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# TRANSDUCER WITH PHASE MODULATION AND ADJUSTABLE SENSITIVITY

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## ABSTRACT

*The work presents an easy converter in order to be used at little displacement. The circuit gives two electrical signals with the same frequency and with different phases, dependent on the displacement.Both signals go to the stereo sound plate input of a calculator and are numericalyl operated with an easy software. The transducer presents the following advantages: it directly measures the shifts (it is a vibrometer) and not the accelerations, which in order to provide shifts must be incorporated twice and the parasite accelerations filtered (for example the gravitational acceleration); it is less sensitive to disturbances because the transmission of the information is performed through phase modulation; it supplies signals of very low frequency, which can be taken over directly by any computer with a sound card, without complicated interfaces; the sensitivity can be conveniently adjusted, by acting directly on some potentiometers.*

KEYWORDS: displacements, phase converter, numerical detector

## 1. INTRODUCTION

The principle of phase modulation is shown in the diagram in Figure 1 and can be clearly explained on a phase analysis diagram as follows:

Oscillator 1 produces harmonic oscillations of $\nu_0$ frequency, by the form

$$u_0 = U_0 \sin 2\pi\nu_0 t \qquad (1)$$

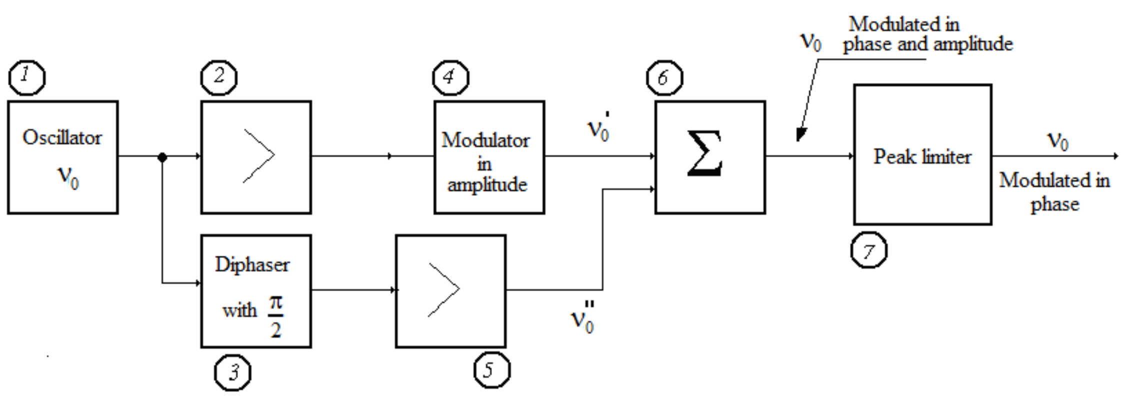
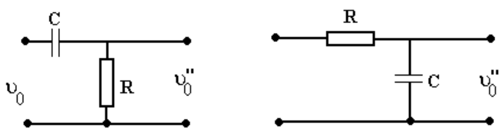



Fig. 1. The Diagram

The oscillations further follow two different paths, through the two circuit branches, a signal passes through the circuit branch formed of amplifier 2 and the modulator in amplitude 4, another diphased signal with $\pi/2$ passes through the diphaser circuit 3 and amplifier 5.

The RC type diphaser decreases the level of the signal and that is why it must be amplified, the diphasing circuit may be an integrator or a derivator as in Figure 2, with the values of the components R and C chosen in such a way so as to be able to correctly accomplish integration or derivation.




a - derivation circuit b - integration circuit

Fig. 2. Diphaser

The signal of $\nu_0''$ frequency will have the (2) form, and the one of $\nu_0'$ frequency

$$u_0'' = U_0'' \sin\left(2\pi\nu_0 t \pm \frac{\pi}{2}\right) \qquad (2)$$

has the (3) form

$$u_0' = U_0' \sin 2\pi\nu_0 t \qquad (3)$$

with

$$U_0' = U_{0m} + U_{mm} \cdot \sin\omega_m t \qquad (4)$$

where $U_{0m}$ is the repause voltage of the modulating signal and is $U_{mm}$ the amplitude of the

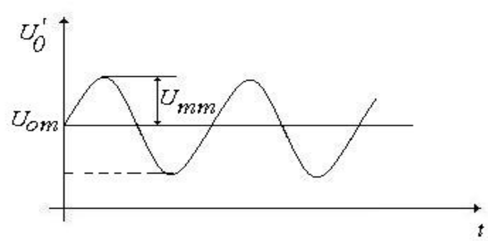



Fig. 3. Modulated signal

modulating signal of $\omega_m$ pulsation, from Figure 3.

It is obvious that $U_{0m}$ may have any value, including the null one, making it that $U_0'$ may have strictly positive values and symmetrically negative or asymmetrical ones. From what it is to be demonstrated (and drawn out of practice too) it is well known that $U_0' > 0$ , so

$$U_{0m} > U_{mm} \qquad (5)$$

In the Σ adder, the two $\nu_0'$ and $\nu_0''$ signals are simply superposed,

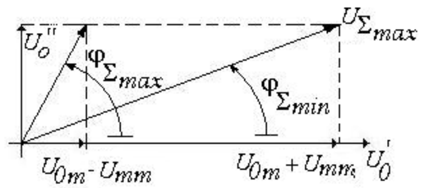



Fig. 4. Summing the two signals

according to the phase diagram in Figure 4. According to Figure 4 there is a $U_\Sigma$ tension of variable amplitude:

$$U_\Sigma = \sqrt{U_0''^2 + U_0'^2} \qquad (6)$$

and variable phase

$$\phi_\Sigma = arctg \frac{U_0''}{U_0'} \qquad (7)$$

The signal from the output from Σ is

$$u_\Sigma = U_\Sigma \sin\left(2\pi\nu + \varphi_\Sigma\right) \qquad (8)$$

By limiting the amplitude this becomes

$$u_\Sigma' = U_{\Sigma const} \sin(2\pi\nu_0 + \varphi_\Sigma) \qquad (9).$$

## 2. THE CONSTRUCTION OF THE TRANSDUCER

The diagram practically conveys all the functional elements so that it can be easily used. The oscillator 1 with quartz crystal produces the signal of $\nu_{01}$ frequency, which on one of the branches is amplified by amplifier 2. Next there are two diphasing amplifiers named 3 and 4, which have as a charge two primary inductances from a differential inductive transformer 5, inductances with opposed signals. The coupling with the secondary inductance is variable, either by a core shift, either by a secondary inductance shift. It is important for unit 5 to supply a modulated signal of the form provided in Figure 3. To adjust the values $U_{0m}$ and $U_{mm}$ it must intervene from amplifiers 3 and 4 instead of intervening each time on the position of the secondary inductance.

In the P2 point, the two signals are superposed, the one modulated in amplitude and the diphased one with π/2, are followed by limiter 9, after which it will be obtained a signal of form (9). This signal will be of $\nu_{01}$ frequency, with values of MHz or hundreds of Hz.

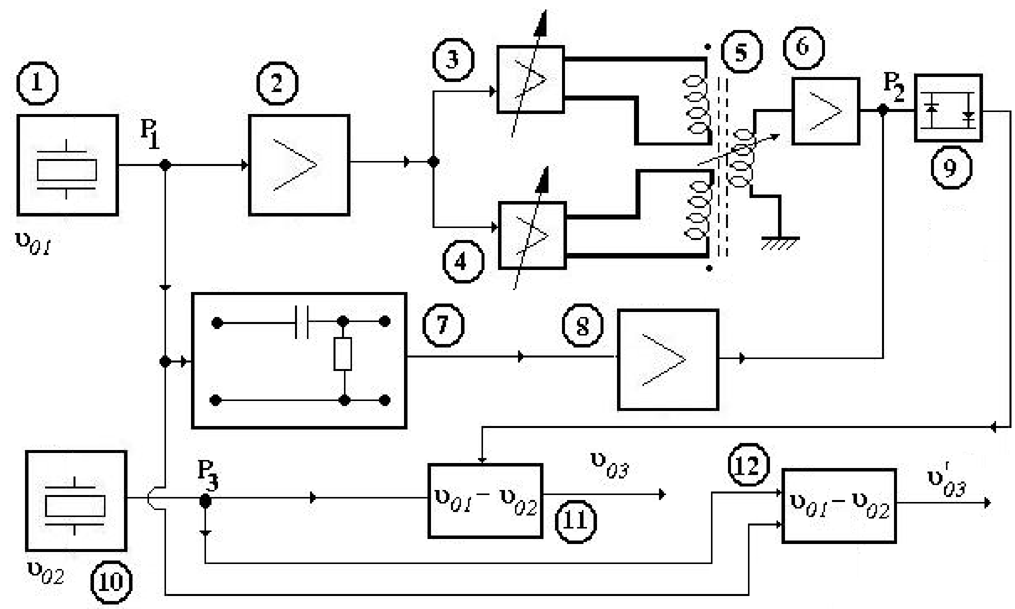



Fig. 5. The diagram of the Small shifts transducer

By mixing through reduction in unit 11 with a signal of $\nu_{02}$ frequency by 1-2 KHz lower than $\nu_{01}$ you get a signal of $\nu_{03}$ frequency, very low, but phase modulated according to the movements noticed by the differential transformer 5. In order to easily detect the phase variations of the $\nu_{03}$ frequency signal, it must be compared to the ever constant phase of the signal, which results from mixing by the reduction of the $\nu_{01}$ and $\nu_{02}$ frequencies without any phase shifting on the way. To be noted that the signals from the outputs of units 11 and 12 have the same ($\nu_{03}$ and $\nu_{03}^{'}$) frequency, equal to $\nu_{01} - \nu_{02}$, but with different diphases shiftings between them. The two $\nu_{03}$ and $\nu_{03}^{'}$ frequency signals enter a programmable computer through the stereo input terminals into the sound card. With a simple soft the two signals are perceived, decoded according to the variation of the $\nu_{03}$ phase versus the $\nu_{03}^{'}$ standard signal and are found out the shifts of the transducer element from unit 5, Figure 5, shifts which can be produced, for example, by vibrations.

## 3. CONCLUSIONS

The transducer presents the following advantages:

- it directly measures the shifts (it is a vibrometer) and not the accelerations, which in order to provide shifts must be incorporated twice and the parasite accelerations filtered (for example the gravitational acceleration);
- when the vibration's signal has components into a wide frequency spectrum, then the choice becomes important, to the parameter which describes the vibration movement. So, while the movement emphasizes the low frequency response, the acceleration emphasizes the high frequency response. The practice shows that when measuring RMS values of speed, during the whole frequency spectrum, between 10Hz an 1000Hz, this has an almost constant spectrum on the whole frequency values and becomes a good expression of vibration's intensity.
- for the high values of frequency, because of accelerometer's resonance, its sensibility rises, but the output signal will not well represent the vibration movement;
- this issue can be solved by choosing an accelerometer with working frequency band bigger in high values frequency or using pass band filters which could be usually found together with amplifiers and integrating circuits into measuring instruments, filters which cut signals of high frequency from the accelerometer resonance;
- if vibration measuring is done in low frequency domain then resonance accelerometer effects could be avoided through simple mechanical methods. For example, a high limit value decreasing in 0.5-5 kHz domain could be realized by

introducing a material, rubber type, between the accelerometer and the surface on which this will be installed;

- it is balanced, through the stabilization of the signals with the help of the oscillators with quartz crystal, if oscillator is realized with CMOS circuits it also gets the advantage of low power consumption and constant frequency for a wide range of input working voltage which does not claim changes into necessary circuit value elements;
- it is less sensitive to disturbances because the transmission of the information is performed through phase modulation, the phase modulation is used especially for data transmission (in impulses) because it delivers a bigger protection than the perturbations;
- it supplies signals of very low frequency, which can be taken over directly by any computer with a sound card, without complicated interfaces;
- the sensitivity can be conveniently adjusted, by acting directly on some potentiometers.

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