German Jordanian University

School of Electrical Engineering and IT

Department of Electrical and Communication Engineering

Communication Circuit Lab Manual

Experiment 6

Voltage Controlled Oscillator

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Theory

Oscillators are circuits that produce an output waveform without an external signal source. The key to oscillator operation is positive feedback. A positive feedback network produces a feedback voltage (V_F) that is in phase with the input signal (V_{in}) as shown in figure1. The amplifier shown in the figure produces a 180° voltage phase shift, and the feedback network introduces another 180° voltage shift. This results in a combined 360° voltage phase shift, which is the same as a 0° shift. Therefore, V_F is in phase with V_{in}. (Positive feedback can also be achieved by using an amplifier and a feedback network that both generate a 0° phase shift).

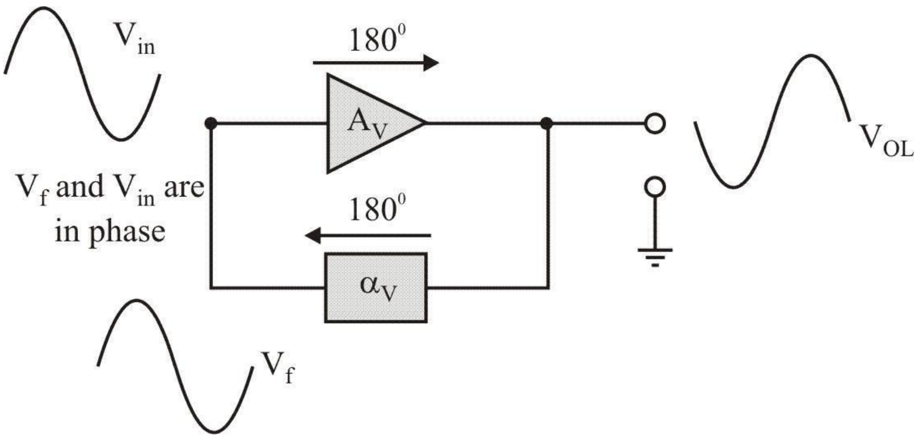

Figure 1

Figure 1 also illustrates the basic principle of how the oscillator produces an output waveform without any input signal. An oscillator only needs a brief trigger signal as an input signal to the circuit. This can be provided by noise produced by switching the supply, or a momentarily opened switch. This results in a signal at the output from the amplifier, a portion of which is fed back to the input by the feedback network. In figure1 no input is given but the circuit continues to oscillate because the feedback network is supplying the input to the amplifier. The feedback network delivers an input to the amplifier, which in turn generates an input for the feedback network. This circuit action is referred to as regenerative feedback and is the basis for all oscillators.

Hence two requirements for oscillator operation are as follows:

1. The circuit must have regenerative feedback : that is, feedback that results in a combined 360° (or 0°) voltage phase shift around the circuit loop.

2. The circuit must receive some trigger signal to start the oscillations :

There is one other requirement for oscillator operation. The circuit must fulfill a condition referred to as the Barkhausen criterion. We know that the active component in a feedback amplifier produces a voltage gain (A_V) while the feedback network introduces a loss or attenuation (α_V). In order for an oscillator to work properly, the following relationship must be met:

$$A_V \alpha_V = 1$$

This relationship is called the Barkhausen criterion. If this criterion is not met, one of the following occurs:

1. If $A_V \alpha_V < 1$, the oscillations die out after a few cycles.

2. If $A_V \alpha_V > 1$, the oscillator drives itself into saturation and cutoff clipping.

These principles are illustrated in figure 2 and 3.

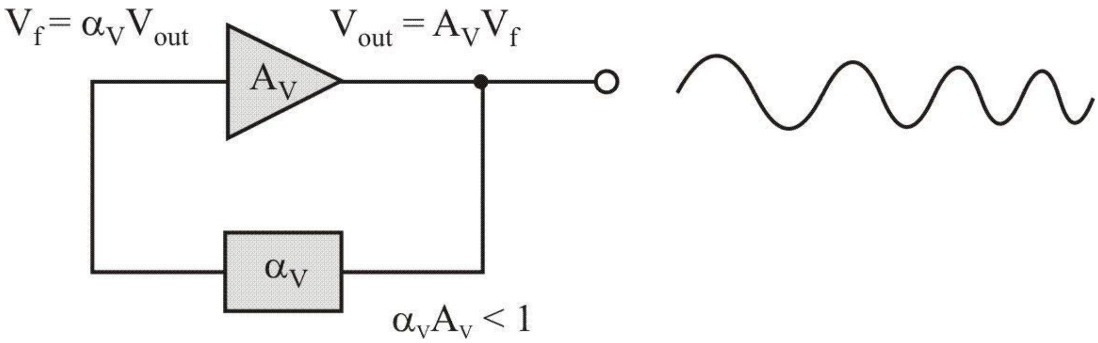

Figure 2

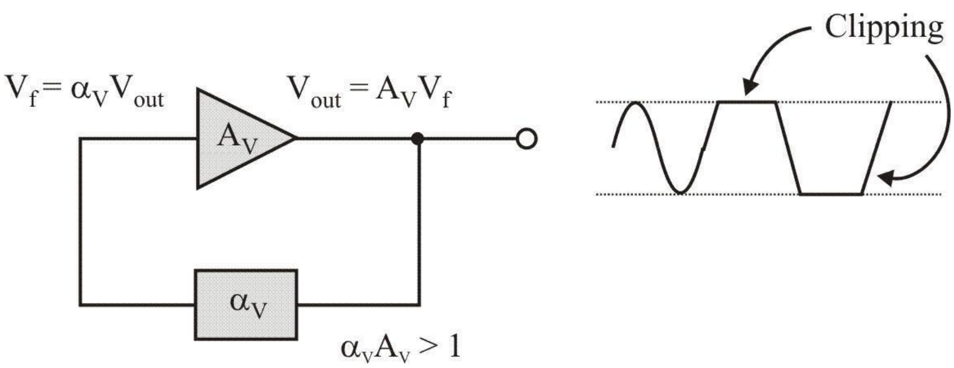

Figure 3

If $A_V\alpha_V$ <1, each oscillation results in a lower-amplitude signal being fed back to the input (as shown in figure 2). After a few cycles, the signal fades out. This loss of signal amplitude is called damping. If $A_V\alpha_V$ >1, each oscillation results in a larger and larger signal being fed back to the input (as shown in figure 3). In this case, the amplifier is quickly driven into clipping. When $A_V\alpha_V$ =1, each oscillation results in a consistently equal signal being fed back to the input (as shown in figure 4). Since there is always some power loss in the resistive components, in practice $A_V\alpha_V$ must always be kept just slightly greater than 1.

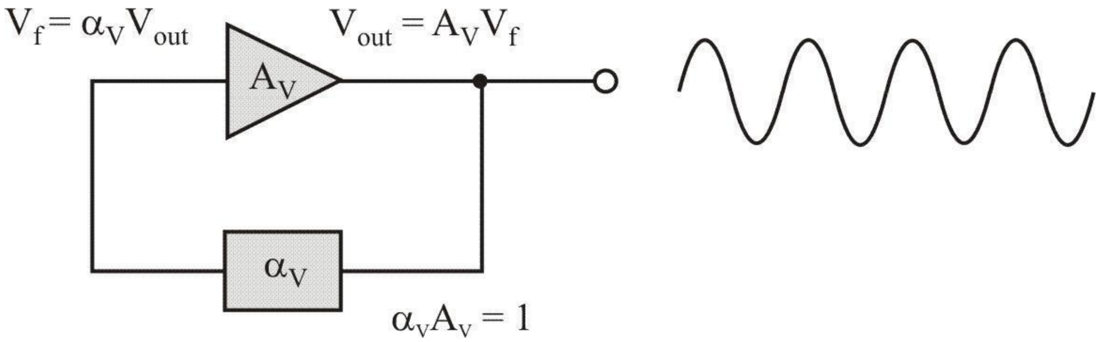

Figure 4

Voltage Controlled Oscillator

A **Voltage Controlled Oscillator** or **VCO** is an electronic oscillator specifically designed to be controlled in oscillation frequency by a voltage input. The frequency of oscillation, or rate of repetition, is varied with an applied DC voltage,

For high-frequency VCOs the voltage-controlled element is commonly a varicap diode connected as part of an LC tank circuit. For low-frequency VCOs, other methods of varying the frequency (such as altering the charging rate of a capacitor by means of a voltage controlled current source) are used.Here we are using the altering charge method of capacitor used for low frequency application.

A basic block diagram of VCO is shown in figure 5 below.

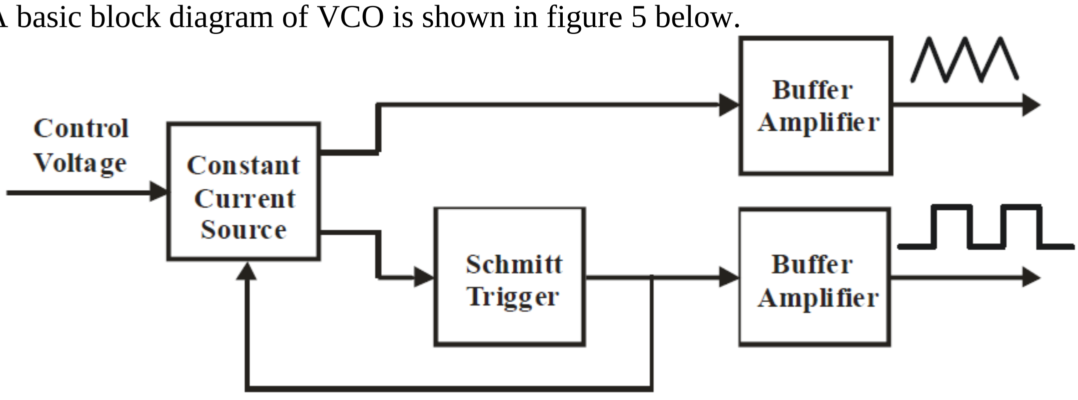

Figure 5

The VCO uses an integrator or constant current source ,a comparator or schmitt trigger ,buffer amplifier and control voltage source also considered as a precision charge source to perform its operation.VCO generates a triangular waveform as the basis for its other output i.e. square wave. The triangular waveform is generated by repeatedly charging and discharging a capacitor from a constant current source or integrator.These traingular output consist of ramp output from integrator (which has DC voltage as input) and then discharging of capacitor through fixed resistance.

A voltage threshold is set at the noninverting terminal input of the schmitt trigger by the voltage divider network of R4 and R5.This divider network sets some constant reference voltage which is either positive or negative depending upon the output .

Now when ramp voltage is applied at the inverting terminal and the point till it's amplitude is less than that at non inverting terminal reference voltage ,the output is positive supply voltage .This high output makes the transistor on.Now the supply DC voltage applied at the inverting terminal input of integrator makes its discharge path to the ground through transistor and variable potentiometer. Hence this potentiometer makes the charging time of capacitor variable .

Now as the ramp voltage at inverting terminal of schmitt trigger becomes greater than the reference voltage schmitt trigger inverts the output to negative bias voltage .This makes the transistor off and hence the capacitor discharges through the fixed resistance R1, R2 and R3.As the voltage across the capacitor decreases and becomes more negative than the reference voltage at the non inverting terminal the output triggers to the positive supply voltage and in this way output of schmitt trigger ,triggers between positive and negative supply voltage.

This produces a linearly ascending or descending voltage ramp at the output of integrator.

Now the input control voltage act as a chargesource and this controls the output frequency .The amount of charge or Voltage at the input decides the charging time and the time for which transistor is 'On' decides discharging time and hence this decides the output frequency.

Experiment - Part1

Objective :

Study of the operation of Voltage Controlled Oscillator (VCO) having triangular waveform output.

Equipments Needed :

a. Analog board; **AB27**

b. Oscilloscope.

c. DC power supplies ±12V

d. 2mm patch chords.

Circuit diagram :

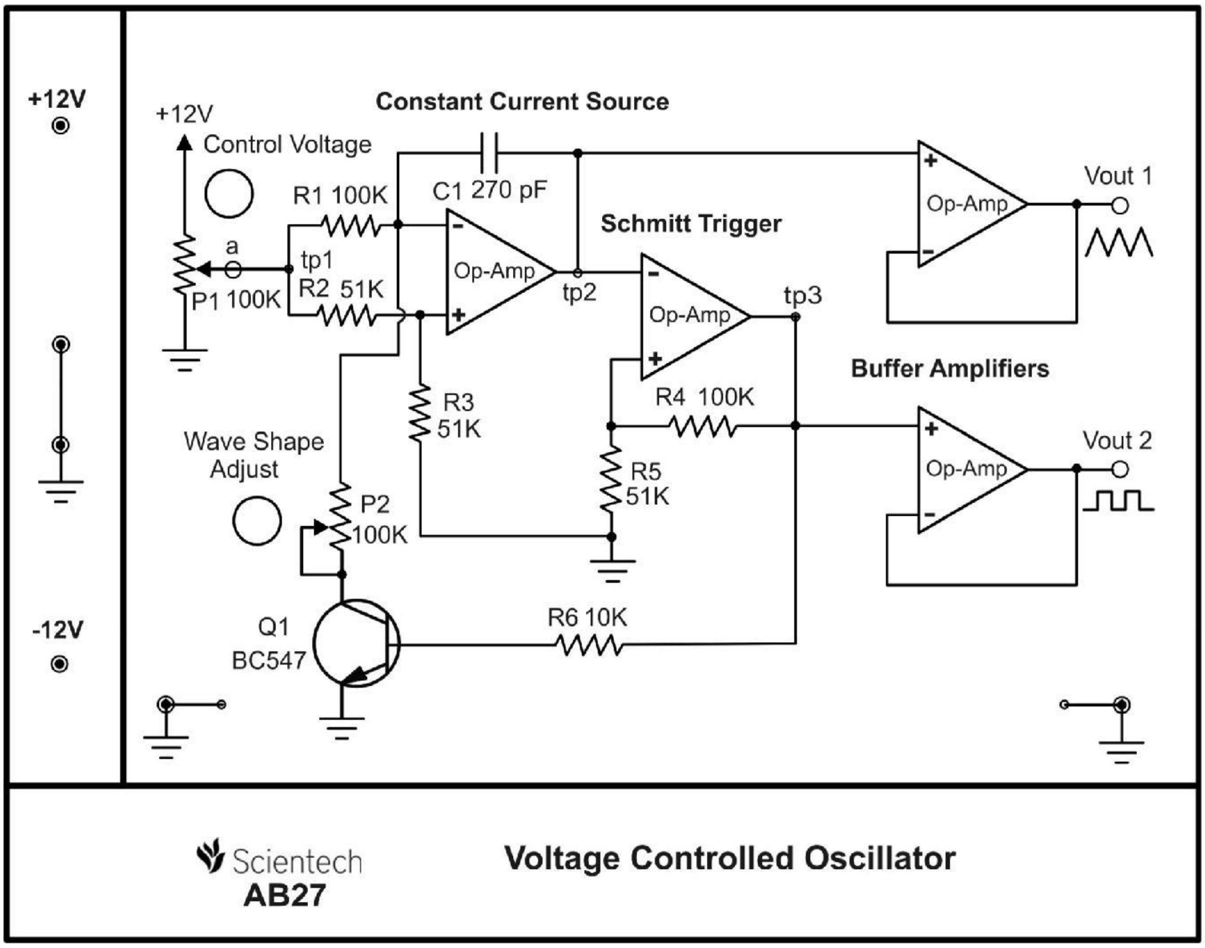

Figure 6

Procedure :

1. Connect the power supply at the indicated position given in board.
2. Move the knob of potentiometer P1 (control voltage) fully anticlockwise.
3. Connect the multimeter between socket ‘a’ and ‘Gnd’.
4. Connect the triangular output (Vout1) on CRO.
5. Adjust the wave shape adjust potentiometer P2 so that output is triangular wave.
6. Vary the input voltage using potentiometer P1, measure the input voltage and frequency of output waveform on multimeter and CRO respectively and note down the reading

Observation Table :

Frequency (Hz)	Input Voltage(Volts)	S. No.
		1.
		2.
		3.
		4.
		5.
		6.
		7.
		8.
		9.
		10.
		11.
		12.
		13.
		14.
		15.

Result :

The frequency of output square waveform is found to be varying with input voltage i.e frequency of output is voltage controlled.

Experiment - Part 2

Objective :

Study of the operation of Voltage Controlled Oscillator (VCO) having square waveform output

Equipments Needed :

1. Analog board **AB27**.
2. Oscilloscope.
3. DC power supplies +12V from external source or ST2612 Analog Lab.
4. 2mm patch chords.

Circuit diagram :

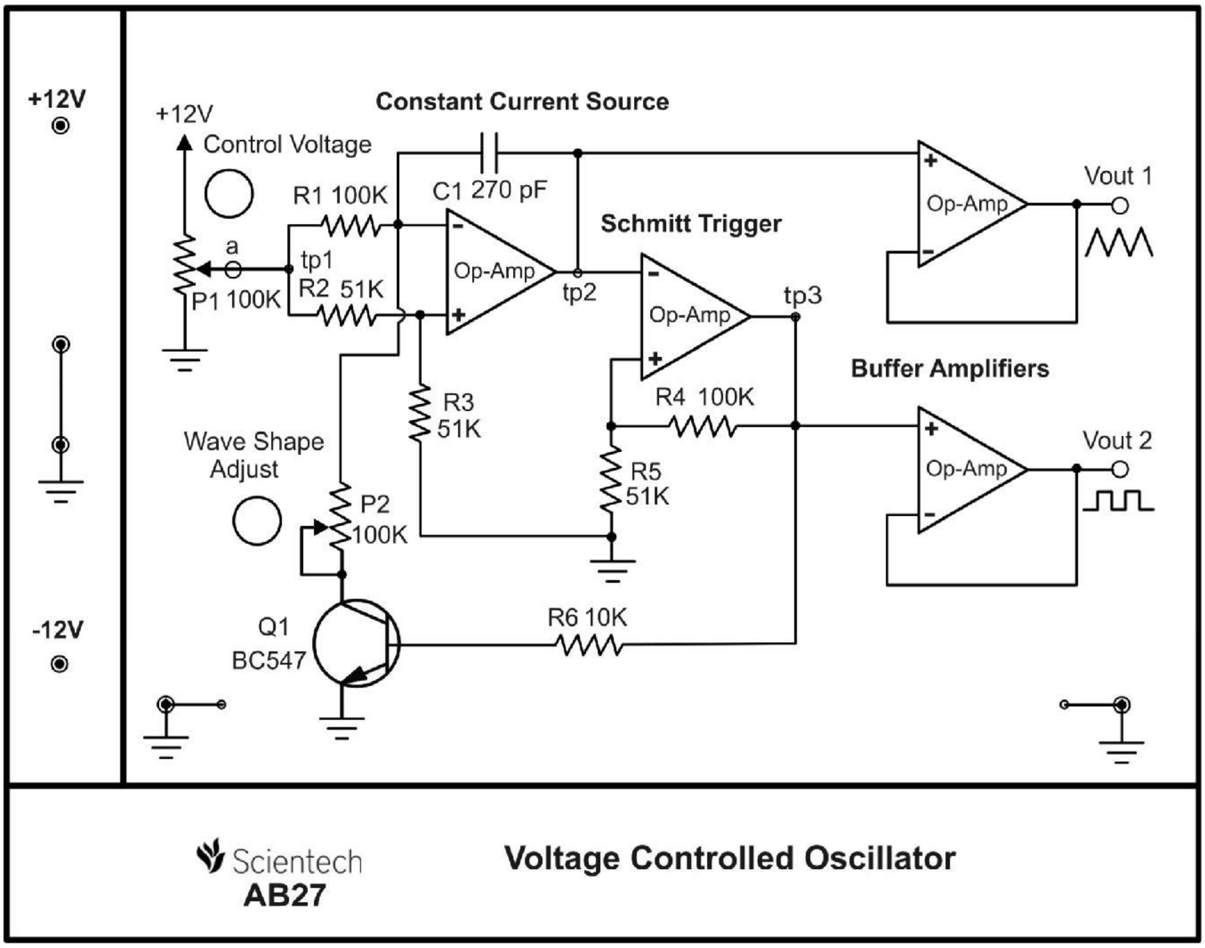

Figure 7

Procedure :

1. Connect the power supply at the indicated position given on board.
2. Move the knob of potentiometer P1 (control voltage) fully anticlockwise.
3. Connect the multimeter between sockets ‘a’ and ‘Gnd’.
4. Connect the square output (Vout1) on CRO.
5. Adjust the wave shape adjust potentiometer P2 so that output is square wave
6. Vary the input voltage using potentiometer P1, measure the input voltage and frequency of output waveform on multimeter and CRO respectively and note down the reading

Observation Table :

S.No.	Input Voltage(Volts)	Frequency (Hz)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

Table 2

Results :

The frequency of output square waveform is found to be varying with input voltage i.e frequency of output is voltage controlled.