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# 1 Basic safety precautions

Ensure that you have the necessary competence to assemble and use this system. Otherwise, request the assistance of an experienced technician.

Before connecting the high-voltage transformer, check that the measurement module is operating by using the TEST function of the attached software (refer to chapters 3 and 4).

The electronic module works with voltages of less than 30 v, but the dangerous plate voltage used for testing the vacuum tubes will be running through the circuit as soon as you connect the high-voltage transformer (see Chapter 3: Connecting the measurement module). Never touch any part of the system when it is plugged; should you wish to do so, ensure that at least the high voltage transformer is unplugged. No capacitor is present in the high voltage line; hence any risk disappears when this transformer is unplugged.

Observe the connection diagram of Chapter 3, and do not leave out the fuses ; they contribute to general security and can help protect the tubes under test.

Before testing any tube, carefully check the connections, the parameters settings and the applied voltages.

Never use the mains as a source of high-voltage; use only insulated transformers with separated– primary and secondary (ies).

## 2 Installing the software

The software works with all versions of Windows, starting with Win95 s.e.

**Strictly observe the following procedure in order to correctly run the system:**

- Go to the root directory of your hard disk C:\
- Create a new directory by a right click on your mouse. Name this directory “ lampemetre ”
- Now copy all the files and the directory in the Cr-rom and ensure that the directory “ datas ” has been properly installed.
- Look for the file « Confdt.dta » and right click on it. Once the window opens select “Properties”. On the new window deactivate “read only”. Click “Apply”, then “Ok”.

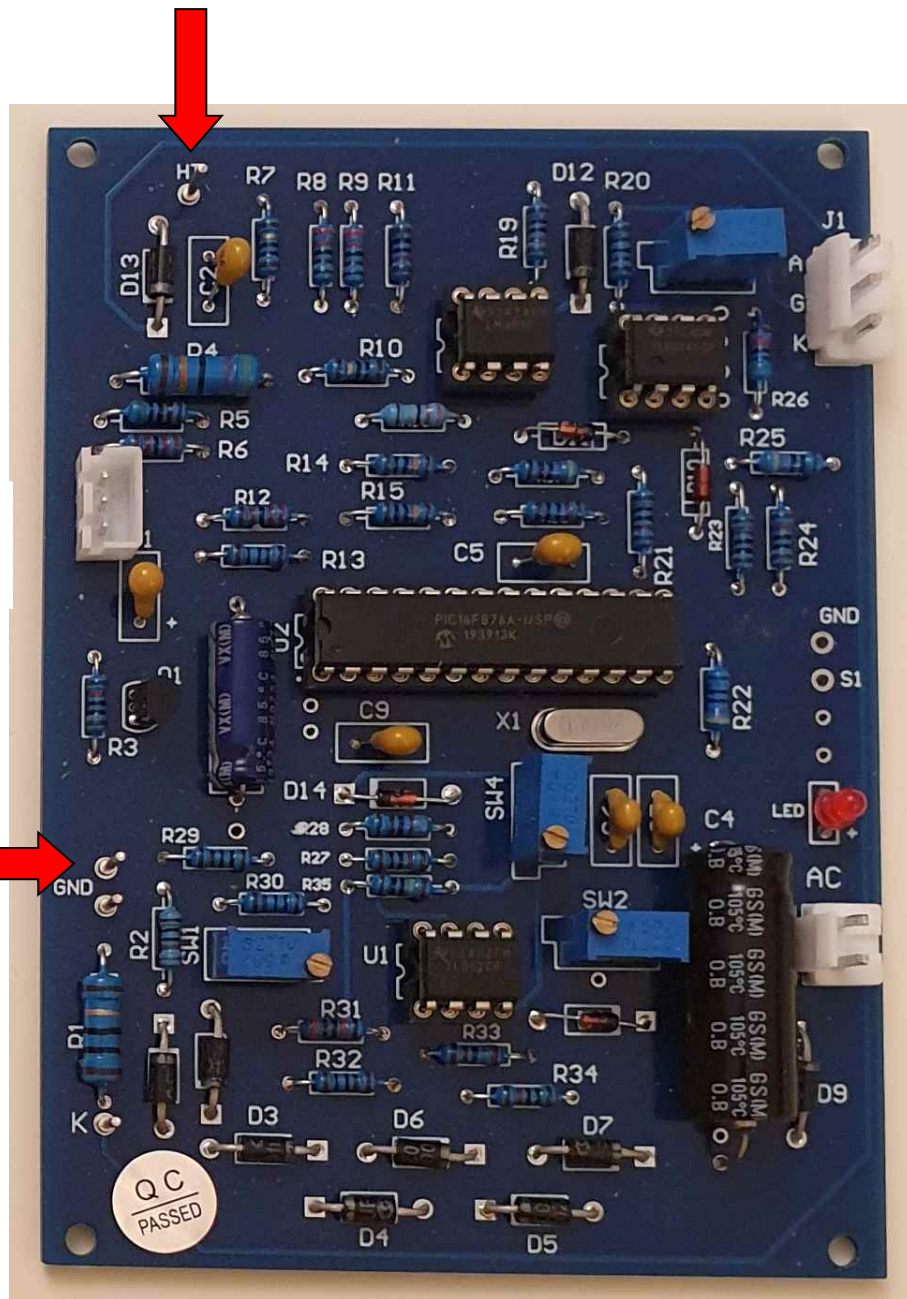
The installation is now complete. You can now run the software by clicking on:



Lampemetre.exe

### 3 Connection of the measurement module

High voltage Input 1



Tube connections:

Plate  
Grid 1  
Cathode

24 - 28v a.c.

Connection details

High voltage Input 1 & Input 2 refer to the transformer high voltage secondary ( Plate voltage )

Prepare the three wires which are connected to the corresponding pins of the tube socket: Plate, Grid and Cathode. The type of socket and the connections depend on the type of vacuum tube you wish to test. A separate transformer will supply the heating voltage

Attention: The Plate wire is potentially dangerous because of high voltage. Insulate it carefully before applying power.

Connect the 24 volt transformer and check that there is no short circuit. Plug it in: the LED diode should light up and remain steady. If this does not happen, then there is a power supply problem. To correct this, first check the presence of 24 volts ac and its connections.

Connect the computer to the module, and launch the software. Select the usb port then click "Test". When the warning message appears, click "ok".

The LED diode should switch off and the computer should display  $V_{plate} : 0V$ ,  $I_{32} : 0mA$  (0.2 mA max),  $I_{256} : 0 mA$ ,  $V_{grid} : - 31V$ . If this does not happen, check the usb port which you have selected, the connections and ensure that the LED emits a steady light. If not, switch off and on the 24 volts in order to reset the system.

Click « stop » ; the four values will disappear and the LED will again light up.

Unplug from mains. Now, connect the high voltage transformer. To ensure the safety of your first trial runs, you can use a 12 or 24 volts transformer.

Attention: the 2 transformers – « high voltage » and "module supply" must be in phase. If not, you will not get any published curves, and the measured test voltage will be 0 volts. Should this be the case, you should invert the connection of any of the two transformers.

Switch back on and again click « Test » then « ok ». The voltage  $V_{plate}$  should now be equal to 1.3 times the effective value of the connected high voltage transformer. For example: 33 volts will be displayed if a 24 volt transformer is used as the high voltage transformer; 150 volts will be displayed for a 110 volt transformer, etc. These values are guideline values.

If  $V_{plate}$  indicates 0V, click « Stop », switch off and check the connections of the high voltage transformer. If everything is correctly done, invert the 2 secondary wires of this transformer (incorrect placement of wires, as earlier indicated ), and then run a new test.

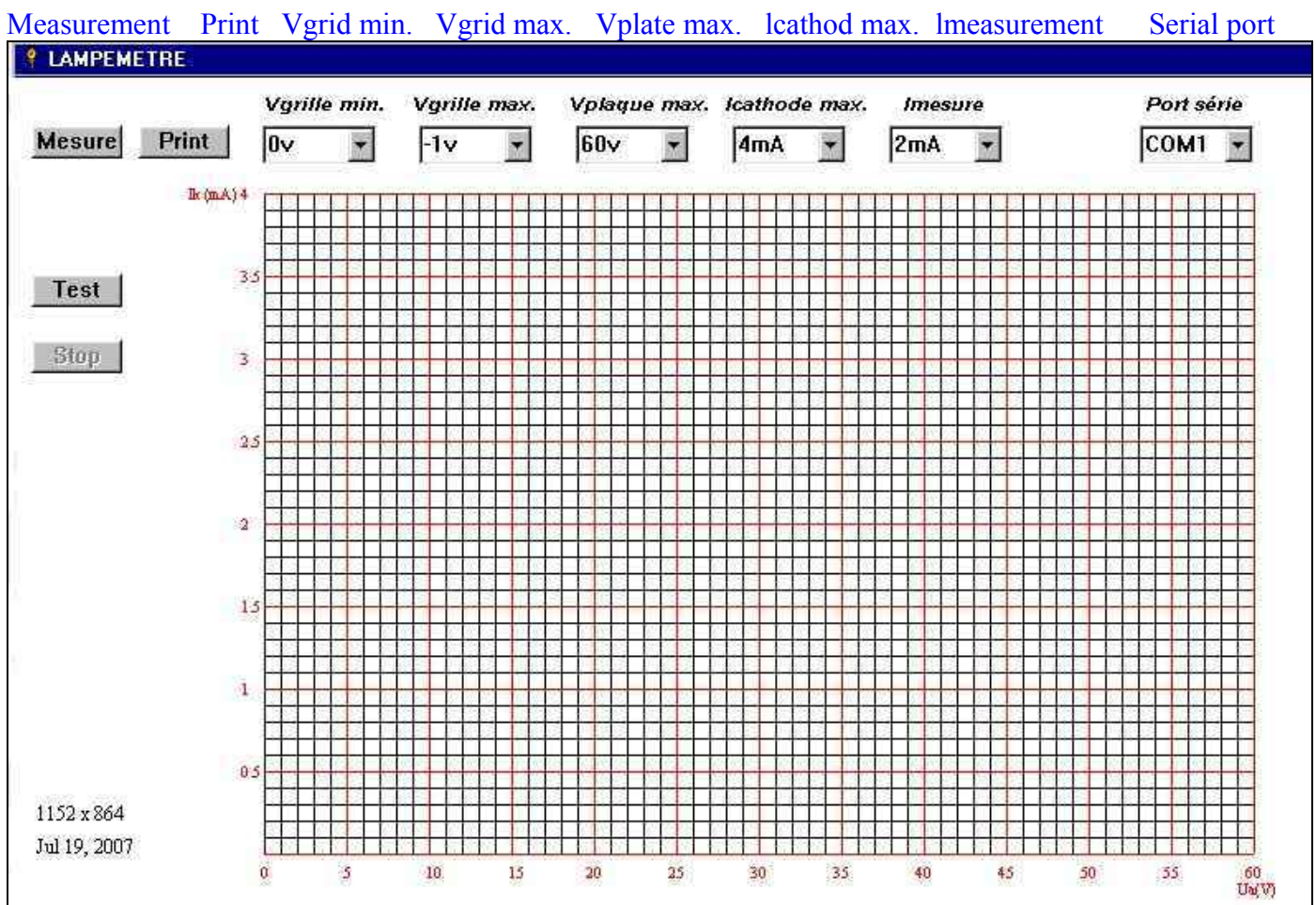
The module is now ready to carry out measurements.

## 4 Getting started

This analyzer can run on two modes :

- Independent mode with xy visualisation on oscilloscope .
- Computer mode with full features. This mode will be presented first:
- Connect the module to the computer through an USB input.
- Launch the software by double clicking on « lampemetre.exe » with the CD supplied or directly from the hard disk of the computer (generally, this would be C:\programs\lampemetre).

The following screen will appear :



First of all, select the usb port to which the module is connected; for USB serial adapter use, this information can also be found under the category “USB to serial port”. First, click “Start”, then “Parameters”, then “Control Panel”, then “System”, then the tab “Management of peripherals”. Look for “USB serial converter”, right click on it then you will get the port n°

Check that the LED light on the module is on; in the event it is not, reset or switch the module off and on.

Then click on the « Test » button. When the warning message appears on the screen, click “OK”. Four values will appear in real time under the button “Stop”; these values correspond to, respectively:

- Vplate : This is the maximum anode test voltage, which is approximately 1.3 x the effective voltage of the (high voltage) transformer.
- I32 : normally at 0/0.1 (used for calibration ; see that section).
- I256 : normally at 0 (used for calibration ; see that section).
- Vgrid : normally -31v (used for calibration ; see that section).

If these values appear, the communication is working well, and the module is functioning. If these values do not appear, refer to the chapter on calibration procedures. Now click on the “Stop” button, and the four values will disappear.

Now, preset the measurement parameters :

The following indicators will appear above the display grid :

Vgrid min. : this refers to the minimum grid voltage, adjustable from 0v to -31v.

Vgrid max. : This refers to the maximum grid voltage, adjustable from 0v to -31v

Vplate max. : This refers to the maximum voltage of the X axis, adjustable from 60v to 480v.

Icathode max. : This refers to the maximum current of the measurement, adjustable from 4mA to 256mA.

Imeasurement : This refers to the cathode current used for measurement of the calculated parameters, adjustable from 1mA to 120mA.

Before measuring a vacuum tube, you must enter correct parameters. The simplest method is to use the manufacturer datasheet. You may wish to refer to this excellent web address for the characteristics of thousands of vacuum tubes: <http://www.tubedata.org/>

After completing all the parameters, you can now begin testing. Ensure that the tube is correctly connected. Click on the “Measure” button: it may be possible that a message will ask you to re-adjust the X axis if the voltage value is too high in respect of the selected value in the Vplate max.

The curves will then appear from Vgrid min. to Vgrid max, by increments of one volt. Only one curve will be traced if you select identical values for “Vgrid min” and “Vgrid max.”.



Five values will now appear under the « Stop » button. They are, respectively:

$R_p$  : This refers to the internal resistance of the vacuum tube using the measurement values  $I_{ref}/V_{ref}$

$G_m$  : This refers to the slope of the vacuum tube in mA/V using the measurement values  $I_{ref}/V_{ref}$ .

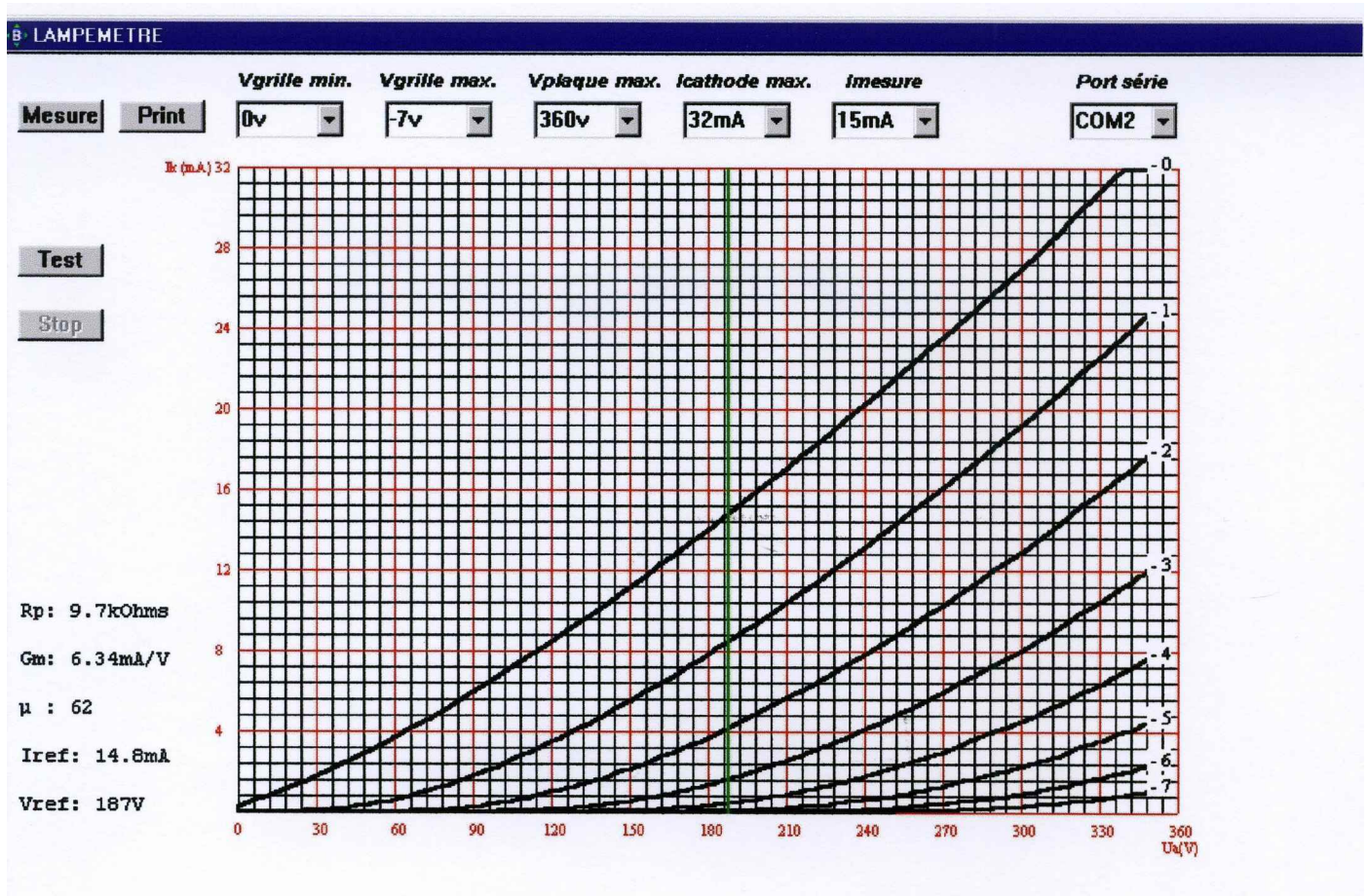
$\mu$  : This refers to the amplification factor of the vacuum tube using the measurement values  $I_{ref}/V_{ref}$ .

$I_{ref}$  : This value refers to the current value used for computed data.

$V_{ref}$  : This refers to the value of the plate voltage relative to  $I_{ref}$

On the display grid, a green vertical line will show the five preceding values of the measurement, at the intersection point of the voltage curve on the min. grid.

Example (triode 12AT7 weak) :



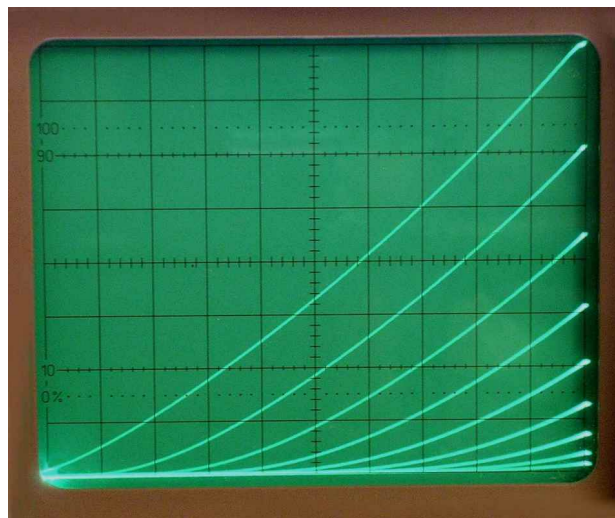
The measurement point is the intersection of the green axis with the 0v curve of the voltage grid; the requested measurement current was 15mA; the module took the nearest point:  $I_{ref}$  to 14.8mA.



Autonomous mode :

Even if you do not have a computer, you can use the module and visualise a curve array on your oscilloscope. But you would not be able to adjust the test conditions nor access the calculated parameters (internal resistance, slope and amplification factor).

The following screen shows you how curves will appear on an oscilloscope: the voltage grid changes from -8v to 0v and allows for the testing of the most frequently used vacuum tubes.



The horizontal axis reflects the plate voltage.

The vertical axis reflects the image of the cathode current.

To enter this mode, you have to connect the two “Mode” pins together. Refer to Chapter 3: Connection of measurement module – diagram for connections.

The oscilloscope has to be switched to XY mode.

The X input of the oscilloscope must be connected to the « Plate » pin.

The Y input of the oscilloscope will be connected to pin 1 of the TL062 for currents which are inferior to 32mA or to pin 7 of the TL062 for currents which are superior to this.

Upon power on, the LED will blink to confirm that you are on autonomous mode.

Adjust the X and Y sensitivity depending on the high voltage and the cathode current.

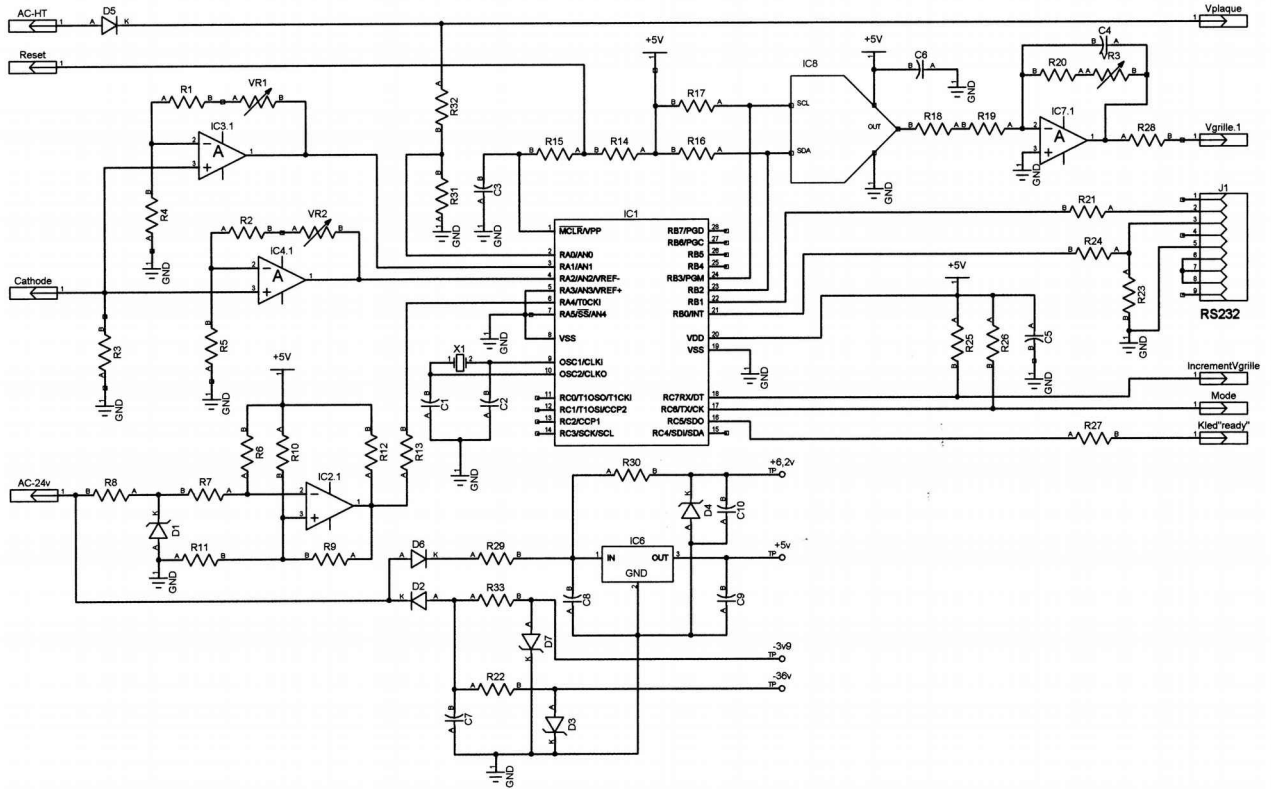
In this mode, the vacuum tube is constantly under test, and you should respect its dissipation limits.

## 5 Main functions

The system can be used in various ways :

- Characterisation and measurement of vacuum tubes.
- Publication of families of curves.
- Tube matching.
- Testing of parameters under different conditions of use.
- Measurement beyond limits set by the manufacturer: the very weak dissipation of the vacuum tube under testing allows for the verification of characteristics beyond limited conditions.

## 6 Circuit description



Schematic of the measurement module

## Nomenclature of the components :

R1	20 kOhm
R2	8,2 kOhm
R3	10 Ohm – 2 Watts
R4	1,5 kOhm
R5	10 kOhm
R6	100 kOhm
R7	4,7 kOhm
R8	10 kOhm
R9	3,9 Mohm
R10	100 kOhm
R11	10 kOhm
R12	10 kOhm
R13	100 Ohm
R14	10 kOhm
R15	1 kOhm
R16	2,2 kOhm
R17	2,2 kOhm
R18	100 Ohm
R19	10 kOhm
R20	47 kOhm
R21	1 kOhm
R22	470 Ohm
R23	27 kOhm
R24	27 kOhm
R25	27 kOhm
R26	27 kOhm
R27	470 Ohm
R28	1 kOhm
R29	390 Ohm
R30	1 kOhm
R31	5 kOhm
R32	470 kOhm – 2 Watts
R33	47 kOhm

C1	12 pF
C2	12 pF
C3	0,1 $\mu$ F
C4	22 pF
C5	0,1 $\mu$ F
C6	0,1 $\mu$ F
C7	220 $\mu$ F – 63 V
C8	100 $\mu$ F – 25 V
C9	2,2 $\mu$ F – 16 V
C10	0,1 $\mu$ F
D1	Zener 3,9 V – $\frac{1}{4}$ W
D2	1N4007
D3	Zener 36 V – $\frac{1}{2}$ W
D4	Zener 6,2 V – $\frac{1}{4}$ W
D5	1N4007
D6	1N4007
IC1	16F876A
IC2	LM393
IC3	TL062 (1/2)
IC4	TL062 (1/2)
IC5	-
IC6	78L05
IC7	TLE2141
IC8	DAC5571
J1	Sub-D 9 points F Connector

VR1	5 kOhm – adjustable
VR2	5 kOhm – adjustable
VR3	20 kOhm – adjustable

The 24-volt ac supply transformer delivers all necessary voltages to run the module :

After rectifying the half negative periods by D2, a voltage of about -34 volts is present on the C7 condenser. This voltage is limited by R22 – D3 and feeds IC7. A second limiting circuit R33 – D7 feeds IC3 and IC4 with -3.9volts.

The half positive periods are rectified by D6 and, after going through R29, a voltage of about +9 volts is available on the C8 condenser. A 78L05 regulator delivers +5 volts to IC1, IC2, IC7 and IC8.

A second limiting circuit R30 – D4 produces the +6.2volts destined for IC3 – IC4.

The comparator IC2 synchronises the test cycles on half positive alternations (see below : measurement cycle).

IC3 and IC4 amplify the cathode current in order to enable measurement through the Analogue to Digital converter embedded in the microprocessor (pins 2, 3, and 4).

A divider network R31 – R32 reduces the high voltage for the same reason.

IC3 is used for currents ranging from 0 to 32mA, and IC4 takes the relay for superior currents.

The grid bias voltage is generated by the Digital to analogue converter IC8, followed by the IC7 leveller amplifier.

Measurement cycle :

IC2 delivers a pulse for each half positive cycle of the 50 hertz sinus. It is important to put the two transformers of the module in phase (see Chapter 3: Connection...), so that the leading edge of the pulse (pin 1 of IC2) corresponds to the rise in high voltage (Plate).

During this rising phase, which lasts 5mS, 64 points of high voltage measurement are obtained at constant intervals by the microprocessor and sent to the computer. These points of measurement are processed by the software to calibrate the X axis of the display grid (axis Ua).

Next, the max voltage Vgrid (the most negative) is applied to the vacuum tube and a cycle of 64 samplings is again obtained. This time, the cathode currents are measured and sent to the computer together in respect of the previous 64 voltage samples.

This cycle lasts 5mS and is repeated until the Vgrid min value (the least negative) is reached with an interval of about one second between measurements. The grid voltage is maintained at -31 volts between cycles, which keeps the dissipation of the vacuum tube to a minimum.

## 7 Calibration procedures and verification

The module is pre-calibrated, but it may be necessary to re-calibrate it through time. To do this, activate the "Test" function of the software; the LED will switch off. Do not connect any vacuum tube at this time.

Cathode current :

Apply a voltage of +0.3 volts between cathode input and ground, and adjust VR1 (to the left of TL064) to read 30mA as the value I32.

Apply a voltage of +2 volts between cathode input and ground, and adjust VR2 (to the right of TL064) to read 200mA as the value I256.

Grid voltage :

Connect a voltmeter on « Grid » and adjust VR3 (beside TLE2141) to read -31 volts.

Check the value of the Vplate which should be about 1.3x the effective value of the high voltage.

Exit this mode by clicking « Stop ». The LED will again illuminate , and the measurement values will disappear from the screen.

### **Trouble shooting :**

The LED does not illuminate:

Unplug the RS232 cable from the computer ; reset (switch off and on) ; check the 24 volts module supply and the +5 volts (pin 8 of LM393, for example).

No curves on the screen :

Check the the phases of the two high-voltage transformers and module supply respectively and invert the connection of one of them.

Check the connections of the vacuum tube under test, the continuity and the heating of the filament.

USB does not respond :

Wrong selected USB port, check the port n°.

Wrong connections of the vaccum tube under test.



## 8 Technical characteristics

Module supply: 24 to 28V a.c. / 300mA min.

Measurement mode : synchronised to quarter period of 50 Hz mains.

Sampling : 10 bits monotone (1024 steps)

Precision of the calculated measurements : 10%

Precision of the plate voltage measurement : 5%

Precision of the cathode current measurement 32mA range: 0.1mA +/- 1 bit

Precision of the cathode current measurement 256mA range: 0.551mA +/- 1 bit

Number of samples by measurement : 64 per 5mS cycle

Maximum anode voltage : 480 volts

Software compatibility : Win95 to Vista included.

Minimal screen resolution : 800 x 600, 256 colours

Disk space : 10 Moctets minimum

RAM memory : 256 Moctets minimum

### **Data File Format :**

Type: Binary file

Octet n°

1 – 7 : Reserved

8 : I cathode max

9 – 16 : Reserved

17 – 144 : 128 octets = 64 samples for X axis = Vplate  
1 sample = 10 octets ( 10 bits on 2 octets ) MSD first

145 – 4241: up to 32 curves data samples  
One curve has 64 samples ( same as Vplate )  
Each sample is synchronized with the corresponding Vplate sample