Automatic System for Measuring the Gain Frequency Response. Prototype Realization

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Abstract – **The study of Gain Frequency Response (GFR) in low frequency range of 20 kHz sets higher requirements for the development of practical measuring. After a period of development, the AudioPrecison [1] company developed many professional devices [2] for the study of the Gain Frequency Response of Low Frequency Amplifiers (LFA). Many of these devices continue to be improved using multi-methods research. And multi-method allows visualization of the output characteristic in symmetric, thus it assesses the distortion in the signal. The prototype created is an example of the technical solution of this type of system which uses a specialized generator MAX038.**

Keywords – **measurement, gain frequency response, prototipe.**

I. TASK OF THE ARTICLE

A. Base structure of the new measurement system

General structural diagram of the proposed measurer is shown in Fig.1. Unlike its conceptual design this structure does not use the phase compensation. General scheme of the system is shown in Fig.2.

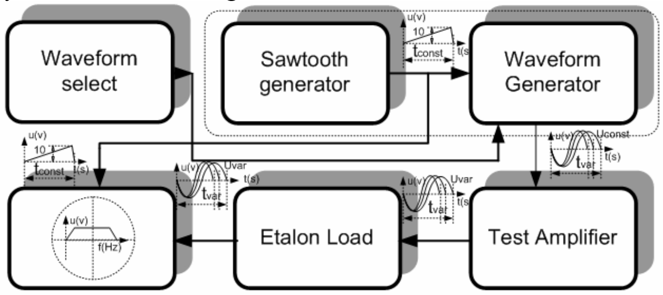

Fig.1. General structure diagram of the proposed measurer of GFR

B. Dimensioning the chain in order to determine the frequency [3]

To calculate, we choose the linear range of variation of control current Iin (from 10µA to 400µA). The range of the control current defines the output frequency and we need to define minimal resistor (maximum control current). We use the middle of the range and define the start position in current Iinmax=200µA. Then we calculate the minimal value of the restrictive resistance:

$$R_{MIN} = \frac{U_{ET}}{I_{in_{\max}}} = \frac{2,5}{200.10^{-6}} = 12,5.10^3\,\Omega \qquad (1)$$

Similarly, for the selected value of the minimum I_{inmin}=10µA, we define the maximum restrictive resistance:

$$R_{MAX} = \frac{U_{ET}}{I_{in_{\min}}} = \frac{2,5}{10.10^{-6}} = 250.10^3\,\Omega \qquad (2)$$

From the resistance calculated in this way, the values divide into two parts: a constant resistance value with a standard 12kΩ determining the maximum current in the chain ($I_{in_{\max}} = 208\mu A$), and adjustable resistance (potentiometer) with default value 220kΩ. Then the minimum current in the chain is determined by the expression:

$$I_{in_{\min}} = \frac{U_{ET}}{R+RP} = \frac{2,5}{12.10^3 + 200.10^3} = 11,8.10^{-6}\,A \qquad (3)$$

where: $R_{in} = R + RP$

Under the certain restrictive values for resistance and having in mind the minimum frequency (F0=0,2Hz), the maximum value of the reference capacitor is determined by the equation:

$$C_{F\max} = \frac{U_{in}}{R_{in}F_0} = \frac{2,5}{212.10^3.0,2} = 60.10^{-6}\,F \qquad (4)$$

Choose the standard unit C_{Fmax}=100 µF

Next we determine the frequency ranges of the frequency and choose the standard values of the participating units. After calculation of all the values and selection of the electronic components, the frequency range is divided into the following ranges - Table.I.

TABLE.I.
FREQUENCY RANGE

C_F , F	$F_{0\min} Hz$	$F_{0\max}$ Hz	Freq. range
100µ	0,11	2.08	0,1-2Hz
10µ	1,13	20,83	1-20 Hz
1µ	11,36	208,33	10-200 Hz
100n	113,63	2083,33	100-2000Hz
10n	1135,33	20833,33	1000-20kHz
1n	11363,33	208333,33	10kHz-200kHz
0,1n	113,63.103	2,08.106	100kHz – 2MHz
12p	947,17.103	17,36.106	1MHz – 10MHz

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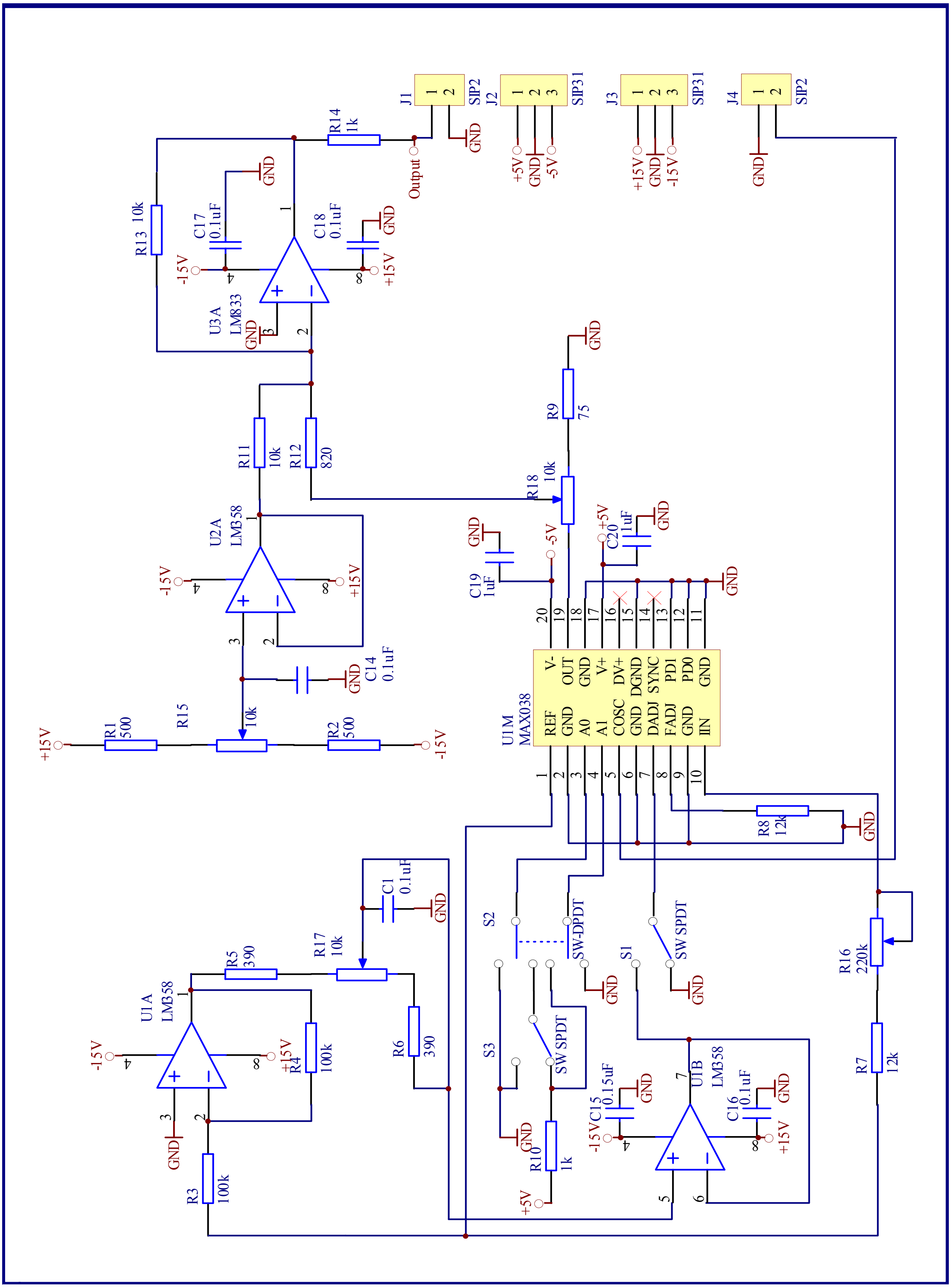


Fig.2. Scheme of the prototype

After designing the management chain and the necessary frequency range, the received values are put into the principal scheme shown in Fig.2. The developed model for measuring of GFR maintains stable amplitude in the waveform generator [4]. When we change frequency, the output linearity is maintained below 0.4%. According to the attached manufacturer's data the maximum non-linearity should be 0.5% [3].

MAX038 integrated circuit is suitable for realization of the generator voltage with different shaped signals. The application of this type of measurement is as generators for laboratory purposes and for diagnosis of other electronic devices [2]. In case the device output signal amplitude is higher than the maximum for the outcome of the MAX038, an additional amplifier requires to be used [5], [6].

C. Dimensioning of the chain of the output amplifier

The output signals of the MAX038 are Level 2 $V_{p\text{-}p}$. This requires the use of a voltage amplifier to achieve output amplitude of 6V. In order to development a sawtooth generator, output amplitude is required to 10V. This requires the use of precise output amplifier whose use has proved to be uneconomic. To solve this problem a precision amplifier with a narrow bandwidth is used. This causes significant non-linearity in output amplitude with frequency of $f = 0 \div 10\ MHz$. A bipolar transistors scheme or scheme with operational amplifier can be used as a voltage amplifier.

Using a scheme with bipolar transistors is associated with a number of difficulties, since to obtain the quality of the voltage amplifier, transistors must operate in a scheme Common Emitter or Common Base one. The input resistance of these systems is relatively low. The use of operational amplifiers is more convenient, since the modern operational amplifier (OA) has a relatively high transmission rate, a rate of gain without feedback (> 100 dB), higher rate of increase of output voltage, very high input and low output impedance. In practice it can be assumed that the OA is managed only by voltage, as input current is very small.

Initial requirements for the selection of an operational amplifier:

- Low Voltage Noise: $U_n < 10$ nV/Hz;
- Gain Bandwidth – $f_t > 10$ MHz;
- High slew rate: S > 5 V/µS;
- Low offset voltage: $U_{off} < 0.5$ mV;
- Low THD < 0,005 %;
- Supply voltage : $U_{cc} > 6$ V;

For the output amplifier corresponding to the criteria we choose LM833 set by selecting parameters [7]:

- Low Voltage Noise: $U_n < 4{,}5$ nV/Hz;
- Gain Bandwidth – $f_t > 15$ MHz;
- High slew rate: S = 7 V/µS;
- Low offset voltage: $U_{off} = 0.3$ mV;
- Low THD = 0,002 %;
- Supply voltage : $U_{cc} = 7 - 18$ V;

Using structure schematic of this noninverting amplifier is show in fig.3.

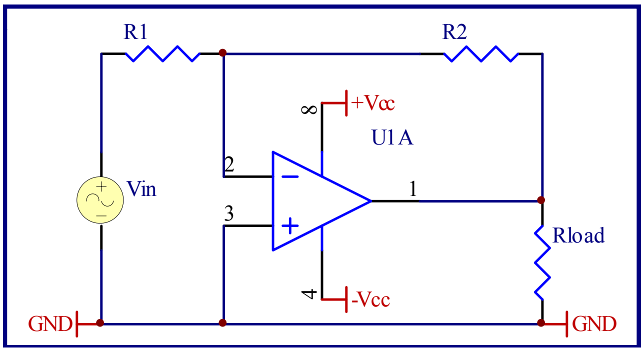
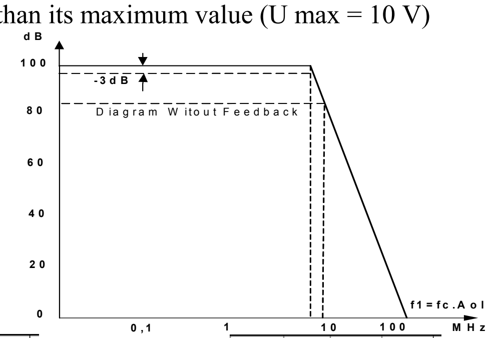


Fig.3. Base schematic of the noninverting amplifier

Graphical determination of the working frequency range is shown in fig.4. The reported values indicate the maximum working frequency of the amplifier. This means that during a research in the area over 7 MHz frequencies, inhibition of output signal will be monitored. To overcome these shortcomings we choose amplifier output voltage to be twice smaller than its maximum value (U max = 10 V)



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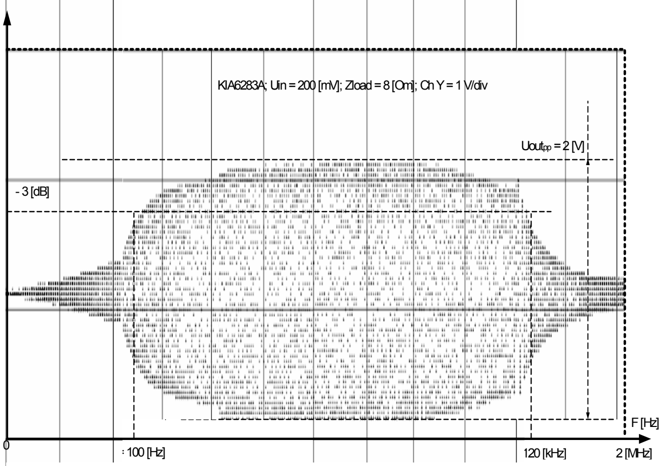

Fig.5. KIA6283A, parameters $U_{in} = 200\ mV$ $Z_{Load} = 8\ \Omega$

L l measurement of Response

A actical developme ctical r he audio amplifie ed out. The p his study is to sho ut characteristics at different input levels. The results of the survey are shown in fig.5. and fig.6.

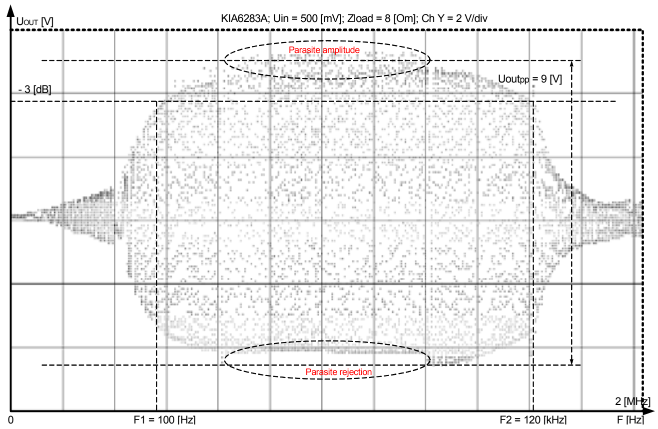

Fig.6. KIA6283A, parameters $U_{in} = 500\ mV$ $Z_{Load} = 8\ \Omega$

On fig.5.is indicated the result of the research in LFA KIA6283A [8] at a parameter $U_{in} = 200\ mV$ and $Z_{Load} = 8\ \Omega$; measurement the LFA KIA6283A [8] with parameters $U_{in} = 500\ mV$ is shown in fig.6. The research of KIA6283 shows significant non-linearity in GFR at the entry level change to $U_{in} = 500\ mV$. In this case frequency parasitic signal is seen during the half positive period. During the negative half period we see the parasitic rejection. The continuity of the rejected signal is the same as the one of the parasitic amplitude.

II. Conclusion

From the results obtained we can be define the following main conclusions:

- The developed model for measuring of GFR maintains stable amplitude in the waveform generator. When we change frequency, the output linearity is maintained below 0.4%. According to the attached manufacturer's data the maximum non-linearity should be 0.5%;
- The research of KIA6283A shows significant non-linearity in GFR at the entry level change to $U_{in} = 500\ mV$. In this case frequency parasitic
- signal is seen during the half positive period. During
- the negative half period we see the parasitic rejection.
- The continuity of the rejected signal is the same as the one of the parasitic amplitude;
- In the study of a synthesized output stage, a high linearity of the output characteristic at low input levels $U_{in} = 200\ mV$ is seen. Another characteristic is the receipt of peaks and a significant frequency in frequency rejection areas. These shortcomings appear from unevenness in the output characteristic of the load;
- When raising the entry level $U_{in} = 500\ mV$, higher amplitudes are observed and rejection of frequency area in different locations of amplitude characteristics. These shortcomings appear from unevenness in the output characteristic of the load;
- To achieve maximum linearity and quality of the output amplitude characteristic is necessary to study simultaneously both sinus waves of the baseline voltage. Thus, synchronized reporting parameters are observed.

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