Technical Information Manual

MODELS N-126/N-186

GENERAL PURPOSE HIGH-VOLTAGE POWER SUPPLIES

Contents

C.A.E.N. MODELS N-126 / N-186

GENERAL-PURPOSE HIGH-VOLTAGE NIM POWER SUPPLIES

1 MODELS OVERVIEW

C.A.E.N. MODELS N-126 and N-186 *are general-purpose high-voltage NIM Power Supplies housed in a one-unit wide NIM module. Model N-126 has two High-Voltage ranges at 3 kV and 8 kV; model N-186 has a single range at 15 kV.*

Their wide range of current and voltage along with a versatile scheme of protection, monitoring and control functions make them ideal for powering the full spectrum of detectors, such as photomultipliers (PMs), wire chambers, streamer tubes, silicon detectors and so on. In spite of their small size they are among the most complete, sophisticated and versatile HV Power Supplies available.

Among their most relevant features there are:

- **Wide Voltage-Current Capability.** Model **N-126** can operate in two ranges:
  0 to 8 kV / 500 μA or **0 to 3 kV / 3 mA.**
  Model **N-186** has a single voltage range: **0 to 15 kV**;
  its current limits are **400 μA below 8 kV** and **200 μA above 8 kV.**
  Therefore, the units can cover all available commercial PM tubes and all types of resistive chains.
- **Selection of polarity.** On the N-126 the user can select positive or negative voltage levels by changing the specific jumpers connection *inside* the unit (see Section 5). For the N-186 the selection of polarity is made at the factory upon customer specifications, and cannot be changed by the user.
- **Digital and Analog Displays.** All operational parameters (voltage, current and voltage-rate) can be monitored on a 4-digit LED display. Additionally, current can also be monitored continuously on a analog meter, where small or rapid changes of current drain by the load can easily be assessed; this is a key factor when testing sensitive devices such as proportional chambers and streamer tubes.
- **Flexibility in Functions and Controls** which include:

* Two levels of preset current limits,
* LOCAL or REMOTE control of Output Voltage,
* Variable RAMP-UP and RAMP-DOWN, which are provided for voltage-rate sensitive detectors.
* Local or Remote INHIBIT.
* A variety of operational modes, and

- **Sophisticated Safety Features.**

  Operational safety includes:

  * a versatile overload protection scheme, with three different modes selectable by the user, and
  * presetting of a specified HV limit.

  Handling safety is obtained through careful design. All HV components are incapsulated in silicon rubber and no HV is on the printed circuit board so that the maintainance personnel cannot accidentally be exposed to it.

□ The front panel and the rear panel of models N-126 and N-186 are respectively shown at Figure 1 and 2, on the two fold-out pages at the end of this Manual. For your convenience, keep the photograph of your model folded out to easily associate descriptions and explanations with the layout of your model

The High-Voltage output connector, which is on the back panel, is a **SHV** *female connector for model N-126, and* **HV LEMO** *self-locking female connector (round, single pole) for the N-186. All other connectors except the HV output are LEMO 00 type.*

2 SPECIFICATIONS

OUTPUT VOLTAGE/CURRENT

On Model N-126, two High-Voltage ranges can be selected by means of the locked switch, below the HV output on the rear panel, *(labelled 500 $\mu A/5$ mA)*. This switch also changes the full-scale range of the analog current meter.[1] The HV ranges are:

0 to 8 kV — 500 μA maximum output current,

0 to 3 kV — 3 mA maximum output current.

Model N-186 has a single voltage range: **0 to 15 kV**; the maximum output current however depends on the actual voltage; it is:

below 8 kV — 400 μA, and

above 8 kV — 200 μA.

Positive or Negative Polarity Selection. On Model N-126 changeover of polarity can be done by the user following the procedure detailed at section 5; on Model N-186 the HV polarity must be specified by the user, before delivery, and cannot be modified.

PARD (Periodic and random Deviation) data are:

- 500 mV_{pp} at full load at 3 kV or 8 kV (Model N-126),
- 2 V_{pp} at full load at 15 kV (Model N-186).

OUTPUT VOLTAGE CONTROL

Two values of output voltage, V_0 and V_1, can be chosen, by means of the front panel (NIM) V_{SEL} input:

$$V_{SEL} \text{ False or missing} \Rightarrow V_{OUT} = V_0,$$
$$V_{SEL} \text{ True} \Rightarrow V_{OUT} = V_1.$$

V_1 is set with the screwdriver adjustable potentiometer (*labelled V1*).

When V_0 is selected, the control of V_{OUT} depends on the position of the LOCAL/REMOTE locked switch on rear panel.

- In LOCAL Mode, V_0 is adjusted with the 10-turn potentiometer on the front panel.
- In REMOTE Mode: V_{OUT} is set by a **negative** voltage on the rear panel V_{SET} connector.

[1] This switch cannot be inadvertently operated. To change voltage range, first pull the lever out and then operate the switch.

Conversion Ratio	: 1 kV/1V (Model N-126)
	: 2 kV/1V (Model N-186)
Input Impedance	: 10 kΩ
Accuracy	: ± 1 %

The ouput voltage cannot however exceed the preset value V_{MAX}, set with the screwdriver adjusted potentiometer **VMX** *on the front panel. Accuracy is ± 2 %. V_{MAX} is a* **hard** *limit which cannot be overridden.*

OUTPUT CURRENT LIMITS

Two presettable values, I_0 and I_1, can be chosen by means of the front panel (NIM) I_{SEL} input:

I_{SEL} False or missing $\Rightarrow$ max $I_{OUT} = I_0$,
I_{SEL} True $\Rightarrow$ max $I_{OUT} = I_1$.

The values of I_0 and I_1 can be preset with the screwdriver adjustable potentiometers on the front panel, labelled **I0** and **I1**.

If the output current drain is higher than the preset value active at that time, an OVERLOAD condition occurs. The various possible courses of action in the presence of an OVERLOAD are detailed in Section 4.2.

OUTPUT VOLTAGE RATE

The rate-of-change of output voltage can be adjusted by acting on the **Ramp-up** and **Ramp-down** parameters. These are set by means of the screwdriver adjustable potentiometers on the front panel, **RUP** and **RDW**.

Ramp-up and Ramp-down range is from **1 V/s** to **1 kV/s** and can be varied continuously; the 4-digit LED display to visualize the data has a resolution of **1 V/s**. Note that the settings of these parameters apply to the *absolute values* of Voltage. For instance, in case of negative polarity selection, the Ramp-up parameter is the amount of **negative** voltage level increase in the unit time, and therefore corresponds to an actual **decrease** of the voltage output.

IMPORTANT: *do not attempt to set these two parameters at 0 V/s (which would act as a voltage level lock). The Models do not operate properly under such condition. This malfunction causes random, weird errors on other operational parameters.*

These parameters are provided for voltage rate sensitive detectors. Additionally, the possibility of selecting two values of preset voltage levels, V_0 and V_1, and switching between them under external control, offers a practical way of cycling the High Voltage for conditioning streamer tubes or, when powering Photomultipliers, to reduce their supply voltage to a safe value without altering the long-term acquired characteristics of low dark current.

Ramp-up is always active, both in LOCAL or REMOTE mode. Ramp-down is overridden in KILL mode.

POWER REQUIREMENTS: (for both Models)

+24 V	250 mA
−24 V	250 mA
+12 V	110 mA
−12 V	100 mA
+ 6 V	80 mA.

3 MONITORING and DISPLAYS

In order to monitor, *both locally or remotely,* the relevant parameters and functions of model N-126, the unit features a number of displays and monitor lines for maximum convenience, ease of use and efficiency.

Local monitoring is based on front-panel displays, which are:

- **single LED** displays:
  - The two uppermost LEDs indicate:
    - ▷ *For Model N-126 only:*
      POLARITY (red for positive, yellow for negative polarity)
    - ▷ *For Model N-186 only:*
      Polarity is indicated by the sign next to the Red LED, which is ON when the Module is powered;
      The yellow LED (labelled OVR), normally off, *blinks* when High-Voltage is above 6 kV.
      This is used in conjunction with the 4-digit LED display to determine Voltage, see next item.

  The other LEDs on the third row from top indicate:
  - HIGH-VOLTAGE ON (red),
  - INHIBIT mode ON (green),
  - REMOTE mode ON (yellow),
  - OVERLOAD condition ON (red).
- **a 4-digit LED display,** that, in conjunction with the rotary switch selector, lets the operator visualize all the important operational parameters of the module.

  These are:
  - V0 and V1, the two settable values of the output voltage;
  - VMX, the preset value of the output voltage limit;
  - RUP and RDW, the settable Ramp-up and Ramp-down voltage-rate parameters;
  - I0 and I1, the two settable values of the maximum output current;
  - and finally IOUT and VOUT, the actual values of the output current and voltage.

Values are shown in Volts, microamperes and Volts per second respectively for Voltage, Current and Voltage-rate data.

For Model N-186 only: Since the 4-digit display does not allow reading out Voltages above 9999 Volts, the unambiguous estimate of the output voltage requires the uppermost yellow LED (*labelled OVR*) which blinks when Voltage is above 6000 Volts. For instance, a reading of 3500 Volts shows an output voltage of 3500 Volts if OVR is off, and of 13500 Volts if OVR blinks.

For both Models, this display is instrumental not only to visualize preset values, but also when actually **setting** the operational parameters. Indeed, to preset any one of them, the user must select, through the rotary switch, the specific parameter and then, by acting on the screwdriver adjusted potentiometer, turn until the desired value appears on the display.

- **the analog current meter** which *constantly* shows the output current drain.

  For Model N-126 only: The meter has two ranges. Full-scale range is selected by the rear-panel upper locking switch (that also selects the High-Voltage range) and is indicated by two LEDs above the meter itself; full-scale values are either 500 μA or 5000 μA.

  For Model N-186 only: the meter has a single range of 500 μA.

  The analog meter is useful to appreciate small or rapid variations of the current drain, which is a key factor when testing sensitive devices like proportional chambers or streamer tubes.

For remote monitoring of the output voltage and current, there are two output ports (Lemo 00 connectors) on the rear panel:

- **VMON** output for voltage monitoring.
  Conversion ratio is 1 kV/1V for model N-126; 2 kV/1V for model N-186.

- **IMON** output for current monitoring. Conversion ratio is:
  For Model N-126: 100 μA/1V for 500 μA max current setting, and 1 mA/1V for 3 mA max current setting.
  For Model N-186: 200 μA/1V.

- **An OVERLOAD condition** can be monitored at the STATUS output connector *(labelled STS)* on the front panel. When the OVERLOAD occurs, STATUS becomes NIM TRUE.
  This line is not automatically reset by clearing the overload condition; it must be reset by the RESET command (switch on RST position) in LOCAL mode, or, in REMOTE mode, by the INHIBIT command.

4 OPERATING MODES

Both Models feature a variety of operational states and also the same local and remote control of the states. The states are entered or changed by acting on the switches, pushbutton and/or NIM inputs located on the front panel, below the analog meter. LOCAL or REMOTE control is determined by the position of the LOCAL/REMOTE switch on the rear panel.

There are four modes (Normal, Restart, KILL and INHIBIT) for operations **not triggered** by an OVERLOAD condition. These are controlled by the three-position switch at right *(top label HV ON)* or by the pushbutton, or by NIM inputs.

In presence of an OVERLOAD, there are three modes to react to this condition (KILL, CONSTANT-CURRENT, INHIBIT) which are selected by the three-position switch *(top label OVL PROT)* at left on the front panel.

4.1 Normal, RESTART, KILL and INHIBIT

Normal mode. *(switch on central position, HV ON).* **except at switch-on,** this is the default state of the Module, where voltage and current are supplied to the load under the constraints imposed by the operational parameters.

RESTART When the unit is initially powered, or after the clearing of an OVERLOAD condition, the Module is in a Reset state, where no High-Voltage or power is supplied to the load. In order to return to normal operation *press the three-position switch to the right, on the momentary position RESTART (labelled RST).* This clears the internal memories and lets the Module resume normal operation, under the constraints imposed by the operational parameters. NOTE that the voltage is brought to the preset level at the Ramp-up rate.

IMPORTANT: before starting operation with the RESTART command, *check and/or adjust the operational parameters.* This can be done with the usual procedures, without affecting the load in any way. This is not only important after an OVERLOAD, but also at SWITCH-ON; the old pre-set values may damage the load.

INHIBIT *locally,* **right** *switch on left position (labelled INH); or electrically, by a NIM TRUE level at the INH input)*
In INHIBIT mode, the Module drops the output voltage to zero at the RAMP-DOWN rate until zero is reached. As soon as the INHIBIT command is removed the output voltage tends again to the preset active voltage limit (V0 or V1) at the RAMP-UP rate.

KILL *(actuated by KILL pushbutton or by a NIM TRUE pulse at the KILL input)*

In KILL mode, the Module stops supplying power to the load and the output voltage is quickly brought to zero, regardless of the Ramp-down value. The KILL LED is turned ON.

KILL mode overrides all other operating modes of the Module. KILL mode is cleared by a RESTART command, which also clears the KILL LED and opens the TRIP-OFF contact.

Minimum pulse length at KILL NIM input is 10 μs.

4.2 OVERLOAD PROTECTION

When the current drain exceeds the preset value active at that time (I_0 or I_1), an OVERLOAD condition occurs. This condition is indicated by a NIM TRUE level at the STATUS output connector and by the OVL LED which is turned ON.

The user can choose between three modes with which the module can react to an OVERLOAD. *These modes are selected by the front panel three-position switch at left (top label OVL PROT)*. The modes are:

KILL .... (left *switch on KILL position at right)*
At OVERLOAD, the Module stops supplying power to the load, and the output voltage is rapidly brought to zero, regardless of the Ramp-down value. The TRIP-OFF rear contact is closed and the KILL LED is turned ON.

CONSTANT-CURRENT mode .... (left *switch on central position)*
At OVERLOAD, the unit acts like a constant-current generator. The output voltage drops to a value determined by the product of the programmed current limit active at that time, and the resistive value of the load.

INHIBIT .... (left *switch on INH position at left)*
At OVERLOAD, the output voltage drops to zero with a slope determined by the RAMP-DOWN value. The INHIBIT LED is turned ON.

Except for the CONSTANT-CURRENT mode (that does not stop the Module from functioning), to resume operation after a KILL or INHIBIT:

- *in LOCAL mode*, use the RESTART command **RST** which also clears the LED and the STATUS and TRIP-OFF outputs.
- *In REMOTE mode*, use a NIM TRUE pulse at the INHIBIT input (min length 10 μs). This also clears the LED and the STATUS and TRIP-OFF lines.

5 SELECTION OF POLARITY (MOD N-126 only)

Model N-126 lets the user select the High-Voltage polarity with simple operations which are detailed in this Section. Note that the polarity is indicated by the two LEDs at the top of the front panel.

1. In order to change polarity the user must remove the side covers and the top grid on the Module, thereby accessing the Printed Circuit Board.
2. Lay the PCB, components side up and refer to Figure 3. As it can be seen, a large, black module (labelled F in the figure) is conspicuous on the Board. This is the High-Voltage multiplier and bears a "High-Voltage Danger" sign. The module has a tongue (labelled A) that, depending on the way module F was inserted, may or may not press the switch SW, thereby determining HV polarity, as shown in figures a) and b). Figure 3 a) shows the POSITIVE polarity configuration (switch released), and Figure 3 b) shows the NEGATIVE polarity arrangement, with the switch SW pressed by the tongue A.
3. If the polarity must be changed, loosen screw D that holds module F to the Board through the square bracket. DO NOT make screw C loose.
4. Extract module F from its contacts, by pressing with the thumb through the hole in the PCB, on the opposite side, right under the module. Tighten screw D to the module and loosen screw D' on the opposite side of the module, to make it ready to fit into the bracket.
5. Rotate module F, as required, to properly position tongue A. Push the module back into the contacts and at the same time, if negative polarity was selected, keep the switch actuator pressed.
6. Tighten screw D'.
7. Reassemble the unit.
8. At power-on, check that the correct polarity LED is ON.

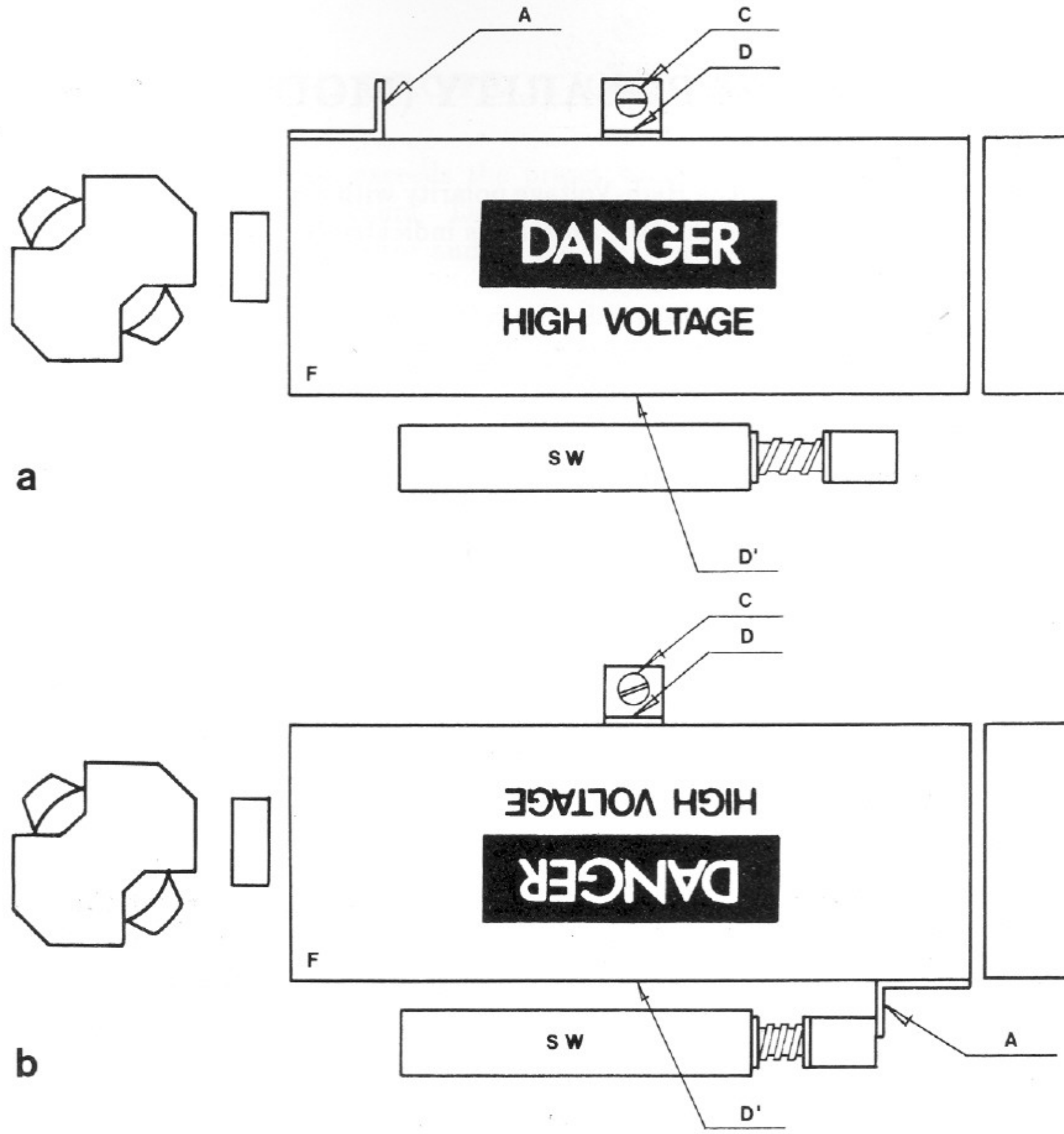

Figure 3: Selection of Polarity

6 SUMMARY TABLES

6.1 Operational Parameters

The Operational Parameters control the ways and limits with which the voltage and current are supplied to the load.
They are set by means of the screwdriver-adjustable potentiometers on the front panel, **V0** is however set with the 10-turn potentiometer.
The value of each operational parameter can be monitored on the 4-digit LED display, after being chosen with the rotary switch selector.

Table 1: **Features of the Operational Parameters**

NAME	RANGE	REMARKS
V0	0 to max HV range	Selected by VSEL = False or missing
V1	0 to max HV range	Selected by VSEL = True
VMX	0 to max HV range	**Hard** High-Voltage protection. VOUT cannot exceed VMX.*
RUP (Ramp-up)	1 V/s to 1 kV/s	Output Voltage rate away from zero. Active in LOCAL or REMOTE mode. For negative polarity is absolute value.
RDW (Ramp-down)	1 V/s to 1 kV/s	Output Voltage rate towards zero. As above. Overridden by KILL mode.
I0	0 to max current limit	Selected by ISEL = False or missing
I1	0 to max current limit	Selected by ISEL = True

*VMX overrides V0 and V1. VOUT stops at VMX if V0,V1 $\geq$ VMX.

6.2 Functions

Table 2 below summarizes the available functions on both Models.

Table 2: **Summary of Functions**

NAME	DESCRIPTION	STIMULUS
VSEL	Selects Output Voltage:[1] VSEL False/Missing Selects V0 VSEL True Selects V1	NIM levels at VSEL front panel connector
ISEL	Selects Current Limits: ISEL False/Missing Selects I0 ISEL True Selects I1	NIM levels at ISEL front panel connector
INH	INHIBIT; Drops Voltage to zero at Ramp-down rate	1) NIM True level on INH, or 2) (HV ON) switch in INH pos., or 3) at OVERLOAD, if (OVL PROT) switch on INH pos.
KILL	KILL mode; rapidly drops Voltage to zero[2]	1) KILL pushbutton, or 2) NIM True pulse at KILL, or 3) at OVERLOAD, if (OVL PROT) switch on KILL position.
RST	RESTART; resumes Module operation	(HV ON) switch on mom. pos. RST
STS	STATUS line; becomes NIM True at OVERLOAD	OVERLOAD condition
TRIP-OFF	contact is closed at KILL	at OVERLOAD (KILL mode)

[1] change of voltage takes place at Ramp-up or Ramp-down rate

[2] KILL overrides Ramp-down and all other modes

7 OPERATIONAL HINTS

This Section includes a number of useful hints, which are provided to help the reader get familiar with the usage of Model N-126 or N-186 and to avoid common mistakes, which may cause load damage. Read this Section first if you are having problems using the Units. Refer to the previous Sections for more detailed information on the features and commands of the Models.

- When the Model is powered, at switch-on the unit is in a reset state: no High-Voltage is supplied to the load. BEFORE PRESSING RST, to get the Module started, CHECK AND ADJUST, as required, POLARITY, ALL OPERATIONAL PARAMETERS and the MODES.
- On Model N-126, the user must select the High-Voltage range with the rear panel locked switch at the top, which also selects the full-scale range of the analog current meter.
- The user has a choice of two settable values of High-Voltage (V0 and V1) and of current limits (I0 and I1), selected by VSEL and ISEL. Note that **V0** is set with the 10-turn potentiometer. When switching from one HV value to the other, the transition takes place at a rate given by the settable parameters RUP (Ramp-up) or RDW (Ramp-down).
- **VMX** is provided to set a **hard** limit to the output voltage, for maximum load protection. Remember that if V0 or V1 are larger than VMX, the output voltage will actually reach a threshold at VMX.
- Local monitoring of all the Module parameters is made with the 4-digit LED display and the rotary switch Selector. On Model N-186 the 4-digit LED display shows the four least significant digits of the output voltage, the yellow LED at the top then *blinks* if output voltage is above 6000 V.
  Remote monitoring of output voltage and current is made via the VMON and IMON analog outputs on the rear panel.
- The user must select between LOCAL or REMOTE CONTROL of the output Voltage. This is made with the rear panel LOCAL/REMOTE switch. In REMOTE mode, the output voltage is set by a *negative* analog voltage level at the VSET input (if V0 is active).
- The user must also initially choose among three modes to react to an OVERLOAD condition (KILL, INHIBIT, CONSTANT-CURRENT), that can be selected with the three-position switch labelled OVL PROT.

After an overload, the Module can be restarted with the RST command, in local mode, or by a short pulse (10 μs min) at the INH input, in remote mode.

- It is also possible, independently from an OVERLOAD condition, to set the unit in KILL or INHIBIT mode, both manually or electrically.
- KILL mode overrides Ramp-down and all other modes.

8 CALIBRATION PROCEDURES

The Modules have been thoroughly and carefully tested before delivery to insure maximum reliability and precision. Particular care is given to the High-Voltage calibrations, which are made with C.A.E.N. instrumentation and a reference HV voltmeter standard.

If the unit (or one of its components) gets damaged and/or parts need replacements, the user must remember that calibrations are usually lost.

Consequently, if such a situation occurs, or if the calibration is anyhow suspected, the user is advised to return the unit to C.A.E.N. labs. Our Technical Service shall take care of repairing the Module and shall also check all the calibrations.

If the user intends to proceed independently, the following guidelines are provided to test the calibration of his unit.

8.1 Equipment Requirements

For either Model:

- One High-Voltage Voltmeter,
- One 4.5-digit Voltmeter,
- One Oscilloscope.

8.2 Calibrations for Mod. N-126

The user must refer to the Electrical Diagrams for identification of the various components.

IMPORTANT: *the following tests must be performed strictly sequentially.*

- **Reference Voltage calibration.**
  1. Using the 4.5-digit voltmeter, act on P14 to set V_{REF}, at the negative pin of C46, equal to -8.030 Volts.

- **N-126 Digital Readout Adjustment**

2. Select V0 position with the rotary switch on the front panel,
3. Turn V0 potentiometer on the front panel to zero and act on P13 to get a readout of 0 or 1 (unstable zero).
4. Turn V0 potentiometer to its maximum and act on P15 to get a readout of 8030.

- **Low- & High-Range Voltage Calibration (POSITIVE Polarity)**

5. Set Positive Polarity and select 8 kV/500 μA range.
   NOTE: from now on, the values of voltage and current are those displayed on the Module's digital readout, when the corresponding parameter is selected by the rotary switch.
6. Set the High-Voltage to zero Volts and start the Module (with the RST command). Turn P7 fully clockwise.
7. Select VOUT and, with no load, act on P1 until the display shows 0 or 1.
8. Connect the HV voltmeter at the Module output. Set a low HV value (about 20 V) with the V0 potentiometer, and act on P7 until the HV voltmeter shows a value equal to the preset value displayed on the N-126 readout, which must be also equal to VOUT.
9. Set V0 to $\simeq$ 5000 V and act on P11 until VOUT and V0 are identical, then act on P9 to obtain the same value on the HV voltmeter.

- **Low- & High-Range High-Voltage Calibration (NEGATIVE Polarity)**

10. Set Negative Polarity
11. As above at Point 8, set a low voltage value, about 20 V, on V0, start the Module and connect the HV voltmeter at the output. Act on P3 to make the HV reading equal to the N-126 digital readout.
12. Set about 5000 V on V0 and act on P10 to make VOUT and the HV voltmeter readings equal to the reading for V0.

- **Current & Overload calibration**

13. Set V0 to zero Volts and act on P4 to get IOUT = 0.
14. Set I0 = 0 and, with the oscilloscope on pin 14 of IC2, act on P5 until the level jitters to -12 V (critical balance condition), to adjust the overload detector.
15. With no load, set maximum output voltage, with the module active, and act on trimmer R30 to get IOUT = 0 or 1 (unstable zero).

16. Set the output voltage to 8000 V and, with the HV voltmeter connected, verify that:

$$IOUT = \frac{8000}{R_{VHV}} \quad \mu A$$

where R_{VHV} is the internal resistance of the HV voltmeter. Take note of the exact value.
(The same test can be done with a reference resistor, here for convenience the HV voltmeter resistor is suggested.)

17. Set I0 equal to the current determined at the previous point and act on P8 as at point 14.

18. Set again Positive Polarity.

19. Set V0 to zero, start the Module and act on P2 to get IOUT = 0 or 1 (unstable zero).

20. Set the output voltage to 8000 V and, having connected the HV voltmeter at the output, act on P6 to make IOUT equal to the value noted at point 16.

8.3 Calibrations for Mod. N-186

The user must refer to the Electrical Diagrams for identification of the various components.

IMPORTANT: *the following tests must be performed strictly sequentially.*

- **Reference Voltage calibration.**

1. Using the 4.5-digit voltmeter, act on P14 to set V_{REF}, at the negative pin of C46, equal to -7.550 Volts.

- **N-186 Digital Readout Adjustment**

2. Select V0 position with the rotary switch on the front panel,
3. Turn V0 potentiometer on front panel to zero and act on P13 to get a readout of 0 or 1 (unstable zero).
4. Turn V0 potentiometer to its maximum and act on P15 to get a readout of 5.100 with the OVR LED blinking.

- **Low- & High-Range Voltage Calibration**

5. NOTE: from now on, the values of voltage and current are those displayed on the Module's digital readout when the corresponding parameter is selected by the rotary switch.
   Set zero Volts of High-Voltage and start the Module (with the RST command). Turn P7 fully clockwise.
6. Select VOUT and, with no load, act on P1 until the display shows 0 or 1 V.
7. Connect the HV voltmeter at the Module output. Set a low HV value (about 50 V) with the V0 potentiometer and act on P7 until the HV voltmeter shows a value equal to the preset value, displayed on the N-186 readout, which must be also equal to VOUT.
8. Set V0 to $\simeq$ 8000 V and act on P11 until VOUT and V0 are identical, then act on P9 to obtain the same value on the HV voltmeter.

- **Current & Overload calibration**

9. Set V0 to zero and act on P4 to get IOUT = 0.
10. Set I0 = 0 and, with the oscilloscope on pin 14 of IC2, act on P5 until the level jitters to -12 V (critical balance condition), to adjust the overload detector.

11. With no load, set maximum output voltage, with the module active, and act on trimmer R30 to get IOUT = 0 or 1 (unstable zero).

12. Set the output voltage to 15000 V and, with the HV voltmeter connected, it must be:

$$IOUT = \frac{15000}{R_{VHV}} \quad \mu A$$

where R_{VHV} is the (known) internal resistance of the HV voltmeter. FOR NEGATIVE POLARITY models: take note of the exact value. FOR POSITIVE POLARITY models: act on trimmer P6 to obtain this value of current.
(This test can be done with a reference resistor; here, for convenience, the HV voltmeter resistor is suggested.)

13. Set I0 equal to the current determined at the previous point and act on P8 as at point 10.