A NEW METHOD IN CONVERTING SINUSOIDAL SIGNAL TO OPTICAL SIGNAL AND RELATED TRANSMISSION SYSTEM OF THIS METHOD

Eldar MUSAYEV **İsmail TEKİN** **Sait Eser KARLIK**

Uludağ University
Faculty of Engineering and Architecture
Department of Electronics Engineering
Bursa / TURKEY

Abstract- **A newly developed method for converting sinusoidal signal to optical signal is given in this paper. The proposed method does not consist the LED's DC current content of the classical method. Each half period of the sinusoidal signal flows through LED being rectified and being converted to current. Sampling the current reduces LED's average current. The proposed method is explained with time diagrams. A new transmission system based on this method and required equations are given.**

Index Terms- **Optoelectronics, transmission, LED, sinusoidal signal, optical signal.**

I. INTRODUCTION

In systems operating with sinusoidal signals (e.g. industrial systems and secret audio communication systems) converting sinusoidal signal to optical signal requires a fixed phototransmitter current. When determining the operating point of the device that drives the phototransmitter (e.g. BJT), the optical signal formed during the conversion of both periods of the sinusoidal signal must be similar to the input signal.

The time diagrams about the classical conversion method and phototransmitter connection form are shown in Fig. 1 and Fig. 2 respectively.

Here, the current of the phototransmitter (LED or laser) can be determined from

$$I_L = I_{CQ} + I_{ms}.\sin\omega t \qquad (1)$$

Taking the integral of this equation, the current of the phototransmitter can be written as

$$I_L = I_{CQ} \qquad (2)$$

This current must be lower than the nominal current of the phototransmitter ($I_L \le I_N$). Considering the maximum value of the sinusoidal signal, the maximum phototransmitter current can be obtained as

$$I_{L_m} = 2.I_{ms} + I_{\min} \qquad (3)$$

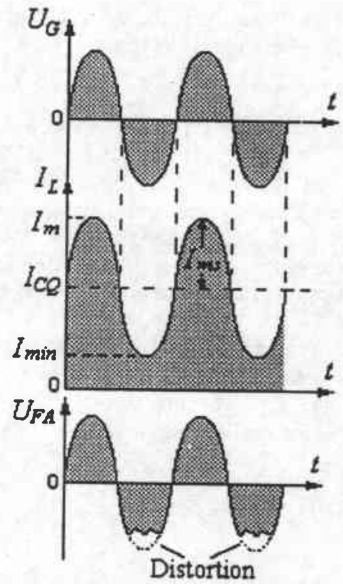

Fig. 1. Time Diagrams of The Classical Method

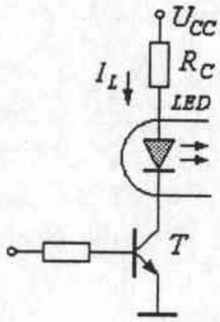

Fig. 2. Phototransmitter Connection Form

If K_L is the conversion constant of phototransmitter in converting current to light, the maximum light intensity of the optical signal will be

$$P_m = K_L\left(2.I_{ms} + I_{\min}\right) = 2.K_L.I_{ms} + K_L.I_{\min} \qquad (4)$$

Here, $P_{min} = K_L \,.\, I_{min}$ is the minimum light intensity of the optical signal. This minimum light intensity must be higher than the minimum light intensity that can be detected by the photodetector.

Otherwise distortion of sinusoidal signal can be seen at the photodetector output.

The disadvantages of the classical method are as follows:

1. Current flows continuously through the phototransmitter.
2. The minimum light intensity of the phototransmitter must be higher than the minimum light intensity that can be detected by the photodetector. Otherwise signal distortion can take place.

To overcome these disadvantages a new conversion method was developed.

II. NEWLY PROPOSED CONVERSION METHOD

In this new method, the positive and negative half-periods of the input signal, that is in the current form, flow through the semiconductor phototransmitter (LED or laser) being rectified. The time diagrams that explain the method are shown in Fig. 3.

The input signal is rectified and applied to the phototransmitter. Considering a sinusoidal input signal, the average current that flows through the phototransmitter becomes

$$I_{ort} = \frac{I_{ms}}{\pi} \quad (5)$$

Here I_{ms} is the peak value of the sinusoidal signal.

When sinusoidal signal is sampled by square pulses as shown in Fig. 3, the current that flows through the phototransmitter in one half period can be calculated from

$$I_{ort.n.} = D.I_{ort} = I_{ort}\left(\frac{n\Delta t}{T/2}\right) = \frac{I_{ms}}{\pi}\frac{n\Delta t}{T/2} \quad (6)$$

$D = \dfrac{n\Delta t}{T/2}$ is the ratio of sampling pulses to half period. Assuming duty cycle is equal to 50% ($\Delta t_p = \Delta t_s = \Delta t$) as shown in Fig. 4.a, the number of sampling pulses that can be placed in a half period will be

$$n = \frac{T/2}{2.\Delta t} \quad (7)$$

The duration of half period can be determined in terms of the duration of pulses from (7) as

$$\frac{T}{2} = 2.n.\Delta t \quad (8)$$

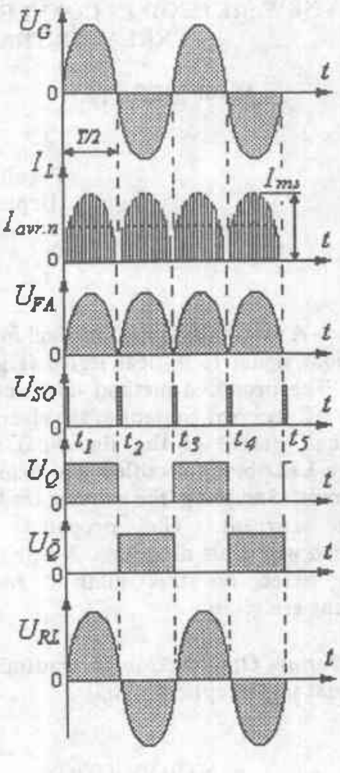

Fig. 3. Time Diagrams of The New Method

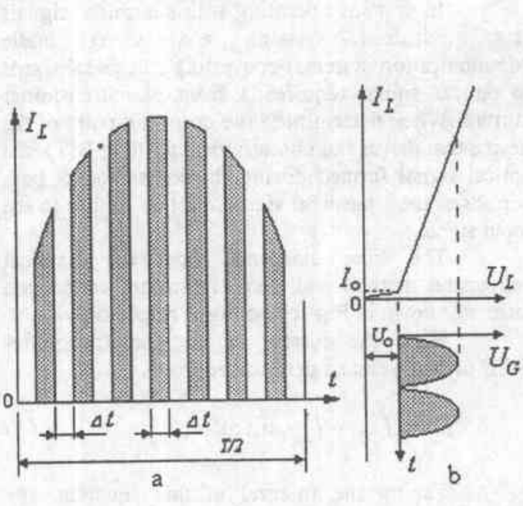

Fig. 4. (a) Time Diagram of Sampled Current
(b) Time Diagram Used in Explaining The Reducing Process of LED's Starting Region Effect

Taking all these into consideration, the average current of phototransmitter becomes

$$I_{ort.n.} = \frac{I_{ms}}{\pi}\frac{n.\Delta t}{2.n\Delta t} = \frac{1}{2}\frac{I_{ms}}{\pi} \quad (9)$$

when sampling is performed. It can be seen from the last equation that average current reduces to its half value. The light intensity of the semiconductor phototransmitter will be

$$P_L = n.K_L \frac{I_{ms}}{2\pi} \qquad (10)$$

If LED is used as phototransmitter, a small I_0 current can be let to flow through LED in order to reduce the starting region effect of the LED current-voltage characteristics. Fig. 4 explains this condition. U_0 of Fig. 4 is the LED threshold voltage.

Taking the threshold current value into consideration, the total current of phototransmitter becomes

$$I_L = I_{ort.n} + I_0 = I_0 + \frac{I_{ms}}{2\pi} \qquad (11)$$

In general, since current I_0 is very small it can be neglected in computations.

An optoelectronic system designed according to this method will be explained in Section 3.

III. OPTOELECTRONIC SYSTEM BASED ON THE NEW CONVERSION METHOD

The diagram of the optoelectronic system that operates with this new method is shown in Fig. 5.

System has been designed for sinusoidal signal transmission and audio communication in industrial applications. The numbered circuit blocks in Fig. 5 are as follows:

1. rectifier and sampling circuit
2. power stage
3. photosignal amplifier
4. the circuit that detects the zero regions of photosignal and produces short duration pulses
5. flip-flop
6. analog switch
7. analog switch

When a sinusoidal signal is applied to the input of the rectifier, an average current flows through LED. This current is converted to light by LED and crossing the medium, this light falls on the light sensitive region of the photodetector. Photodetector converts this light to photosignal and U_{FA} signal is obtained at its output (Fig. 3). This signal is amplified to the required level by the amplifier. Analog switch and zero detection circuit are connected to the output of the amplifier. Short duration pulses (U_{SO} in Fig. 3) are produced by zero detection circuit at the zero regions of the signal obtained at the amplifier output. These pulses come to the clock input of the flip-flop. Flip-flop opens and closes the analog switches periodically. One half period (e.g. positive half period) flows through the first analog switch while the other period flows through the second switch. Variable signal is re-obtained at the bridge circuit with T1.....T4 transistors. That means, the output signal on the load

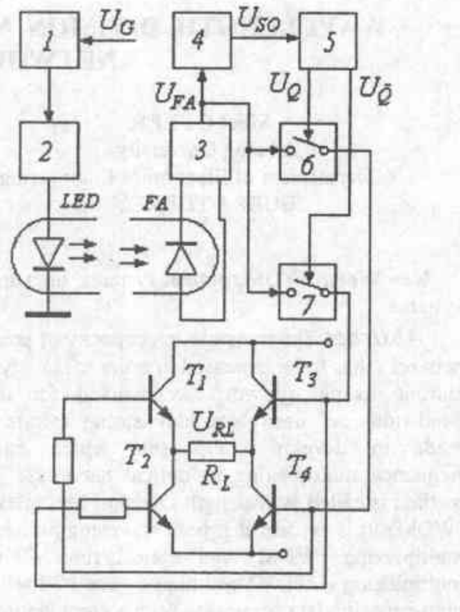

Fig. 5. Diagram of The Optoelectronic System

R_L is re-obtained in sinusoidal form. Here, transistors T1 and T4 are active during t_1 and t_2 intervals and transistors T_2 and T_3 are active during t_2 and t_3 intervals (Fig. 3). The bridge circuit can be designed with MOSFETs. The system can be used for transmitting sinusoidal signal, performing secret communication, achieving connectionless audio control and wireless connection of two audio systems in short distances.

IV. CONCLUSION

A new conversion method has been developed for transmitting sinusoidal signal. The distortions of sinusoidal signals has been reduced and the phototransmitter current has been increased with this method. So the transmission distance has been increased. The required equations of system design based on this method have been obtained. An optoelectronic system that operates with the new method has been developed.

REFERENCES

[1] E. MUSAYEV, Elektronik Devreleri II Ders Notları, Uludağ University Department of Electronics Engineering, Bursa, 1998

[2] E.MUSAYEV, Optoelektronik, Uludağ University Press, Bursa, 1997