VN920-E

Single-channel high side driver

Features

Type	$R_{DS(on)}$	I_{OUT}	V_{CC}
VN920-E VN920-12-E	16 mΩ	30 A	36 V

- CMOS compatible input
- Proportional load current sense
- Shorted load protection
- Under voltage and overvoltage shutdown
- Overvoltage clamp
- Thermal shutdown
- Current limitation
- Protection against loss of ground and loss of V_{CC}
- Very low standby power dissipation
- Reverse battery protected (see *Application schematic on page 16*)
- In compliance with the 2002/95/ec european directive

PENTAWATT   **PENTAWATT in-line**
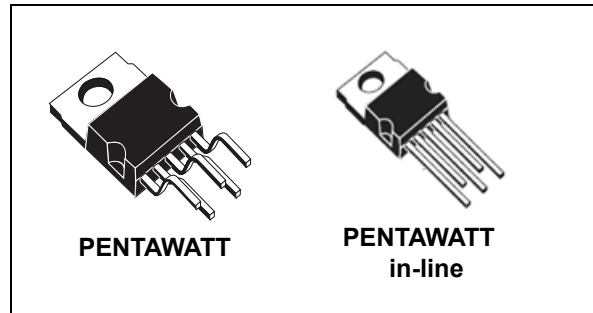
Description

The VN920-E is a monolithic device designed in STMicroelectronics VIPower™ M0-3 technology, intended for driving any kind of load with one side connected to ground. Active V_{CC} pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility able).

Active current limitation combined with thermal shutdown and automatic restart protect the device against overload. The device integrates an analog current sense output which delivers a current proportional to the load current. Device automatically turns off in case of ground pin disconnection.

Table 1.   Device summary

Package	Order codes	
	Tube	**Tape and reel**
PENTAWATT	VN920-E	-
PENTAWATT in-line	VN920-12-E	-

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1 Block diagram and pin description

Figure 1. Block diagram
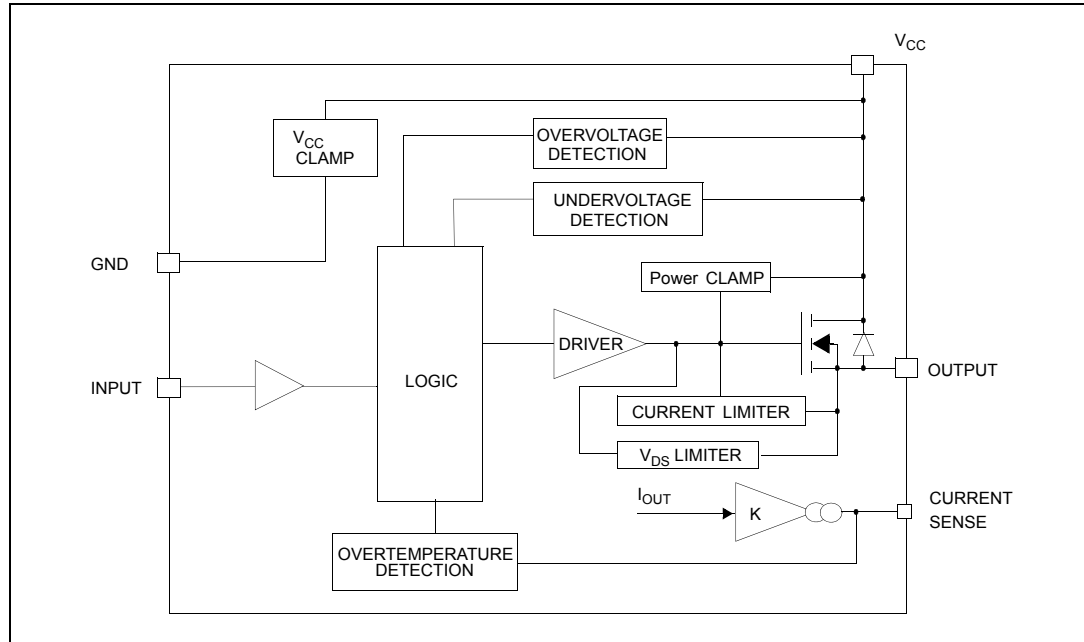
Figure 2. Configuration diagram (top view)
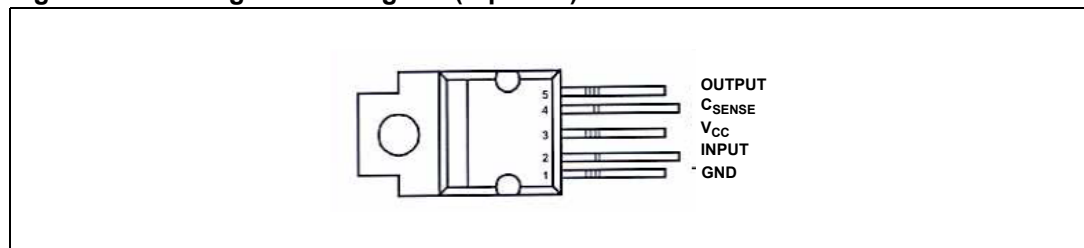
Table 2. Suggested connections for unused and not connected pins

Connection / pin	Current Sense	N.C.	Output	Input
Floating		X	X	X
To ground	Through 1KΩ resistor	X		Through 10KΩ resistor

2 Electrical specifications

Figure 3. Current and voltage conventions
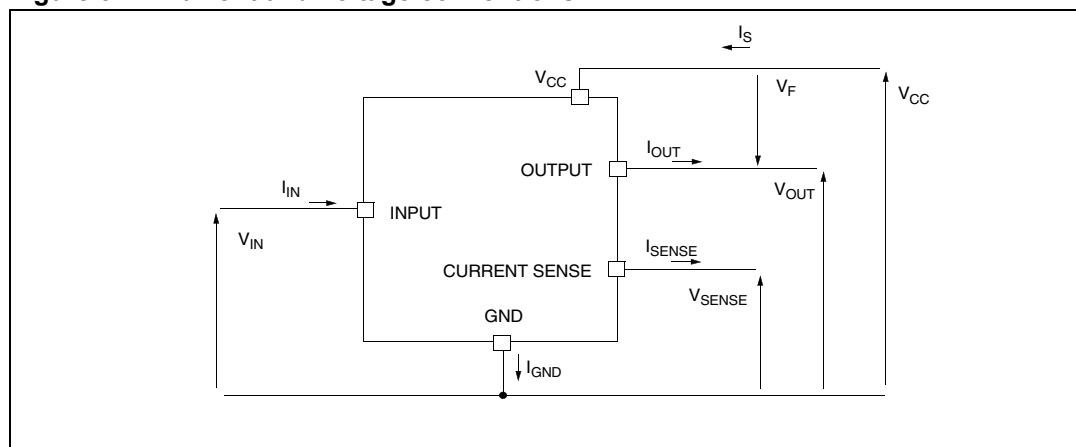
2.1 Absolute maximum ratings

Stressing the device above the rating listed in the "Absolute maximum ratings" table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to Absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics sure program and other relevant quality document.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	DC supply voltage	41	V
$- V_{CC}$	Reverse DC supply voltage	- 0.3	V
$- I_{gnd}$	DC reverse ground pin current	- 200	mA
I_{OUT}	DC output current	Internally limited	A
$- I_{OUT}$	Reverse DC output current	- 21	A
I_{IN}	DC input current	+/- 10	mA
V_{CSENSE}	Current sense maximum voltage	- 3 + 15	V V
V_{ESD}	Electrostatic discharge (human body model: R = 1.5KΩ; C = 100pF) – Input – Current sense – Output – V_{CC}	 4000 2000 5000 5000	 V V V V

Table 3.   Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
E_{MAX}	Maximum switching energy (L = 0.25mH; R_L = 0Ω; V_{bat} = 13.5V; T_{jstart} = 150°C; I_L = 45A)		mJ
P_{tot}	Power dissipation $T_C \leq 25°C$	96.1	W
T_j	Junction operating temperature	Internally limited	°C
T_c	Case operating temperature	- 40 to 150	°C
T_{stg}	Storage temperature	- 55 to 150	°C

2.2   Thermal data

Table 4.   Thermal data

Symbol	Parameter	Max. value	Unit
$R_{thj-case}$	Thermal resistance junction-case (max)	1.3	°C/W
$R_{thj-lead}$	Thermal resistance junction-lead (max)	-	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient (max)	61.3	°C/W

2.3   Electrical characteristics

Values specified in this section are for 8V < V_{CC} < 36V; -40°C < Tj < 150°C, unless otherwise stated.

Table 5.   Power

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating supply voltage		5.5	13	36	V
V_{USD}	Undervoltage shutdown		3	4	5.5	V
V_{OV}	Overvoltage shutdown		36			V
R_{ON}	On-state resistance	I_{OUT} = 10A; T_j = 25°C; I_{OUT} = 10A; I_{OUT} = 3A; V_{CC} = 6V			16 32 55	mΩ mΩ mΩ
V_{CLAMP}	Clamp voltage	I_{CC} = 20mA[1]	41	48	55	V
I_S	Supply current	Off-state; V_{CC} = 13V; V_{IN} = V_{OUT} = 0V		10	25	μA
		Off-state; V_{CC} = 13V; V_{IN} = V_{OUT} = 0V; T_j = 25°C		10	20	μA
		On-state; V_{CC} = 13V; V_{IN} = 5V; I_{OUT} = 0A; R_{SENSE} = 3.9 kΩ			5	mA
$I_{L(off1)}$	Off-state output current	V_{IN} = V_{OUT} = V_{SENSE}= 0V	0		50	μA

Table 5. Power (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{L(off2)}$	Off-state output current	$V_{IN} = V_{OUT} = V_{SENSE} = 3.5V$	-75			µA
$I_{L(off3)}$	Off-state output current	$V_{IN} = V_{OUT} = V_{SENSE} = 0V$; $V_{CC} = 13V$; $T_j = 125°C$			5	µA
$I_{L(off4)}$	Off-state output current	$V_{IN} = V_{OUT} = V_{SENSE} = 0V$; $V_{CC} = 13V$; $T_j = 25°C$			3	µA

1. V_{clamp} and V_{OV} are correlated. Typical difference is 5V.

Table 6. Switching (V_{CC}=13V)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$R_L = 1.3Ω$ (see *Figure 5*)	-	50	-	µs
$t_{d(off)}$	Turn-off delay time	$R_L = 1.3Ω$ (see *Figure 5*)	-	50	-	µs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L = 1.3Ω$ (see *Figure 5*)	-	See *Figure 15*	-	V/µs
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L = 1.3Ω$ (see *Figure 5*)	-	See *Figure 16*	-	V/µs

Table 7. Logic inputs

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage				1.25	V
I_{IL}	Low level input current	$V_{IN} = 1.25V$	1			µA
V_{IH}	Input high-level voltage		3.25			V
I_{IH}	High-level input current	$V_{IN} = 3.25V$			10	µA
$V_{I(hyst)}$	Input hysteresis voltage		0.5			V
V_{ICL}	Input clamp voltage	$I_{IN} = 1mA$ $I_{IN} = -1mA$	6	6.8 - 0.7	8	V V

Table 8. V_{CC} output diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_F	Forward on voltage	$- I_{OUT} = 2A$; $T_j = 150°C$	-	-	0.6	V

Table 9. Protections[1]

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature		135			°C
T_{hyst}	Thermal hysteresis		7	15		°C
I_{lim}	DC short circuit current	$V_{CC} = 13V$ $5V < V_{CC} < 36V$	30	45	75 75	A A

Table 9. Protections[1] (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{demag}	Turn-off output clamp voltage	$I_{OUT} = 2A$; $V_{IN} = 0V$; $L = 6mH$	$V_{CC} - 41$	$V_{CC} - 48$	$V_{CC} - 55$	V
V_{ON}	Output voltage drop limitation	$I_{OUT} = 1$ A; $T_j = -40°C...150°C$		50		mV

1. To ensure long term reliability under heavy over-load or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device operates under abnormal conditions this software must limit the duration and number of activation cycles.

Table 10. Current sense ($9V \leq V_{CC} \leq 16V$)[1]

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
K_1	I_{OUT}/I_{SENSE}	$I_{OUT} = 1A$; $V_{SENSE} = 0.5V$; $T_j = -40°C...150°C$	3300	4400	6000	
dK_1/K_1	Current sense ratio drift	$I_{OUT} = 1A$; $V_{SENSE} = 0.5V$; $T_j = -40°C...150°C$	-10		+10	%
K_2	I_{OUT}/I_{SENSE}	$I_{OUT} = 10A$; $V_{SENSE} = 4V$; $T_j = -40°C$ $T_j = 25°C...150°C$	4200 4400	4900 4900	6000 5750	
dK_2/K_2	Current sense ratio drift	$I_{OUT} = 10A$; $V_{SENSE} = 4V$; $T_j = -40°C...150°C$	-8		+8	%
K_3	I_{OUT}/I_{SENSE}	$I_{OUT} = 30A$; $V_{SENSE} = 4V$; $T_j = -40°C$ $T_j = 25°C...150°C$	4200 4400	4900 4900	5500 5250	
dK_3/K_3	Current sense ratio drift	$I_{OUT} = 30A$; $V_{SENSE} = 4V$; $T_j = -40°C...150°C$	-6		+6	%
I_{SENSE0}	Analog sense leakage current	$V_{CC} = 6...16V$; $I_{OUT} = 0A$; $V_{SENSE} = 0V$; $T_j = -40°C...150°C$	0		10	µA
V_{SENSE}	Max analog sense output voltage	$V_{CC} = 5.5V$; $I_{OUT} = 5A$; $R_{SENSE} = 10k\Omega$ $V_{CC} > 8V$, $I_{OUT} = 10A$; $R_{SENSE} = 10k\Omega$	2 4			V V
V_{SENSEH}	Sense voltage in over temperature condition	$V_{CC} = 13V$; $R_{SENSE} = 3.9k\Omega$		5.5		V
$R_{VSENSEH}$	Analog sense output impedance in over temperature condition	$V_{CC} = 13V$; $T_j > T_{TSD}$; output open		400		Ω
t_{DSENSE}	Current sense delay response	To 90% I_{SENSE}[2]			500	µs

1. See *Figure 4*.

2. Current sense signal delay after positive input slope.
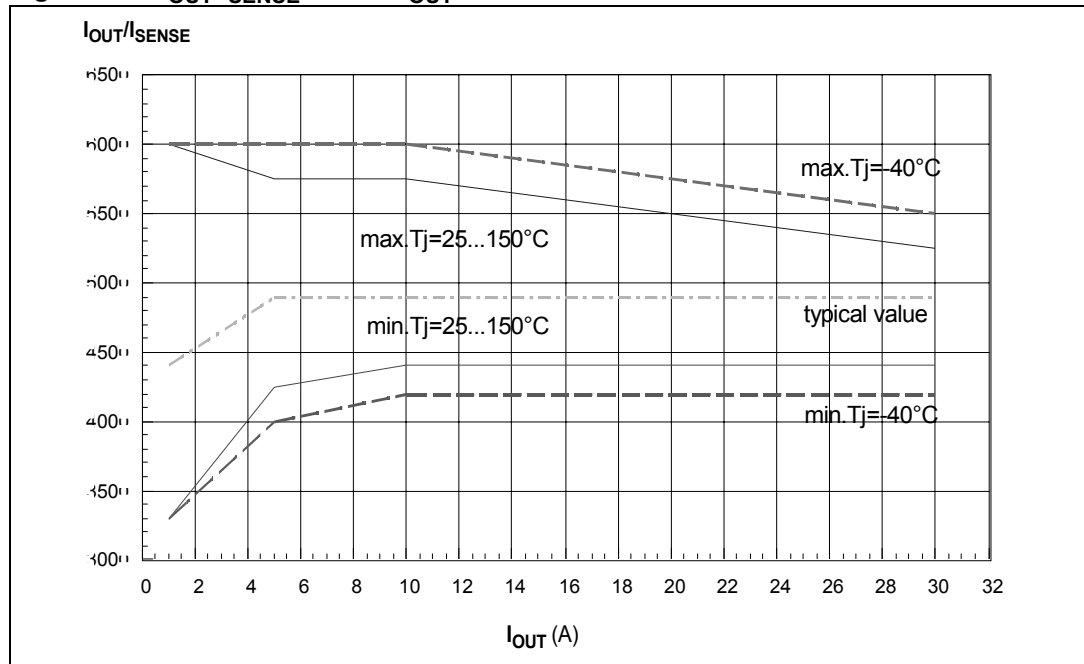
Figure 4. I_{OUT}/I_{SENSE} **versus** I_{OUT}

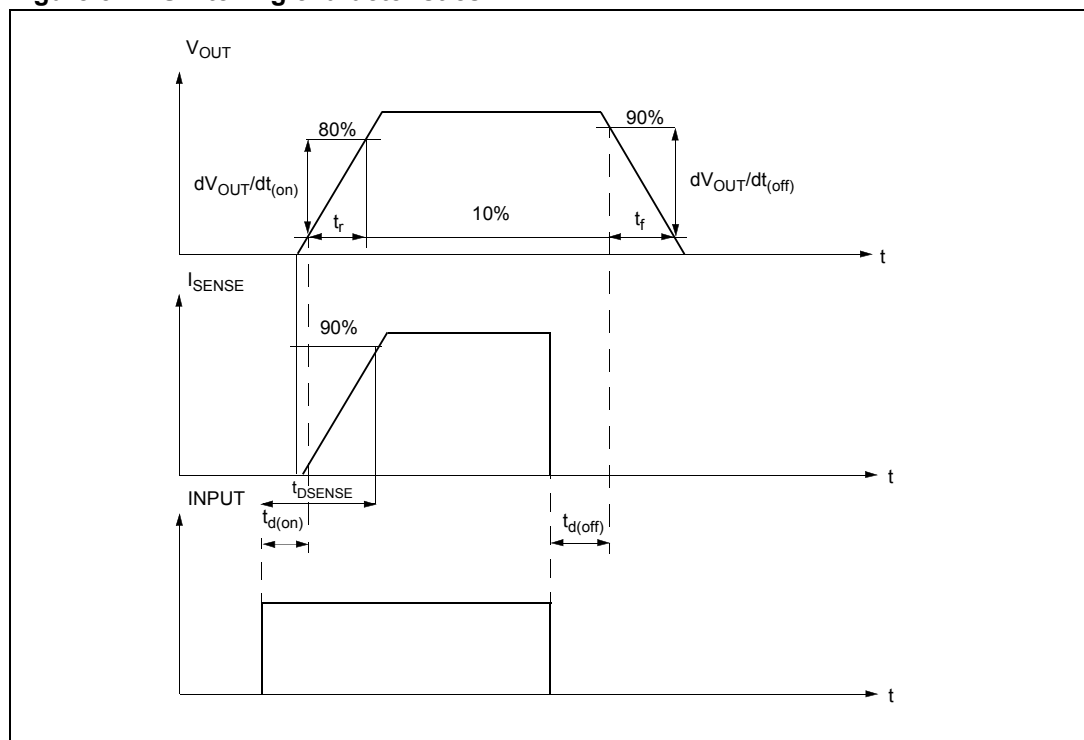**Figure 5.** Switching characteristics

Table 11.   Truth table

Conditions	Input	Output	Sense
Normal operation	L H	L H	0 Nominal
Over temperature	L H	L L	0 V_{SENSEH}
Undervoltage	L H	L L	0 0
Overvoltage	L H	L L	0 0
Short circuit to GND	L H H	L L L	0 $(T_j<T_{TSD})$ 0 $(T_j>T_{TSD})$ V_{SENSEH}
Short circuit to V_{CC}	L H	H H	0 < Nominal
Negative output voltage clamp	L	L	0

Table 12.   Electrical transient requirements (part 1/3)

ISO T/R 7637/1 Test pulse	Test level				
	I	II	III	IV	Delays and impedance
1	- 25V	- 50V	- 75V	- 100V	2ms, 10Ω
2	+ 25V	+ 50V	+ 75V	+ 100V	0.2ms, 10Ω
3a	- 25V	- 50V	- 100V	- 150V	0.1µs, 50Ω
3b	+ 25V	+ 50V	+ 75V	+ 100V	0.1µs, 50Ω
4	- 4V	- 5V	- 6V	- 7V	100ms, 0.01Ω
5	+ 26.5V	+ 46.5V	+ 66.5V	+ 86.5V	400ms, 2Ω

Table 13.   Electrical transient requirements (part 2/3)

ISO 7637-2: 2004(E) Test pulse	Test level results			
	I	II	III	IV
1	C	C	C	C
2	C	C	C	C
3a	C	C	C	C
3b	C	C	C	C
4	C	C	C	C
5	C	E	E	E

Table 14. **Electrical transient requirements (part 3/3)**

Class	Contents
C	All functions of the device are performed as designed after exposure to disturbance.
E	One or more functions of the device are not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device.

Figure 6.   Waveforms
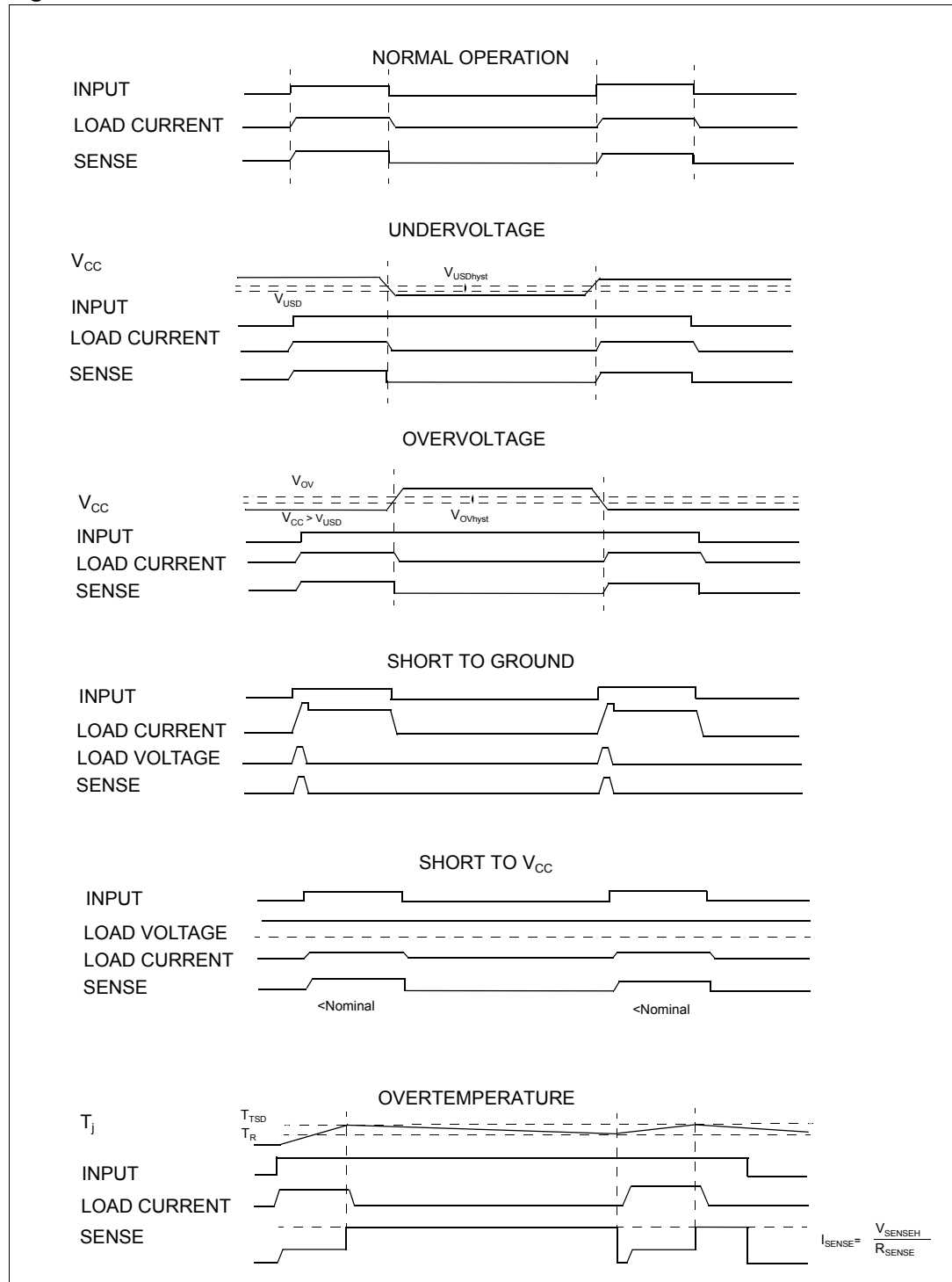
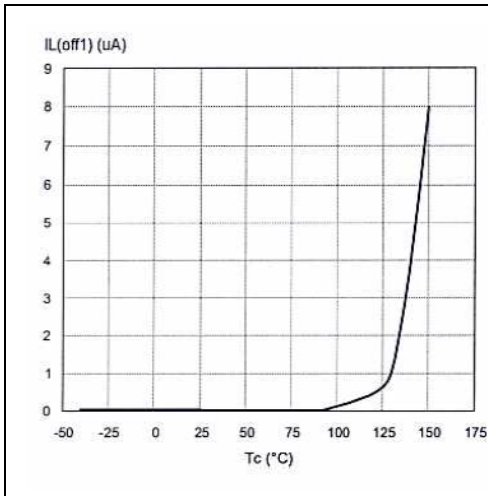## 2.4 Electrical characteristics curves

Figure 7.   Off-state output current

Figure 8.   High level input current
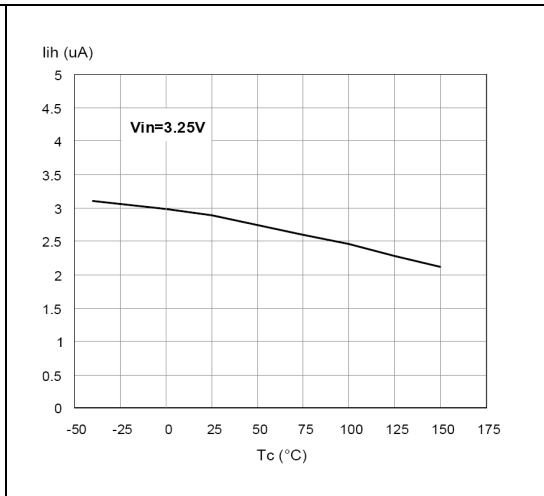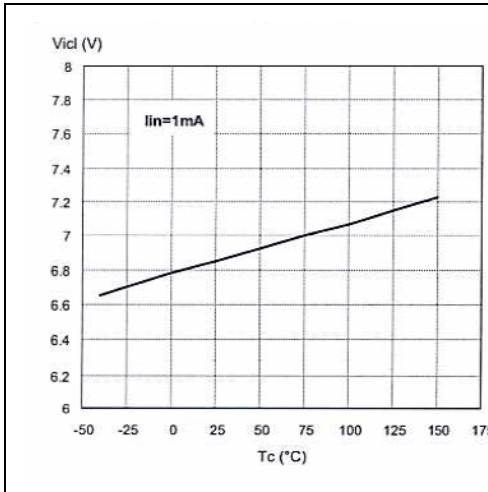

Figure 9.   Input clamp voltage

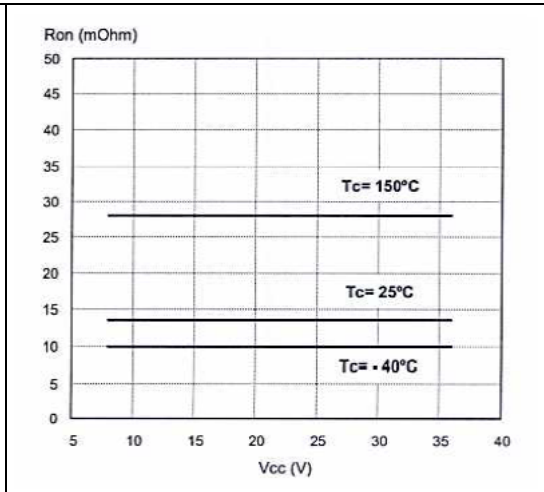**Figure 10.   On-state resistance vs V$_{CC}$**

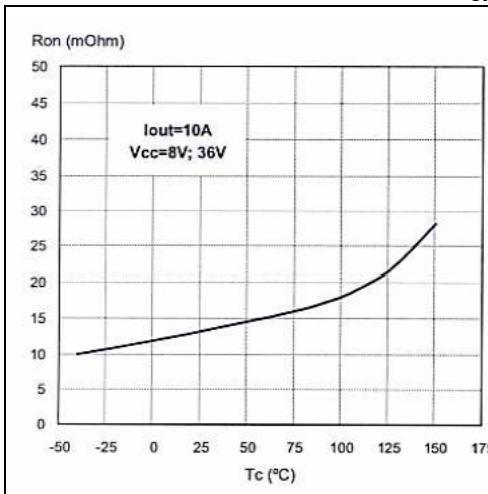**Figure 11.   On-state resistance vs T$_{CASE}$**

Figure 12.   Input high level voltage
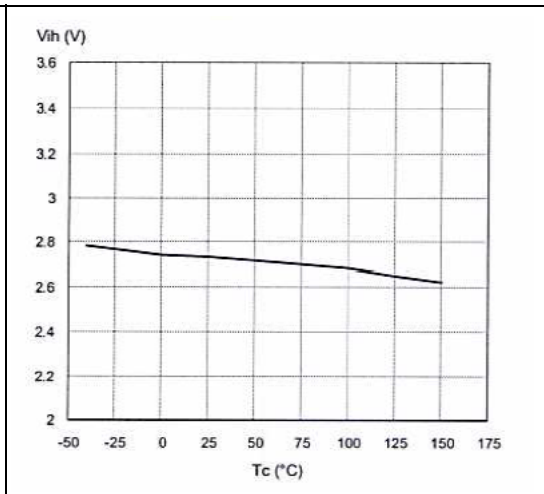
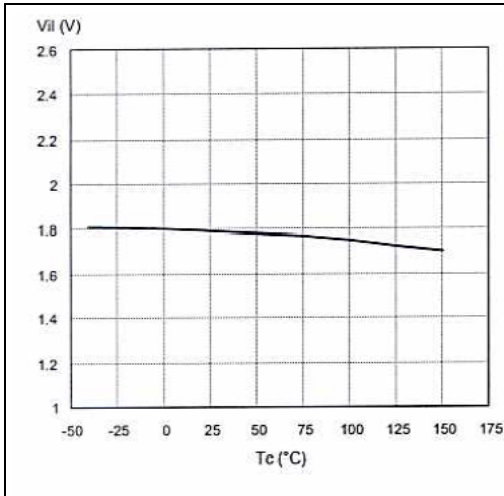**Figure 13.   Input low level voltage**

Figure 14.   Input hysteresis voltage
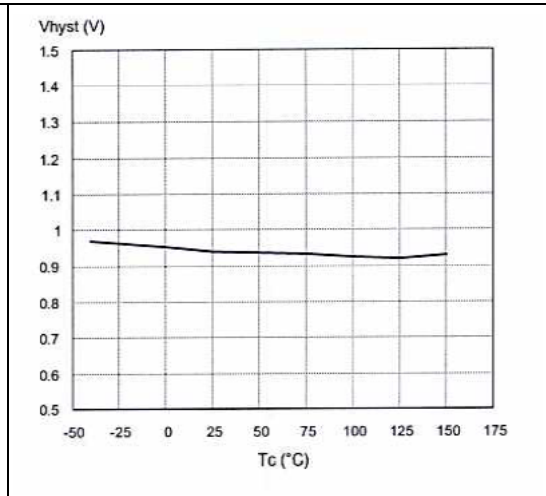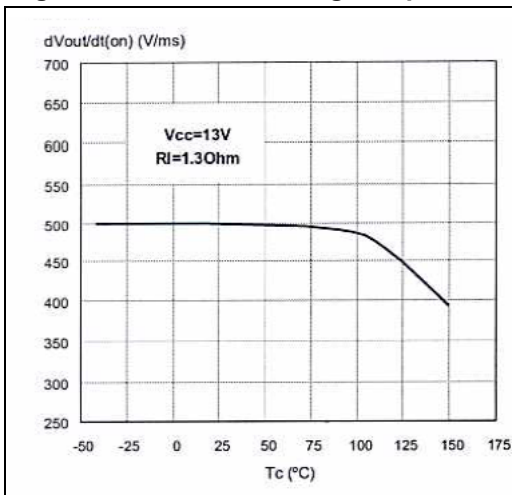

Figure 15.   Turn-on voltage slope
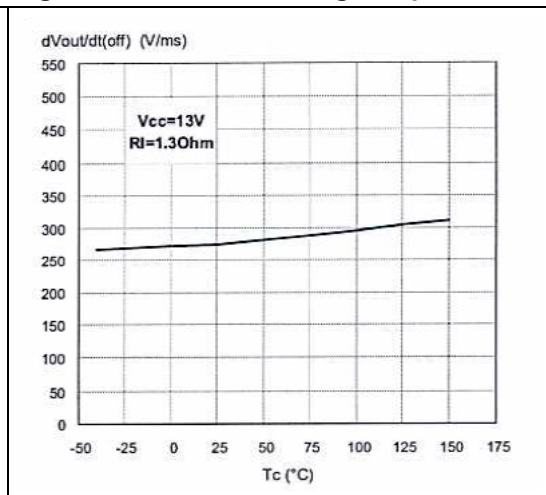

Figure 16.   Turn-off voltage slope

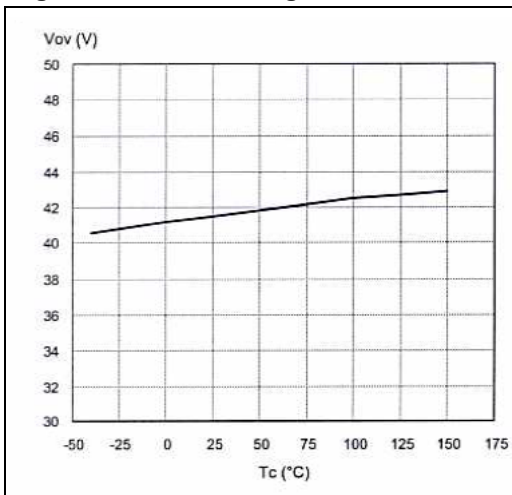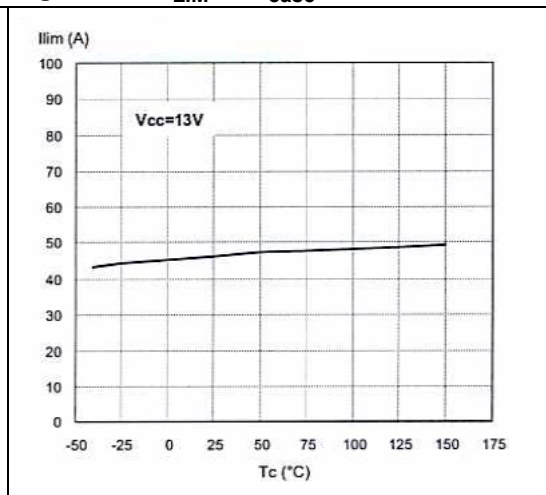**Figure 17.   Overvoltage shutdown**

Figure 18. I_{LIM} vs T_{case}

3 Application information

Figure 19. Application schematic
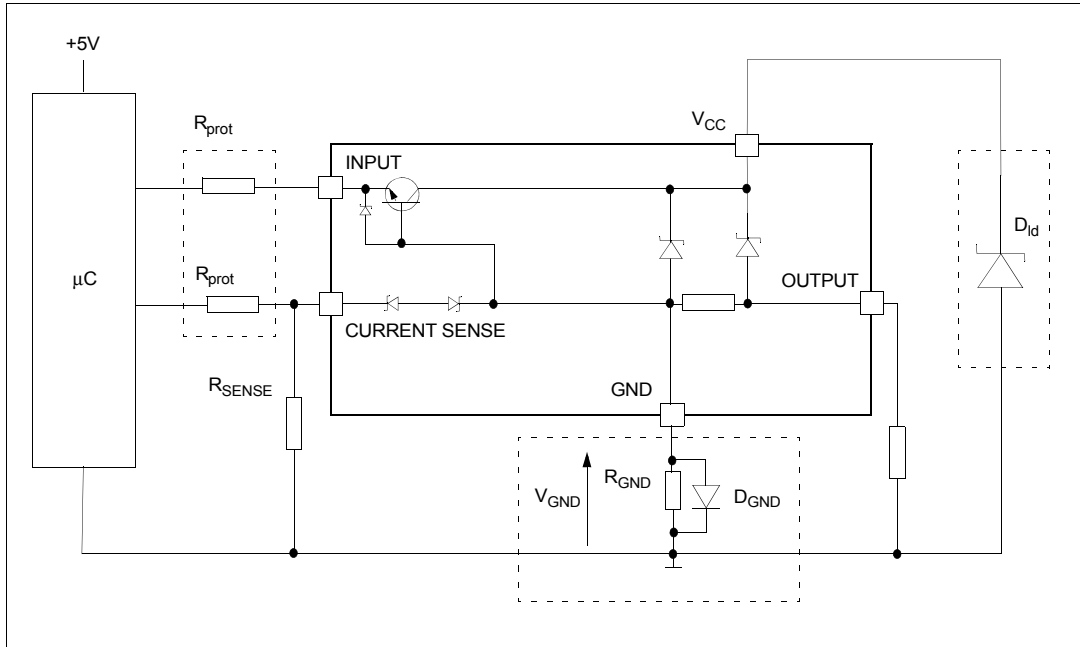
3.1 GND protection network against reverse battery

3.1.1 Solution 1: resistor in the ground line (R$_{GND}$ only)

This can be used with any type of load.

The following is an indication on how to dimension the R$_{GND}$ resistor.

1. R$_{GND} \leq 600mV / (I_{S(on)max})$.
2. R$_{GND} \geq (- V_{CC}) / (- I_{GND})$

where - I$_{GND}$ is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device datasheet.

Power Dissipation in R$_{GND}$ (when V$_{CC}$ < 0: during reverse battery situations) is:

$$P_D = (- V_{CC})^2 / R_{GND}$$

This resistor can be shared amongst several different HSDs. Please note that the value of this resistor should be calculated with formula (1) where I$_{S(on)max}$ becomes the sum of the maximum on-state currents of the different devices.

Please note that if the microprocessor ground is not shared by the device ground then the R$_{GND}$ will produce a shift (I$_{S(on)max}$ * R$_{GND}$) in the input thresholds and the status output values. This shift will vary depending on how many devices are ON in the case of several high-side drivers sharing the same R$_{GND}$.

If the calculated power dissipation leads to a large resistor or several devices have to share the same resistor then ST suggests to utilize Solution 2 (see below).

3.1.2 Solution 2: diode (D$_{GND}$) in the ground line

A resistor (R$_{GND}$ = 1kΩ) should be inserted in parallel to D$_{GND}$ if the device drives an inductive load.

This small signal diode can be safely shared amongst several different HSDs. Also in this case, the presence of the ground network will produce a shift (≈600mV) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift will not vary if more than one HSD shares the same diode/resistor network.

Series resistor in INPUT lines is also required to prevent that, during battery voltage transient, the current exceeds the absolute maximum rating.

Safest configuration for unused INPUT pin is to leave it unconnected, while unused SENSE pin has to be connected to ground pin.

3.2 Load dump protection

D$_{ld}$ is necessary (voltage transient suppressor) if the load dump peak voltage exceeds the V$_{CC}$ max DC rating. The same applies if the device is subject to transients on the V$_{CC}$ line that are greater than the ones shown in the ISO T/R 7637/1 table.

3.3 MCU I/Os protection

If a ground protection network is used and negative transient are present on the V$_{CC}$ line, the control pins will be pulled negative. ST suggests to insert a resistor (R$_{prot}$) in line to prevent the μC I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of μC and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of μC I/Os.

-V$_{CCpeak}$/I$_{latchup}$ ≤ R$_{prot}$ ≤ (V$_{OHμC}$-V$_{IH}$-V$_{GND}$) / I$_{IHmax}$

Calculation example:

For V$_{CCpeak}$= - 100V and I$_{latchup}$ ≥ 20mA; V$_{OHμC}$ ≥ 4.5V

5kΩ ≤ R$_{prot}$ ≤ 65kΩ.

Recommended values: R$_{prot}$ =10kΩ.

4 Package and packing information

4.1 ECOPACK® packages

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.

ECOPACK® is an ST trademark.

4.1.1 PENTAWATT (vertival) mechanical data

Figure 20. PENTAWATT (vertical) package dimensions
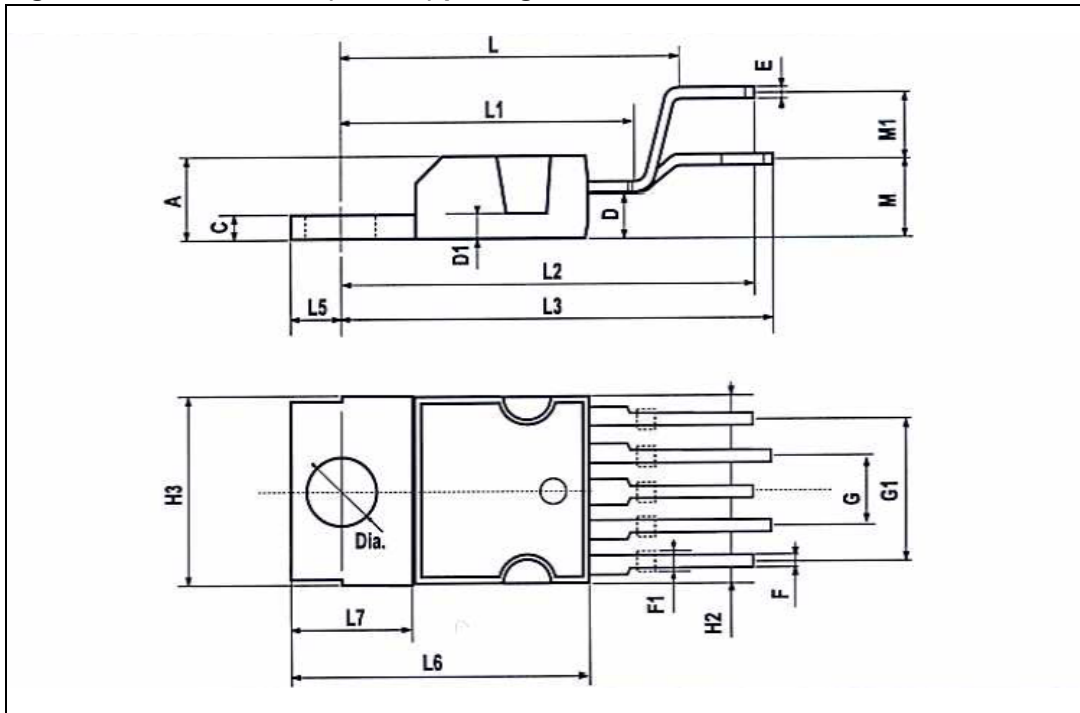
Table 15. PENTAWATT (vertical) mechanical data

Symbol	millimeters		
	Min	Typ	Max
A			4.8
C			1.37
D	2.4		2.8
D1	1.2		1.35
E	0.35		0.55
F	0.8		1.05

Table 15.   PENTAWATT (vertical) mechanical data (continued)

Symbol	millimeters		
	Min	**Typ**	**Max**
F1	1		1.4
G	3.2	3.4	3.6
G1	6.6	6.8	7
H2			10.4
H3	10.05		10.4
L		17.85	
L1		15.75	
L2		21.4	
L3		22.5	
L5	2.6		3
L6	15.1		15.8
L7	6		6.6
M		4.5	
M1		4	
Diam.	3.65		3.85

4.1.2 PENTAWATT (in-line) mechanical data

Figure 21. PENTAWATT (in-line) package dimensions
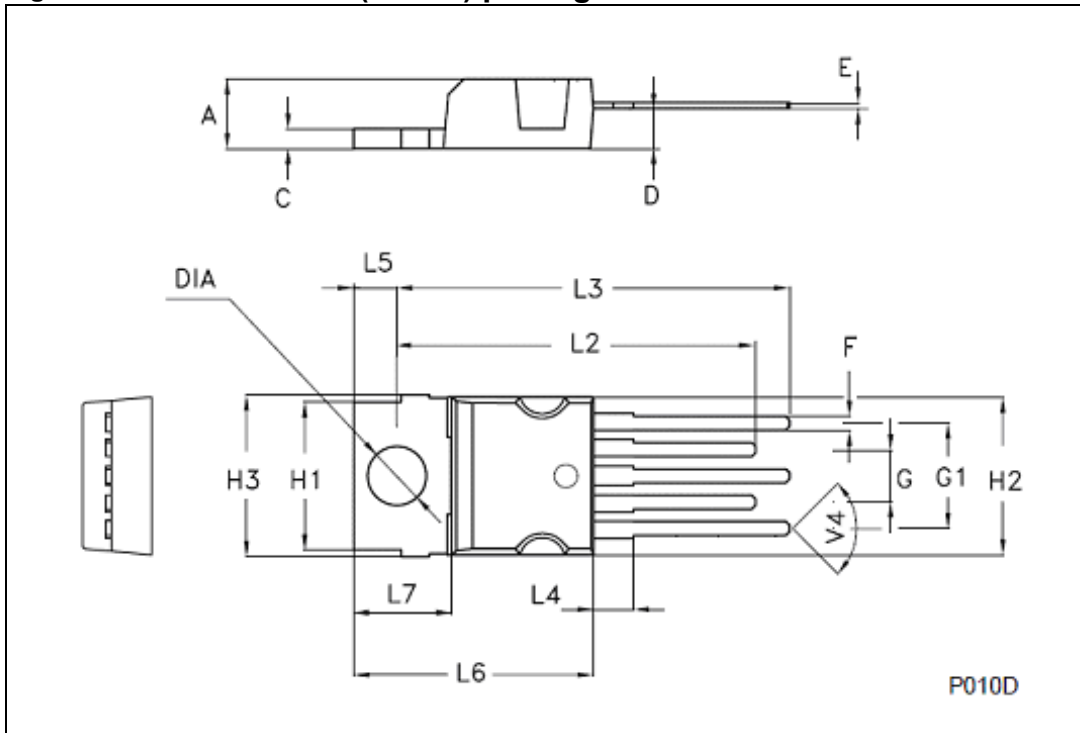
Table 16.   PENTAWATT (in-line) mechanical data

Symbol	millimeters		
	Min	**Typ**	**Max**
A	4.3		4.8
C	1.17		1.37
D	2.4		2.8
E	0.35		0.55
F	0.8		1.05
F2	1.1		1.4
F3	1.25		1.55
G	3.2		3.6
G1	6.6		7
H1	9.3		9.7
H2			10.4
H3	10.05		10.4
L2	23.05		23.8
L3	25.3		

Table 16. **PENTAWATT (in-line) mechanical data (continued)**

Symbol	millimeters		
	Min	**Typ**	**Max**
L4	0.9		2.9
L5	2.6		3
L6	15.1		15.8
L7	6		6.6
V4		90°	
Diam.	3.65		3.85

4.2 PENTAWATT packing information

Figure 22. **PENTAWATT tube shipment (no suffix)**

Base Q.ty	50
Bulk Q.ty	1000
Tube length (± 0.5)	532
A	18
B	33.1
C (± 0.1)	1

All dimensions are in mm.
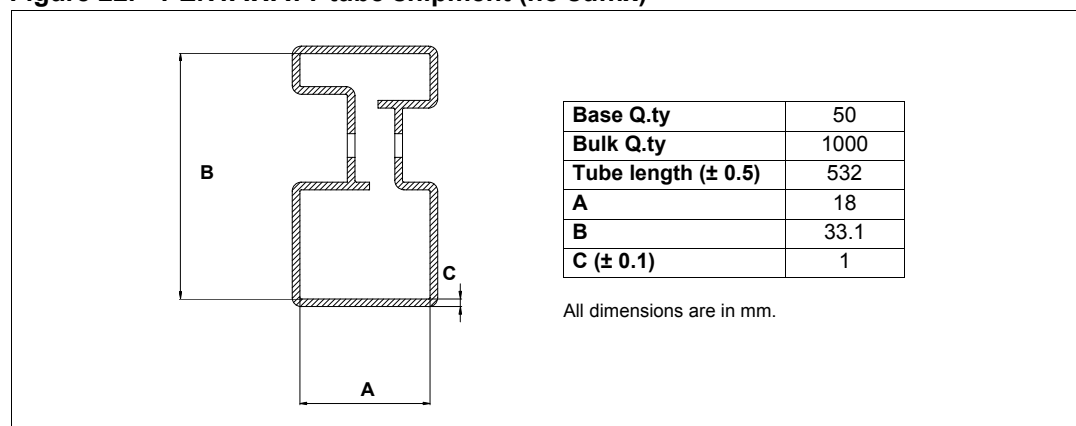
5 Revision history

Table 17. Document revision history

Date	Revision	Changes
22-Oct-2004	1	Initial release.
22-Sep-2009	2	Removed all the references to VN920B5-E and VN920SO-E
08-Oct-2009	3	Added PENTAWATT in-line package: – Updated *Table 1: Device summary*. – Added *Section 4.1.2: PENTAWATT (in-line) mechanical data*.

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