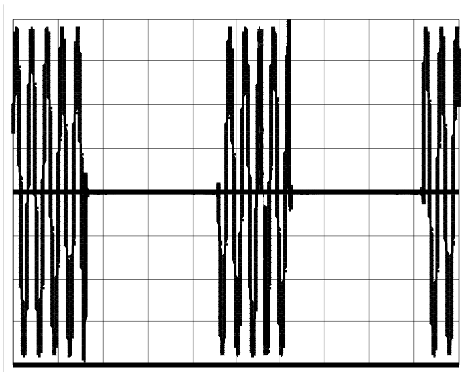
Electronic Measurements

Master degree in Electronics Engineering

Assorted examples – 9 January 2020

Question n. 1

- Discuss the phases that form the operating cycle of an oscilloscope.
- Describe oscilloscope trigger circuits, explain trigger control and their effect.
- Explain the trigger *hold-off* function and provide an example where an adjustable *hold-off* time is needed
- The figure below reproduces a signal, as shown on an oscilloscope display. Horizontal scale factor is 50 ns/div and the horizontal axis on the display is divided into N_V= 500 time slots. Maximum ADC sampling frequency is 500 MHz, memory depth is 10^5 samples.



a) indicate a trigger setting that allows a stable trace to be displayed;
b) determine the time distance between consecutive samples in the acquisition memory;
c) calculate the time resolution that can be obtained on the screen by using horizontal cursors;
d) based on information obtained so far, explain how signal samples are processed while moving from the acquisition memory to the display graphic memory;
e) considering the indicated sampling rate and the features of the signal displayed in the figure, indicate a possible value for the oscilloscope bandwidth. Motivate your answer.

Question n. 2

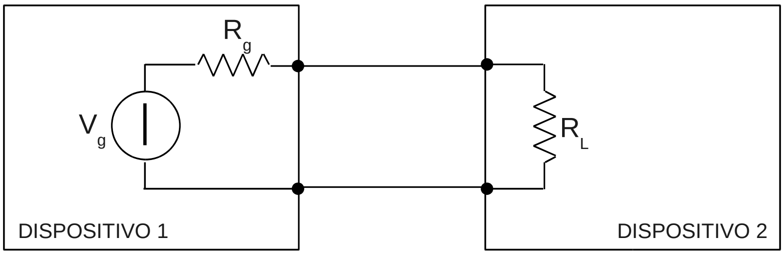
- Describe the functional elements of an oscilloscope input channel and discuss what is involved in ensuring a correct reproduction of the measured signal.
- Explain the use and operation of a passive probe. Explain how and why verification of the probe compensation is needed.
- A signal source with a 600 Ω output impedance produces a symmetric square wave with an open-circuit peak-to-peak amplitude of 4 V, period 2 μs, edge rise/fall times 80 ns. This waveform is to be measured by a digital oscilloscope.
  a) oscilloscope input impedance values are: R_i = 1 MΩ, C_i = 12 pF. What is the difference between connecting the source to the oscilloscope by a simple coaxial cable and using a passive probe instead? Is the use of a passive probe worth considering in this case?
  b) specify the requirements that ensure signal edge duration can be measured with an accuracy better than 10%;
  c) assume the instrument maximum sampling rate is 500 MHz and acquisition memory depth is 10 000 samples. Select from the following list of values: 10 ns/div, 20 ns/div, 50 ns/div, 100 ns/div, 200 ns/div the horizontal scale factor that provides the best resolution when measuring the square wave rise time.

Question n. 3

Draw a vector signal analyzer functional diagram and explain the main features of each element in the diagram.
Discuss modulation domain analysis and compare the main features of a constellation diagram and of a vector diagram.

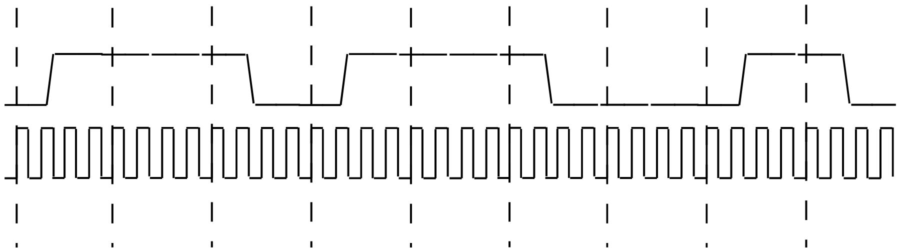
Question n. 4

Signal integrity measurements are needed for a 2 Mbit/s serial line linking two digital devices. The schematic of the basic electrical circuit is shown in the figure, where R_g = 1300 Ω and R_L = 100 kΩ (assume electric parameters of the connecting line are negligible).



Nominal voltage levels are: 0 V for logic '0'; +3 V for logic '1'. Transition times between the two levels is about 10% of the symbol period.

Besides the 2 Mbit/s serial line signal, a system clock at the fundamental frequency of 8 MHz can be acquired.



Signal acquisition is by a digital oscilloscope with a 100 MHz bandwidth, 8-bit analogue-to-digital converter and 500 MHz maximum sampling rate. Scale factors can be varied according to a 1-2-5-10 sequence and can vary between 10 mV/div and 10 V/div for the vertical scale, between 1 s/div and 5 ns/div for the horizontal scale. Instrument input impedance is the parallel of a 1 MΩ resistance and a 12 pF capacitance.

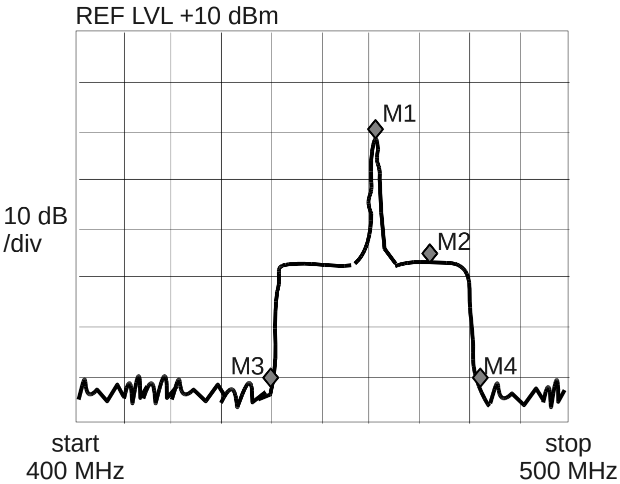
1. check whether instrument bandwidth is adequate for these signals;
2. assess the loading effect introduced by the instrument in the following two configurations and indicate which is preferable:
   a) connection by a coaxial cable, length 60 cm, capacitance 0.8 pF/cm;
   b) connection by a compensated passive 1:10 probe, length 1 m, capacitance 1 pF/cm.
3. describe the measurement configuration that allows to acquire the eye diagram on the serial line and specify all necessary oscilloscope settings, such as vertical and horizontal scale factors and trigger controls (level, slope, *hold-off* time if necessary);
4. for the scale factors determined at point 3. above, calculate amplitude and time resolution for the screen cursors (the horizontal axis is divided into 1000 time slots); assuming memory depth is 10^5 samples, determine the time separation between consecutive samples in the acquisition memory.

Question n. 5

Explain differences in the use of a swept-frequency spectrum analyzer when a discrete spectrum or a continuous spectrum signal is measured.

Question n. 6

The figure shows a spectrum analyzer trace. The instrument input impedance is 50 Ω and resolution bandwidth for this measurement is 100 kHz.



Markers M1, M2, M3 ed M4 shown in the figure (position shown by a grey diamond) correspond to the following measured values:

M1: -11.8 dBm, 461.7 MHz M2: -37.6 dBm, 472.0 MHz
M3: -61.5 dBm, 440.0 MHz M4: -61.5 dBm, 482.1 MHz

Based on these indications, determine:

- the RMS value of the sinusoidal component indicated by marker M1;
- the power spectral density of the continuous spectrum component;
- the total signal power
- the minimum *sweep time* required to ensure that indications provided are correct.

Question n. 7

- Explain the organization of memories in a digital oscilloscope. Specifically:
  - management of pre- and post-trigger samples in the acquisition memory;
  - management of variable persistence in the video memory.
- Discuss whether aliasing can occur during acquisition.
- Discuss whether aliasing can affect the displayed trace. Is it possible to have aliasing effects on the displayed trace when no aliasing affects the acquired trace?

Question n. 8

- Present the block diagram of an arbitrary waveform generator.
- Referring to the block diagram, discuss the steps involved in reproducing an analogue signal starting from a sequence of numerical values.
- Indicate how amplitude and frequency regulations can be implemented.