CAEN
Tools for Discovery

A7501B

Single Channel High Reliability, High Voltage Power Supply Box

A tailored Solution for Large Area experiments in harsh environment

Overview

A7501B is a High Voltage Power Supply unit designed for operating in challenging environmental conditions and high thermal excursions. It relies on A7501 high efficiency HV DC-DC converter housed on a custom carrier board.

In order to ensure its functionality for long working periods under severe environmental conditions, several technical and electrical precautions have been implemented in the design of A7501B. Stress relief techniques on cabling and soldering points, electrical redundancies, communication lines protection, special PCB layout, and use of specific materials to minimize the thermal expansion of both PCBs and housing mechanics have been carefully studied to minimize possible failures of the device due to the harsh operating environment.

All these features make A7501B an ideal solution for Large Area experiments where the possibility of a prompt maintenance intervention is reduced.

Features

- Based on **A7501** high efficiency HV DC-DC converter - *www.caen.it/products/a7501*
- 2100 V/100 µA output ranges
- Available with positive or negative polarity
- Operating temperature range: **-40°C ÷ 70°C**
- Designed for long working life in harsh environment
  - Specific materials chosen to minimize issues due to thermal expansion
  - PCB layout optimized for high reliability in the worst environmental conditions
  - Redundancy of internal connections
  - Connection and cabling with stress relief on solder points
  - Stress absorption by means of silicone resin
  - Several solutions from Aerospace electronics design
  - Coated against humidity, dust and salt fog
- Assembly optimized for easy maintenance operation
- Buffered communication lines to protect both the inner HV DC-DC converter and the connected control device

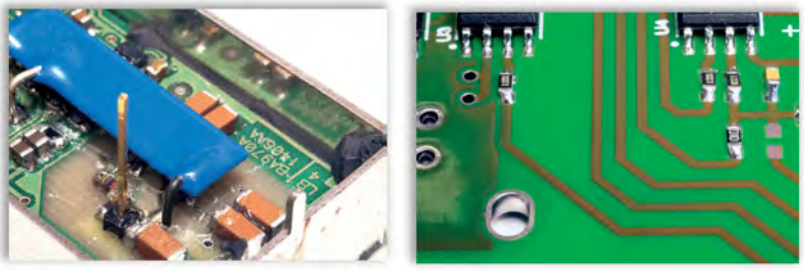


Fig.1: Special materials and layout have been adopted to minimize possible issues due to thermal expansions

Materials and Layout

The materials chosen for the carrier and box has been selected taking into account their linear expansion coefficients and the required temperature working ranges in order to avoid too intense mutual stress.

Specific studies on the mechanics layout has been realized in order to reduce the thermal expansion effects on the mechanic and electronic components and to assure the electrical continuity also in case of a single point of failure.

www.caen.it/products/a7501b/

Layup

A The mutual slip between different electronic layers has been taken into account. Dedicated mechanical precautions have been studied to effectively reduce the stress on the connection point. The metal case of A7501P HV DC-DC converter embedded in the unit is glued onto the carrier board by means of a silicone resin, guaranteeing therefore a flexible yet reliable connection of the two parts.

Assembly

Particular attention has been paid to the module assembly. In order simplify the maintenance operations, the electronic board has been fixed to only one of the mechanical support so that it can be easily extracted. Protection from water and dust is assured with a dedicated IP53-like gasket.

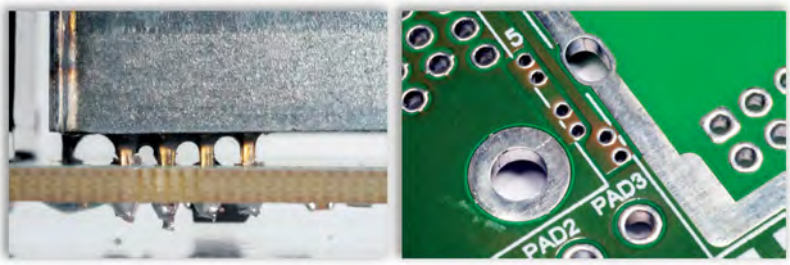


Fig.2: Dedicated solutions to reduce the stress on soldering points are used in A7501PB

Coating

Both the A7501 HV DC-DC converter and the A7501PB carrier board are protected against humidity, dust and salt fog by means of a proper conformal coating. Moreover, A7501 is completely filled with a silicone elastomer to completely encapsulate the HV DC-DC converter. This allows a good mechanical flexibility in case of thermal expansions of the inner PCB.

Cabling

Thanks to the experience gain in the aerospace applications and following the indication of the European Space Standard ECSS-Q-ST-70-38C, specific assembly has been implemented in order to reduce the stress on the solder point of wires on the printed circuit.

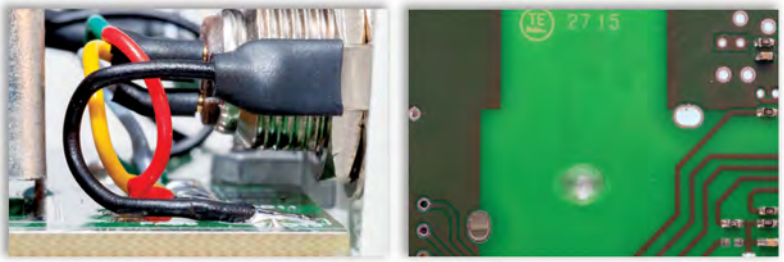


Fig.3: Stress relief cabling techniques from aerospace applications

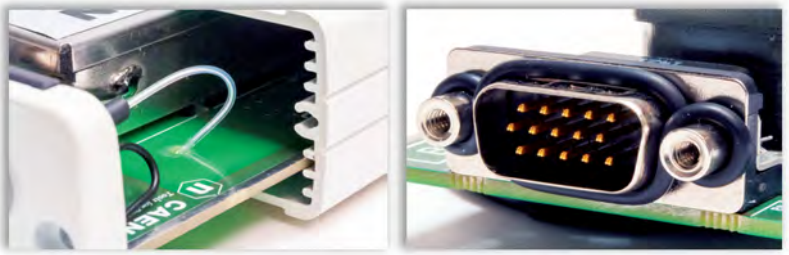


Fig.4: Protection from water and dust. Easy assembly for simplified maintenance

Certification

- Radiated Emissions : CEI EN 61326-1 Class A
- Radio frequency electromagnetic fields: CEI EN 61326-1
- Radio frequency common mode: CEI EN 61326-1
- Electrostatic discharges (ESD): CEI EN 61326-1
- Surges immunity test: CEI EN 61326-1
- Voltage dips and interruptions: CEI EN 61326-1
- Magnetic field immunity test: CEI EN 61326-1
- Electrical Safety: CEI EN 61010-1

Characterization and measurements

Each A7501B is provided with a complete test report showing:

- Linearity, Integral non-linearity (INL) and INL distribution of
  - Output Voltage (Vout) vs. Voltage Setting (Vset)
  - Output Voltage (Vout) vs. Voltage Monitor (Vmon)
  - Current Monitor (Imon) vs. Voltage Setting (Vset)
- Full Load Test
- Efficiency
- Short Circuit test
- Output Ripple

An example of Test Report is available at page 7

Technical Specifications

General Features

Number of Channels	1 (Based on A7501 PCB mount HV DC-DC converter)	
Output Voltage (Vout)	0 ÷ ±2100 V	
Maximum Output Current (Iout)	100 µA @ ±2100 V	
Output Polarity	Available positive or negative	
Output Connector	4200 VDC High Voltage connector	LEMO ERA.0S.250.CTL
Imon & Temperature Connector	4-pin G-Type Mini XLR	Amphenol AG4MCC
Control Connector	15-pin Sub-Miniature D Connector	TE Connectivity 5749768-1
Protection	Over current short circuit, sparks and humidity	

Environmental

Operating temperature	-40° C ÷ +70° C
Storage temperature	-55° C ÷ +85° C
Altitude	< 2000 m

Performance

Output Ripple (Full Load)	5 mVpp 10 mVpp	Typical Maximum
Efficiency	~ 60% @ Vout = 2100 V (-20° C ÷ +70° C)	
Vout / Temperature coefficient	< 60 ppm/ °C	
Vset vs. Vout Integral Non Linearity	< ±0.3% (-40° C ÷ +70° C)	
Vmon vs. Vout Integral Non Linearity	< ±0.3% (-40° C ÷ +70° C)	
ΔVout/Vout (for ±5% Vin variations)	< 1.5 X 10^{-3} @ full scale	

Analog Set/Monitor Voltages

Vmon Output (positive analog monitor)	0 ÷ +5 V
Vset Input (positive analog command)	0 ÷ +2.5 V
Imon Output	0 ÷ +2.5 V

Mechanical

Form Factor	Alloy Box	Enclosure material: Panel material:	Aluminium Zinc and Aluminium alloy
Dimension	63 W x 35 H x 119 L mm^3		

Power Requirement

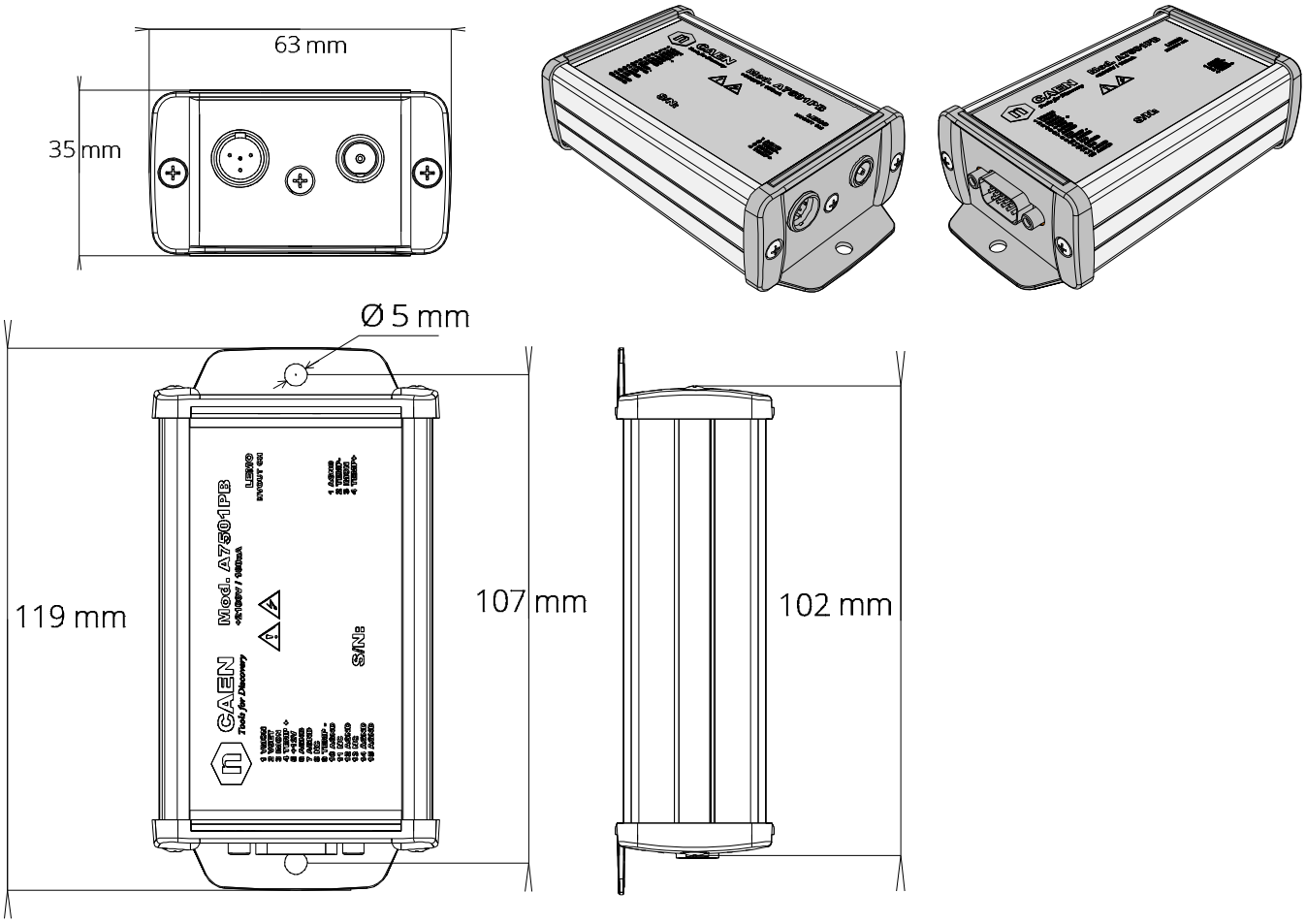
+12 V	< 410 mW	@ 2100 V / 110 µA (Rload ≈ 20 MΩ)

Technical Specifications (continued)

Regulatory

Radiated Emissions:	CEI EN 61326-1 Class A
Radio frequency electromagnetic fields	CEI EN 61326-1
Radio frequency common mode	CEI EN 61326-1
Electrostatic discharges (ESD)	CEI EN 61326-1
Surges immunity test	CEI EN 61326-1
Voltage dips and interruptions	CEI EN 61326-1
Magnetic field immunity test	CEI EN 61326-1
Electrical Safety	CEI EN 61010-1

Mechanical Dimension



Connectors and Pin-out

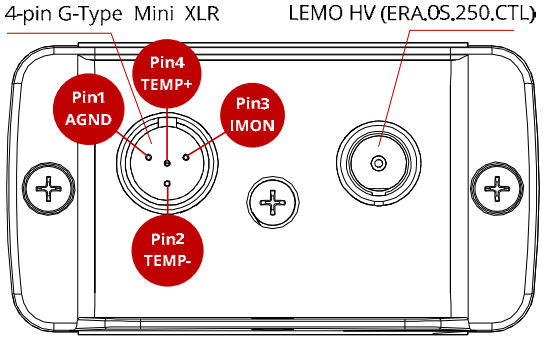


Fig.5: A7501B Front panel, LEMO HV and 4-pin Mini XLR connectors for Auger IMON and temperature remote inputs.

Pin Number	Name	Description	Direction
1	AGND		
2	TEMP -	TEMP - remote input	IN
3	IMON	IMON remote input	IN
4	TEMP +	TEMP + remote input	IN

Tab 1: 4-pin Mini XLR connectors pin description

Connectors and Pin-out (continued)

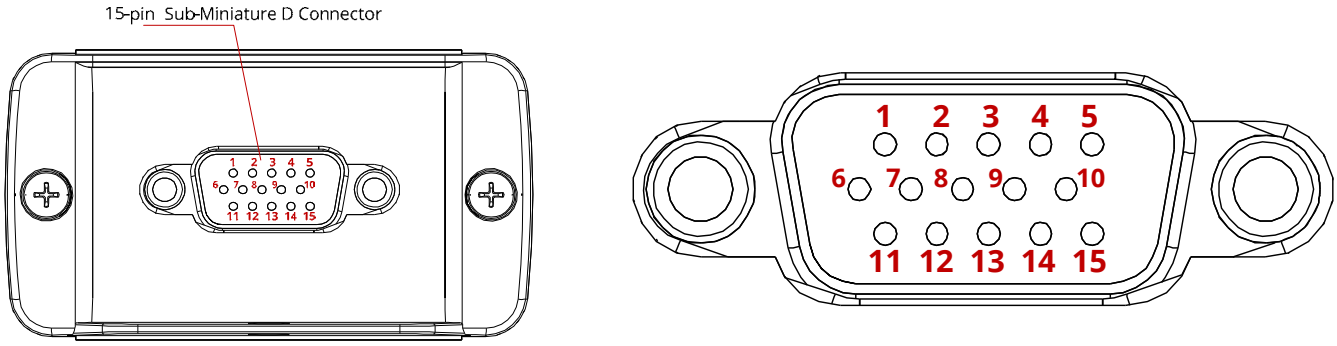


Fig.5: A7501PB Back panel with 15-pin Sub-Miniature connector and pin numbering

Pin Number	Name	Description	Direction
1	VMON	A7501 Vmon (Buffered)	OUT
2	VSET	A7501 Vset (connected with filter)	IN
3	IMON	Buffer Out of IMON remote input (4-pin Mini XLR connector on front panel)	OUT
4	TEMP+		OUT
5	+12V	A7501 Voltage Supply (Vin)	IN
6	AGND		
7	AGND		
8	N. C.		
9	TEMP -		OUT
10	AGND		
11	N. C.		
12	AGND		
13	N. C.		
14	AGND		
15	AGND		

Tab 2: 15-pin Sub-Miniature connector pin description

Ordering Option

Description	Code
A7501PB +2.1kV 100µA HV Power Supply Module BOXED	WA7501PBXAAA
A7501NB -2.1kV 100µA HV Power Supply Module BOXED	WA7501NBXAAA

Reference Document

Anastasi, G. A., Buscemi, M., Aglietta, M., Caruso, R., Castellina, A., Costa, S., ... & Zampieri, A. (2022). Validation of high voltage power supplies for the 1-inch photomultipliers of AugerPrime, the Pierre Auger Observatory upgrade. Journal of Instrumentation, 17(04), T04003.
DOI: https://doi.org/10.1088/1748-0221/17/04/T04003

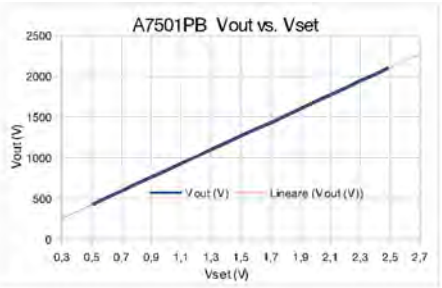
Test Report Example

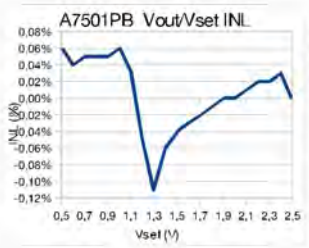
A7501PB – s/n 500

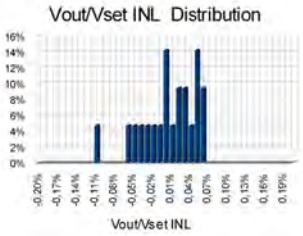
Vset (V)	Vout (V)	Vmon (V)	Imon (V)	Iin (mA)	PWR_in (mW)	Vout/Vset	Vout/Vset INL	Vout/Vmon	Vout/Vmon INL	Imon/Vset	Imon/Vset INL
0,0011	14,5050	0,0256	0,0086	4,5430	56,1722	12962,5053	69,42%	567,3568	-3,01%	7,6929	90,28%*
0,0969	85,2191	0,1933	0,0563	7,6793	94,9511	879,5535	0,14%	440,9144	-0,44%	0,5816	1,54%*
0,2017	173,1214	0,4017	0,1157	9,3209	115,2497	858,1752	-0,17%	430,9948	-0,15%	0,5736	0,36%*
0,3034	258,8357	0,6048	0,1736	10,5982	131,0425	853,2463	-0,06%	427,9457	-0,05%	0,5723	0,19%*
0,4025	342,6365	0,8035	0,2302	11,7218	144,9354	851,2033	0,03%	426,4381	-0,01%	0,5719	0,15%*
0,5050	429,0848	1,0084	0,2886	12,8058	158,3393	849,7334	0,06%	425,4927	0,02%	0,5716	0,11%
0,6000	509,0444	1,1980	0,3427	13,7834	170,4273	848,4314	0,04%	424,9034	0,04%	0,5711	0,04%
0,7037	596,4919	1,4055	0,4018	14,8489	183,6008	847,6978	0,05%	424,4076	0,04%	0,5710	0,02%
0,8021	679,4165	1,6021	0,4578	15,8333	195,7735	847,0250	0,05%	424,0683	0,05%	0,5708	-0,01%
0,9049	766,0859	1,8076	0,5164	16,8560	208,4180	846,5936	0,05%	423,8148	0,06%	0,5707	-0,02%
1,0046	850,1297	2,0069	0,5733	17,8445	220,6407	846,2682	0,06%	423,6100	0,06%	0,5707	-0,02%
1,1042	933,7488	2,2056	0,6300	18,8291	232,8149	845,6583	0,03%	423,3547	0,05%	0,5706	-0,04%
1,2006	1014,2179	2,3979	0,6849	19,7823	244,6008	844,7902	-0,05%	422,9616	-0,01%	0,5704	-0,05%
1,2953	1093,3403	2,5872	0,7389	20,7225	256,2259	844,0866	-0,11%	422,5925	-0,07%	0,5704	-0,05%
1,4000	1181,9447	2,7976	0,7990	21,7692	269,1677	844,2546	-0,06%	422,4831	-0,07%	0,5707	-0,01%
1,5045	1270,1411	3,0067	0,8587	22,8067	281,9963	844,2460	-0,04%	422,4405	-0,05%	0,5707	0,00%
1,5978	1348,8736	3,1932	0,9120	23,7322	293,4396	844,1978	-0,03%	422,4212	-0,04%	0,5708	0,01%
1,7047	1439,0038	3,4070	0,9730	24,7936	306,5637	844,1534	-0,02%	422,3673	-0,03%	0,5708	0,01%
1,8043	1523,0730	3,6062	1,0299	25,7873	318,8508	844,1122	-0,01%	422,3469	-0,02%	0,5708	0,02%
1,9037	1606,9198	3,8050	1,0867	26,7806	331,1325	844,0924	0,00%	422,3178	-0,01%	0,5708	0,02%
2,0016	1689,4866	4,0007	1,1425	27,7586	343,2247	844,0566	0,00%	422,3019	0,00%	0,5708	0,02%
2,1045	1776,3029	4,2064	1,2013	28,7889	355,9648	844,0326	0,01%	422,2833	0,00%	0,5708	0,02%
2,2047	1860,7986	4,4067	1,2583	29,7897	368,3382	844,0056	0,02%	422,2614	0,01%	0,5707	0,01%
2,3015	1942,4889	4,6004	1,3131	30,7654	380,4028	843,9957	0,02%	422,2434	0,02%	0,5705	-0,03%
2,3973	2023,2810	4,7920	1,3680	31,7253	392,2717	843,9720	0,03%	422,2239	0,02%	0,5706	0,00%
2,4914	2101,9784	4,9782	1,4216	32,6592	403,8188	843,6828	0,00%	422,2329	0,03%	0,5706	-0,01%

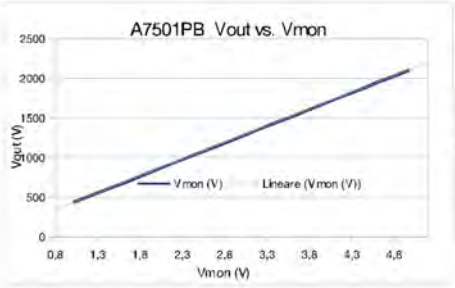
Interpolation line slope "m"					842,280282		421,27101		0,57058073		
Interpolation line intercept "q"					3,49251475		4,17202466		0,0001983		

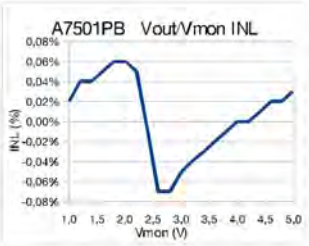
* step out of relevant range (Vout<400V). This step has been discarded for statistics.

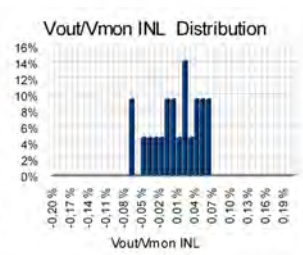


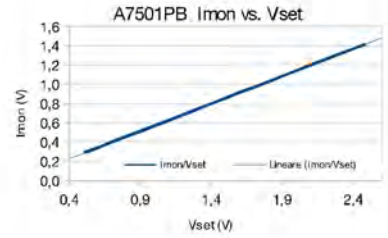


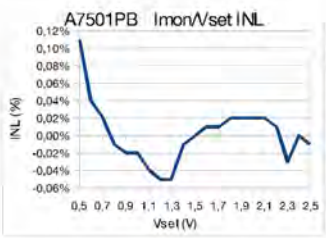


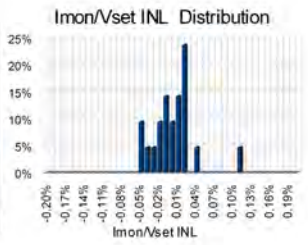












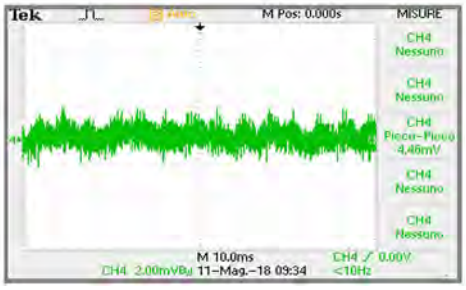
(*) Imon is not an A7501PB module internally generated parameter. A7501PB receives Imon value from detector as input signal and provides it as buffered output.

FULL LOAD TEST

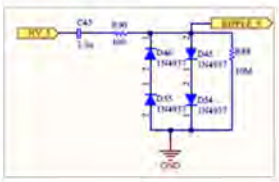
Vset (v)	Vout (V)	Iout (uA)	Pout (mW)	Vin (V) (*)	Iin (mA) (**)	Pin (mW)	Efficiency	Short Circuit test	Input current in cc mode
2,491432	2101,9784	104,99	220,69	12,364637	32,66	403,8188337	54,65%	**PASSED**	30,4711518

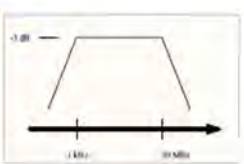
(*) +12 Vin supply maximum reached value during complete test

(**) Input current is due both to A7501P module and to box buffering components absorption. The box components current absorption related part is ~ 2,5 mA



Output Ripple
Vout = 2100V / Load = 20 Mohm
5mt HV cable





CAEN S.p.A.
Via Vetraia 11
55049 - Viareggio - Italy
Phone +39.0584.388.398
Fax +39.0584.388.959
info@caen.it - **www.caen.it**

CAEN GmbH
Brunnenweg 9
64331 Weiterstadt
Phone +49 (0)212 254 4077
Mobile +49 (0)151 16 548 484
info@caen-de.com - **www.caen-de.com**

CAEN Technologies, Inc.
1 Edgewater Street - Suite 101
Staten Island, NY 10305 - USA
Phone +1.718.981.0401
Fax +1.718.556.9185
info@caentechnologies.com
www.caentechnologies.com

CAENspa India Private Limited
B205, BLDG42, B Wing,
Azad Nagar Sangam CHS,
Mhada Layout, Azad Nagar, Andheri West
Mumbai, Maharashtra 400053, India
info@caen-india.in - **www.caen-india.in**