Electronic Measurements
Master degree in Electronics Engineering

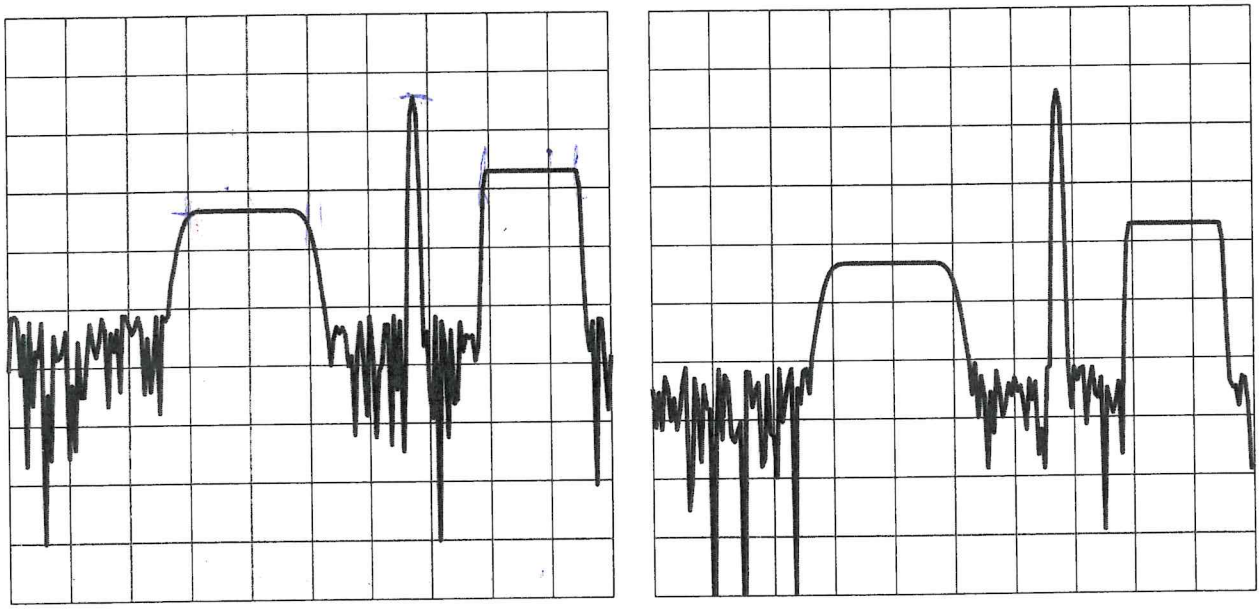
WRITTEN TEST – 17 July 2024

Name Student number

TIME TO COMPLETE: 90 minutes

Exercise n. 1

The two figures below reproduce the screen of a spectrum analyser, where the **same** signal is measured with different settings of *resolution bandwidth*: **left**: B_R = 1 MHz, **right** B_R = 100 kHz.



Main instrument specifications are:

- frequency range: from 10 kHz to 3 GHz;
- input impedance: 50 Ω;
- *resolution bandwidth* ($B_R = 2B_{\text{-3dB}}$): can be varied from 300 Hz to 10 MHz in a 1-3-10 step sequence;
- selectivity ($B_{\text{-60dB}}/B_{\text{-3dB}}$) = 15;
- $ENBW/B_R$ = 1.4.

Scale references on the display are:

- start frequency: 1200 MHz; stop frequency: 1500 MHz;
- reference level: 0 dBm;
- vertical scale factor: 10 dB/div.

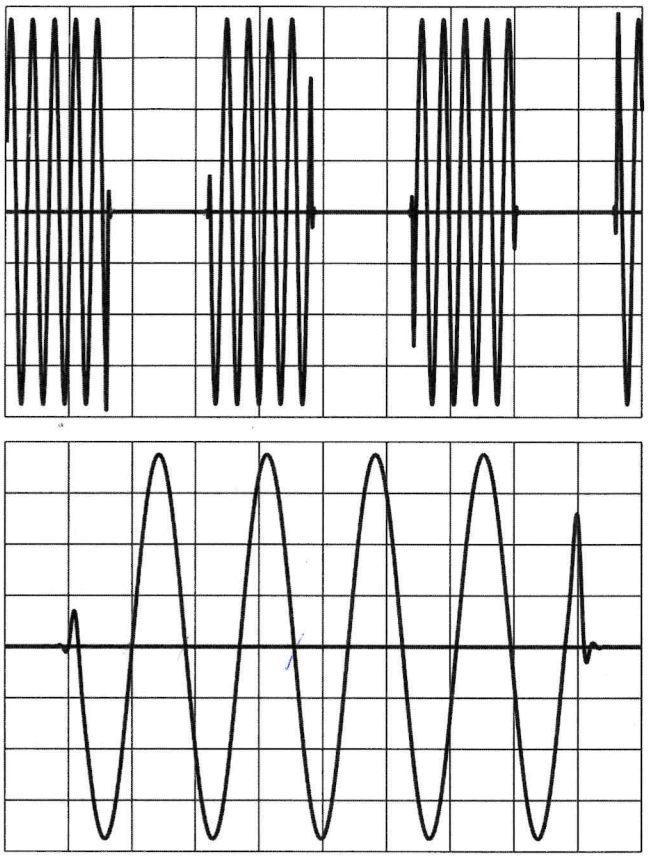
Using the approximate values that can be obtained from either trace:

a) determine the nature (either discrete- or continuous-spectrum) of the three components
b) determine the rms value of sinusoidal (discrete spectrum) components, if any are present;
c) determine the power spectral density of continuous-spectrum components, if any are present, providing values in [dBm/Hz];
d) calculate the total power of the signal and report its value by a suitable sub-multiple of [W].

Exercise n. 2

The two figures below reproduce an oscilloscope display showing the same signal with different timebase and trigger settings. Screen resolution: horizontal axis N_x = 1000 intervals, vertical axis N_x = 640 levels. Maximum ADC sampling frequency is 1 GHz, memory depth is 10^5 samples.
The spectral analysis function (FFT) provided by the instrument employs data acquired over an observation interval having length $2T_W$, where T_W is the interval shown in the figure below (hence, FFT is computed from $2N_x$ sample values). A Hanning window is selected, for which:

$2B_{-6dB}/F = 2$; side lobe attenuation > 32 dB; WCSL = 1.42 dB



Instrument settings are:

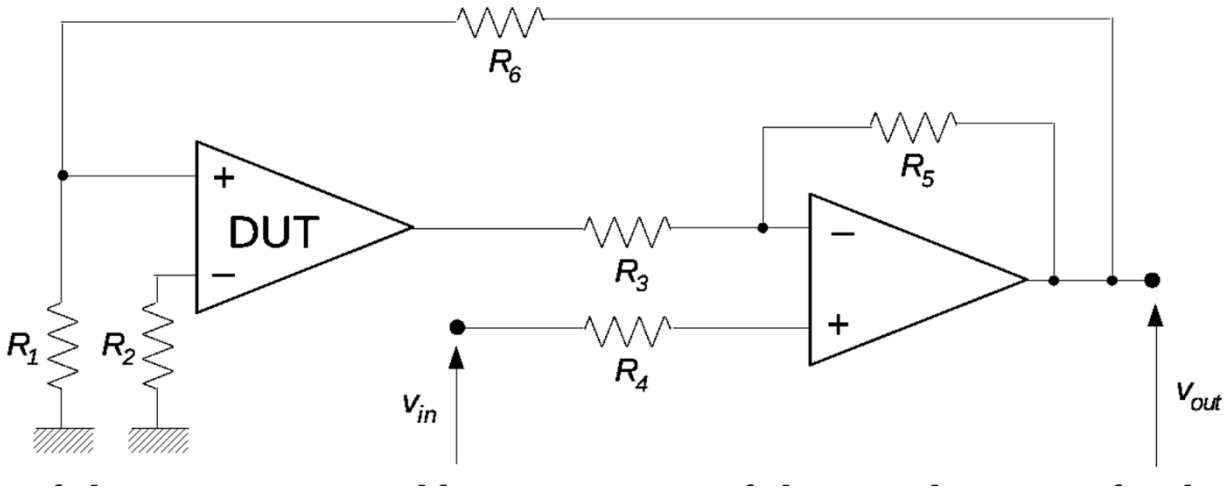
- vertical scale factor **0.5 V/div**
- horizontal scale factor **1 µs/div** for the top trace
- horizontal scale factor **200 ns/div** for the bottom trace

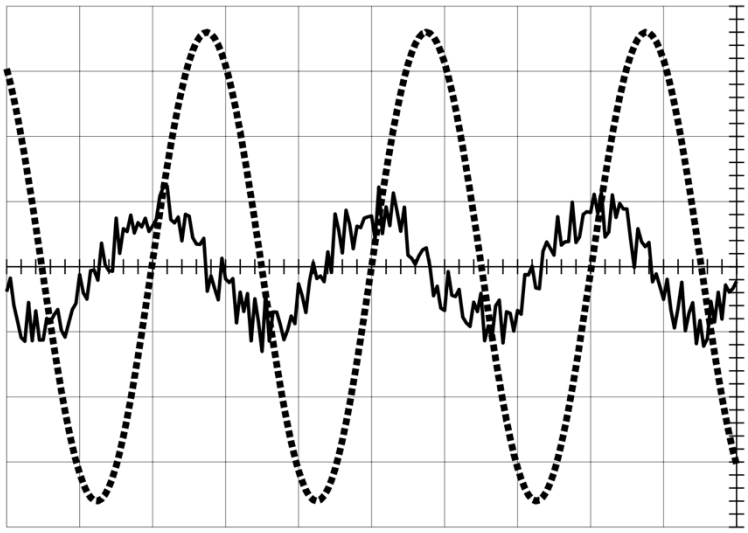
a) discuss which trigger setting could be suitable for the trace (regardless of timebase setting);
b) for each timebase setting:
   - determine the time interval between consecutive samples in the acquisition memory;
   - calculate the time resolution provided by horizontal cursors on the instrument screen;
c) selecting first the timebase setting best suited for the purpose:
   - determine the sinewave period assuming the use of time cursors;
   - determine the period of the modulating square wave assuming the use of time cursors;
d) the selecting first the timebase setting best suited for the purpose:
   - determine the step F on the frequency axis and the frequency span;
   - taking as references the values determined at point c) above, determine the frequency values provided by the spectral analysis function for the sinewave frequency and for the square wave fundamental frequency;
   - discuss the possibility of spectral interference

Exercise n. 3

Consider the test circuit shown below, where resistor values are:

R1 = R2 = 47 Ω R3 = R4 = 1 kΩ R5 = R6 = 47 kΩ





The purpose of the circuit is to enable measurement of the open-loop gain for the operational amplifier indicated as DUT. Waveforms measured at the test circuit input and output are represented by the two oscilloscope traces shown in the figure that follows, respectively:

- dotted line (v_{in}), vertical scale factor **100 mV/div**
- continuous line (v_{out}), vertical scale factor **10 mV/div**

Horizontal scale factor is **100 ms/div** and the time axis is divided into N_V = 1000 intervals. Quantization levels for the vertical scale are 256 (8 bits).

1. Discuss which is the best setting for the trigger level;
2. Determine:
   - horizontal and vertical **resolutions** for the two traces, assuming the use of cursors;
   - the **DUT estimated open-loop gain**, value to be indicated in dB;
   - the **DUT estimated phase shift**, value to be indicated in degrees;
3. Discuss possible improvements to the measurement accuracy.