

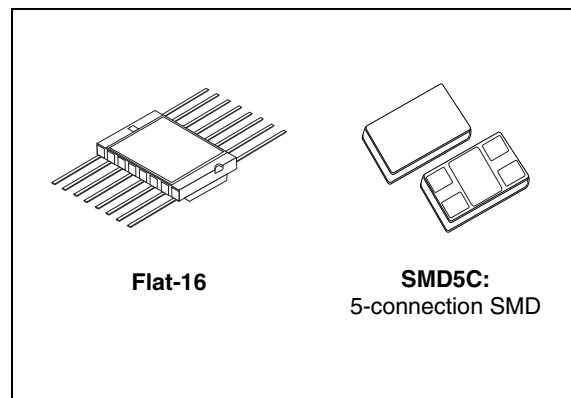
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**Rad-Hard adjustable negative voltage regulator**

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**Features**

- 3 A low dropout voltage
- Optional overtemperature and overcurrent protection
- Adjustable overcurrent limitation
- Load short circuit monitoring
- Adjustable output voltage
- Inhibit (ON/OFF) TTL-compatible control
- Programmable output short-circuit current limitation
- Remote sensing operation
- Rad-Hard: sustains 300 krad in Mil-1019.6 at High & ELDRS low dose rate conditions
- Heavy ions, SEL and SEU immune; able to Sustain  $2 \times 10^{14}$  protons/cm<sup>2</sup> and  $5 \times 10^{14}$  neutrons/cm<sup>2</sup>

**Description**

The RHFL7913 adjustable is a high performance Rad Hard negative voltage regulator. Available in Flat-16 and new SMD5C hermetic ceramic packages, it is specifically intended for space and harsh radiation environments. It provides exceptional electrical performances, high speed and low dropout voltage.

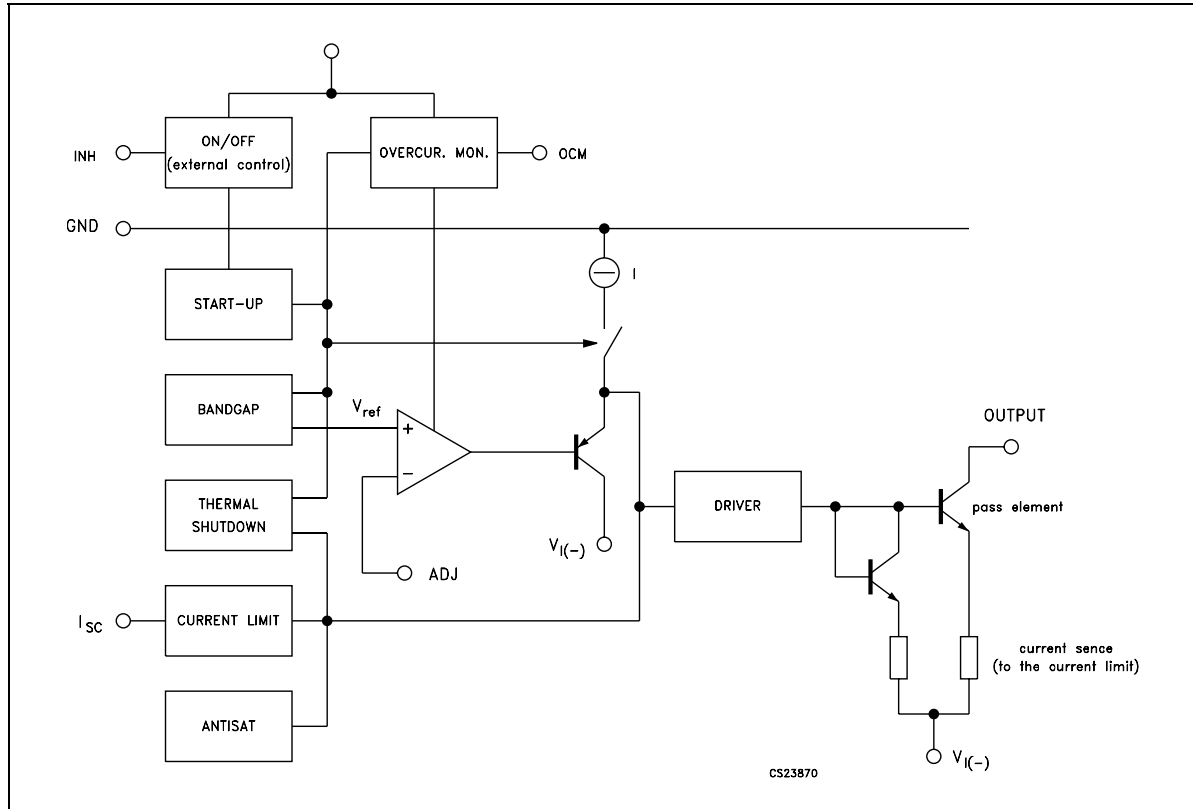
Input supply ranges from -3 V to -12 V. It also provide logical control / monitor functions (inhibit, output monitor, short-circuit control) from/to external positive voltage signals, while the entire RHFL7913 adjustable analog functions are biased at negative voltages with respect of ground pin. The device is QML-V qualified with SMD 5962-02532.

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# 1 Diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin configuration (top view for Flat-16, bottom view for SMD5C)

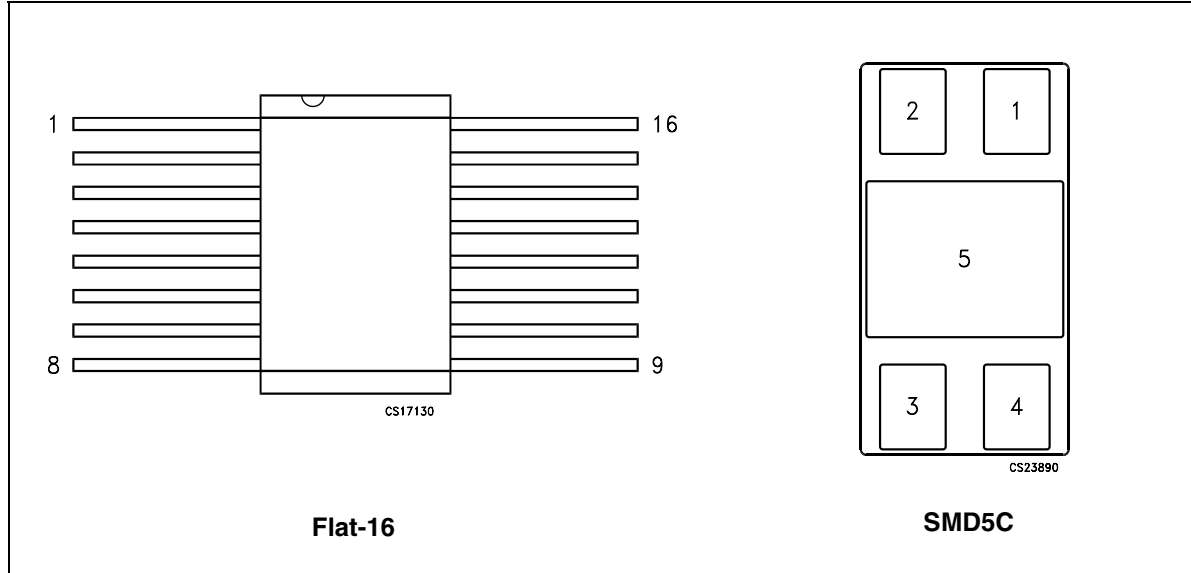


Table 1. Pin description

Pin n°	Flat-16	SMD5C
DSCC Part Ident.	TBD	TBD
1	$V_I$ , Negative Input	TBD
2	$V_I$ , Negative Input	TBD
3	$V_I$ , Negative Input	TBD
4	$I_{SC}$	TBD
5	OCM	TBD
6	$V_{PLUS}$ , Positive Supply	
7	GND	
8	N.C.	
9	N.C.	
10	$I_{NHIBIT}$	
11	ADJ	
12	N.C.	
13	$V_O$ , Negative Output	
14	$V_O$ , Negative Output	
15	$V_O$ , Negative Output	
16	$I_{NHIBIT}$	

### 3 Maximum ratings

**Table 2. Maximum operating ratings (see [Note](#)):**

Symbol	Parameter	Value	Unit	
$V_I$	DC input voltage $ V_{IN} - V_{PLUS} $	-12	V	
$V_{PLUS}$	Logical block supply voltage $V(+)-V(GND)$ , unless grounded	+5		
$V_I$	DC voltage, $V_{IN-GND}$ , $V_{PLUS}=0V$	-12		
$V_I$	DC voltage, $V_{IN-GND}$ , $V_{PLUS}=+3V$	-9		
$V_O$	DC output voltage range	-9 to -1.20		
$I_{OUT}$	Output current	RHFL7913KPA	2	A
		RHFL7913SCA	3	
$P_D$	TC = 25 °C power dissipation	RHFL7913KPA	15	W
		RHFL7913SCA	15	
$T_{STG}$	Storage temperature range	-65 to +150	°C	
$T_{OP}$	Operating junction temperature range	-55 to +150		
ESD	Electrostatic discharge capability	Class 3		

*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
$R_{thJC}$	Thermal resistance junction-case, Flat-16 and SMD5C	8.3	°C/W
$T_{SOLD}$	Maximum soldering temperature, 10 sec.	300	°C

**Table 4. Recommended operating conditions**

Symbol	Parameter	Value	Unit	
$V_I$	Input voltage range $V_I$ (at $V_{PLUS}=0V$ )	-12 to -3.7	V	
$V_{PLUS}$	Positive supply range	0 to +3	V	
$V_O$	Output voltage range	$V_{PLUS}=0V, V_I=-12$ to -3.7V	-9.5 to -1.2	V
		$V_{PLUS}=+3V, V_I=-9$ to -3.7V	-6.5 to -1.2	V
$T_A$	Ambient operating temperature range	-55 to +125	°C	

## 4 Electrical characteristics

**Table 5. Electrical characteristics**

 ( $T_J = 25^\circ\text{C}$ ,  $V_I = V_O + 2.5\text{ V}$ ,  $C_I = C_O = 1\ \mu\text{F}$ , unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_I$	Operating input voltage	$I_O = 1\text{ A (KPA) or } 2\text{ A (SCA)}$	-12		-3.7	V
$V_O$	Operating output voltage	$I_O = 1\text{ A}, V_O = -1.2\text{V, FLAT } 16$	-1.28		-1.16	V
		$I_O = 1\text{ A}, V_O = -9\text{V, FLAT } 16$	-9.6		-8.7	
		$I_O = 2\text{ A}, V_O = -1.2\text{V, SMD5C}$	-1.28		-1.16	
		$I_O = 2\text{ A}, V_O = -9\text{V, SMD5C}$	-9.6		-8.7	
$\Delta V_O / \Delta V_I$	Line regulation	$V_I = V_O - 2.5\text{V to } -12\text{V}, I_O = 5\text{mA}, T_J = 25^\circ\text{C}$			0.2	
		$V_I = V_O - 2.5\text{V to } -12\text{V}, I_O = 5\text{mA}, T_J = -55^\circ\text{C and } +125^\circ\text{C}$			0.5	
$\Delta V_O / V_O$	Load regulation	$V_I = V_O - 2.5\text{V}, I_O = 5\text{mA to } 400\text{mA}, T_J = 25^\circ\text{C}$			0.4	%
		$V_I = V_O - 2.5\text{V}, I_O = 5\text{mA to } 400\text{mA}, T_J = -55^\circ\text{C and } +125^\circ\text{C}$			0.5	
		$V_I = V_O - 2.5\text{V}, I_O = -5\text{mA to } 1\text{A}, T_J = 25^\circ\text{C}$			0.5	
		$V_I = V_O - 2.5\text{V}, I_O = 5\text{mA to } 1\text{A}, T_J = -55^\circ\text{C and } +125^\circ\text{C}$			0.6	
$I_Q$	Quiescent current ON MODE	$I_O = 5\text{mA}, V_I = V_O - 2.5\text{V}, T_J = 25^\circ\text{C}$	-3			mA
		$I_O = -30\text{mA}, V_I = V_O - 2.5\text{V}, T_J = 25^\circ\text{C}$	-6			
		$I_O = 300\text{mA}, V_I = V_O - 2.5\text{V}, T_J = 25^\circ\text{C and } +125^\circ\text{C}$	-15			
		$I_O = 300\text{mA}, V_I = V_O - 2.5\text{V}, T_J = -55^\circ\text{C}$	-20			
		$I_O = 1\text{ A}, V_I = V_O - 2.5\text{V}, T_J = 25^\circ\text{C and } +125^\circ\text{C}$	-30			
		$I_O = 1\text{ A}, V_I = V_O - 2.5\text{V}, T_J = -55^\circ\text{C}$	-50			
		$I_O = 2\text{ A}, V_I = V_O - 2.5\text{V}, V_{INH} = 0, T_J = +25^\circ\text{C and } +125^\circ\text{C}$ Only for SMD5C	TBD			
		$I_O = 2\text{ A}, V_I = V_O - 2.5\text{V}, V_{INH} = 0, T_J = -55^\circ\text{C}$ Only for SMD5C,	TBD			
$I_Q$	Quiescent current OFF MODE	$V_O = -1.2\text{V}, V_I = -7\text{V}, V_{PLUS} = +5\text{V}, V_{INH} > 2.3\text{V}, T_J = -55^\circ\text{C to } +125^\circ\text{C}$			1	mA

**Table 5. Electrical characteristics (continued)**  
 ( $T_J = 25\text{ }^\circ\text{C}$ ,  $V_I = V_O + 2.5\text{ V}$ ,  $C_I = C_O = 1\text{ }\mu\text{F}$ , unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_D$	Dropout voltage	$I_O = 400\text{mA}$ $V_O = -2.5\text{V to } -9\text{V}$ , $T_J = 25^\circ\text{C}$	-450			mV
		$I_O = 400\text{mA}$ $V_O = -2.5\text{V to } -9\text{V}$ , $T_J = -55^\circ\text{C and } +125^\circ\text{C}$	-500			
		$I_O = 1\text{A}$ $V_O = -2.5\text{V to } -9\text{V}$ , $T_J = 25^\circ\text{C}$	-750			
		$I_O = 1\text{A}$ $V_O = -2.5\text{V to } -9\text{V}$ , $T_J = -55^\circ\text{C and } +125^\circ\text{C}$	-800			
$I_{PLUS}^{(1)}$	$V_{PLUS}$ Current	$V_I = -5.5\text{V}$ , $V_{PLUS} = 5\text{V}$ , $V_{INH} = 5\text{V}$ , $T_J = 25^\circ\text{C}$			0.75	mA
		$V_I = -5.5\text{V}$ , $V_{PLUS} = +5\text{V}$ , $V_{INH} = 5\text{V}$ $T_J = -55^\circ\text{C and } +125^\circ\text{C}$			1	
$SVR^{(1)}$	Supply voltage rejection	$V_I = V_O - 2.5\text{V}$ , $I_O = 5\text{mA}$ , $F = 120\text{Hz}$	60			dB
		$V_I = V_O - 2.5\text{V}$ , $I_O = 5\text{mA}$ , $F = 33\text{kHz}$	20			
$t_{PLH}^{(1)}$	Inhibit propagation delay	$V_{INH} < 0.8\text{V}$ , $V_{PLUS} = 5\text{V}$ , $V_I = V_O - 2.5\text{V}$ $I_O = 400\text{mA}$			20	$\mu\text{s}$
$t_{PHL}^{(1)}$	Inhibit propagation delay	$V_{INH} > 2.3\text{V}$ , $V_{PLUS} = 5\text{V}$ , $V_I = V_O - 2.5\text{V}$ $I_O = 400\text{mA}$			100	
$V_{INH(ON)}$	Inhibit voltage	$V_I = -7\text{V}$ $V_{PLUS} = +5\text{V}$ $I_O = 5\text{mA}$ $T_J = -55^\circ\text{C to } 125^\circ\text{C}$			0.8	V
$V_{INH(OFF)}$			2.3			
$I_{SH}$	Shutdown input current	$V_{INH} = 5\text{V}$		15		$\mu\text{A}$
$V_{OCM}$	OCM pin voltage	Sinked $I_{OCM} = 10\text{mA}$ , active low		0.38		V
en	Output noise voltage	$f = 10\text{Hz to } 100\text{kHz}$ $I_O = 5\text{mA to } 2\text{A}$		40		$\mu\text{Vrms}$

1. These values are guaranteed by design. For each application it's strongly recommended to comply with the maximum current limit of the package used.

## 5 Device description

The RHFL7913 adjustable contains a NPN-type power element controlled by signal resulting from amplified comparison between internal temperature compensated band-gap cell and the fraction of the desired output voltage value, generated by an external resistor divider bridge. The NPN structure allows access to lower drop out levels because its base current can be routed to ground pin and not to output. To control and monitor the device from / to the external logic world – usually operating in positive voltage area – a dedicated logic interface block (INHIBIT and OCM functions) has been implemented with +3 V to +5 V supplied line (V+). In case V(+) = 0 V, inhibit and OCM functions are not available: In this condition, INHIBIT function is ON and OCM pin is “no care”. The device is internally protected by several blocks.

### 5.1 ADJ pin

The load voltage feed back comes from an external divider resistor bridge middle point to ADJ pin established between load terminals.

### 5.2 Inhibit ON-OFF control

When INHIBIT pin is TTL-high (positive), the device switches off current and voltage output. The device is ON when INHIBIT pin is set TTL-low.

### 5.3 Overtemperature protection

A temperature detector internally monitors power element junction temperature. The device goes OFF circa 165 °-175 °C are reached, and returns ON when circa 100 °C. When internal temperature detector reaches 170 °C, the active power element can be at 225 °C: Device reliability cannot be granted during extensive operation duration with these conditions.

### 5.4 Overcurrent protection

I<sub>SC</sub> pin. An internal non-fold back short-circuit limitation is set with I<sub>SHORT</sub> > 4 A (V<sub>O</sub> is 0 V). This value can be downward modified by an external resistor connected between I<sub>SC</sub> and V<sub>I</sub> pins, with a typical value range of 10 kΩ to 200 kΩ. To keep excellent V<sub>O</sub> regulation, it is necessary to set I<sub>SHORT</sub> 1.6 times greater than the maximum desired application I<sub>O</sub>. When I<sub>O</sub> reaches I<sub>SHORT</sub> – 300 mA, the current limiter overrules regulation and V<sub>O</sub> starts to drop and OCM flag is risen. When no current limitation adjustment is required, I<sub>SC</sub> pin shall be left unbiased (as it is in 3 pin packages).

### 5.5 OCM pin

Goes low when current limiter starts to be active, otherwise V<sub>OCM</sub> = V (+). It is bufferized and can sink 10 mA. OCM pin is internally pulled-up by a 50 kΩ resistor. Can left open when V (+) = 0.



## 5.6 Alternates to

RHFL7913 is recommended to replace all industry negative regulators due to its exceptional radiation performances. To replace 3-terminal industry devices, use customized RHFL7913 fixed voltage versions.

## 6 Application information

Adjusting output voltage: R1 resistor must be connected between  $V_O$  and ADJ pins. R2 resistor must be connected between ADJ and GND pins. Resistor values can be derived from the following formula:

$$V_O = V_{ADJ} (1 + R1/R2) \text{ with } V_{ADJ} = -1.20 \text{ V}$$

To access all RHFL7913 adjustable functionality,  $V (+)$  shall be set at 3.0 V (max 5 V). As a consequence,  $V_I (-)$  cannot be greater than -9.0 V (resp. -7 V) due to -12 V maximum operation rating.

The device is functional as soon as  $V_I - V_O$  voltage difference is slightly above power element saturation voltage. The adjustable pin to Ground resistor shall not be greater than 10 k $\Omega$  to make output feedback error be below 0.2%. A minimum 0.5 mA  $I_O$  is necessary to set to ensure perfect "no-load" regulation. It can be wise to dissipate this current into the divider bridge resistor.

All available  $V_I$  pins shall always be PCB interconnected, the same for all available  $V_O$  pins, otherwise device stability and reliability cannot be granted. The INHIBIT function switches off output current in an electronic way, is very quickly. According to Lenz' Law, external circuitry reacts with  $-Ldi/dt$  terms which can be of high amplitude in case some series-inductance exists. Effect would be large transient voltage developed on both device terminals. External Schottky diodes may prevent voltage excursions beyond max ratings. In the worst case, a 14 V Zener diode shall protect the device input. In case of inductive load, a input-output protection diode can be necessary to prevent  $V_O$  to be greater than  $V_I$  during transient operation.

The device has been designed for high stability and low drop out operation: minimum 1  $\mu$ F input and output tantalum capacitors are therefore mandatory. Typical industry PCB design practices 10  $\mu$ F capacitors values are acceptable. Capacitor ESR range is from 0.5  $\Omega$  to over 20  $\Omega$  Such range turns out to be useful when ESR increases at low temperature. When large transient currents are expected, larger value capacitors are necessary.

In case of high current operation with expected short-circuit events, caution shall be considered relatively to capacitors. They shall be connected as close as possible from device terminals. As some tantalum capacitors may permanently fail when submitted to high charge-up surge currents, it is recommended to decouple them with 470 nF polyester capacitors.

RHFL7913 adjustable being manufactured with very high speed bipolar technology (6 GHz  $f_T$  transistors), the PCB layout shall be performed with unprecedented care, very low inductance, low mutually coupling lines, otherwise high frequency parasitic signals may be picked-up by the Device resulting into system self-oscillation. In difficult high current circumstances (coming from PCB layout) a 470 nF polyester capacitor connected between  $V_O$  and ADJ pin increases stability margins. Benefit is SVR performances extended to far higher frequencies.

## 6.1 Remote sensing operation

When load is physically far away from device output, the adjustable line can be set as a kelvin sense line by implementing the divider resistor bridge as close as possible from device, with a decoupling capacitor. The adjust pin kelvin sense line (to be not coupled with power line) picks-up load voltage (load also locally decoupled with a capacitor). This layout eliminates ohmic drop in load power wire. Similarly, by taking advantage of two separate ground terminals: power ground pin shall be directly connected to load ground terminal which is also the system ground, device signal ground shall be separately connected to load ground terminal by another kelvin line: In this way, ground ohmic errors are minimized because the only current flowing into device signal ground pin kelvin line is device  $I_q$  (a matter of a few mA).

## 7 Die information

RHFL7913 adjustable is also available in die form. Space dice are electrically tested by STMicroelectronics in such a way that, when mounted in proper thermal and electrical substrate, they are in full compliance with equivalent packaged device:

DIE physical dimensions.

DIE size: 110 mils x 166 mils

DIE thickness: 375  $\mu\text{m}$  +/-25  $\mu\text{m}$  (14.8 mils +/- 1 mil)

Pad size:

$V_I$ ,  $V_O$  pads: 245  $\mu\text{m}$  x 544  $\mu\text{m}$

Control pads: 184  $\mu\text{m}$  x 184  $\mu\text{m}$

Interface materials

Top Metallization: Al/Si/Cu 1.05  $\mu\text{m}$  +/- 0.15  $\mu\text{m}$

Backside metallization: None

Glassivation

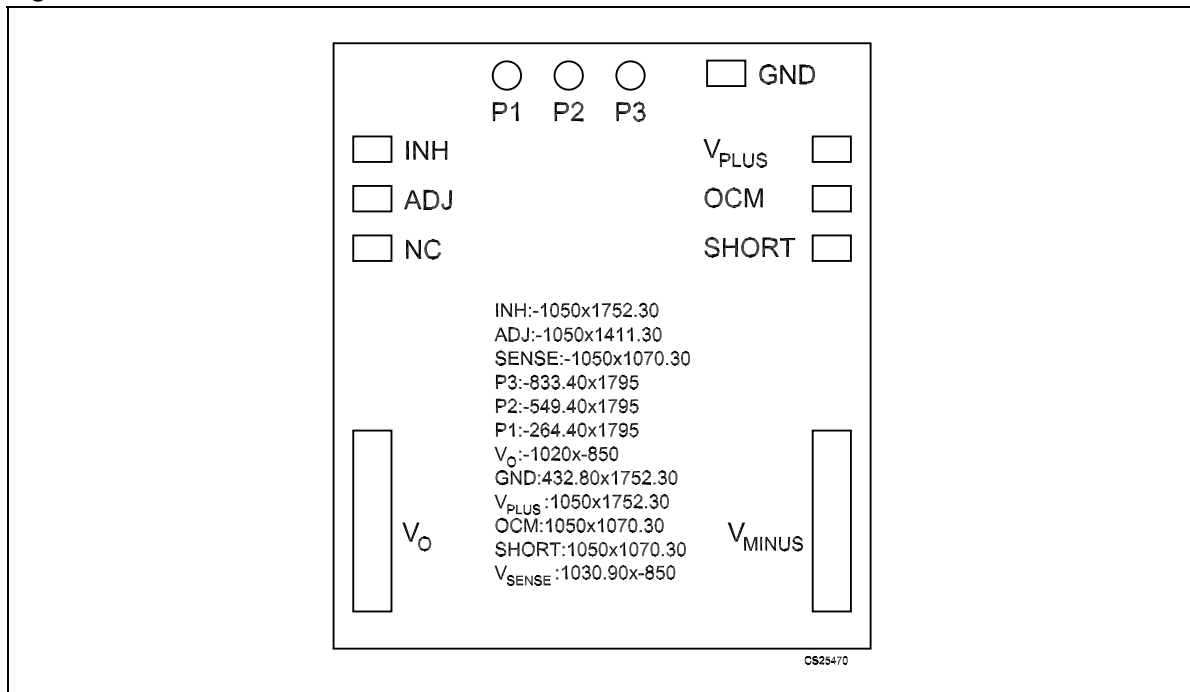
Type: P.Vapox + Nitride

Thickness: 0.6  $\mu\text{m}$  +/- 0.1  $\mu\text{m}$  + 0.6  $\mu\text{m}$  +/-0.08  $\mu\text{m}$

Substrate: Silicon (connected to  $V_I = V_{\text{minus}}$ )

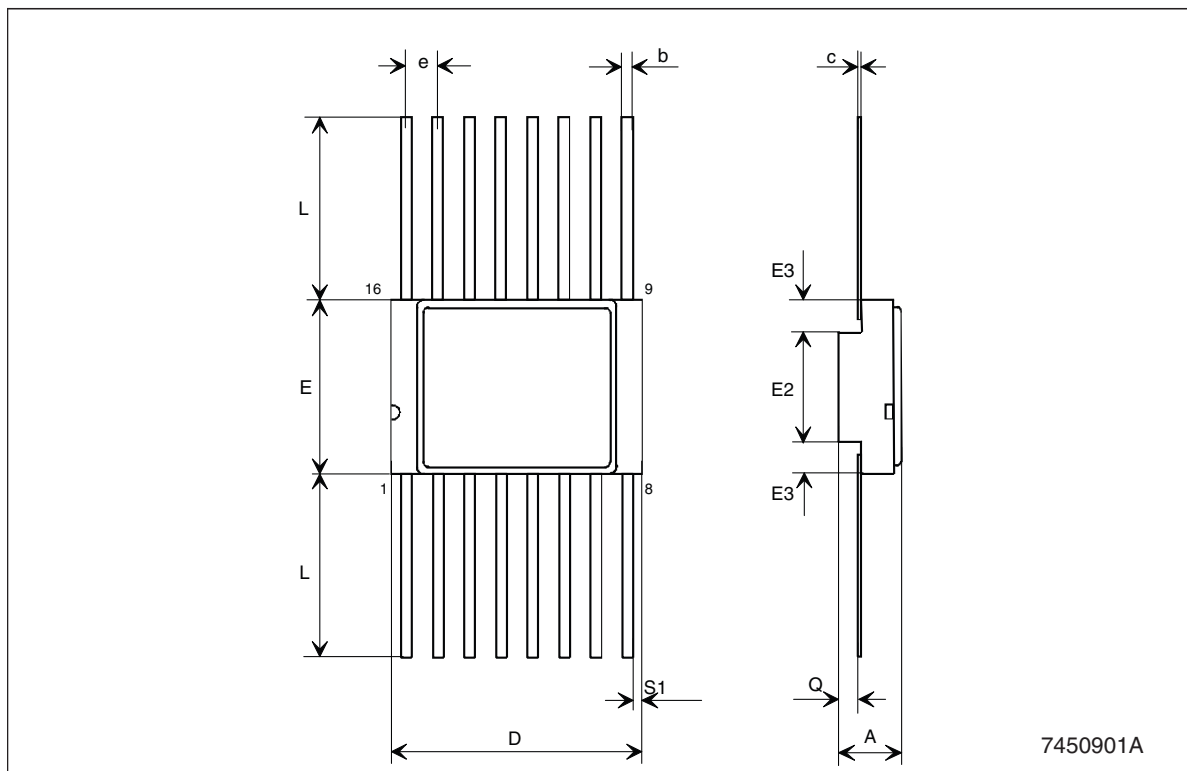
The SENSE pad is layout on the die but is not electrically connected to the IC and shall be left non-bonded during hybrid bonding.

Figure 3. DIE size



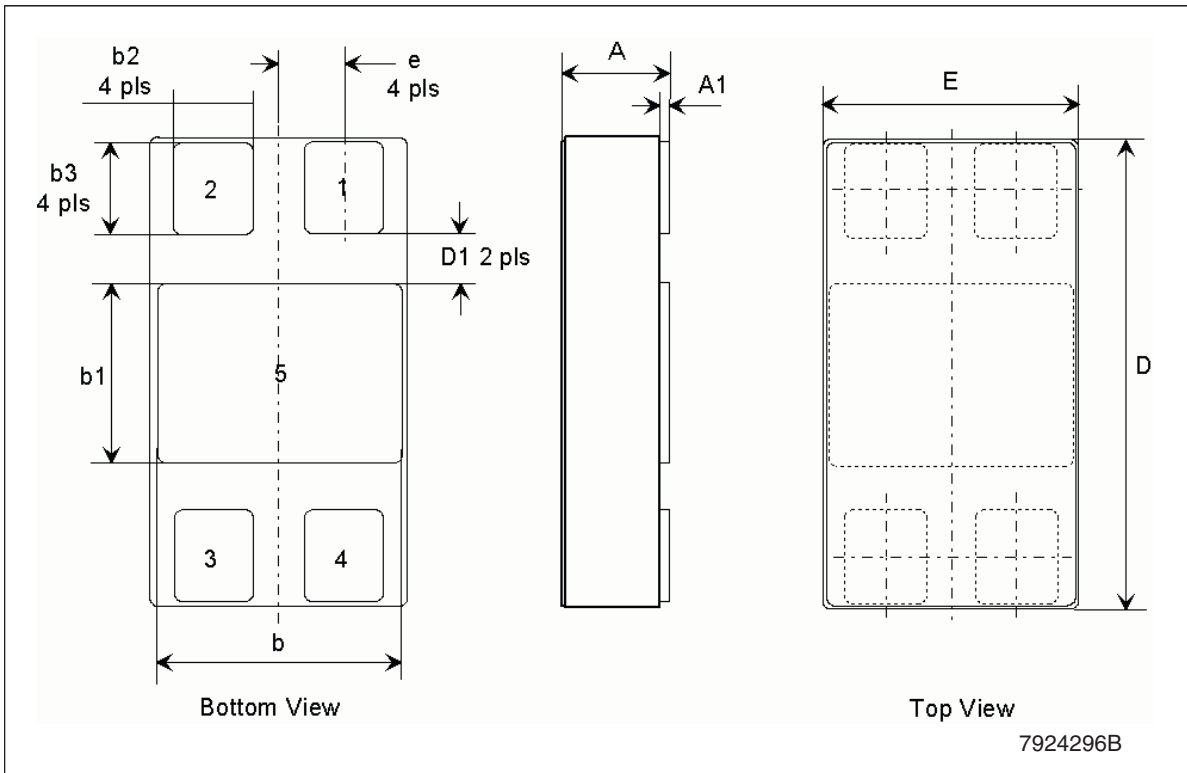
### FLAT-16 (MIL-STD-1835) mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.16		2.72	0.085		0.107
b		0.43			0.017	
c		0.13			0.005	
D		9.91			0.390	
E		6.91			0.272	
E2		4.32			0.170	
E3	0.76			0.030		
e		1.27			0.050	
L		6.72			0.265	
Q	0.66		1.14	0.026		0.045
S1	0.13			0.005		



**SMD5C mechanical data**

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.84	3.00	3.15	0.112	0.118	0.124
A1	0.25	0.38	0.51	0.010	0.015	0.020
b	7.13	7.26	7.39	0.281	0.286	0.291
b1	4.95	5.08	5.21	0.195	0.200	0.205
b2	2.28	2.41	2.54	0.090	0.095	0.100
b3	2.92	3.05	3.18	0.115	0.120	0.125
D	13.71	13.84	13.97	0.540	0.545	0.550
D1	0.76			0.030		
E	7.39	7.52	7.65	0.291	0.296	0.301
e		1.91			0.075	



## 8 Packaging

RHFL7913 adjustable is available in high thermal dissipation 16 pin hermetic Flat package, which bottom flange is metallized to allow direct soldering to heat sink (efficient thermal conductivity). It is also available in SMD5C hermetic ceramic package.

## 9 Order codes

**Table 6. Order codes**

Die	Flat-16	SMD5C	Terminal finish	Quality level
	RHFL7913KPA1		GOLD	EM1
	RHFL7913KPA2		GOLD	EM2= EM1 + 48hours BI
	RHFL7913KPA-01V		GOLD	QML-V
	RHFL7913KPA-02V		SOLDER	QML-V
		RHFL7913SCA1	GOLD	EM1
		RHFL7913SCA2	GOLD	EM2= EM1 + 48hours BI
		RHFL7913SCA-03V	GOLD	
L7913ADIE2S				EM1 die
L7913ADIE2V				QML-V

*Note:* EM1: Engineering parts, full temperature range, flight packages, no burn-in  
EM2: Same as above but with burn-in, used in Satellite EQMs

**Table 7. Part number - SMD equivalent**

ST part number	SMD part number
RHFL7913KPA-01V	5962F0253201VXC
RHFL7913KPA-02V	5962F0253201VXA
RHFL7913SCA-03V	
L7913ADIE2V	5962F0253201V9A

**Table 8. Environmental characteristics**

Parameter	Conditions	Value	Unit
Output voltage thermal drift	-55 °C to +125 °C	40	ppm/°C
Output voltage radiation drift	From 0 kRad to 300k Rad at 0.55rd/sec	8	ppm/krad
Output voltage radiation drift	From 0 kRad to 300 kRad, MIL1019.5	6	ppm/krad



## 10 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
16-May-2006	1	First release.
22-Aug-2006	2	The pin description for SMD5C on table 1 has been updated.
19-Dec-2007	3	Modified: <a href="#">Table 6</a> .

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