Electronics Lab Course
Experiment #0: Introduction and Preparational Experiment

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Contents

1 Aims of the experiment

The aim of this experiment is to understand the tools used in the electronics lab course. In order to do so, the termini of bandwidth and ramp-up time are introduced.

2 Theoretical background

2.1 Amplitudes of AC voltage

To describe AC voltage amplitudes, the following voltages can be used:

$$\begin{aligned}
\text{peak-to-peak-voltage:} \quad U_{PP} &= max\{U(t)\} - min\{U(t)\} \\
\text{peak-voltage {\tiny (symmetric and most times also asymmetric voltage):}} \quad U_P &= max\{|U(t)|\} \\
\text{root-mean-square-amplitude-voltage:} \quad U_{RMS} &= \sqrt{\langle U^2(t) \rangle}
\end{aligned}$$

2.2 Measuring instruments

Every measuring instrument is made up of two parts:

- Measuring unit
- Displaying unit

2.2.1 Measuring unit

The measuring unit measures the measurand and controls the displaying unit. It is made up itself of another 3 subunits:

- Measuring amplifier
- Area selection network
- Measuring converter

2.2.2 Displaying unit

The displaying unit allows us to read the value of the measurement. If the measuring instrument is an analogue one, it consists of a pointer a coil which steers the pointer and a scale. If it is a digital one, it consists of a counter which -most times- gets it's input from a so called dual-slope converter[1] and a LCD.

2.3 The oscilloscope

The oscilloscope is a measuring instrument for voltage. It steers an electron-beam through plate-capacitors, which stand perpendicular to each other (x-steering: time, y-steering: measurand), which allows to observe processes by time.
For a static display, a toggle switch and the trigger are used. The toggle switch steers the electron-beam back to the beginning of the scale, after it passes it's end. For a static display, the period of the process must be a integer multiple of the displaying-period. That is, what the trigger is for.

[1]it measures a measurand by the time it takes to decharge a build-in capacitor

3 Preperational exercises

3.1 0.2.1.A

$$\begin{aligned} U(t) &= U_0 \cdot \sin(\omega t) \\ U_{PP} &= 2 \cdot U_0 \\ U_P &= U_0 \\ U_{RMS} &= \tfrac{U_0}{\sqrt{2}} \end{aligned}$$

3.2 0.2.1.B

For a symmetrical rectangular voltage[2]

$$\begin{aligned} U_{RMS} &= \frac{U_0}{\sqrt{2}} \\ &= 7.07\,\mathrm{V} \end{aligned}$$

3.3 0.2.2.C

3.3.1 0.2.2.C.1

$$\begin{aligned} \text{To proof:} \quad R_i &= \frac{U_2 - U_1}{I_1 - I_2} \\ U_n &= U_0 \frac{R_n}{R_n + R_i} \\ I_n &= \frac{U_n}{R_n} \\ \Leftrightarrow I_n &= U_0 \frac{1}{R_n + R_i} \\ U_2 - U_1 &= U_0 \left(\frac{R_2}{R_2 + R_i} - \frac{R_1}{R_1 + R_i} \right) \\ I_1 - I_2 &= U_0 \left(\frac{1}{R_1 + R_i} - \frac{1}{R_2 - R_i} \right) \\ \Rightarrow \frac{U_2 - U_1}{I_1 - I_2} &= \frac{\left(\frac{R_2}{R_2+R_i} - \frac{R_1}{R_1+R_i} \right)}{\left(\frac{1}{R_1+R_i} - \frac{1}{R_2+R_i} \right)} \\ &= \frac{R_2 (R_1 + R_i) - R_1 (R_2 + R_i)}{R_2 + R_i - R_1 - R_i} \\ &= \frac{R_i (R_2 - R_1)}{R_2 - R_1} \\ &= R_i \end{aligned}$$

[2]In this case with $U_P = 10\,\mathrm{V}$

3.3.2 0.2.2.C.2

$$\begin{aligned}
U_0 &= 10\,\mathrm{V} \\
U_n(50\,\Omega) &= 5\,\mathrm{V} \\
U_n &= U_0 \frac{R_n}{R_n + R_i} \\
\Rightarrow R_i &= 50\,\Omega
\end{aligned}$$

3.4 0.3.3.E

$$\begin{aligned}
\text{To proof:} \quad B\Delta t &= 0.35 \\
B &= \frac{1}{2\pi\tau} \\
\Delta t &= t(0.9U_0) - t(0.1U_0) \\
\text{Decharging-function of a capacitor:} \quad U(t) &= U_0 \exp\left(-\frac{t}{\tau}\right) \\
\frac{0.1}{0.9} &= \exp\left(-\frac{\Delta t}{\tau}\right) \\
\Leftrightarrow \Delta t &= -\ln\left(\frac{1}{9}\right)\tau \\
&= 2.197\tau \\
\Rightarrow B\Delta t &= \frac{2.197}{2\pi} \\
&\approx 0.35
\end{aligned}$$

4 Procedure

4.1 0.4.1.a

Different signals at different frequencies and amplitudes shall be observed at the oscilloscope.
In order to do so, we connect the CH1-input of the oscilloscope with generator-output by BNC. The BNC is connected without reflexion and the oscillscpe is triggered.

4.2 0.4.1.b

Δt of a rectangular voltage shall be determined by measuring the delay from $0.1U_0$ to $0.9U_0$ with the oscilloscope.[3]

[3] We must also pay attention to the bandwidth of the oscilloscope which is - so says the manual - 60 MHz

5 Measurement

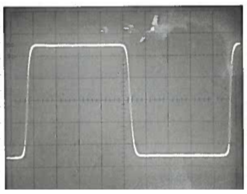
5.1 0.4.1.a

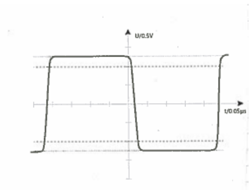
The following signals were observed:

- Sinus
- Triangular
- Rectangular
- pos. ramp
- neg. ramp

5.2 0.4.1.b

$$t \text{ at } 10\%\text{: } 0.45\text{Scp.}$$
$$t \text{ at } 90\%\text{: } 0.18\text{Scp.}$$
$$1\text{Scp.}[t] = 0.05\text{s}$$
$$1\text{Scp.}[U] = 0.5\text{V}$$
$$f = 2\text{MHz} = B$$
$$U_{PP} = 2.6\text{V}$$





ΔScp.$= 0.05$

6 Evaluation

The manual says the delay of the oscilloscope is less than 6ns. So we approximate it at (5 ± 1)ns

So we get $\Delta_{signal} = (0.1446 \pm 0.5) \cdot 10^{-8}$s and for the bandwidth $B = (24.2 \pm 0.837)$MHz.