SUPPLEMENTARY LABORATORY MANUAL

SC1005 : Digital Logic

Wiring & Troubleshooting Digital Circuits

COMPUTER ENGINEERING COURSE
COMPUTER SCIENCE COURSE

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WIRING AND TROUBLESHOOTING DIGITAL CIRCUITS

1. OBJECTIVES

1.1 To outline the general wiring procedures for digital circuits.

1.2 To introduce the student to troubleshooting procedures.

1.3 To list some of the common faults found in digital circuits.

2. WIRING PROCEDURES

2.1 Figure 1 shows a logic IC mounted on a typical prototype circuit board which is also commonly known as a “bread board”.

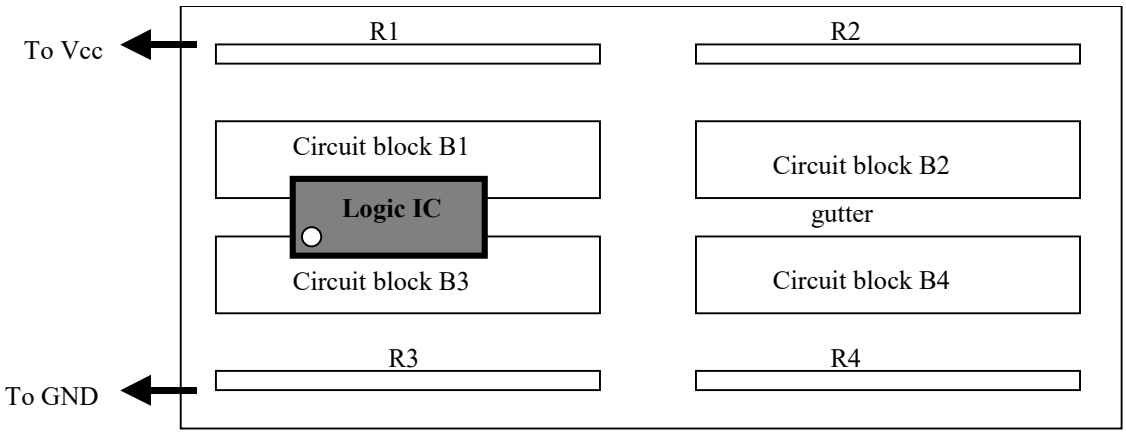

Figure 1 A typical bread board with a mounted IC

2.2 On this circuit board, there are four horizontal rows of holes, two at the top (R1, R2) and two at the bottom (R3, R4). Each of these rows are internally connected to form a bus. However, the four rows are **not** connected to one another. These rows are usually used to provide Vcc and GND to the circuit board.

2.3 There are also four circuit blocks (B1, B2, B3 and B4) on this circuit board. Within each circuit block, each column of holes are internally connected. However, different columns are not connected to one another. The four circuit blocks are also not connected to one another. **An IC should be mounted such that it sits across the gutter between two circuit blocks** as shown in Figure 1. All the metal pins on the IC should be fully inserted into the holes to ensure proper contacts.

2.4 After mounting the necessary ICs, the logic circuit should be wired up neatly using properly stripped wires. The wires should be laid around the IC such that the IC can be removed easily from the bread board without having to first remove the wires.

2.5 **Do not** apply power to the logic circuit while you are still wiring it up.

2.6 If it is necessary to remove an IC, always use an IC puller. **Never** remove an IC with your fingers or with a pair of pliers.

3. TROUBLESHOOTING

A digital circuit does not always function properly once it has been wired up. The problem can be due to human error or circuit faults. In such a situation, you will need to troubleshoot the circuit. In troubleshooting, you first establish that there is a fault with the circuit, next you isolate the cause of the fault, and finally you rectify the fault. The following steps are recommended to systematically troubleshoot a logic circuit:

(a) Visually inspect the circuit to make sure that the circuit is correctly wired up. Look out for loose or damaged wires and bread boards, missing or wrong components and connections. Note that a logic output should only be connected to a logic input (say, of another gate), but not to another logic output.

(b) Make sure that the correct Vcc is being applied to the circuit. You can make use of the digital multimeter (DMM) to check this. Note that every integrated circuit chip requires a pair of Vcc and GND connections.

(c) Study the circuit diagram and learn how the circuit is supposed to operate normally. Work out the logic flow from inputs to outputs.

(d) Examine the circuit operation by using different logic input combinations and record the test results. If the circuit operates normally, there is no need for further troubleshooting. Otherwise, proceed to step (e).

(e) Analyse the test results recorded in step (d) and select a possible location for the fault.

(f) Using the knowledge obtained in step (c), perform input and output checks at the suspected location. If nothing appears abnormal, return to step (e). Otherwise, carry on to step (g).

(g) Once the location of the fault has been identified, you will proceed to determine the actual fault and rectify it. The next section gives a list of common faults in digital circuits.

4. COMMON FAULTS IN DIGITAL CIRCUITS

4.1 **Defective components**: Components normally fail because of age, excessive current due to improper design, improper connections or overheating. **Connecting Vcc and GND wrongly to the IC is one of the most common cause for overheating.** Digital ICs can suffer from four types of internal failures:

(a) inputs or outputs shorted to ground or Vcc
(b) inputs or outputs open
(c) shorts between pins other than ground or Vcc
(d) internal circuit failure

This fault can easily be rectified by replacing the faulty IC.

4.2 **Power supply**: All logic ICs use voltage to represent logic levels, thus a faulty power supply with the wrong voltage level can cause ICs to malfunction. This fault can be easily identified by using the digital multimeter to check the Vcc of all ICs.

To rectify the problem, replace the power supply.

4.3 **IC loading problems**: When a logic output is used to drive a large number of logic inputs, the device fan-out can be exceeded. In such a case, the voltage levels cannot correctly represent the logic levels. To rectify this problem, reduce the number of inputs connected to an output or use a buffer.

4.4 **Improper input signal characteristics**: A digital circuit output is expected to respond to a set of inputs in a specific way. However, this can be true only if the input signal meets the requirements of the digital circuit. Such requirements usually include voltage, current, frequency, noise level and etc. The input signal can be easily checked by using a digital multimeter or an oscilloscope.

5. CONCLUSION

A concise guide has been provided on the wiring and troubleshooting of digital circuits. This guide is in no way comprehensive and the students are encouraged to pick up additional troubleshooting techniques in the course of carrying out laboratory experiments on digital circuits.

As modern digital circuit design is increasingly adopting a software approach using Hardware Description Languages (HDLs) and programmable logic devices, logic designers who have access to such tools may not need to “get their hands dirty” these days. Nevertheless, having some exposure to physical circuit connection and experience in troubleshooting will enable beginners to appreciate the physical and electrical aspects of logic circuit design.

Important:

Connecting Vcc and GND wrongly to the IC is one of the most common cause for IC overheating and damage.