%	1001100000
6	11	21	-70.711%	-70.711%	1010000000
		22	-83.147%	-55.557%	1010100000
	12	23	-92.388%	-38.268%	1011000000
		24	-98.079%	-19.509%	1011100000
7	13	25	-100%	0%	1100000000
		26	-98.079%	19.509%	1100100000
	14	27	-92.388%	38.268%	1101000000
		28	-83.147%	55.557%	1101100000
8	15	29	-70.711%	70.711%	1110000000
		30	-55.557%	83.147%	1110100000
	16	31	-38.268%	92.388%	1111000000
		32	-19.509%	98.079%	1111100000

Note: The positive number means that the output current is flowing from OUTx1 to OUTx2, vice versa for a negative value.

### 6.3 PWM current control

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

The voltage of the sense pins ( $V_{SENSEA}$  and  $V_{SENSEB}$ ) is compared to the respective internal reference generated based on the sequencer value (see [Table 9. Target reference and current direction according to sequencer value \(full-step mode\)](#) and [Table 10. Target reference and current direction according to sequencer value \(not full-step mode\)](#)).

When  $V_{SENSEX} > V_{REFX}$ , the integrated comparator is triggered, the OFF time counter is started and the decay sequence is performed.

The decay sequence starts turning on both the low sides of the full bridge. When 5/8<sup>ths</sup> of the programmed OFF time ( $t_{OFF,SLOW}$ ) has expired, the decay sequence performs a quasi-synchronous fast decay.

**Table 12. ON, slow decay and fast decay states**

Current direction <sup>(1)</sup>	ON	Slow decay	Fast decay (quasi-synch)
Zero (power bridge disabled)	HSX1 = OFF	HSX1 = OFF	HSX1 = OFF
	LSX1 = OFF	LSX1 = OFF	LSX1 = OFF
	HSX2 = OFF	HSX2 = OFF	HSX2 = OFF
	LSX2 = OFF	LSX2 = OFF	LSX2 = OFF
$X_1 \rightarrow X_2$	<b>HSX1 = ON</b>	HSX1 = OFF	HSX1 = OFF
	LSX1 = OFF	<b>LSX1 = ON</b>	<b>LSX1 = ON</b>
	HSX2 = OFF	HSX2 = OFF	HSX2 = OFF
	<b>LSX2 = ON</b>	<b>LSX2 = ON</b>	LSX2 = OFF
$X_1 \leftarrow X_2$	HSX1 = OFF	HSX1 = OFF	HSX1 = OFF
	<b>LSX1 = ON</b>	<b>LSX1 = ON</b>	LSX1 = OFF
	<b>HSX2 = ON</b>	HSX2 = OFF	HSX2 = OFF
	LSX2 = OFF	<b>LSX2 = ON</b>	<b>LSX2 = ON</b>

1. The current direction is set according to [Table 9. Table 9 and Table 9. Target reference and current direction according to sequencer value \(full-step mode\)](#) [Table 10. Target reference and current direction according to sequencer value \(not full-step mode\)](#).

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

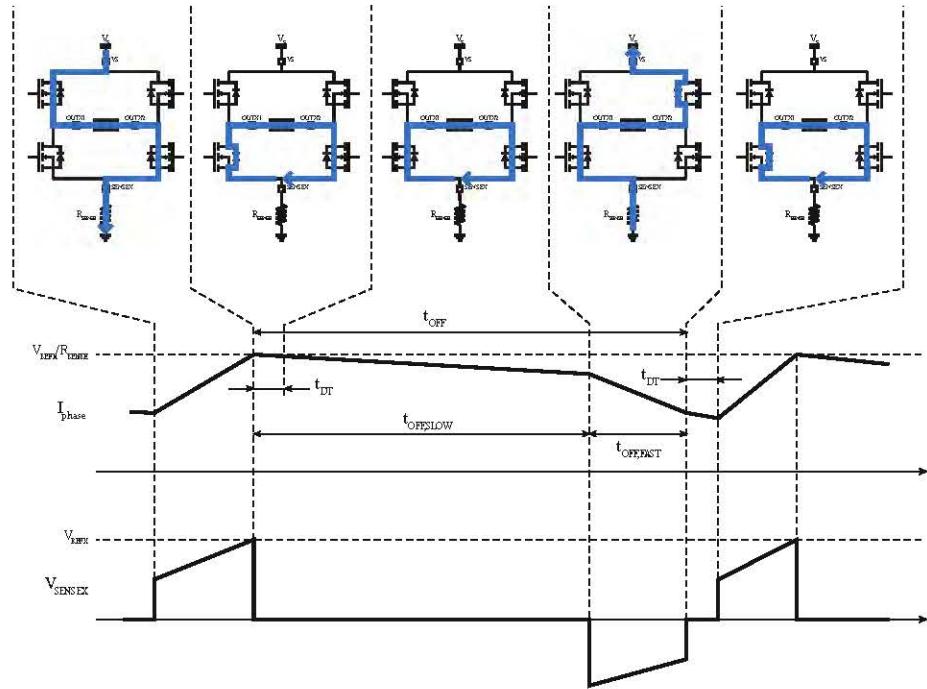
#### Equation 1

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

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

- The sense resistor dissipates energy and provides dangerous negative voltages on the SENSE pins during 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 the  $R_{SNSx}$  value, the higher the peak current error due to noise on the  $V_{REF}$  pin and the input offset of the current sense comparator. Values of  $R_{SNSx}$  that are too low must be avoided.

Figure 6. PWM current control sequence

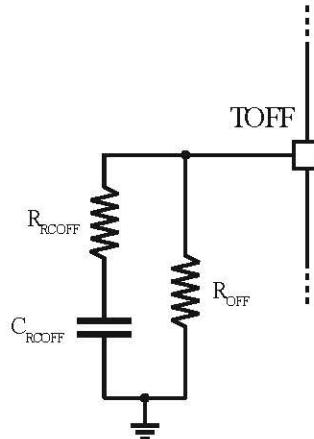


## 6.3.1

**OFF time adjustment**

The total OFF time (slow decay + fast decay) is adjusted through an external resistor connected between the TOFF pin and ground, as shown in Figure 6. PWM current control sequence. 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 Table 12. ON, slow decay and fast decay states indications.

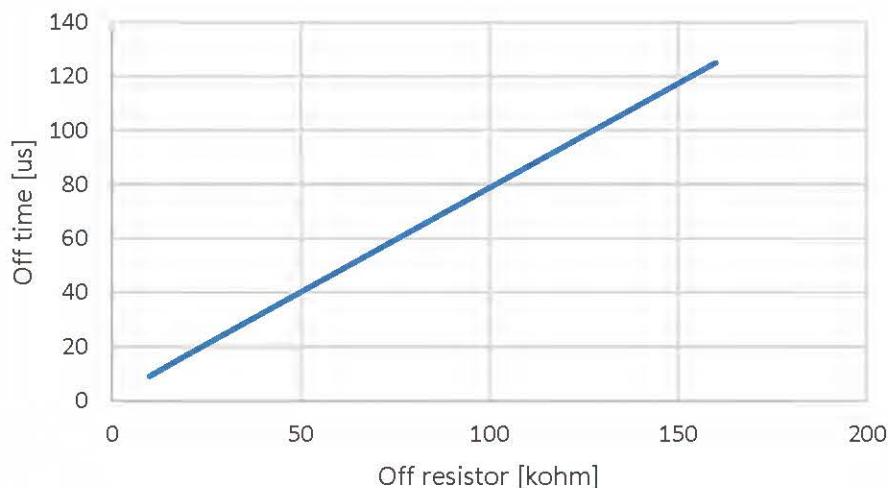
Figure 7. OFF time regulation circuit



The relationship between the OFF time and the external resistor value is shown in Figure 7. OFF time regulation circuit. The value typically ranges from 10  $\mu$ s to 150  $\mu$ s.

**Table 13.** Recommended  $R_{RCOFF}$  and  $C_{RCOFF}$  values according to  $R_{OFF}$ 

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

**Figure 8.** OFF time vs.  $R_{OFF}$  value

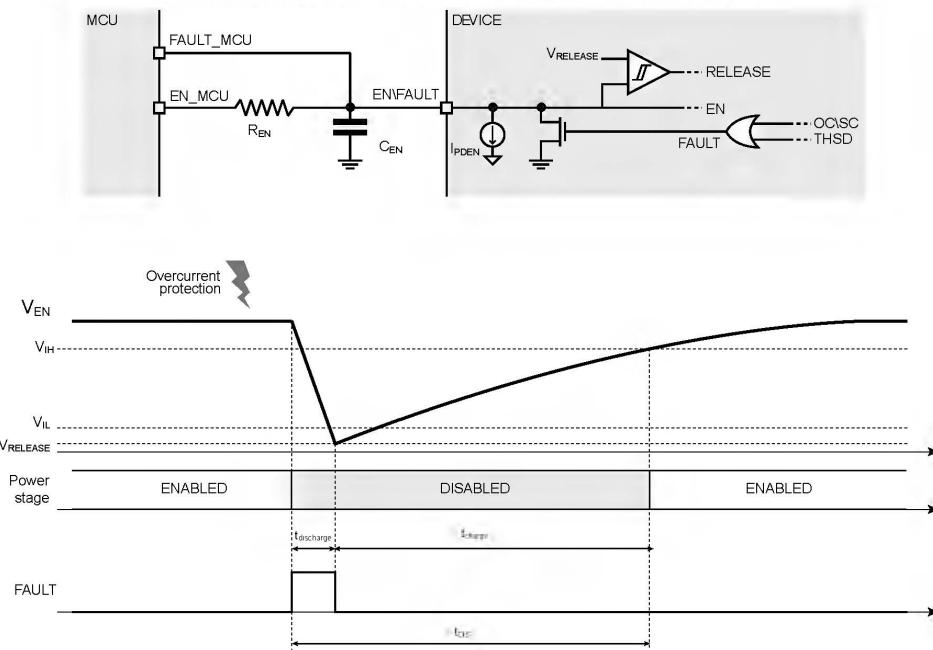
## 6.4

### Overcurrent and short-circuit protection

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

When the overcurrent or short-circuit protection is triggered, the power stage is disabled and the ENFAULT input is forced low through the integrated open-drain MOSFET discharging the external  $C_{EN}$  capacitor (refer to [Figure 9. Overcurrent and short-circuit protection management](#)).

The power stage is kept disabled and the open-drain MOSFET is kept ON until the ENFAULT input falls below the  $V_{RELEASE}$  threshold, then the  $C_{EN}$  capacitor is charged through the external  $R_{EN}$  resistor.

**Figure 9.** Overcurrent and short-circuit protection management

The total disable time after an overcurrent event can be set sizing properly the external network connected to the EN\FAULT pin (refer to [Figure 9. Overcurrent and short-circuit protection management](#)):

**Equation 2**

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

But  $t_{charge}$  is normally much higher than  $t_{discharge}$ , thus we can consider the following:

**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  $V_{DD}$  is the pull-up voltage of the  $R_{EN}$  resistor.

Figure 10. Disable time versus  $R_{EN}$  and  $C_{EN}$  values ( $V_{DD} = 3.3$  V)

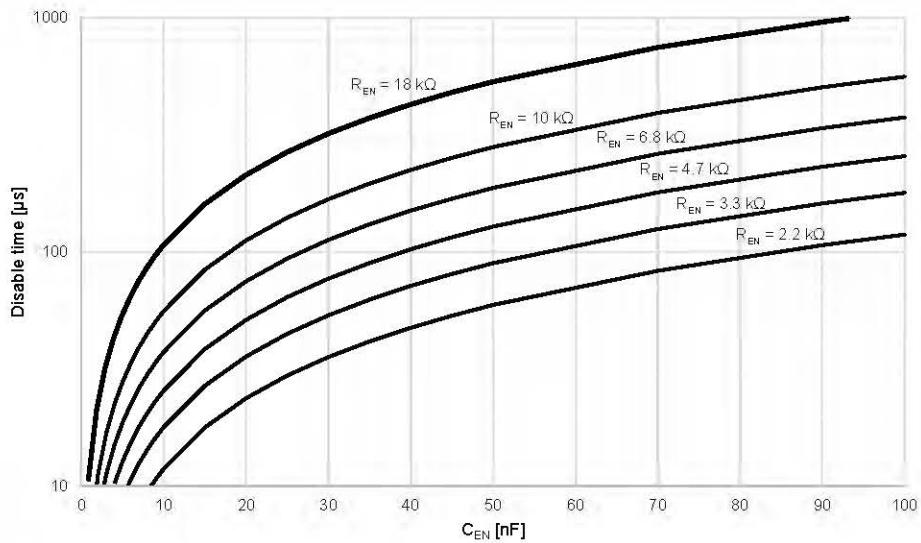
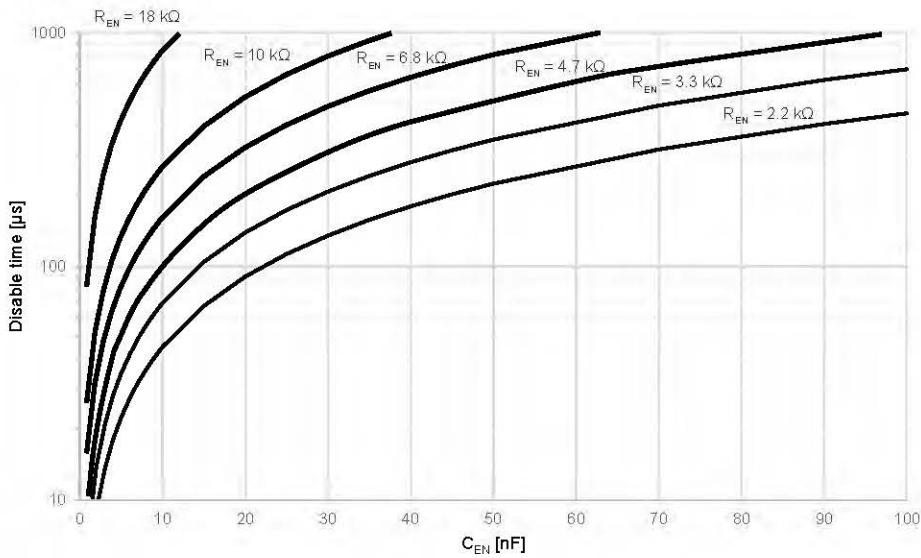


Figure 11. Disable time versus  $R_{EN}$  and  $C_{EN}$  values ( $V_{DD} = 1.8$  V)



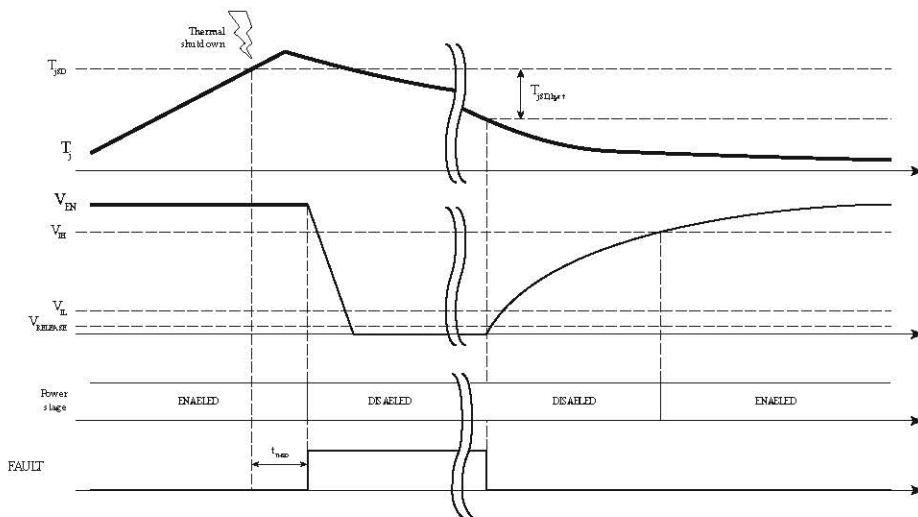
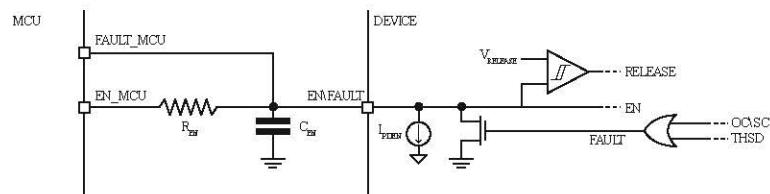
## 6.5 Thermal shutdown

The device embeds circuitry protecting it from the overtemperature conditions.

When the thermal shutdown temperature is reached, the power stage is disabled and the ENFAULT input is forced low through the integrated open-drain MOSFET (refer to Figure 12. Thermal shutdown management).

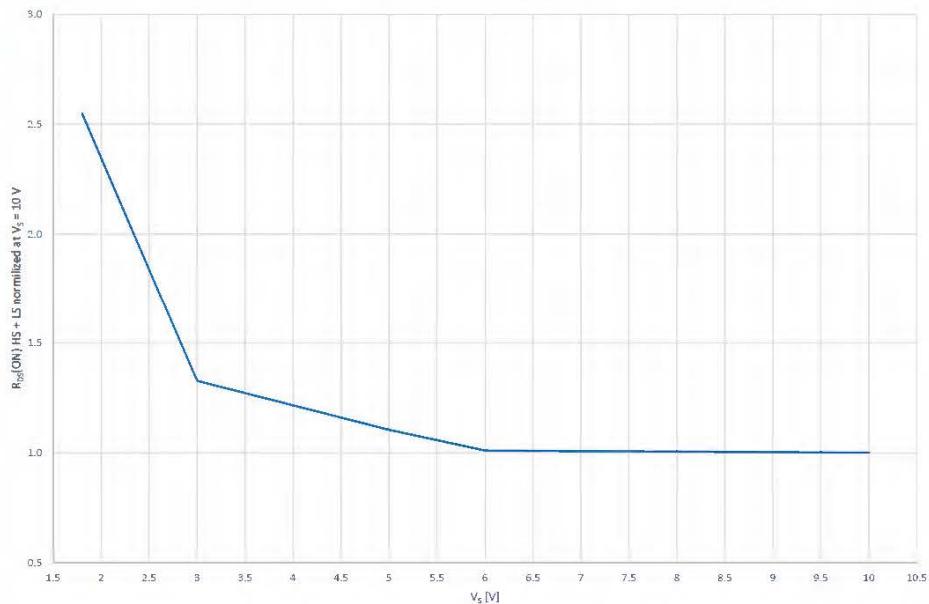
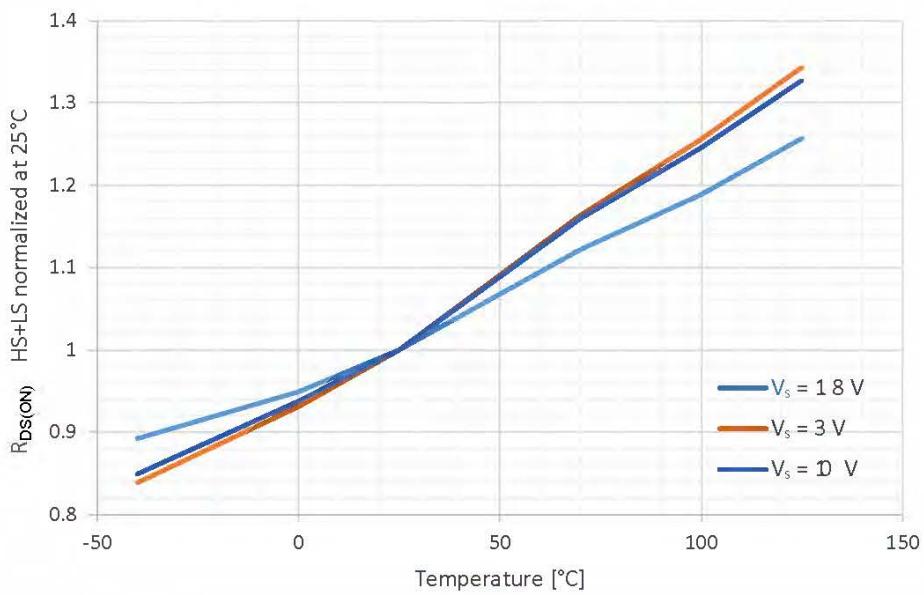
The protection and the ENFAULT output are released when the IC temperature returns below a safe operating value ( $T_{jSD} - T_{jSD,Hyst}$ ).

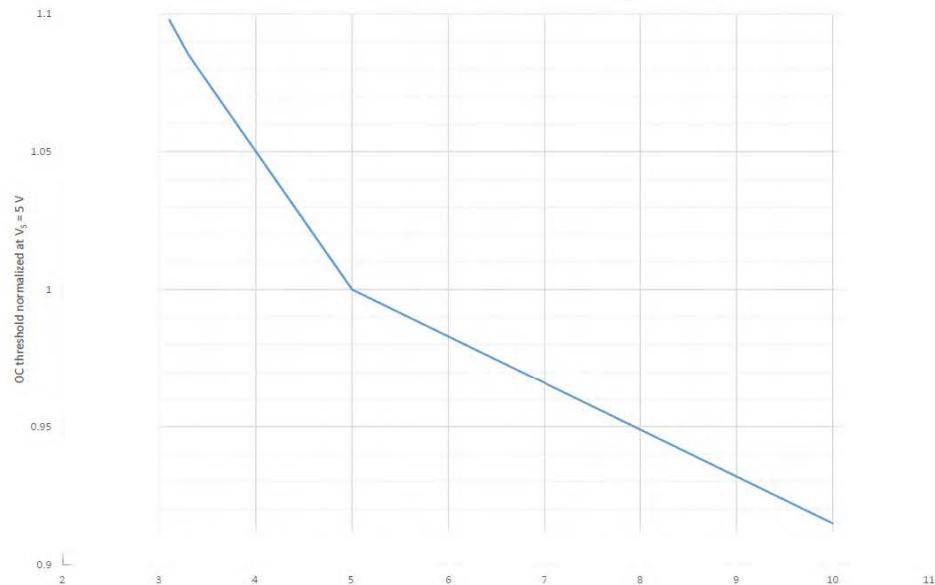
**Figure 12. Thermal shutdown management**



## 7

## Graphs

**Figure 13.** Power stage resistance versus supply voltage**Figure 14.** Power stage resistance versus temperature

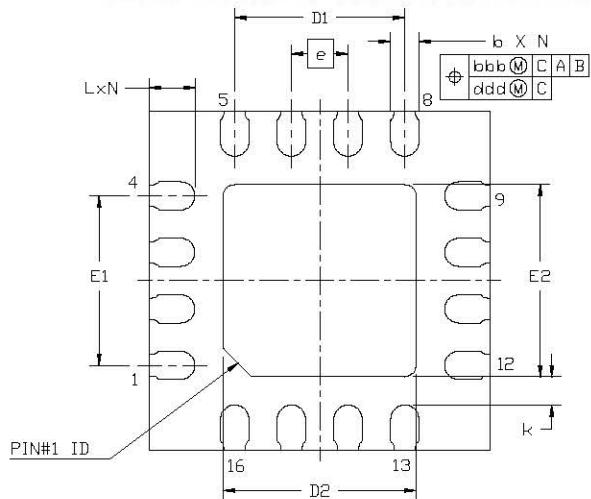
**Figure 15.** Overcurrent threshold versus supply voltage

## 8 Package information

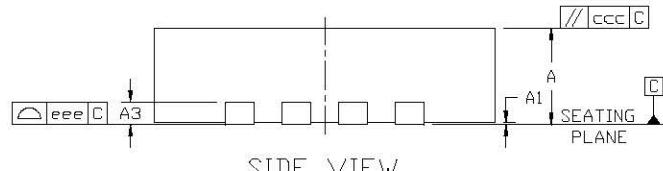
In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

## 8.1 VFQFPN 3x3x1.0 16L package information

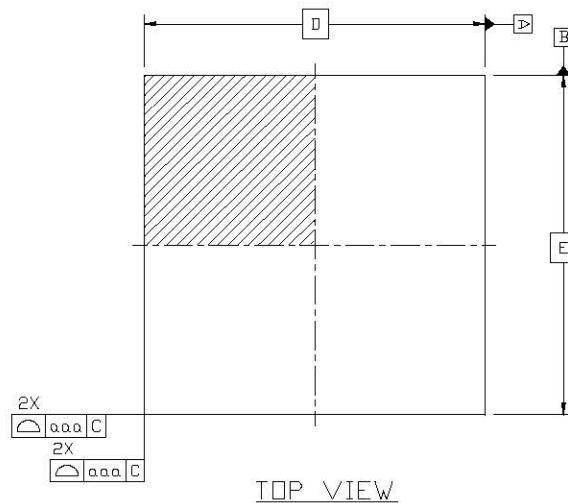
Figure 16. VFQFPN 3x3x1.0 16L package outline



BOTTOM VIEW



SIDE VIEW



TOP VIEW

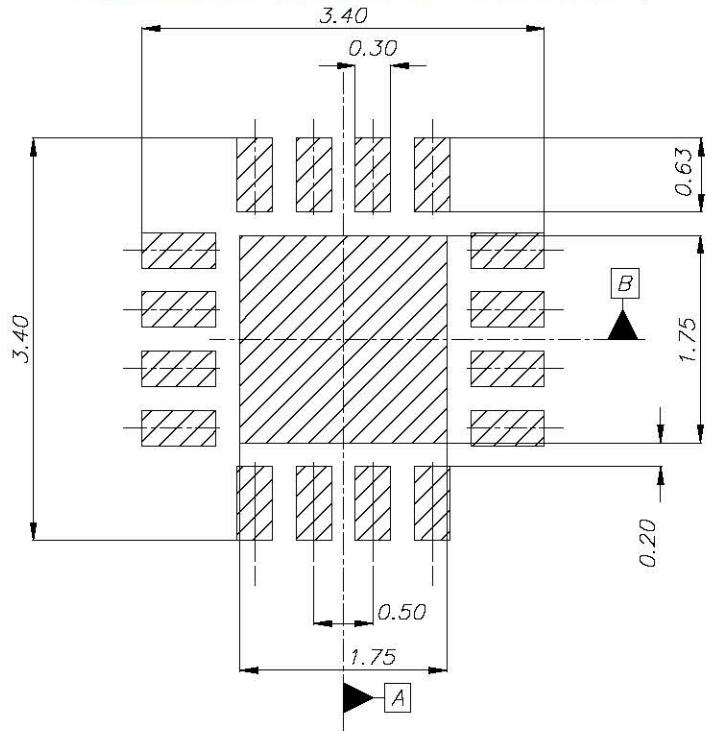
**Table 14. Table A: Package dimensions**

SYMBOL	Dimensions [mm]		
	Min. (mm)	Nom.	Max.
A	0.80	0.90	1.00
A1	0.00	0.02	0.05
A3		0.20	
b	0.20	0.25	0.30
D		3.00 BSC	
D1		1.50 BSC	
D2	1.60	1.70	1.80
e		0.50 BSC	
E		3.00 BSC	
D2		1.50 BSC	
E2	1.60	1.70	1.80
L	0.30	0.40	0.50
k	0.20		
N		16	

**Table 15. Table B: Position and form tolerance**

SYMBOL	TOLERANCE OF FORM AND POSITION
aaa	0.15
bbb	0.10
ccc	0.10
ddd	0.05
eee	0.08
fff	0.10

**Figure 17.** VFQFPN 3x3x1.0 16L recommended footprint



## Revision history

Table 16. Document revision history

Date	Version	Changes
06-May-2016	1	Initial release.
30-Jun-2016	2	<ul style="list-style-type: none"><li>- Updated document status to Datasheet - production data on page 1.</li><li>- Updated Table 1 (changed Max. value of VS from 12 to 11) and Table 7 (changed <math>t_{OFF}</math> value from <math>\geq 47 \mu s</math> to <math>\geq 37 \mu s</math>).</li></ul>
28-Nov-2016	3	<ul style="list-style-type: none"><li>- Updated Figure 1 in <a href="#">Section 1 Block diagram</a> (replaced by new figure).</li><li>- Updated Table 2 in <a href="#">Section 2.2 Recommended operating conditions</a> (added <math>t_{INW}</math> symbol).</li><li>- Updated Table 3 in <a href="#">Section 2.3 Thermal data</a> (replaced by new table).</li><li>- Updated Table 8 in <a href="#">Section 6.2 Microstepping sequencer</a> [removed "Sequencer module (binary)" column].</li><li>- Added Table 11 in <a href="#">Section 6.2 Microstepping sequencer</a>.</li><li>- Updated Table 13 in (updated title).</li><li>- Updated Figure 13 in (replaced by new figure).</li><li>- Minor modifications throughout document.</li></ul>
21-Mar-2019	4	Updated <a href="#">Section 8.1 VFQFPN 3x3x1.0 16L package information</a>
09-Dec-2020	5	Updated Figure 9 in <a href="#">Section 6.4</a> , <a href="#">Figure 16</a> and <a href="#">Figure 17</a> . Updated <a href="#">Table 14</a> and added <a href="#">Table 15</a>

## Contents

<b>1</b>	<b>Block diagram</b>	<b>2</b>
<b>2</b>	<b>Electrical data</b>	<b>3</b>
<b>2.1</b>	Absolute maximum ratings	3
<b>2.2</b>	Recommended operating conditions	3
<b>2.3</b>	Thermal data	3
<b>2.4</b>	ESD protection	4
<b>3</b>	<b>Electrical characteristics</b>	<b>5</b>
<b>4</b>	<b>Pin description</b>	<b>7</b>
<b>5</b>	<b>Typical application</b>	<b>8</b>
<b>6</b>	<b>Functional description</b>	<b>9</b>
<b>6.1</b>	Standby and power-up	9
<b>6.2</b>	Microstepping sequencer	9
<b>6.3</b>	PWM current control	12
<b>6.3.1</b>	OFF time adjustment	14
<b>6.4</b>	Overcurrent and short-circuit protection	15
<b>6.5</b>	Thermal shutdown	18
<b>7</b>	<b>Graphs</b>	<b>19</b>
<b>8</b>	<b>Package information</b>	<b>21</b>
<b>8.1</b>	VFQFPN 3x3x1.0 16L package information	22
<b>Revision history</b>		<b>25</b>
<b>Contents</b>		<b>26</b>
<b>List of tables</b>		<b>27</b>
<b>List of figures</b>		<b>28</b>

## List of tables

<b>Table 1.</b>	Absolute maximum ratings . . . . .	3
<b>Table 2.</b>	Recommended operating conditions . . . . .	3
<b>Table 3.</b>	Thermal data . . . . .	3
<b>Table 4.</b>	ESD protection ratings . . . . .	4
<b>Table 5.</b>	Electrical characteristics . . . . .	5
<b>Table 6.</b>	Pin description . . . . .	7
<b>Table 7.</b>	Typical application values . . . . .	8
<b>Table 8.</b>	Step mode selection through MODEx inputs . . . . .	9
<b>Table 9.</b>	Target reference and current direction according to sequencer value (full-step mode) . . . . .	11
<b>Table 10.</b>	Target reference and current direction according to sequencer value (not full-step mode) . . . . .	11
<b>Table 11.</b>	Example . . . . .	12
<b>Table 12.</b>	ON, slow decay and fast decay states . . . . .	13
<b>Table 13.</b>	Recommended $R_{RCOFF}$ and $C_{RCOFF}$ values according to $R_{OFF}$ . . . . .	15
<b>Table 14.</b>	Table A: Package dimensions . . . . .	23
<b>Table 15.</b>	Table B: Position and form tolerance . . . . .	23
<b>Table 16.</b>	Document revision history . . . . .	25

## List of figures

<b>Figure 1.</b>	Block diagram . . . . .	2
<b>Figure 2.</b>	Pin connection (top view) . . . . .	7
<b>Figure 3.</b>	Typical application schematic . . . . .	8
<b>Figure 4.</b>	STCK and DIR timing . . . . .	10
<b>Figure 5.</b>	Mode selection example . . . . .	10
<b>Figure 6.</b>	PWM current control sequence . . . . .	14
<b>Figure 7.</b>	OFF time regulation circuit . . . . .	14
<b>Figure 8.</b>	OFF time vs. $R_{OFF}$ value . . . . .	15
<b>Figure 9.</b>	Overcurrent and short-circuit protection management . . . . .	16
<b>Figure 10.</b>	Disable time versus $R_{EN}$ and $C_{EN}$ values ( $V_{DD} = 3.3$ V) . . . . .	17
<b>Figure 11.</b>	Disable time versus $R_{EN}$ and $C_{EN}$ values ( $V_{DD} = 1.8$ V) . . . . .	17
<b>Figure 12.</b>	Thermal shutdown management . . . . .	18
<b>Figure 13.</b>	Power stage resistance versus supply voltage . . . . .	19
<b>Figure 14.</b>	Power stage resistance versus temperature . . . . .	19
<b>Figure 15.</b>	Overcurrent threshold versus supply voltage . . . . .	20
<b>Figure 16.</b>	VFQFPN 3x3x1.0 16L package outline . . . . .	22
<b>Figure 17.</b>	VFQFPN 3x3x1.0 16L recommended footprint . . . . .	24

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, please refer to [www.st.com/trademarks](http://www.st.com/trademarks). All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2020 STMicroelectronics – All rights reserved