



VB409 VB409SP / VB409(022Y)

DOUBLE OUTPUT HIGH VOLTAGE REGULATOR POWER I.C.

TYPE	$I_{CL(in)}$	$I_{CL(out)}$	V_{OUT}
VB409			
VB409(022Y)	1 A	80 mA (*)	5V $\pm$ 5% Reg.
VB409SP			16V Not Reg

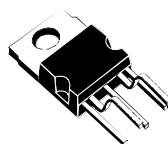
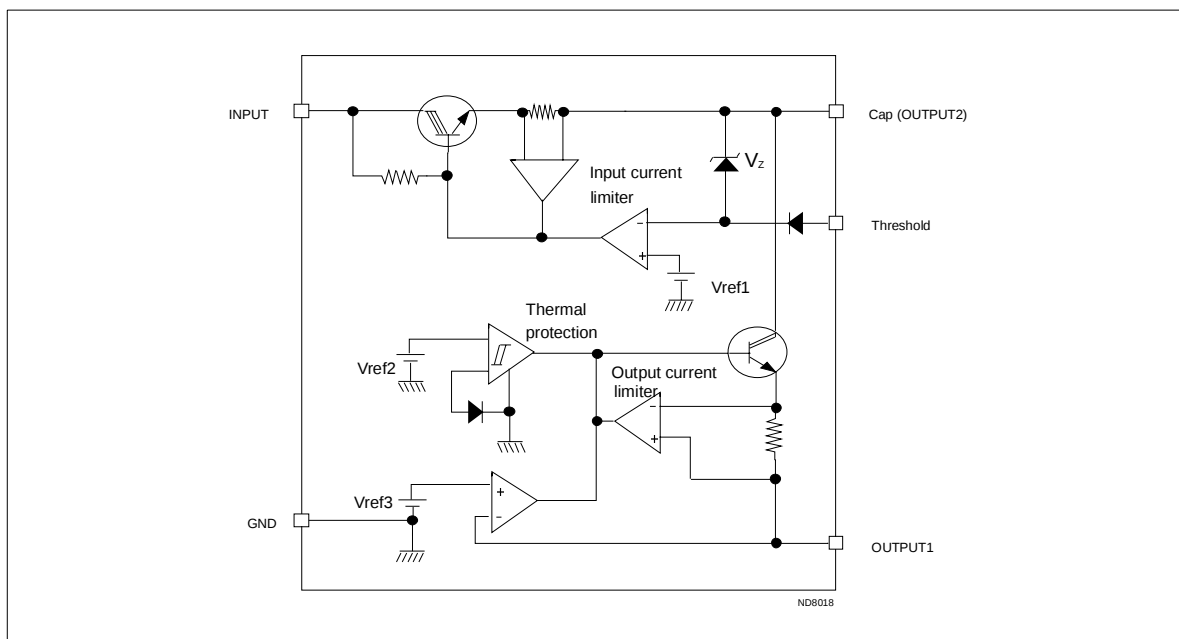
(*) Minimum value

- 5 V DC REGULATED OUTPUT1 VOLTAGE
- OUTPUT1 CURRENT LIMITED TO 80 mA
- 16V NOT REGULATED OUTPUT2 VOLTAGE
- THERMAL SHUT-DOWN PROTECTION
- INPUT OVERCURRENT PROTECTION
- POWER DISSIPATION INTERNALLY LIMITED

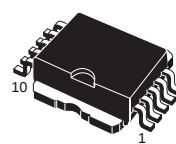
DESCRIPTION

The VB409, VB409SP, VB409(022Y) are fully protected positive voltage regulators designed in STMicroelectronics High Voltage VIPower™ M1-2 technology. The devices can be connected directly to the rectified mains. They are well suited for applications powered from the AC mains and requiring a 5V DC regulated output and/or max 16V not regulated output voltages without galvanic insulation. VB409, VB409SP,

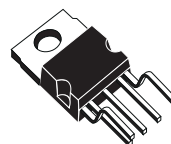
BLOCK DIAGRAM



PENTAWATT HV(022Y)



PowerSO-10™



PENTAWATT HV

ORDER CODES:

PENTAWATT HV(022Y) VB409(022Y)
PowerSO-10™ VB409SP
PENTAWATT HV VB409

VB409(022Y) provide up to 80 mA minimum output current (internally limited) at 5V. The included over current and thermal shutdown provide protections for the device.

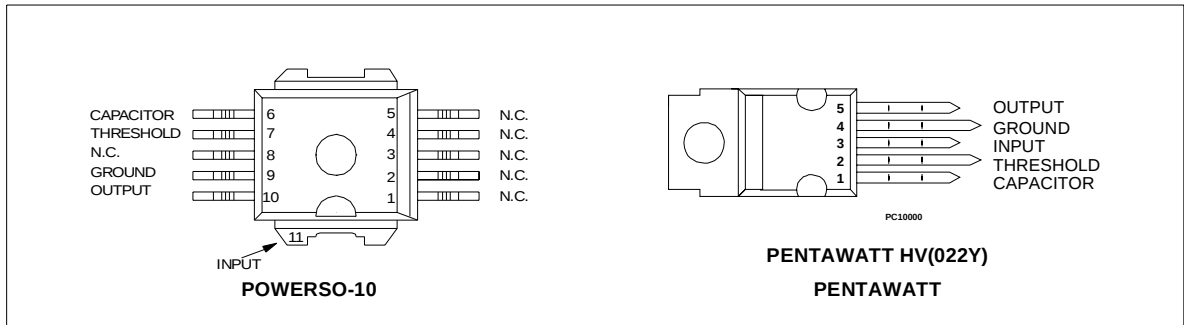
ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value	Unit
V_{IN}	Maximum input operative voltage (*)	580	V
$\Delta V_{IN,OUT}$	Input to output voltage	- 0.2 to 420	V
I_{OUT1}	Output current	Internally limited	mA
P_{TOT}	Power dissipation at $T_C=25^{\circ}\text{C}$	Internally limited	W
I_{IN}	Input current	Internally limited	A
T_j	Junction operating temperature	- 40 to 150	$^{\circ}\text{C}$
T_{STG}	Storage temperature	- 55 to 150	$^{\circ}\text{C}$

THERMAL DATA

Symbol	Parameter		Value		Unit
			PENTAWATT	POWERSO-10	Unit
$R_{thj-amb}$	Thermal resistance junction-ambient	(MAX)	60	50	$^{\circ}\text{C/W}$
$R_{thj-case}$	Thermal resistance junction-case	(MAX)	1	0.9	$^{\circ}\text{C/W}$

CONNECTION DIAGRAM (TOP VIEW)

ELECTRICAL CHARACTERISTICS ($C=100\mu\text{F}$; $-25^{\circ}\text{C}<T_j<85^{\circ}\text{C}$) (unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Minimum input voltage		12			V
BV_{IN-GND}	Breakdown voltage input-ground in off state	$I_{IN-GND}=500\mu\text{A}$; $V_{cap}=0\text{V}$; $V_{th}=13\text{V}$; $OUT=$ open	580			V
V_{OUT}	Output voltage		4.75	5	5.25	V
$\Delta V_{OUT}/\Delta V_{cap}$	Cap regulation	$V_{cap}=8$ to 12V ; $T_j=25^{\circ}\text{C}$; $I_{OUT1}=0\text{A}$			9	mV/V
$\Delta V_{OUT}/\Delta I_{OUT}$	Load regulation	$I_{OUT1}=1$ to 40mA ; $V_{cap}=10\text{V}$; $T_j=25^{\circ}\text{C}$			500	$\mu\text{V}/\text{mA}$
$I_{CL(out)}$	Output current limit	$T_j=25^{\circ}\text{C}$	80		120	mA
T_{jsh}	Junction temperature shutdown limit		140			$^{\circ}\text{C}$
ΔT_{jsh}	Junction temperature shutdown hysteresis			30		$^{\circ}\text{C}$
I_d	Quiescent current	$T_j=25^{\circ}\text{C}$			2	mA
V_d	Dropout voltage (V_{cap} to V_{OUT})	$T_j=25^{\circ}\text{C}$; $I_{OUT1}=20\text{mA}$		1.5	2.5	V
$I_{CL(in)}$	Input clamp current	$T_j=25^{\circ}\text{C}$ (See Fig. 1)	1		2	A
$\Delta V_{cap}/\Delta T$	Drift of capacitor pin voltage in temperature			-15		mV/ $^{\circ}\text{C}$

(*) The ratio $R1/R2$ (see fig. 4) must be: $R1/R2 \leq 11$ in order to not exceed the limit of the device.

ELECTRICAL CHARACTERISTICS (Continued)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{\text{cap(max)}}$	Max clamped voltage on cap pin	$T_J=25^\circ\text{C}$	15	16	17	V
V_{ref1}	Reference threshold Voltage		11	12	13	V
I_{th}	Minimum current on threshold pin to switch-off the device		30			μA

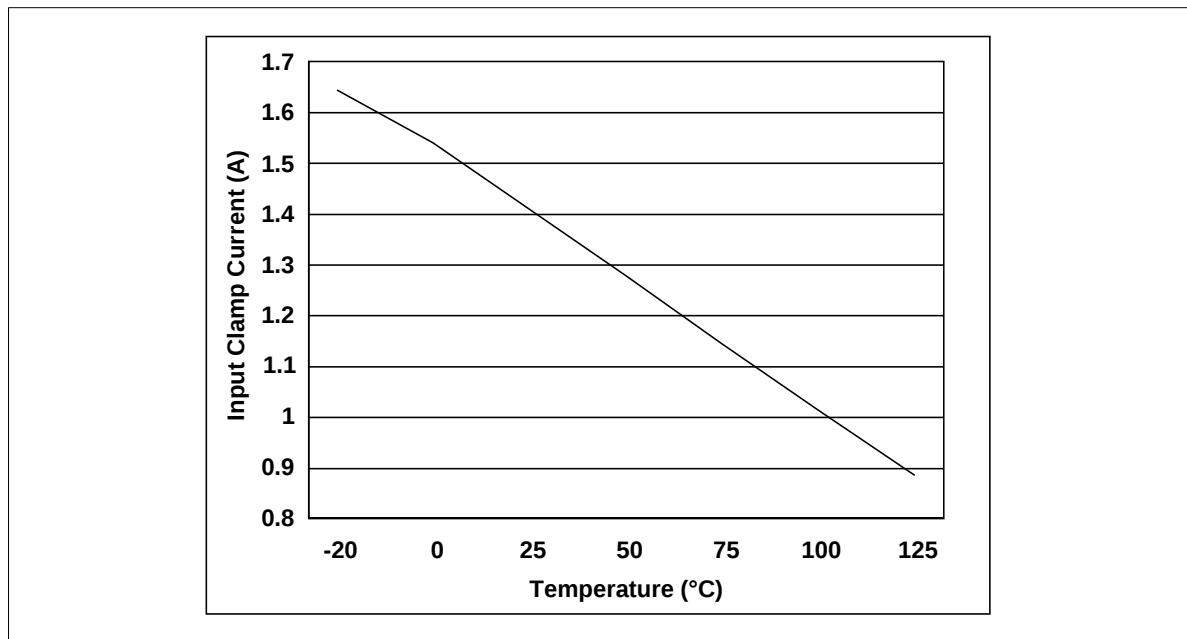
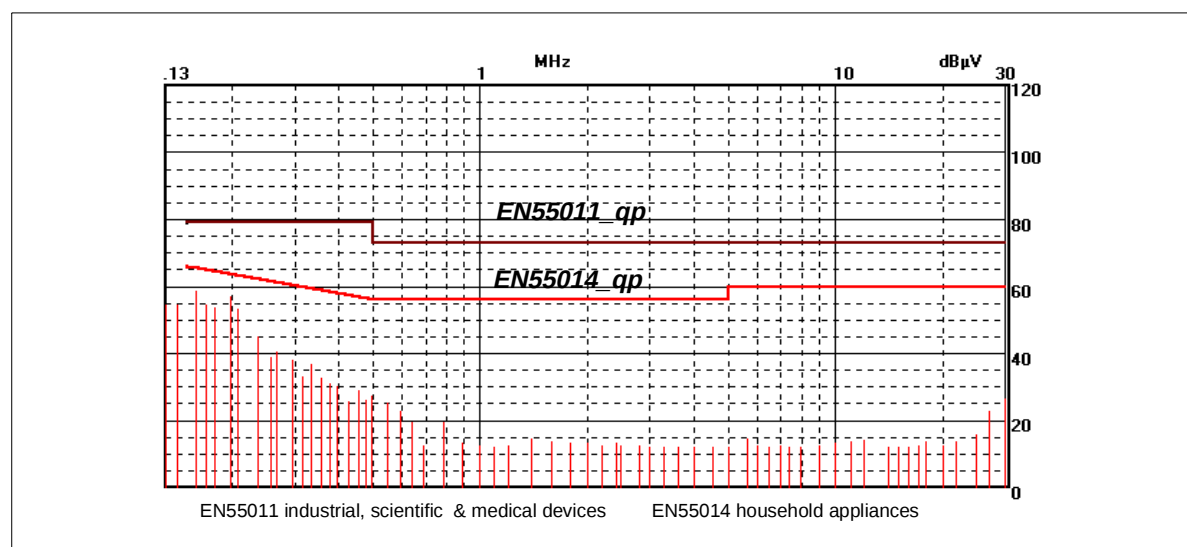
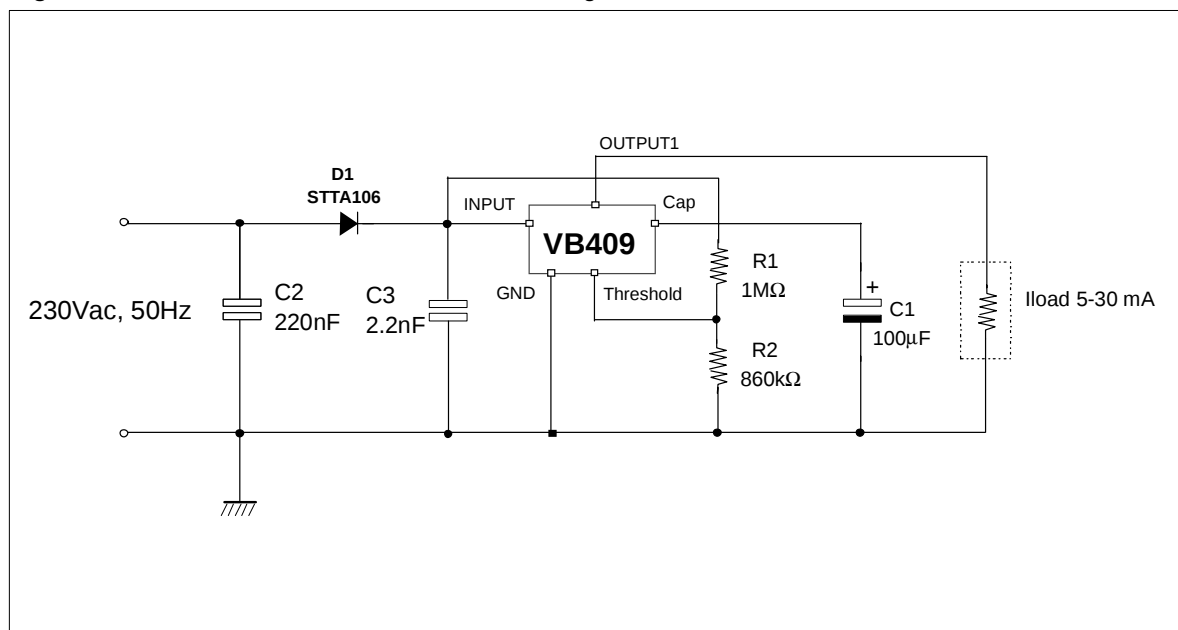
Figure 1: Input clamp current vs Temperature**Figure 2:** EMC test results

Figure 3: Electrical schematic used for EMC testing



OPERATION DESCRIPTION

The VB409, VB409(022Y), VB409SP contain two separate stages, as shown in the block diagram. The first stage is a preregulator that translates the high rectified mains voltage to a low voltage and charges an external electrolytic capacitor. The second stage is a simple 5V regulator. The typical operating waveforms are shown in Figure 5. The device may be driven by a half wave or by a full wave using a bridge rectifier. Current flowing through the regulator stage is provided by a bipolar trlinton. It conducts for a limited time ($0-t_1$; $t_2-T/2$), set by external divider (R1-R2). The values of R1 and R2 have to be chosen in order to achieve the internal threshold value at the decided Vmains voltage. When the threshold pin voltage goes over V_{ref1} , the series trlinton is switched off and remains in this state until voltage at the threshold pin again drops below the internal threshold. Using this technique, energy is drawn from the AC mains only during the low voltage portions of each positive half cycle, thus reducing the dissipation in the first stage. During the conduction angle, current provided by the trlinton is used to supply the loads and to charge the capacitor C1. In such a way, when the trlinton switches off, the loads receive the required currents by the capacitor discharge. For this reason it is important to properly set the conduction angle: during this period C1 has to reach a sufficient charge to guarantee that, at the end of discharging, the voltage drop between the capacitor and the OUTPUT1 pin is over 2.5V. Assuming that conduction angle has been set, two different possibilities can occur:

- 1) C1 value is such to reach $V_{cap(max)}$ within the conduction angle. As the comparator also senses C1 voltage, when V_{cap} goes over $V_{cap(max)}$, the trlinton would switch off. But doing so, the capacitor would discharge

through the load so reducing its voltage. As soon as V_{cap} drops below $V_{cap(max)}$, the trlinton switches on. As a consequence the trlinton reaches a stable condition limiting the current to a value sufficient to supply the loads and hold the capacitor voltage just below $V_{cap(max)}$ (see figures 5b and 5c).

- 2) C1 value is such to reach $V_{cap(max)}$ outside the conduction angle. In this case the trlinton doesn't reduce the current, but holds it to a constant value ($I_{CL(in)}$) during the whole conduction angle (see figures 6a and 6b).

Thus for each period the capacitor is charged twice. The ripple on the capacitor (OUTPUT2) depends on the following causes:

- value of the capacitor
- value of the total current supplied

Thus it is possible to reduce it choosing the proper capacitor value according to the formula:

$$C = \frac{\Delta Q}{\Delta V} = I_{tot} \cdot \frac{\Delta t}{\Delta V}$$

with $\Delta t \cong T/2$

The device has integrated current limit and thermal shutdown protections. The thermal shutdown turns the low voltage stage off (OUTPUT1=0V) if the die temperature exceeds a predetermined value. Hysteresis in the thermal sense circuit holds the device off until the die temperature cools down. Be careful that the thermal protection doesn't act on the OUTPUT2.

CONDUCTION ANGLE CHOICE

The power stage is a bipolar one; so in order to not exceed its SOA limits the ratio R1/R2 must be ≤ 11 . Further choosing R1 and R2 in such a way that the capacitor is charged to its maximum voltage value ($V_{cap(max)}$) at the end of the conduction period, the power dissipated will be minimized.

APPLICATION EXAMPLE FOR THE POWER DISSIPATION OPTIMIZATION

In case of $I_{OUT2}=\text{constant}$ the average power dissipated on the device ($\bar{P}_{\text{device}}$) can be calculated as follow:

$$\bar{P}_{\text{device}} = \bar{P}_{\text{IN}} - (I_{OUT2} \cdot \bar{V}_{OUT2}) - (I_{OUT1} \cdot V_{OUT1}) \quad (1)$$

where $\bar{P}_{\text{IN}}$ = average input power and $\bar{V}_{OUT2}$ = average OUTPUT2 voltage

Assuming that

$$I_{\text{tot}} = I_{OUT1} + I_{OUT2} \quad (2)$$

it is possible to use the below table data to evaluate through the formula (1) the minimum average power dissipation on the device.

Table 1 (with $R1=1M\Omega$)

	$V_{OUT2(\text{max})}$ (V)	$V_{OUT2(\text{min})}$ (V)	$\bar{V}_{OUT2}$ (V)	I_{tot} (mA)	$R2$ (K Ω)	$\bar{P}_{\text{IN}}$ (W)
$C=220\mu\text{F}$	14.9	12.8	13.8	40	470	1.7
	14.5	12.7	13.5	35	560	1.3
	15	15.5	14.2	30	560	1.1
$C=100\mu\text{F}$	15.4	12.2	13.7	25	1000	0.8
	15.4	12.9	14.1	20	1000	0.7
	15.5	13.6	14.5	15	1000	0.5
$C=47\mu\text{F}$	15.8	13.3	14.5	10	1000	0.3
	15.8	13.4	15.1	5	1000	0.2

APPLICATION EXAMPLE:

Assuming that:

$C=100\mu\text{F}$; $I_{OUT1}=15\text{mA}$ and $I_{OUT2}=10\text{mA}$, according to the formula (2), then $I_{\text{tot}}=25\text{mA}$

With these values, the Table 1 reports: $R1=R2=1M\Omega$; $\bar{V}_{OUT2}=13.7\text{V}$.

Using formula (1) the minimum average power dissipation is:

$$\bar{P}_{\text{device}} = 0.8 - (10 \cdot 13.7) \cdot 10^{-3} - (15 \cdot 5) \cdot 10^{-3} \cong 0.6\text{W}$$

Figure 4: Application scheme

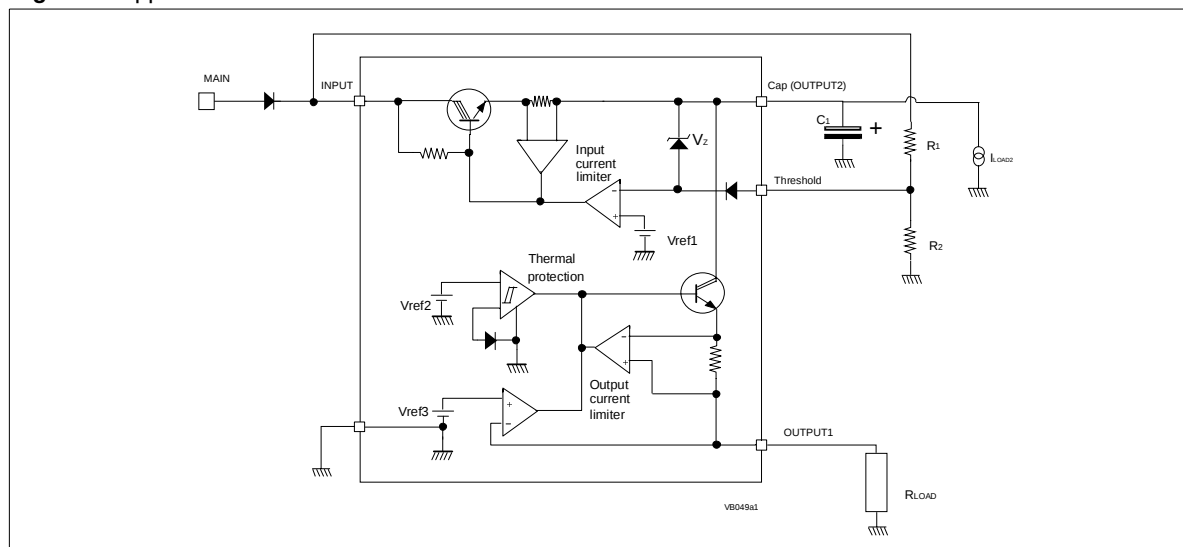
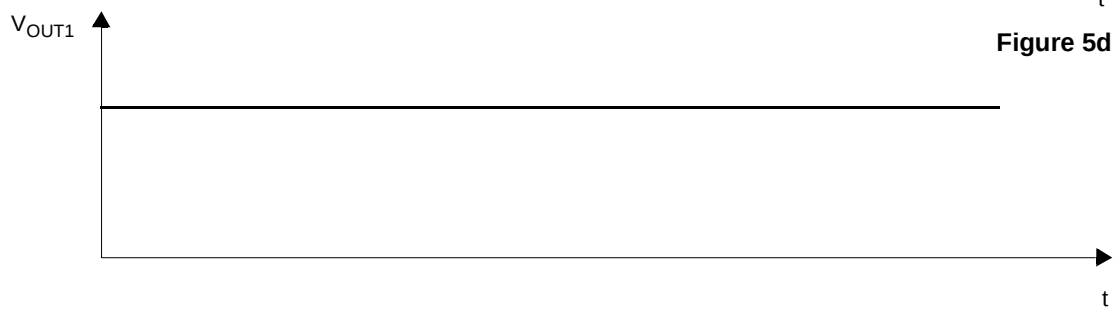
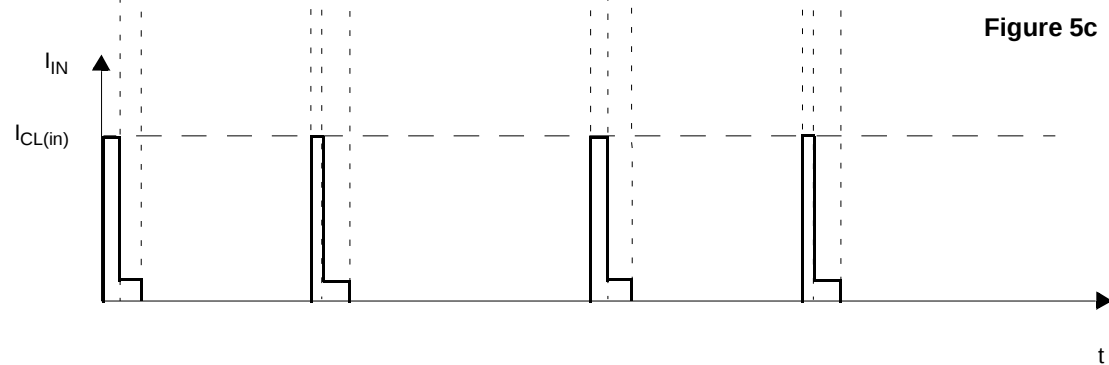
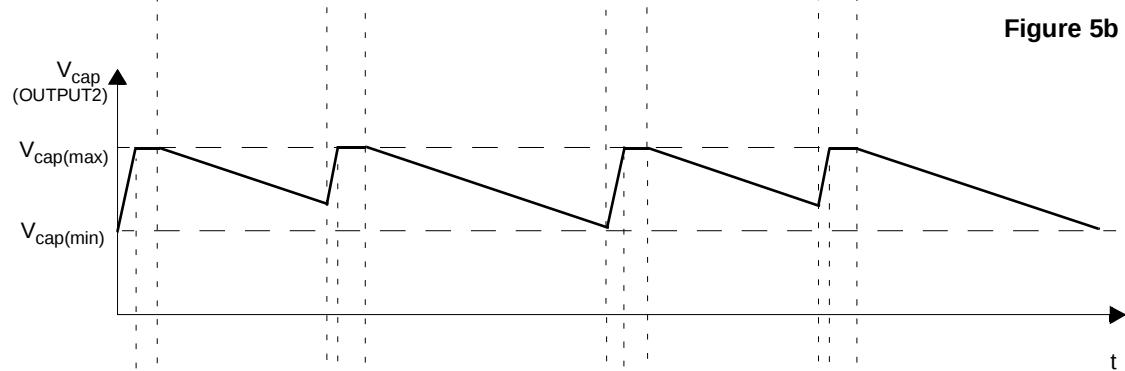
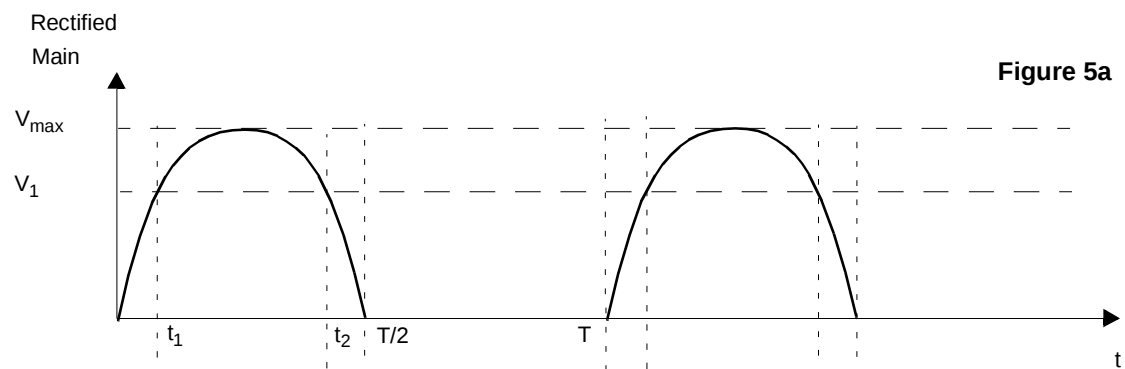
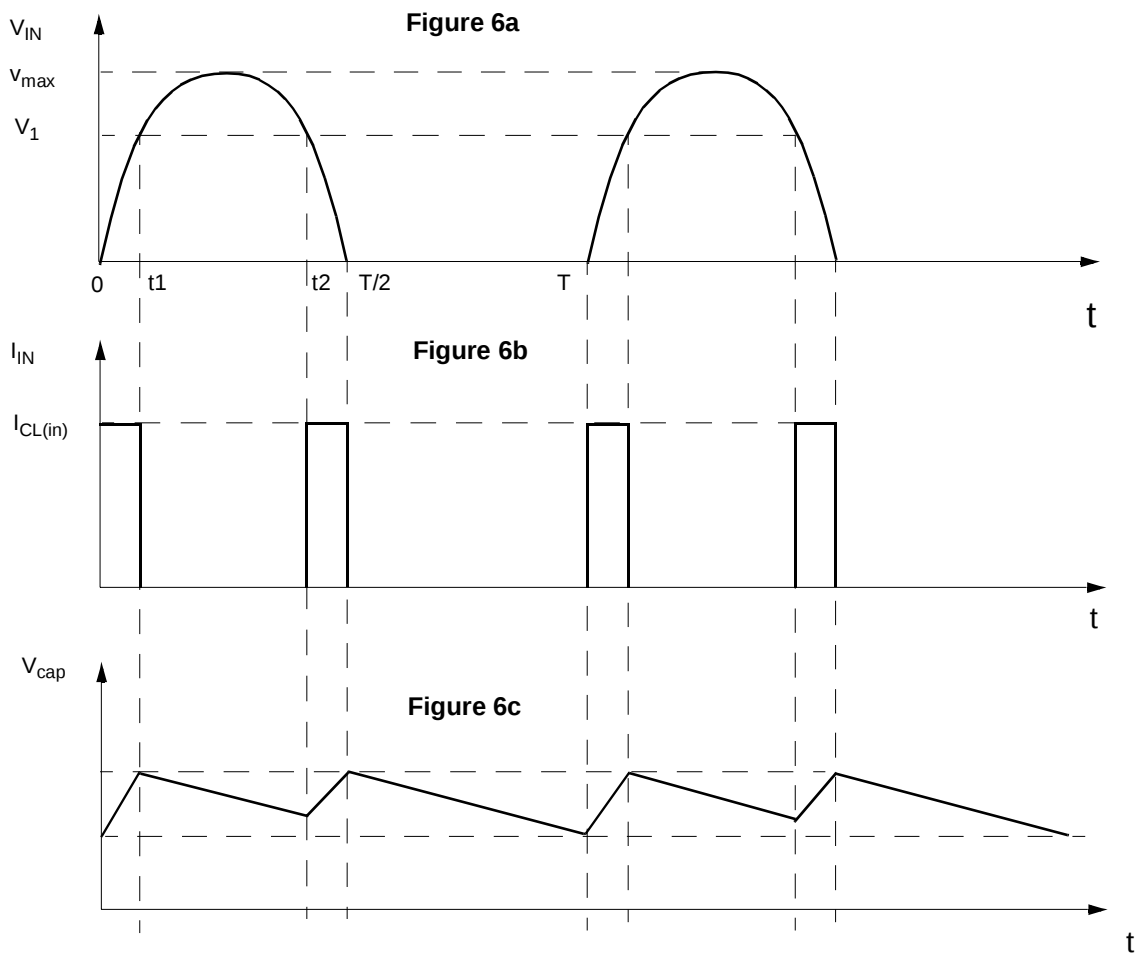


Figure 5: typical waveforms

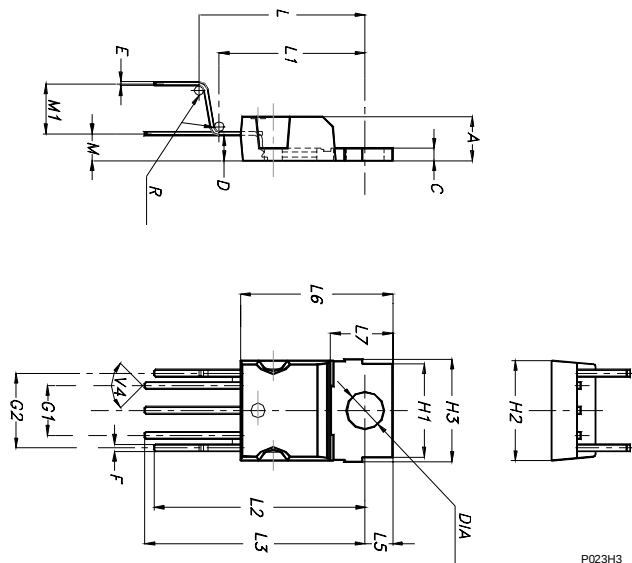
As before explained, the device also senses the preregulator voltage (V_{cap}), so that as soon as the capacitor reaches its maximum voltage, the trilinton reduces the current so limiting furtherly

power dissipation. On the contrary if the capacitor doesn't reach the maximum value, the trilinton supplies current at a steady value (I_{max}) during the whole conduction angle:



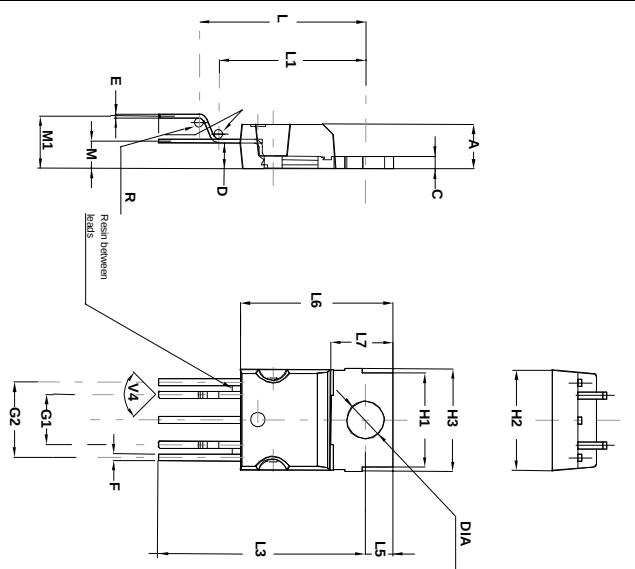
PENTAWATT HV MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.30		4.80	0.169		0.189
C	1.17		1.37	0.046		0.054
D	2.40		2.80	0.094		0.11
E	0.35		0.55	0.014		0.022
F	0.60		0.80	0.024		0.031
G1	4.91		5.21	0.193		0.205
G2	7.49		7.80	0.295		0.307
H1	9.30		9.70	0.366		0.382
H2			10.40			0.409
H3		10.05	10.40		0.396	0.409
L	15.60		17.30	6.14		0.681
L1	14.60		15.22	0.575		0.599
L2	21.20		21.85	0.835		0.860
L3	22.20		22.82	0.874		0.898
L5	2.60		3	0.102		0.118
L6	15.10		15.80	0.594		0.622
L7	6		6.60	0.236		0.260
M	2.50		3.10	0.098		0.122
M1	4.50		5.60	0.177		0.220
R	0.50			0.02		
V4	90° (typ)					
Diam	3.65		3.85	0.144		0.152



PENTAWATT HV 022Y (VERTICAL HIGH PITCH) MECHANICAL DATA

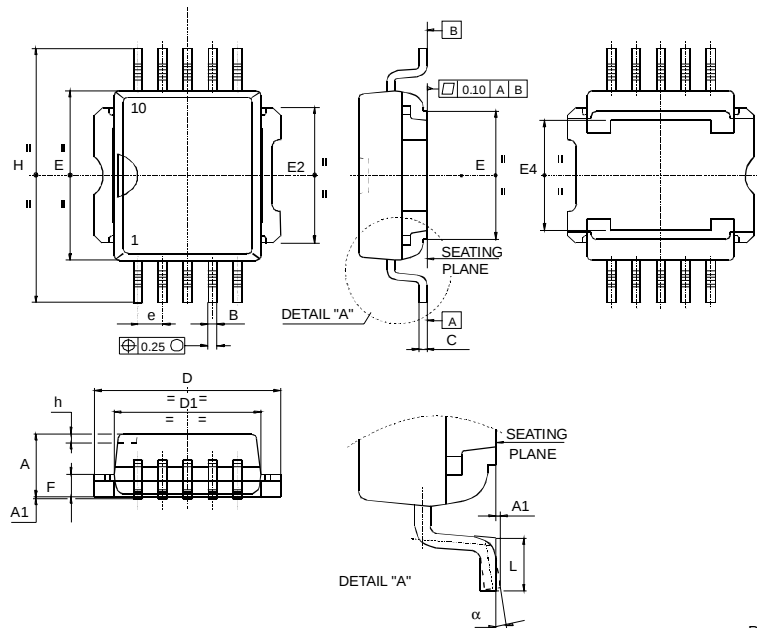
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.30		4.80	0.169		0.189
C	1.17		1.37	0.046		0.054
D	2.40		2.80	0.094		0.110
E	0.35		0.55	0.014		0.022
F	0.60		0.80	0.024		0.031
G1	4.91		5.21	0.193		0.205
G2	7.49		7.80	0.295		0.307
H1	9.30		9.70	0.366		0.382
H2			10.40			0.409
H3	10.05		10.40	0.396		0.409
L	16.42		17.42	0.646		0.686
L1	14.60		15.22	0.575		0.599
L3	20.52		21.52	0.808		0.847
L5	2.60		3.00	0.102		0.118
L6	15.10		15.80	0.594		0.622
L7	6.00		6.60	0.236		0.260
M	2.50		3.10	0.098		0.122
M1	5.00		5.70	0.197		0.224
R		0.50			0.020	
V4		90°			90°	
Diam.	3.70		3.90	0.146		0.154



PowerSO-10™ MECHANICAL DATA

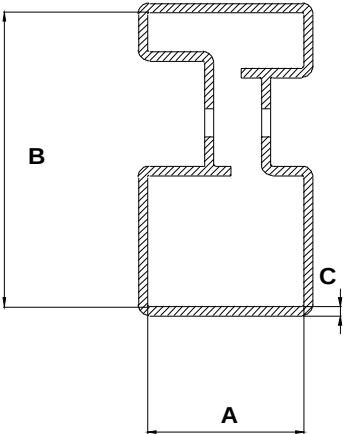
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	3.35		3.65	0.132		0.144
A (*)	3.4		3.6	0.134		0.142
A1	0.00		0.10	0.000		0.004
B	0.40		0.60	0.016		0.024
B (*)	0.37		0.53	0.014		0.021
C	0.35		0.55	0.013		0.022
C (*)	0.23		0.32	0.009		0.0126
D	9.40		9.60	0.370		0.378
D1	7.40		7.60	0.291		0.300
E	9.30		9.50	0.366		0.374
E2	7.20		7.60	0.283		300
E2 (*)	7.30		7.50	0.287		0.295
E4	5.90		6.10	0.232		0.240
E4 (*)	5.90		6.30	0.232		0.248
e		1.27			0.050	
F	1.25		1.35	0.049		0.053
F (*)	1.20		1.40	0.047		0.055
H	13.80		14.40	0.543		0.567
H (*)	13.85		14.35	0.545		0.565
h		0.50			0.002	
L	1.20		1.80	0.047		0.070
L (*)	0.80		1.10	0.031		0.043
α	0°		8°	0°		8°
α (*)	2°		8°	2°		8°

(*) Muar only POA P013P



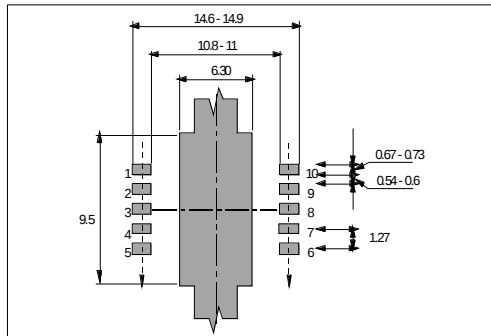
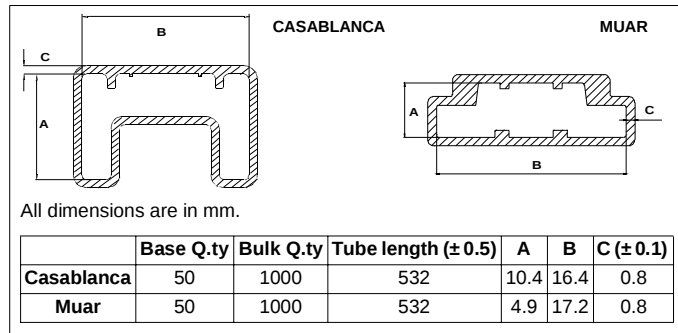
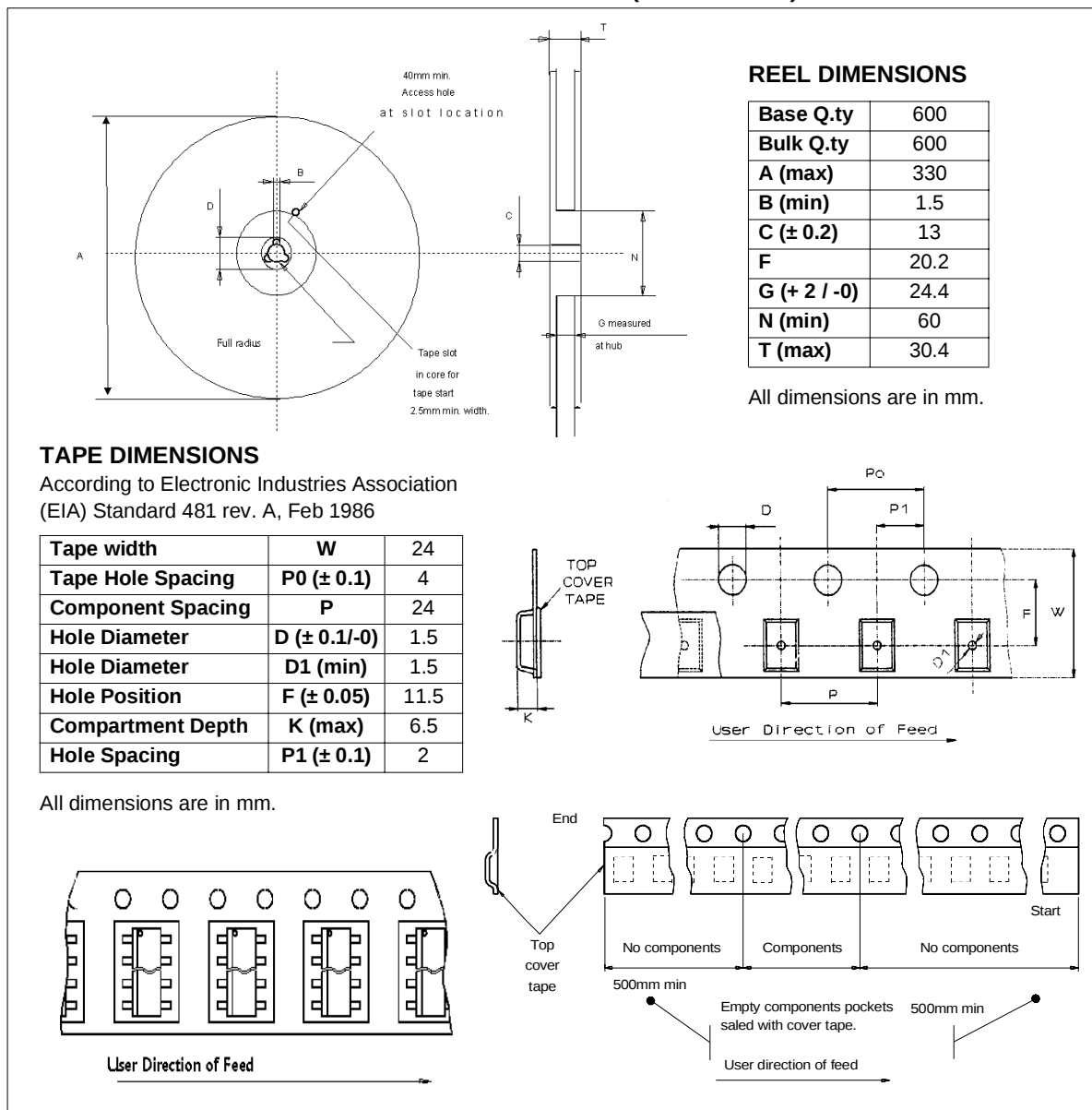
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PENTAWATT HV TUBE SHIPMENT (no suffix)



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.

PowerSO-10™ SUGGESTED PAD LAYOUT**TUBE SHIPMENT (no suffix)****TAPE AND REEL SHIPMENT (suffix "13TR")**

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