# Technical Information Manual

Revision n. 0

15 December 2000

**JEM-X**

*HV POWER SUPPLY*
*FLIGHT MODEL 1*

# *GENERAL SAFETY PRECAUTIONS*

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use the product only as specified.
Only qualified personnel should perform service procedures.

## Injury Precautions

**Use Proper Power Cord and HV Cables.**
To avoid fire hazard, use only the power cord and HV cables specified for this product.
**Avoid Electric Overload.**
To avoid electric shock or fire hazard, do not apply a voltage to a load that is outside the range specified for that load.
**Avoid Electric Shock.**
To avoid injury or loss of life, do not connect or disconnect cables while they are connected to a voltage source.
**Do Not Operate in Wet/Damp Conditions.**
To avoid electric shock, do not operate this product in wet or damp conditions.
**Do Not Operate in an Explosive Atmosphere.**
To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

## Product Damage Precautions

**Use Proper Power Source**.
Do not operate this product from a power source that applies more than the voltage specified.
**Do Not Operate With Suspected Failures.**
If you suspect there is damage to this product, have it inspected by qualified service personnel.

## Terms in this Manual

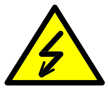
These terms may appear in this manual:
**WARNING:**
Warning statements identify conditions or practices that could result in injury or loss of life.
**CAUTION:**
Caution statements identify conditions or practices that could result in damage to this product or other property.

## Terms and Symbols on the Product

These terms may appear on the product:

- **DANGER** indicates an injury hazard immediately accessible as you read the marking.
- **WARNING** indicates an injury hazard not immediately accessible as you read the marking.
- **CAUTION** indicates a hazard to property including the product.

The following symbols may appear on the product:



**DANGER**
**High Voltage**

**ATTENTION**
**Refer to Manual**

# TABLE OF CONTENTS

# LIST OF FIGURES



# LIST OF TABLES

# *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 |
| **$T_{Ramp\text{-}up/Ramp\text{-}Down}$:** | 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. General description

## 1.1. Technical Specifications Table

**Table 1.1 - Technical specifications of the JEM-X HV Power Supply**

(these specifications apply for T=20°C)

| | |
|---|---|
| **Packaging** | 220x140x49.6 mm (see § 2.1.2, p.14 for details) |
| **Weight** | 1140 gr |
| **Operating temperature** | -25° ÷ +35°C |
| **Number of output channels** | 2 |
| **Polarity** | positive |
| **Output voltages ($V_{OUT}$) (*)** | • *dV channel*: 300 ÷ 2500 V (ref. To Vc)<br>• *Vc channel*: 300 ÷ 2500 V (ref. to AGND) |
| **Output Current ($I_{OUT}$)** | see Table 1.1, p.11 |
| **Maximum Voltage ($V_{MAX}$ hardware)** | see Table 1.1, p.11 |
| **Maximum Current ($I_{MAX}$)** | see Table 1.1, p.11 |
| **Voltage set resolution (*)** | • *dV channel*: 8 bit<br>• *Vc channel*: 8 bit |
| **Under-Voltage Threshold ($\lvert V_{+12}\rvert + \lvert V_{-12}\rvert$)** | 22.8 V |
| **Frequency** | 32.6 kHz |

*(*) see Fig. 1.1, p.10 and Table 1.1, p.11 for further details on voltage and current specifications.*

## 1.2. *Overview*

The JEM-X High Voltage Power Supply has been specially designed for the JEM-X Experiment in the *INTEGRAL* Project.

It is essentially composed by a High Voltage (HV) Multiplier and a Control Board equipped with an Interface connector to be inserted into the JEM-X crate. Its function is to deliver two output high voltages to supply the JEM-X detector.

Its features include a wide range of operating temperature (-25° ÷ +35°C), light weight (about 1 kg) and low absorption over the whole operating temperature range.

The JEM-X Power Supply delivers the following output voltages (refer to Fig. 1.1):

- **Vc channel**: +2.5 kV output voltage with reference to the ground;
- **dV channel:** +2.5 kV differential output voltage with reference to the Vc channel, as shown in Fig. 1.1.

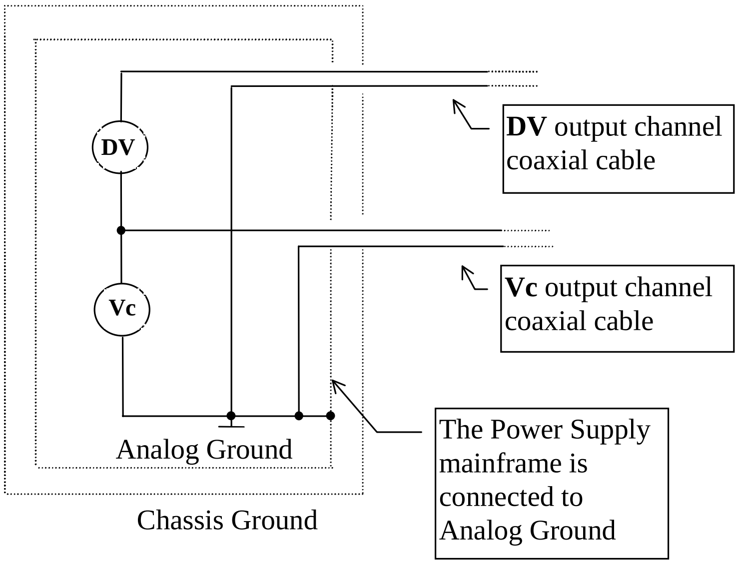



**Fig. 1.1 – Output channels of the JEM-X High Voltage Power Supply**

**Table 1.1 – Voltage and current specifications for the output channels**

(these specifications apply for T=20°C)

| *Channel* | $V_{OUT}$ | $V_{MAX}$ | $V_{MAX}$ hardware | $V_{RES}$ | $I_{OUT}$ (**) | $I_{MAX}$ | $T_{Ramp-Up/Ramp-Down}$ |
|---|---|---|---|---|---|---|---|
| ***dV*** | 300 ÷ 2500 V | 2500 V | 2676 V | 8 bits | 15 µA | 101 µA | 30 V/s |
| ***Vc*** | 300 ÷ 2500 V | 2500 V | 2667 V | 8 bits | 15 µA | 94 µA | 30 V/s |

*(**) nominal load is 10 µA.*

The output voltage $\mathbf{V_{OUT}}$ of each channel can be set via software by a write access to the relevant register (see § 5.1.1, p.26 for the setting of the $\mathbf{V_{OUT}}$ parameter).
Both the maximum output current $\mathbf{I_{MAX}}$ and the maximum output voltage $\mathbf{V_{MAX}}$ **hardware** are set at the factory, but can be changed by replacing the relevant resistors on the Printed Circuit Board (PCB). For further details please refer to § 6.1, p.32.
The **Ramp-Up/Ramp-Down** parameters as well can be changed by replacing the relevant resistors and capacitors on the PCB, as explained in the Section mentioned above.

The *dV* and *Vc* channels are powered on/off simultaneously.

At Power-On (**ON** command) the two channels are set to a $\mathbf{V_{MIN}}$ output voltage <300 V and then reach the programmed $\mathbf{V_{OUT}}$ value at a 30 V/s **Ramp-Up** rate. The $\mathbf{V_{MIN}}$ value from which the channel starts the Ramp-Up depends also on temperature and consequently may vary from time to time: however, its value will be always less than 300 V. The **Ramp-Up/Ramp-Down** rate is followed any time the output voltages $\mathbf{V_{OUT}}$ are changed, according to the $\mathbf{V_{OUT}}$ values programmed in the relevant setting registers.

The **OFF** command turns the channels off according to the discharge time of the internal capacitors of the power supply. A further Off command (**OFF SPACECRAFT**) is available, which allows to override also the ON command.

A **RESET** command is also available to turn the channels off and reset the registers. For further details on the commands please refer to § 5.3, p.30.

**Over-Current**, **Over-Voltage** and **Under-Voltage** protections have been foreseen, as well as protection against short-circuit for unlimited time.
The **Over-Current** protection is of the constant current type, i.e. the channel cannot draw more than the $\mathbf{I_{MAX}}$ current and behaves like a current generator.

The **Over-Voltage** protection is done by clamping to the maximum voltage $\mathbf{V_{MAX}}$**.hardware**, while the **Under-Voltage** protection is achieved by reducing the $\mathbf{V_{OUT}}$ values as soon as the Under-Voltage Lockout threshold is reached (i.e. $(|V_{+12}| + |V_{-12}|) < 22.8$ V).

## 1.3. *Short Functional description*

The JEM-X High Voltage Power Supply is composed of two parts:

- High Voltage Multiplier;
- Control Board with the Interface Connector.

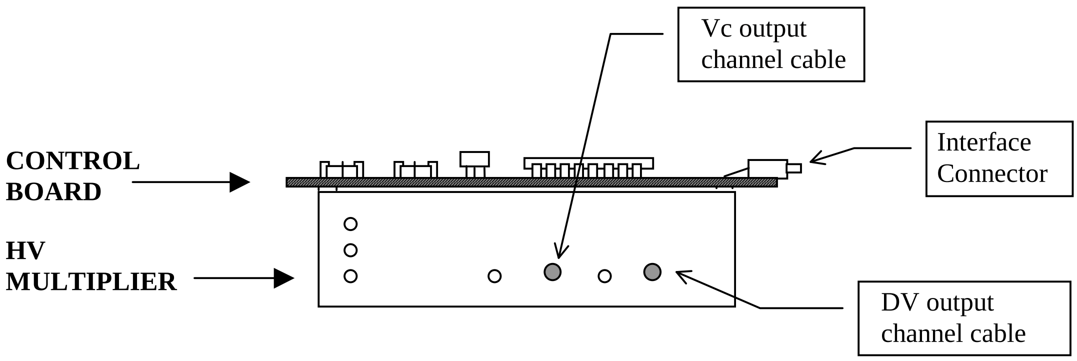



**Fig. 1.1 – The JEM-X High Voltage Power Supply**

The two parts are assembled as shown in Fig. 1.1: the Control Board is mounted onto the HV Multiplier box by means of six screws. The Control Board and the HV Multiplier are electrically connected by 8 gold-coloured shielded cables.

The HV Multiplier delivers the output voltages of the dV and Vc channels, according to the specifications given in Table 1.1, p.11.
The output voltages of the Vc and dV channels are delivered by means of 2 white-coloured coaxial cables. The shielding of these cables is referred to Analog Ground, as shown in Fig. 1.1.

**WARNING**: HV cables requires careful handling in order to avoid damage to the JEM-X Power Supply.

**WARNING**

**HIGH VOLTAGE CABLES REQUIRE EXTREMELY CAREFUL HANDLING!**

The Interface connector is mounted on an edge of the Control Board as shown in Fig. 1.1. It interfaces the JEM-X Power Supply with the crate into which the module must be inserted. Both powering and control of the JEM-X Power Supply are provided by means of this connector. Mechanical and electrical specifications of the connector are reported in § 2.2.2.1, p.17.

During test procedures the module can be alternatively connected to the PC Interface Module which allows powering and full control of the JEM-X Power Supply from a standard PC.
The set-up is shown in Fig. 1.3: please note that both the HV Power Supply and the PC Interface module must be placed on an insulated plain.

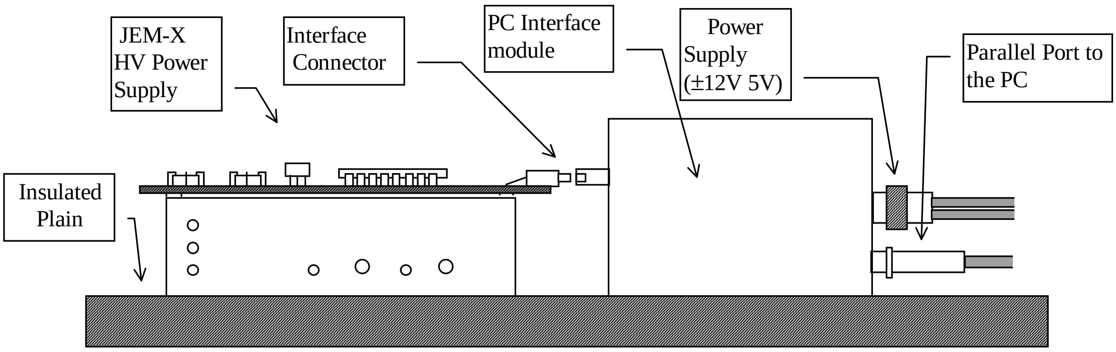



**Fig. 1.3 – The JEM-X High Voltage Power Supply and the PC Interface Module**

# 2. Technical Specifications

## 2.1. Mechanical specifications

### 2.1.1. Packaging

The JEM-X Power Supply overall dimensions are 220x140x49.6 mm.

### 2.1.2. Mechanical Parts

See Fig. 2.1, p.15. for the HV Power Supply box mechanical drawings Fig. 2.1, p.15.

The side views of the HV Power Supply are shown in
Fig. **2.2** and Fig. 2.3 at page 16.

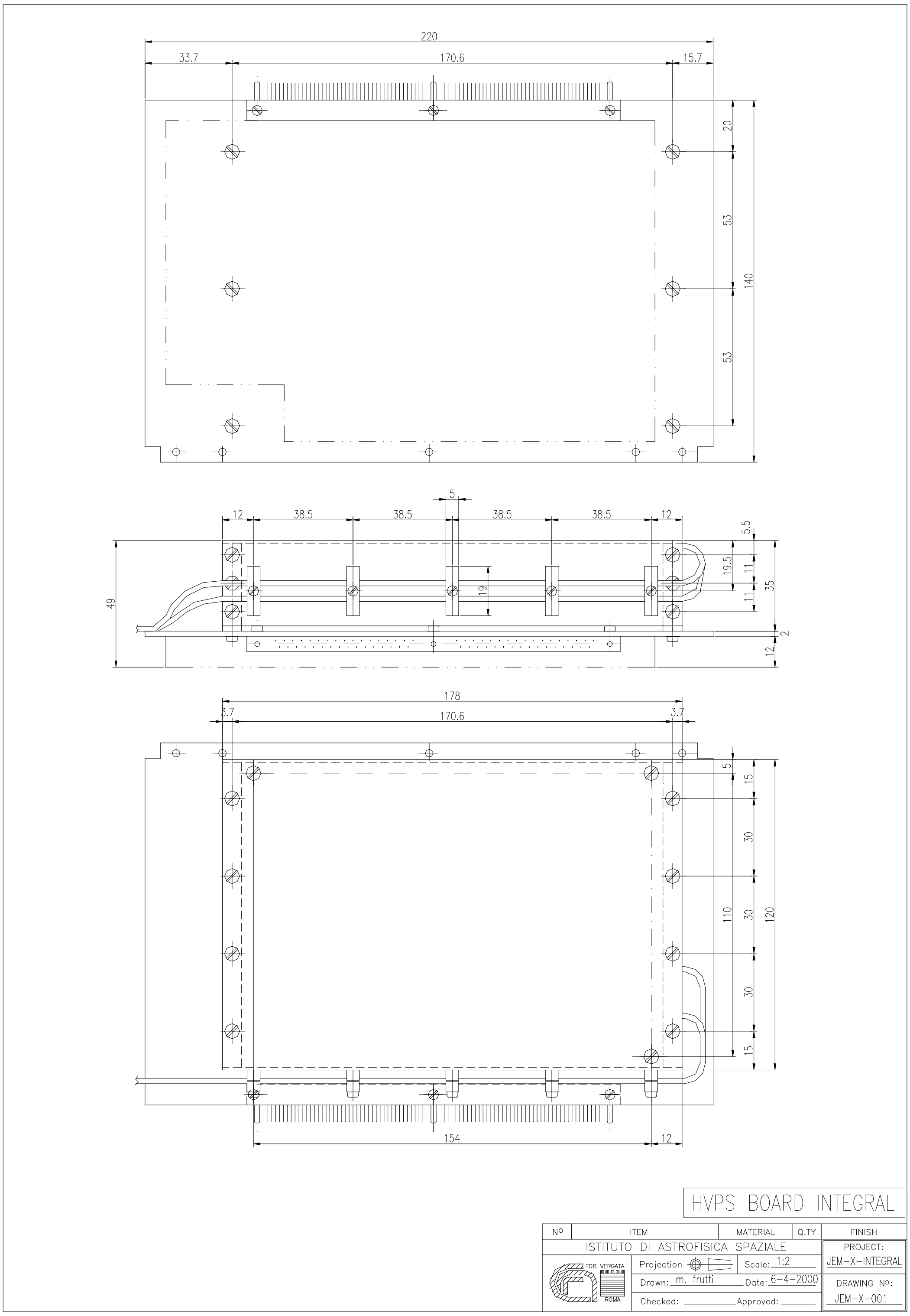



**Fig. 2.1 – HVPS box mechanical drawings**

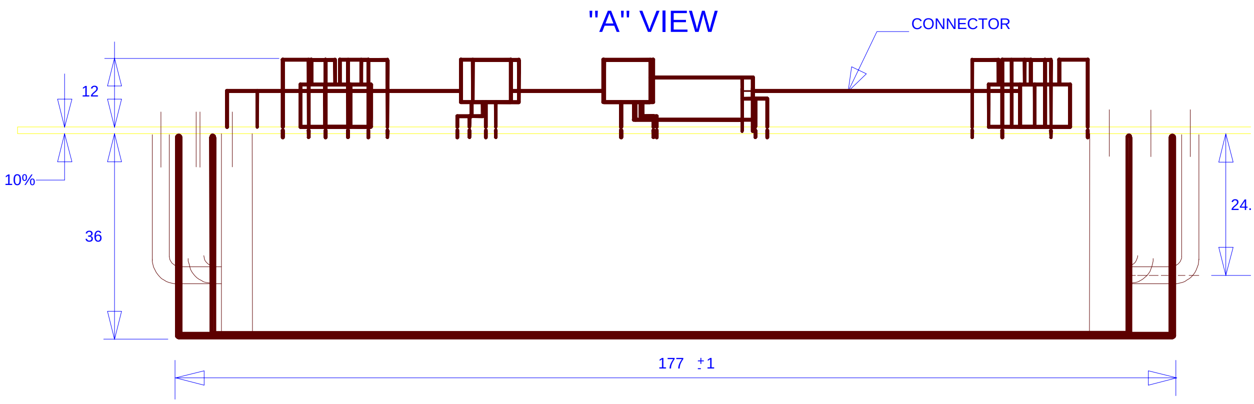



**Fig. 2.2 – Mechanical specifications of the JEM-X High Voltage Power Supply:** ***side A*** **view**

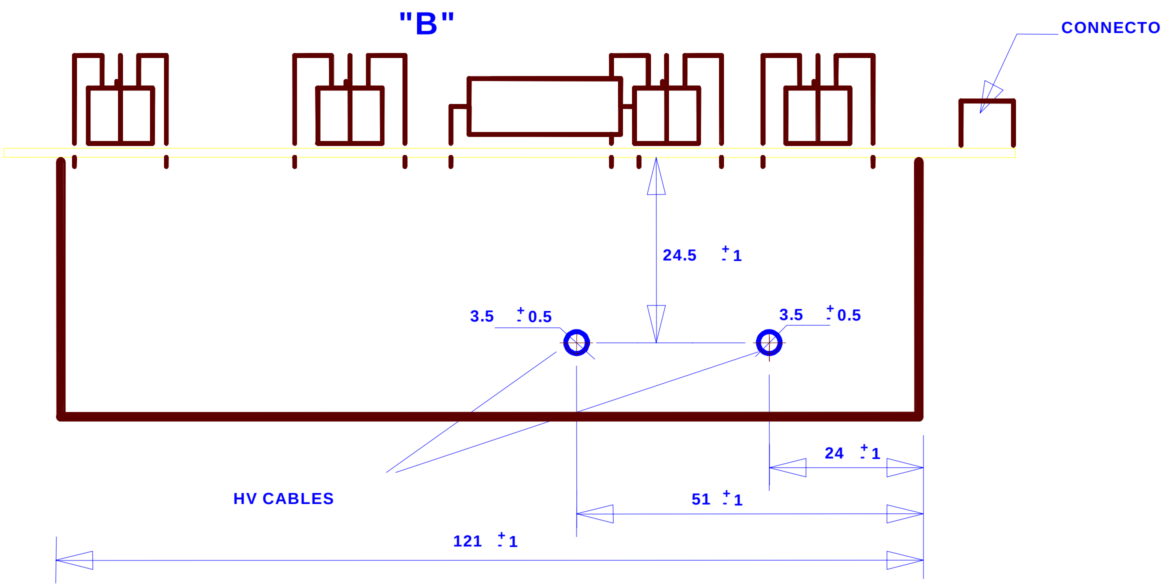



**Fig. 2.3 – Mechanical specifications of the JEM-X HV Power Supply:** ***side B*** **view**

## 2.2. Electrical specifications

### 2.2.1. Power Requirements

The HV Power supply has three power supply sources: +12 V, -12 V and +5 V (tolerance: ±5%) provided through the Interface Connector.
The absorption is less than 2.7 W @ ±12 V with maximum load. This absorption value applies over the whole operating temperature range.

### 2.2.2. External connections

#### 2.2.2.1. Interface Connector

***Function:*** it interfaces the HV power supply module with the crate. It delivers power supply to the module and allows its control via the signals listed below. This connector can be alternatively used to connect the HV Power Supply to the PC Interface module during test procedures

***Mechanical specifications:*** FRB CONNECTRON 96-pin male HE801 connector.
***Electrical specifications:***

**TEMP1**: *output signal*; it gives the temperature of the sensor T1. The output voltage value must be divided by 10 mV in order to obtain the temperature value in °K. See § 5.1.7, p.29 for further details.

**TEMP2**: *output signal*; it gives the temperature of the sensor T2. The output voltage value must be divided by 10 mV in order to obtain the temperature value in °K. See § 5.1.7, p.29 for further details.

**dVMON**: *output signal*; it gives the output voltage value $V_{OUT}$ of the dV channel.

**VCMON**: *output signal*; it gives the output voltage value $V_{OUT}$ of the Vc channel.

**BCSN**: *active low TTL signal*; data bus enable.

**DIR**: *TTL signal*; it determines the data bus direction (read/write).

**CSN**: *active low TTL signal*; slot selection.

**A0, A1**: *TTL signal*; register addressing. The only valid address is 00, corresponding to the register containing the DAC setting. All the other address are not meaningful.

**DB0…15**: *TTL signal*; it allows to set the 16-bit register for the $V_{OUT}$ setting as specified in § 5.1.1, p.26.

**/RESET**: *active low, TTL signal*; it turns all the channels off and resets the 16-bit register.

**OFF**: *trailing-edge active, TTL signal*; it turns the channels off.

**ON**: *leading-edge active, TTL signal*; it turns the channels on according to the Ramp-Up parameter. This signal is overridden by the OFF SPACECRAFT signal.

**S/C A, S/C K**: *active high signal (galvanically insulated)*; this is the **OFF SPACECRAFT** signal and is active from +12 to +16 V with trigger threshold at +8 V±1 V. It turns all the channels off. It overrides the ON signal.

**+12V**: *input signal*; +12 V power supply source.

**-12V**: *input signal*; -12 V power supply source.

**AGND**: Analog Ground; it is connected to the HV Multiplier box.

**+5V**: *input signal*; +5 V power supply source.

**DGND**: Digital Ground.

The pin assignment of the Interface Connector is given in APPENDIX A (see Fig. A.1 p. 41).

#### 2.2.2.2. dV and Vc channel High Voltage Cables

The HV cables are L-type coaxial cables (GORE, part number GSC 05-81739-00).
Refer to Fig. 1.1, p.10 for details on the shielding.

# 3. Manufacturing and Assembly procedures

## 3.1. Check List of Manufacturing and Assembly procedures

**Table 3.1 - List of manufacturing and assembly procedures**

| ✓ | Procedure | Reference |
|---|---|---|
| | Assembly of the transformers of the HV Multiplier | See § 3.3, p.19. |
| | Potting of the transformers of the HV Multiplier | See § 3.3, p.19. |
| | Components soldering on the Control Board | See § 3.4, p.20. |
| | Components soldering on the PCB of the HV Multiplier | See § 3.4, p.20. |
| | Potting of the HV Multiplier | See § 3.6, p.20. |
| | Final assembly of the HV Power Supply | See § 2.1.2, p.14 and § 3.7, p.23. |

## 3.2. Materials List

For a detailed list of the materials constituting the Power Supply please refer to APPENDIX B.

## 3.3. Transformers assembly

The transformers for the HV Multiplier were assembled at the factory, in compliance with specs MIL-PRF-27F, through the following phases:

1. Selection of the toroidal cores which present the best permeability stability vs. temperature through test in thermal room between –20 °C and +40 °C.
2. Winding of transformer’s primary with FEP wire insulated up to 18 kV.
3. Shielding of transformer’s primary with copper sheet and connection of a FEP wire to the shield.
4. Coating by resin Urethane Compound URALANE 5753; the transformer is coated two times at two days distance and put in oven at 65 °C (for two days) to let the resin dry.
5. Transformer’s secondary winding with enameled double insulation wire (the first and the last 3 turns with twisted wire).
6. Coating by the same resin; the transformer is then put in oven at 65 °C to dry for two days.

<u>Materials employed:</u>
HV wire for the primary: REYNOLDS code 178-8287 red
Enameled copper wire: diam 0.125 mm
Resin: URALANE 5753
Ring core: R25/10 grade N30 Siemens

Electrical characteristics:
Primary: 16 turns with bifilar wire evenly spaced over the toroid
Secondary : 460 turns evenly spaced over the toroid (without overlapping)

## 3.4. Components Soldering

The electrical components on both the Control Board and the Printed Circuit Board of the HV Multiplier were soldered by ESA qualified personnel (following ESA specs PSS-01-708).

## 3.5. Components assembly and soldering on the DAC daughter board

A new DAC daughter board has been employed into the HVPS Flight Model 2 to obtain 8 bit resolution on both dV and Vc channel. Here below is briefly explained the assembly and soldering procedure of the DAC daughter board over the Control PCB.

1. Soldering of the pins 0.5 mm with solder alloy Sn 63 (eutectic alloy, melting at 183 °C) on the daughter card instead of solder alloy Sn 96 (eutectic alloy, melting at 221 °C) because better result have been found after the assembly inspection of a sample.

2. Soldering inspection with particular attention to the alloy soldering height (1 mm about).

3. Daughter card functional test through pins insertion on the relative connectors of a prototype board.

4. Fixing of the three spacers to the daughter card through Urethane Compound URALANE 5753 (the same used for HV potting) to damp possible thermal expansion differences on the Z axis between pins and PCB.

5. Fixing of the daughter card and the relative spacers to the HVPS PCB through Urethane Compound URALANE 5753.

6. Pins soldering with solder alloy Sn 63 (eutectic, melting at 183 °C) on the HVPS PCB taking care to minimise the soldering time in order to reduce reflow problems.

7. Inspection of the HVPS PCB solderings on the soldering side of the daughter card.

## 3.6. Potting process

The potting process of the HV Multiplier was performed by using a two-component resin (CIBA URALANE 5753) as potting material.

The potting process consisted of three phases: a first phase during which the resin was applied to the HV Multiplier PCB (both sides) and to the internal box sides, a second phase during which the PCB was inserted inside the metallic box and then covered with the resin so as to reach the level of the PCB (8-mm high resin layer) and, finally, a third phase during which the resin was poured into the container until all critical components were fully covered (about 20-mm high resin layer).

In more detail, the procedure observed during potting process is as follows:

1) the aluminium container and the PCB, completely assembled, were cleaned manually by using isopropylic alcohol;

2) the container and the PCB were heated up to 60°C for an hour;

3) Resin preparation:

   - both the resin (component A) and catalyst (component B) were checked to detect any eventual undissolved particle or crystallisation process. The check showed that the two components were perfectly liquid and free from impurities;

   - 500 gr of Component B was carefully mixed with 5 drops of FURANE AF-4 anti-foam material in a glass container;

   - the mixture obtained was taken to a pressure of 29 mmHg for 5 minutes;

   - 100 gr of Component A was added to the previous mixture; the mixture was taken to a pressure of 29 mmHg for 5 minutes;

4) the mixture was applied by brush to both sides of the PCB and to the box internal sides. No primer was used. No adhesion problems were detected;

5) the PCB was inserted into the aluminium container, kept at ambient temperature for 24 h and subsequently at 70 °C for 24 h; then a functional test was performed to verify the absence of any microdischarge process;

6) a further amount of resin was prepared according to the procedure as in point 3 and the mixture obtained was carefully poured into the container until the level of the PCB was reached (8-mm high layer). The latter operation was performed paying particular attention to avoid air bubbles;

7) the box filled with resin up to 8 mm was taken to a 29 mmHg pressure for 5 minutes;

8) polymerisation occurred after keeping the box at room temperature (about 25°C) for 48 hours in a clean room;

9) a further amount of resin was prepared according to the procedure as in point 3;

10) the resin obtained was poured into the container until all critical components of the PCB, except for the highest ones such as the toroidal transformers T1 and T2, their connecting cables and the HV capacitors C25, C26, C27, C28, C29, C94, C95, were completely covered (about 20-mm high layer). Particular attention was paid to avoid the inclusion of air bubbles into the resin;

11) the box filled with resin up to 20 mm was taken to a 29 mmHg pressure for 5 minutes;

12) the HV Multiplier was kept at ambient temperature for 4 h; then the zones to be still covered with resin (see point 10) were delimited with mylar sheets;

13) a further amount of resin was prepared according to the procedure as in point 3 and all components were completely covered;

14) the mylar was subsequently removed and resin applied a second time by brush to those parts previously in contact with mylar.

15) polymerization occurred after keeping the HV Multiplier at room temperature (about 25°C) for 10 days in a clean room;

16) a functional test was performed to verify the absence of any microdischarge process;

17) a conductive paint LORD AEROGLAZE Z307 was applied over the whole coated surface;

18) finally the HV multiplier was kept for 16 h at 65 °C.

## *3.7. Mechanical Parts Assembly*

The HVPS box consist of 3 aluminium parts: a 1 mm thick U case and two 7.5 mm thick box sides. Here below the box assembly procedure is shortly described:

1. Control and HV cables connected to the HV PCB are inserted within the holes in the box sides putting a heatshrink tube between the cable and mechanics.
2. A first coating of PCB and box internal sides is performed by brush (see § 3.6 for the potting procedure).
3. The PCB is fixed to the mechanics through three 5-mm teflon spacers with 3 stainless steel flat head screws (type DIN395, 3MA) and 3 stainless steel nuts.
4. The box sides are fixed to the U case through 10 stainless steel flat head screws (type DIN395, 3MA).
5. One day wait for the resin to catalyze
6. Complete coating (see § 3.6)
7. The coated box is then fixed to the control PCB through 6 stainless steel screws and washers putting a sil-pad sheet between PCB and mechanics to guarantee electrical insulation and ensure a good thermal contact.

# 4. Hardware installation and set-up

## 4.1. Safety information

Before starting any procedure of installation or operation of the product, please read thoroughly the *General Safety Precautions* Section located at the beginning of this Manual.

Moreover, pay particular attention to the grey areas where further safety notes are emphasised as shown in the examples below:

**WARNING**

**HV CABLES REQUIRE EXTREMELY CAREFUL HANDLING!**

## *4.2. Installation*

Before installing the JEM-X HV Power Supply check to have thoroughly read the safety rules listed at the beginning of this Manual.

To install the HV Power Supply refer to the following procedure:

1) Attach the two HV cables of the HV Power Supply to the relevant connectors: during this operation **pay particular attention to anchor perfectly the shielding and the HV wire of each HV coaxial cable to the relevant connector** and **verify that there is no contact between the shielding and the HV wire**;
2) Turn off the crate into which the Power Supply must be inserted;
3) Insert the Power Supply into the crate until the Interface Connector is thoroughly plugged into the relevant backplane connector.

**WARNING**: Before turning on the HV Power Supply check thoroughly that the HV cables are correctly connected to the utiliser and verify that the shielding and the HV wire of the coaxial cables are perfectly anchored to the relevant connectors and insulated between themselves.

**WARNING**

**ANCHOR PERFECTLY THE SHIELDING AND THE HV WIRE**

**OF EACH HV COAXIAL CABLES TO THE RELEVANT CONNECTOR!**

**WARNING**

**VERIFY THAT THERE IS NO CONTACT**

**BETWEEN THE SHIELDING AND THE HV WIRE!**

# 5. *Operating mode*

## 5.1. *The Channel parameters and their setting*

### 5.1.1. *Output Voltage ($V_{OUT}$)*

The Output Voltage $\mathbf{V_{OUT}}$ of the dV channel and of the Vc channel can be set via software in the following voltage ranges:

- **dV channel: 300 ÷ 2500 V;**
- **Vc channel: 300 ÷ 2500 V.**

These values can be set by a write access to the 16-bit Register shown in Fig. 5.1 with a resolution of 8 bit for the $\mathbf{V_{OUT}}$ value of the dV channel and of 8 bit for the $\mathbf{V_{OUT}}$ value of the Vc channel.

The bits from DB4 to DB11 are used to set the $\mathbf{V_{OUT}}$ value for the dV channel, while the bits from DB0 to DB3 and from DB12 to DB15 are used for the setting of the $\mathbf{V_{OUT}}$ of the Vc channel:

| | |
|---|---|
| DB4 | LSB of the $\mathbf{V_{OUT}}$ value for the dV channel; |
| DB11 | MSB of the $\mathbf{V_{OUT}}$ value for the dV channel; |
| DB0 | LSB of the $\mathbf{V_{OUT}}$ value for the Vc channel; |
| DB15 | MSB of the $\mathbf{V_{OUT}}$ value for the Vc channel; |

16-bit register of the HV Power Supply

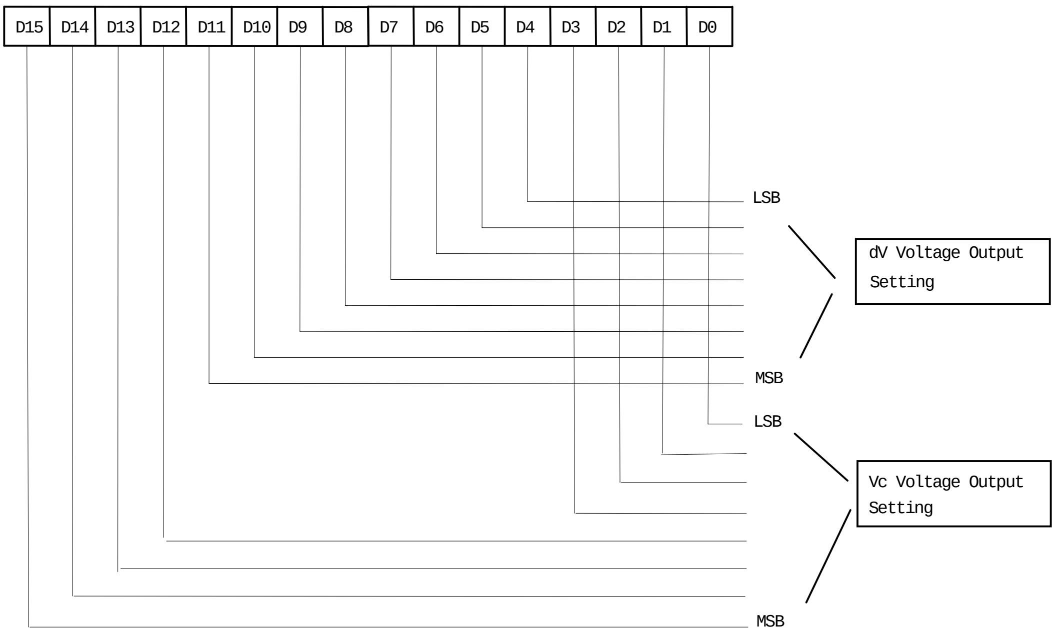



**Fig. 5.1 – The 16-bit Register for the setting of the $V_{OUT}$ values of the dV and Vc channels**

For example, in order to set 0xDC HEX on the DAC relative to the dV channel and 0xC8 HEX on the DAC relative to the Vc channel, corresponding in binary notation to:

11011100 for the dV channel,

11001000 for the Vc channel,

the word to be written in the 16-bit Register is (refer to Fig. 5.1):

**1100110111001000.**

Please refer to § 2.2.2.1, p.17 and to the figure in APPENDIX D for the location of the Interface Connector pins corresponding to the register bits.

The value to be written (in bits) in the DAC of the VC channel in order to obtain the $\mathbf{V_{OUT(VC)}}$ voltage (in Volt) output of the VC channel is given by:

$$\mathbf{DAC_{(VC)} = m_{Vset(VC)} * V_{OUT(VC)} + q_{Vset(VC)}}$$

Where the $\mathbf{m_{Vset(VC)}}$ and $\mathbf{q_{Vset(VC)}}$ coefficients are as follows:

| | | |
|---|---|---|
| $\mathbf{m_{Vset(VC)}}$ = | 0.1013603 | (bit/ Volt), |
| $\mathbf{q_{Vset(VC)}}$ = | -1.190815 | (bit). |

The value to be written (in bit) in the DAC of the dV channel in order to obtain the $\mathbf{V_{OUT(dV)}}$ output voltage (in Volt) of the dV channel is given by:

$$\mathbf{DAC_{(dV)} = m_{Vset(dV)} * V_{OUT(dV)} + q_{Vset(dV)}}$$

where the $\mathbf{m_{Vset(dV)}}$ and $\mathbf{q_{Vset(dV)}}$ coefficients are as follows:

| | | |
|---|---|---|
| $\mathbf{m_{Vset(dV)}}$ = | 0.0998953 | (bit/ Volt), |
| $\mathbf{q_{Vset(dV)}}$ = | 0.0069927 | (bit). |

$\mathbf{DAC_{(VC)}}$ and $\mathbf{DAC_{(dV)}}$ are consequently the values which must be set in the DACs in order to obtain, respectively, $\mathbf{V_{OUT(VC)}}$ and $\mathbf{V_{OUT(dV)}}$ values at the outputs of the Vc and dV channels.

The relation between the actual output voltages, $\mathbf{V_{OUT(VC)}}$ and $\mathbf{V_{OUT(dV)}}$, and the monitored output voltages, $\mathbf{V_{mon(VC)}}$ and $\mathbf{V_{mon(dV)}}$ (refer to § 2.2.2.1, p.17 and to the figure in APPENDIX D for the location of the Interface Connector pins corresponding to the $\mathbf{V_{mon(VC)}}$ and $\mathbf{V_{mon(dV)}}$ values), is as follows:

$$\mathbf{V_{out(VC)} = m_{Vmon(VC)} * V_{mon(VC)} + q_{Vmon(VC)}}$$

$$\mathbf{V_{out(dV)} = m_{Vmon(dV)} * V_{mon(dV)} + q_{Vmon(dV)}}$$

Where:

| | | |
|---|---|---|
| $\mathbf{m_{Vmon(VC)}}$ = | 998.7642573 | |
| $\mathbf{q_{Vmon(VC)}}$ = | 1.560937909 | (Volt) |
| $\mathbf{m_{Vmon(dV)}}$ = | 1001.702446 | |
| $\mathbf{q_{Vmon(dV)}}$ = | 0.424173206 | (Volt) |

All equations and coefficients listed above have been obtained by calibrating the HV Power Supply according to the procedure explained in § 6.2, p.37. They obviously differ from model to model and therefore the above coefficient values apply only for this Flight Model. Consequently the calibration must be performed for each Model of HV Power Supply.
The Power Supply has been hardware calibrated at the factory for a precision of approximately 2%. In order to increase reading and set precision, it is suggested the User should perform the calibration procedure explained in § 6.2, p.37.

### *5.1.2. Maximum Programmable Output Voltage ($V_{MAX}$)*

The Maximum Programmable Output Voltage $\mathbf{V_{MAX}}$ is the maximum output voltage value which can be programmed via software, i.e. the maximum value which can be set for the $\mathbf{V_{OUT}}$ parameter. For this Flight Model it corresponds to:

- dV channel: $\mathbf{V_{MAX}}$ = 2500 V;
- Vc channel: $\mathbf{V_{MAX}}$ = 2500 V.

The $\mathbf{V_{MAX}}$ values for the dV and for Vc channels can be changed by replacing the relevant resistors.

### *5.1.3. Maximum Output Voltage ($V_{MAX}$ hardware)*

$\mathbf{V_{MAX}}$ **hardware** is the hardware protected maximum output voltage. The $\mathbf{V_{MAX}}$ **hardware** values for the dV and the Vc channels are set at the factory and, for this Flight Model, are respectively (at +20°C temperature):

- dV channel: $\mathbf{V_{MAX}}$ **hardware** = 2676 V;
- Vc channel: $\mathbf{V_{MAX}}$ **hardware** = 2667 V.

The value of the $\mathbf{V_{MAX}}$ **hardware** parameters can be changed by replacing the relevant resistors on the Printed Circuit Board (PCB). However, these values cannot exceed the $\mathbf{V_{MAX}}$ values of the relevant channel more than 140 V.
For further details on the hardware setting of the $\mathbf{V_{MAX}}$ **hardware** parameters please refer to § 6.1, p.32.

### *5.1.4. Output Current ($I_{OUT}$)*

This parameter is the output current at the relevant channel with a nominal load of 10 µA.

### *5.1.5. Maximum Output Current ($I_{MAX}$)*

$\mathbf{I_{MAX}}$ is the hardware protected maximum output current. The $\mathbf{I_{MAX}}$ values for the dV and the Vc channels are set at the factory and, for this Flight Model, are respectively (at +20°C temperature):

- dV channel: $\mathbf{I_{MAX}}$ = 101 µA;
- Vc channel: $\mathbf{I_{MAX}}$ = 94 µA.

The value of the $\mathbf{I_{MAX}}$ can be changed by replacing the relevant resistors on the Printed Circuit Board (PCB). For further details on the hardware setting of the $\mathbf{I_{MAX}}$ parameters please refer to § 6.1, p.32.

### 5.1.6. Ramp-Up/Ramp-Down parameter

The **Ramp-Up/Ramp-Down** parameters determine the rate at which the voltage values at the outputs of the Dv and Vc channels vary to reach the $\mathbf{V_{OUT}}$ values set in the relevant DACs. The **Ramp-Up/Ramp-Down** values for the dV and the Vc channels are set at the factory and, for this Flight Model, are respectively:

- dV channel: **Ramp-Up/Ramp-Down** = 30 V/s;
- Vc channel: **Ramp-Up/Ramp-Down** = 30 V/s.

The **Ramp-Up/Ramp-Down** rate is followed:

- during the Power-On of the Power Supply, as the channels ramp up from the $\mathbf{V_{MIN}}$ value (<300 V) to the $\mathbf{V_{OUT}}$ value set in the relevant DAC;
- any time the $\mathbf{V_{OUT}}$ value must increase/decrease according to the value set in the relevant DAC.

The values of t **Ramp-Up/Ramp-Down** parameters can be changed by replacing the relevant resistors and capacitors on the Printed Circuit Board (PCB). For further details on the hardware setting of the **Ramp-Up/Ramp-Down** parameters please refer to § 6.1, p.32.

### 5.1.7. TEMP1 and TEMP2 parameters

The TEMP1 and TEMP2 parameters correspond to the temperature readout of the relevant sensor placed on the control board. For the exact location of these sensor on the PCB (named V1 and V2, respectively), please refer to the figure in APPENDIX D.

The temperature detected by these sensors can be inferred from the output voltages on the pins TEMP1 and TEMP2 of the Interface Connector (see APPENDIX A for pin assignment and § 2.2.2.1, p.17 for electrical specifications of the signals) by taking into account the following equations:

$$\mathbf{TEMP1\ (°K) = V_{TEMP1}\ (mV) / a}\ ,$$

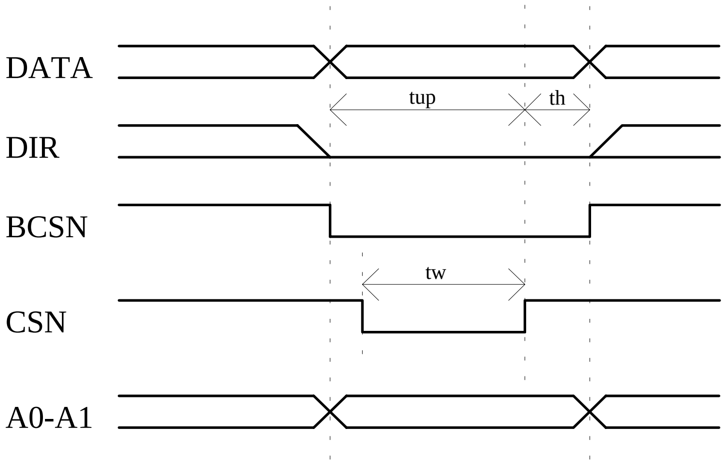
where $\mathbf{V_{TEMP1}}$ is the voltage readout at the TEMP1 pin of the Interface Connector and the coefficient ***a*** is equal to 10 mV/°K, and, similarly:

$$\mathbf{TEMP2\ (°K) = V_{TEMP2}\ (mV) / a}\ ,$$

where $\mathbf{V_{TEMP2}}$ is the voltage readout at the TEMP2 pin of the Interface Connector and the coefficient ***a*** is equal to 10 mV/°K.

## 5.2. Write cycle timing

The following figure shows the timing of the write cycle:




Tup > 100nS

Th > 0nS

Tw > 50nS

**Fig. 5.2 – Write cycle timing**

Refer to § 2.2.2.1, p.17 for details on the electrical signals reported in this graph.

## 5.3. Operating commands

### 5.3.1. ON command

The **ON** command allows to turn the channels on. It is a leading-edge active, TTL signal sent to the HV Power Supply via the relevant pin on the Interface Connector (refer to the figure in APPENDIX D). As the ON signal is sent, the channels are set to the relevant $V_{MIN}$ values (<300 V) and then reach the relevant programmed $V_{OUT}$ output voltage values according to the Ramp-Up parameter.

The **ON** signal is overridden by the **OFF SPACECRAFT** signal.

### 5.3.2. OFF command

The **OFF** command allows to turn the channels off. It is a trailing-edge active, TTL signal sent to the HV Power Supply via the relevant pin on the Interface Connector (refer to the figure in APPENDIX D). As the OFF signal is sent, the channels are turned off within a time which depends on the discharge time of the internal capacitors of the power supply.

### *5.3.3. OFF SPACECRAFT command*

The **OFF SPACECRAFT** command allows to turn all the channels off. It is sent to the Power Supply via the relevant pins **S/C A, S/C K** of the Interface Connector (refer to the figure in APPENDIX D). It is a galvanically insulated, active high signal which is active from +12 to +16 V with trigger threshold at +8 V (±1 V) and 50µs≤tr≤500µs, 50µs≤tf≤500µs and $t_{pulse}$=13ms (±2ms). As the OFF SPACECRAFT signal is sent, the channels are turned off within a time which depends on the discharge time of the internal capacitors of the power supply.
The **OFF SPACECRAFT** signal overrides the ON signal.

### *5.3.4. RESET command*

The **RESET** command turns the channels off and resets the DAC registers. It is a active low, TTL signal sent to the HV Power Supply via the relevant pin of the Interface Connector (refer to the figure in APPENDIX D). resets the DAC registers. As the RESET signal is sent, the channels are turned off within a time which depends on the discharge time of the internal capacitors of the power supply.

# 6. *Calibration of the HV Power Supply by factory*

## 6.1. *Calibration procedure for the setting of the* $V_{MAX}$ **hardware** *and* $I_{MAX}$ *parameters*

### 6.1.1. *Hardware Setting of the* $V_{MAX}$ **hardware** *of the Vc channel*

The $\mathbf{V_{MAX}}$ **hardware** setting is performed by means of the R193 and R193A resistors located on the PCB of the control board as indicated in the figure APPENDIX C.

The hardware set-up is shown in Fig. 6.1, p.32. The calibration procedure is as follows:

1) set the Vc channel in the "*open loop*" condition, i.e. the condition in which a fault is simulated in the voltage regulation loop so that the channel delivers the maximum voltage;
2) set the dV channel to the minimum voltage;
3) set the Vc channel to the maximum voltage with $R_{Vc\ load}$ = open;

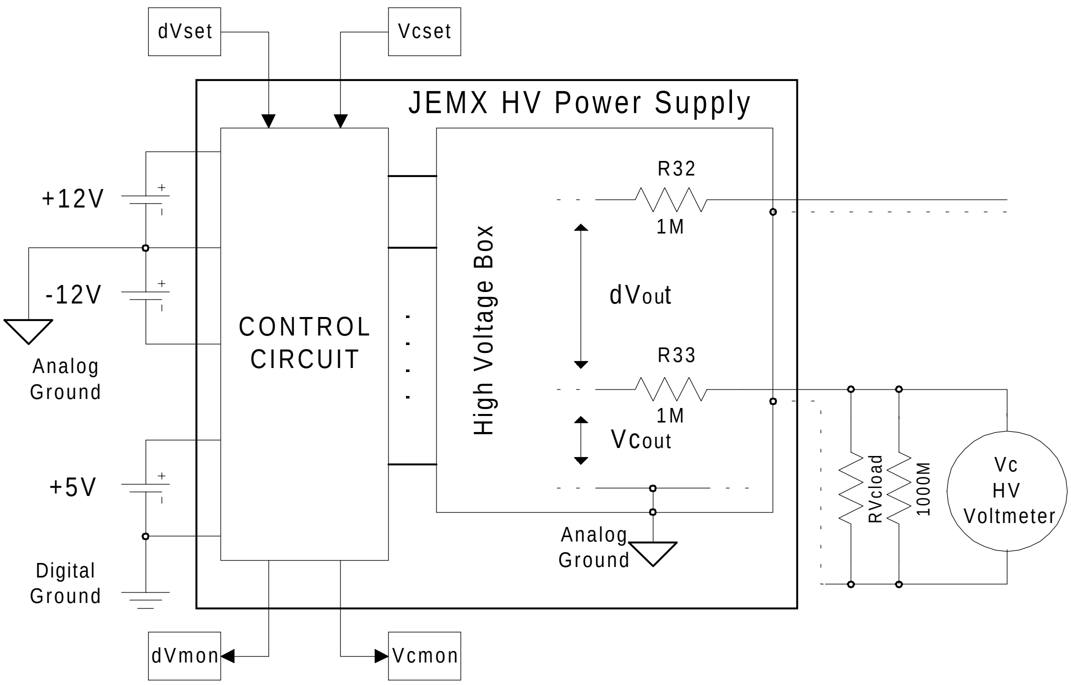



**Fig. 6.1 – Hardware Set-up for the $V_{MAX}$ setting of the Vc channel**

4) adjust the two resistors R193 and R193A until the maximum output voltage value is reached. The value can be inferred from the readout of the HV Voltmeter *Vc(HV Voltmeter)* taking into account that:

**Vcmax = [(1M+1000M)/1000M]*Vc(HV Voltmeter);**

5) set the Vc channel in the "closed loop" condition, i.e. the standard operating condition of the voltage regulation loop;
6) set the Vc channel at the maximum voltage with a $R_{Vc\ load}$ = 200 MΩ (20µA);
7) set the dV channel at the maximum voltage;
8) check that the Vc channel delivers the maximum programmed voltage and that the output of the U30A chip (pin 1 of U30 component) is not saturated negatively.

### 6.1.2. *Hardware Setting of the* $V_{MAX}$ hardware *of the dV channel*

The **$V_{MAX}$ hardware** setting of the dV channel is performed by means of the R143 and R143A resistors located on the PCB of the control board as indicated in the figure of APPENDIX D.

The hardware set-up is shown in Fig. 6.2, p.33 and the procedure is as follows:

1) set the dV channel in the "*open loop*" condition, i.e. the condition in which a fault is simulated in the voltage regulation loop so that the channel delivers the maximum voltage;
2) set the Vc channel to the minimum voltage;
3) set the dV channel to the maximum voltage with $R_{dV\ load}$ = open;

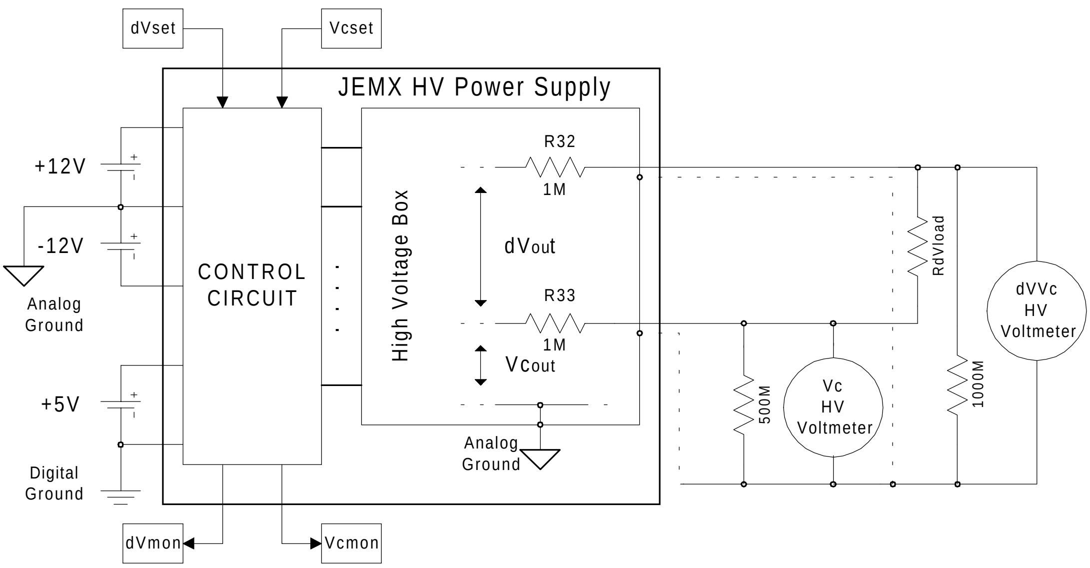



**Fig. 6.2 – Hardware Set-up for the $V_{MAX}$ setting of the dV channel**

4) adjust the two resistors R143 and R143A until the maximum output voltage value is reached. This value can be inferred from the readout of the HV Voltmeter *Vc(HV Voltmeter)* taking into account that:

**dVmax =**

**[(1M+1000M)/1000M]* dVVc(HV Voltmeter) - [(1M+500M)/500M]*Vc(HV Voltmeter);**

5) set the dV channel in the "closed loop" condition, i.e. the standard operating condition of the voltage regulation loop;
6) set the dV channel at the maximum voltage with a $R_{dV\ load}$ = 200 MΩ (20µA);
7) set the Vc channel at the maximum voltage;
8) check that the dV channel delivers the maximum programmed voltage and that the output of the U24A chip (pin 1 of the U24 component) is not saturated negatively.

### *6.1.3. Hardware Setting of the $I_{MAX}$ of the Vc channel*

The hardware setting of the $I_{MAX}$ of the Vc channel occurs in three steps:

STEP 1 - calibration of the current differentials by adjusting the R221 and R221A resistors;
STEP 2 - adjustment of the R200 and R200A resistors in order to compensate the variations of the -12 V power supply;
STEP 3 - setting of the $I_{REF}$ by adjusting the R202 resistor (refer to Fig. 6.1, P.32 for the hardware set-up);
STEP 4 - adjustment of the R227 resistor so that the Over-Current condition is kept as the dV channel voltage varies (refer to Fig. 6.1, p.32 for the hardware set-up).

In order to accomplish the STEP 1 refer to the following procedure:

1) set the dV channel to 0;
2) set the dV and Vc channels without load;
3) adjust the R221 and R221A so that the output of the current differential (pin 14 of the U30 component) does not change varying the voltage of the Vc channel;

In order to accomplish the STEP 2 refer to the following procedure:

1) set the dV channel to 0;
2) set the Vc channel to the maximum voltage;
3) adjust the R200 and R200A resistors so that the voltage on the pin5 of the U30 component does not change varying the -12 V power supply (power supply variation of ±0.6V);

In order to accomplish the STEP 3 refer to the following procedure:

1) set the dV channel to the maximum voltage;
2) set the Vc channel to the maximum voltage with $R_{VC\ load}$ = 20 MΩ (150 µA);

3) adjust the R202 resistor until the current loop starts to control the regulation, i.e. as the U30B comparator output (pin 7 of the U30B comparator) is no longer saturated negatively.

In order to accomplish the STEP 4 refer to the following procedure:

1) put the Vc channel in the Over-Current condition by inserting a $R_{VCload}$=20 MΩ;
2) adjust the R227 resistor so that the Vc channel is always in Over-Current as the dV channel voltage varies (dV channel not limited in current).

### *6.1.4. Hardware Setting of the* $I_{MAX}$ *of the dV channel*

The hardware setting of the $I_{MAX}$ of the Vc channel occurs in three steps:

STEP 1 - calibration of the current differentials by adjusting the R164 and R164A resistors;
STEP 2 - adjustment of the R150 and R150A resistors in order to compensate the variations of the -12 V power supply source;
STEP 3 - setting of the $I_{REF}$ by adjusting the R152 resistor (refer to Fig. 6.3, p.36 for the hardware set-up);
STEP 4 - adjustment of the R226 resistor so that the Over-Current condition is kept as the Vc channel voltage varies (refer to Fig. 6.1, p.32 for the hardware set-up).

In order to accomplish the STEP 1 refer to the following procedure:

1) set the Vc channel to 0;
2) set the dV and Vc channels without load;
3) adjust the R164 and R164A so that the output of the current differential (pin 14 of the U24 component) does not change varying the voltage of the dV channel;

In order to accomplish the STEP 2 refer to the following procedure:

1) set the Vc channel to 0;
2) set the dV channel to the maximum voltage;
3) adjust the R150 and R150A resistors so that the voltage on the pin5 of the U24 component does not change varying the -12 V power supply (power supply variation of ±0.6V);

In order to accomplish the STEP 3 refer to the following procedure:

1) set the Vc channel to the maximum voltage;
2) set the dV channel to the maximum voltage with $R_{dV\ load}$ = 20 MΩ (150 μA);
3) adjust the R152 resistor until the current loop starts to control the regulation, i.e. as the U24B comparator output (pin 7 of the U24B comparator) is no longer saturated negatively.

In order to accomplish the STEP 4 refer to the following procedure:

1) put the dV channel in the Over-Current condition by setting the dV channel at the maximum voltage and by inserting a $R_{dVload}$=20 MΩ;
2) adjust the R226 resistor so that the dV channel is always in Over-Current as the Vc channel voltage varies (Vc channel not limited in current).

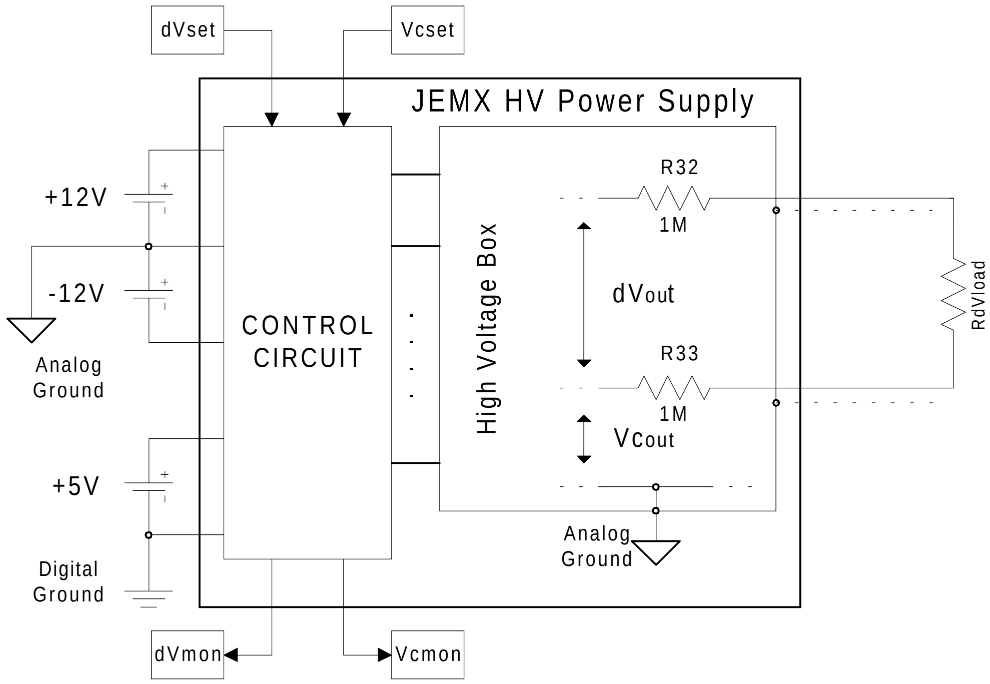



**Fig. 6.3 – Hardware Set-up for the $I_{MAX}$ setting of the dV channel**

**N:B:** The HV Voltmeters used in the hardware set-ups have an internal impedance which has been sketched in the figures as a resistor in parallel to the Voltmeter itself. In general, the internal impedance is as follows:

The HV voltmeter *Vc(HV Voltmeter)* impedance is 500 MΩ;
The HV voltmeter *dV(HV Voltmeter)* impedance is 1000 MΩ.

Only in the case of the hardware set-up of Fig. 6.1, p.32 the HV voltmeter *Vc(HV Voltmeter)* impedance is 1000 MΩ.

## *6.2. Calibration procedure for the $V_{OUT}$ setting of the dV and Vc channels*

### *6.2.1. Hardware Set-up*

Fig. 6.4 shows the hardware set-up to perform the calibration procedure in order to infer the coefficients for the setting of $V_{OUT}$ and $V_{MON}$ of the Vc and dV channels.
Four voltmeters were used together with the HV Power Supply:

- two HV Voltmeters, namely *Vc (HV Voltmeter)* and *dVVc (HV Voltmeter)*, with an input impedance of 500 MΩ and 1000 MΩ, respectively, and 1 V-resolution;
- two Low Voltage Precision Voltmeters with 100 μV-resolution.

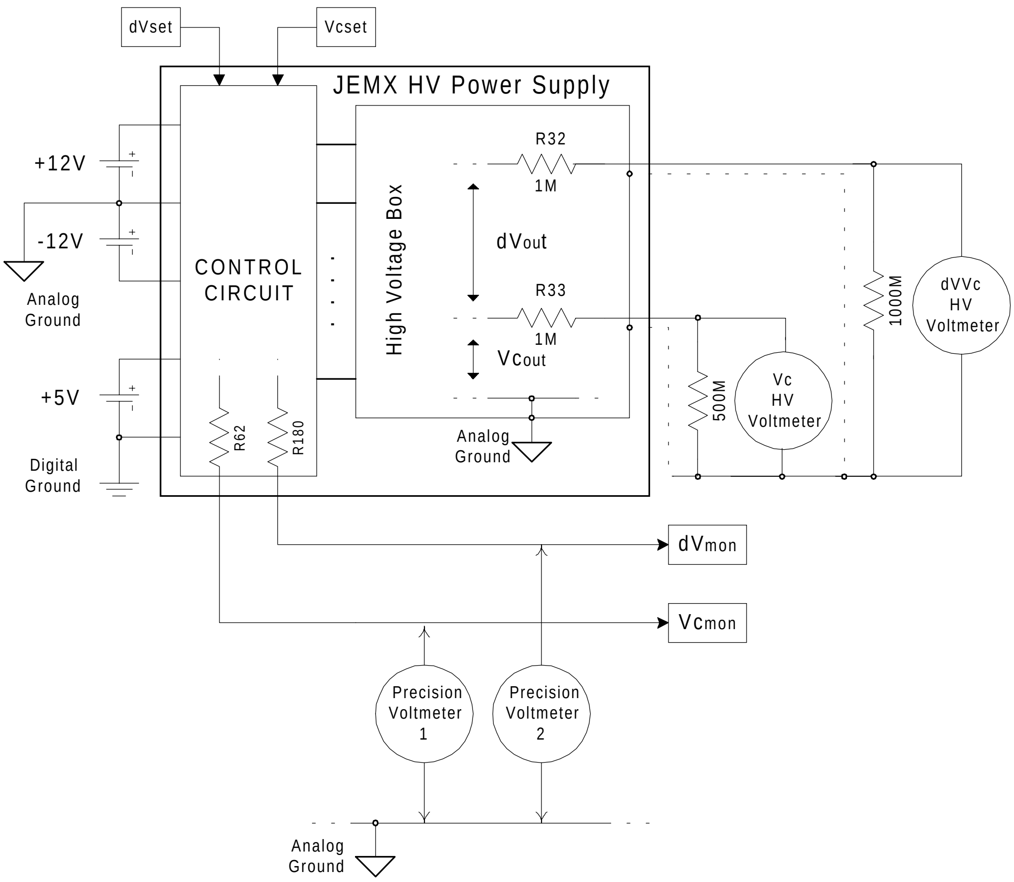



**Fig. 6.4 – Hardware Set-up for the procedure to calculate the coefficients for $V_{OUT}$ setting**

### 6.2.2. Calibration procedure for the Vc channel

In order to calibrate the $V_{SET}$ and $V_{MON}$ of the Vc channel, refer to the following procedure:

- set the dV channel to 0;
- set the Vc channel to 100d (*Vcset1*) and calculate the output voltage value (*Vcout1*) from the readout of the HV voltmeter (*Vc(HV Voltmeter)*, refer to Fig. 6.4):

**Vcout1 = [(1M+500M)/500M]*Vc1(HV Voltmeter);**

- measure the monitored output voltage (*Vcmon1*) by means of the Precision Voltmeter 1 (refer to Fig. 6.4);
- set the Vc channel to 200d (*Vcset2*) and calculate the output voltage value (*Vcout2*) from the readout of the HV voltmeter (*Vc(HV Voltmeter)*, refer to Fig. 6.4):

**Vcout2 = [(1M+500M)/500M]*Vc2(HV Voltmeter);**

- measure the monitored output voltage (*Vcmon2*) by means of the Precision Voltmeter 1 (refer to Fig. 6.4).

The coefficients which are given in the formulas of § 5.1.1, p.26 for the setting of the $V_{OUT}$ parameters, can be obtained from the following equations:

$$m_{Vset(VC)} = [Vcset2 - Vcset1]/[Vcout2 - Vcout1] ,$$
$$q_{Vset(VC)} = [Vcset2 - (m_{Vset(VC)} * Vcout2)] ,$$

and

$$m_{Vmon(VC)} = [Vcout2 - Vcout1]/ [Vcmon2 - Vcmon1] ,$$
$$q_{Vmon(VC)} = [Vcout2 - (m_{Vmon(VC)} * Vcmon2)].$$

### 6.2.3. Calibration procedure for the dV channel

In order to calibrate the $V_{SET}$ and $V_{MON}$ of the dV channel, refer to the following procedure:

- set the Vc channel to 0;
- set the dV channel to 100d (*dVset1*) and calculate the output voltage value (*dVout1*) from the readout of the HV voltmeters (*Vc(HV Voltmeter)* and *dVVc(HV Voltmeter)*, refer to Fig. 6.4):

**dVout1 =**

**[(1M+1000M)/1000M]*dVVc1(HV Voltmeter) – [(1M+500M)/500M]*Vc1(HV Voltmeter);**

- measure the monitored output voltage (*dVmon1*) with the precision Voltmeter 2;
- set the dV channel to 200d (*dVset2*) and calculate the output voltage value (*dVout2*) from the readout of the HV voltmeters (*Vc(HV Voltmeter)* and *dVVc(HV Voltmeter)*, refer to Fig. 6.4):

**dVout2 =**

**[(1M+1000M)/1000M]*dVVc2(HV Voltmeter) – [(1M+500M)/500M]*Vc2(HV Voltmeter);**

- measure the monitored output voltage (*dVmon2*) by means of the Precision Voltmeter 2 (refer to Fig. 6.4).

The coefficients which are given in the formulas of § 5.1.1, p.26 for the setting of the $V_{OUT}$ parameters, can be obtained from the following equations:

$$\mathbf{m_{Vset(dV)} = [dVset2 - dVset1]/[\,dVout2 - dVout1]}\ ,$$
$$\mathbf{q_{Vset(dV)} = [dVset2 - (m_{Vset(dV)} * dVout2)]}\ ,$$

and

$$\mathbf{m_{Vmon(dV)} = [Vout2 - Vout1]/\,[dVmon2 - dVmon1]}\ ,$$
$$\mathbf{q_{Vmon(dV)} = [Vout2 - (m_{Vmon(dV)} * dVmon2)]}\ .$$

# *APPENDIX A*

# Electrical diagrams

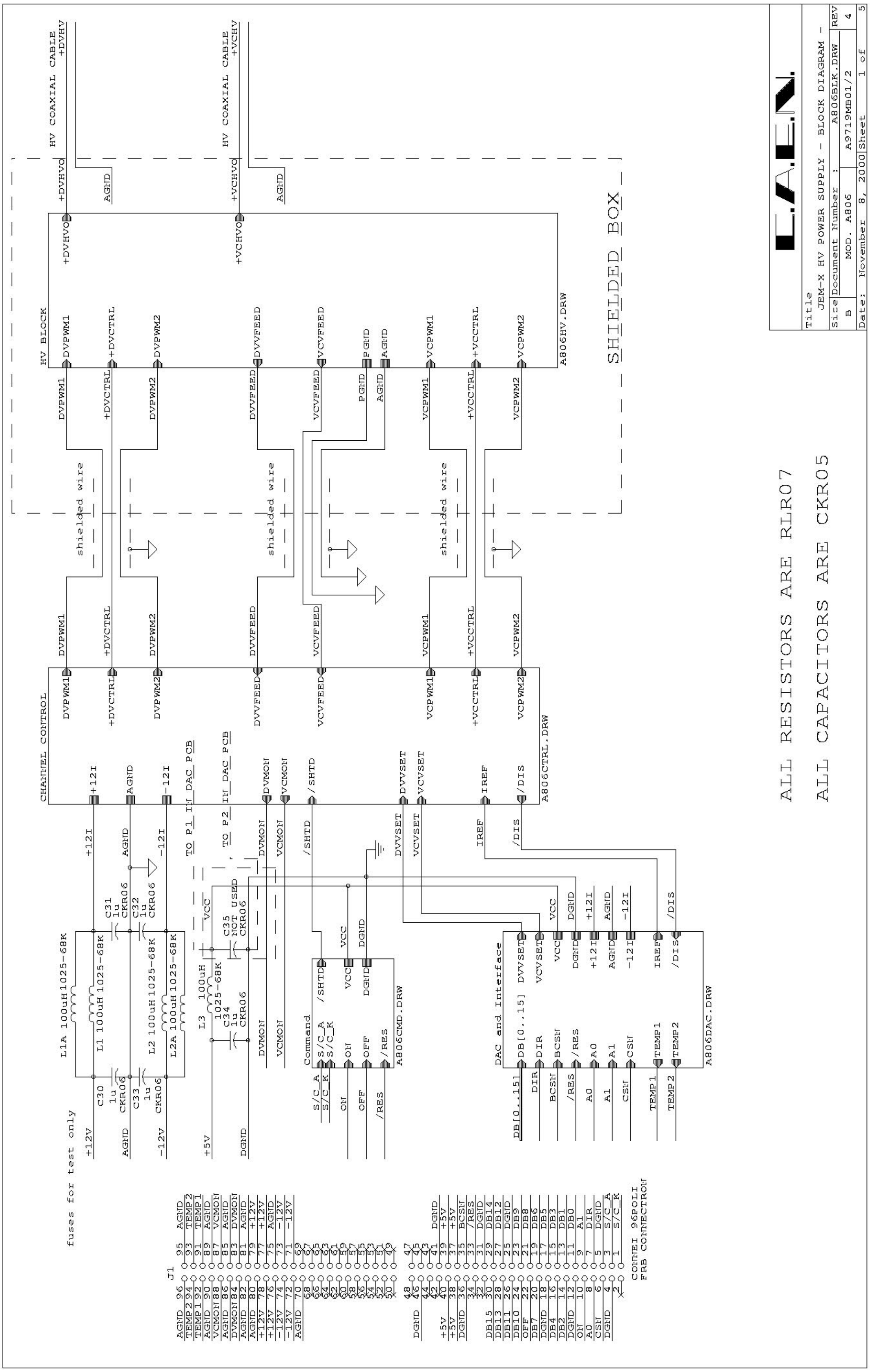



**Fig. A.1 – JEM-X HV Power Supply block diagram**

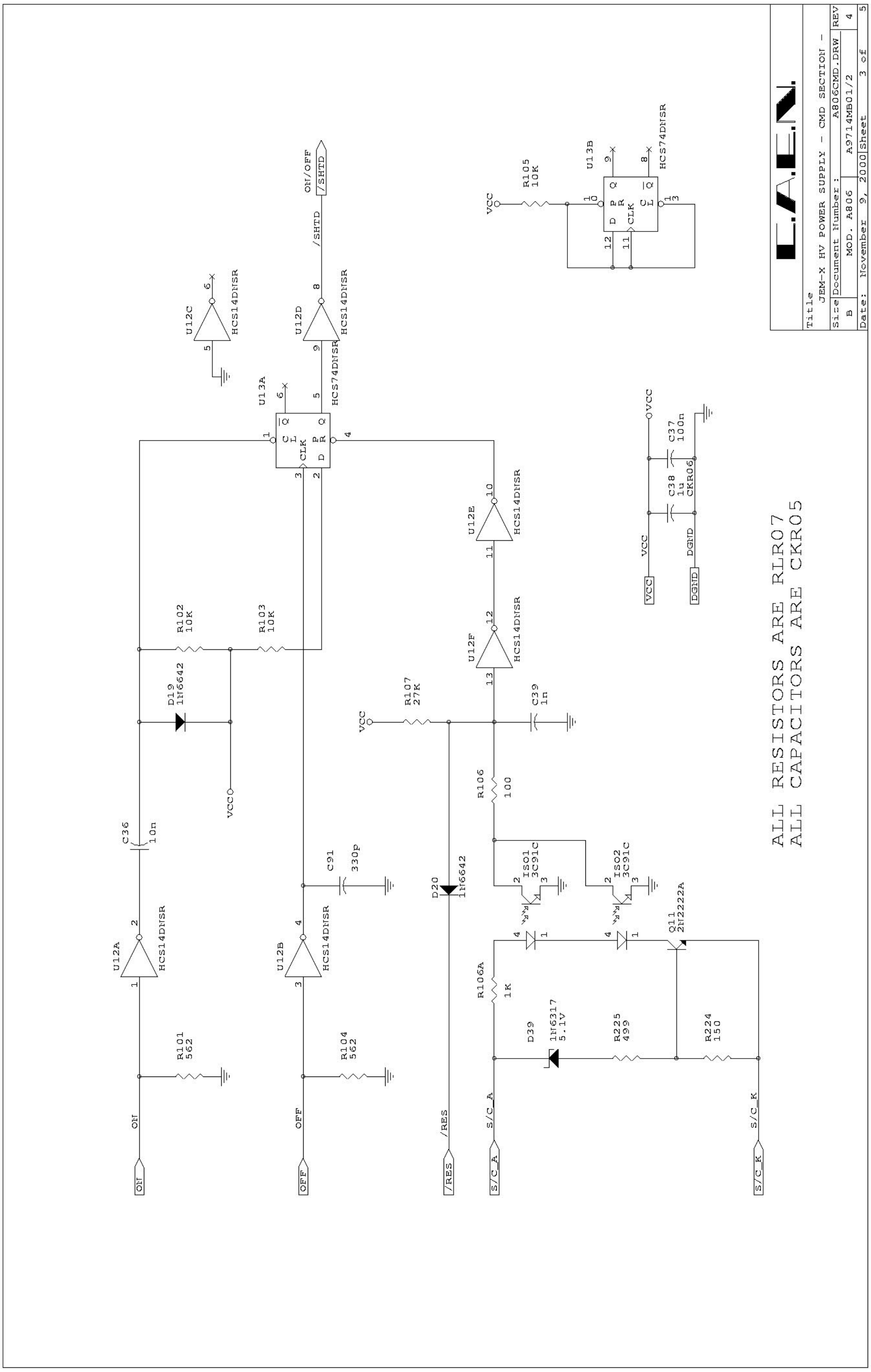


**Fig. A.2 – JEM-X Power Supply CMD section**

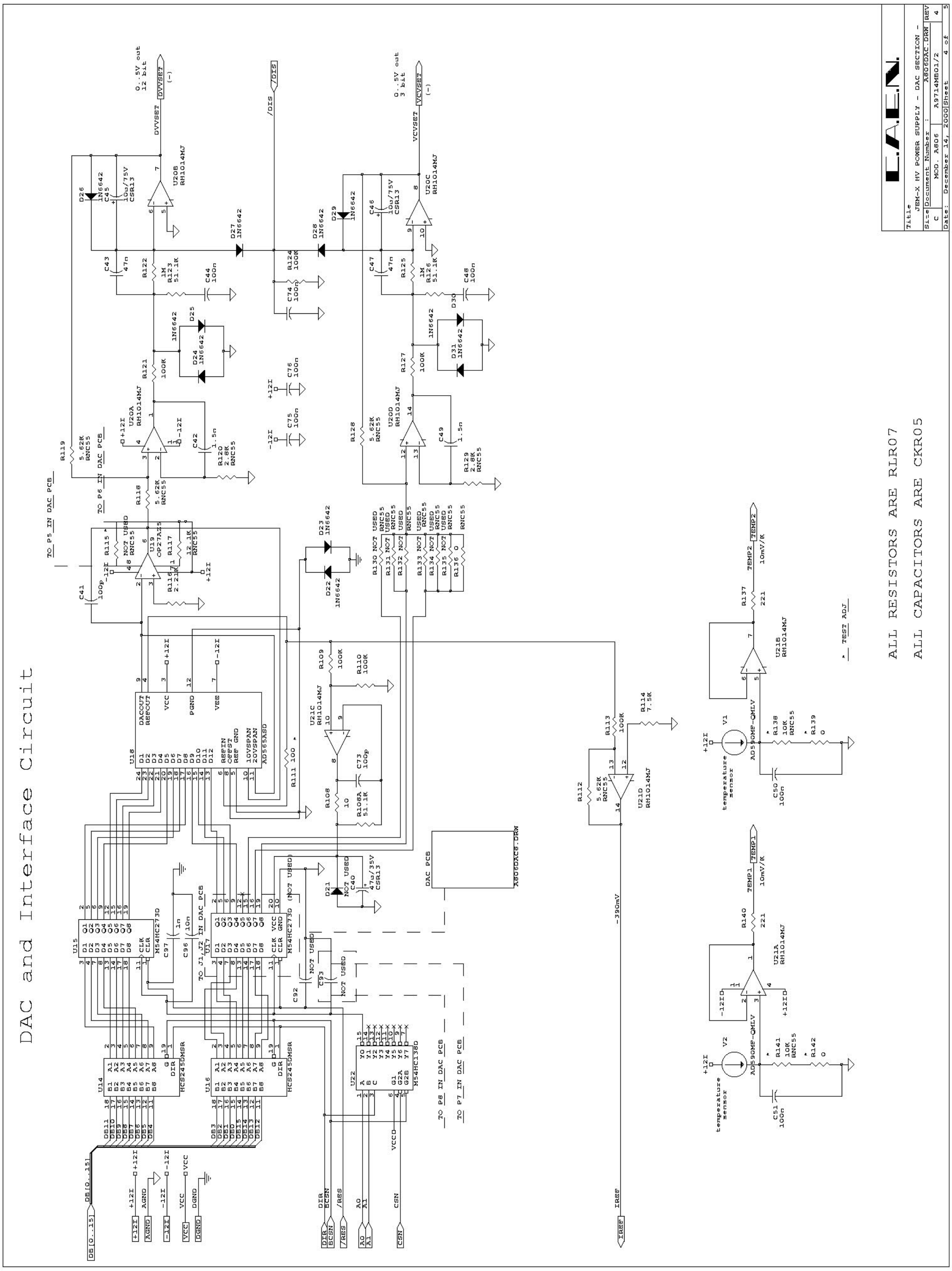
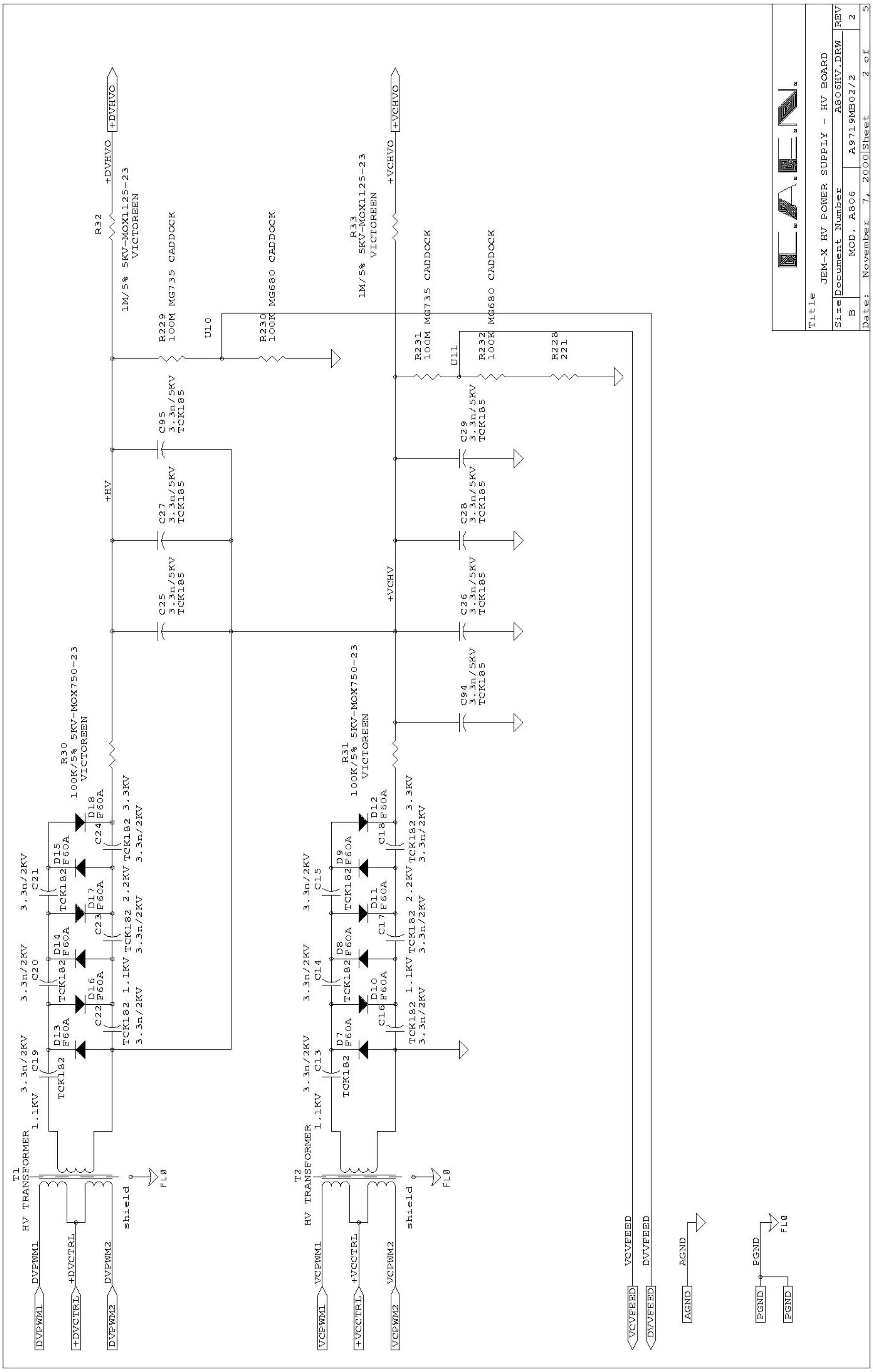



**Fig. A.3 – JEM-X Power Supply DAC section**




## Fig. A. 4 – JEM-X Power Supply HV board

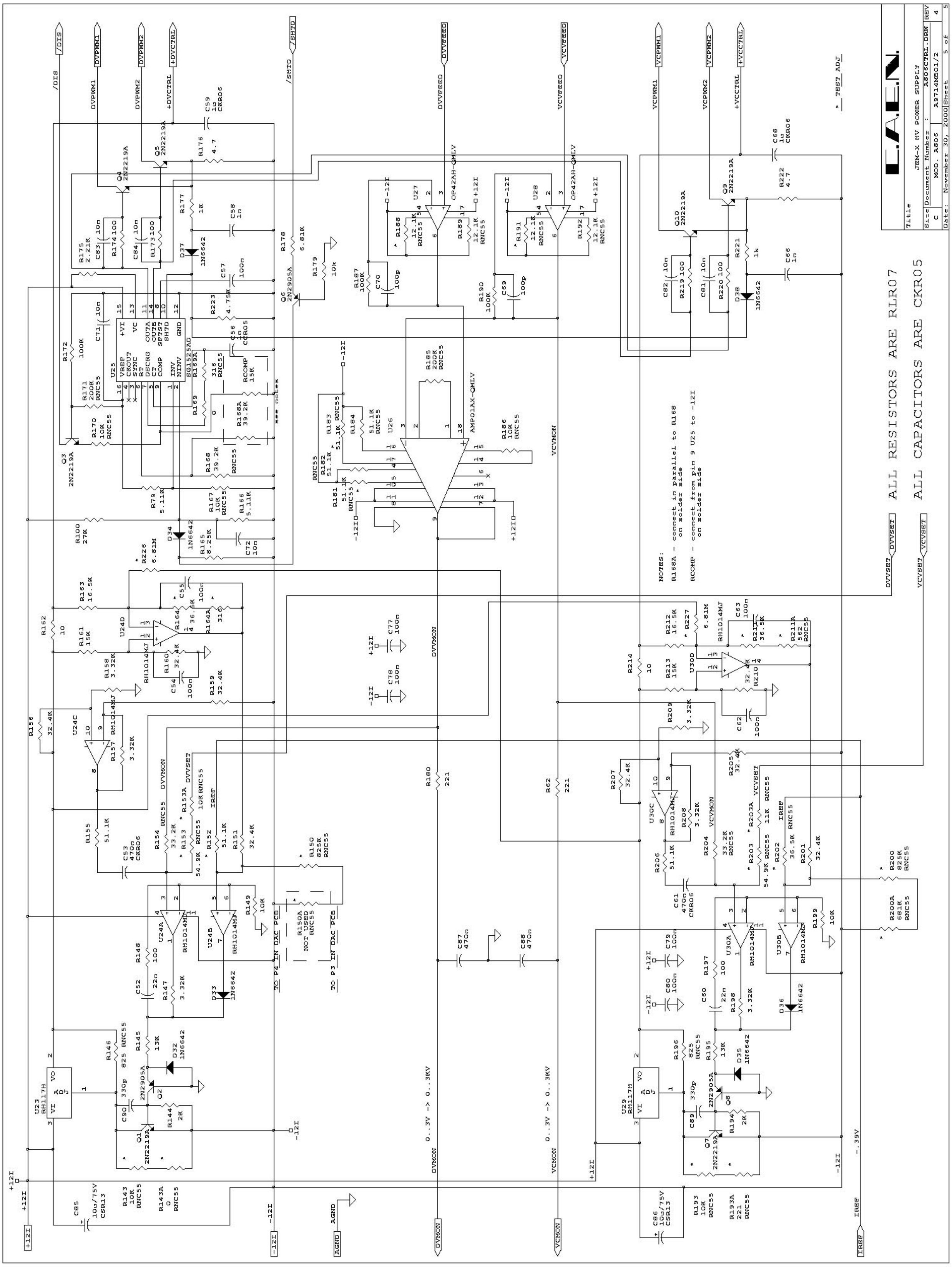


**Fig. A..5 – JEM-X Power Supply Control**

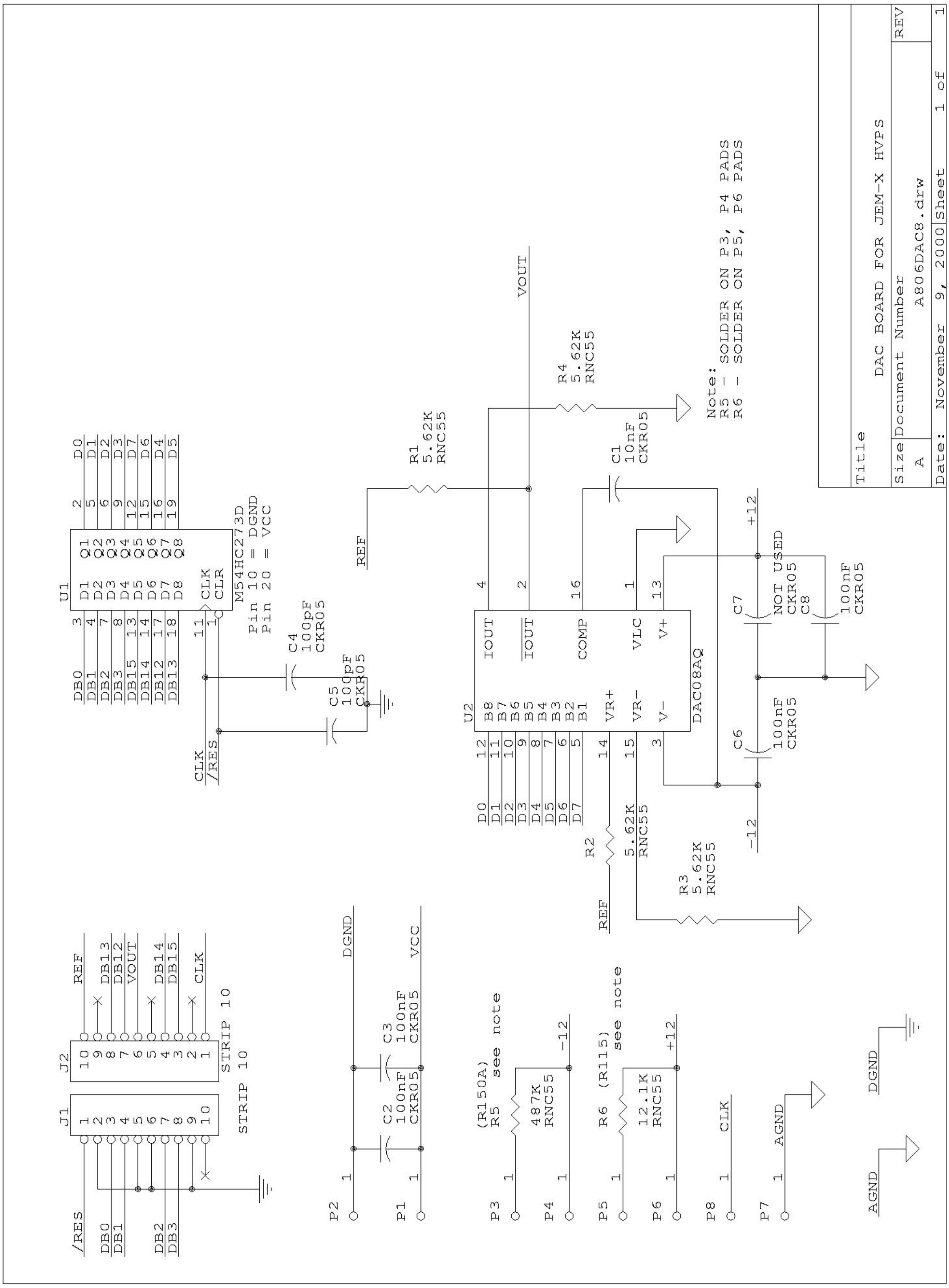



**Fig. A.6 – JEM-X Power Supply DAC daughter board**

# *APPENDIX B*

# Materials list

# Mechanichal parts list

# Processes list

# Part list

# Components list

# Declared material list

| Programme name: INTEGRAL | Group: JEM-X | Doc No: | Page:1/2 |
|---|---|---|---|
| | | Issue/Rev.: | Date: 08.11.2000 |

| 1 Item No: | 2 Commercial identification | 3 Chemical nature and type of product | 4 Procurement info: Manufacturer / Supplier Spec. Issue/rev. | 5 Summary of processing parameters | 6 Use and Location | 7 Environment code R | A | T | 8 Size code | 9 9.1 Corr | SCC | Flam | OFFG. | OuTG. | 9.2 Justification for approval | 9.3 Prime App. | 10 ESA App. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Uralane 5753 | Uretane System Encapsulating | CIBA IAS-CNR | Curing Temp 7 days 25°C | Potting HV Multiplier | | | | | | | | | | | | |
| 2 | Uralane 5750 | Thinner | CIBA IAS-CNR | | Potting HV Multiplier | | | | | | | | | | | | |
| 3 | AF-4 | Anti Foam Agent | CIBA IAS-CNR | | Potting HV Multiplier | | | | | | | | | | | | |
| 4 | EC-2216 | Epoxy Electrical Resin | 3M | Curing Temp 2 hrs 66°C | Adhesive | | | | | | | | | | | | |
| 5 | Aereoglaze Z307 | One part absorptive conductive Polyurethane | LORD IAS-CNR | Curing Temp 7 days 25°C | Coating HV Box | | | | | | | | | | | | |
| 6 | CV-1152 | RTV Silicone | NUSIL | Curing Temp 7 days 25°C | Conformal coating | | | | | | | | | | | | |
| 7 | AV-138M | Epoxy | CIBA | Curing Temp 1 day 25°C | Adhesive | | | | | | | | | | | | |
| 8 | HV998 | Hardener | CIBA | | Adhesive | | | | | | | | | | | | |

## Declared material list

Programme name: **INTEGRAL** Group: **HVPS JEM-X** Doc No: Issue/Rev.: Page:2/2 Date:10.10.99

| 1 Item No: | 2 Commercial identification | 3 Chemical nature and type of product | 4 Procurement info: Manufacturer / Supplier Spec. Issue/rev. | 5 Summary of processing parameters | 6 Use and Location | 7 Environment code R | A | T | 8 Size code | 9.1 Corr | SCC | Flam | OFFG. | OuTG. | 9.2 Justification for approval | 9.3 Prime App. | 10 ESA App. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | A2 | Inox 18/8 | | | Screw | | | | | | | | | | | | |
| 10 | Aluminium 99,5 | UNI 9001/2 | | | HV box | | | | | | | | | | | | |
| 11 | Anticordal 6082 | UNI 9006/4 | | | HV box | | | | | | | | | | | | |
| 12 | SIL-PAD 400 | Silicone rubber and fiberglass, 0.009 in | Berquist | | Control Board | | | | | | | | | | | | |
| 13 | Double-Sided and Multilayer PCBs | Polyimide | PRINTCA AS | | Control B. and HV PCBs | | | | | | | | | | | | |
| 14 | SHRINK-KON | Heatshrink tubing MLP | Thomas & Betts | Shrink 200°C | Cable protection | | | | | | | | | | | | |

## Declared mechanical parts list

Programme name: **INTEGRAL** Group: **JEM-X** Doc No: Issue/Rev.: Page:1/1 Date:10.10.99

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 9.1 | 9.2 | |
| Item No: | Commercial identification | Type of part | Procurement info: 1) Manufacturer 2) Supplier 3) Proc. Spec. Issue/rev. | 1) Elementary functions 2) Main characteristics | 1) Use 2) Location | Environment code 1) Radiation 2) Ambiance 3) Temp. | Criticality and hazards | Justification for approval and prime comments | Prime App. | ESA |
| 1 | Aluminium Box | HV Box | 1)T.E.M. | 1)Fasten HV box to Control Board 2)Aluminium | 1) HV Multiplier and PCB 2) HVPS | | | | | |
| 2 | Flat Head, Cross-Slotted M3x8-A2 | Screw | | 1)HV Box Assembly 2)A2 | 2)HVPS | | | | | |
| 3 | Cheese-Headed, Cross-Slotted M3x10-A2 | Screw | | 1)Fasten HV PCB HV Box | 2)HVPS | | | | | |

## Declared processes list

Programme name: **INTEGRAL** Group: **JEM-X** Doc No: Issue/Rev.: Page:1/1 Date:10.10.99

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 9.1 | 9.2 | |
| Item No: | Process identification | Specification issue/rev. | Process description | Use and location | Manufacturer name | Associated items in materials list | Criticality of the process | Justification for validation approval | Prime valid. | ESA |
| 1 | Trasformer Assembly | | | HV Multiplier | CAEN | | | | | |
| 2 | Transformer Potting | | Vacuum chamber | HV Multiplier | CAEN | | | | | |
| 3 | Components soldering | | ESA qualified personal | Control Board PCB | CAEN | | | | | |
| 4 | Components soldering | | ESA qualified personal | HV PCB | CAEN | | | | | |
| 5 | Cleaning | | Immersion Washing | HV and Control Board PCBs | CAEN | | | | | |
| 5 | HV Multiplier Potting | | Vacuum chamber | HV Box | CAEN | | | | | |
| 6 | Coating | | | Cover the HV Box | CAEN | | | | | |
| 7 | HVPS Assembly | | | To join connect the HV Box with Control Board | CAEN | | | | | |
| 8 | Coating | | | Cover the Control Board | CAEN | | | | | |

**JEM-X Declared Parts List.**

Date:30/11/2000 **Flight Model 1** Doc No:

Issue/Rev:

| Item | Quantity | Reference | Parttype | Manufact. | Description | Package | Function | Comments |
|---|---|---|---|---|---|---|---|---|
| 1 | 12 | C13,C14,C15,C16,C17,C18, C19,C20,C21,C22,C23,C24 | 3.3n/2KV | EUROFARAD | TCK182 | Radial | | |
| 2 | 7 | C25,C26,C27,C28,C29,C94, C95 | 3.3n/5KV | EUROFARAD | TCK185 | Radial | | |
| 3 | 8 | C30,C31,C32,C33,C34,C38, C59,C68 | 1u | KEMET | CKR06 | Radial | | |
| 4 | 3 | C35,C92,C93 | NOT USED | | CKR06 | Radial | | |
| 5 | 8 | C36,C71,C72,C81,C82,C83, C84,C96 | 10n | KEMET | CKR05 | Radial | | |
| 6 | 17 | C37,C44,C48,C50,C51,C54, C55,C57,C62,C63,C74,C75, C76,C77,C78,C79,C80 | 100n | KEMET | CKR05 | Radial | | |
| 7 | 4 | C39,C58,C66,C97 | 1n | KEMET | CKR05 | Radial | | |
| 8 | 1 | C40 | 47u/35V | KEMET | CSR13 | Axial | | |
| 9 | 4 | C41,C69,C70,C73 | 100p | KEMET | CKR05 | Radial | | |
| 10 | 2 | C42,C49 | 1.5n | KEMET | CKR05 | Radial | | |
| 11 | 2 | C43,C47 | 47n | KEMET | CKR05 | Radial | | |
| 12 | 4 | C45,C46,C85,C86 | 10u/75V | KEMET | CSR13 | Axial | | |
| 13 | 2 | C52,C60 | 22n | KEMET | CKR05 | Radial | | |
| 14 | 4 | C53,C61,C87,C88 | 470n | KEMET | CKR06 | Radial | | |
| 15 | 1 | C56 | 1n | KEMET | CCR05 | Radial | | |
| 16 | 3 | C89,C90,C91 | 330p | KEMET | CKR06 | Radial | | |
| 17 | 12 | D7,D8,D9,D10,D11,D12,D13, D14,D15,D16,D17,D18 | F60A | SEMTECH | HV diode | G42 | | |
| 18 | 19 | D19,D20,D22,D23,D24,D25, D26,D27,D28,D29,D30,D31, D32,D33,D34,D35,D36,D37, D38 | 1N6642 | | | Axial | | |
| 19 | 1 | D21 | NOT USED | | | Axial | | |
| 20 | 1 | D39 | 1N6317 | | 5.1V Zener Diode, 1/2W | Axial | | |
| 21 | 2 | ISO1,ISO2 | 3C91C | MITEL | OPTO coupler | TO-72 | | |
| 22 | 1 | J1 | CONNE196POLI | FRB CONNECTRON | Connector | | | |
| 23 | 5 | L1A,L1,L2A,L2,L3 | 100uH | DELEVAN | 1025-68K inductor | Axial | | |
| 24 | 6 | Q1,Q4,Q5,Q7,Q9,Q10 | 2N2219A | | Transistor | TO-39 | | |
| 25 | 3 | Q2,Q6,Q8 | 2N2905A | | Transistor | TO-39 | | |
| 26 | 1 | Q3 | 2N2219A | | Transistor | TO-39 | | |
| 27 | 1 | Q11 | 2N2222A | | Transistor | TO-18 | | |
| 28 | 3 | R161,R213,RCOMP | 15K | | RLR07 | Axial | | |
| 29 | 2 | R31,R30 | 100K/5% | VICTOREEN | 5KV-MOX750-23 | Axial | | |
| 30 | 2 | R32,R33 | 1M/5% | VICTOREEN | 5KV-MOX1125-23 | Axial | | |
| 31 | 6 | R62,R137,R140,R180, R228,R193A | 221 | DALE | RLR07 | Axial | | |
| 32 | 2 | R79,R166 | 5.11K | DALE | RLR07 | Axial | | |
| 33 | 2 | R107,R100 | 27K | DALE | RLR07 | Axial | | |
| 34 | 2 | R104,R101 | 562 | DALE | RLR07 | Axial | | |
| 35 | 6 | R102,R103,R105,R149,R179, R199 | 10K | DALE | RLR07 | Axial | | |
| 36 | 3 | R106A,R177,R221 | 1K | DALE | RLR07 | Axial | | |
| 37 | 8 | R106,R111,R148,R173,R174, R197,R219,R220 | 100 | DALE | RLR07 | Axial | | |
| 38 | 5 | R108A,R123,R126,R155, R206 | 51.1K | DALE | RLR07 | Axial | | |
| 39 | 3 | R108,R162,R214 | 10 | DALE | RLR07 | Axial | | |
| 40 | 9 | R109,R110,R113,R121,R124, R127,R172,R187,R190 | 100K | DALE | RLR07 | Axial | | |
| 41 | 4 | R112,R118,R119,R128 | 5.62K | DALE | RNC55 | Axial | | |
| 42 | 1 | R114 | 7.5K | DALE | RLR07 | Axial | | |
| 43 | 8 | R115,R130,R131,R132,R133, R134,R135,R150A | NOT USED | | RNC55 | Axial | | |
| 44 | 2 | R116,R175 | 2.21K | DALE | RLR07 | Axial | | |
| 45 | 5 | R117,R188,R189,R191,R192 | 12.1K | DALE | RNC55 | Axial | | |
| 46 | 2 | R120,R129 | 2.8K | DALE | RNC55 | Axial | | |
| 47 | 2 | R122,R125 | 1M | DALE | RLR07 | Axial | | |
| 48 | 3 | R136,R169,R143A | 0 | DALE | RNC55 | Axial | | |
| 49 | 8 | R138,R141,R143,R167,R170, R186,R193,R153A | 10K | DALE | RNC55 | Axial | | |
| 50 | 2 | R139,R142 | 0 | DALE | RLR07 | Axial | | |

**JEM-X Declared Parts List.**
**Flight Model 1**

Date:30/11/2000

Doc No:
Issue/Rev:

| Item | Quantity | Reference | Parttype | Manufact. | Description | Package | Function | Comments |
|---|---|---|---|---|---|---|---|---|
| 51 | 2 | R144,R194 | 2K | DALE | RLR07 | Axial | | |
| 52 | 2 | R145,R195 | 13K | DALE | RLR07 | Axial | | |
| 53 | 2 | R196,R146 | 825 | DALE | RNC55 | Axial | | |
| 54 | 6 | R147,R157,R158,R198,R208, R209 | 3.32K | DALE | RLR07 | Axial | | |
| 55 | 2 | R150,R200 | 825K | DALE | RNC55 | Axial | | |
| 56 | 8 | R151,R156,R159,R160,R201, R205,R207,R210 | 32.4K | DALE | RLR07 | Axial | | |
| 57 | 3 | R164,R211,R202 | 36.5K | DALE | RLR07 | Axial | | |
| 58 | 2 | R203,R153 | 54.9K | DALE | RNC55 | Axial | | |
| 59 | 2 | R154,R204 | 33.2K | DALE | RNC55 | Axial | | |
| 60 | 2 | R212,R163 | 16.5K | DALE | RLR07 | Axial | | |
| 61 | 1 | R165 | 8.25K | DALE | RLR07 | Axial | | |
| 62 | 2 | R168,R168A | 39.2K | DALE | RNC55 | Axial | | |
| 63 | 2 | R169A,R164A | 316 | DALE | RLR07 | Axial | | |
| 64 | 2 | R185,R171 | 200K | DALE | RNC55 | Axial | | |
| 65 | 2 | R222,R176 | 4,7 | DALE | RLR07 | Axial | | |
| 66 | 1 | R178 | 6.81K | DALE | RLR07 | Axial | | |
| 67 | 5 | R181,R182,R183,R184,R152 | 51.1K | DALE | RNC55 | Axial | | |
| 68 | 1 | R200A | 681K | DALE | RNC55 | Axial | | |
| 69 | 1 | R211A | 562 | DALE | RLR07 | Axial | | |
| 70 | 1 | R223 | 4.75K | DALE | RLR07 | Axial | | |
| 71 | 1 | R224 | 150 | DALE | RLR07 | Axial | | |
| 72 | 1 | R225 | 499 | DALE | RLR07 | Axial | | |
| 73 | 2 | R226,R227 | 6.81M | DALE | RLR07 | Axial | | |
| 74 | 1 | R203A | 11K | DALE | RLR07 | Axial | | |
| 75 | 2 | R229,R231 | 100M | CADDOCK | MG735 | Axial | | |
| 76 | 2 | R230,R232 | 100K | CADDOCK | MG680 | Axial | | |
| 77 | 2 | T2,T1 | HV Transformer | CAEN | TR-Ring-Jemx | | | |
| 78 | 1 | U12 | HCS14DNSR | ST | Hex Inverting Schmitt Trigger | DIL14 | | |
| 79 | 1 | U13 | HCS74DNSR | ST | Dual D-FF, Set and Reset | DIL15 | | |
| 80 | 2 | U14,U16 | HCS245DMSR | Harris | Octal Bus Transceiver | DIL20 | | |
| 81 | 1 | U15 | M54HC273D | ST | Octal D-FF, CLK and Reset | DIL20 | | |
| 82 | 1 | U18 | AD565ASD | Analog Devices | D-A converter 12bit | DIL24 | | |
| 83 | 1 | U19 | OP27AZ5 | Analog Devices | OP-Amplifier | DIL8 | | |
| 84 | 4 | U20,U21,U24,U30 | RH1014MJ | Linear Technology | Quad OP-Amplifier | DIL14 | | |
| 85 | 1 | U22 | M54HC138D | ST | 3-8 decoder | DIL16 | | |
| 86 | 2 | U23,U29 | RH117H | Analog Devices | Voltage Regulator, V+ | TO-39 | | |
| 87 | 1 | U25 | SG1525AD | ST | PWM Regulator | DIL16 | | |
| 88 | 1 | U26 | AMP01AX-QMLV | Analog Devices | Instrumentation Amplifier | DIL18 | | |
| 89 | 2 | U27,U28 | OP42AH-QMLV | Analog Devices | OP-Amplifier | DIL8 | | |
| 90 | 2 | V2,V1 | AD590MF-QMLV | Analog Devices | Temperature transducer | FP (F-2A) | | |
| **List of the components of DAC board** | | | | | | | | |
| 91 | 1 | C1 | 10nF | KEMET | CKR05 | Radial | | |
| 92 | 4 | C2,C3,C6,C8 | 100nF | KEMET | CKR05 | Radial | | |
| 93 | 2 | C4,C5 | 100pF | KEMET | CKR05 | Radial | | |
| 94 | 1 | C7 | NOT USED | | CKR05 | Radial | | |
| 95 | 4 | R1,R2,R3,R4 | 5.62K | DALE | RNC55 | Axial | | |
| 96 | 1 | R5 | 487K | DALE | RNC55 | Axial | | |
| 97 | 1 | R6 | 12.1K | DALE | RNC55 | Axial | | |
| 98 | 1 | U1 | M54HC273D | ST | Octal D-FF, CLK and Reset | DIL20 | | |
| 99 | 1 | U2 | DAC08AQ | Analog Devices | D-A converter 8bit | DIL16 | | |

**HVPS JEM-X Declared Component List.**

Date:08/11/2000

Doc No:
Issue/Rev:

| item | Part Type | Manufact. | Description | Package | Function | Comments |
|---|---|---|---|---|---|---|
| 1 | 1N6642 | | Si diode | Axial | | |
| 2 | F60A | Semtech | HV diode | G42 | HV diode | |
| 3 | 1N6317 | | Si diode | Axial | 5.1V Zener Diode, 1/2W | |
| 4 | 2N2905A | | IC linear | TO-39 | Transistor | |
| 5 | 2N2219A | | IC linear | TO-39 | Transistor | |
| 6 | 2N2222A | | IC linear | TO-18 | Transistor | |
| 7 | RH117H | Analog Devices | IC linear | TO-39 | Voltage Regulator, V+ | |
| 8 | 3C91C | Mitel | Opto | TO-72 | OPTO coupler | |
| 9 | OP27AZ5 | Analog Devices | IC linear | DIL8 | OP-Amplifier | |
| 10 | OP42AH-QMLV | Analog Devices | IC linear | TO-99 | OP-Amplifier | |
| 11 | RH1014MJ | Linear Technology | IC linear | DIL14 | Quad OP-Amplifier | |
| 12 | AMP01AX-QMLV | Analog Devices | IC linear | DIL18 | Instrumentation Amplifier | |
| 13 | AD590MF-QMLV | Analog Devices | IC | FP (F-2A) | Temperature transducer | |
| 14 | SG1525AD | ST | IC | DIL16 | PWM Regulator | |
| 15 | AD565ASD | Analog Devices | IC | DIL24 | D-A converter 12bit | |
| 16 | HCS14DNSR | ST | IC Digital | DIL14 | Hex Inverting Schmitt Trigger | |
| 17 | HCS74DNSR | ST | IC Digital | DIL14 | Dual D-FF, Set and Reset | |
| 18 | M54HC138D | ST | IC Digital | DIL16 | 3-8 decoder | |
| 19 | HCS245DMSR | Harris | IC Digital | DIL20 | Octal Bus Transceiver | |
| 20 | M54HC273D | ST | IC Digital | DIL20 | Octal D-FF, CLK and Reset | |
| 21 | DAC08AQ | Analog Devices | IC | DIL16 | D-A converter 8bit | |
| 22 | Mox750-23 | Victoreen | HV resistor | Axial | 100KOhm 2KV, 5% | |
| 23 | Mox1125-23 | Victoreen | HV resistor | Axial | 1MOhm 5KV, 5% | |
| 24 | MG735 | Caddock | HV resistor | Axial | HV Resistor Dividers 100MOhm 10KV 1% | |
| 25 | MG680 | Caddock | HV resistor | Axial | HV Resistor Dividers 100KOhm 2KV 1% | |
| 26 | RNC55 | Dale | Resistor | Axial | Metal Film 1% 1/10W - 25 ppm / °C | |
| 27 | RLR07 | Dale | Resistor | Axial | Metal Film 2% 1/4W - 25 ppm / °C | |
| 28 | CCR05 | Kemet | Capacitor | Radial | Ceramic | |
| 29 | CKR05 | Kemet | Capacitor | Radial | Ceramic | |
| 30 | CKR06 | Kemet | Capacitor | Radial | Ceramic | |
| 31 | CSR13 | Kemet | Tantalum | Axial | Tantalum | |
| 32 | TCK182 | Eurofarad | HV Capacitor | Radial | Ceramic 2KV | |
| 33 | TCK185 | Eurofarad | HV Capacitor | Radial | Ceramic 5KV | |
| 34 | 1025-68k | DELEVAN | Inductor | Axial | | |
| 35 | TR-Ring-Jemx | CAEN | Transformer | Toroidal | HV Transformer | |
| 36 | CONNEI 96 pin | FRB Connectron | Connector | | ESA Approved connector | |
| 37 | Double-Sided PCB | PRINTCA AS | PCB | | HV Multiplier | Specification: ESA-PSS-01-710 |
| 38 | Multilayer PCB | PRINTCA AS | PCB | | Control Board | Specification: CNES/QFT/SP.0117 |
| 39 | RAYDEX CDT 24AWG | RAYDEX CDT | Coaxial cable | | LV cable: Control Board to HV box | |
| 40 | GSC 05-81739-00 | GORE | Coaxial cable | | HV cable: HV Box Output | ESA/PSS-01-720<br>Antony and Brown Test Grade "0" |

# *APPENDIX C*

# PCB of the Control board and

# DAC daughter board

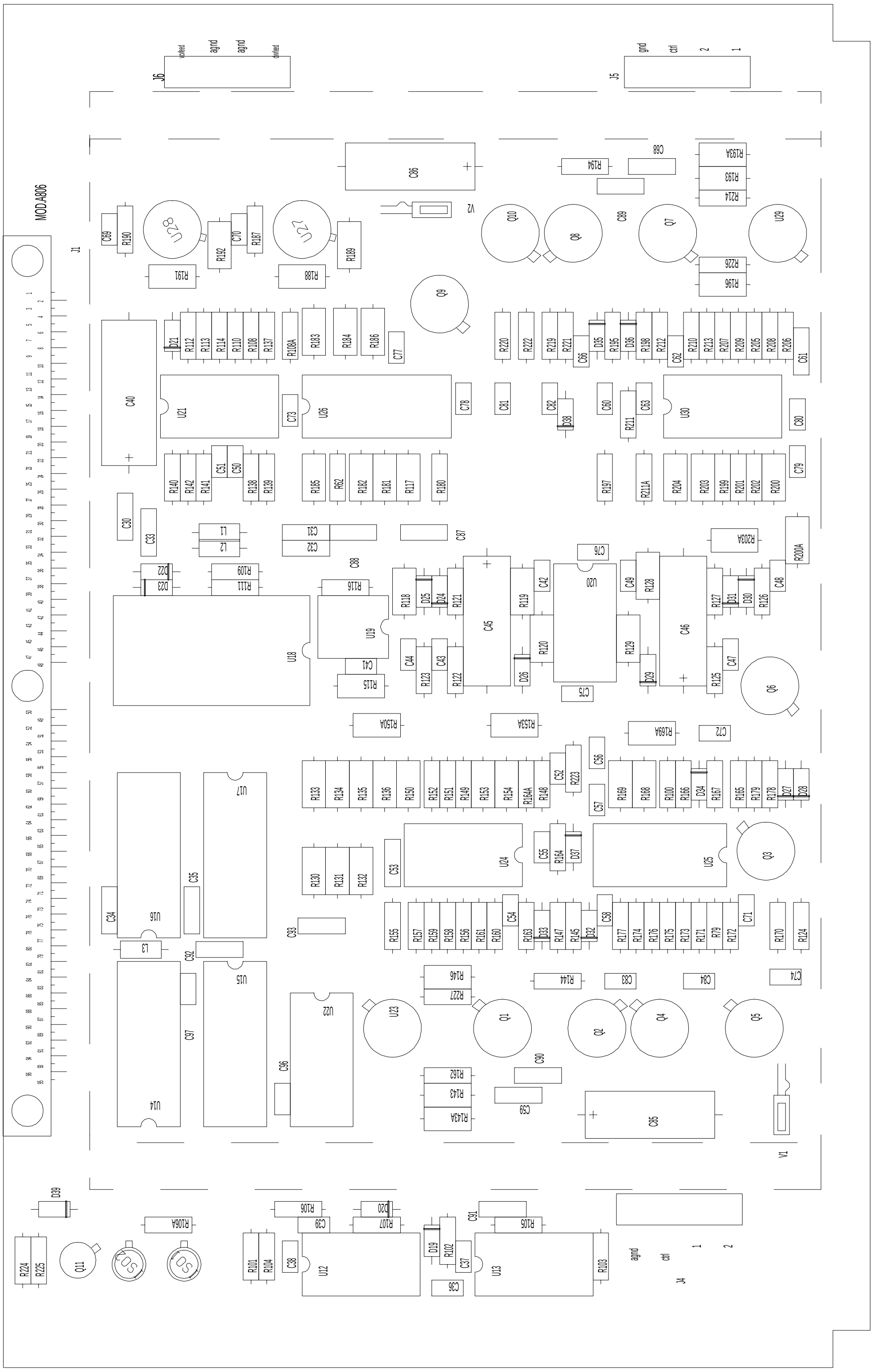


**Fig.C.1 – Control board PCB**

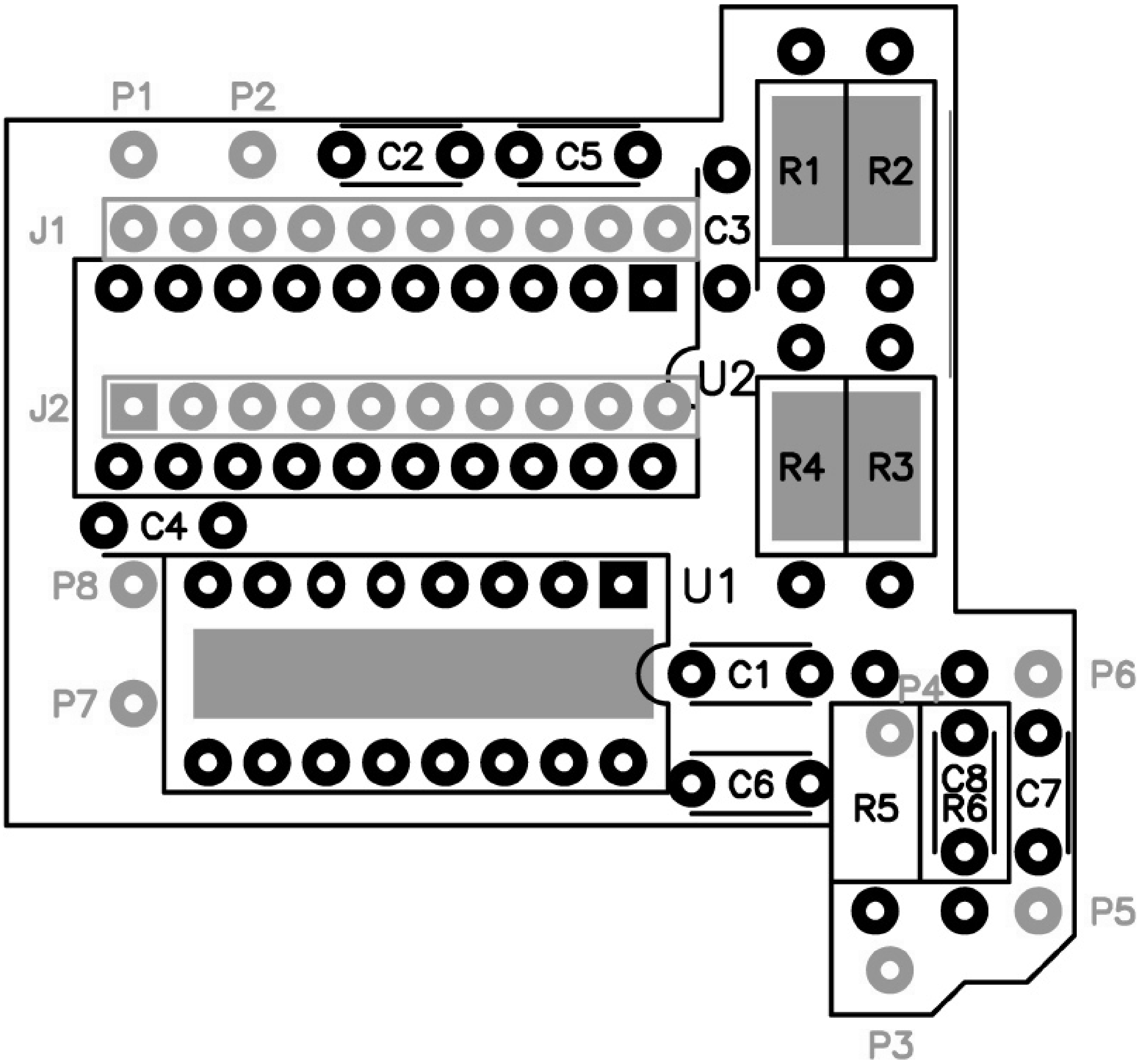



**Fig.C.2 – DAC daughter board PCB**