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Design of Simple Signal Generator Base on Simulator

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ABSTRACT

Function signal is often used as signal input in experiments of communication electronic circuit. In this paper, we designed a simple signal generator circuit. The square wave is generated by LM339 comparator, then by referring to the square wave, the capacitor is charged and discharged by a constant current to generate a triangular wave. We use the NE5532 operational amplifier to generate sawtooth wave on the basis of unidirectional conduction of diode characteristic. As a result, the triangular wave outputs the sine wave through the non-linear limiter. By adjusting the values of the components, the output frequency varies from several hundred kilohertz to a megahertz, with an amplitude of 0.5V to 1.5V. Finally, we welded the real circuit and measured the frequency and amplitude of each function signal with the oscilloscope. The results are satisfactory.

Key words: Function Signal, Signal Generator, LM339 Comparator, Non-Linear Limiter, Unidirectional Conduction of Diode

INTRODUCTION

The signal generator is a device capable of providing electrical signals in various frequencies, waveforms and output levels. It is indispensable in electronic experiments. There are many function signal generators in the market whose prices are relatively high. However, only basic functions are generally needed in most experiments, such as providing signals with certain frequency or amplitude, which causes a certain waste of resources. In this paper, a simple and yet effective signal generator is made by using simulators.

CIRCUIT DESIGN OF SIGNAL GENERATER

According to the whole circuit design, the triangular wave is generated by charging and discharging a constant current capacitor, and it is input as the negative terminal of LM339 comparator to output square wave. The sawtooth wave is obtained by the unidirectional conduction of diode feature to change the size of the resistor to make the capacitor charge and discharge rapidly. Finally, the sine wave is obtained from the triangle wave through the non-linear limiter.

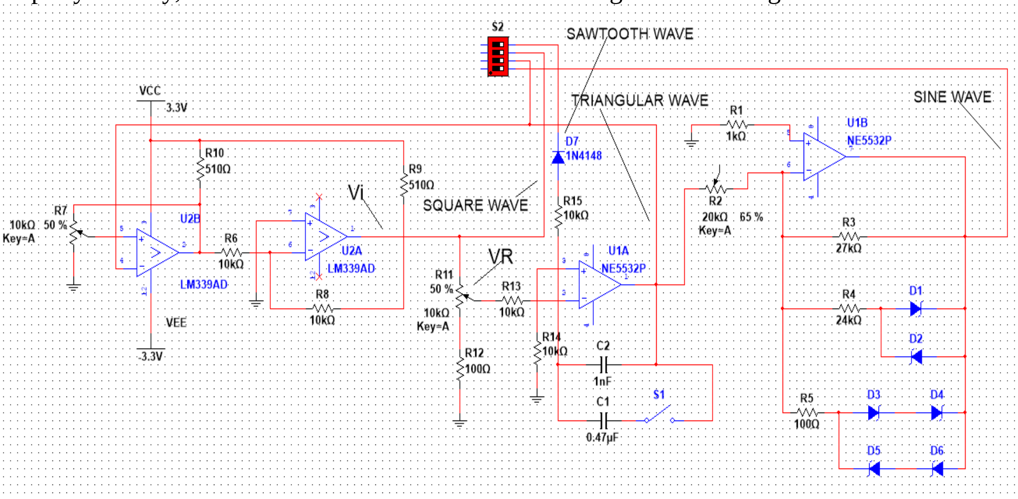

Fig. 1 Signal Generator Circuit

The Generation of Square Wave

It is relatively more simple to obtain square wave. The principle is similar to a self-generating square/triangular wave generator using only the CMOS Operational Transconductance Amplifiers (OTAs) and a grounded capacitor [1]. In order to generate square wave, the output voltage of the comparator is input at the positive end, which will be divided by the variable resistor, and the subsequent triangular wave is input at the negative end. Since the LM339 comparator has a faster jump speed, the output square wave has less distortion.

The Generation of Triangular Wave

Triangular wave is generated by charging and discharging a capacitor with a constant current. Capacitor terminal current $i = c\frac{du}{dt}$, so voltage $u = \frac{1}{C}\int \quad idt$. When there is a constant current i, the formula for the voltage becomes $u = \frac{Ki}{C}t$, indicating a linear relationship between the voltage u and the time t. The charge harvested by capacitor is affected by the charging and discharging frequency [2]. After conversion, the frequency of the triangle wave's frequency $f = \frac{V_i}{4RCV_R}$. Therefore, we can conclude that by adjusting the slide rheostat we are able to change the voltage at the negative end; that is, to achieve the frequency adjustment of the triangular wave.

To increase the frequency adjustable range of triangular waves, we adopt 0.47μF and 1nF capacitances. After calculation, we obtain the frequency adjustable range shown in figure 2. Through practical test, the low frequency band range of triangular wave is 304mHZ to 156.54HZ, and the high frequency band range is 144.80HZ to 63.662 kHZ. The ratio of maxima and minima is approximately 210000. The resultant wide frequency band indicates a good performance of triangular waves.

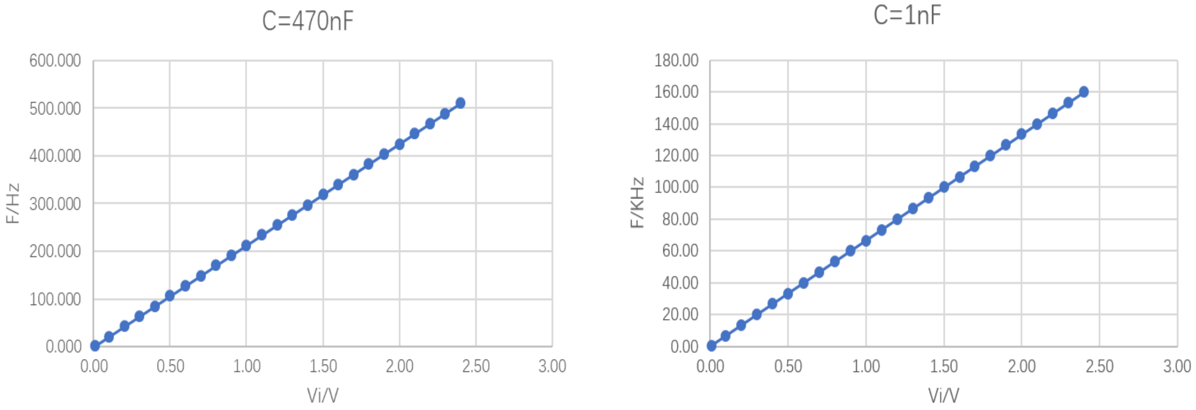

Fig. 2 The frequency of a triangular wave produced by 1NF and 470NF capacitances

The Generation of Sawtooth Wave

The principle of generating sawtooth is similar to that of the triangle wave despite the fact that the switch is closed when the sawtooth wave is generated. Because of the unidirectional conduction of diode characteristic, the charging condition of the capacitor is the same as triangle wave's by controlling the direction of the diode. The discharging condition is extremely fast, which transforms the generation of triangular waves into sawtooth waves. In this case, we have added a variable resistor to the circuit to adjust the slope of the sawtooth rapid charge (discharge) waveform instead of a instantaneous jump.

The Generation of Sine Wave

The sine waveform is generated using a novel algorithm resulting from simple method used to generate sine signal in analogue circuits [3]. In this paper, the sine wave is generated by limiting the amplitude of diode.

Schottky diode has the advantages of low forward pressure drop, short reverse recovery time, and can be used in high frequency occasions. The resistance of schottky diode varies with the voltage, which contribute to limiting circuit.

When the input triangular wave reaches a certain voltage amplitude, the circuit will limit the waveform as the figure 3 shown. When the input triangular wave voltage reaches 0.5V, the circuit will begin to limit the waveform even though the effect is limited. When the triangular wave voltage reaches 1.0V, the power of limitation will be increased further, and the better sinusoidal wave will be generated.

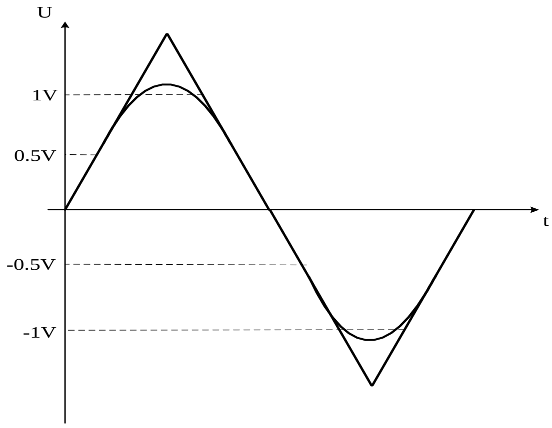

Fig. 3 The limiting effect of a diode on triangular wave

In addition, we can also use Venn bridge oscillation. However, the frequency range is too large and it is difficult to reach the amplification factor A=1 in the oscillation condition of Venn bridge. Therefore, the non-linear limitting circuit is selected after we considered all these factors.

External Switch Section

In this paper, the output part of each waveform in the circuit is connected to the rotating switch, and the variable resistance in the circuit is also connected to the knob to adjust. This can both eliminate the influence on other waveforms' output and enable the adjustment of all required waveforms under one switch.

CHECK THE OUTPUT WAVEFORM

Pictures of Real Products

Fig. 4 Circuit Object

Waveform of Each Function Signal

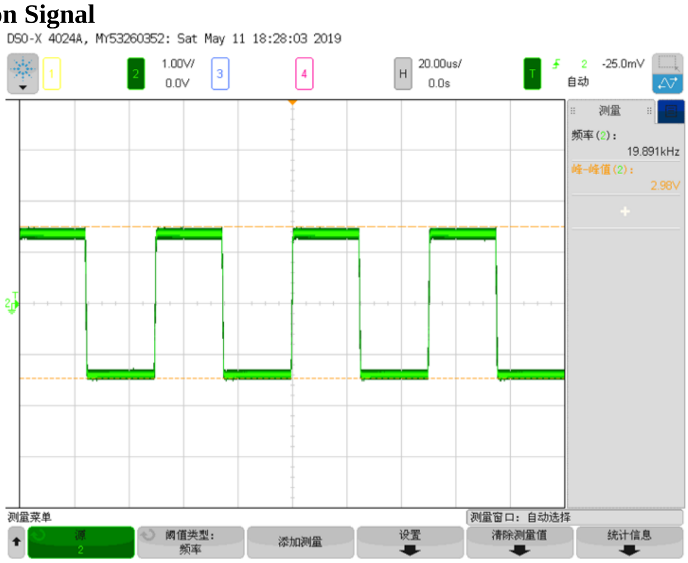

Fig. 5 Square Wave: $u_0 = 1.49V, f = 19.9kHZ$

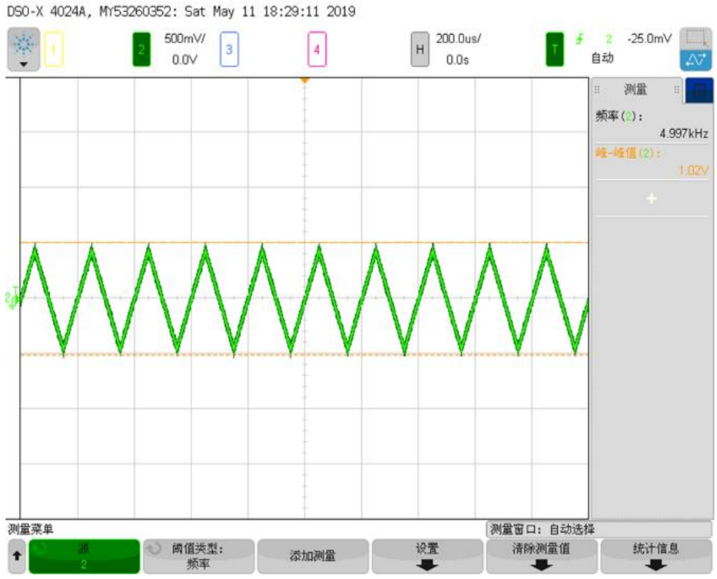

Fig. 6 Triangle Wave： $u_0 = 0.51V, f = 5.0kHZ$

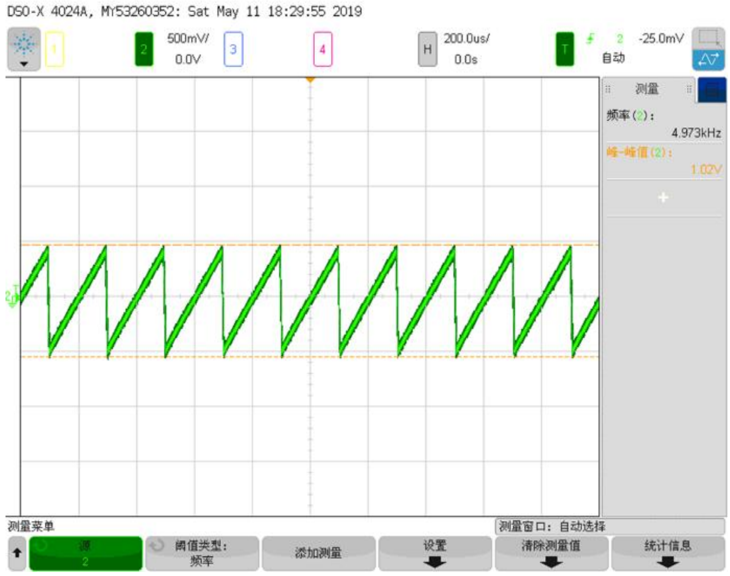

Fig. 7 Sawtooth Wave： $u_0 = 0.51V$， $f = 4.97kHZ$

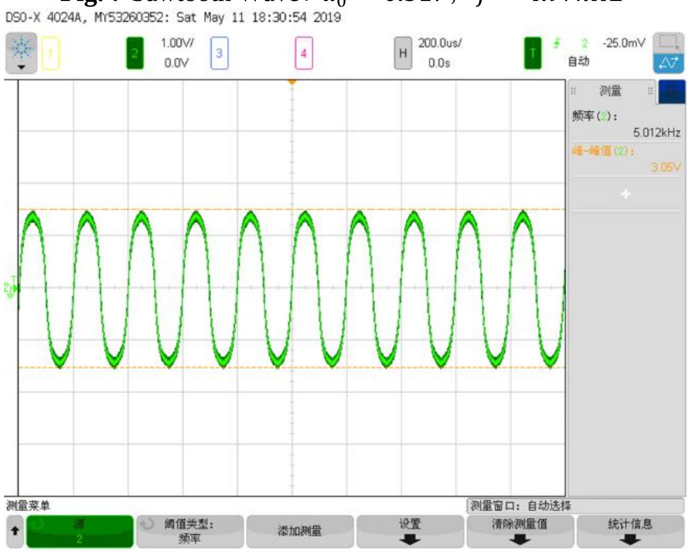

Fig. 8 Sine Wave： $u_0 = 1.52V$， $f = 5.01kHZ$

CONCLUSION

In conclusion, we can change the frequency and amplitude of the output waveform by adjusting the resistance of the sliding rheostat. The frequency range of the measured triangular wave is 304.44mHZ to 63.652kHZ, while the range of amplitude is 0.5V to 1.5V. The frequency range of sine wave is 144.53mHZ to 156.95kHZ, while the amplitude range is about 1.0V to 1.5V.

The function signal generator we designed has several advantages. Firstly, it can adjust the waveform, amplitude, and frequency easily. Secondly, it has a large wave frequency adjustment range. Thirdly, the waveform does not distort as the frequency increases. Last but not the least, the cost is very low. Meanwhile, there are many things to be improved. For example, we can add more stages of clipping circuit to the output circuit of sine wave to achieve a more perfect sine wave. Since partial waveform is distorted due to circuit composition, we will pay attention to this issue and make improvements in future experiments.

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