Test Report

Revision n. 0

15 december 2000

JEM-X

HV POWER SUPPLY
FLIGHTMODEL 1

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GLOSSARY

Vc channel:	+ 3 kV output channel with reference to ground
dV channel:	+ 3 kV differential output channel with reference to Vc
V_{OUT}:	output voltage from Vc or dV
V_{MAX}:	maximum programmable output voltage
$V_{MAX\ hardware}$:	output voltage hardware limit set by the factory
V_{RES}:	voltage setting resolution
I_{OUT}:	output current from Vc or dV
I_{MAX}:	maximum output current from Vc or dV
$T_{Ramp-up/Ramp-Down}$:	output voltage slew-rate
TEMP1/TEMP2:	temperature readout of the relevant sensors placed on the control board
dV_{set}:	dV channel DAC value (bit)
Vc_{set}:	Vc channel DAC value (bit)
Vc_{OUT}:	output voltage between Vc and AGND without load
dV_{OUT}:	output voltage between dV and Vc both without load
$Vc_{\ HV\ voltmeter}$:	Vc measured by a HV voltmeter
$dVVc_{\ HV\ voltmeter}$:	voltage between dV and AGND measured by a HV voltmeter
Vc_{MON}:	Vc ouptut monitor signal
dV_{MON}:	dV output monitor signal

1. Test procedures and measurements

The following Sections are devoted to describe the thermal tests and vacuum tests performed on the JEM-X HV Power Supply.

1.1. Thermal test procedure

The thermal test was performed in the **-20°C ÷ +40°C** temperature range for six different load conditions:

- **Rload(Vc)=Rload(dV)=200MOhm, to measure Psupply.**
- **Rload(Vc)=Rload(dV)=200Mohm+Voltmeters**
- **Rload(Vc)=1Gohm, Rload(dV)=open and Vc feedback-loop open to measure Vmax(Vc).**
- **Rload(Vc)=500Mohm, Rload(dV)=1Gohm and dV feedback-loop open to measure Vmax(dV).**
- **Rload(Vc)=19.2Mohm, Rload(dV)=1Gohm, to measure Ilim(Vc).**
- **Rload(Vc)=142.8Mohm, Rload(dV)=19.6Mohm**

In the Tables of the following subsections we reported the measurements on all the parameters necessary to provide a complete overview of the correct operation of the HV Power Supply. Besides these fundamental parameters (**Vcset, dVset, Vcmon , dVmon , Vcout, dVout, Pd** and **Vripple**), we tested as well:

- channels stability;
- channel regulation in the condition of maximum output voltage and load;
- correct operation of the ON, OFF, OFF SC, RESET, WRITE commands;
- correct power-On of the HV Power Supply without any delay or other kind of problems.

N. B.: Here below there are the main features and conditions on the parameters measured and listed in the Tables:

- The Vcset and dVset are the values at the inputs of the DAC register;
- The Vcmon and dVmon voltages are the voltage values read on the monitor outputs of the Interface connector. The readout error on these values is ±1 mV;
- The Vcout and dVout voltages are the voltage values before the 1MOhm HV resistors in series to the outputs calculated on the basis of the HV Voltmeters readouts as follows:

  Hardware set-up of Fig. 1.4, p.12:

  Vcout=[(1M+500M)/500M]*Vc(HV Voltmeter);
  dVout=[(1M+1000M)/1000M]*dVVc(HV Voltmeter) – Vcout;

The HV Voltmeters have 1 V resolution: therefore, these data have a precision of ±1 V.

- The absorbed power Pd is relative to the power supply (±12V) and was calculated by multiplying the power supply voltage set at +12V and –12V by the current readout of an 1 mA-resolution Amperometer placed in series to the two power supply branches;
- The voltage ripple V_{ripple} at the output of the HV channels was measured with a 10Hz÷15MHz-bandwidth Test Module.

1.1.1. Thermal test set-ups and measurements

The results of the measurements performed with **Rload(Vc)=Rload(dV)=200MOhm** are listed in Table 1.1, p. 8 while the relevant hardware set-up is shown in Fig. 1.1, p.8.

The results of the measurements performed with **Rload(Vc)=Rload(dV)=200Mohm+Voltmeters** are listed in Table 1.2-Table 1.6, p. 9-10, while the relevant hardware set-up is shown in Fig. 1.2, p.9.

The results of the measurements performed **Rload(Vc)=1Gohm, Rload(dV)=open and Vc feedback-loop open to measure Vmax(Vc)** are listed in Table 1.7, p. 11, while the relevant hardware set-up is shown in Fig. 1.3, p.11.

The results of the measurements performed with **Rload(Vc)=500Mohm, Rload(dV)=1Gohm and dV feedback-loop open to measure Vmax(dV)** are listed in Table 1.8, p.12, while the relevant hardware set-up is shown in Fig. 1.4, p.12.

The results of the measurements performed with **Rload(Vc)=19.2Mohm, Rload(dV)=1Gohm** are listed in Table 1.9, p.13, while the relevant hardware set-up is shown in Fig. 1.5, p.13.

The results of the measurements performed with **Rload(Vc)=142.8Mohm, Rload(dV)=19.6Mohm** are listed in Table 1.10, p.14, while the relevant hardware set-up is shown in Fig. 1.6, p.14.

In Table 1.11 and Fig. 1.7 at page 15 the measurements of the HV Power Supply Switching Frequency are shown as a function of temperature.

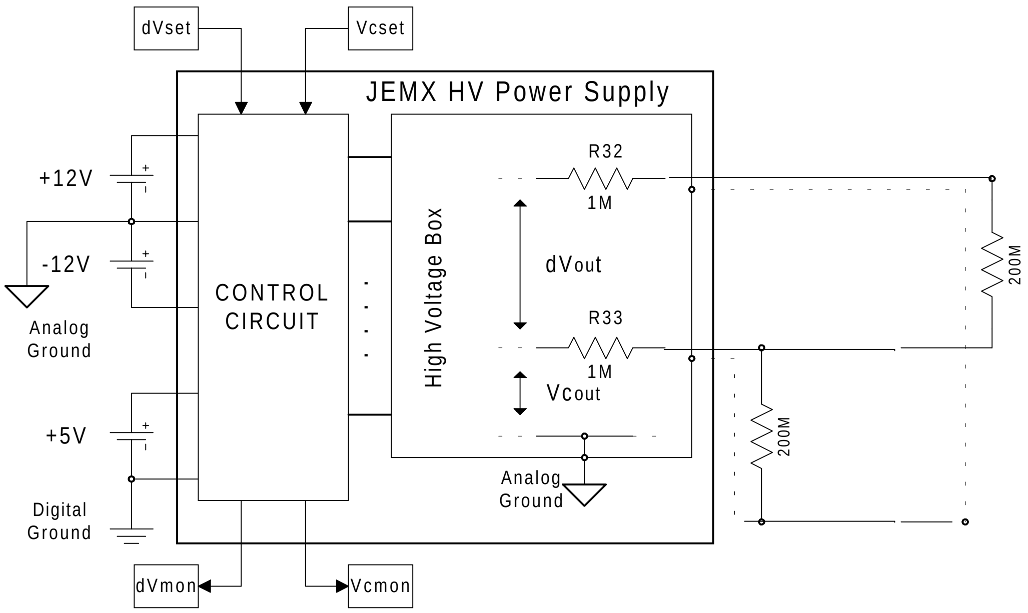

Fig. 1.1 – Hardware set-up for thermal test with Rload(Vc) = Rload(dV) = 200MOhm

Table 1.1 - Measurements with Rload(Vc) = Rload(dV) = 200MOhm

	Vcset = dVset = 255d	Vcset = dVset = 200d	Vcset = dVset = 150d	Vcset = dVset = 100d	Vcset = dVset = 50d
Temp	Psupply(W)	Psupply(W)	Psupply(W)	Psupply(W)	Psupply(W)
35	**2.71**	**2.398**	**2.128**	**1.875**	**1.641**
30	**2.661**	**2.36**	**2.101**	**1.857**	**1.633**
20	**2.536**	**2.262**	**2.029**	**1.811**	**1.611**
10	**2.414**	**2.172**	**1.965**	**1.771**	**1.591**
0	**2.309**	**2.092**	**1.906**	**1.731**	**1.569**
-10	**2.246**	**2.045**	**1.874**	**1.708**	**1.551**
-20	**2.276**	**2.07**	**1.889**	**1.715**	**1.552**
-25	**2.303**	**2.09**	**1.902**	**1.722**	**1.551**

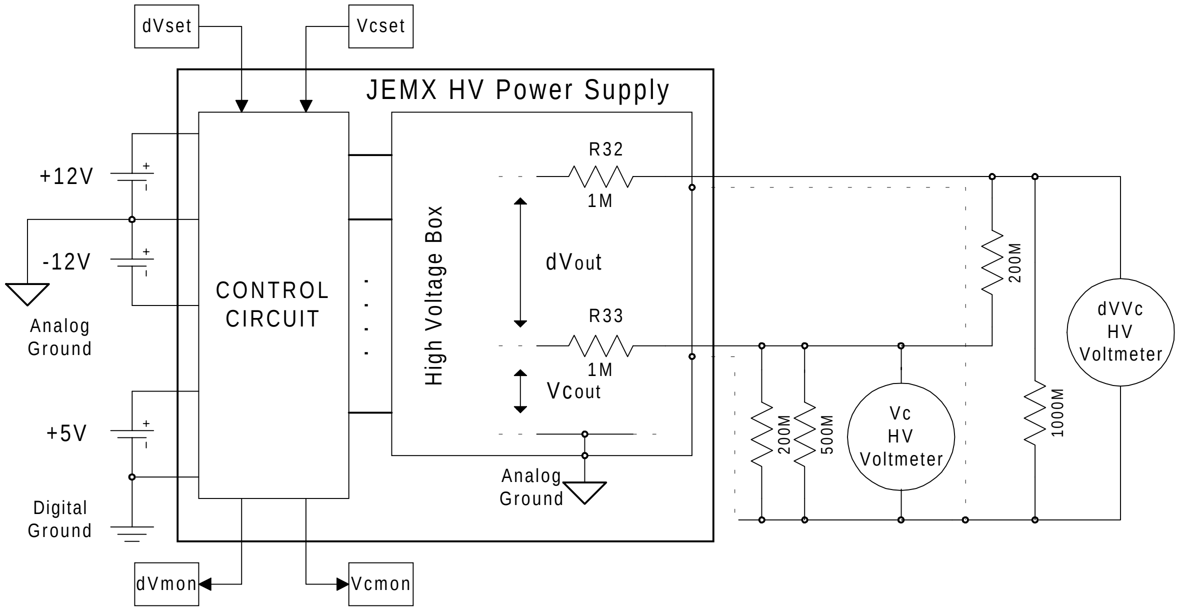

Fig. 1.2 – Hardware set-up for thermal test with Rload(Vc) = Rload(dV) = 200Mohm + Voltmeters

Table 1.2 - Measurements with Rload(Vc) = Rload(dV) = 200Mohm+Voltmeters, Vcset=dVset=255d

Vcset = dVset = 255d						
Temp	Vc HV Volt	dVVc HV Volt	Vcout	dVout	Vcmon	dVmon
35	2522	5062	2526.954	2552.808	2.5296	2.548
30	2522	5061	2526.959	2551.797	2.5295	2.548
20	2522	5059	2526.969	2549.775	2.5293	2.5479
10	2522	5057	2526.979	2547.753	2.5292	2.5479
0	2522	5055	2526.989	2545.731	2.5292	2.5479
-10	2521	5053	2525.987	2544.726	2.5292	2.548
-20	2522	5052	2527.004	2542.698	2.5293	2.5482
-25	2522	5051	2527.009	2541.687	2.5294	2.5483

Table 1.3 - Measurements with Rload(Vc) = Rload(dV) = 200Mohm+Voltmeters, Vcset=dVset=200d

Vcset = dVset = 200d						
Temp	Vc HV Volt	dVVc HV Volt	Vcout	dVout	Vcmon	dVmon
35	1981	3975	1984.897	2004.048	1.9859	1.9983
30	1981	3974	1984.902	2003.037	1.9859	1.9983
20	1981	3973	1984.907	2002.026	1.9858	1.9982
10	1981	3971	1984.917	2000.004	1.9858	1.9982
0	1981	3970	1984.922	1998.993	1.9859	1.9982
-10	1981	3968	1984.932	1996.971	1.986	1.9983
-20	1981	3968	1984.932	1996.971	1.9862	1.9984
-25	1981	3967	1984.937	1995.96	1.9863	1.9985

Table 1.4 - Measurements with Rload(Vc) = Rload(dV) = 200Mohm+Voltmeters, Vcset=dVset=150d

Vcset = dVset = 150d						
Temp	Vc HV Volt	dVVc HV Volt	Vcout	dVout	Vcmon	dVmon
35	**1489**	**2986**	1491.938	1504.533	**1.4925**	**1.4987**
30	**1489**	**2986**	1491.938	1504.533	**1.4924**	**1.4986**
20	**1489**	**2984**	1491.948	1502.511	**1.4924**	**1.4986**
10	**1489**	**2983**	1491.953	1501.5	**1.4925**	**1.4986**
0	**1489**	**2982**	1491.958	1500.489	**1.4926**	**1.4986**
-10	**1489**	**2981**	1491.963	1499.478	**1.4927**	**1.4986**
-20	**1490**	**2981**	1492.975	1498.461	**1.4929**	**1.4987**
-25	**1490**	**2980**	1492.98	1497.45	**1.493**	**1.4988**

Table 1.5 - Measurements with Rload(Vc) = Rload(dV) = 200Mohm+Voltmeters, Vcset=dVset=100d

Vcset = dVset = 100d						
Temp	Vc HV Volt	dVVc HV Volt	Vcout	dVout	Vcmon	dVmon
35	**995**	**1994**	996.97	1004.019	**0.99753**	**0.99891**
30	**996**	**1994**	997.982	1003.002	**0.99754**	**0.9989**
20	**996**	**1993**	997.987	1001.991	**0.99753**	**0.99887**
10	**996**	**1992**	997.992	1000.98	**0.99761**	**0.99888**
0	**996**	**1991**	997.997	999.969	**0.99769**	**0.99889**
-10	**996**	**1991**	997.997	999.969	**0.99783**	**0.99894**
-20	**996**	**1990**	998.002	998.958	**0.99798**	**0.99901**
-25	**997**	**1990**	999.014	997.941	**0.9981**	**0.99908**

Table 1.6 - Measurements with Rload(Vc) = Rload(dV) = 200Mohm+Voltmeters, Vcset=dVset=50d

Vcset = dVset = 50d						
Temp	Vc HV Volt	dVVc HV Volt	Vcout	dVout	Vcmon	dVmon
35	**504**	**1003**	505.033	501.465	**0.50402**	**0.49919**
30	**504**	**1002**	505.038	500.454	**0.50407**	**0.4992**
20	**504**	**1002**	505.038	500.454	**0.5041**	**0.49918**
10	**504**	**1001**	505.043	499.443	**0.50422**	**0.49919**
0	**504**	**1001**	505.043	499.443	**0.50433**	**0.4992**
-10	**504**	**1000**	505.048	498.432	**0.50452**	**0.49922**
-20	**504**	**1000**	505.048	498.432	**0.50468**	**0.49928**
-25	**505**	**1000**	506.06	497.415	**0.50478**	**0.49932**

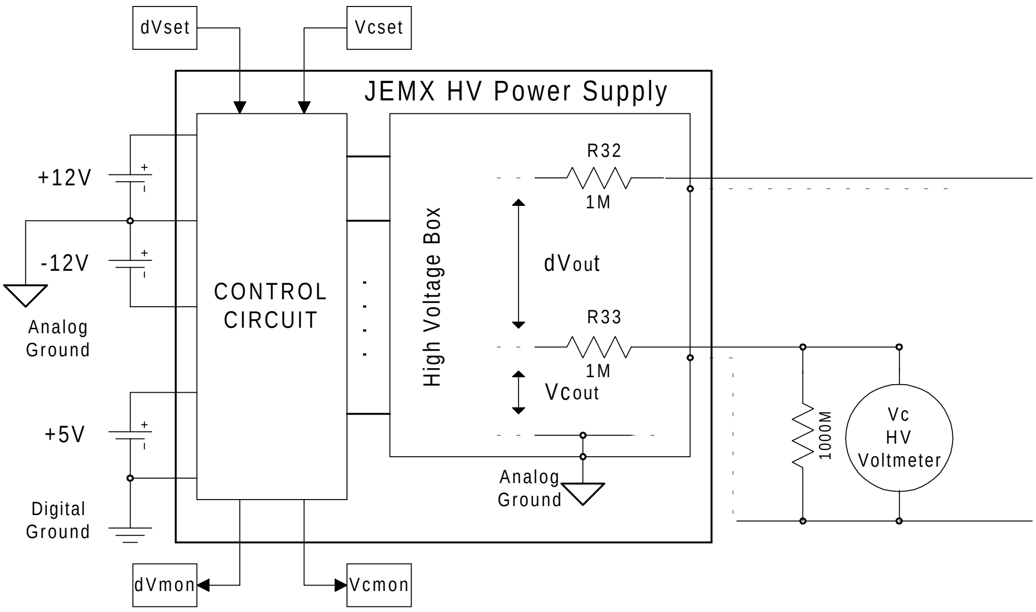

Fig. 1.3 – Hardware set-up for thermal test with Rload(Vc)=1Gohm, Rload(dV)=open and Vc feedback-loop open

Table 1.7 - Thermal test measurements with Rload(Vc)=1Gohm, Rload(dV)=open and Vc feedback-loop open

Vcset = dVset = 0d		
Temp	VcHV Volt	Vcout
35	**2646**	2648.646
30	**2653**	2655.653
20	**2664**	2666.664
10	**2673**	2675.673
0	**2674**	2676.674
-10	**2668**	2670.668
-20	**2657**	2659.657
-25	**2652**	2654.652

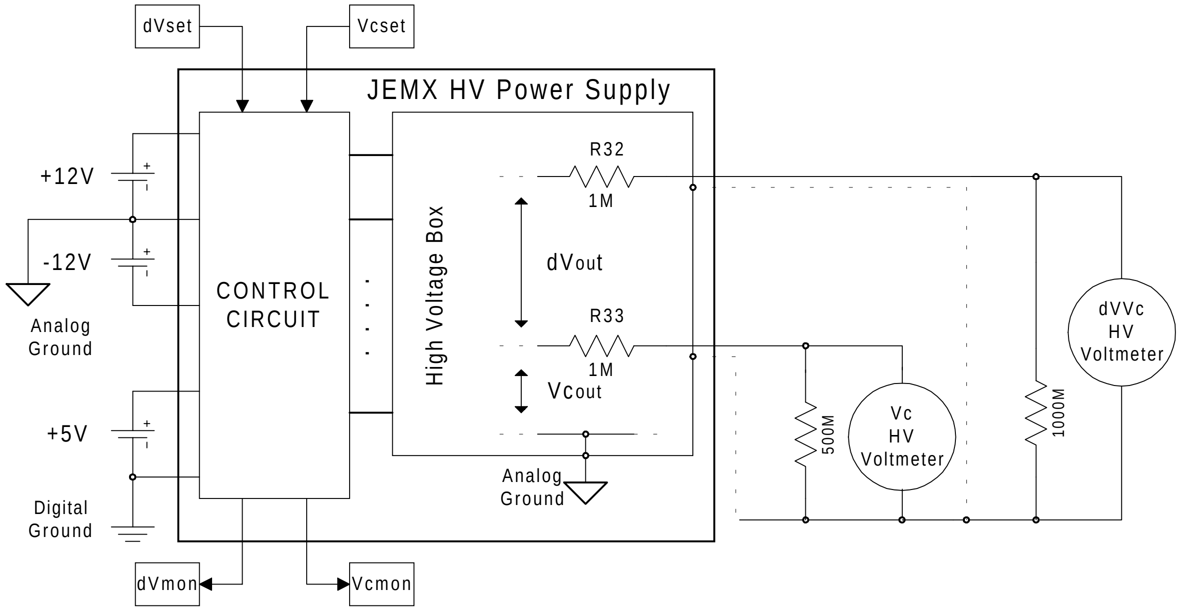

Fig. 1.4 – Hardware set-up for thermal test with Rload(Vc)=500Mohm, Rload(dV)=1Gohm and dV feedback-loop open

Table 1.8 - Thermal test measurements with Rload(Vc)=500Mohm, Rload(dV)=1Gohm and dV feedback-loop open

Vcset = dVset = 0d			
Temp	dVVcHV Volt	VcHV Volt	dVout
40	**2809**	**145**	2666.519
30	**2812**	**145**	2669.522
20	**2818**	**145**	2675.528
10	**2822**	**145**	2679.532
0	**2819**	**144**	2677.531
-10	**2808**	**143**	2667.522
-20	**2797**	**141**	2658.515
-20	**2797**	**141**	2658.515

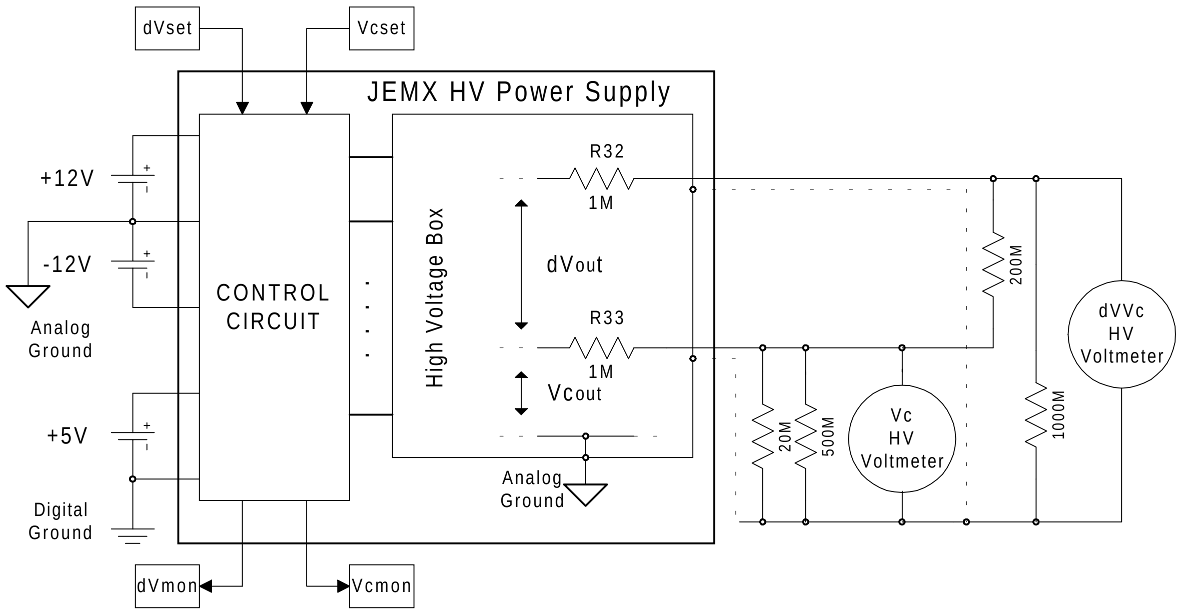

Fig. 1.5 – Hardware set-up for thermal test with Rload(Vc)=19.2Mohm, Rload(dV)=1Gohm

Table 1.9 - Thermal test measurements with Rload(Vc)=19.2Mohm, Rload(dV)=1Gohm

Vcset = dVset = 255d			
Temp	VcHV Volt	dVVcHV Volt	Ilim(Vc) (uA)
35	**1651**	**4293**	80.897
30	**1719**	**4363**	84.763
20	**1875**	**4527**	93.615
10	**2062**	**4723**	104.229
0	**2272**	**4942**	116.154
-10	**2313**	**4983**	118.491
-20	**2295**	**4963**	117.475
-25	**2280**	**4945**	116.635

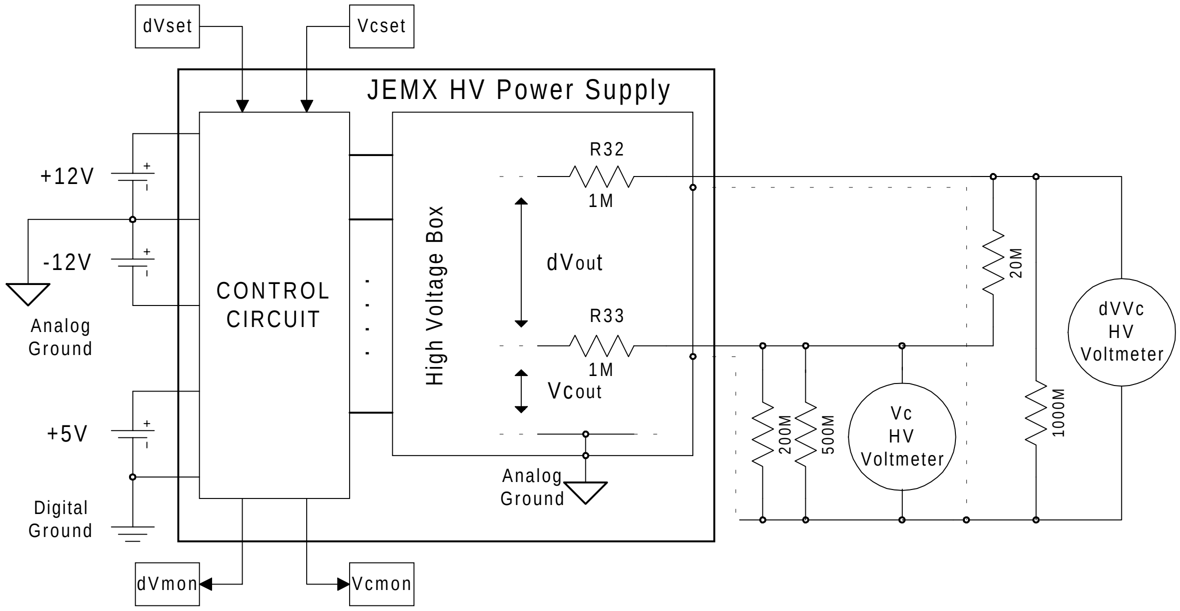

Fig. 1.6 – Hardware set-up for thermal test with Rload(Vc)=142.8Mohm, Rload(dV)=19.6Mohm

Table 1.10 - Thermal test measurements with Rload(Vc)=142.8Mohm, Rload(dV)=19.6Mohm

Vcset = dVset = 255d			
Temp	dVVcHV Volt	VcHV Volt	Ilim(dV) uA
35	**4136**	**2594**	88.946
30	**4192**	**2597**	91.917
20	**4349**	**2604**	100.324
10	**4545**	**2614**	110.75
0	**4757**	**2625**	122.017
-10	**4884**	**2631**	128.799
-20	**4810**	**2628**	124.82
-25	**4749**	**2625**	121.569

Table 1.11 - HV Power Supply Switching Frequency vs. temperature

T [°C]	-25	-20	-10	0	10	20	30	35
$F_{Switching}$ [kHz]	31.5	31.6	31.9	32.1	32.3	32.6	32.8	32.9

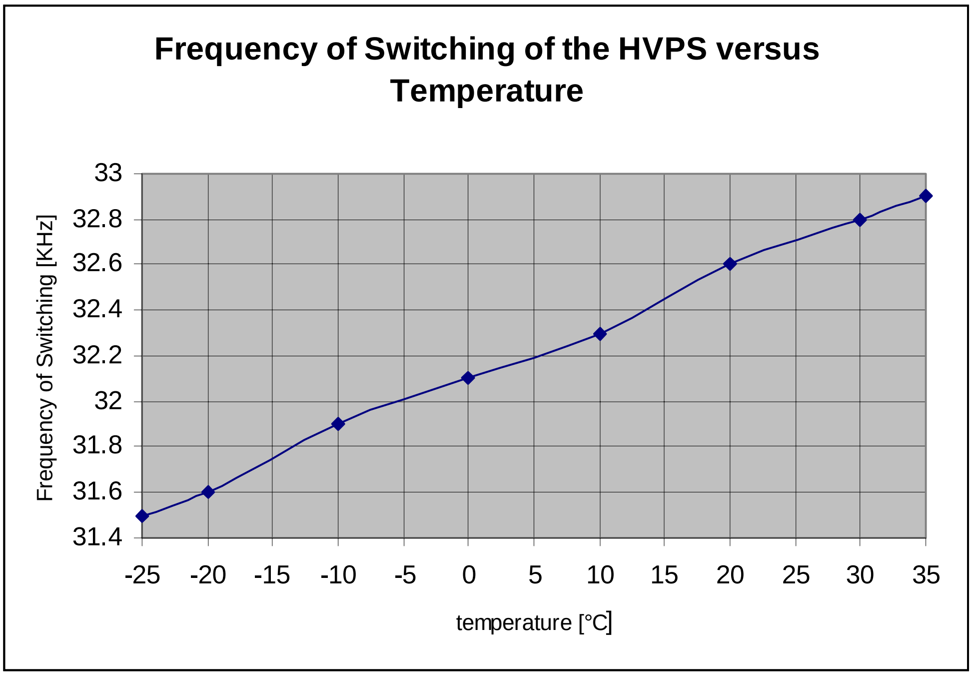

Fig. 1.7 – HV Power Supply Switching Frequency vs. temperature

1.2. *Vacuum test procedure*

and the 200 Mohm loads has been inserted on the outputs.
The vacuum test has been performed with the following set up:

1- L'HVPS has been inserted in the vacuum chamber and controlled through a manual test box placed outside the chamber. The two HV cables have been passed through two holes realised on a flange hermetically closed with filler. The control cables have been connected to three DB25 connectors of which the vacuum chamber was provided.
2- The HV outputs have been connected to two HV test boxes and to two HV voltmeters with 1 Gohm input impedance. The 200 Mohm loads has been inserted on the outputs.
3- The two test boxes outputs have been connected to the two channels of a digital oscilloscope. The two channels had a 50 mV/div vertical sensitivity.
4- The HVPS has been supplied by a bench triple-output power supply (+5V, +12V, -12V).

Fig. 1.8 shows the connection scheme.

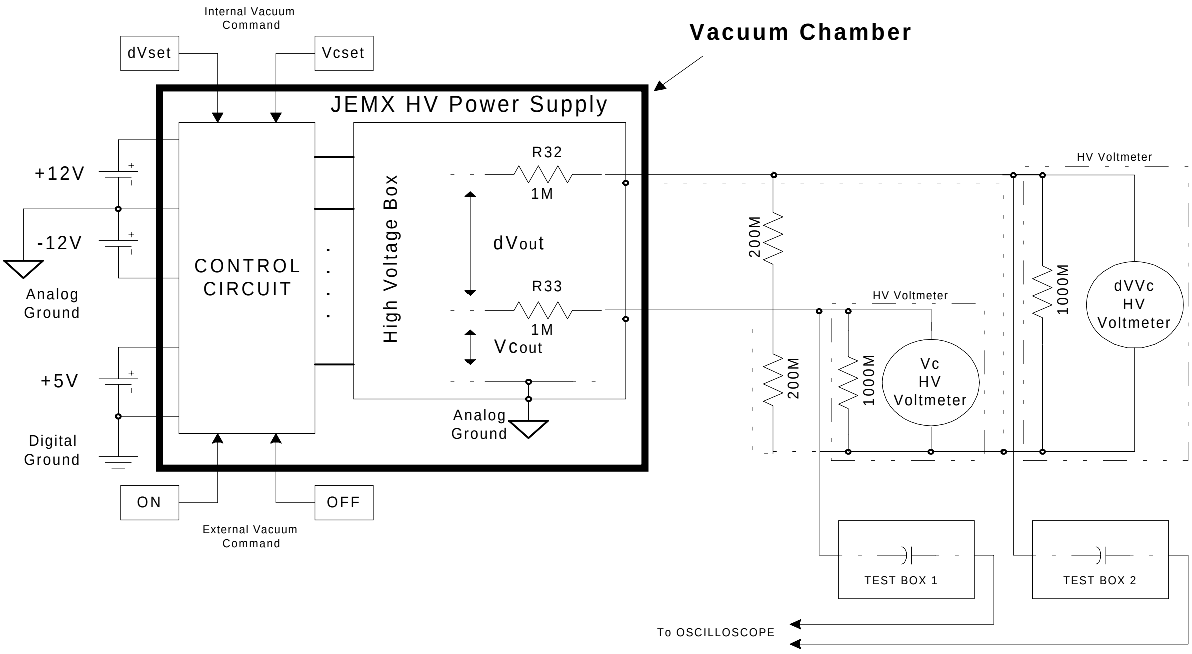

Fig. 1.8 – Hardware set-up for vacuum test

Fig. 1.9 shows Test Box 1 and 2 schemes

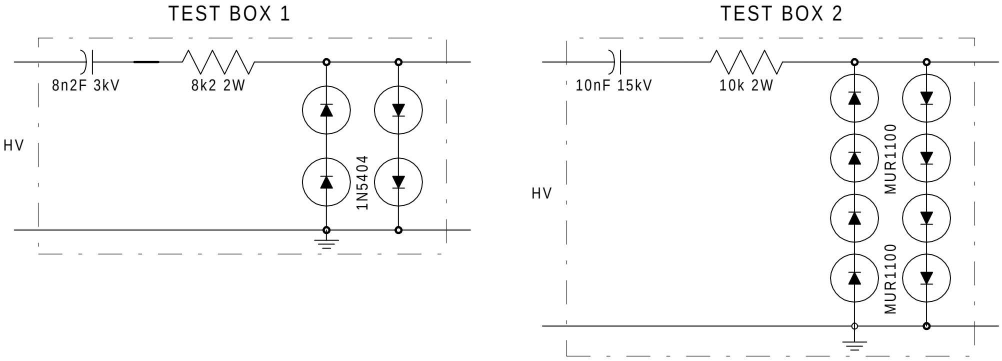

Fig. 1.9 – HV test box diagrams

The following procedure has been performed for the test in the vacuum chamber:

1- The HVPS has been switched on and set at Vcset=dVset=255d. After the ramp-up, the Vc output has reached 2523V and the dV output 5054V.
2- We verified through an oscilloscope that no HV discharges occurred.
3- The vacuum chamber pump has been switched on at h. 13:15 and the internal pressure has reached the value of 0.2 mbar at h.13:27. During the ramp-down we verified with the oscilloscope that no HV discharges occurred.
4- At h. 14:30 the internal pressure has reached the value of 0.11 mbar and no HV discharges occurred.
5- At h. 14:30 the pump has been switched off.
6- At h. 15:45 with the pressure of 12 mbar the pump has been switched on.
7- At h. 16:10 the internal pressure has reached the value of 0.11 mbar and no HV discharges occurred. The pump has been switched off
8- At h. 16:30 with the pressure of 0.6 mbar the valve controlling the air flux from outside was open and internal pressure went rapidly to 400 mbar. We verified with the oscilloscope that no HV discharges occurred and the pump has been switched on.
9- At h. 16:40 the internal pressure has reached the value of 0.3 mbar the pump has been switched off. HVPS has been switched off and later switched on again. No HV discharges occurred.
10- At h. 16:50 the valve controlling the air flux from outside was open and internal pressure raised to room pressure. An HVPS On/Off cycle was performed and neither HV discharge or malfunctioning occurred.
11- At h. 17:00 the test finished.

The reading of the absorbed currents on +12V e –12V has been performed on the analog ammeters of the bench power supply. So the values are just an indication since they are effected by a high reading error.

Table 1.12 – Vacuum test measurement

Time	Pressure	Vc HV Voltmeter	DV HV Voltmeter	Ripple (Vc)	Ripple (dV)	Ipw(+12V)	Ipw(-12)
h 13:15	1000 mbar	2523	5054	<20mVpp	<40mVpp	100mA	115mA
h 13:27	0.2 mbar	2523	5054	<20mVpp	<40mVpp	100mA	115mA
h 14:30	0.11 mbar	2524	5057	<20mVpp	<40mVpp	100mA	115mA
h 15:45	12 mbar	2524	5058	<20mVpp	<40mVpp	100mA	115mA
h 16:10	0.11 mbar	2524	5058	<20mVpp	<40mVpp	100mA	115mA
h 16:30	0.6 mbar to 400 mbar	2524	5058	<20mVpp	<40mVpp	100mA	115mA
h 16:40	0.3 mbar	2524	5058	<20mVpp	<40mVpp	100mA	115mA
h 16:50	1000 mbar	2524	5058	<20mVpp	<40mVpp	100mA	115mA

Vacuum test conclusions

No discharges on the HV outputs have been detected. The Vc output voltage, the ripple and the absorptions did not change according to the pressure and during time. The small change measured on the dV channel is due to a temperature variation and is not dependent by pressure how it has been shown during thermal tests.
The test gave a positive result.