Electronics I. laboratory measurement guide

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General information

E.1 Requirements for starting the measurements

Laboratory measurements build upon knowledge gained in the theoretical and practice course lessons. There are entry questions (test) before every lab session. The questions can be found in this guide. The answers can be found in the knowledge gained in classes and from technical literature. This measurement guide does not replace classroom participation and further studying!

E.2 Formal and content requirements for lab reports

For each laboratory session, a laboratory report has to be submitted (at the beginning of the next measurement, or in two weeks). The formal and content requirements and deadlines for the reports will be told by the laboratory teacher at the first class (which will be about the course requirements, fire and safety rules and instrument use). Also, please find more details on our website at: http://mti.kvk.uni-obuda.hu/node/143

E.3 The measurement panel

In this subject the students have to build the circuits on measurement panels that contain a "breadboard" and banana plug sockets. The breadboard can be used to easily and quickly build test circuits using through-hole mounted components and simple wires (max. 0.5mm diameter solid copper). The circuit is connected by wires to the banana plug sockets, from where banana plug wires are used to connect to the power supplies, multimeters etc.
The building of circuits needs patience, care and concentration!

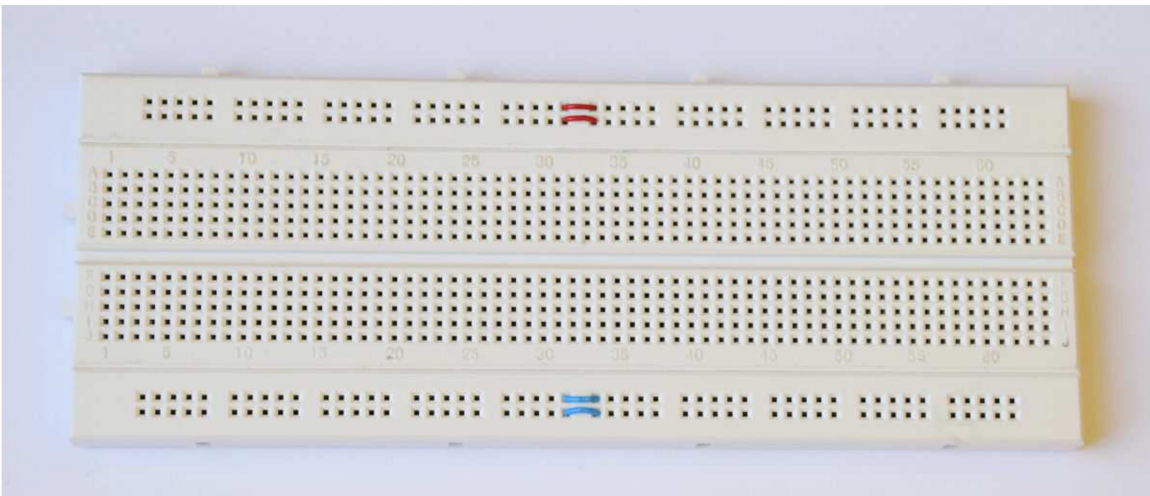

Figure 1. : The breadboard

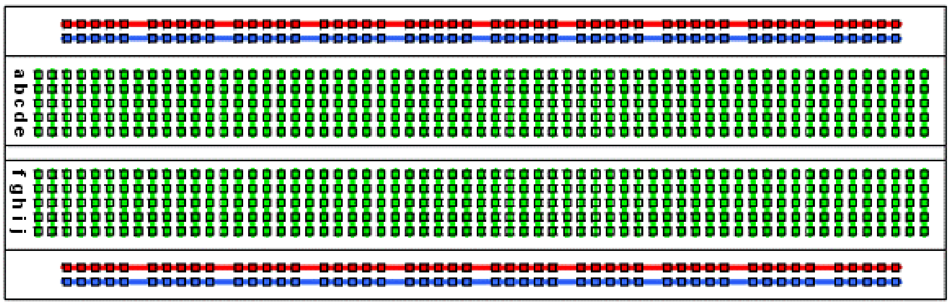

Figure 2. : connections of the breadboard (colors are arbitrary)

The breadboard used in the laboratory has the following structure:
There are two lines along both longer edges, in the figure denoted by red and blue colors (some breadboard versions have these colors on them, the currently used type in pure white, but functions the same). The 50 points along a colored line are electrically connected. The four such lines are independent. These can be useful for the voltage supply connections in cases when more than one point in the circuit needs to connect to the same potential (in some measurements for example you need plus and minus voltages plus zero, so three of the four lines can be used for these). The inner part has 2x64 lines of 5 points each. The 5 points of a line (denoted by green on the figure, not shown on the real board) are connected electrically (these are named a..e and f..j). To use integrated circuits (IC) place them across the central division such that half of the pins are on the a..e side and the other half is on the f..j side.

In our laboratory the breadboards are mounted onto an aluminium plate which has banana plug and BNC connections for cables to allow easy interfacing to instruments. The right side contains the BNC connectors for coaxial cables. Coaxial cables are made up of an internal wire, coated with an insulator and a metal mesh or foil called shielding on the outside. The shielding protects the internal wire from radiated (electromagnetic) interferences. The shieldings of the BNC connectors of instruments with this connector (function generator, oscilloscope) are connected to the ground potential to "carry away" the interference, noise. On our panel, the shielding of the connectors are directly connected to the metal plate (thus make sure no cable - that is not intended to - touches the plate). The banana plug just to the left (the one without the red or black plastic ring) is also connected to the metal plate, so use this as the common zero point for the power supply and the oscilloscope and function generator in measurements which need these.

Figure 3. : The breadboard as it is used in the laboratory

E4. The instruments at the electronics laboratory

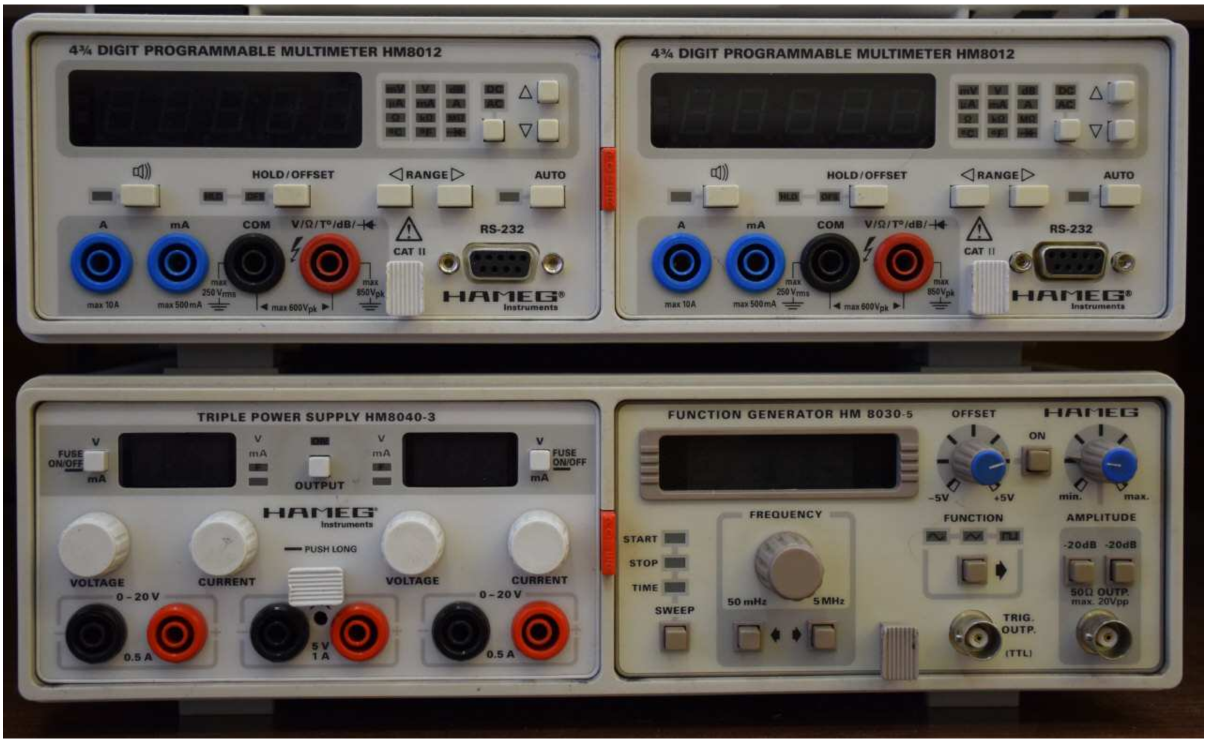

Figure 4. : The electrical instruments at the lab, without the oscilloscope

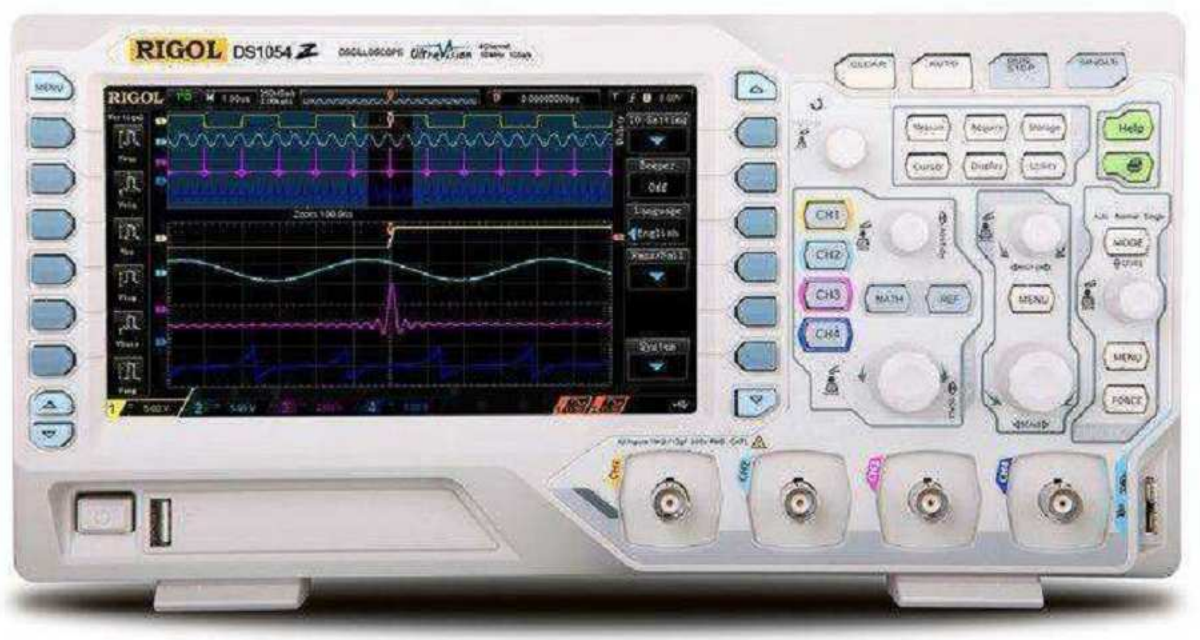

Figure 5: the digital oscilloscope

E.5 The HM8040-3 triple power supply

A power supply unit (PSU) is one of the most important instruments for laboratory work. It supplies the operational voltages and currents to the measured circuits. We are using the HM8040-3 type triple power supply. Its operation is similar to other types of power supplies.

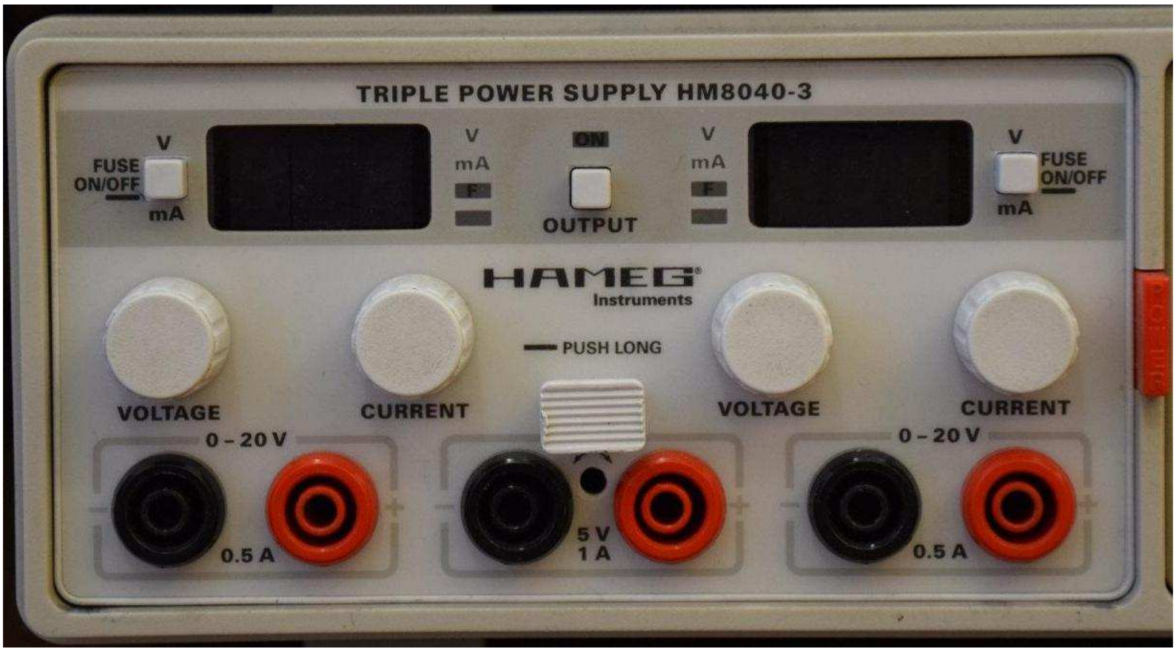

Figure 6. : the Hameg HM8040-3 power supply unit

The triple power supply has one fix voltage output and two controllable. The middle output is constant 5V with a current limit of 1A. This can be useful for digital circuits (which often need 5V), however be careful that the current limit is very large, thus if there is some wrong connection, your circuit elements can be damaged even though the power supply will be saved by the limit. In our laboratory measurements the middle output is not needed and not advised to be used.

The other two outputs are identical in operation. The voltages can be set continuosly between 0...20V with 0.1V displayed precision using the “VOLTAGE” knob. The current limits can be set up between 0...500mA using the “CURRENT” knob.

All three outputs are galvanically independent from each other and from the mains. This way it is possible to connect them in series, creating for example a 40V output or creating -20V,0V,+20V double supply.

The display either shows the output voltage or the output current. Switch between these modes using the “V/mA” button. Note that pressing that button for too long turns on the “FUSE” function (an orange LED will show this mode is active). This mode means that upon reaching the current limit the power supply unit will turn off the output.

There is an “OUTPUT” button in the middle. The configured voltage appears on the outputs only when the output is on (signified by a green LED). Whenever you change your circuit, turn off the output using this button, do the changes then turn the output back on.

The laboratory power supply used in this lab are capable of both voltage generator and current generator mode. The current generator mode is also called a current limit mode. The unit will normally behave as a voltage generator, and will change into current generator when the current limit is reached. This is shown in figure 5.

In these type of supplies, the voltage (V_{set}) can be set up when the Output is set to Off, however the current limit (I_{set}) can only be set up when the Output is On, and there is current flowing. For this reason, we need to short-circuit the + and – outputs (with a banan plug wire) and change to mA display mode, turn the OUTPUT ON and then we can use the CURRENT knob to set up the current limit.

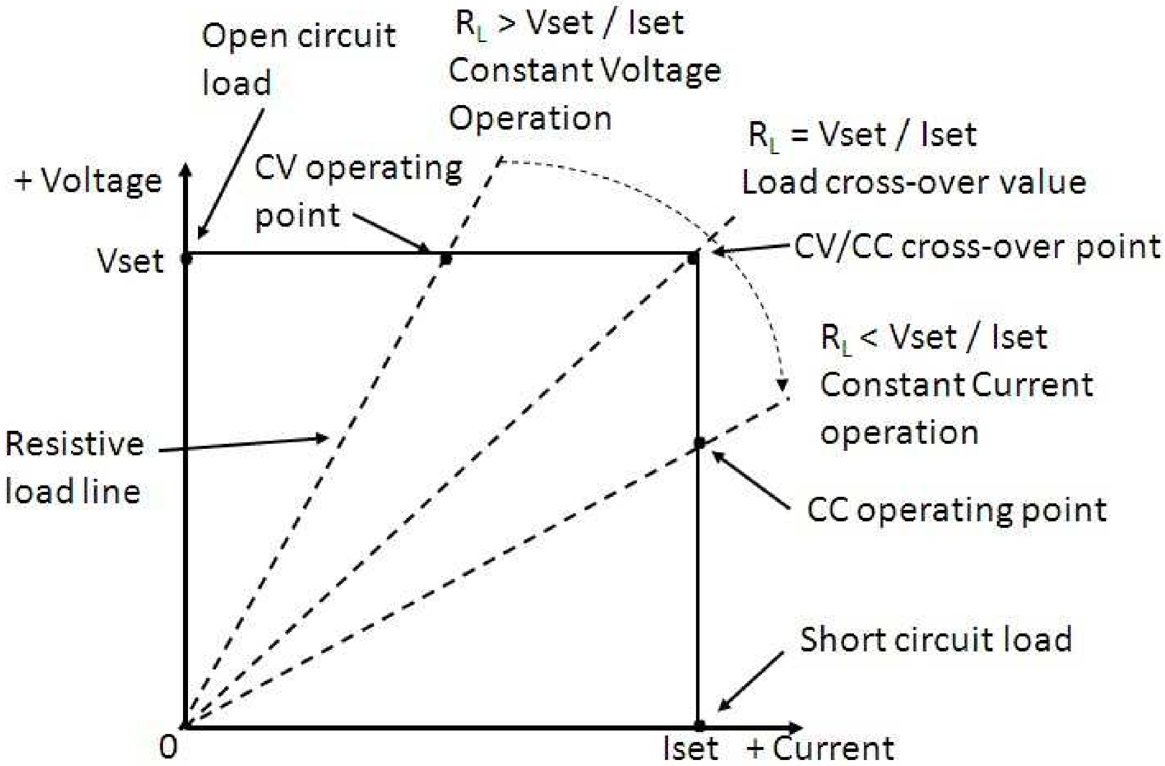

Figure 7. : I-V characteristics of a laboratory power supply

In Figure 5, in the horizontal section, the output voltage is constant (V_{set}), and the current is dependent on the load. This is called CV (Constant Voltage) mode (or voltage generator). In the vertical section, the output current is constant (I_{set}) and the voltage is dependent on the load. This is called CC (Constant Current) mode (or current generator or current limit). The change between the two modes occurs when the load resistance is $R_L=V_{set}/I_{set}$. If the load is larger resistance than this, then we have CV, if the load is smaller resistance, then we have CC mode.

The current limit enables you to protect your supply unit and your components (such as transistors and ICs) from too large current if you connect something wrong. For all measurements in this laboratory, you will be required to set up a current limit before starting the measurements. This will usually be around 20...30mA (this is usually small enough not to damage any component you will be using).

E.6 HM8012 digital multimeter (DMM):

The other very important instrument for electrical engineers is the multimeter. Today we mostly use digital ones, but analogue instruments still have some uses and advantages.
Multimeters are instruments which usually measure voltage, current, resistance and optionally some other quantities (diode forward voltage, temperature, etc.)

Figure 8. : Hameg HM8012 digital multimeter

Many general purpose multimeters (and as such, the HM8012) have four input connectors: a common ("COM", black), two current inputs (A and mA, blue) and a voltage/resistance/diode (red). In all measurements, one of the measuring cables has to be connected to the common input.
Multimeters are usually also galvanically independent, therefore you can measure voltages between any two points as long as the maximum allowed input voltage is not exceeded. The maximum voltages/currents are indicated on the front panel of the instruments.

The "HOLD" button is used to keep the last measured value on the display. (So if you see no change when you should, check this mode.)
A 3x4 LED matrix to the right of the display shows which quantity we are currently measuring. The arrow buttons on the right are used to select between these modes. Left of these, two buttons can be used to change between AC and DC measurements. In DC (Direct Current) mode only the DC component of the input signal is measured. In AC (Alternating Current) mode only the AC component is measured (the DC part is removed, similary as in an oscilloscope in AC setting). This multimeter measures true RMS (effective value) of the voltage. If both AC and DC are turned on, then the true RMS of the total, unchanged signal is measured. Please note that there is an upper frequency limit of AC measurements.

The "RANGE" buttons are used to set the measurement range (that is, the interval in which we can measure). In a lower range (indicated by smaller L number) the precision is increased and the maximum measurable value is decreased. Also the internal resistance of the unit can be different in different ranges. The "AUTO" button enables automatic range control (that is, the instrument will try to select the best range). This has its advantages and disadvantages and for latter reason it is generally not allowed to be used in these measurement sessions.

In case we set up a range in which the maximum measurable value is smaller than the input, an “OFL” (overflow) text will be displayed. In this case, increase the range.

An important attribute of multimeters is the internal resistance (in voltage and current modes). A general voltage meter has az internal resistance (input resistance) of 10..12MΩ. (The HM8012 has 10MΩ in most ranges and 1GΩ in L1 and L2 ranges.) This resistance can be approximated as infinite for most usual purposes (unless the measured circuit is composed of resistors of similar values). The current meter should ideally have 0 internal resistance. We usually also suppose it’s true. Know however, that the smaller ranges (bigger precision) have bigger internal resistances, which can result in increased error in some current measurement cases.

There are two common methods for measuring voltage between two given points of a circuit. First, you can simply measure the voltage between the two points, that is, put the two probes of the multimeter to these points (that is, connect the voltmeter in parallel with the two-pole to be measured). Second, you can use the mthod of node potentials, that is, measure the potential of different points (their voltage relative to a common or reference node which will be defined as the zero potential). Then the voltage between any two points will be the difference of their potentials. This method is commonly used as there are often too many nodes to measure voltages between any two of them, it is simpler to note the node potentials and then later the voltages can be easily calculated. The common node is often the negative pole of the power supply or the ground potential if it is available. This type of measurement will be used for example with transistor circuits.

Current measurement is done by connecting the ampermeter in series with the two-pole whose current we want to measure (similarly like we would connect a water flow meter). Take care to connect the proper input of the ampermeter: the "A" if measuring more than 0,5 ampers (and set the measurement range to "A" also); the "mA" if measuring less than 500mA (and set the range to "mA" also). Most measurements in this laboratory will be done in mA setting. (There are fuses in the ampermeter which can blow if not using the proper setting.)

The third function of the multimeter is resistance measurement. We have to take care to only measure the needed resistance - that is, make sure there are no other elements connected between the two poles of the resistor. Therefore we should remove the resistor from the circuit before measuring it, otherwise the other circuit elements may falsify our reading, and if the circuit has turned on power supply connected to it, we may even damage the instrument. (There are techniques for measuring resistors inside a circuit but we are not dealing with those now.) Also make sure not to touch the two poles (ends, legs, pins) of the resistor with your hands, as this means our body resistance (in the magnitude of 100kΩ) will be connected in parallel. Before removing the resistor from the circuit, turn off the output of the connected power supply.

E.7 The HM8030-5 Function Generator

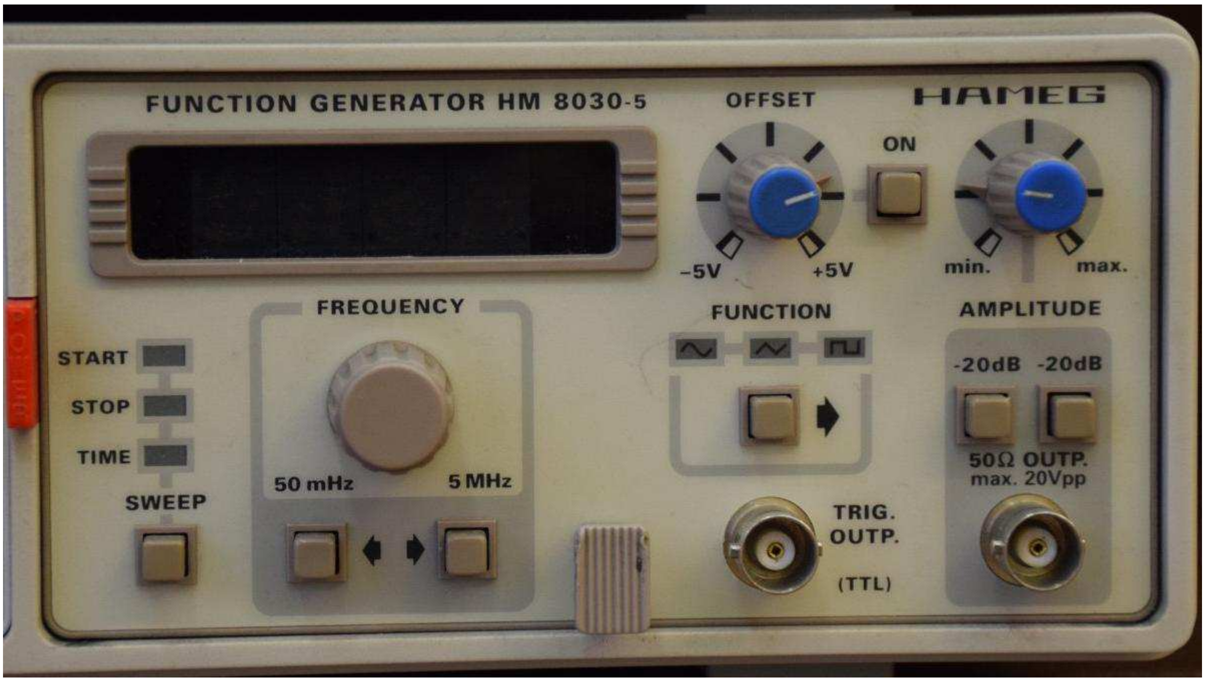

Figure 9. : The Hameg HM 8030-5 function generator

The function of the function generator is to supply test signals to our circuits. This can be for example a sinusoidal signal for an audio amplifier or a TTL level square wave for digital circuits, a triangle wave for comparators and control circuits etc. The laboratory includes a HM8030-5 generator at each setup, as seen in figure 1.6

The most important control is the "FREQUENCY". This instrument can output alternating voltage from 50mHz to 5MHz. The left and right arrows under the potmeter change the "decade", that is, the order or magnitude of the frequency (the place of the decimal point). The potmeter provides a continous frequency setting withing the current range. The actual frequency is shown above these controls in a seven segment display. To the right of it three or four LEDs show the actual output waveform: sine, triangle or square (with 50% duty cycle) (for some types a fourth waveform is squarewave with non-50% duty cycle, also called impulse). The mode can be changed by the button under the LEDs. When none of the LEDs is on, there will be no output signal.

The controls on the left side are used for the SWEEP mode. This provides an output that changes its frequency in time. We are not going to use these in this laboratory course.

The rightmost potmeter ("AMPLITUDE") changes the amplitude (voltage) of the output signal. It can be rotated about 270° between the "MIN" and "MAX" values. The two buttons under ("-20dB") it can each divide the output voltage by ten (so when pressed together, they divide by hundred). (-20 decibels mean divide by ten, -40dB means divide by hundred, -60dB means divide by thousand and so on.) The maximum output voltage is about 20Vpp (peak-to-peak), the minimum is around a few mV. (As you can see the function generator doesn't display the actual output voltage - you have to measure it yourself using an oscilloscope or AC voltmeter).

To the left of the amplitude knob is the "OFFSET" control, together with an "ON" button to enable this option. The offset option, when turned on, adds a DC component to the output signal (shifts it in DC) which can be changed between -5V and +5V.

The function generator doesn't have an output on button, therefore to output signal is alway present at the output connector (except when none of the waveform LEDs are on, as mentioned). There are actually two outputs. One (the BNC connector on the right) is the normal (analogue) output, with the frequency, amplitude and waveform that we have set up. The connector to the left of it is called "TRIG. OUTP." or "TTL". It provides a TTL level (0-5V) 50% duty cycle square wave with the actual frequency. (Therefore it is independent of the amplitude and offset and waveform controls.) In digital technics, TTL levels mean that logical 0 is 0 volts, logical 1 is +5 volts.