Circuit Analyses. Laboration 3 Oscilloscope and function generator

This booklet, signed by the teacher, serves as a receipt for passing the lab. Each student must have a booklet of his own with solid preparation and completed readings.

Name:
Confirmed (Teacher):

Objective In this lab you will learn how to use the oscilloscope to perform measurements. You will also learn how different waveforms can be generated with the function generator.

Equipment

- **Digital multimeter (DMM) Fluke45**
- **Power supply**
- **RCL meter**
- **Breadoard and Components**

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- Oscilloscope DSO-X 2014A

- Functiongenerator PM *5139*

- Digital multimeter (DMM, DVM) Fluke45

Litterature 2000_series_users_guide and presentations.

Report   Write down your measured values, and figures, in this booklet and report to the teacher during the laboration.

Preparation tasks

F1: The oscilloscope input switch
Describe the difference between DC coupled respective AC coupled input. (Coupling DC-AC)
- When is the AC coupling suitable?
- When is it inappropriate?

F2: The oscilloscope triggering
What is the trigger?
- What does the choice of trigger source?
- When is the auto triggering inappropriate?

F3: The oscilloscope Meas functions
Check what the measurement functions involves:
- **Average-N** cycles
- **AC-RMS-N** cycles
- **DC-RMS-N** cycles
- **Pk-Pk**
- **Frequency**
- **Duty Cycle**

F4: Signals mean and rms values

The oscilloscope measurement **Avg** and the DVMs measurement U_{DC} are the signals averages. The oscilloscope measurement **AC-RMS** and DVMs measurement U_{AC} is the "root of signals squared averages", ie their effective values. (RMS Root Mean Square).
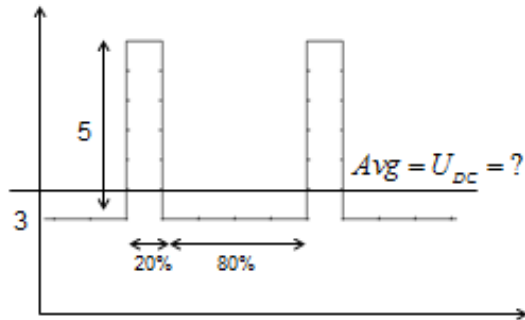
Signal #1. Sine wave. What is the relationship between the **AC-RMS** and the peak-to-peak value **Pk-Pk** ?
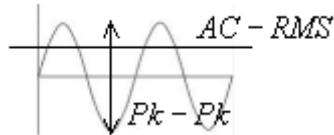
Signal #5. Square wave. What should the RMS value be? Why? **AC-RMS** U_{AC} ?

$$AC\_RMS = U_{AC} = ?$$
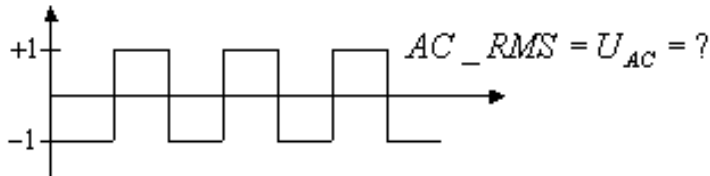
Signal #8. PWM signal. What should the average be? **Avg** U_{DC}?

$$Avg = U_{DC} = ?$$

Signal #9. Ramp (Saw). What should the average be? **Avg** U_{DC}?

$$Avg = U_{DC} = ?$$
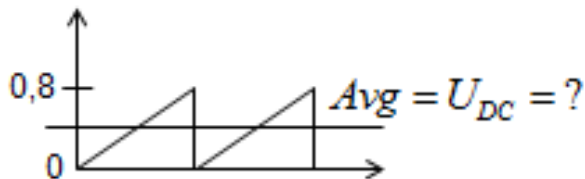
Measurements

M1: Tutorial: Getting Started with DSO-X 2014A.

Follow the tutorial "Getting Started with DSO-X2014A" available on the course website. You will find two attenuation probes under a cover at the oscilloscope's handle. During this tutorial, we use internal test voltages so no other equipment required.
If you want to familiarize yourself with the oscilloscope in advance you can do this tutorial at any time prior to the lab.

During the continuation of the lab, we use the test leads without attenuation probes. Therefore, press the button **Default Setup** to remove the "previous" settings when you continue this lab.

M2: Measurement of a dc voltage

Connect the 5V DC voltage from the DC power supply (without setting an exact value). Measure the voltage with a digital voltmeter DVM (U_{DC}) and the oscilloscope (measuring function **Avg-N**).
• The digital voltmeter accuracy in its datasheet.
The accuracy of the oscilloscope is more difficult to assess. Oscilloscope's resolution is 8 digital bits (maximum 256 steps, a maximum of 0.5% of the measuring range) but the displayed value is also due to the rounding errors incurred during the calculations withthe sample values.
The oscilloscope is primarily intended to show how the signals look like, for the more "precise" measurements one uses specialized measuring instruments (here DVM).

DVM: [   ] +/- [   ] [V] **Oscilloscope:** [   ] [V]

M3: Investigation of signals from the function generator

A DVM can be "configured" to carry out measurements in different ways to measure different aspects of a signal. They are many instruments in one.
The oscilloscope always "sample" the signal the same way, but the result could be *calculated in various ways* before presentation.

With a function generator one can generate different test signals.
You should measure nine different signals from the function generator with the oscilloscope and the DVM. On the next page is a table with various settings of the function generator, and with space for your notes of the readings.

It is important to understand what the oscilloscope's various measuring functions mean, so that one knows how they are affected by the settings of the function generator, and how the DVM measured values correspond to the parameters of the function generator.

Make sure you can explain why the measured values will be what they will be. Especially for the framed boxes in the table.

Here you write your comments to the measurement results:

Signal #1. Does the relationship between the oscilloscope measurements **AC-RMS** and **Pk-Pk** with your preparation task (F4)?

Signal #3. Why do the U_{AC} and **AC-RMS** differ from each other for this signal when they don't do it for signal # 1 and # 2?

Signal #4. Sine signal. Verify if the oscilloscope measurements, and DVM measurements are consistent with the formulas:

$$DC\_RMS = \sqrt{Avg^2 + AC\_RMS^2} \quad U_{ACDC} = \sqrt{U_{DC}^2 + U_{AC}^2}$$

Signal #5. Square wave. Are your measurement of **AC-RMS** and och U_{AC} consistent with your preparation task (F4)?

Signal #6. Square wave. Verify if the oscilloscope measurement, and DVM measurements are consistent with the formulas:

$$DC\_RMS = \sqrt{Avg^2 + AC\_RMS^2} \quad U_{ACDC} = \sqrt{U_{DC}^2 + U_{AC}^2}$$

Signal #8. PWM signal. Are your measurement of **Avg** and U_{DC} consistent with your preparation task (F4)?

Signal #9. Ramp(Saw). Are your measurement of **Avg** and U_{DC} consistent with your preparation task (F4)?

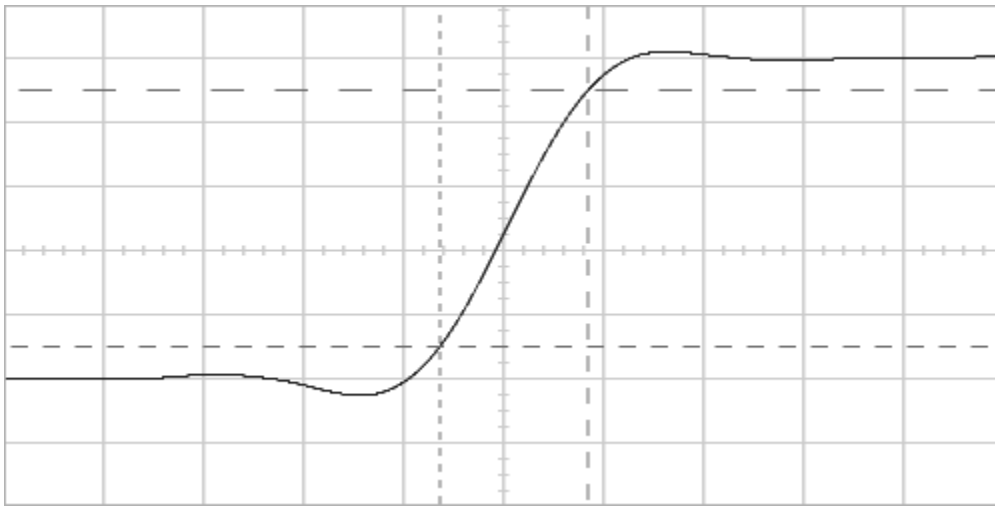| Functiongenerator PM5139					Oscilloscope DSO-X 2014A							DMM Fluke 45		
WAVE-FORM #	DC [V]	AC [$V_{t\text{-}t}$]	FREQ [kHz]	DUTY %	Draw figure	Avg-N [V]	Pk-Pk [V]	Freq [kHz]	Duty %	AC-RMS [V]	DC-RMS [V]	U_{DC} [V] v==	U_{AC} [V] v~	U_{RMS} [V] v== v~
1 sine	0	1	1	—		0			—		—	0		—
2 sine	0	1	100	—		0			—		—	0		—
3 sine	0	1	500	—		0			—		—	0		—
4 sine	1	1	2	—					—					
5 square	0	2	1	50		0			50			0		
6 square	2,5	2,5	30	50					50					
7 square	3	0,5	3	50					50					
8 PWM	3	5	300	20										
9 SAW	0	0,8	1	—					—					

M4:Measurement of rise time.

How fast changes can the oscilloscope register? This depends not only on the oscilloscope, but also on the test leads, so it is not possible to state this once and for all in the oscilloscope data sheets. Instead, it has an built-in measurement function **Rise Time**, rise time.
We assume here that the function generator can generate pulses that have faster rise times than the oscilloscope can measure. Connect the oscilloscope *directly* to the function generator.

Set the function generator to square wave **AC** ≈ 2 V_{t-t}. Choose a high frequency, but such that the output still looks fairly square in shape, about 1 MHz.
Use **Auto Scale**, and **MEAS Rise Time**. At rise time measurement the cursors are placed automatically at 10% level and 90% level, and the time difference between them is measured.

Example of cursor's placement at the rise time measurement.

- How large was the rise time?   (ns)
- Change the connection between the function generator and the oscilloscope by inserting a T-piece. Connect another cable to the T-piece (with the other end open, unconnected). Did the rise time change? (Magic?)

(Rise time indicates the absolute limit of how fast signals one can measure with a certain connection.)

You could use this page for your calculations.