AMPLITUDE STABILISATION OF STIMULATION SIGNAL FOR MICROWIRE SENSOR

Miroslav ŠMELKO*, Pavol KUPČÍK, Pavol LIPOVSKÝ, Katarína DRAGANOVÁ
Technical University of Košice, Faculty of Aeronautics, Rampová 7, 041 21 Košice, Slovakia
**Corresponding author.* E-mail: miroslav.smelko@tuke.sk

Summary. Circuits of automatic volume control (AVC) are widely spread and often used in electrotechnical practice. Its usage brings more advantages like increasing of stability of circuits, for example. The instability is mostly caused by change of temperature of components in the measurement circuit. The use of the AVC ensures repeatability of the measurement in long term point of view. The selected implementation of the AVC circuit into the existing device is discussed in the article. The customized device is the source of stimulation current signal which can be used for generating of precise magnetic fields. Parts of the AVC circuit are described together with their implementation to the customized device. Fundamental/Initial measurements of AVC static characteristics were realized on the customized device prototype.

Keywords: AVC, sensor, stability, excitation, microwire

1. INTRODUCTION

Magnetic microwires in the role of sensing elements react to several physical quantities. The reaction can be sensed in a contact way or more rarely in a contactless way of sensing. They are stimulated by external magnetic field during the contactless sensing procedure. This excitation field can be generated by a current source and a suitable excitation coil. While the magnetic field is the function of current, the accuracy of the whole measurement device is proportional to the accuracy of the excitation current. The measurement device was supplemented with the AVC circuit to ensure long term stability of the excitation current amplitude.

The role of the AVC circuit is to keep the amplitude of the output signal stable [1]-[4] while the input signal amplitude or the output resistance can change. These changes occur mainly due to the change of ambient temperature [5] or frequently by joule heating caused by the device operation.

The AVC circuit itself is a closed loop feedback circuit which uses the signal peak or mean value to the control the gain of the circuit. The AVC circuit is inserted to the signal path in the customized device. Stability of the AVC output signal in wide input signal range improves the stability of the subsequent circuits of the device.

First time the AVC circuit were used to supress the changes of the received signal amplitude in radio receivers. Nowadays they are used in circuits where wide changes of the input signal amplitude are expected and where the wide change of the output signal could lead to the malfunction of circuit or loss of information [1].

The block diagram of a typical AVC circuit is presented in Figure 1. The feedback loop consists of the amplifier part, the detector, the low-frequency filter and the differential amplifier.

ISSN 1339-9853 (online), acta-avionica.tuke.sk ISSN 1335-9479 (print)

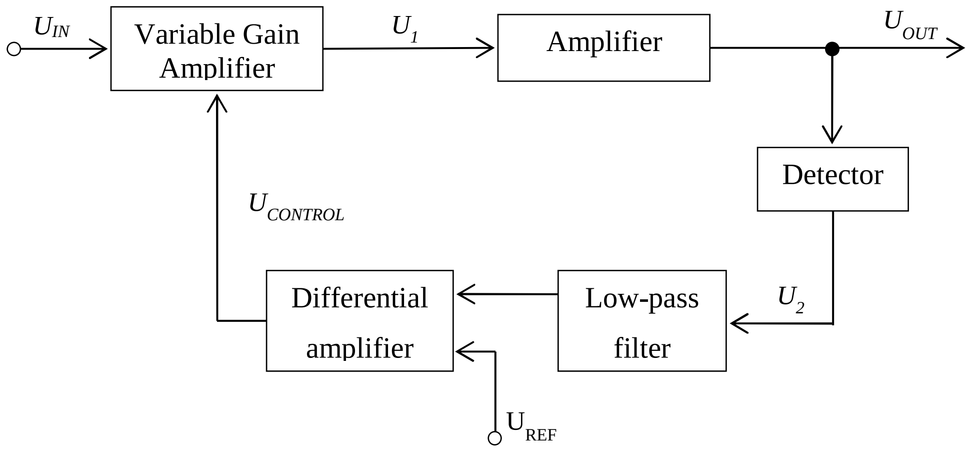

Figure 1 Block diagram of AVC circuit

The input signal U_{IN} is amplified by the amplifier with variable gain. The gain of this unit is controlled by the $U_{CONTROL}$ signal. The signal U_1 from this block is amplified again to ensure the necessary level of the output signal U_{OUT}. The role of the detector is to create the control parameter used for the gain control. This can be the signal amplitude, effective value, power of signal and so on in dependence of the circuit role [4]. The low-pass filter has to filter the carrier frequency to achieve the reaction of the AVC circuit to slow changes of the input signal amplitude only. If the low-pass filter is not present the AVC circuit output oscillates. The signal from the low-pass filter is compared in the differential amplifier with the reference signal U_{REF}. The amplitude of the output signal is selected by the reference signal value. The difference between the detector signal and the reference signal is amplified and represents the control signal for the variable gain amplifier $U_{CONTROL}$ [1], [2].

2 CIRCUIT DESCRIPTION

The customized device is the current source and the AVC circuit is controlled by the image of this current. Conversion of the current into the voltage is realized by the power resistor connected to the output circuit. The resistor voltage drop represents the current flowing through this resistor. Image of the current is amplified by the *IC2A* amplifier (Figure 2). The gain of this block has the influence on the maximal amplitude of the output current signal.

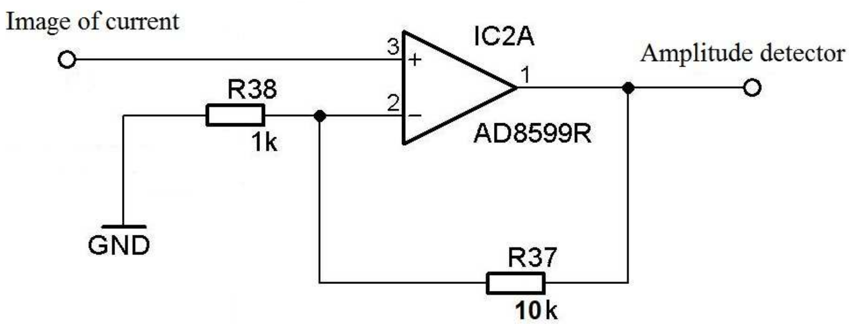

Figure 2 Amplifier stage of the detector

The amplified signal proceeds to the amplitude detector, Figure 3. This block is created by the diode *D7*, capacitor *C66* and resistor *R39*. The diode rectifies the signal and charges the capacitor *C66* to the level equal to the input signal amplitude. The capacitor *C66* and the resistor *R39* create the low-pass filter. To avoid the instability of the subsequent circuits and prevent so called gain pumping the lowest corner frequency is preferred. While the input signal has the 500 Hz frequency the circuit with the largest time constant should be used. The large time constant will increase the reaction time of the circuit to the change of the signal. The resistor *R39* discharges the capacitor during the decrease of the input signal or after turning off of the circuit.

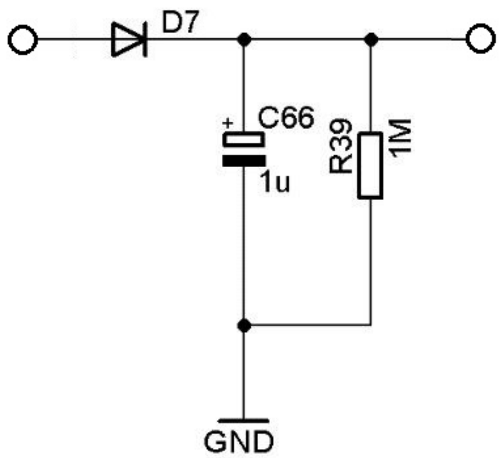

Figure 3 Amplitude detector

Voltage from the amplitude detector proceeds to the differential amplifier *IC5*, Figure 4. The difference between the voltage from the detector and the reference voltage is amplified. The reference voltage is made from the stable current source REF200 by passing the trim *R3*. The required output current can be set by the trim. The maximum output current depends on the power stage supply voltage and the load impedance.

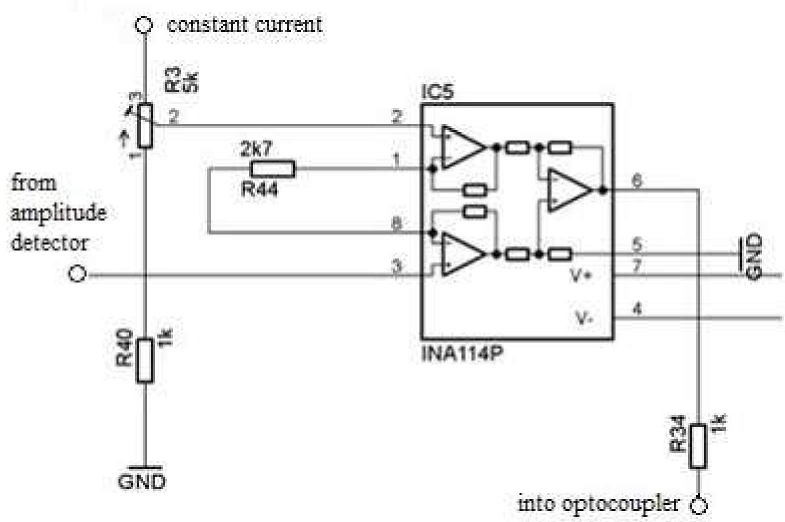

Figure 4 Differencial amplifier

The output of the differential amplifier continues through the resistor *R34* into the optocoupler created from the LED (Light Emitting Diode), photoresistor and mututal case produced on a 3D printer (Figure 5). This casing provides the shading of ambient light. The resistance change is proportional to the light intensity of the LED. The diode so affects the rate change between the photoresistor *PH1* and the resistor *R10*. This change results into the modification of the inverting amplifier gain and corrects the amplitude of the transmitted signal to the required level.

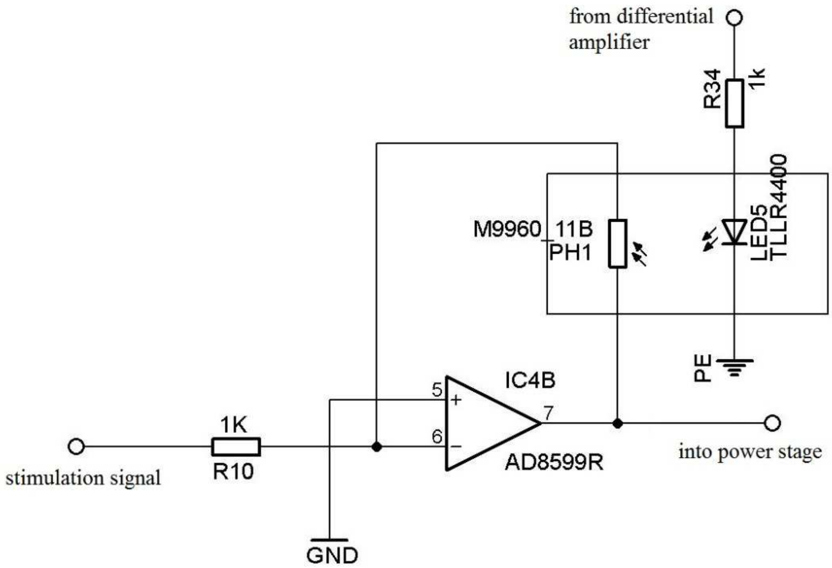

Figure 5 Inverting amplifier gain control by optocoupler controlled by AVC circuit

3 STATIC LOAD CHARACTERISTICS MEASUREMENT

The stimulation current signal source was supplement by the AVC circuit and the characteristics of this source were measured. The measurement of the static load characteristics was performed according to the schematic presented on the Figure 6. The digital multimeter Agilent 34410A was connected to the output of the current source together with the resistor decade Chauvin-Arnourx BR07. Measurements were performed at three operating points 75 mA, 95 mA and 120 mA. The supply voltage of the power stage was ± 27 V. This voltage limits the maximal output current to 120 mA without the significant degradation of the source dynamic parameters. The typical output current of the source is 95 mA during the measurements in practical application. 75 mA is the bottom construction limit of the device caused by the feedback gain set. The device was designed as a power current source and the setting of the operating point corresponds with this goal.

For each operating point the load resistance value was changed in the range from 10 Ω to 110 Ω and vice versa. The values smaller than 10 Ω are close to the short circuit and there is no reason for the AVC circuit to be used in such case. Values higher than 110 Ω require higher supply voltage for the power stage of the device or complicated solution with a voltage booster does not have sufficient current load capability.

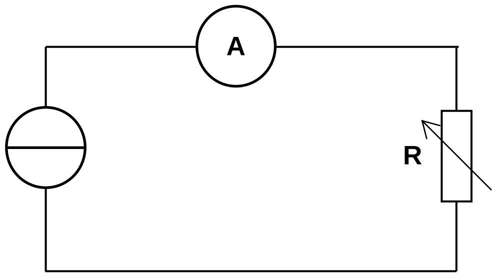

Figure 6 Schematics of static load characteristics measurement

The measured current values for each operating point are noted in tables 1, 2 and 3. The percentage error is illustrated in the Figure 7. For the 75 mA operating point the mean current value in the whole measured range was 75.032 mA. The standard deviation of the current vas σ = 0.13 mA and the maximal error was 0.05 mA thus 0.07 %. For the operating point 95 mA the mean current was 95.043 mA with the standard deviation σ = 0.066 mA. The maximal error was 0.14 mA for this operating point, thus 0.15 %. At the 120 mA operating point the mean value of the current was 119.694 mA with the standard deviation σ = 0.235 mA. The maximal error was 0.68 mA thus 0.57 %.

Tab. 1 Static characteristics measurement at 75 mA

R (Ω)	110	100	90	80	70	60	50	40	30	20	10
I (mA)	75.01	75	75	75	75.05	75.04	75.04	75.04	75.03	75.03	75.02
R (Ω)	10	20	30	40	50	60	70	80	90	100	110
I (mA)	75.02	75.03	75.03	75.03	75.05	75.05	75.05	75.05	75.05	75.05	75.04

Tab. 2 Static characteristics measurement at 95 mA

R (Ω)	110	100	90	80	70	60	50	40	30	20	10
I (mA)	95	95.02	95	94.98	95.14	95.13	95.09	95.06	95.02	94.9	94.9
R (Ω)	10	20	30	40	50	60	70	80	90	100	110
I (mA)	94.9	95	95.01	95.04	95.08	95.13	95.14	95.07	95.05	95.07	95.08

Tab. 3 Static characteristics measurement at 120 mA

R (Ω)	110	100	90	80	70	60	50	40	30	20	10
I (mA)	120	120	119.95	119.91	119.8	119.72	119.63	119.56	119.46	119.4	119.32
R (Ω)	10	20	30	40	50	60	70	80	90	100	110
I (mA)	119.32	119.38	119.46	119.53	119.61	119.68	119.76	119.84	119.93	120.01	120

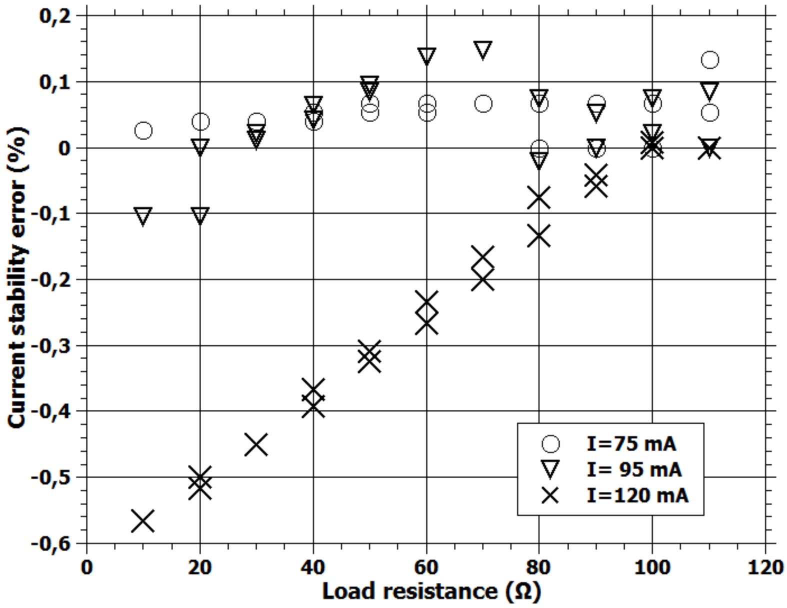

Figure 7 Dependence of current stability error on output load resistance for all three operation points

CONCLUSION

The stimulation signals stability is the key requirement for the correct operation of the circuit with an external excitation. The use of the AVC circuit causes increase in the stimulation current signal stability in the wide range of the output resistances. The current stimulation source was loaded by ohmic load in the range from 10 Ω to 110 Ω. Each measurement was performed at three operating points 75 mA, 95 mA and 120 mA. The maximal regulation error of the output current was 0.57 % which corresponds to 0.68 mA at the operating point 120 mA. At the typical operating point 95 mA the circuit operates with the error between –0.1 % and +0.15 % from the required value.

The operating point current error was in the order of ones of percents before the AVC circuit was implemented. Adding of the AVC circuit increases the output current stability by approximately ten times. The described circuit offers sufficient stability of the output stimulation current and it is possible to use it for the excitation of the measurement circuits.

The advantage of the AVC circuit is also in shorting of the necessary time for the stabilisation of the measurement parameters with respect to the working temperature. Without the AVC circuit the device has to be turned on at least one hour before the measurement. Precise measurements cannot be performed without warming up of measurement device [6], [7]. While the AVC circuit successfully compensates changes of the input parameters, its usage will have positive effect on the temperature stability of the whole measurement device. There is not necessary to wait a long time after the device is turned on and the measurements can be now performed after one minute with the high degree of repeatability.

Acknowledgement

This work has been supported by the grant agencies of the Slovak Republic grants VEGA 1/0201/16, VEGA 1/3074/17 and APVV0266-10.

References

[1] ROSU, Iulian: Automatic Gain Control (AGC) in Receivers [online]. [s.a.]. [cit 2017-05-01]. Dostupné na internete: http://www.qsl.net/va3iul/Files/Automatic_Gain_Control.pdf.

[2] LANGFORD-SMITH, Fritz: Radiotron Designer's Handbook. Sydney: Wireless Press, 1953. 1523 s. Štvrté vydanie. ISBN 978-0750636353

[3] Griffit B. - Tom J. Audio automatic volume control circuit. In: *Solid-State Circuits Conference*. Digest of Technical Papers. 1956 IEEE International

[4] Kang G. - Lidd M. Automatic gain control. In: *Acoustics, Speech, and Signal Processing, IEEE International Conference on ICASSP '84.*

[5] Draganová K. - Kmec F. - Laššák M. Temperature dependence measurements of low-cost sensors. In: *New Trends in Signal Processing 2012: proceedings of the International Scientific Conference NTSP 2012*: 16. - 18.5.2012, Tatranske Zruby. - Liptovsky Mikulas: Armed Forces Academy of Gen. M. R. Stefanik, 2012 S. 48-52. - ISBN 978-80-8040-447-5

[6] Lipovský p. - Čverha A. - Hudák J. - Blažek J. - Praslička D. Noise characteristics of microwire magnetometer. In: *Acta Physica Polonica A*. Vol. 126, no. 1 (2014), p. 384-385. - ISSN 1898-794X

[7] Hudák J. et al. Fluxgate sensors based on magnetic microwires for weak magnetic fields measurement . In: *Journal of Electrical Engineering: Magnetic Measurement 2015. - Bratislava: STU*, 2015 Roč. 66, č. 7s (2015), s. 153-156. - ISSN 1335-3632