LINEAR INTEGRATED–CIRCUIT FUNCTION GENERATOR

OBJECTIVES:

1. To observe the operation of a linear integrated-circuit function generator.
2. To observe the frequency-versus-timing capacitance characteristics of a voltage-controlled oscillator.
3. To observe the frequency-versus-timing resistance characteristics of a voltage-controlled oscillator.
4. To observe the frequency-versus-input voltage characteristics of a voltage-controlled oscillator.

INTRODUCTION:

A linear integrated circuit function generator contains a voltage-controlled oscillator (VCO) which is a free-running oscillator with a stable frequency of oscillation that depends on a timing capacitance, a timing resistance, and an external control voltage. The output from a voltage -controlled oscillator is a frequency and its input is a bias or control signal that can be either a dc or an ac voltage. In this experiment the operation of an XR-2206 linear integrated circuit (LIC) function generator is examined. The XR-2206 function generator is a precision monolithic voltage -controlled oscillator that can provide simultaneous sine and square wave outputs or simultaneous triangular and square wave outputs over a frequency range from 0.01 Hz to 1 MHz.

Linear integrated-circuit function generators feature excellent temperature stability, low sine wave distortion, linear frequency-versus-amplitude output characteristics, and a wide linear sweep frequency range. Typical applications for LIC function generators are waveform generation, sweep generation, AM and FM modulators, voltage-to-frequency conversion, frequency shift keying, and phase-locked loops.

The block diagram for the XR-2206 function generator chip is shown in Figure 9-1. The XR-2206 comprises four functional blocks: a voltage-controlled oscillator, an analog multiplier and sine shaper, a unity gain buffer amplifier, and a set of current switches.

MATERIALS REQUIRED:

Equipment:

1 - protoboard
1 - dual dc power supply (+12 V dc and -5 V dc to + 5 V dc)
1 - audio frequency signal generator
1 - standard oscilloscope (10 MHz)
1 - assortment of test leads and hookup wire

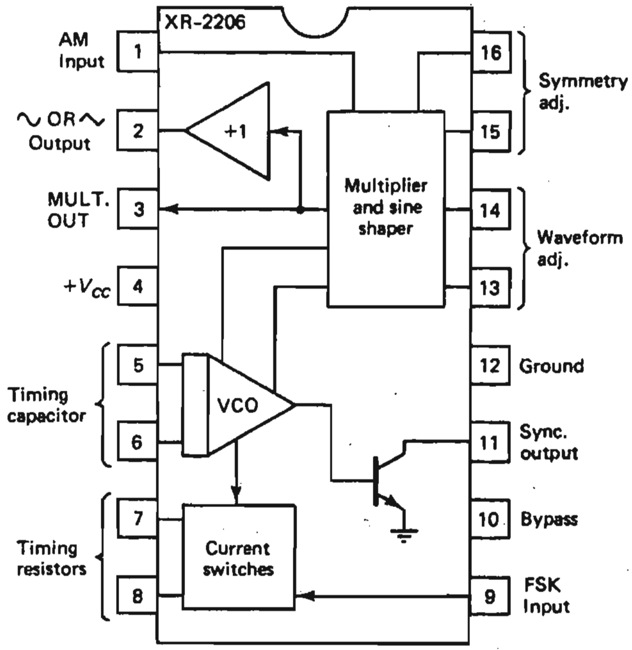

FIGURE 9-1 XR-2206 Functional block diagram

Parts List:

- 1 - XR-2206 LIC function generator
- 1 - 150 ohm resistor
- 3 - 4.7 k-ohm resistors
- 1 - 6.8 k-ohm resistor
- 2 - 10 k-ohm resistors
- 1 - 22 k-ohm resistor
- 2 - 47 k-ohm resistor
- 1 - 100 k-ohm resistor
- 1 - 1 k-ohm variable resistor
- 1 - 10 k-ohm variable resistor
- 1 - 0.001 μF capacitor
- 1 - 0.01 μF capacitor
- 1 - 0.1 μF capacitor
- 3 - 1 μF capacitors
- 1 - 10 μF capacitor

SECTION A Triangular Wave, Sine Wave, and Square Wave Generation

In this section the three output functions available with the XR-2206 function generator are examined. The schematic diagram for the function generator circuit used in this section is shown in Figure 9-2. The function generator circuit shown can be used to simultaneously produce either triangular- and square-wave outputs or sine- and square-wave outputs. The free-running oscillator frequency (f_O) is determined by an external timing capacitor (C_1) connected between pins 5 and 6, and by an external timing resistor (R_1) connected between either pin 7 or pin 8 and ground. Whether pin 7 or 8 is selected, is determined by the voltage level on pin 9. If pin 9 is open circuited or connected to an external voltage ≥ 2 V, pin 7 is selected. If the voltage level on pin 9 is ≤ 1 V, pin 8 is selected. The output frequency can be varied by changing either the resistance of R_1, the capacitance of C_1, or both.

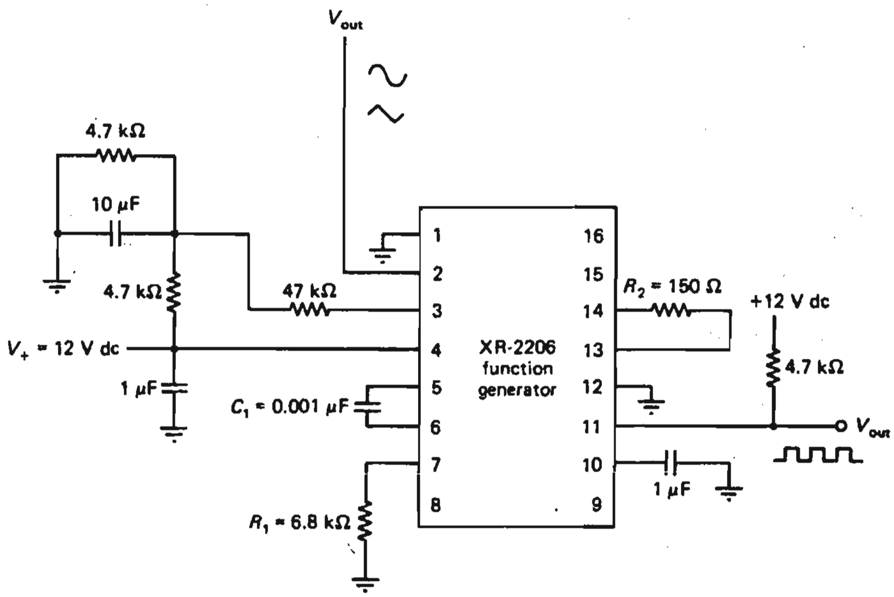

FIGURE 9-2 XR-2206 Function generator schematic diagram

Procedure

1. Construct the function generator circuit shown in Figure 9-1 (note that pin 9 open circuited).
2. Calculate the VCO free-running frequency using the following formula.

$$fo = \frac{1}{RC}$$

where

fo = VCO free-running frequency (hertz)
$R = R_1$ (ohms)
$C = C_1$ (farads)

3. Sketch the waveform observed on pin 2 of the function generator.
4. Measure the frequency of the waveform sketched in step 3 and compare it to the value calculated in step 2.
5. Sketch the waveform observed on pin 11 of the function generator.
6. Measure the frequency of the waveform sketched in step 5 and compare it to the value calculated in step 2.

7. Replace R_2 with a 1 k-ohm variable resistor wired as a rheostat.

8. Vary R_2 until a sine wave with minimum distortion is observed on pin 2 of the function generator.

9. Sketch the waveform observed in step 8.

10. Measure the frequency of the waveform sketched in step 9.

SECTION B Output Frequency-versus-Timing Capacitance

In this section the output frequency-versus-timing capacitance characteristics of the XR-2206 are examined. The schematic diagram for the function generator circuit used in this section is shown in Figure 9-3. With pin 9 open circuited, the VCO will produce an output frequency which is proportional to the timing capacitance C_1 between pins 5 and 6 and the input current to pin 7. The input current is produced by an internal bias voltage and a timing resistor R_1 placed between pin 7 and ground. If R_1 is held constant, the function generator output frequency is proportional to the capacitance of timing capacitor C_1.

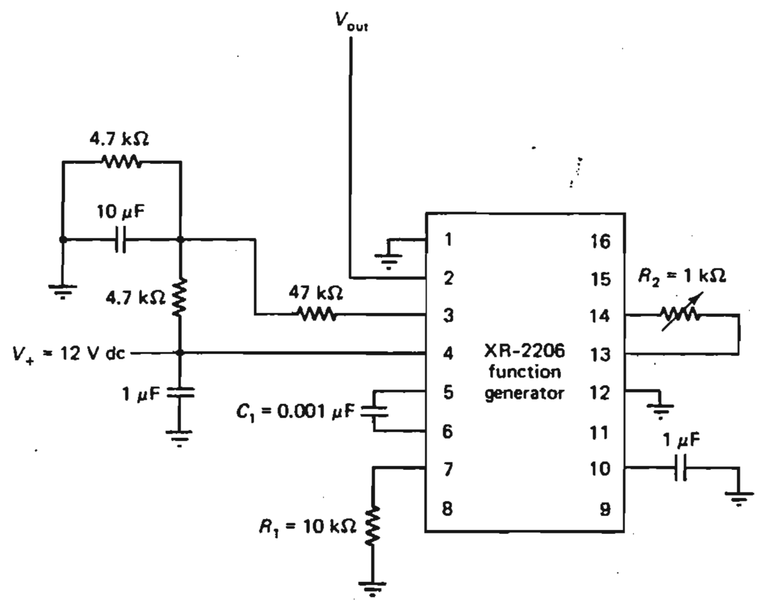

FIGURE 9-3 XR-2206 Function generator schematic diagram for measuring output frequency-versus-timing capacitance and output frequency-versus-timing resistance.

Procedure

1. Construct the function generator circuit shown in Figure 9-3.

2. Calculate the VCO free-running oscillator frequency.

3. Adjust R_2 until a sine wave with minimum distortion is observed at V_{out}.

4. Measure the frequency and amplitude of the waveform observed in step 3.

5. Repeat steps 2 through 4 for the following values for C_1: 0.01 µF, 0.1 µF, 1 µF, and 10 µF.

6. Construct a graph showing the output frequency-versus-timing capacitance for the capacitance values given and frequencies measured in steps 4 and 5.

7. Construct a graph showing the output amplitude-versus-frequency characteristics for the frequencies and amplitudes measured in steps 4 and 5.

8. Describe the relationship between the timing capacitance, output frequency, and output amplitude.

SECTION C Output Frequency-versus-Timing Resistance

In this section the output frequency-versus-timing resistance characteristics of the XR-2206 function generator are examined. The function generator circuit used in this section is identical to the circuit used in Section B and shown in Figure 9-3. If the capacitance of timing capacitor C_1 is held constant, the function generator output frequency is proportional to the input current to either pin 7 or pin 8, which is a function of the resistance of timing resistor R_1. Consequently, for a fixed capacitance C_1, the function generator output frequency is proportional to the resistance of R_1.

Procedure

1. Construct the function generator circuit shown in Figure 9-3.

2. Calculate the VCO free-running frequency.

3. Adjust R_2 until a sine wave with minimum distortion is observed at V_{out}.

4. Measure the frequency and amplitude of the waveform observed in step 3.

5. Repeat steps 2 through 4 for the following values for R_1: 10 k, 22 k, 47 k, and 100 k ohms.

6. Construct a graph showing the output frequency-versus-timing resistance for the resistance values given and frequencies measured in steps 4 and 5.

7. Construct a graph showing the output amplitude-versus-frequency characteristics for the frequencies and amplitudes measured in steps 4 and 5.

8. Describe the relationship between the timing resistance, output frequency, and output amplitude.

9. Place a 10 k-ohm variable resistor (rheostat) in parallel with R_1.

10. Vary the resistance of the rheostat and describe what effect varying it has on the frequency and amplitude of the output waveform.

SECTION D Sweep-Frequency Operation

In this section the operation of the XR-2206 function generator as a sweep-frequency oscillator is examined. The schematic diagram for the sweep-frequency oscillator circuit used in this section is shown in Figure 9-4. The frequency of oscillation of the XR-2206 function generator is proportional to the total timing current (I_T) drawn from pin 7. Pin 7 is a low-impedance point that is internally biased at + 3 V with respect to pin 12 (ground). The output frequency varies linearly with timing current over a range of current values from 1 μA to 3 mA. Thus, the output frequency can be controlled by applying an external voltage (V_C) to the selected timing pin as shown in Figure 9-4. In essence, the VCO performs voltage-to-frequency conversion.

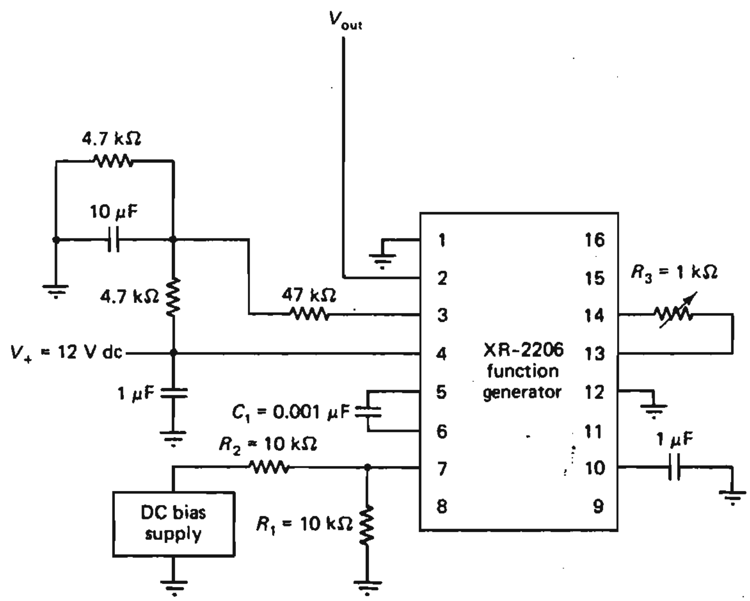

FIGURE 9-4 XR-2206 Function generator sweep frequency operation.

Procedure

1 Construct the sweep-frequency oscillator circuit shown in Figure 9-4.

2. Adjust the dc control voltage V_C to 0 V.

3. Adjust R_3 until a sine wave with minimum distortion is observed at V_{out}.

4. Measure the frequency of oscillation and output amplitude for the following values of V_C: - 5, - 4, - 3, - 2, -1, 0, 1, 2, 3, 4, and 5 Vdc.

5. Construct a graph showing the output frequency-versus-control voltage for the control voltages given and frequencies measured in step 4.

6. Construct a graph showing the output amplitude-versus-frequency characteristics for the control voltages given and frequencies measured in step 4.

7. Describe the relationship between the dc control voltage, output frequency, and output amplitude.

SECTION E Summary

Write a brief summary of the concepts presented in this experiment on linear integrated circuit function generators. Include the following items:

1. The relationship between output frequency and timing capacitance.
2. The relationship between output frequency and timing resistance.
3. The relationship between output frequency and input current.
4. The relationship between output frequency and control voltage.
5. The concept of sweep-frequency generation.