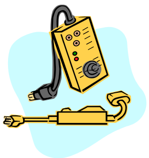
LAB INSTRUMENTATION. RC CIRCUITS.

I. OBJECTIVE

a) Becoming accustomed to using the lab instrumentation (voltage supply, digital multimeter, signal generator, oscilloscope) necessary to the experimental study of some electronic devices and circuits.



II. COMPONENTS AND INSTRUMENTATION

The instruments we will use are the ones available in the *Electronic Devices and Circuits* lab: regulated power supply, digital multimeter, signal generator and dual channel oscilloscope. For electrical connections we will use conductors equipped with jacks at both ends and screened probes.

III. THEORETICAL ASPECTS

1. THE POWER SUPPLY

A regulated power supply has the purpose of maintaining the output voltage constant at the variation in certain limits of some quantities (input voltage, load, temperature, etc.).

The d.c. power supplies are used for feeding most of the electric circuits, supplying them d.c. electric power.

In the lab we use triple power supply (HM8040) that contains three floating supplies: two independent supplies (0-20V/0.5A) and one dependent supply (5V/1A).

Fig. 1. The front panel of the power supply HM8040

On the front panel the double power supply has (Fig.1):

- OUTPUT - push button for activating/deactivating all the outputs ;
- the optic working LED: is on when the supply is powered with the network voltage;
- each independent supply has two output terminals: red for plus and black for minus ;
- potentiometers for adjusting the output voltage (VOLTAGE) and the limiting current (CURRENT):
- 3-digit switchable display for current and voltage. Display resolution is 0.1V / 1Ma

ATTENTION

If during an experiment the ampermeter of the source shows a high value (over 100mA) turn off the supply because there can be a fault on the experimental board.

2. THE DIGITAL MULTIMETER

The digital multimeter is an electronic instrument use to measure resistances, voltages and currents (dc and ac). For ac sinusoidal signals the effective value is measured. The signal processing and results display is digital.

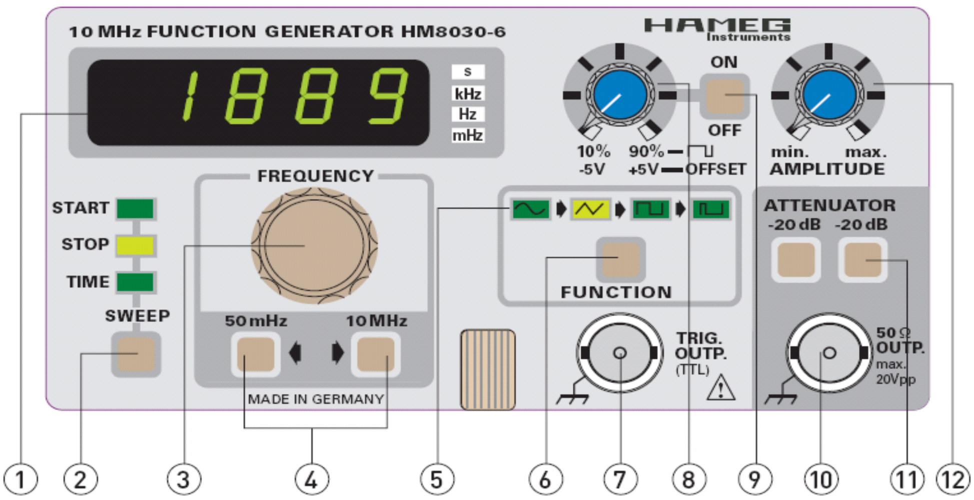
For each quantity the apparatus is equipped with several measuring domains. The best reading precision is obtained using the domain that has the smallest end of scale, without outrunning the scale.

Usually the multimeters have three measuring terminals:

– the measuring terminal (V, Ω, mA, hot wire, “+”); usually the wire applied to this terminal has the red color for all measured quantities except the direct current with an intensity greater than 2A. Sometimes the mA and V,Ω terminals are separated;
– the measuring terminal (10A: hot wire, “+”) only for measuring high values of direct current intensity (max 10A);
– the reference terminal (COM, cold wire, ground, “-“) with respect to which all the measurements are made; usually the wire applied to this terminal is black.

3. THE SIGNAL GENERATOR

The signal generator is an electronic instrument that provides variable signals of different shapes (sine, square, triangle, pulse, etc) allowing the modification of several parameters: amplitude, frequency, duty cycle, etc. The generator is used to apply variable signals to the electronic circuit that are experimentally studied.



Control elements of HM8030-6

① **DISPLAY (7 segment LED)**
5-digit frequency meter. LED indicators for mHz, Hz, kHz and s

② **SWEEP (push button) and Indication (LEDs)**
Button activates internal sweep generator. The LEDs indicate the function chosen with the SWEEP-Button. Settings are changed with ③ or ④.

③ **FREQUENCY (adjustment knob)**
Continuous and linear frequency fine adjustment, with the setting range from 0.09 to 1.1 (approx 0.045 to 1.1 in 10 MHz-range) overlapping the ranges selected with ④

④ **FREQUENCY (2 pushbuttons)**
Frequency range selection from 50 mHz to 10 MHz in 8 decade steps.

⑤ ∿ – ⋀ – ⊓ – ⊓ **(LED s)**
Indication of selected function.

⑥ ∿ – ⋀ – ⊓ – ⊓ **(pushbutton)**
Mode selection: Triangle, Sine, Square, Pulse and Off.

⑦ **TRIGGER OUTPUT (BNC connector)**
This short-circuit-proof output supplies a square signal in synchronism with the output signal. It is TTL compatible and has a duty-factor of approx. 50%.

⑧ **OFFSET (adjustment knob)**
Adjustment of the positive or negative offset voltage. This DC voltage can be super-imposed on the output signal. The max. offset voltage is ±5V (o.c.) or ±2.5V respectively when terminated into 50Ω. The offset voltage is available to all functions except for pulse and activated by ⑨. In operation mode OFF (no function activated) it can be used separatey. In pulse mode the pulse width is set with this control from 10% to 90%.

⑨ **ON (pushbutton)**
Activates the offset function except in pulse mode. If the ON-button is pushed in pulse mode, pulse width is set with the control ⑧ from 10% to 90%. In OFF-position the fixed pulse width amounts to 50%.

⑩ **50Ω OUTPUT (BNC connector)**
Short-circuit proof signal output of the generator. The output impedance is 50Ω and the max. output amplitude is $20V_{pp}$ (o.c.) or $10V_{pp}$ respectively when terminated into 50Ω.

⑪ **–20dB, –20bB (pushbutton)**
Two fixed attenuators, 20dB each. They can be used separately. When both pushbuttons are activated, a total attenuation of 40dB results. Including the amplitude control ⑫, the max. attenuation amounts to 60dB (factor 1000).

⑫ **AMPLITUDE (adjustment knob)**
Continuous adjustment of the output amplitude from 0 to –20dB terminated into 50Ω.

4. THE CATHODIC OSCILLOSCOPE

The oscilloscope is the most useful and versatile electronic test instrument. As usually used, it lets us “see” voltages in a circuit as a function of time, triggering on a particular point on the waveform so that a stationary display results.

The images obtained on the screen are called oscillograms. The oscilloscope can be used for:

– visualizing the time variation of electric voltages, as for measuring their parameters: peak to peak value, amplitude, the value of the dc component, period (frequency);
– visualizing the relationship between two time varying voltages, being able to determine the ratio of the frequencies and their phase difference;
– tracing the characteristic curves of some devices or materials (static characteristics of some devices or electric circuits, the hysteresis cycle of ferromagnetic materials, etc.)

The oscilloscope can work in two modes:

– **Y-t** mode: the y(t) curve appears on the screen
– **Y-X** mode: the y(x) curve appears on the screen, by eliminating the time between the y(t) and x(t) relations.

The oscilloscopes used in lab are: HAMEH HM303, HM304, HM507, HM1507 or Metrix OX6152. All the oscilloscopes are the same functions.

CONTROL ELEMENTS, SIGNALING AND ACCESS ON THE FRONT PANEL OF THE OSCILLOSCOPE

- POWER switch: by acting on the switch the oscilloscope will be supplied with the network voltage 230V a.c.;
- Adjusting elements for the control of the spot’s (trace’s) intensity and clarity on the oscilloscope screen: Brightness (controls the intensity of the trace), Focus (controls the focus of the trace) Astigmatism (is used in correlation with the focus to obtain a well defined spot);

ATTENTION

An **too big** intensity can cause the destruction of the luminescent substance on the screen of the oscilloscope;

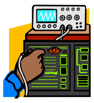
- Adjusting elements for the spot (trace) movement on the vertical and horizontal: one for both channels on the x axis and one for each on the y axis;
- The magnifying glass on the X and Y axis: allows the visualization of the magnified signal on the vertical and horizontal with a certain factor usually 5 or 10 for the accurate reading of the signal to be measured;
- Calibrating knobs for the oscilloscope;
- Selecting device of the channel we want to visualize on the screen: we can display the signal taken from one channel, both signals simultaneous or the sum of the signals on the two channels;
- Knob, switch or potentiometer for:
    - Adjusting the scale factor:
    - time (one for both channels)
    - voltage (one for each channel)
- Switch for the coupling manner of the input signal (AC, DC, GND);
  *The oscilloscope is dc-coupled (**DC**): what we see on the screen is the signal voltage, dc value and all. If we want to see a small signal riding on o large dc voltage we can switch the input to ac coupling (**AC**) which capacitively couples the input with a time constant of about 0.1 second. The*

*oscilloscope also has a grounded input position (**GND**), which lets us see where zero volts is on the screen.*
- Switch for the selection of the working mode Y-t or Y-X;
- Switch for synchronizing: internal or external;
- Switch for selecting the channels (one channel, the other one or both);
- Input BNC jacks: one for each channel;
- BNC jacks for applying an external synchronization signal (when the time base works in external synchronization regime).

III. EXPLORATIONS AND RESULTS

1. OBTAINING DC VOLTAGES

1.1. ONE SIGN VOLTAGE (UNIPOLAR)



Exploration

- Adjust the voltage of one supply at desired voltage;
- Activate the output of the voltage source (OUTPUT pushbutton)
- Measure the voltage with the digital multimeter on the 0-20V DC domain, the “COM” terminal connected to the ‘-‘ terminal of the supply;

Results

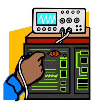
- Are the voltages read on the buit-in voltmeter and with the multimeter identical or different? Why?
- Having to power a circuit with +12V with respect to the ground, which terminal of the supply will we connect to the ground wire and which to the power wire of the circuit? What if the circuit has to be powered with –12V with respect to the ground?
- Is it possible to obtain a dc voltage of 40V with the double supply? If yes, how?

Remarks

- For supplying an electronic circuit, we first adjust the voltage of the power supply at the desired value, connect the supply wires of the circuit and finally activate the output of the source.
- Any time we make some modifications in the experimental board (changing the connections, introducing a measuring instrument, etc.) we will do it with the board not supplied.

2. VOLTAGE VISUALIZATION WITH THE OSCILLOSCOPE

2.1. SETING THE OSCILLOSCOPE



Exploration

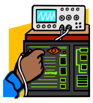
- Power on the oscilloscope using the POWER switch.
- Place the spot in the center of the screen using the vertical and horizontal displacement potentiometers.
- Select the one channel visualization in Y-t mode.

ATTENTION

Working with an extremely bright spot leads to the destruction of the luminescent substance on the cathode tube screen.

- You may adjust the focus and astigmatism potentiometer to obtain a more clearly delimited spot.
- If the spot doesn't appear you can act on the horizontal and vertical deflection knobs or/and the brightness potentiometer.

2.2 VISUALIZING IN Y-T MODE



Exploration

a) One signal visualization: do following

After starting the oscilloscope make the operations:

- Select the DC position if we want to visualize the signal with its dc component, or the AC position if we want to visualize just the alternating component of the signal.
- Generate a sinusoidal signal from the signal generator.
- Using a coaxial probe connect the output terminal of the signal generator with an input terminal of the oscilloscope (channel 1 or channel 2)
- From the time base change the time measure to be able to visualize the signal.

b) Visualizing two signals simultaneously

- Apply to one channel a variable signal from the signal generator and to the other channel a dc voltage from the power supply.
- Adjust the oscilloscope settings to be able to visualize both signals simultaneously.
- To obtain the optimum image on the oscilloscope screen you adjust the X and Y position knobs.

Results

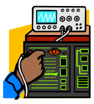
a) One signal visualization

- Draw the waveform obtained on the oscilloscope screen.

b) Visualizing two signals simultaneously

- Draw the two waveforms obtained on the oscilloscope screen.

2.3. MEASUREMENTS IN Y-T MODE



Exploration

To help the measurements, the oscilloscope screen is squared. Each division contains 5 subdivisions. The measurement of voltages and time (period) is done by direct reading of the spot deviation on vertical (Volt/div) respectively on the horizontal (Time /div).

a) Voltages measurements

You can measure amplitude, peak-to-peak value and dc component of a signal. To do this, you multiply the vertical deviation read on the screen with the indication corresponding to the position of the knob. For example: if the total vertical deviation is 4.2 div and the knob is in the position 0.1V/div the total value of the voltage is:

4,2 div x 0,1 V/div = 0,42 V

b) Period measurement

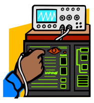
The measurement is made using the time base knob indications. To do this you multiply the number of horizontal divisions, corresponding to a period, with the indications corresponding to the position of the knob. For example, if the horizontal deviation is 4.6 divisions and the indication is 5ms/div, the Ty period will be:

Ty = 4,6 div x 5ms/div = 23ms

Results

Draw the waveforms obtained on the oscilloscope screen. Read and write the amplitude of the signals. Compute and write the frequency of the signals.

2.4. MEASUREMENTS IN Y-X MODE



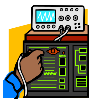
Exploration

- Apply two signals on both channels of the oscilloscope.
- Set the oscilloscope in Y-X working mode by pushing the XY button.

Results

Draw the graphic obtained on the oscilloscope screen.

3. RC Circuits



Exploration

- Build the circuits in Fig. 5. Apply the following input voltages:
  - sine wave, 10 V amplitude, 0.5 kHz frequency
  - sine wave, 10 V amplitude, 10 kHz frequency
  - sine wave, 10 V amplitude, 100 kHz frequency
- On the oscilloscope, in Y-t mode, visualise the input and output signals, simultaneously, for all three cases.

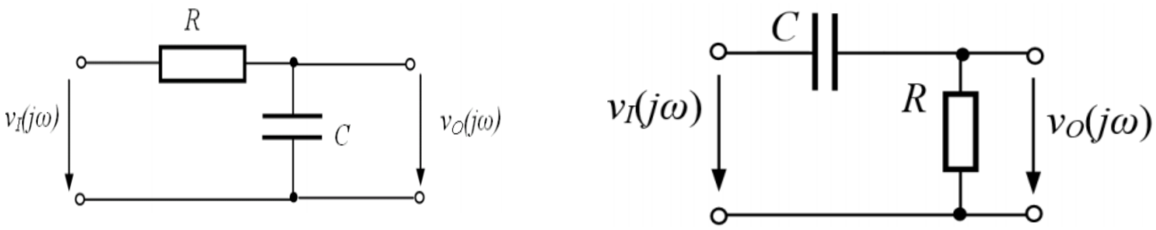


Fig. 5. RC Circuits

Results

Draw the waveforms from the oscilloscope. Determine the cut-off frequency of the circuits.