**TRANSISTOR SWITCH INVERTER**

OBJECTIVES

When you complete this experiment, you will be able to:

1. Build, test, and demonstrate a bipolar inverter switch.

2. Build, test, and demonstrate a MOSFET inverter switch.

MATERIALS REQUIRED

* 2N3904 npn transistor
* IRFD110 or 2N7000 MOSFET (or equivalent)
* 10 kΩ pot
* 470 kΩ, ¼ W resistor
* 1 kΩ, ¼ W resistor
* 10 kΩ, ¼ W resistor
* 1 kΩ, ¼ W resistor
* DMM
* Oscilloscope
* Function generator (with de or TTL output)
* DC power supply

INTRODUCTION

There are two ways that a transistor is used: either as a switch or as an amplifier. To use the transistor as a switch, you either turn it on or off. Biasing a transistor so that it conducts creates a closed switch. Biasing the transistor so that it does not conduct creates an open switch.

Both BTJs and MOSFETs may be used as switches. MOSFETs are the most common today, but BJTs are still widely deployed where beneficial. In this experiment you will work with both types.

PROCEDURE

1. Construct the BJT inverter circuit shown in Figure 1.

2. Initially connect the base resistor to ground to simulate a 0-V input. Measure the VCE output.

3. Connect the 10 kΩ base resistor to +5 V. Measure VCE, VBE, and VCB.

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| Figure 1 |
| Figure 2 |
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4. From your data, is this transistor saturated? Explain.

5. *Note:* Look up the minimum hFE in the transistor data sheet to verify your answers.

6. Using the values of resistance in Figure 1, calculate the base and collector currents when the transistor conducts.

7. Given the hFE in the step above, is the transistor saturated?

8. Connect the base resistor to the function generator TTL output (0 to 3.5 V). Set the function generator for a frequency of 100 kHz. Observe the input and output signals on the oscilloscope simultaneously. What is the relationship between the input and output signals?

9. Use the horizontal sweep control to spread the output signal so that you can see the rise and fall times. Measure the rise time (tr) and fall time (tf). Use the special measurement features on the oscilloscope if available.

10. Build the MOSFET inverter shown in Figure 2.

11. Apply power to the circuit. Initially set the pot so that the gate-source voltage is zero. Measure the drain output voltage (VDS).

12. While monitoring the DC output voltage from drain to ground, slowly turn the 10 kΩ pot to apply voltage to the gate. Monitor the DC gate voltage with the DMM. At some point, the drain voltage should begin to drop sharply. As soon as it drops to some very low value (<1 V) and no further increases in gate voltage produce a lower output, stop varying the pot. Measure the pot arm voltage. This is the gate threshold voltage (VTH). You may want to repeat this step again just to be sure you find the gate voltage just at the point at which the output first drops to its low value. Record the drain output voltage with VTH applied.

13. Disconnect the 10 kΩ pot, and connect the gate of the MOSFET directly to the function generator output. Set the function generator to produce 12-V p-p square waves at a frequency of 100 kHz. Does the circuit work OK? Describe what you see. Explain what is going on.

QUESTIONS

1. What is the output voltage of a transistor switch with the input at zero?

2. Which transistor, BJT or MOSFET, has the lowest output voltage with the input at a high positive value?

3. How would the output be affected if a load resistor was connected between the output and ground?