Lab 7. Systems for measuring electroacoustic parameters of phonic devices

Equipment: laptop, Audio Precision APx525, audio amplifier, load

Purpose:
Getting to know about structure (from end user point of view), measurement methodology and typical parameters of audio amplifiers. Measurements of input parameters, nominal parameters and linear and nonlinear distortion.

Problems to prepare:
1. Audio amplifier classes.
2. Parameters and methodology of measurements of audio amplifiers (presented in the exercise)

Equipment:
1. For measurement: integrated consumer amplifier
2. Measurement system: Audio Precision APx525
3. For demonstration: different types of amplifiers

Program:

1. Define a type of tested device (consumer / professional, preamplifier / integrated / power amplifier) and functions of the device
2. Enabling / disabling the amplifier function important for measurements (gain, EQ etc)
3. Define signal path (**Signal Path Setup**) according to measuring setup
4. Input and output parameters:

To obtain following parameters you need: graph of the *output voltage versus the source e.m.f* and graph of the *THD versus the source e.m.f* (use **Stepped Level Sweep** function):

NOTE 1: source e.m.f. and input voltage of the amplifier is it the same?

NOTE 2: source e.m.f. expressed in dBu will be helpful (what is dBu?)

   a) Minimum source e.m.f. for rated distortion-limited output voltage
   b) Output voltage and power (distortion-limited)
   c) Maximum effective output power (distortion-limited at 10 %)

5. Frequency response (use **Stepped Frequency Sweep** function)

Measure for two positions of the **Source Direct** switch of the amplifier:

   a) Gain-frequency response
   b) Frequency range
   c) Deviation of frequency response in the 20 Hz – 20 kHz band

6. Amplitude non-linearity:
   a) total harmonic distortion and noise (**THD+N**) and total harmonic distortion (**THD**) under standard measuring conditions
   b) Modulation distortion of the nth order (where n=2 or n=3)

function ***IMD (SMPTE) / IMD Type***: ***MOD***, measure single-number value and Distortion Product Ratio (***MOD Distortion Product Ratio***)

   c) Difference-frequency distortion of the nth order

function ***IMD (SMPTE)*** **/ IMD Type**: ***DFD***, measure single-number value and distortion components (***DFD Distortion Product Ratio***).

7. Signal to noise ratio (use **Signal to Noise Ratio**)
8. Demonstration of various types of electroacoustic amplifiers.

Reference:

[1] APx500 User's Manual
[2] PN-EN IEC 60268-3:2018-10 Urządzenia systemów elektroakustycznych -- Część 3: Wzmacniacze (english version)

Most important sections: 3.2, 4.1, 10, 15.5, 15.6, 15.11, 15.12
Available at: D-21, pl. Grunwaldzki 11, entrance A, second floor, room 203,
To entrance to D-21: http://biblioteka.pwr.edu.pl/en/news/security-gates-in-a-building-d21-9.html

Measuring setup:

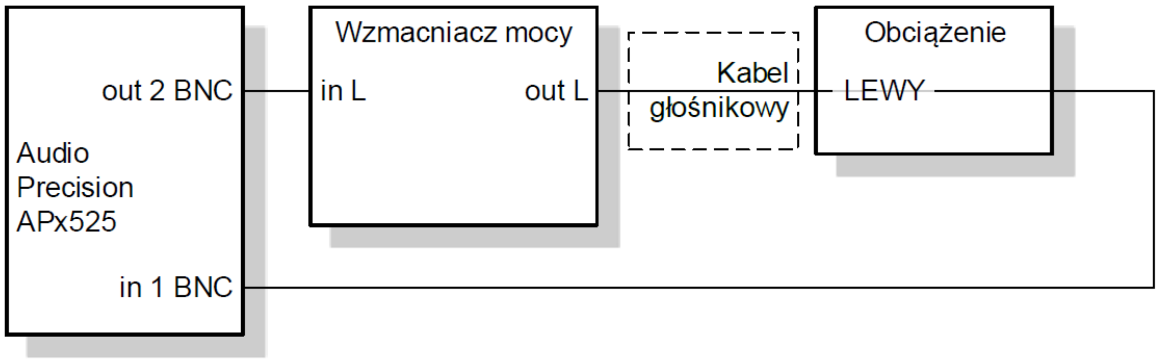

Fig. 1. Block diagram for audio amplifier measuring setup.

Selected definition:

Rated conditions – distortion-limited parameters f.ex. rated source e.m.f., rated output voltage or power. These parameters are measured for THD = 1%. Amplifier works under rated conditions when some of conditions are fulfilled (section 4.1.2.1)

Standard measuring conditions - These are obtained by bringing the amplifier under rated conditions (see 4.1.2) and then reducing the source e.m.f. to a level of – 10 dB referred to the rated source e.m.f.

Source e.m.f. - electromotive force of the source (output voltage of a generator, f.ex. Audio Precision)

Minimum source e.m.f. for rated distortion-limited output voltage – it is the output voltage of the generator when the output signal of the amplifier is distorted (THD = 1%)

Output voltage/power – output voltage/power of the amplifier

Power should be calculated: $P_2=U_2^2/R_2$

Maximum effective output power (distortion-limited at 10 %) – Output power of the amplifier when THD = 10%

Gain-frequency response - Variation, as a function of frequency, of the e.m.f. gain (ratio of the output voltage to the source e.m.f.), expressed in decibels, relative to its value at a specified reference frequency (normally the standard reference frequency is 1 kHz).

Frequency range – range from lower frequency to upper frequency; lower and upper frequency is cutoff frequencies when a signal is attenuated by 3 dB

Deviation of frequency response in the 20 Hz – 20 kHz band – describe maximum differences compared to the level for 1 kHz (expressed as f.ex. +0,3 dB , -1,2 dB)

Amplitude non-linearity:

Total harmonic distortion – a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency

Total harmonic distortion + noise – This measurement is much more common and more comparable between devices. It is usually measured by inputting a sine wave, notch filtering the output, and comparing the ratio between the output signal with and without the sine wave

Modulation distortion of the nth order (where n=2 or n=3) – The following characteristics should be specified:

a) Modulation distortion of the second order:
When f1 and f2 are the frequencies of two sinusoidal input signal of specified amplitude ratio, the second-order modulation distortion is given by the ration of the arithmetic sum of the output voltages at frequencies f2+f1 and f2-f1 to the output voltage at frequency f2.

b) Modulation distortion of the third order:
When f1 and f2 are the frequencies of two sinusoidal input signal of specified amplitude ratio, the third-order modulation distortion is given by the ration of the arithmetic sum of the output voltages at frequencies f2+2f1 and f2-2f1 to the output voltage at frequency f2.

It is desirable to choose f1 to be between 0,5 octave and 1,5 octaves above the lower limit of the effective frequency range and f2 to be between 0,5 octave to 1,5 octave below the upper limit of that range.

The source e.m.f. at the frequency f1 is adjusted to produce an output voltage $U_{2,f1}$ of 12 dB below the rated output voltage and the source e.m.f. at f2 for an amplitude ratio of 4:1, to produce an output voltage $U_{2,f2}$ 24 dB below the rated output voltage

Difference-frequency distortion of the nth order – The following characteristics should be specified:

a) Difference frequency distortion of the second order:
When f1 and f2 are the frequencies of two equal amplitude sinusoidal signals, separated by a specified frequency difference, the difference-frequency distortion of the second order is given by the ratio of the output voltage $U_{2,f2-f1}'$ at frequency f2-f1 to the reference voltage $U_{2,ref}$, which is equal to twice the output voltage $U_{2,f2}$
b) Difference frequency distortion of the third order:
With signals as under item a), the difference-frequency distortion of the third-order is given by the ratio of the arithmetic sum of the output voltages at frequencies $2f_2-f_1$ and $2f_1-f_2$ to the reference voltage $U_{2,ref}$ which is equal to twice the output voltage $U_{2,f2}$.

The source frequencies f1 and f2 are adjusted to have a frequency difference of 80 Hz, unless there is a good reason to choose otherwise.

Each source is connected in turn by means of the switch and the source e.m.f.s of each source adjusted to produce an output voltage $U_{2,f1}$ or $U_{2,f2}$ respectively of 16 dB below the rated output voltage.

Signal to noise ratio – The ratio, expressed in decibels, of the rated output voltage (sinusoidal signal for reference frequency – typically 1 kHz) to the wide-band, or a weighted sum of the output voltages or the octave/third-octave band output voltages produced by the different noise components. Noise should be weighted with A weighting curve (for analog input).