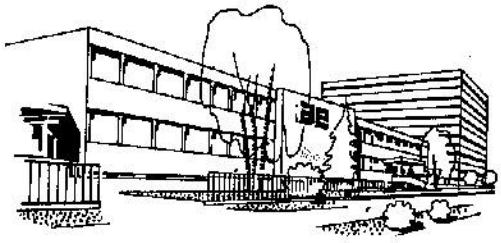
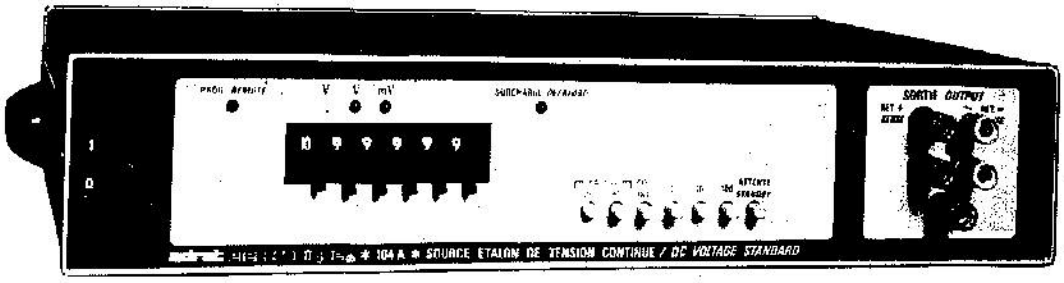
ADRET *ELECTRONIQUE*®





DC VOLTAGE STANDARD

1 μV/110 V

104 A

ADRET *ELECTRONIQUE*®

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CHAPTER I

INTRODUCTION

The 104 is a D.C. voltage generator adjustable from $\pm$ 1µV to $\pm$ 110 V. It is intended for use as a stable and precise source for such applications as measurement of voltage by the opposition method, calibration of digital voltmeters, checking linearity of operational amplifiers, etc....

There are three output voltage ranges; 1 V, 10 V and 100 V. The stability and precision are identical with those obtained from the internal reference voltage. Voltage selection is by means of six lever switches in local mode or, in remote mode, by coded signals when the equipment is fitted with one of the two options (BCD parallel or IEEE 488/CEI 625 interface).

The DC signal is available as a 4-wire output through connectors on both front and rear panels. Voltage range, standby, polarity and maximum output current are selected by 7 push-buttons.

CHAPTER II

SPECIFICATIONS

RANGE:

- 1 V : ± 1 µV to ± 1.099999 V
- 10 V : ± 10 µV to ± 10.99999 V
- 100 V : ± 100 µV to ± 109.9999 V

RESOLUTION:

- 1 V range : 1 µV
- 10 V range : 10 µV
- 100 V range : 100 µV

CURRENT COMPLIANCE:

0 to 110 mA throughout the range with possible limitation setting at 25 mA or 50 mA.

ACCURACY (at 23°C ± 1° over a 3 month period):

After 1½ hour warm-up and 70% relative humidity

- 1 V range : ± 0.005% of range ± 0.003% of displayed value
- 10 V range : ± 0.001% of range ± 0.003% of displayed value
- 100 V range : ± 0.001% of range ± 0.005% of displayed value

INDEPENDENT LINEARITY:

0.001% throughout the range

★ STABILITY at constant temperature ± 1°C within + 15° and + 35°C:

	1 V range	10 V range	100 V range
Over a 2 hour period After 2 hours operation	± 10 µV ± 0.0006% *	± 20 µV ± 0.0005% *	± 200 µV ± 0.0006% *
Over a 24 hour period After 12 hours operation	± 10 µV ± 0.001% *	± 20 µV ± 0.0008% *	± 200 µV ± 0.001% *
Over a 7 day period After 12 hours operation	± 15 µV ± 0.0015% *	± 25 µV ± 0.001% *	± 250 µV ± 0.0015% *
Over a 3 month period After 7 days operation	± 15 µV ± 0,0025 % *	± 25 µV ± 0,002 % *	± 250 µV ± 0,0025 % *

* of the values shown

NOISE:

Within a band of 0.1 Hz to 20 KHz

- 1 V and 10 V Sub-ranges: 10 µV RMS
- 100 V Sub-range : 60 µV RMS

INTERNAL RESISTANCE:

Ri $<$0.1 milliohm throughout the range

INTERNAL IMPEDANCE:

(from DC to 10 kHz):

For an AC load current up to 20% of the DC component.

- 1 V Sub-range : Zi $\leqslant 2\Omega$
- 10 V Sub-range : Zi $\leqslant 2\Omega$
- 100 V Sub-range : Zi $\leqslant 8\Omega$

SETTLING TIME:

- Around 100 ms, at 1.10^{-4} of the displayed value
- Around 50 ms, at 1.10^{-3} of the displayed value

MAINS VARIATION :

$\pm$ 0.001% of the selected sub-range, for $\pm$ 10% of mains variation.

TEMPERATURE COEFFICIENT:

5 µV $\pm$ 0.0001% of the displayed value by /°C

4 WIRES OUTPUT

(Remote regulation).

The voltage drop in the load connecting wires must be less than 0.1 V in order to keep the accuracy.

- Maximum permissible capacitive load: 0.22 µF
- Four quadrants operation, with maximal current direct of reverse
- Dielectric strength : $\pm$ 500 V between terminals and ground.

COMMON MODE REJECTION: - 140 dB

SIGNAL INHIBIT:

In "STAND-BY" position corresponding to a zero display.

PROTECTION:

Protected output against short-circuits with overload indicator. All performances are immediately restored upon short-circuit removal.

PROGRAMMING (Option):

of voltage: 1µV to 110 V

of polarity: + or -

of inhibit (standby)

of LOCAL/REMOTE mode

- PARALLEL BCD programming

(Option 104-1)

1 - 2 - 4 - 8 codes

TTL logic with current sink

"0" level: 0 V to + 4 V

"1" level: +2 V to + 5 V

- IEEE Bus programming

(Option 104-2)

Interface: IEEE standard 488-1975

Functions: SHØ-AH1-TØ-TEØ-L1-LEØ-RL2-
PPØ - DC1 - DT1 - CØ

POWER SUPPLY:

- Voltage : 115 V - 230 V ± 13%
- Frequency : 50 to 400 Hz
- Consumption: 30 W
  Natural cooling.

ENVIRONMENT:

- Calibration: at + 23°C ± 1°C with 70% relative humidity.

- Operation: from + 15°C to + 35°C

  (Within 0° to + 15°C and + 35°C to + 50°C the performances are no longer guaranteed).

- Storage temperature: - 20°C to + 70°C

SIZE/WEIGHT:

19" rack adaptable

- Height: 88 mm (2U)
- Width: 440 mm
- Depth: 360 mm
- Weight: around 10 kg

OPTIONS:

104-1: BCD parallel programming

104-2: IEEE 488-1875 programming

104-3: External 1/100 divider (auxiliary unit)

104-4: 19" rack mounts

NANOVOLT EXTENSION (auxiliary unit):

1/100 divider - internal resistance: 2 $\Omega \pm 5\%$

compatible with 10 V and 1 V sub-ranges

- On 10 V: Sub-range 0 to 100 mV, resolution 100 nV
- On 1 V: Sub-range 0 to 10 mV, resolution 10 nV.

CHAPTER III

OPERATING INSTRUCTIONS

PREPARING FOR USE

This section gives information about electrical installation, environmental conditions and 19-inch rack adaption of the Type 104 DC Supply.

DELIVERY OF EQUIPMENT

The instrument is delivered in a cardboard carton and is protected by an expanded polyurethane foam injection process. The package contains the instrument specified on the delivery note together with the mains lead.

The guarantee covers damage caused during delivery from ADRET ELECTRONIQUE. Check that the equipment has suffered no mechanical damage in transit.

IDENTIFICATION

Manufacturing references for the 104 are given on a label rivetted to the rear panel.

MAINS CONNECTION

THE 104 Standard Supply is designed to work on mains voltages of 115 V or 230 Vrms $\pm$ 13% at frequencies within the range 50 to 400 Hz. Power consumption is 30 W.

The equipment is delivered adjusted to operate on 230 Vrms and the input circuit is protected by a 315 mA fuse. Connection is made via the 3-pin socket located on the "Mains filter and selector" housing on the rear panel. This housing also contains the input voltage selector and the fuse. The use of this device gives perfect safety as it is only possible to gain access to these components when the mains lead is disconnected from the instrument.

When the instrument is not compatible with the mains voltage, follow the instructions shown in Figure 3.1 which give the sequence of operations necessary to make the correct adjustment.

1. Slide out the transparent cover.
2. Operate the FUSE-PULL lever to withdraw the fuse from the housing.
3. Remove the "Voltage Selector" printed circuit from its location and then position it as shown in the figure so the value corresponding to the mains voltage is on the left.
4. Insert the fuse between the metal clips and return the FUSEPULL lever to its original position.
   (115 V: 630 mA fuse)
5. Replace the cover in its original position. The mains voltage to be applied to the equipment must be the same as indicated through the cover.

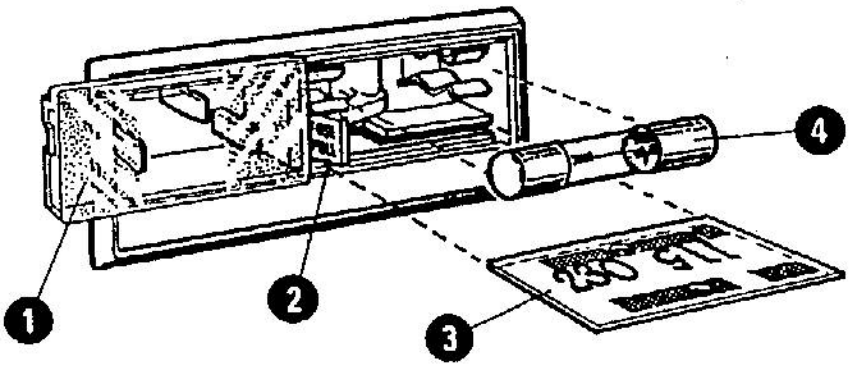


FIGURE 3.1: ADJUSTING THE 104 TO CORRECT MAINS VOLTAGE

ENVIRONMENT

Technical specifications of the 104 are valid for all applications of the equipment in environments where the ambient temperature is within the range + 15°C to + 35°C.

STORAGE

The equipment must be stored in a non-humid place where the temperature remains within the range -20°C to + 70°C.

19-Inch RACK MOUNTING

The 104 can be mounted in a 19-inch rack by means of two 2U adapters supplied on request. Two metal brackets, ADRET reference Nos 0380007500 and 0380007600, are fitted (as shown in figure 3.2) to the sides of the instrument and fixed by four screws.

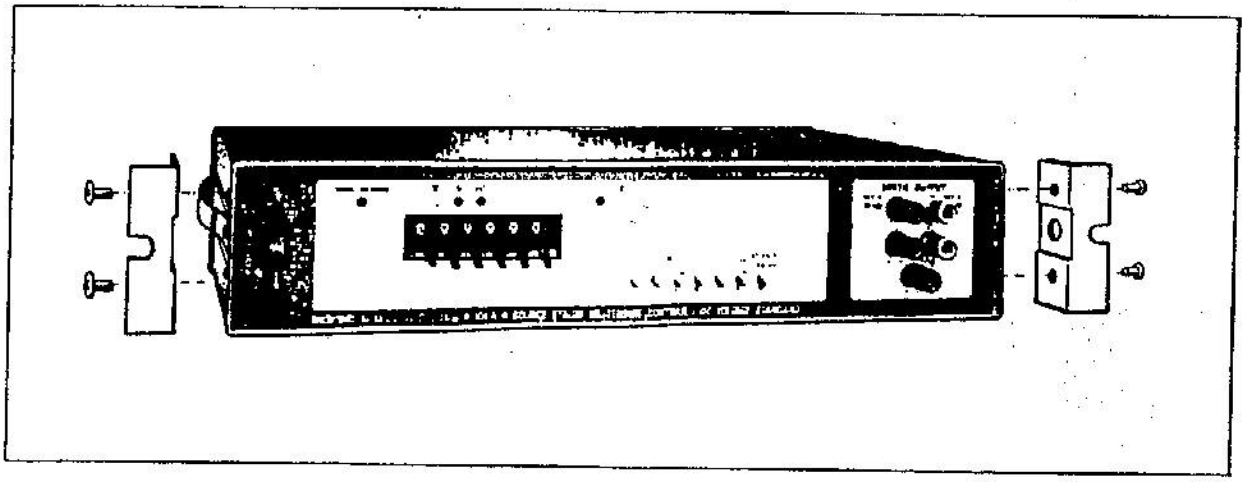
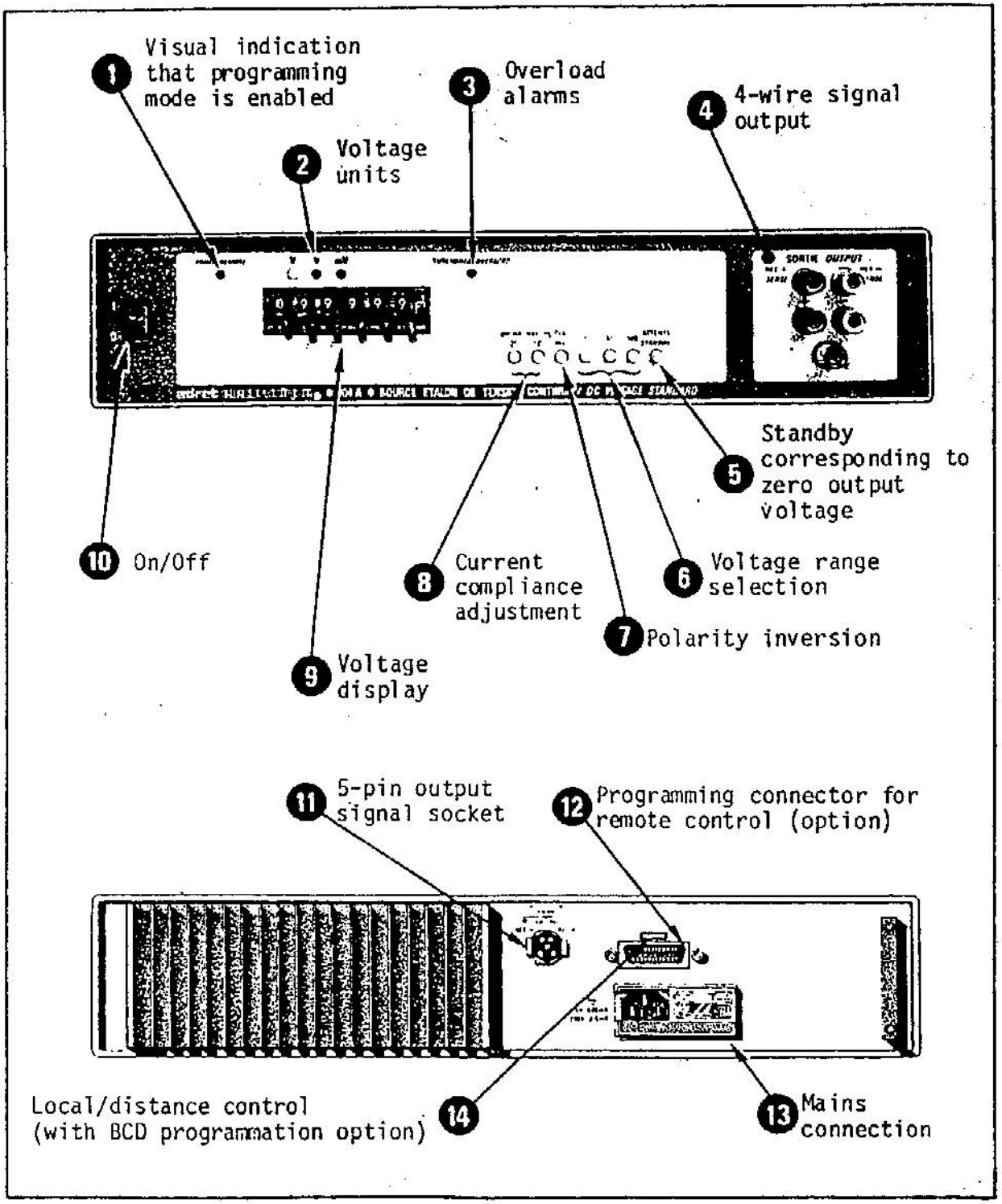


FIGURE 3.2: MOUNTING THE 104 IN A 19-INCH RACK

OPERATION

This section describes the functions of the instrument controls and also the operating procedure for setting up the output signal.

DESCRIPTION OF EQUIPMENT



INITIAL CHECKS

a) Press the "STANDBY" button.

b) Connect the instrument to the mains and then switch on using the "ON/OFF" switch ⓫

VOLTAGE UNITS

c) Consecutively select the 1 V, 10 V and 100 V ranges by means of the push-buttons ❹ , checking that the corresponding "Units" indicators ❸ light up.

- 1 V range : right hand "mV" indicator lights
- 10 V range : left hand "V" indicator lights
- 100 V range : central "V" indicator lights

OVERLOAD

d) Release the standby button.

e) Short-circuit the + and - terminals ❺ then, in all three ranges, check that the "OVERLOAD" indicator ❸ lights when the output voltage is greater than 10mV.

CURRENT LIMITING

f) Select a voltage range and load the instrument so that an output current of 30 mA is obtained.

g) Press the "25 mA" button ❽ ; the overload indicator ❸ should light up.

h) Adjust the load to obtain an output current of 55 mA. Press the "50 mA" button ❾ ; the overload indicator ❸ should light up.

POLARITY INVERSION

i) Check that the output voltage is positive when the "POL INV" button is released.

j) Press the "POL INV" button ❼ and check that output signal polarity has inverted.

PROGRAMMING (Option)

k) Check that enabling the remote mode lights up the "PROG" indicator ❷.

OPERATING INSTRUCTIONS

The DC output can be obtained in either of two modes: "Local", by means of push buttons and lever switches or "Remote", if the equipment is fitted with one of the two available programming options (parallel BCD or IEEE 488-1975/CEI 625 interface).

LOCAL MODE

a) Select the voltage range: 1 V, 10 V or 100 V. To ensure the best accuracy of the instrument, check the 1 V range for all applications up to 1.1 V, the 10 V range for applications from 1.1 V to 11 V and the 100 V range for applications from 11 to 110 volts.

b) Select the output voltage using the six lever switches.

c) Select the output voltage polarity using the "POL INV" button; the voltage is positive when the button is released, and negative when pressed in.

d) Press either the 25 mA or the 50 mA button to limit the maximum load current. If both buttons are released the maximum load current can reach 110 mA.

e) Connect the Voltage Standard to its load.

The DC voltage is available on a 4-wire output either at four terminals located on the front panel, or at a 4-pin plus earth socket on the rear panel.

Remote control enables the specifications to be maintained at the terminals of a load by compensating for the effect of the resistance of the connecting cables.

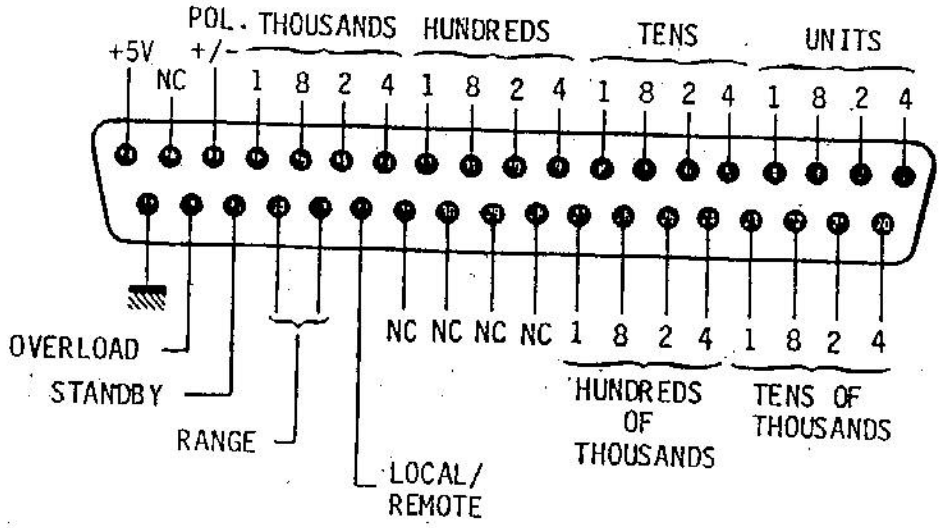
REMOTE MODE

- "PARALLEL BCD" Programming option

Connect the programmer to the 37-pin socket on the rear panel.

All equipment controls, apart from current limitation, are programmable in BCD 1-2-4-8 codes. Programming is carried out in positive logic using signals compatible with TTL levels.

The pin-allocation for the 37-pin socket is given in Figure below



Pin allocation of Remote Connection Socket: DC 37 P SOURIAU

OPERATING MODE

The operating mode is selected by the switch ⓫ in LOCAL mode and four the programmation connector in REMOTE mode, the logic signal having the precedence over the switch apply a logic level "1" to pin 32 to select LOCAL mode and logic level "0" to enable the REMOTE mode. The switch position to indifferent in that case.

When the controller is not connected to the instrument, the switch ⓫ must be set ou "LOCAL".

VOLTAGE RANGE

To select a voltage range, apply logic signals to pins 33 and 34 according to the table below:

Range	Pins 33	34
1 V	0	0
10V	0	1
100V	1	1

VOLTAGE

Apply a logic level "1" to the pins corresponding to the selected values to obtain the required output voltage.

BCD Codes	PIN NUMBERS					
4	1	5	9	13	20	24
2	2	6	10	14	21	25
8	3	7	11	15	22	26
1	4	8	12	16	23	27

[illegible] V Range	10^0 µV	10^1 µV	10^2 µV	10^0 mV	10^1 mV	10^2 mV
10 V Range	10^1 µV	10^2 µV	10^0 mV	10^1 mV	10^2 mV	10^0 V
100 V Range	10^2 µV	10^0 mV	10^1 mV	10^2 mV	10^0 V	10^1 V

Range extension is achieved by programming the most significant 8 and 2 codes.

POLARITY

Apply logic level "0" or "1" to pin 17 to obtain positive or negative output voltage respectively.

STANDBY

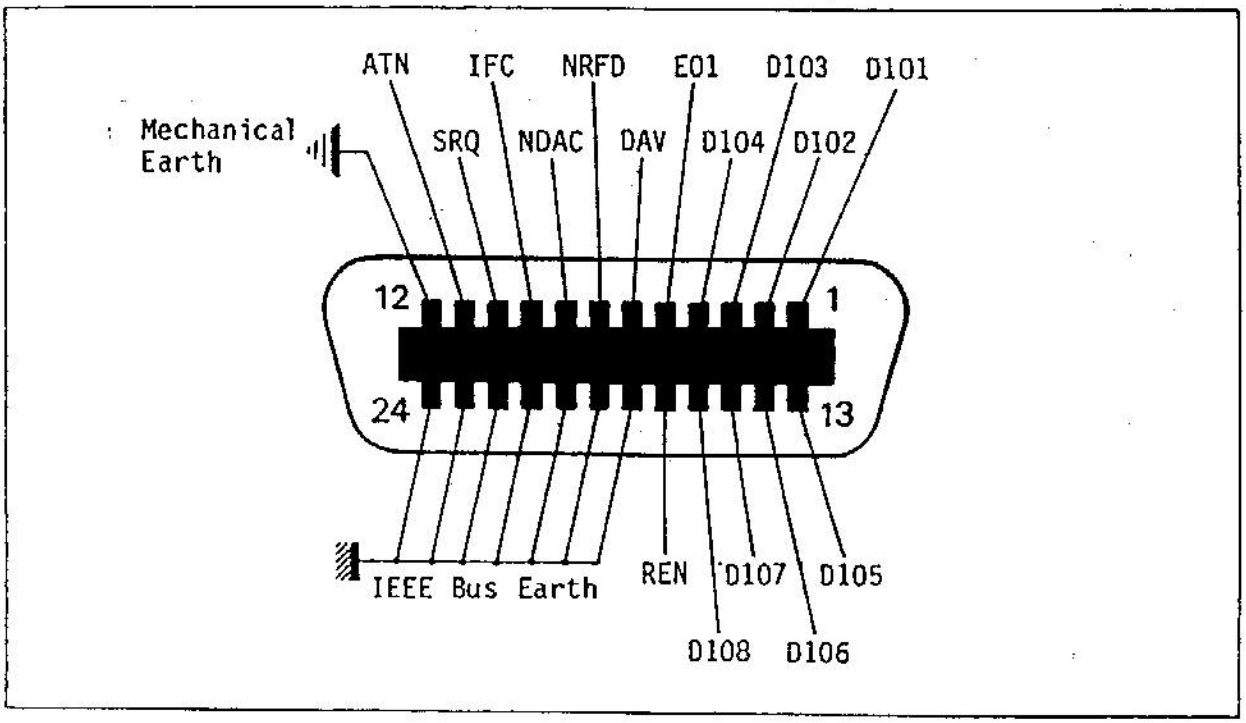
Apply logic level "0" to pin 35 to set the instrument on "Standby" (this condition corresponds to zero indicated voltage).

OVERLOAD

The signal indicating current overload appears at pin 36; a logic level "0" indicates normal operation and the alarm condition is indicated by the appearance of logic level "1".

- IEEE 488 INTERFACE OPTION

The voltage standard is programmed according to the IEEE 488 standard. Connection to the remote controller is via the rear 24-pin connector of which the pin allocation is shown in the figure below.



IEEE INTERFACE BUS CONNECTOR.

ADDRESSING

Five internal switches numbered 1 to 5 , select the instrument address in binary codes corresponding to decimal addresses between 0 and 30.

- Remove the top panel of the instrument; the switches are located near the power supply transformer.
- Put the switch or switches in the "ON" position to select the binary code corresponding to the chosen address.
- Enable the "Listen Only" mode by putting the sixth switch in the "ON" position. The instrument thus functions in a permanently addressed mode but, in accordance with the interface standard, the voltage standard can only be programmed by remote switching, i.e., by being addressed once.

The "PROG" indicator on the front panel lights as soon as the instrument is addressed and all manual controls are inhibited with the exception of the "ON/OFF" switch and the 25 mA and 50 mA current limiting buttons.

The return to "LOCAL" mode can be initiated in different ways:

- Giving the order GTL (Go to Local),
- Applying logic level "1" to the REN line,
- Applying logic level "0" to the IFC line.

VOLTAGE

The output voltage is selected by programming the "RxVt" characters; "Rx" represents the range and "Vt" represents the value of the DC signal.

. Replace "x" by 1, 2 or 3 to select the 1 V, 10 V or 100 V ranges respectively.

. Replace "t" by a complete number corresponding to the output voltage. This number should be expressed in microvolts for the 1 V range, in tens of microvolts for the 10 V range and in hundreds of microvolts for the 100 V range.

A negative voltage is obtained by in seting a minus sign (-) after the "V".

If the programmed number contains a point, comma or any character other than a figure, the figures appearing after this character are ignored. Because of this the use of floating point format is forbidden.

Furthermore, if a certain number of characters are inserted between the letter "V" and the number representing the voltage, these characters are ignored except for the letters R and S and also the command RC (Carriage Return).

Programming Examples

Order	Selected Range	Output Voltage
R1 V 1000	1 V	+ 1000 µV
R1 V - 1000	1 V	- 1000 µV
R2 V 100	10 V	+ 1000 µV
R2 V 1090000	10 V	+ 10.9 V
R3 V 10	100 V	+ 1000 µV
R3 V - 1090000	100 V	- 109 V

- It is not necessary to specify a range again in order to vary the output voltage within that same range.
- The output voltage must be specified every time the range is changed.
- Polarity inversion is achieved by programming the part relating to voltage (V100). A minus sign is inserted between the letter "V" and the number indicating the voltage (V-100).

INHIBITION

Program the character "S", followed by "RC" (Carriage Return), or by a question mark (?).

The output level inhibit ends with the programming of a new voltage.

DATA VALIDATION

The 104 Voltage Standard will accept input data on receipt of the command RC (Carriage Return), which is usually transmitted automatically by the controller at the end of a message, or of the command GET (Group Executive Trigger) which enables simultaneous validation of data from several equipments, or simply on receipt of a question mark (?).

The opposite function is initiated by the commands DCL (Device Clear) and SDC (Selected Device Clear) which cancel the programming of the Rx Vt control.

CHAPTER IV

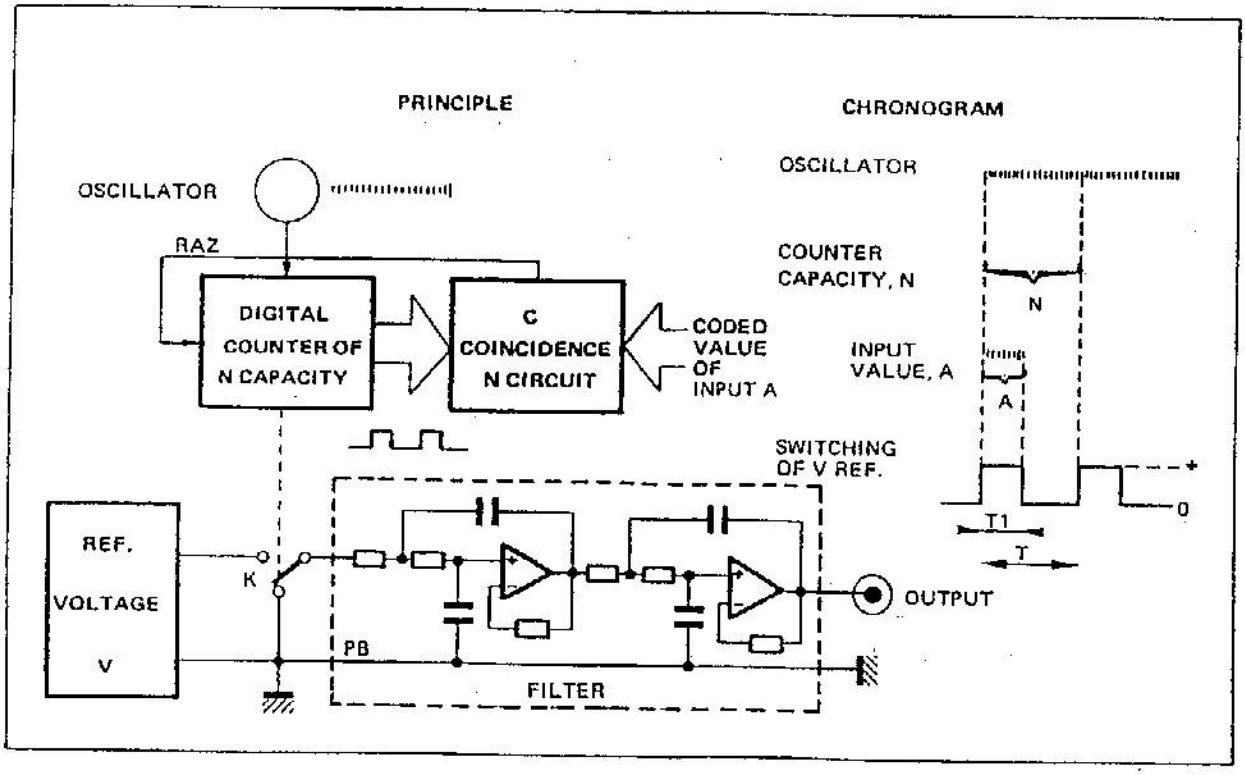
PRINCIPLE OF OPERATION

The operating principle of the 104 is the time division of a reference voltage. The implementation of the original principle (patented by ADRET) is based on digital generation of voltage by pulse width modulation (also called PWM). This eliminates the use of potentiometric division or any other electro-mechanical component.

The method of obtaining the final voltage is shown in the functional schema and its chronogram.

A quartz controlled oscillator generates clock pulses which are controlled by a digital counter of capacity N. The counter outputs are fed into a coincidence circuit, C, whose other input, input A, is the coded value corresponding to the displayed voltage. During the time T1, which is a function of A, the switch K connects the reference voltage to the filter input which is normally connected to earth. The filter is therefore supplied during the time T1/T of the period, i.e. A/N. The Fourier analysis of the waveform produces a constant term + Vo.

Vo = Vref.A/N, which is therefore proportional to the coded value of input A.



PRINCIPLE OF OPERATION OF THE 104

FUNCTIONAL DESCRIPTION (See flow chart plate III-1)

The output of a 4 MHz quartz-controlled oscillator is divided by 4 and applied to the inputs of three counters, the first two dividing by 10 and the third by 11. These counters provide 1100 discrete states in each counting cycle which itself has a periodic frequency of 909 Hz. Coincidence between these states and the data from either the numerical switches or from an external command (programming) is sensed by the "Coincidence I" circuit for the three most significant figures and by the "Coincidence II" circuit for the other three figures.

The coincidence circuit output pulses, whose width is proportional to the displayed or programmed figures, are applied to the "Voltage Reference" card via pulse transformers T1 and T2. A third transformer T3 is used for synchronization of the "Coincidence I" output signal.

The pulses are shaped at the input of the "Reference" card by circuits TR1 and TR2 to provide pulses of variable width and with amplitude exactly equal to the reference voltage. This voltage, 11 V, is of high precision and is produced by circuit R1 which directly feeds switch K4 and indirectly, via A1, the circuits TR2, TR1, CP1 and CRG1.

The voltage pulses proportional to the 3 most significant figures are phase synchronised with the original oscillator by P1 and then applied to the active filter FL1 via switch K1 which is itself operated by P1.

The low-pass filter FL1 (pass band 25 Hz) removes the AC components and outputs a calibrated voltage of 11.0000 volts. This output is then summed across a 100 ohm resistor with the voltage proportional to the three least significant digits which is the output from circuit TR1 across a 100 Kohm resistor.

The signal produced by this summation is applied to amplifier A11 which, depending on the polarity chosen, feeds a negative or positive voltage to the active filter FL2.

Filter FL2 is of the same type as FL1 and has a highly damped response to prevent any overshoot phenomena. The "primary" DC voltage obtained from the "VOLTAGE REFERENCE" card is routed to the "PREAMPLIFIER" card.

The preamplifier card multiplies the "primary" DC voltage by 1/10, 1 or 10 according to the voltage range selected 1 V, 10 V or 100 V.

The gain appropriate to the chosen range is selected at the input of A2 by simultaneous switching of the main and return lines to the 6 Kohms and 54 Kohms resistors. Switching is achieved by means of relays A, B and K9. With a gain of 10 (corresponding to the 100 V range) the input voltage to negative feedback amplifier A3 is attenuated in the ratio 1/10 by circuits CR1 and CG2.

Any irregularity in the output of the equipment (short-circuit, current limiting or voltage limiting) is sensed by amplifier A3 and fed to the preceeding amplifier A2 which reacts to the sudden change and triggers an overload signal via photo-coupler PC1. The preamplifier card output voltage is applied to the input of power amplifier AP1 which operates in class AB and can supply a maximum output of 109,9999 V with a maximum current of 110 mA. The corresponding power delivered to the load is approximately 12 W.

The controls for polarity inversion (CP1), range calibration (CRG1), gain (CG2) and overload are isolated from the analogue side by the four photo-couplers PC1, PC2, PC3 and PC4.

The "Carrier" card contains the power amplifier, the power supply circuits and the circuits for range switching, polarity selection and associated functions. The four output leads are connected to the front panel terminals by a screened cable.

CHAPTER V

CALIBRATION AND GENERAL TESTING

This chapter gives all the information and describes all the adjustments necessary to check and calibrate the instrument during routine maintenance.

The Voltage Standard should be checked at approximately 3 month intervals to guarantee the operational performance of the instrument.

Adjustments must be made under environmental conditions as specified in Chapter II, i.e. Ambient Temperature 23°C ± 1°C at 70% relative humidity. Also, the inspection procedure must not commence until after a warm-up time of 2 hours.

Fourteen tests are sufficient to adjust the voltage standard. A centre-zero voltmeter (±10 µV full scale), a digital voltmeter with readout to 2 000 000 (class 10^{-5}) and a screened connecting cable are required to correctly adjust the instrument.

ADJUSTMENTS AND CHECKS

Remove the top panel to gain access to the adjustment points. At each adjustment point will be found a potentiometer with a silkscreened label.

Tests should be conducted in the sequence given in the procedure described below:

1 ZERO ACCURACY: 1 V RANGE

- Select + 0 V on the 104
- Connect the centre-zero voltmeter to the output of the voltage standard.
- Wait for 5 minutes, then adjust the potentiometer marked "ZERO GAMME (ZERO RANGE) ± 1 V" until the measured voltage is ≤ ± 5 µV.

2 ZERO ACCURACY: - 10 V RANGE

. Select - 0 V

. Wait 5 minutes and adjust the potentiometer marked "ZERO -" until the measured voltage is $\leq \pm$ 20 µV.

3 ZERO ACCURACY: + 10 V RANGE

. Select + 0 V

. Wait 5 minutes and adjust the potentiometer marked "ZERO +" until the measured voltage is $\leq \pm$ 20 µV

4 REPEAT ADJUSTMENTS 1,2 AND 3 IF NECESSARY.

5 ZERO ACCURACY: 100 V RANGE

. Select 0 V and check that the measured voltage is $\leq \pm$ 500 µV

6 GAIN: - 10 V RANGE

. Select - 10.9 V

. Wait 5 minutes and adjust the potentiometer marked "- 10 V" until the measured voltage is within the range - 10.89995 to - 10.90005 V.

7 GAIN: +10 V RANGE

. Select + 10.9 V

. Wait 5 minutes and adjust the potentiometer marked "+ 10 V" until the measured voltage is between + 10.89995 and + 10.90005 V.

8 REPEAT ADJUSTMENT 6 AND 7 IF NECESSARY.

9 UNIFORMITY ADJUSTMENT

. Select the + 10 V range

. Connect a digital voltmeter to the output of the 104 Voltage Standard and select the 1 V range.

. Select 10 mV on the Voltage Standard and take the corresponding from the digital voltmeter.

. Select 9.99 mV and adjust the potentiometer marked "MONOT" until the measured voltage is 10 digits below the previous reading.

. Adjust to within $\pm$ 3 digits.

10 GAIN: - 1 V RANGE

- Select - 1.09 V
- Wait 5 minutes and adjust the potentiometer marked "- 1 V" until the measured voltage is between - 1.089995 and - 1.090005 V.

11 GAIN: + 100 V RANGE

- Select + 1.09 V and check that the measured voltage is between +1.089990 and + 1.090010 V. If this is not so, repeat adjustment 10 to distribute the errors.

12 GAIN: - 100 V RANGE

- Select - 109.9 V
- Wait 5 minutes and adjust the potentiometer marked "- 100 V" until the measured voltage is between - 109.8990 and - 109.9010 V.

13 GAIN: + 100 V RANGE

- Select + 109.9 V and check that the measured voltage is between + 109.8990 and + 109.9010 V. If this is not so, repeat adjustment 12 to distribute the errors.

14 INDEPENDENT LINEARITY

- Select the 10 V range
- Select voltages successively in 1 V steps checking that the errors in linearity are $\leqslant$0.001 %.

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