Circuit 2 Bistable Multivibrator

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

Discussion

The bistable multivibrator is a multivibrator that has two stable states. These are referred to as the set state and the reset state.

At any given time, it can be in either of these two states.

It will remain in the last state to which it was switched until an input signal is applied that causes it to switch to the opposite state.
The circuit used to accomplish this basically consists of two dc coupled transistor switches.

They are cross-connected collector-to-base so that when one transistor is turned on its output signal allows the other transistor to turn off.

Thus, there is always one high output and one low level output.
When $V_{cc}$ is first applied to the circuit, both Q1 and Q2 tend to conduct. However, because both sides of the circuit are not evenly balanced; one transistor will conduct more than the other.

For example, assume that Q1 conducts more than Q2. As a result, Q1 collector voltage decreases more rapidly than Q2.
The negative-going voltage at the collector of Q1 is coupled through feedback resistor R2 to the base of Q2. This voltage acts to reduce the forward base-emitter voltage on Q2, thereby decreasing its conduction.

As Q2 decreases conduction its collector voltage increases. Since Q2 collector voltage is fed back through R3 to the base of Q1, the forward bias-emitter bias on Q1 increases. This, in turn, tends to allow Q1 to conduct more, reinforcing the action still further.

As a result, Q1 goes into saturation and Q2 goes into cutoff.
In this state, the multivibrator is said to be in the RESET state. This is because the SET output at the collector of Q1 is at a low potential and the RESET output at the collector Q2 is at a high potential.

The SET state would require a high potential at the collector of Q1 and a low potential at the collector of Q2.

**Note:** The choice of which output is the SET and which is the RESET is usually arbitrary, but is often determined by the requirements of the circuit it is used to drive.
Because the bistable multivibrator remains in one of two stable states until switched, it can be used in the following circuits:

- latching circuit
- digital memory circuit
- switching circuit
- counting circuit
- frequency divider circuit
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, C2 - Capacitor, 0.002µF
- C3 Capacitor, 100pF
- Q1, Q2 - NPN Transistor, 2N2219A
- R1, R4 - Resistor, 1KΩ, ¼ W
- R2, R3 - Resistor, 22KΩ, ¼ W
- R5 - Resistor, 10KΩ, ¼ W
- CR1, CR2 – Diode, 1N4004
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 bistable multivibrator circuit as shown.

2. Adjust the variable positive dc power supply so that $V_{cc}$ equals 9.0 Vdc.

In the following procedure steps you will demonstrate the operation of a multivibrator that requires a dc level on the set and reset inputs to change state.
3. For a moment, connect R5 (10K) from the base of Q2 to the +9V. Remove R5.

   This momentarily dc level action at the RESET input of Q2, triggers the circuit to the SET condition.

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

   $V_{c1} = \underline{\text{Vdc}}$

   $V_{b1} = \underline{\text{Vdc}}$

   $V_{e1} = \underline{\text{Vdc}}$
5. Measure and record the dc voltage at the collector, base, and emitter of Q2.

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

6. As a result of your measurements, the SET state of the circuit necessitates that
   a. Q1 is reverse biased and Q2 is forward biased.
   b. Q1 is forward biased and Q2 reversed biased.
7. For a moment, connect R5 (10K) from the base of Q1 to the +9V. Remove R5.

This momentarily dc level action at the SET input of Q1 triggers the circuit to the RESET condition.

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

\[ V_{c1} = \text{__________ Vdc} \]

\[ V_{b1} = \text{__________ Vdc} \]

\[ V_{e1} = \text{__________ Vdc} \]
9. Measure and record the dc voltage at the collector, base, and emitter of Q2.

\[ V_{c2} = \text{_________ Vdc} \]

\[ V_{b2} = \text{_________ Vdc} \]

\[ V_{e2} = \text{_________ Vdc} \]

10. As a result of your measurements, the RESET state of the circuit necessitates that

a. Q1 is reverse biased and Q2 is forward biased.

b. Q1 is forward biased and Q2 is reverse biased.
To SET the multivibrator, a positive voltage is applied to the base of Q2.

To reset it, a positive voltage is applied to the base of Q1.

☐ 11. Explain the transistor switching action when a positive dc trigger is applied to either base of Q1 or Q2.
12. Reduce the variable positive DC power source to zero.

In the following procedure steps, you will modify the circuit to demonstrate the operation of a triggered bistable multivibrator.
13. Modify the circuit by adding the following components as shown:
   - Capacitors C1, C2, C3
   - Resistor R5
   - Diodes CR1, CR2,
   
   Do not connect the generator at this time.

14. Adjust the variable positive dc power supply so that $V_{cc}$ equals 9.0 Vdc.
15. Connect the AF Generator to the input capacitor C3.

16. Connect channel 1 to the junction of v1 and C3.

17. While observing the signal on Channel 1 of the oscilloscope, adjust v1 for a 20 Vp-k Vp-k square wave output at a frequency of 1kHz.

CH 2 Oscilloscope Settings
- CH1 Vertical Deflection 10V/cm
- CH2 Vertical Deflection 5V/cm
- Horizontal 500μS/cm
- Coupling DC
- Trigger CH1, Internal
- Mode Dual (CH1 and CH2)
18. With the oscilloscope in the Dual Mode (CH1 and CH2), connect channel 2 of the oscilloscope to the RESET output of Q1. Trigger on channel 2.

**Figure 2-19**

- Vertical Deflection 5V/cm
- Coupling DC
- Trigger CH2, Internal
19. Observe the RESET output signal on channel 2. Measure the time period of one complete cycle.

Time period = ___________ μS

20. Calculate the frequency of the RESET output signal.

Frequency = ___________ Hz

\[ F = \frac{1}{T} \]
21. Underline the correct answer.

The RESET output signal on channel 2 is (twice, one-half) the frequency of the input signal frequency on channel 1.

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

23. Can the triggered bistable multivibrator circuit act as a frequency divider for different input frequencies settings?
   a. Yes
   b. No

Name: _______________________________________  Date: _____________

Instructor approval: ____________________________________________
Review Questions

1. Which of the following is true statement?
   a. A bistable multivibrator is free-running.
   b. A bistable multivibrator has one stable state.
   c. A bistable multivibrator has two stable states.
   d. A bistable multivibrator has no stable states.

2. Which of the following statements is false?
   a. A bistable multivibrator has a timing circuit that determines its on time.
   b. The bistable multivibrator must be externally switched to change states.
   c. When the SET output is high, the RESET output is low.
   d. When the RESET output is high, the SET output is low.

3. To RESET this multivibrator, a positive voltage is applied to the
   a. collector of Q1.
   b. base of Q1.
   c. emitter of Q2.
   d. base of Q2.

Figure 2-22