CHAPTER 6

BEHAVIOURAL STUDY OF AN OPAMP BASED SQUARE WAVE GENERATOR
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6.1 INTRODUCTION

A square wave is a kind of non-sinusoidal waveform, most typically encountered in electronics and signal processing. An ideal square wave alters regularly and instantaneously between two levels [2,3,4].

Square waves are universally encountered in digital switching circuits and are naturally generated by binary logic devices. They are used as timing references or “clock signals” because their fast transitions are suitable for triggering synchronous logic circuits at precisely determined intervals. As frequency domain graph shows square wave contain a wide range of harmonics, thses can generate electromagnetic radiation or pulses of current that interfere with other nearby circuits, causing noise or errors[6,7,8,9].

In musical terms they are described as sounding hollow and therefore used as the basis for wind instruments sound created using subtractive synthesis[11,12].
6.2 Examining the Square Wave

A square wave contains only odd integer harmonics. Using Fourier series, an ideal square wave may be written as an infinite series of the form:

\[ x_{\text{square}}(t) = \sum_{k=1}^{\infty} \frac{\sin((2k-1)t)}{(2k-1)} \]

A curiosity of the convergence of the Fourier Series representation of the square wave is the Gibbs Phenomenon. Ringing artifacts in the non-linear square wave can be shown to be related to this phenomenon. The ratio of the high period to the total period of a square wave is called the *Duty Cycle*. A true square wave has a 50\% duty cycle equal high and low periods. The average level of square wave is also given by duty cycle, so by varying the on and off periods and the diverging, it is possible represent two limiting levels. This is the basis of PULSE WIDTH MODULATION (PWM).

Here is an attempt to produce square wave using operational amplifier. The first circuit uses opamp and zener diode. In the next step this circuit is connected in cascade to get pulse width modulated wave and a square wave also.
6.3 PROPOSED CIRCUITS

FIG 6.1: THE PROPOSED SQUARE WAVE GENERATOR
FIG 6.2: TWO SQUARE WAVE GENERATORS CONNECTED IN CASCADE

Fig 6.1 shows a square wave generator. The circuits consist of a Stimulus source of 5V which provides the input signal to the circuit. Capacitor C1=1nf is the feedback capacitor. Besides this a zener diode and two resistances R2 and R3 of 1 KΩ are connected in the circuit. Output is taken across R3.
Fig 6.2 shows another circuit which produces pulse width modulated wave and also a square wave for certain values of resistances and capacitors. This circuit is the cascade connection of the first one. Input signal is provided by stimulus source of 5V. The component values are given as follows:

\[ R_1 = R_5 = 10\, \text{K}, \quad R_2 = R_4 = 5\, \text{K}, \quad R_3 = 1\, \text{K}, \quad C_1 = C_2 = 1\, \mu\text{F}, \] two zener diodes of Dbreak model, and two operational amplifiers.

**6.4 Parameter Variation**

For the values shown in fig 6.1, the input and output signals are given in fig 6.3. The circuit works well only for the specified temperature i.e. 27 Deg. Cel. A small change in the component values vanishes the output square wave. One thing to be noted that the input and the output signals are 180 deg out of phase.

The performance of the 2\textsuperscript{nd} circuit basically depends upon the values of resistors. For the values shown in fig 6.2 a pulse width modulated wave is obtained as shown in fig 6.4. Now, it is seen that the output changes considerably with change in the resistor values i.e. fig 6.5 is the output for \( R_2 = 1\, \text{Mega}\Omega \) and fig 6.6 represents output signal for \( R_4 = 1\, \text{Mega}\Omega \). If both the values are taken at same time, a square wave is obtained which is shown in fig 6.7.

The temperature analysis of the circuit shown in fig 6.2 shows that output signal is deshaped with increase in temperature from 100 to 300 deg cel. The
special this which is found is that at 500 deg cel. the output signal is obtained as a sine wave similar to the input signal and the circuit is behaving like unity gain amplifier. These are shown in figures 6.8 and 6.9.

6.5 Results and Discussion

**FIG 6.3: INPUT AND OUTPUT SIGNALS OF FIG 6.1**

**FIG 6.4: INPUT AND OUTPUT SIGNALS OF FIG 6.2**

135
FIG 6.5: OUTPUT SIGNAL OF 2\textsuperscript{ND} CIRCUIT FOR R2=1MEGA\Omega

FIG 6.6: OUTPUT SIGNAL OF 2\textsuperscript{ND} CIRCUIT FOR R4=1MEGA\Omega
FIG 6.7: OUTPUT SIGNAL OF 2ND CIRCUIT FOR R2=R4=1MEGAΩ

FIG 6.8: OUTPUT SIGNAL OF 2ND CIRCUIT AT 100 DEG CEL.
FIG 6.9: OUTPUT SIGNAL OF 2ND CIRCUIT AT 500 DEG CEL.

The analyses leads to the result that the first circuit is a sensitive circuit which work only for the specified temperature for which it is designed. For second circuit it is concluded that this circuit may produce various types of pulse width modulated waves of different duty cycles for different values of resistors. It may also give square wave output for specific values of R2 and R4. Besides this the circuit may behave like unity gain amplifier at 500 deg Celsius temperature.

6.6 CONCLUSION

From the above discussion it is concluded that both the circuits may be used to generate square wave. Second circuit is multipurpose circuit for different component values and temperatures. Pulse width modulated waves of different duty cycles can be obtained from this circuit which may be used in different digital applications.
REFERENCES


