Circuit 3 Monostable Multivibrator

Objective
Upon completion of this procedure, you will be able to determine the functional characteristics of a typical monostable multivibrator. You will verify your results by taking voltage and waveform readings.

Discussion

The monostable multivibrator has only one stable initial condition (state) and that is the “reset” state at the collector of Q2. When a pulse or trigger is applied to the input, the monostable is turned on, or triggered to the “set” state. After a period of time, determined by the RC circuit (C2, R4), the circuit returns to the “reset” state automatically. Because the monostable multivibrator provides a single output pulse for each input trigger, it is also referred to as the single-shot or one-shot multivibrator.
Initially, Q1 is cut off. +9 volts is present at the collector of Q1 to ground. Initially, Q2 is on hard. Zero volts is present at the collector of Q2 to ground.

Initially, Q1 is cut off and transistor Q2 is in saturation. The reason for this is because the base of Q1 is isolated from any bias voltage, while Q2 base current is supplied by the $V_{cc}$ voltage applied to the base of Q2 through R4, driving Q2 into saturation. The low potential at the collector of Q2 is coupled back through feedback resistor R2 to the base of Q1, insuring that Q1 is initially at cutoff. With Q1 off and Q2 on, timing capacitor C2 is forced to charge positive at Q1 collector and negative at Q2 base. It retains this charge indefinitely as long as the circuit is in the stable state.
The circuit is triggered to the set state by a positive input pulse. Capacitor C1 and resistor R1 form a differentiating circuit, producing a positive “spike” at the base of Q1. This raises the base-emitter junction of Q1 above cutoff momentarily, triggering it into conduction. When Q1 collector voltage begins to decrease, C2 is forced to follow the negative excursion at the collector. The voltage drop across R4 produces a negative voltage on the base of Q2, driving it into cutoff. The amount of time Q2 remains cut off is determined by the discharge time constant of C2 and R4 toward $V_{cc}$. 

**Figure 3-3**
Once switching action is started, it continues regardless of any additional polarity changes in the input signal. When Q2 goes to cutoff, its collector goes positive, coupling a positive pulse to the output circuit and also through feedback R2 to the base of Q1. The positive pulse fed back to Q1 base also assists in the switching action, as well as holding Q1 in conduction.
The circuit remains in this temporary unstable state until sufficient charge has leaked off C2 and negative voltage drop across R4 has decreased sufficiently to allow the base of Q2 to rise above cutoff. When this occurs, Q2 goes into conduction again, driving the output negative. The negative signal fed back to the base of Q1 again drives Q1 into cutoff and the circuit automatically reverts back to its initial stable state.

The resultant output at the collector of Q2 is a positive pulse, the width of which is primarily determined by the time constant of R4 and C2.
The monostable multivibrator provides an output signal source having a constant amplitude and width independent of the input plus width.

It is used as a pulse stretcher or expander, a pulse delay circuit, or a pulse squaring circuit.

It is used in frequency dividers, countdown circuits, and synchronization circuits.

**Figure 3-6**
Wiring Scheme

The above photo shows average part placement and wiring scheme. Feel free to design your own and use as much space on the breadboard as needed for your layout. Component parts in your kit may be different in color or size from in the photo but should be the correct value or part number from the bill of materials.

Equipment and Materials

In order to complete this job sheet, you will need the following equipment:

- FACET base unit
- Multimeter/ Generator
- Oscilloscope, dual trace
- BREADBOARD MODULE
- C1 - Capacitor, 100pF
- C2 - Capacitor, 0.01μF
- SAMPLE - Capacitor, 0.01μF
- Q1, Q2 -NPN Transistor, 2N2219A
- R1 - Resistor, 10KΩ, ¼ W
- R2, R4 -Resistor, 22KΩ, ¼ W
- R3, R5 -Resistor, 1KΩ, ¼ W
Safety

Safety rules are common sense ideas that help prevent injury. Use the following list as a reminder of standard safety rules before you begin any procedure.

- Rules to avoid injury should be remembered.
- You cause safety, it doesn’t just happen.
- Machinery and equipment can be dangerous.
- Always be interested in working safety.
- FACET trainers have current and voltage levels that, under normal circumstances, are harmless to a normal, healthy person.
- The sensation of current flow through the body is called electric shock.
- A surprise shock can cause involuntary muscle spasms, which can result in secondary injuries.
- Know electricity and respect it.

For additional information on the proper use of FACET equipment, refer to Appendix A — Safety found at the back of this guide.
Procedure

1. Connect the monostable multivibrator circuit as shown. Do not connect the generator to the input at this time.

2. Adjust the variable positive dc power supply so that Vcc equals 9.0 Vdc.

3. Measure and record the dc voltage at the collector, base and emitter of Q1.

\[
V_{C1} = \underline{\ \ \ \ \ \ \ } \text{Vdc}
\]

\[
V_{B1} = \underline{\ \ \ \ \ \ \ } \text{Vdc}
\]

\[
V_{E1} = \underline{\ \ \ \ \ \ \ } \text{Vdc}
\]
4. Measure and record the dc voltage at the collector, base and emitter of Q2.

\[ V_{C2} = \text{___________} \text{ Vdc} \]
\[ V_{B2} = \text{___________} \text{ Vdc} \]
\[ V_{E2} = \text{___________} \text{ Vdc} \]

5. As a result of your measurements, transistor
   a. Q1 is reverse biased and transistor Q2 is forward biased.
   b. Q1 is forward biased and is transistor Q2 reversed biased.
6. Connect the AF Generator to the input capacitor C1.

7. While observing the signal on Channel 1 of the oscilloscope, adjust v1 for a 20 Vpk-Vpk square wave output at a frequency of 1kHz.
8. With the oscilloscope in the Dual Mode (CH1 and CH2), connect channel 2 of the oscilloscope to the base of Q1.

**Figure 3-13**

- CH 2 Oscilloscope Settings
  - Vertical Deflection 5V/cm
  - Coupling DC
  - Trigger CH1, Internal
Figure 3-14

The positive and negative transitions of the input square wave (CH1) are differentiated by C1 and R1.

These negative and positive spikes are applied to the base of Q1 (CH2). The positive spike raises the base-emitter junction of Q1 above cutoff momentarily, triggering it into conduction.

The negative spike at the base of Q1 is of no importance in this circuit.
9. Move the CH1 probe to the output at the collector of Q2.

Once Q1 begins conducting, C2 is forced to follow the negative excursion at the collector and discharges through R4. This action produces a negative voltage on the base of Q2, driving it into cutoff.

When Q2 goes to cutoff, its collector goes positive, coupling a positive pulse to the output circuit. In addition, this positive pulse is fed back through R2 to the base of Q1 holding it in conduction.

The width of the positive output pulse is determined by the time constant of C2 and R4.
10. While observing the oscilloscope display, momentarily place a 0.01\(\mu\)F sample capacitor across \(C_2\) to double its value.

11. Is there a direct relationship between the RC time constant of the timing components (\(C_2\) and \(R_4\)) and the output pulse width?
   a. Yes, an approximation of the width can be determined by calculating the RC time constant.
   b. No, \(C_2\) had no effect.
12. Move the CH2 probe to observe the AF Generator input trigger signal as shown.

13. While observing the oscilloscope display, increase the AF Generator frequency to 2kHz and then decrease the frequency to 500kHz.

14. While observing the oscilloscope display, increase the AF Generator frequency to 2kHz and then decrease the frequency to 500kHz.
   a. Yes
   b. No

15. Does the frequency of the positive output pulse change?
   a. Yes
   b. No

16. Underline the correct answer. The width of the positive output pulse is determined by the RC timing circuit and is (dependent, independent) of the width of the AF Generator input trigger signal.

Name: ___________________________ Date: ____________

Instructor approval: ___________________________
Review Questions

1. Prior to the input trigger, the monostable multivibrator output condition is in the in the
   a. set state.
   b. reset state.
   c. input/reset state.
   d. output/set state.

![Figure 3-18](image_url)
2. The output pulse width of a single-shot multivibrator is determined by which of the following?
   a. Trigger frequency
   b. Trigger width
   c. Trigger amplitude
   d. Timing RC circuit
3. In the stable condition of the monostable multivibrator circuit used in this exercise, the transistor(s)
   a. Q1 and Q2 are both on.
   b. Q1 and Q2 are both off.
   c. Q1 is on and Q2 is off.
   d. Q1 is off and Q2 is on.