

Digital circuit design using Small Scale Integration (SSI) devices

Digital Electronic Circuits

Laboratory session 2

1 Material

- Components: 1x7400, 1x7410, 1x1K resistor, 1xLED.
- Instruments: power supply, waveform generator and oscilloscope.
- Other: breadboard and wires.

2 Introduction

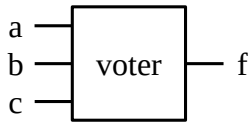
The 7400 series of Integrated Circuits (IC's) is a collection of chips that include many basic and not-so-basic digital functions. The most simple chips use a small scale of integration (SSI) and include just a few logic gates: inverters, AND, OR, NAND, NOR, etc. that can be connected on a breadboard using external wires to quickly implement simple digital circuits that can be tested in the laboratory. Once tested, a final Printed Circuit Board (PCB) may be fabricated and the chips soldered to it to produce a final implementation of the project.

Building complex digital circuits using SSI devices is time-consuming and error-prone, therefore SSI devices has been largely displaced by configurable chips (like FPGA's) for digital circuit prototyping and implementation. However, building digital circuits with SSI devices on a breadboard is still a great way to understand how digital circuits come to life from a bunch of logic gates.

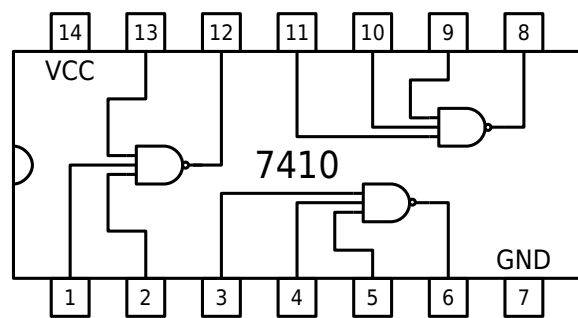
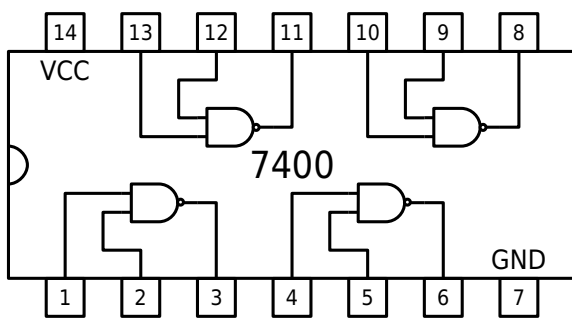
In this lab exercise, we will implement and test a simple digital circuit using SSI devices on a breadboard.

3 Theoretical exercise

1. Design a voting circuit with three input ports (a, b, c) and one output port f using strictly only NAND gates (no inverters allowed). Use the Karnaugh map technique to design an optimum circuit.



2. Draw the interconnections to implement the design using a 7400 and a 7410 IC's.



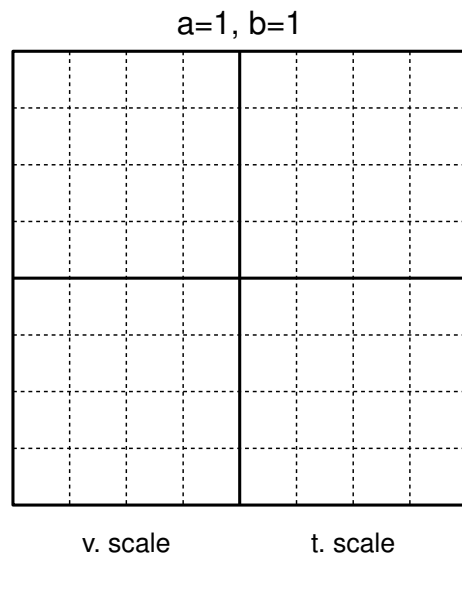
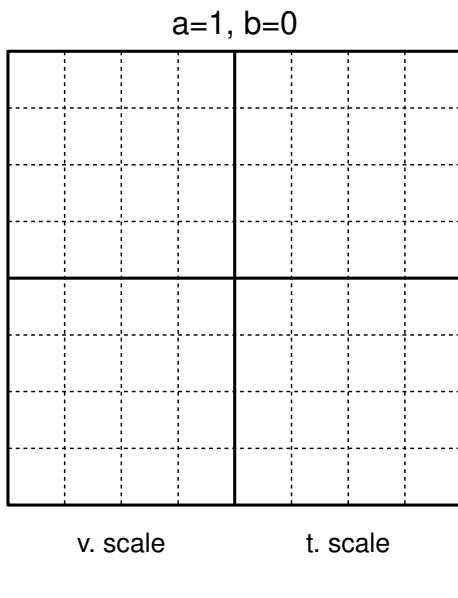
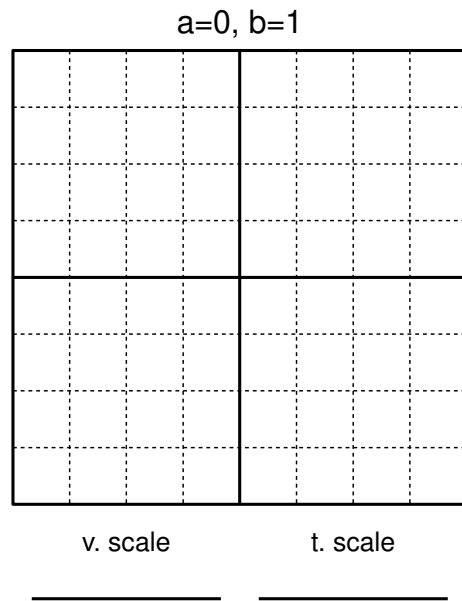
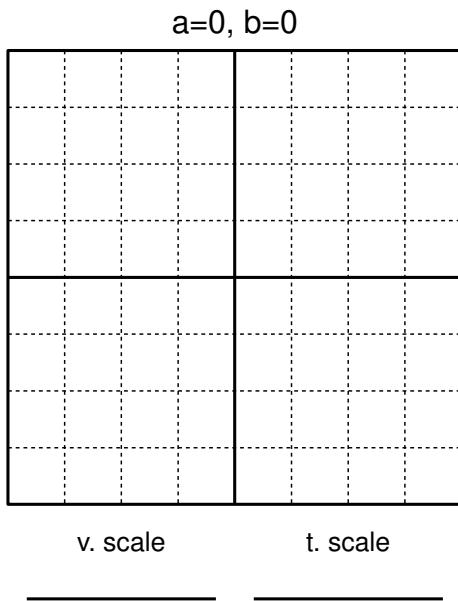
4 Practical exercise

1. Mount the circuit using a breadboard and wires. Polarize the IC's at 5V using a power supply.
2. Connect wires to the circuit input terminal (a, b, c) and LED with a current-limiting resistor to the output terminal (f) so that the LED will activate when $f=1$. Connect the input terminals to 0 (0V) and 1 (5V) going through all possible combinations and derive the truth table of the circuit from the output observed at the LED. Compare with the expected behavior of the voting circuit from section 3.

If the results differ or the circuit just do not work, check the circuit and try to find out what is wrong. You may use these guidelines:

- Is the power supply connected and set to 5V? If the voltage cannot be set and there is a red light in the voltage source there may be a short-circuit. Disconnect the power supply from the circuit and check the connections.
 - Are the wires coming from the voltage supply correct? Sometimes the wires are broken inside the plastic cover.
 - Are the IC connected to the voltage supply (VCC and GND)?
 - Use a measure instrument (voltmeter or oscilloscope) to measure the voltage in the circuit nodes starting at the input nodes. Check if the voltage at each node is what is expected by taking into account the expected value of the inputs and the function of the gate connected to the node. If a gate's output is not what you expect and the IC is correctly polarized, the IC may be damaged. Try with another one.
3. Generate a 50KHz square signal from 0V to 5V using the waveform generator. Connect the square signal to input port c. Test the circuit in the following conditions and draw the waveforms of c and f as observed in the oscilloscope.
- a) a=0, b=0 b) a=0, b=1 c) a=1, b=0 d) a=1, b=1

Check that the output is what expected from the circuit operation.



4. For the case in which a=0 and b=1, measure the delay from a transition in c to a transition in f for both fall (t_{pHL}) and rising (t_{pLH}) edges.

$t_{pHL} =$

$t_{pLH} =$