1. Introduction

The aim of the laboratory was to familiarize with two basic types of signal modulation – AM and FM. Former uses changes of amplitude to convey information while the latter changes signal's frequency. They of course result in different shapes but also spectrums. AM appears as a single peak of carrier frequency surrounded symmetrically by 2 lower peaks, moved by the value of modulating frequency. FM on the other hand, has carrier frequency surrounded by several symmetrical peaks moved by the multiple of the modulating frequency.

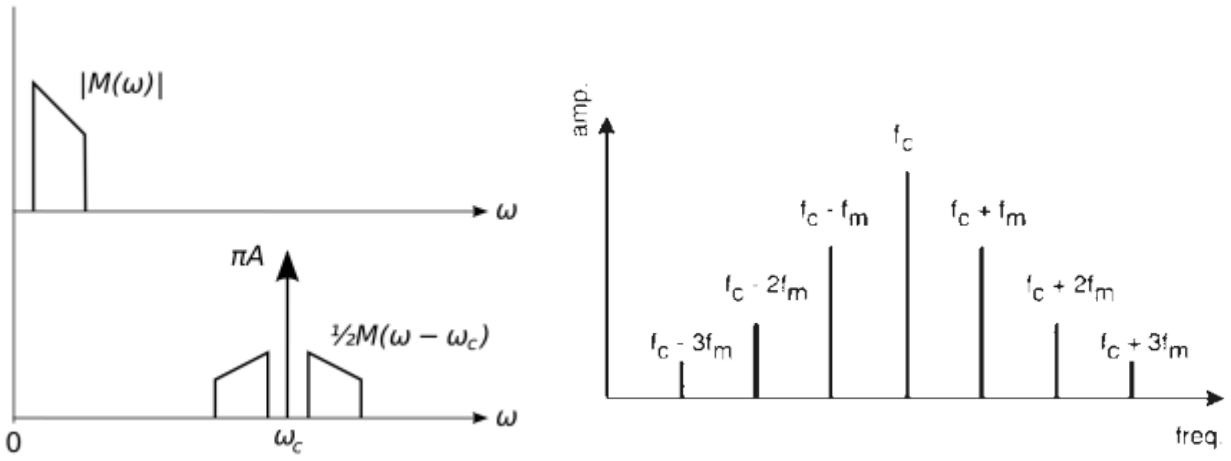

Figure 1 AM spectrum (left), FM spectrum (right)

2. Results

2.1. AM

Carrier wave frequency was set as 5 kHz and generated using DDS algorithm on DAC from previous laboratory. Modulation signal frequency was set as 100 Hz generated by Analog Discovery and fed to ADC. Modulation was achieved by multiplying DAC output by ADC input.

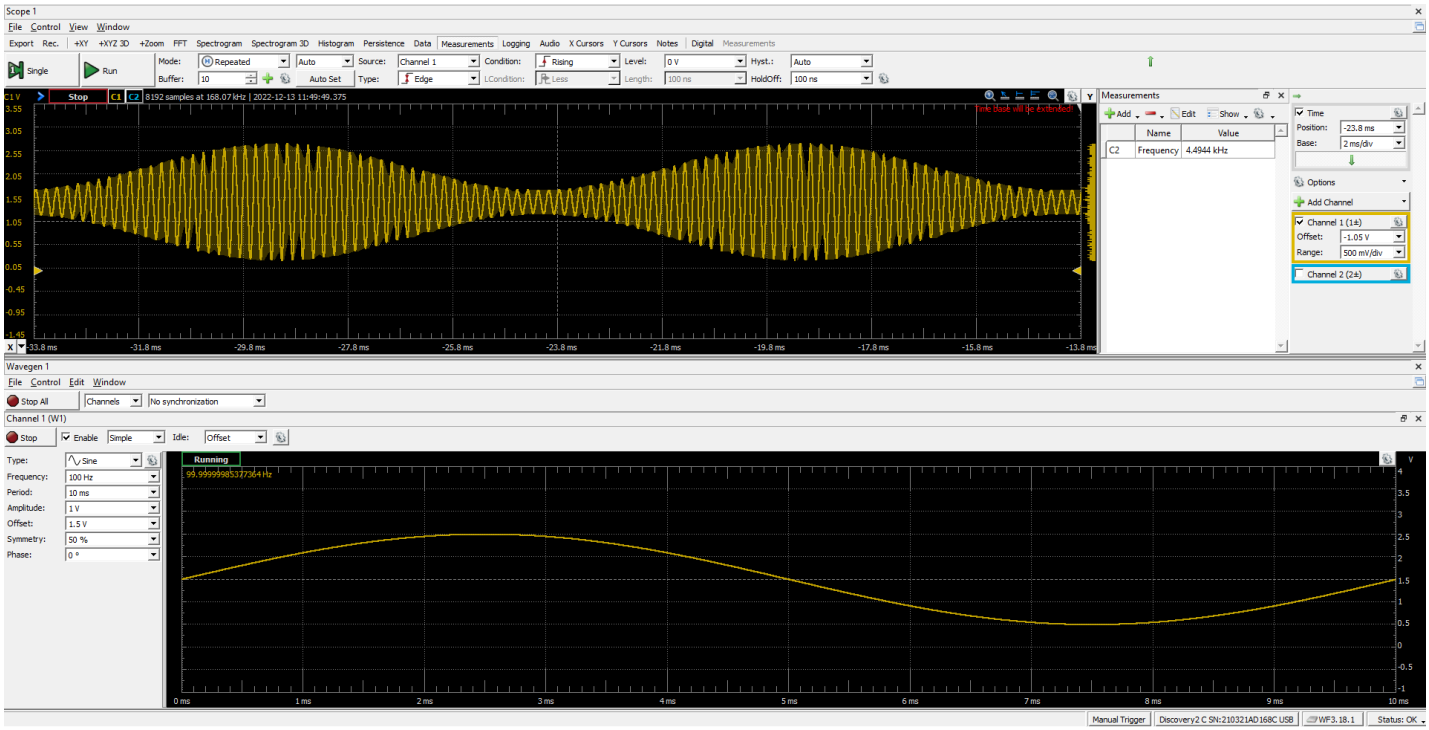

Figure 2 AM signal (top) and modulation signal (bottom)

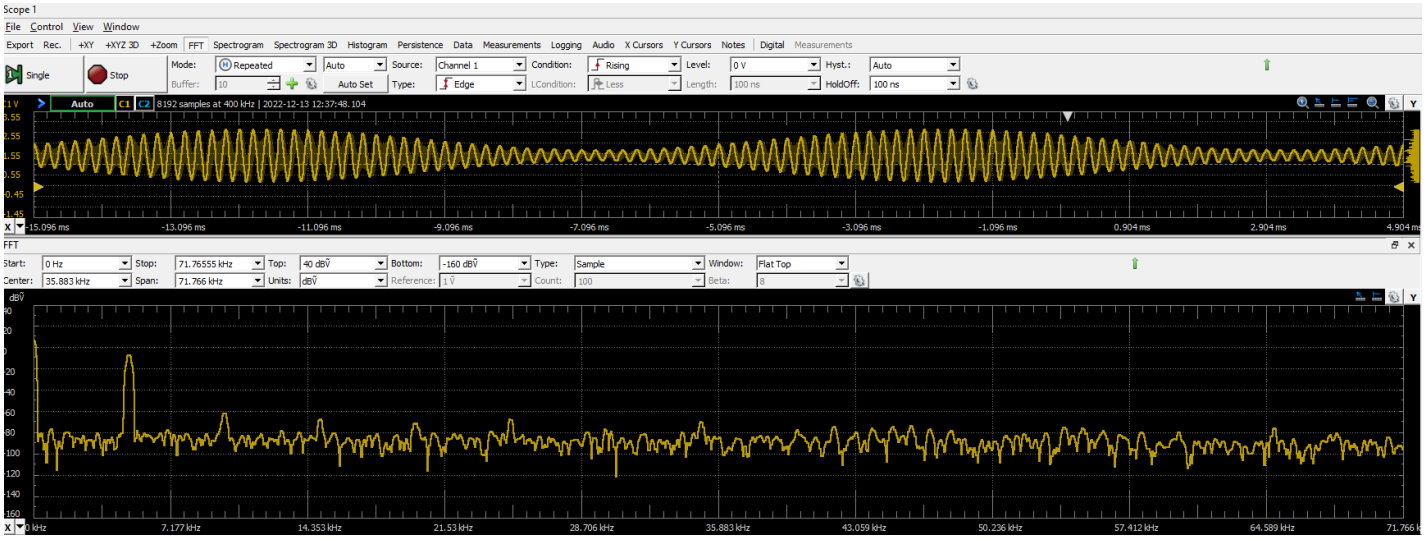

Figure 3 FFT of AM signal

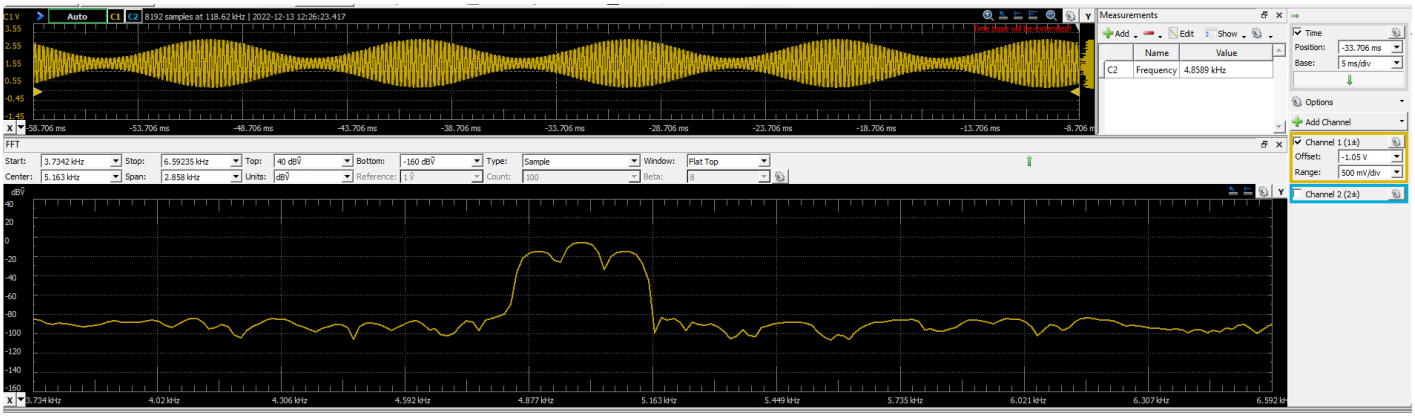

Figure 4 Close-up on carrier frequency

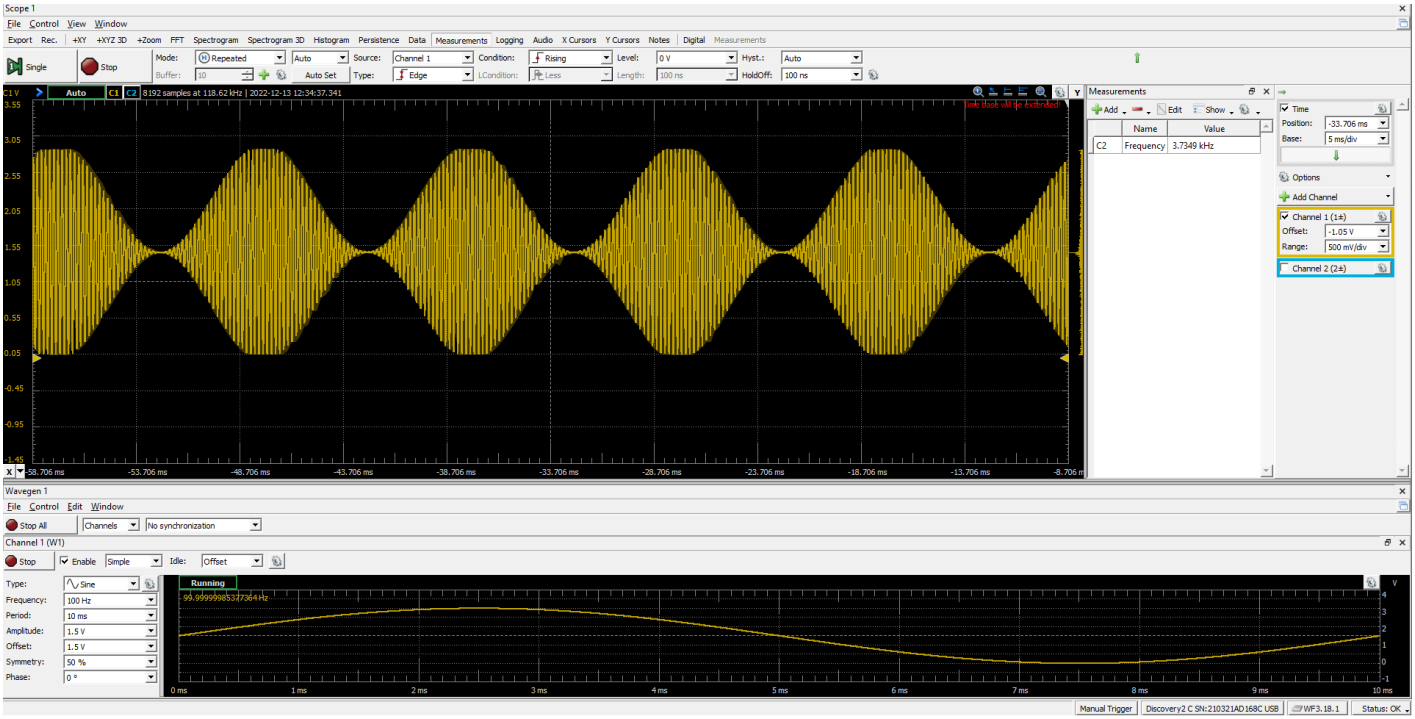

Figure 5 Modulation signal with higher amplitude

By combining carrier and modulating wave, we can achieve Amplitude Modulation – information is carried as changes in amplitude of modulated signal. This produces characteristic shape shown on Fig.2. Changing amplitude of modulation signal causes modulated wave to drop its amplitude to 0 as shown on Fig.5.

As expected performing FFT on modulated signal reveals biggest peak at carrier frequency (Fig.3). Zooming on it shows that there are 2 symmetrical peaks around center frequency. They are caused by integration of modulating signal and are moved from the center frequency by frequency od modulating signal, which is 100 Hz in this case (Fig.4). Smooth characteristic is caused by resolution of measurements.

2.2. FM

Carrier wave frequency was set as 5 kHz and generated using DDS algorithm on DAC from previous laboratory. Modulation signal frequency was set in range 1 - 300 Hz generated by Analog Discovery and fed to ADC. Modulation was achieved by multiplying phaseStep in DDS algorithm by ADC input which change the step of outputted frequency.

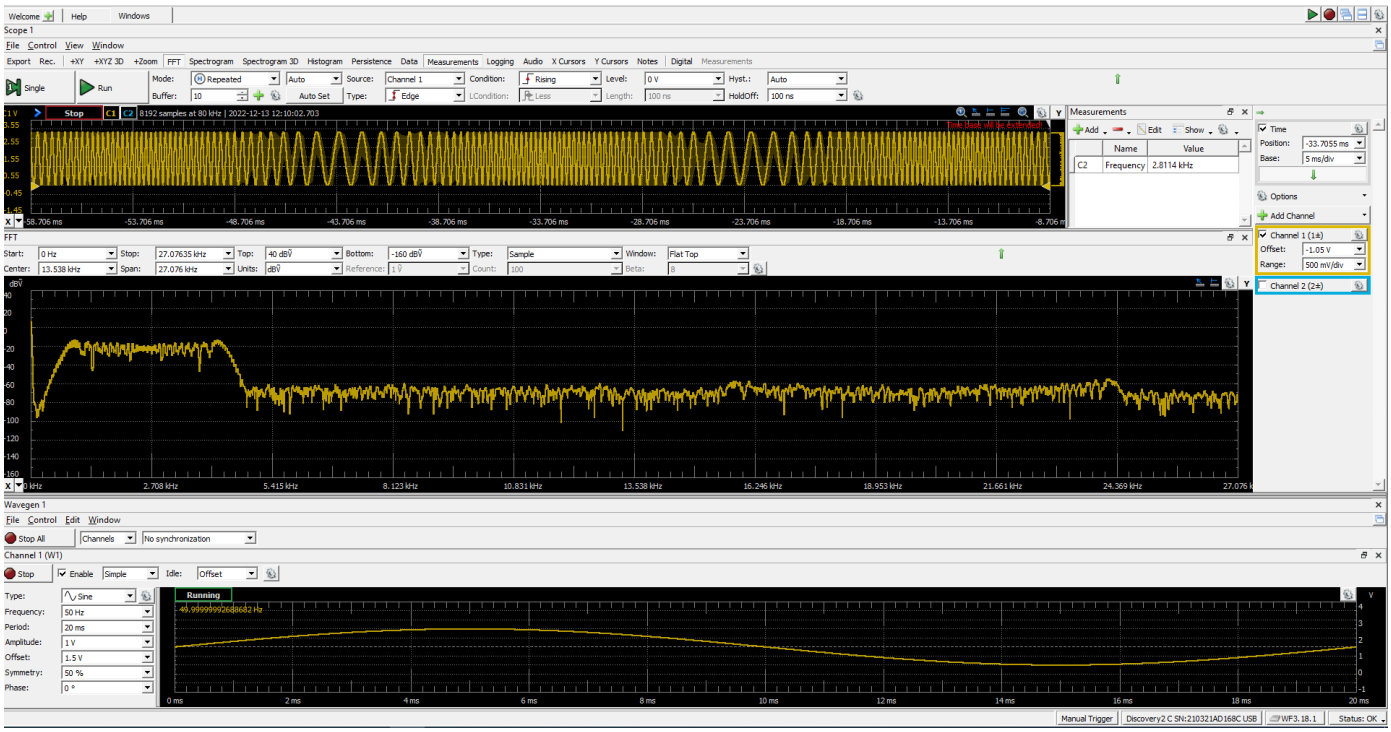

Figure 6 FM signal (top) and modulation signal (bottom) with FFT (center) for modulating frequency 50 Hz

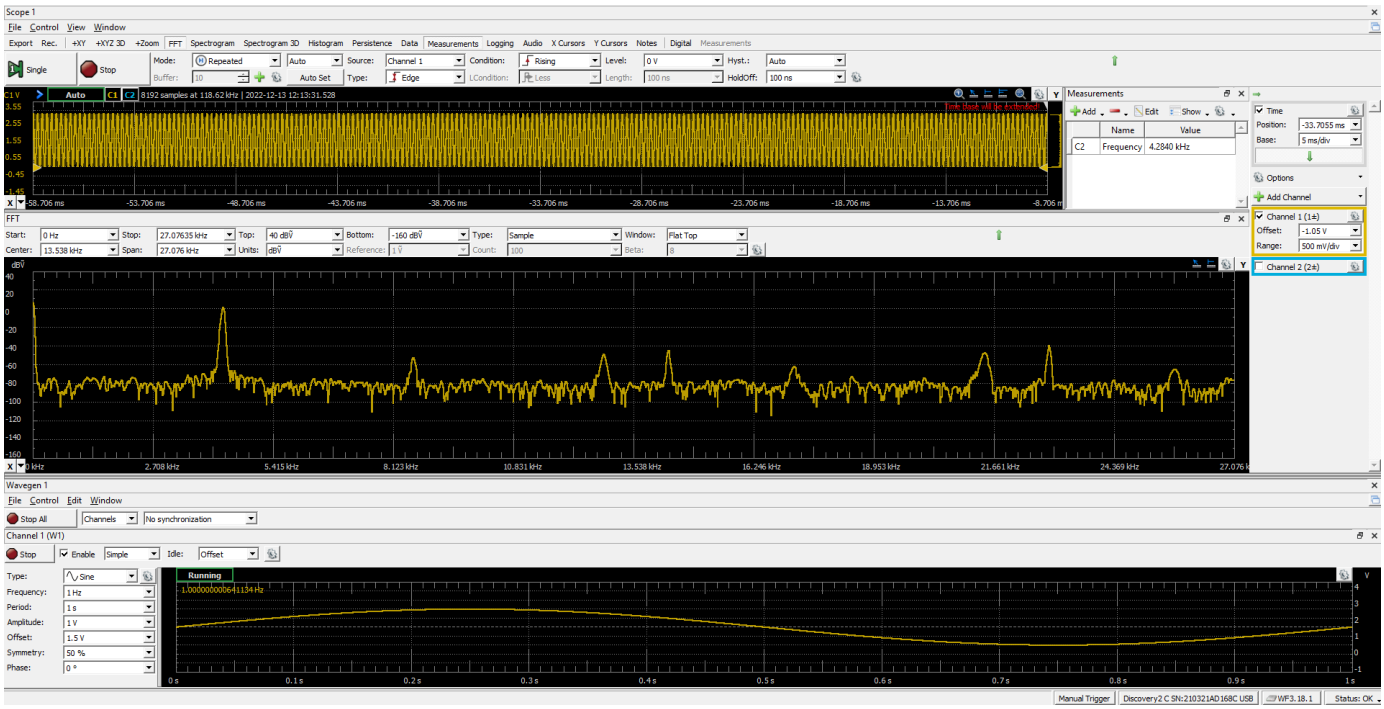

Figure 7 FM signal (top) and modulation signal (bottom) with FFT (center) for carrier frequency 1 Hz (part 1)

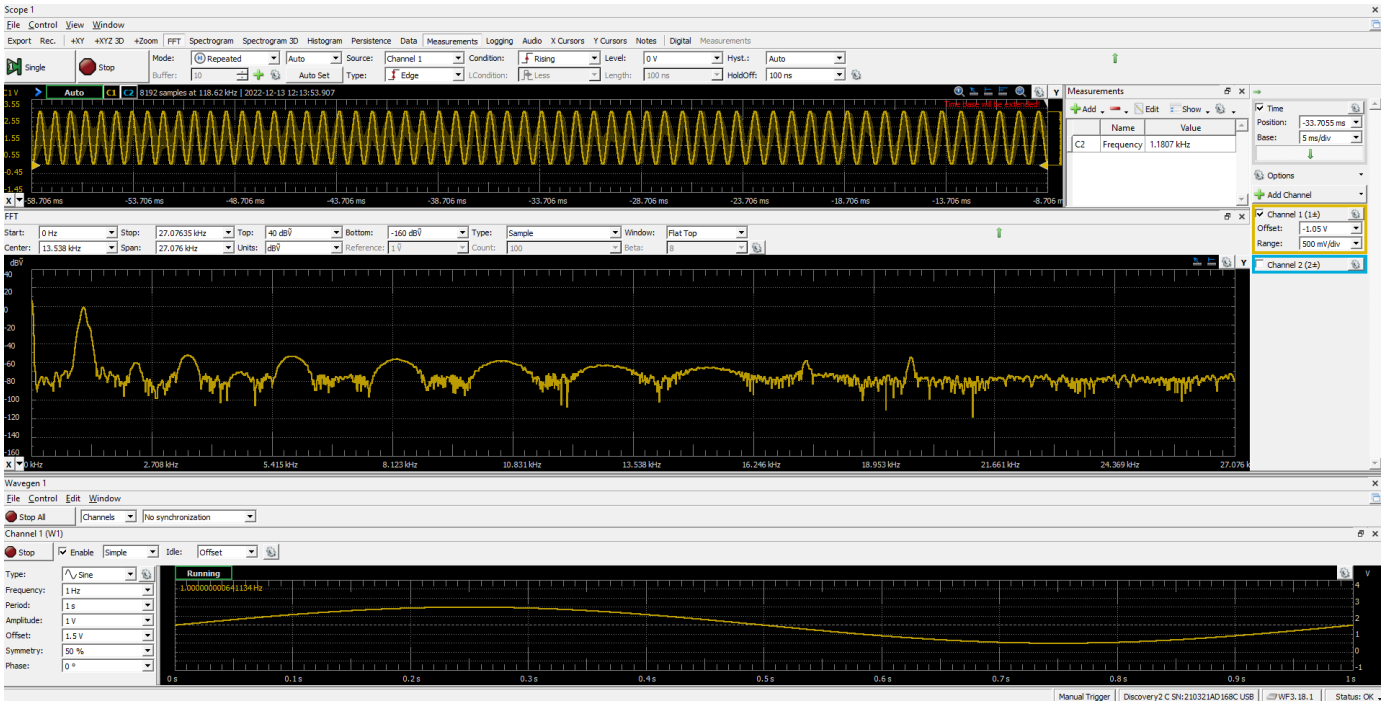

Figure 8 FM signal (top) and modulation signal (bottom) with FFT (center) for carrier frequency 1 Hz (part 2)

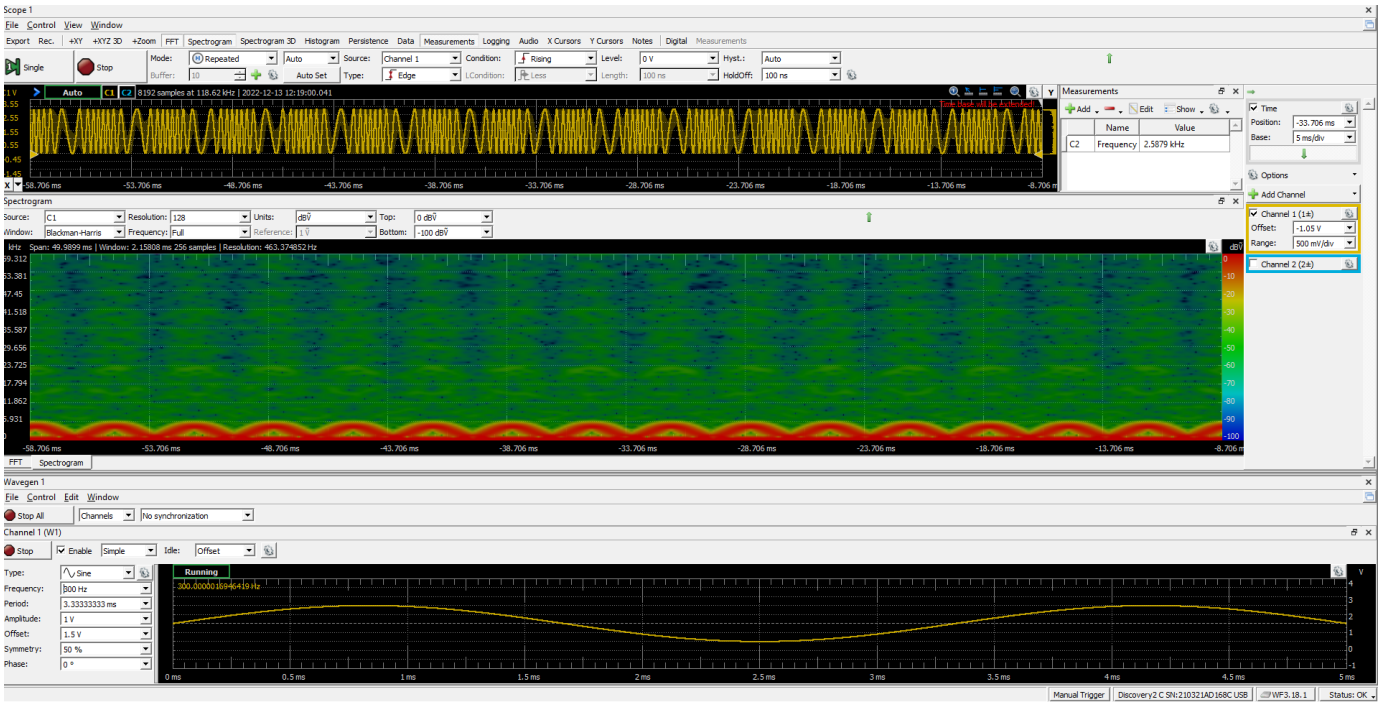

Figure 9 Spectrogram for carrier frequency 300 Hz

In the FM, information is carried as changes of frequency – this is shown on Fig. 6 (top). Performing FFT shows us that the frequency is changing but in case of modulating frequency equal to 50 Hz, changes were too fast to be seen dynamically. That is why there is no peak, rather a constant line between two frequencies on Fig. 6. To better observe changes, modulation frequency was lowered to 1 Hz. Fig. 7 and 8 shows peak on two extreme frequencies – peak was moving between them as the frequency of modulated signal varied. For another visualization, modulating frequency was increased to 300 Hz and FM was shown on spectrogram ("waterfall"). This is shown on Fig. 9 where we can observe peaks and drops of signal frequency.