# Galvanomagnetic Regulator of Induction Motor Rotation Frequency

Anatolii T. Aleksandrov[1], Nikola D. Draganov[2]

*Abstract* – **Galvanomagnetic ICs exhibit stable conversion characteristics, high sensitivity and have small dimensions and a low price. On the basis of their advantages, a regulator of induction motor rotation frequency with a galvanomagnetic analogue-to-digital converter has been developed, built around specialized ICs LM2917 and MLX1881. The system provides for both rotation frequency regulation and process monitoring. The paper presents the synthesized flow chart and schematic diagram of the regulator. It studies its operation algorithm and manifests its conversion characteristics.**

*Keywords* - **galvanomagnetic sensors, magneto-sensitive integrated circuits, control, regulator, digital-to-analogue converter**

## I. INTRODUCTION

Modern electronic and automatic systems in the area of electronics, chemistry, medicine, food industry normally have an induction motor as its major component and its rotation frequency needs to be regulated. This stems from the necessity for providing the optimal speed for the manufacturing processes.

There are various methods and devices available for rotation frequency regulation. They are differentiated by several basic criteria, the most important of them being the type of the process control system – open (without feedback) or closed-loop (with a feedback). The devices available for rotation frequency regulation also differ in the elements providing the feedback – direct (when the rotation frequency is monitored) and indirect (when the current in the stator winding is monitored), as well as in the way of regulation [1, 3, 4].

Over the last few years the development of microelectronics has brought about the introduction of galvanomagnetic sensors in many areas of electronics, automatics, electric drives. Magneto-sensitive integrated circuits (MSICs) have been developed, based on a Hall sensor, which are characterized by low price, high sensitivity and linear conversion characteristics [3, 5, 6, 7, 8].

The aim of the work presented in the paper is the synthesis and study of a galvanomagnetic device, allowing the regulation of induction motor rotation frequency.

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## II. PRESENTATION

A regulator of induction motor rotation frequency has been synthesized, built around a galvanomagnetic analogue-to-digital converter based on specialized ICs LM2917 and MLX1881. The flow chart of the device is presented in Fig. 1. It consists of a galvanomagnetic digital-to-analogue converter (GMDAC), a control unit (CU), a supply unit (power supply) and an induction motor (IM).

The GMDAC has been synthesized on the basis of a magnetosensitive integrated circuit MLX1881 manufactured by Melexis and an integrated frequency-to-voltage converter LM2917 manufactured by National Semiconductor [2]. This unit makes it possible to monitor and convert the rotation frequency of the induction motor rotor, proportional to the change in output voltage. The GMDAC entirely replaces the devices that have been used so far for monitoring of rotor rotation frequency, including tachogenerators, rotary incremental encoders, etc.

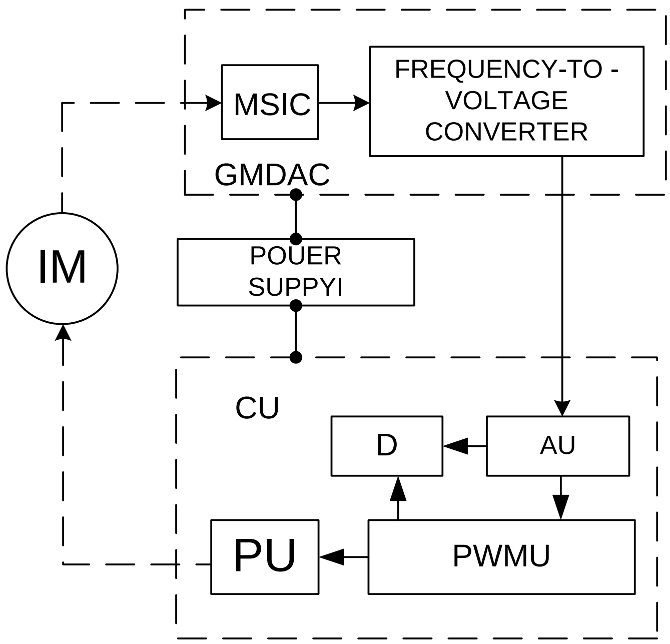



Fig. 1. Flow chart of a galvanomagnetic regulator of induction motor rotation frequency

The rotation frequency monitoring in the GMDAC is performed by a magneto-sensitive IC, which is mounted in the IM stator. This IC has been developed using MOS technology and is able to sense magnetic fields with minimum intensity $B_{min}=5mT$. This allows it to be built in electric motors having different powers. As a result of the rotor rotation, the MSIC generates a pulse series with frequency proportional to the rotor rotation frequency. Using the frequency-to-voltage converter, the pulse series from the MSIC is converted into proportionally varying voltage. The stable and linear conversion characteristics of MSIC MLX1881 and of the integrated converter LM2917 make it possible to precisely monitor and convert the induction motor rotation frequency.

The parameters characterizing the GMDAC, obtained after the latter has been studied [2], are as follows: maximum reading frequency $f_{max}$=850*Hz* , maximum output voltage at frequency *f*=850*Hz* and supply voltage $U_{DD}$=12*V* – $U_{DD}$=12*V*, current consumption at *f*=850*Hz* and $U_{DD}$=12*V* – $I_{DD}$=0,5*A*

The control unit consists of an assigning unit (AU), display (D), pulse-width modulation unit (PWMU) and power unit (PU).

The control unit establishes the way the system is controlled. Depending on that, the type of circuit solutions of the AU and PU is determined. In this case control through pulse-width modulation of the control signal is established, which ensures smooth characteristics and easy implementation.

The schematic diagram of the galvanomagnetic regulator of induction motor rotation frequency is presented in Fig. 4, and its operation principle is illustrated by means of the time charts in Fig. 2.

When the device is switched on, the electric motor starts to unwind up to a certain predefined speed. As a result of unwinding the IM rotor, the MSIC (IC 1) starts generating the pulse series ($U_{P1}=\varphi(t)$, (Fig. 2a), whose frequency is proportional to the rotor rotation frequency. The generated pulse series starts at the input of the integrated frequency-to-voltage converter (IC 2), which converts it to a voltage level. By means of the potentiometer-type voltage divider (R4, R5) and the trimmer potentiometer PR3, the voltage level is entered at the non-inverting input of the comparator IC 3.1. An assigning voltage level from the potentiometer-type voltage divider (R7, R8) and potentiometer PR6 is entered at the other input of the same comparator.

When the signal from the GMDAC ($U_{P2}$, Fig. 3b) becomes greater than the assigned one ($U_{P3}$, Fig. 3b), a high level ($U_{P4}$, Fig. 3c) is established at the comparator output IC 3.1. This high level is entered at the non-inverting input of the comparator IC 3.2. A signal ($U_{P5}$) from the saw-tooth voltage generator is entered at the other input of the same comparator, the generator consisting of an integrated circuit IC 3.3, resistors R9, R19, R11 and capacitor C2. The amplitude of the linearly varying voltage is 5*V*, and its frequency is 50 *Hz*.

As a result of the dynamic comparison of the levels – the assigned one and the one measured, a pulse series ($U_{P6}=\varphi(t)$) is obtained at the comparator output IC 3.2 (point p6, Fig. 4), with a variable mark-to-space ratio depending on the current value of the signal from the GMDAC, whose magnitude is proportional to the rotation frequency of the IM shaft.

The width-modulated signal controls a triac optocoupler IC4, which has a built-in null detector. Thanks to this feature, the optocoupler not only performs a galvanic sweep of the circuit, but also allows commutation of the switching element only when the supply mains voltage passes through zero.

The induction motor IM is connected in the power circuit of the triac switch S1. Its smooth control depends entirely on the frequency of the saw-tooth generator voltage.

Thus, whenever the motor rotation frequency decreases, mark-to-space ratio of the control pulses ($U_{P6}$, Fig. 2d) will increase, and consequently, the IM rotation frequency will increase to the level defined by the assigned voltage ($U_{P3}$, Fig. 2b).

The proposed device for regulation of IM rotation frequency makes it possible to measure and assign the rotation frequency. The display unit is built around a specialized integrated circuit ICL7107. It allows the control of a 3.5-digit LED display VD1. Depending on the position of switch K1, the measurement unit is positioned either in measurement mode (position 1) or in assignment mode (position 2) of the IM shaft rotation frequency. In assignment mode the signal is taken from the sliding switch of the assigning potentiometer PR6, while in measurement mode it is taken from the sliding switch of the trimmer potentiometer PR3. The modes can also be switched automatically with a minimum rotation of the potentiometer axis PR6.

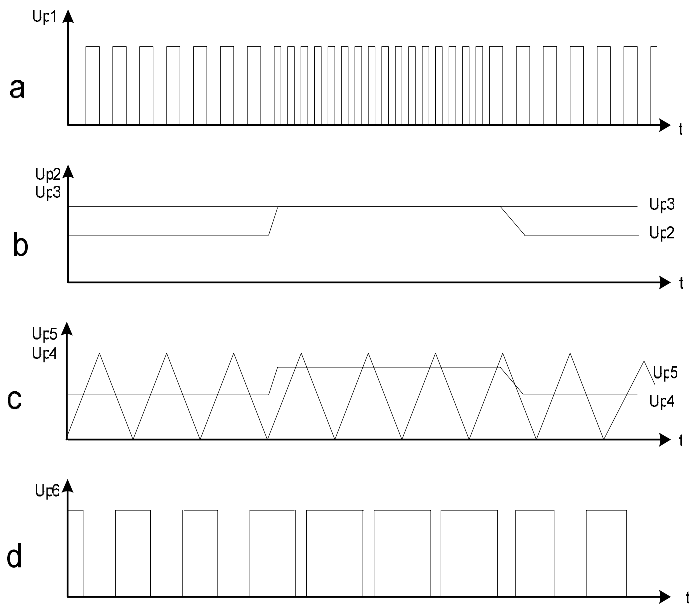



Fig. 2. Time charts illustrating the operation of the galvanomagnetic regulator of induction motor rotation frequency.

In order to prove the efficiency of the proposed galvanomagnetic regulator, experimental tests have been conducted with an IM, type BA 9/2, ~220V/50Hz (manufactured by “Al. Atanasov” Company, Etropole).

The following results have been obtained:

1. The galvanomagnetic device proposed allows: precise regulation of the induction motor rotation frequency within the range from 694 $min^{-1}$ to 1838 $min^{-1}$ with accuracy ±5% with only one magnetosensitive IC; smooth regulation by means of pulse-width modulation; monitoring of the controlled and assigned parameter (rotation frequency).

2. The functional characteristics of the proposed regulator depend mainly on the action of the GMDAC, whose conversion characteristics in optimum operation (*R2*=100*k*Ω,

*C1*=1*μF* **[2]**) mode are presented in Fig. 3. Their analysis shows:

-The dependence $U_{P2}$=φ(f) (Fig. 3a), characterizing the change in voltage at the GMDAC output ($U_{P2}$) upon the frequency (*f* ) of the input voltage is linear up to 850 *Hz*, the output voltage varying 0*V* up to 10.2 *V*. Above 850 *Hz* the change in the rotation frequency of the IM shaft does not affect the magnitude of the output voltage and it remains equal to 10*V*. The transconductance in the operation interval is S = 85 *Hz/V*.

-The value of the current consumed $I_{DD}$ remains relatively constant, and as the frequency changes *f* = 10 ÷ 1000 *Hz*, $I_{DD}$ is within the range 31 ÷ 35 *mA* (Fig. 3b). This is an indicator for the operation of the synthesized frequency regulator in a stationary mode.

-The characteristics presented in Fig. 3c $U_{P2}$=φ($U_{DD}$), illustrating the change in voltage at the GMDAC output depending on the supply voltage when the input signal has a frequency *f* = 100*Hz*; 250*Hz*; 500*Hz*; 750*Hz*; 900*Hz*, show that the sensitivity of the regulation device rises with the rise in frequency.

The experimental results obtained show that the synthesized frequency regulator operates steadily in the frequency range *f* = 10 ÷ 850*Hz*, and its sensitivity rises with the rise in frequency.

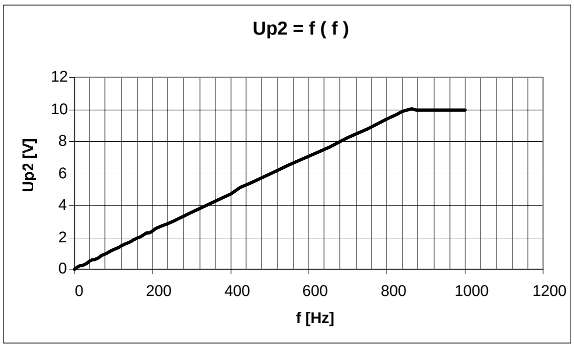
## III. Conclusions

1. A galvanomagnetic device has been developed for regulation of induction motor rotation frequency, built around a magneto-sensitive integrated circuit MLX1881 manufactured by Melexis and an integrated frequency-to-voltage converter LM2917 manufactured by National Semiconductor. The flow chart and the schematic diagram of the regulator have been developed. Time charts are presented, which describe its operation.

2. An optimal operation interval has been established for the synthesized galvanomagnetic regulator: supply voltage $U_{DD}$=12*V*, regulation range from 694 $min^{-1}$ to 1838 $min^{-1}$ with accuracy ±5%, current consumption $I_{DD}$=0,8*A*. It has been determined on the basis of the tests conducted of the conversion characteristics of the galvanomagnetic analogue-to-digital converter, on which the functional characteristics of the regulator are mainly dependent.

3. The proposed galvanomagnetic device for regulation of induction motor rotation frequency is easy to adjust and manufacture, it exhibits small interference from the mains, due to the use of a Zero Cross optocoupler, has low cost and provides good operation. It also exhibits good sensitivity and is capable of adequate response to very fast or very slow rises or falls in the input quantity.

4. The proposed galvanomagnetic regulator of induction motor rotation frequency provides a further concrete application of digital magneto-sensitive integrated circuits.

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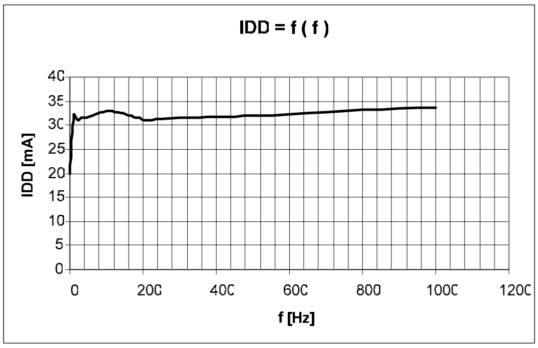


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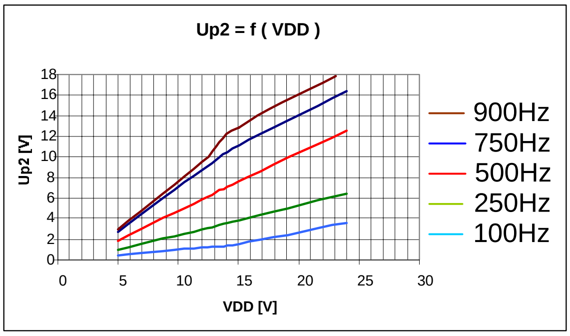


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Fig. 3. Conversion characteristics of the galvanomagnetic digital-to-analogue converter

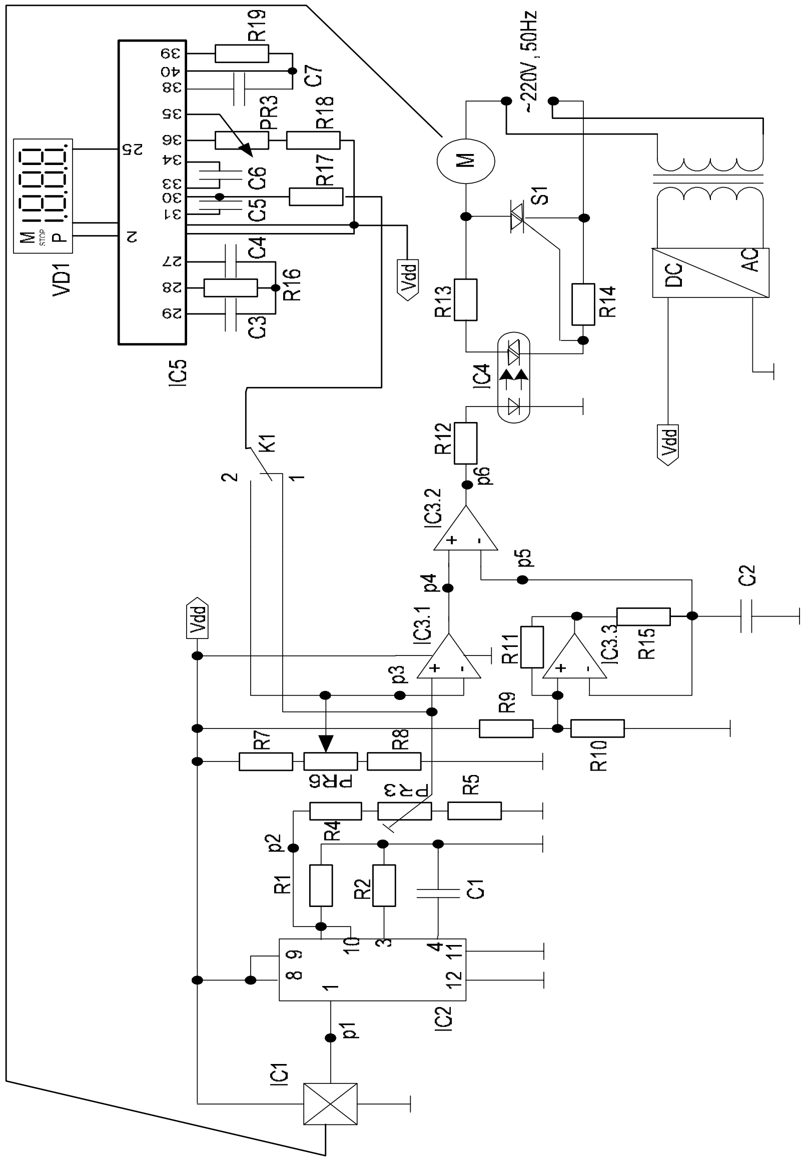


Fig. 4. Schematic diagram of a galvanomagnetic regulator of induction motor rotation frequency


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