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Experimental Investigations of Pulse Oscillators

Recep Emir*1, Sezai Alper Tekin2

*1 Erciyes University, Electrical and Electronics Engineering, Kayseri, TURKEY
2 Erciyes University, Industrial Design Engineering, Kayseri, TURKEY

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Abstract: Experimental investigations of pulse oscillators are presented. Various electronic circuits are operated with pulse signals. The main purpose of this work is to design portable oscillators with alkaline batteries without using electric source. The other purpose is to achieve oscillators with basic and easy to find components. For these purposes, two kind of pulse oscillators are implemented, which are based on opamp and 555 integrateds. Positive and negative alternances of generated pulse signals are adjusted to 5V and 0V, respectively, in accordance with logic 5V standart. Frequency is adjusted to 1Hz to be able to observe alternance transitions. Produced pulse signals are shown simulationally and experimentally. Additionally, both oscillators are evaluated in terms of some properties and advantages.

Kare Dalga Osilatörlerinin Deneysel Olarak Araştırılması

Anahtar Kelimeler
Kare Dalga Osilatörleri,
Opamp,
555,
Entegre

Öz: Kare dalga osilatörlerinin deneysel olarak araştırılması sunulmaktadır. Çeşitli elektronik devreler kare dalga sinyalleriyle çalıştırılır. Bu makalenin temel amacı elektrik kaynağı kullanmadan alkalin pillerle çalışan taşınabilir osilatörler tasarlamaktır. Diğer amaç ise basit ve bulunması kolay elemanlara sahip osilatörler elde etmektir. Bu nedenlerle opamp ve 555 entegrelerine dayanan iki tür kare dalga osilatörü uygulanmaktadır. Üretilen kare dalga sinyallerinin pozitif ve negatif genlikleri, lojik 5V standardına uygun olarak sırasıyla 5V ve 0V olarak ayarlanmıştır. Alternans geçişlerini gözlemleyebilmek için frekans 1Hz'e ayarlanmıştır. Üretilen kare dalga sinyalleri simülasyonlu ve deneysel olarak gösterilmektedir. Ek olarak, her iki osilatör de bazı özellikleri ve avantajları açısından değerlendirilmektedir.

1. Introduction

In recent years, due to big growth in portable electronic devices such as calculators, smart phones, tablets, laptops, the demand for energy efficient and high speed circuits have largely been investigated in very-large-scale-integration (VLSI) systems. Arithmetic and memory units are core parts for most electronic designs and the usage of pulse signals is mostly indispensable [1,2].

Most fundamental logic gates such as NOT-NOR-NAND-XOR-XNOR [3,4] and complex logic circuits such as adders, flip-flops, arithmetic units and some others [5-8] are operated with pulse signals. On the other hand, it is important to use pulse signals in analog designs [9-11]. So the usage of function generators is necessary to control or operate these structures. There are multiple function generator devices generating different AC signals such as sinusoidal, square, triangle and some others in large amplitude and frequency range. However, the function generators have some disadvantages as follows. They are big, need to electric source and cost expensive. For this reason, portable and cheap oscillators operating with alkaline batteries, even if they operate in stable values in terms of amplitude and frequency, provide advantage to control and operate electronic circuits without using electric source and big function generators. Additionally, it is easy to add adjustable property of amplitude and frequency for portable oscillators by using a variable resistor or capacitor.

In this work, experimental investigations of pulse oscillators for electronic circuits are presented. It is important to achieve oscillators with basic and easy to find components. For this purpose, two kind of pulse oscillators are implemented, which are based on opamp and 555 integrateds. Positive and negative alternances of generated pulse signals are adjusted to 5V and 0V, respectively, in accordance with logic 5V standart. Frequency is adjusted to 1Hz to be able to observe alternance transitions. Generated pulse signals are shown simulationally and experimentally. Additionally, these two oscillators are evaluated against each other in terms of some properties and advantages.

2. Material and Method

An AC signal has three components. One of them is the waveform. The other components are amplitude and frequency, which are defined as Voltage and Hertz, respectively. It is important to use basic and easy to find integrateds in designing circuits. For this purpose, two basic integrateds are utilized to design pulse oscillators, which are opamp and 555 integrateds. Both integrateds are core elements in oscillators, they also comprise environmental devices such as diodes, resistors and capacitors. Three components of pulse signals can be defined as in Table 1. The waveform is square. Positive and negative alternances of amplitude are 5V and 0V, respectively, in accordance with logic 5V standart. Frequency is adjusted to 1Hz to be able to observe alternance transitions.

Table 1. Parameters of pulse signal

Waveform	Square
Amplitude+	5V
Amplitude-	0V
Frequency	1Hz

2.1. Pulse oscillator using opamp

Pulse oscillator circuit using opamp [12] is shown in Figure 1. The core element of this oscillator is a basic opamp. It also comprises one capacitor and three resistors.

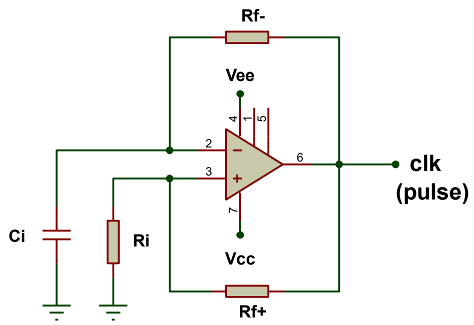

Figure 1. Pulse oscillator using opamp

In pulse oscillator with opamp, amplitude voltage is determined by power supplies and offset voltages of opamp. If pozitif or negative alternance of pulse signal is made equal to ground (0) voltage, reverse power supply is made equal to offset voltage and same power supply is made equal to desired amplitude voltage. Typical pozitive and negative offset voltages of opamp are 2V and -2V, respectively. To acquire 5V pulse signal, which means pozitive alternance is 5V and negative alternance is 0V, V_{CC} and V_{EE} power supplies are adjusted to 5V and -2V, respectively. Considering a standart alkaline battery is near to and less than 1.5V, it is convenient to use four serial connected alkaline battery for V_{CC} and two serial connected alkaline battery for V_{EE}.

In pulse oscillator with opamp, frequency is defined in equation (1.a),

$$f_{Pulse} = \frac{1}{2.R_{f-}.C_i.ln\,(\frac{2.R_{f+}+R_i}{R_i})} \quad (1.a)$$

To adjust f_{Pulse} = 1Hz, the component values can be typically chosen as follows, C_i = 1µF, R_i = 1KΩ, R_{f-} = 470KΩ and R_{f+} = 1KΩ. If these values are written as in the equation (1.b),

$$f_{Pulse} = \frac{1}{2.470.10^3.1.10^{-6}.ln\,(\frac{2.10^3+1.10^3}{1.10^3})} \approx 1Hz \quad (1.b)$$

Before implementation opamp based pulse oscillator, device list is as in Table 2.

Table 2. Device list of opamp based pulse oscillator

Device	Property	Count
Opamp	Standart	1
Capacitor	1µF	1
Resistor	470KΩ	1
Resistor	1KΩ	2
Battery	1.5V	6

Experimental design of pulse oscillator with opamp is seen in the Figure 2 in accordance with chosen component values.

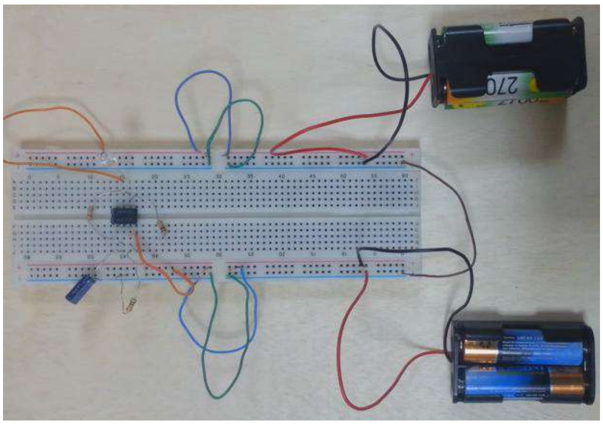

Figure 2. Experimental pulse oscillator using opamp

2.2. Pulse oscillator using 555

Pulse oscillator circuit using 555 [12] is shown in Figure 3. The core element of this oscillator is a basic 555. It also comprises one diode, two capacitor and two resistors.

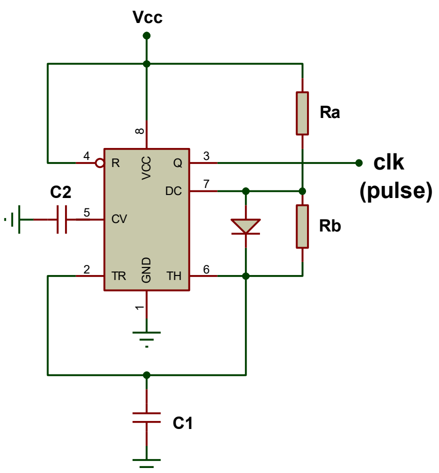

Figure 3. Pulse oscillator using 555

In pulse oscillator with 555, amplitude voltage is determined by power supply. To acquire 5V pulse signal, which means pozitive alternance is 5V and negative alternance is 0V, it is enough to adjust V_{CC} power supply is 5V.

Considering a standart alkaline battery is near to and less than 1.5V, it is convenient to use four serial connected alkaline battery for V_{CC}.

In pulse oscillator with 555, frequency is defined in equation (2.a),

$$f_{Pulse} = \frac{1.44}{(R_A + R_B).C_1} \tag{2.a}$$

To adjust f_{Pulse} = 1Hz, the component values can be typically chosen as follows, C_1 = 10μF, C_2 = 10nF and R_a = R_b = 68KΩ. If these values are written as in the equation (2.b),

$$f_{Pulse} = \frac{1.44}{(68.10^3 + 68.10^3).10.10^{-6}} \approx 1Hz \tag{2.b}$$

Before implementation 555 based pulse oscillator, device list is as in Table 2.

Table 3. Device list of 555 based pulse oscillator

Device	Property	Count
555	Standart	1
Diode	1N4007	1
Capacitor	10μF	1
Capacitor	10nF	1
Resistor	68KΩ	2
Battery	1.5V	4

Experimental design of pulse oscillator with 555 is seen in the Figure 4 in accordance with chosen component values.

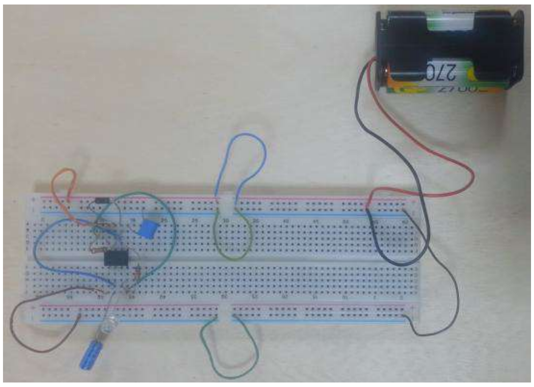

Figure 4. Experimental pulse oscillator using 555

3. Results

3.1. Simulational results

Simulational pulse signals of opamp based and 555 based oscillators are indicated in Figure 5 and Figure 6, respectively. Volt/div and time/div values are adjusted to 5V and 0.5s in oscilloscopes, which means pulse signal should take place one division vertically and two divisions horizontally. Both oscillators produce desired and acceptable pulse signals. Considering more details, vertically, while signal of opamp based is a very little weak, signal of 555 based is more near to desired values. On the other hand, horizontally, while signal of opamp based exceeds somewhat, signal of 555 based is more near to desired values.

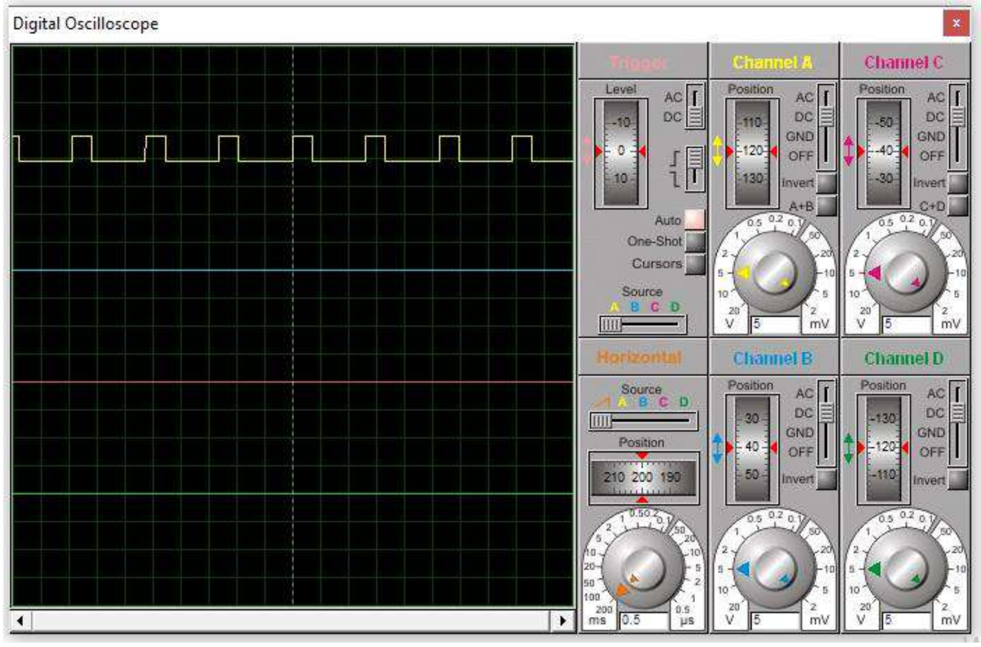

Figure 5. Simulational pulse signal of opamp based oscillator

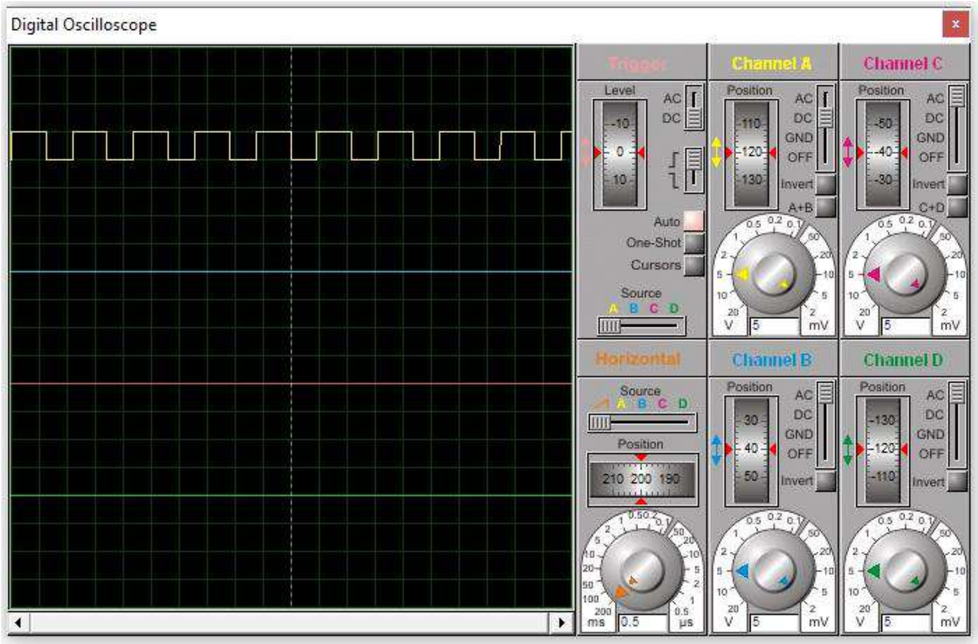

Figure 6. Simulational pulse signal of 555 based oscillator

3.2. Experimental results

Experimental pulse signals of opamp based and 555 based oscillators are indicated in Figure 7 and Figure 8, respectively. Volt/div and time/div values are adjusted to 5V and 0.5s in oscilloscopes, which means pulse signal should take place one division vertically and two divisions horizontally, same as in simulational results. Both oscillators produce desired and acceptable pulse signals. Considering more details, vertically, while signal of opamp based is a very little weak, signal of 555 based is more near to desired values. On the other hand, horizontally, while signal of opamp based exceeds somewhat, signal of 555 based is more near to desired values.

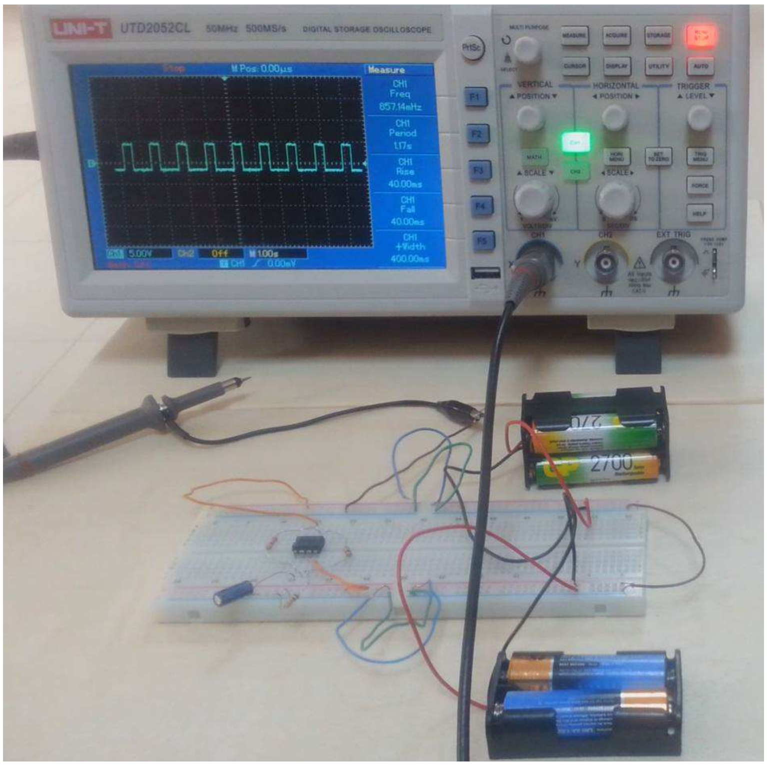

Figure 7. Experimental pulse signal of opamp based oscillator

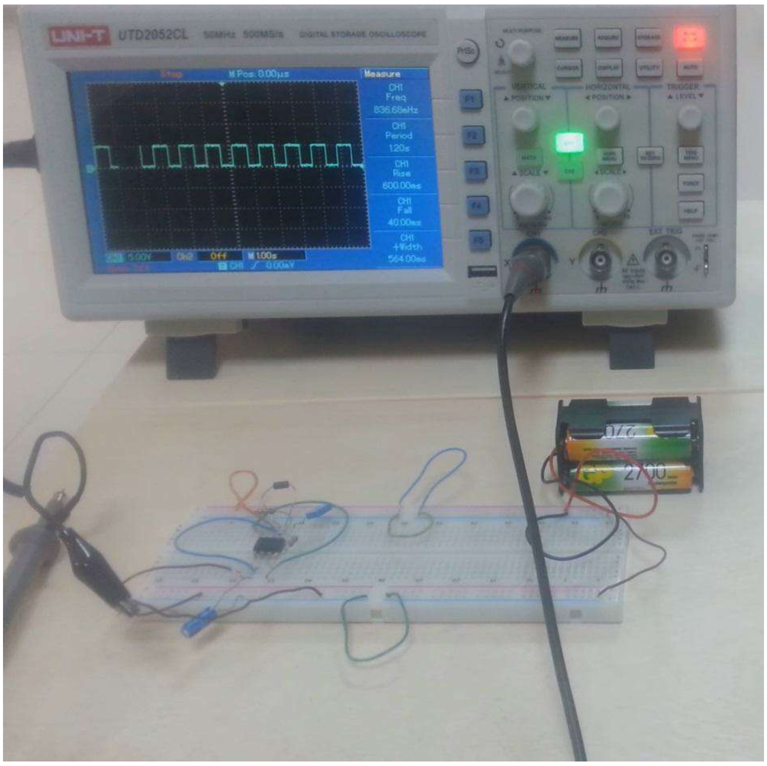

Figure 8. Experimental pulse signal of 555 based oscillator

3.3. Evaluation of oscillators

Both opamp based and 555 based oscillators produce desired and acceptable pulse signals. However, considering more details, produced pulse signals take places a little ahead or behind of necessary values due to real values of alkaline batteries and environmental electronic elements. It is not possible to exactly adjust amplitude and frequency to necessary standart values. On the other hand, it is more possible to exactly adjusting with special produced electronic elements in series production.

Two alternative method is presented to achieve pulse oscillators in this work. Even so, to consider which oscillator should be chosen, both oscillators are compared against each other. In terms of count of alkaline battery, if endurance time is neglected, 555 based oscillator with one power supply and four alkaline batteries is more advantageous than opamp based oscillator with two power supplies and six alkaline batteries. On the other hand, in terms of environmental electronic elements, opamp based with four extra elements is more advantageous than 555 based with five extra elements. Besides, the comparison in terms of cost is possible.

4. Discussion and Conclusion

Two alternative pulse oscillators for electronic circuits are presented, based on opamp and 555 integrateds. Pulse signals are necessary for operating of most analog and logic circuits. Main purpose of this work is to achieve portable oscillators with cheap and easy to find electronic elements. In accordance with logic 5V standart, three components of pulse signals are adjusted. The other important purpose is to eliminate needing electric source by using alkaline batteries. Both oscillators are implemented simulationally and experimentally and both of them produces desired and acceptable pulse signals. Additionally, both oscillators are evaluated in terms of some properties and advantages.

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