Operation Of Complementary Metal Oxide Semiconductor (CMOS) on Three Type of Astable Frequency Generator

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Abstract

Three ranges astable frequency Generator are designed with digital control capacitance circuit using complementary metal oxide semiconductor (CMOS[1]) bilateral switch and frequency generator. The capacitances 1nF, 10nF and 100nF are used to control the frequency three ranges. The variation of the capacitance controlled frequency by a bilateral switch 4016 was displayed by light emitting diode (LED[2]). The output frequency of an astable[3] oscillator was controlled from 45 Hz to 60 kHz.

***Keywords**: CMOS, LED, astable, relaxation oscillator[4]*

1. Introduction

The frequency generators operate only output signal circuits that haven't an input signal. In all sorts of applications, the frequency generators perform to obtain the signal sources. Different types of outputs involving sine wave, square wave, triangular wave, and sawtooth wave operate various types of oscillators generate. The several types of basic oscillators are designed using both transistors and op-amps as the gain element. The sine wave is the most basic waveform in linear circuits. In digital circuits, the rectangular pulse is used because digital circuits need only have two stable conditions. Nonsinusoidal waveforms can be generated by relaxation oscillator[4].

The digital capacitance control of three-range astable frequency generator is designed with CMOS bilateral switch 4016 and frequency generator using 7555 timer IC. A CMOS bilateral switch is used to switch or gate either digital or analogue signals. The digital control of decade range astable frequency circuit consists of decade range digital control of capacitance circuit, astable frequency generator circuit and LED display.

2. The 555 Timer in an Astable Mode and CMOS Bilateral Switch

An oscillator is a circuit that produces a periodic waveform on its output with only the DC supply voltage as an input. Depending on the kind of oscillator, the output voltage can get either sinusoidal or nonsinusoidal. There are two main specifications of the oscillators which are feedback oscillators and relaxation oscillators. The input signal can be got from the feedback oscillator that do not change the phase shift from a fraction of the output signal. A periodic waveform that is generally nonsinusoidal waveform generates using the RC timing circuit from a relaxation oscillator . A multivibrator is a regenerative circuit with two active devices and is an important relaxation oscillator.

There are three different kinds of multivibrator; bistable multivibrator, monostable multivibrator, and astable or free-running multivibrator. Astable multivibrator operate two astable states and the continuous switching action takes place automatically. A 555 timer connected to operate in the astable mode as a free-running relaxation oscillator (astable multivibrator) is shown in Figure 1. The trigger input (TRIG) is connected to the threshold input (THRESH). The external resistor R_1, R_2 and C_{ext} make the timing circuit that sets the frequency of oscillation. The 0.01μF capacitor joined the control (CONT) input to obtain strictly for decoupling and without effect on the operation.

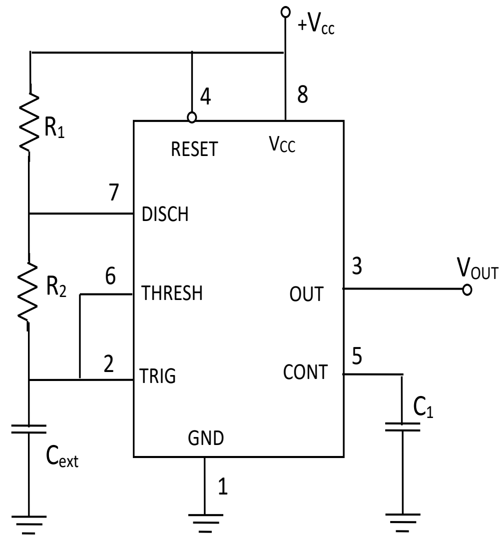

Figure 1. The 555 timer as an astable multivibrator

When the output high C_{ext} begin to charge through the combined resistance ($R_1 + R_2$). The charging time T_1 is determined by the equation.

$$T_1 = 0.693 (R_1 + R_2) C_{ext}$$

When the output low C_{ext} begin to discharge through the resistance R_2, the discharging time T_2 is determined by the equation.

$$T_2 = 0.693 R_2 C_{ext}$$

The total period T is simply the sum of periods T_1 and T_2.

$$T = 0.693\,(R_1 + 2R_2)\,C_{ext}$$

Since time and frequency are related reciprocally, the frequency of oscillation is given by

$$f = \frac{1}{T} = \frac{1}{0.693\,(R_1 + 2R_2)\,C_{ext}} = \frac{1.44}{(R_1 + 2R_2)\,C_{ext}}$$

The time segment T_1 and T_2 are not equal in most cases, so the charge and discharge time for capacitor C_{ext} are also not equal. The duty cycle, DC, of the output signal is the ratio of the period T_1 to the total period T. [1, 2, 3]

The values of output duty cycle depend on the selected external resistor.

$$\text{Duty cycle} = \left(\frac{R_1 + R_2}{R_1 + 2R_2}\right) 100\%$$

On (closed) or off (opened) via a logic-1 or logic-0 signal applied to a high-impedance control terminal depends on CMOS. Such switches undergo a near-infinite closed, impedance and an opened impedance of a few tens or hundreds of ohms. There are three major families of CMOS bilateral switch 4016 ICs, Figure 2, and some of these are available in both '4000'-series and '74HC'-series versions. Figure3 shows the combination of a variety ways to make digitally controlled impedance and filter networks.

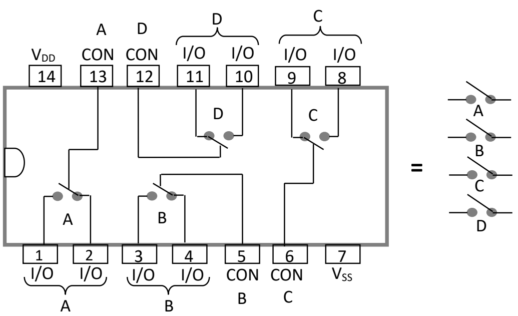

Figure 2. Functional diagram of the 4016B bilateral switch IC

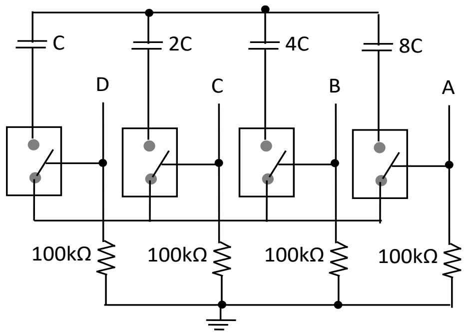

Figure 3. Digital control of capacitance values

3. Result and Discussion

3.1. Astable Frequency Generator using Digital Control of Capacitance

Digital control of three ranges astable frequency generator circuit is shown in Figure 4. The external capacitances C_3= 1nF, C_2= 10 nF, and C_1= 100 nF from the timing circuit that sets the frequency of oscillation. Testing image of the digital control of three range astable frequency circuit is illustrated in Figure 5.

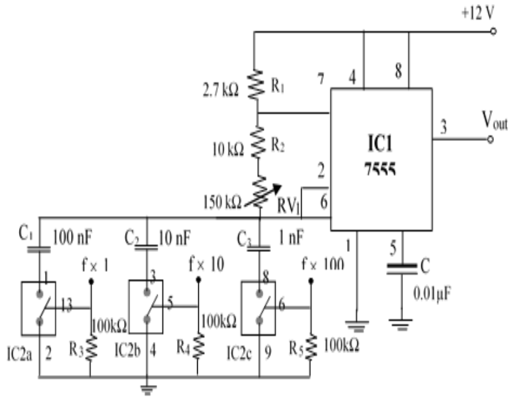

Figure 4. The digital control of three ranges astable frequency generator circuit

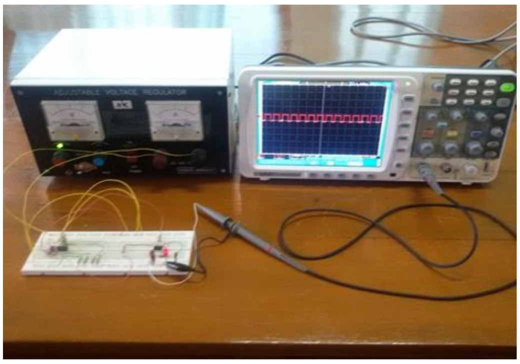

Figure 5. Testing astable frequency generator circuit

For A B CD= 0100, R_1= 2.7 kΩ, R_2 = 10 kΩ,

RV1= 0 kΩ,C_1 =100nF

$$f_{max} = \frac{1.44}{\{R_1+2(R_2+RV1)\}C_{ext}} = \frac{1.44}{(2.7\text{k}\Omega+20\text{ k}\Omega)\ 100\times10^{-9}} \cong 600 \text{ Hz}$$

R_1= 2.7 kΩ, R_2 = 10 kΩ, RV1= 150 kΩ, and C_{ext} = 100 nF

$$f_{min} = \frac{1.44}{\{R_1+2(R_2+RV1)\}C_{ext}} = \frac{1.44}{\{2.7\text{k}\Omega+2(10\text{ k}\Omega+150\text{ k}\Omega)\}100\times10^{-9}} \cong 45 \text{ Hz}$$

Table 1. Three-range digital control of capacitance values and output frequencies

A	B	C	D	C (nF)	Frequency (Hz)	
					minimum	maximum
0	1	0	0	100	45	600
0	0	1	0	10	450	6000
0	0	0	1	1	4500	60000

Figure 6 shows the minimum output frequency of 45Hz four digital inputs A=0, B=1, C=0 and D=0, RV1=150 kΩ and C=100nF. The maximum output frequency 600Hz of digital inputs 0100, C=100nF and RV1=0 kΩ is shown in Figure7. Figure 8 and Figure 9 depicts the minimum frequency 450 Hz and the maximum output frequency 6000Hz four digital inputs A=0, B=0, C=1 and D=0, RV1=150 kΩ, RV1=0 kΩ and C=10nF. When digital inputs are A=0, B=0, C=0 and D=1, the capacitance is 1nF. Figure 10 and Figure 11 illustrate the minimum output frequency of 4500 Hz and maximum output frequency 60000 Hz of digital inputs 0001, RV1 (150 kΩ) and C=1nF.

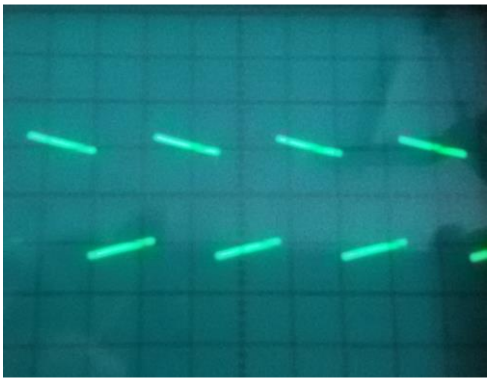

Figure 6. The output frequency 45 Hz for digital input (0100)

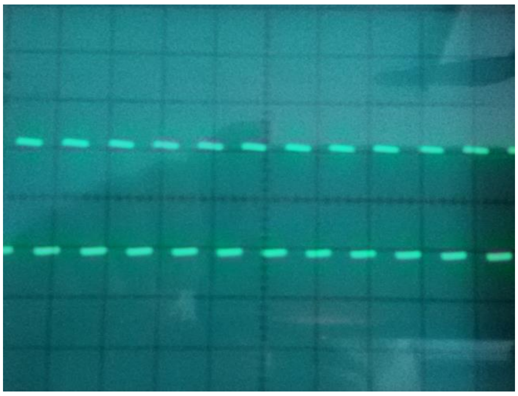

Figure7.The output frequency 600Hz for digital input (0100)

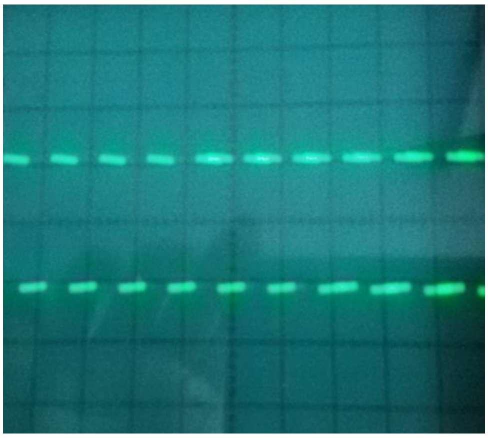

Figure 8.The output frequency 450 Hz for digital input (0010)

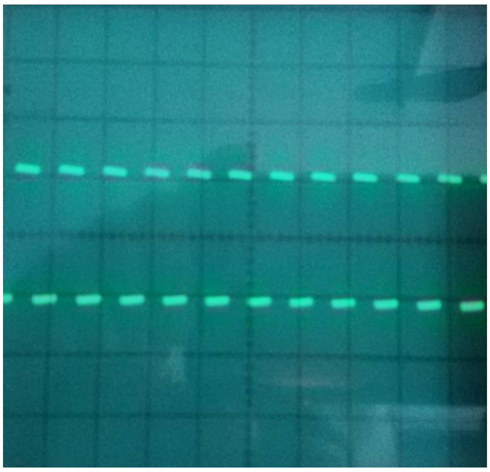

Figure 9. The output frequency 6000 Hz for digital input (0010)

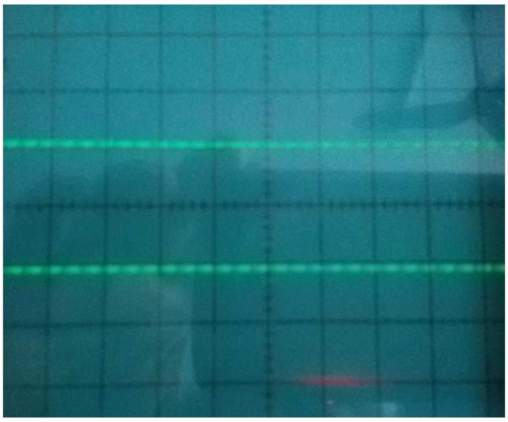

Figure 10. The output frequency 4500 Hz for digital input (0001)

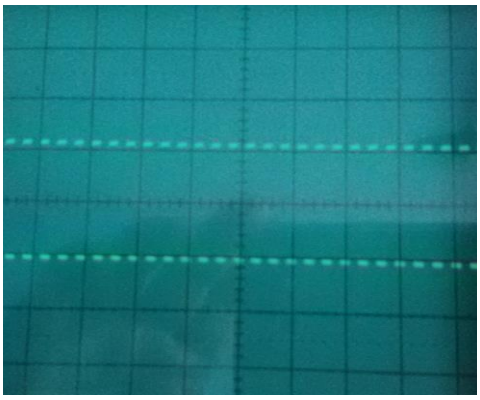

Figure 11. The output frequency 60k Hz for digital input (0001)

4. Conclusion

The digital control of decade range selection astable frequency generator circuit is designed and constructed with CMOS bilateral switch and 555 timer as a frequency generator circuit. The digital control capacitance circuit has a 3-step of digital control capacitances that varies from 1 nF to 100 nF in ×10. The values of capacitance controlled by a CMOS bilateral switch set the frequency of oscillation. The output frequencies of an astable oscillator were controlled from 45 Hz to 60000 Hz. The variation of the frequency controlled by a bilateral switch is displayed on LED.

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