

Measuring the Vibrations of Electric Machines with Optoelectronic Sensor with Increased Noise Immunity

T. Iliev, P. Danailov
Department of Electronics
Technical University of Gabrovo
4 H. Dimitar St., 5300 Gabrovo
Bulgaria, Sofia

Abstract: This document describes a contactless sensor used to measure vibrations of electric machines, transformers and other electromechanical devices. The sensor operates on the principle of variable luminous intensity in optocoupler with entrefer due to the vibrations of the measured device. The increased level of electromagnetic noises and the high level of rotary and fixed magnetic fields require measures to be taken for ensuring higher noise immunity of the sensor. This problem is solved by using appropriate resonance preamplifier and digital filtration in the course of result processing.

Keywords: measurement, vibrations, electric machine, protection against electromagnetic noise

I. Introduction

During operation, electric machines irradiate electromagnetic waves with relatively low frequency within the scope of the base frequency of 50Hz and a spectrum of harmonic and subharmonic frequencies. When the electric machine is turned on asymmetrically or when a kind of transition process is performed, the array of both the spectrum and the amplitude of radiated electromagnetic waves is increased. This fact causes problems to all electronic devices that are used for control, mode monitoring, temperature, vibration monitoring, etc. In particular, when studying the level of vibrations of induction motors' operation in transition mode with the help of optoelectronic sensors, penetrating electromagnetic interferences heterodyne on the desired signal. This does not allow to reduce a value which is typical for this sensors, such as the operating margin, and which shows the desired signal/ penetrating noises ratio.

II. Presentation

Optoelectronic sensor comprises LED 1 irradiating in the visible area and photodiode with expanded area, such as photoreceptor 5 (Figure 1). The optic system 2 creates a parallel pencil that passes along the opaque oscillating object 3 and modulates its intensity, depending on its motion law (oscillation). The other optic system 4 is located before the photoreceptor 5 for the purposes of receiving the entire remaining light and absorbing the external luminous background.

The principle of sensor's operation is based on the amplitude modulation of the luminous intensity and the transformation to electric signal. The transmitter – recipient type optic system ensures high signal/noise ratio, but the adjacency of the sensor to the strong electromagnetic fields around the electric machine create conditions for penetration of shading and its increase. Their spectral specification comprises base frequency of 50Hz, its harmonics and noise from different transition processes. The presence of amplifier in the output circuit of the photoreceptor makes the problem with the filtration of the desired signal more complex.

As a solution of this problem authors suggest to use amplitude modulation of the irradiating LED's intensity by means of sinusoidal signal.

Figure 1: Block scheme of optoelectronic sensor

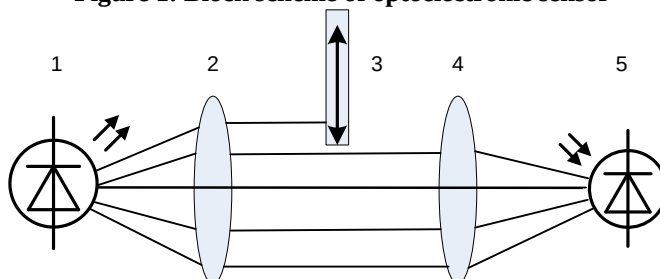


Figure 2 shows the dependence of the LED's luminous flux L_v on the current flow through it I_F [1]. We can see that there is a straight-line sector between the values of I_{F1} and I_{F2} currents that might be used for amplitude modulation of the luminous flux. It turns out to be that the appropriate frequency is the frequency that is standard for audio and TV equipment remote controls – 38kHz, as it is high enough and is not multiple to the network frequency.

Figure 2: Dependence of LED's luminous flux on the current flow through it

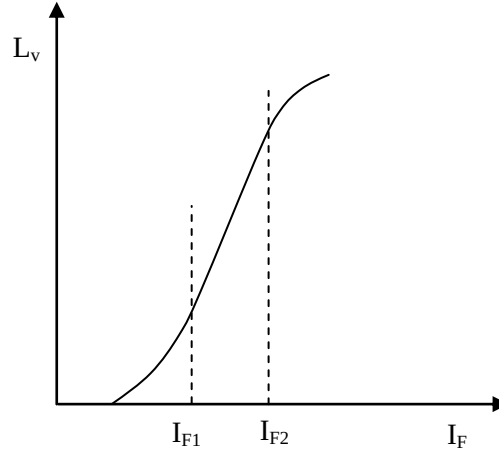
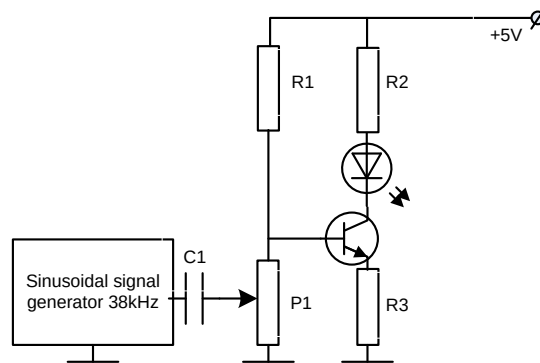


Figure 3 shows an example of a block scheme of the transmitting part of the sensor. The sinusoidal signal generator is realized according to the classic scheme of RC oscillator with Wien-Robinson bridge. The current flowing through the LED is modulated by a driver mixer of the DC element and the AC.

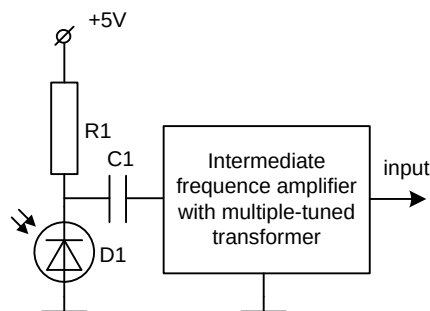
Individual elements of the scheme operate as follows: From the sinusoidal generator, through the capacitor C1, the harmonic signal is transmitted to the potentiometer P1. Resistor R1 and P1 define the operating point of T1, which is experimentally identified during the tuning process. R2 realizes the negative back coupling with current, which is required for the temperature stabilization of T1, and R2 confines the current through the LED. P1 further defines the modulation depth.

Figure 3: Block scheme of the transmitting part of the sensor



The receiving part of the sensor comprises photodiode with expanded area for the purposes of the straight-line dependence of the photocurrent on the light falling on it and on the high integral susceptiveness (Figure 4). The electric signal is realized by intermediate frequency amplifier with multiple-tuned transformer of third order.

Figure 4: Block scheme of the receiving part of the sensor



III. Conclusions

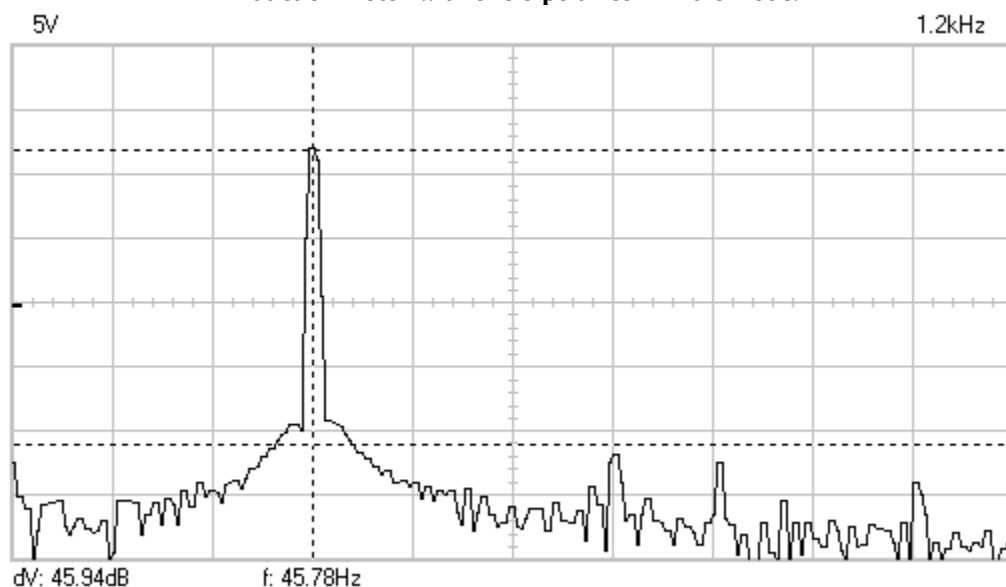
A number of experiments have been performed with the optoelectronic sensor that show the following specificities:

The permeability spectrum of the resonance amplifier comprises frequencies that differ from the base frequency with 2kHz, in case of 90% decrease of amplification at the two borders of the frequency range and practically zero amplification in case of bigger deviation from the base frequency.

The use of detector for separating the modulating element of the base frequency is not needed, provided a spectral analyzer is utilized. The general signal has been detected only for the purpose of recording the electric motor oscillations in .wav format for further study and storing of information.

Figure 5 shows the oscillation spectrum obtained from the optoelectronic sensor at a specific point of the induction motor with one bipolar coil in idle mode. It can be seen that the rotor's rotation frequency is 45,78Hz (2747 s⁻¹), which is different from the frequency creating the rotary field of 50 Hz. The lack of network frequency and its harmonics illustrate the efficiency of measures in terms of shading.

Figure 5: The oscillation spectrum obtained from the optoelectronic sensor at a specific point of the induction motor with one bipolar coil in idle mode.



References

- [1] Kolev Ivan. Optocouplers and their Field of Application. Eng. Iliya Asenov Ivanov. Sofia, 1982. p.20
- [2] Angelov, A., D. Dimitrov. Electric Machines I part. Tehnika, Sofia, 1976. p. 350
- [3] Iliev T., P. Danailov. Study of Induction Motor's Vibrations in Transit Operating Mode. Notices, volume XXVI, TU –Gabrovo, 2002 Gabrovo