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LAB 1 VOLTMETERS AND WAVE FORMS

OBJECTIVE

To establish the connection between AC wave form and readings on different voltmeters. How to interpret the readings and how to make circuits to widen the measurement range.

PREPARATION

This handout contains several preparatory questions to be answered at home before entering the laboratory. The theory given in this handout will be included in lectures, assignments and exams.

EQUIPMENT

-Unilab signal generator with a low impedance (1 ohm) output
-Feedback 603 signal generator
-Dual beam oscilloscope. Preferably Philips 3208
-Digital Voltmeter Fluke 45
-AVO analogue voltmeter (to be used on 3V and 10V AC only(
-Feedback trainer 459
-Feedback trainer kit 461 with
  -Capacitor 100 nF
  -Resistor 470R
  -Resistor 470K
  -Diode BYX36 or similar
- 2 Banana to coax converters

THEORY

Analogue and digital multimeters are aimed at measuring currents and voltages varying sinusodial with time. When using multimeters for measurements on non-sinusodial periodic currents and voltages we have to be careful when interpreting the readings.

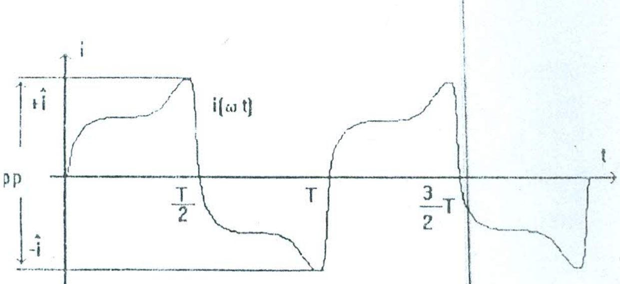


Fig 1. Periodic signal

To describe this time varying current we have several quantities.

AVERAGE VALUE

The average value (mean value) of a time-varying current on a time interval is the DC current that will carry the same amount of charge during that time interval. A signal as in fig 1 (a pure AC signal) will have an average value equal to zero if taken over a one or more complete periods. In order to have an average value attached to a pure AC signal, we calculate the average value on half a period.

$i_{av} = \frac{1}{\frac{T}{2}} \int_0^{\frac{T}{2}} i(\omega t)dt)$	When *i* is a sine wave, $i_{av} = \frac{2}{\pi} i_{max}$

RMS VALUE

The rms value of a time varying current on a time interval is the DC current that dissipate the same amount of heat in a resistor during this time interval. Usually we calculate this using a full period as the time interval. The formula for calculating the rms value is:

$i_{rms} = (\frac{1}{\frac{T}{2}} \int_0^{\frac{T}{2}} i(\omega t)^2 dt)^{\frac{1}{2}}$	When *i* is a sine wave, $i_{rms} = \frac{1}{\sqrt{2}} i_{max}$

FORM FACTOR

The form factor is the ratio of rms value to mean value.

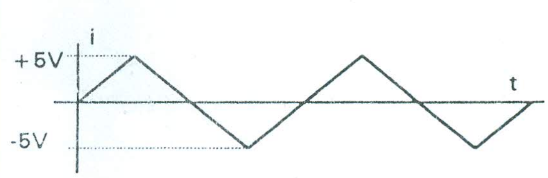
When *i* is a sine wave, the form factor is $= \frac{i_{rms}}{i_{av}} = 1.11$

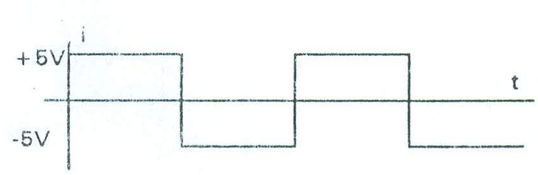
THE CONNECTION BETWEEN SCALING AND READING.

Some AC instruments have a reading proportional to the average value, some have a reading proportional to the rms value, and some have a reading proportional to the peak value. Usually all these different meters are scaled in sine wave rms, so that if you use these different instrument to measure on a pure sine wave, they will all show the same reading. If the signal is not a pure sine wave, the readings will differ.

PREPARATION QUESTIONS

PQ1 Calculate the rms value and the average value (half period) for a triangle formed wave and a square wave with a peak voltage of 10V.





PQ2 If you have a meter with both reading and scale proportional to rms value (sine), what would the reading be if you measured on:

a) Square wave with max value of 6V?
b) Triangle wave with max value of 6V?
c) Pure sine wave with max value of 6V?

PQ3 You have a meter with reading proportional to average (mean) value and scaled in rms (sine). What would your meter read if you measured on the same 3 signals as in PQ2?

FREQUENCY LIMITATIONS

All instruments have an upper frequency limit, which may vary from some kHz to some hundred kHz for ordinary multimeters. Usually they are all capable of handling 400 Hz, which is a widely used frequency for power supply.
In order to measure on signals above the cut-off frequency of the meters, we use special high frequency probes. Passive high frequency probes rectifies the signal and give out a DC voltage that can easily be measured by the multimeter. We are then able to use ordinary DC instruments to measure on signals up to 1 GHz.

DECIBEL

Decibel is a way of taking the ratio between two signal levels. Therefore, the dB value of a signal is a number relating it to another signal level, a reference level. The basic definition of dB relates power levels:

$$\text{dB-value} = 10 \log \left(\frac{\text{actual power level}}{\text{reference power level}} \right)$$

When used to relate voltage levels we often use the formula:

$$\text{dB-value} = 20 \log \left(\frac{\text{actual voltage level}}{\text{reference voltage level}} \right)$$

If you want to express how many dB your signal has dropped from a certain level, this becomes your reference level. This level has a dB-value = 0dB

PROCEDURE

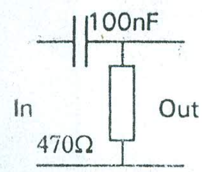
A1: Check that the oscilloscope is correct calibrated by using the 1 Vp-p calibrating signal. If you are unable to calibrate the oscilloscope, take the error into account when using the oscilloscope in the lab. In order to get useful results in this lab, you have to be accurate in your oscilloscope measurements.
Calibrate your AVO-meter to show 0 with no input. (The screw just below the centre of the scale).

A2: Set the output from the Unilab generator to 1 kHz and 10 V peak to peak (Vp-p) sinusodial signal, using the low impedance 1 ohm output. (DO NOT SHORT THE OUTPUT). Control the frequency with the frequency counter function of the Fluke Digital Voltmeter.
Couple the oscilloscope, the Digital Voltmeter (DVM) and the AVO-meter in parallel directly on the output of the signal generator. Use the oscilloscope to control that the output is exactly 10V peak to peak. Take a note of the readings on the DVM and the AVO-meter.

A3: Set the output to square wave, 10V peak to peak (use the oscilloscope). Note the readings on the DVM and the AVO-meter.

A4: Set the output to triangle wave, 10V peak to peak (use the oscilloscope). Note the readings on the DVM and AVO-meter.

A5: Make a high-pass filter using the 100 nF capacitor and the 470 ohm resistor.



Use the signal generator to feed the filter with 1 kHz square wave signal. Couple the oscilloscope, the DVM and the AVO-meter in parallel across the output of the filter. USE THE 3V RANGE OF THE AVO-METER. Adjust the output level of the signal generator until the signal from the filter is 10V peak to peak. (You will have to reduce the output from the generator). Note the readings of the DVM and the AVO-meter.
Make an ACCURATE sketch of half a periode of the output from the filter as seen on the oscilloscope screen, using correct scale of both time-base and voltage/division. (0.1 ms/division).
You should now be able to fill in the columns marked DVM and AVO with the voltage readings from your experiment.

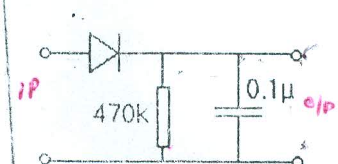
	DVM	AVO	Vpeak	Vmean	Vrms
Sine			10V		
Square			10V		
Triangle			10V		
Square through filter			10V		

A6: Calculate V_{mean} and V_{rms} for all the wave forms. To get this from the output from the filter, the easiest is to use numerical integration on the wave form you have sketched from the oscilloscope screen.

QUESTIONS

1. Are the readings of the DVM proportional to V_{peak}, V_{mean} or V_{rms}? Give your reasons.
2. Answer the same for the AVO-meter.
3. Are the meters intended to show V_{peak}, V_{mean} or V_{rms}? Under which conditions are they intended to show this?
4. Which of the instruments you have used in this experiment would you chose for measuring a periodic signal if you were not sure that it was sinusodial? Give your reasons.

B1: Use the diode, the 0.1 μF capacitor and the 150K resistor to create a peak value measuring circuit.



B2: In order to determine the frequency characteristics of the Fluke Voltmeter, use the Feedback SS0603 signal generator with sinusodial output. Use the oscilloscope to keep the output at a constant 5 V_{p-p} over the whole frequency range and measure this voltage by using the Fluke Voltmeter on AC. The generator should be loaded with the peak value circuit while doing these measurements.

Do the same with the peak value circuit, monitoring the output with the Fluke Voltmeter on DC.

Frequency	10 Hz	10 Hz	100 Hz	100 Hz	10 kHz	10 kHz	100 kHz	100 kHz	500 kHz	500 kHz	700 kHz	700 kHz	1 MHz	1 MHz
DC Direct	1.73													
AC Through circuit														
	V	dB	V	dB	V	dB	V	dB	V	dB	V	dB	V	dB

Plot these two frequency responses in the same axis system on a lin - log - paper, using dB as the vertical scale, with 0 dB at the plateau of each curve.

B3: Why are the readings from this circuit lower than the actual peak value?
Why are the readings falling at lower frequencies?
When would you use a peak value measuring circuit?
How would you make a scale giving correct rms values for sinusodial voltages when using this circuit?

LAB 2 ELECTROMAGNETIC INTERFERENCE

MOTIVATION

The theory needed for this experiment is in a separate handout and will be included in lectures, assignments and exams.

PREPARATION

There are several preparation questions to be answered AT HOME before starting the experiment.

OBJECTS

-To understand how electrical and magnetic fields give unwanted signals in leads and circuits.
-To learn good design methods aimed at reducing interference signals.
-To avoid serious pitfalls when interconnecting equipment.

EQUIPMENT

1 AM/FM radio
1 "Chicken cage"
1 Oscilloscope
1 Probe
1 coax-to-banana converter
1 UNILAB signal generator
1 Power supply
1 Ground plate
2 Plastic tubes
1 Ordinary cable with 1.kohm resistor in series
1 Shielded cable with 1kohm resistor in series
1 Twisted pair cable with 1kohm resistor in series
4 Wooden blocks, 10x5x5 Cm
Lab cables of different lengths