V. SPECTRAL MEASUREMENTS

THEORY: discrete Fourier transform and FFT – Fourier digital spectrum analyzers and their parameters (frequency resolution, frequency span, leakage effect), aliasing, spectrum of periodic signals (mainly of distorted and ideal harmonic signal, triangle wave and square wave), relation between spectrum and waveform, principles of spectral measurements, definitions and relations between harmonic distortion and spectrum of distorted harmonic signals (THD, THD+noise, SINAD), amplitude modulation (AM) and its parameters, principle and parameters of frequency (FM) and phase (PM) modulation, ASK, FSK, PSK.

TASKS:

1. Get familiar with FFT spectral analyzer in PC (application „FFT analyzátor" – icon on the desktop, images or displayed data can be exported to files by clicking the right mouse button and choosing "Export" ... the best way is to set the single measurement / pause mode) Using PC FFT spectral analyzer and also using the spectral analyzer function of DSO 1004 in parallel measure the magnitude spectrum of harmonic, square wave and triangle wave signal with amplitude approx. 1.5V. Take at least 3 measurements for different values of frequencies for example at 200Hz, 2kHz and 20kHz (the frequency of signal can be changed arbitrarily but the maximum is 25kHz). According to the frequency chosen set suitable sampling rate of the FFT analyzer and also the number of samples acquired (frequency resolution, frequency span). Measure the spectra using dB units as well as linear scale. Try to choose various display units – what is their definition and meaning? Try to calculate the conversion between units (for example between Vpp and dBVrms) and check your result using analyzer. Which display mode allows the best spectrum observation? Which device (FFT analyzer or DSO) is displaying the spectrum more precisely? Why?

Identify the harmonic and nonharmonic components in spectrum. Try to guess what the source of them is. For example the power line noise (50Hz) and so on…

Use these as the source of test signal:

a. Simple analog signal generator.

b. DDS generator Agilent 33220A.

Compare the spectrum of these signals with theory. (Compare the ratio of the basic harmonic component and other harmonic components, not the absolute value of components).

Try changing the window function and averaging of measurements. Check their influence.

2a. Set the sampling rate of FFT analyzer to 100kHz. Tune the Agilent 33220A generator in such a way that the frequency of output harmonic signal exceeds the half of the sampling rate, alternatively its multiples. Where is the corresponding component displayed in spectrum analyzer? Notice also the waveform of input signal displayed in the upper graph.

2b. Set the nonharmonic signal and identify the aliasing components (hint: set the sampling rate as a noninteger multiple of input signal frequency, e.g. set the sampling rate to 100kHz, number of samples to 10k and adjust the input frequency slightly about 1kHz.

3. Using FFT spectral analyzer measure the THD and THD + noise for both generators at frequency of 1kHz and amplitude approx. 0.5V and 5V. The values of THD a THD + noise can be read directly from the spectral analyzer but check the displayed value using calculation (take the first 7 harmonics into consideration)

4. Using Agilent 33220A create the amplitude modulated harmonic signal with carrier frequency of 10kHz and amplitude 1 to 2V. Use the internal harmonic signal as the modulation signal. Change the amplitude modulation depth in range of 0 to 100% (5 values minimum). Identify the components of spectrum and check the set depth using a calculation from displayed spectrum components. Display the waveform of modulated signal using DSO at the same time. What is the difference between AM and the superposition of RF and AF harmonic signals in time and spectrum?

5. Set the depth of amplitude modulation to a nonzero value and change the frequency of harmonic modulation signal. How is the spectrum of signal changed? Compare the results with theory.

6. Use a square wave as the modulating signal. This will simulate the transmission of two-level digital data (ASK modulation). Check the spectrum a compare with theory.

7. Using Agilent 33220A generator create the frequency modulated harmonic signal with 10kHz carrier and amplitude 1 to 2V. Use internal harmonic 300Hz signal as the modulation signal. Set the frequency deviation to 600Hz, 1200Hz and 2400kHz gradually. Compare the spectrum with the theory.

8. Using Agilent 33220A generator create the phase modulated harmonic signal with 10kHz carrier and amplitude 1V to 2V. Use internal harmonic 300Hz signal as the modulation signal. Set the phase deviation to 45°, 90° and 180° gradually. Compare the spectrum with the spectrum measured in task 7.

9. Repeat the task 7. for frequency deviation 2kHz and the task 8 for phase deviation 90° using a square wave modulating signal which is simulating a simple two-level digital data (FSK a PSK). Check the spectrum of both modulated signals and compare them with theory. Focus on their bandwidth.