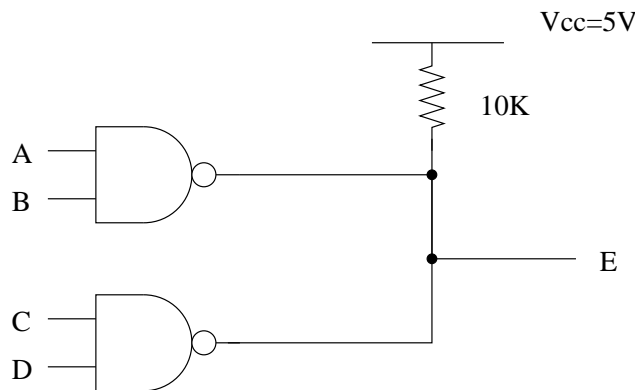


Solution to ELE12EDP 2002 exam's Electronic Design questions

25th October 2004

Question 2. (Project Hardware)

The circuit shown below uses open-collector logic gates (**e.g. 03**). The inputs to the circuit are marked by A, B, C, and D, and the output of the circuit is marked by E. Determine the logic function of the circuit and draw another circuit that is equivalent to this circuit.



The output of an open-collector gate is either logic 0 or Z (electrically disconnected). Each gate is an o/c NAND, so if both inputs are logic 1 then the output will be logic 0, otherwise it will be Z.

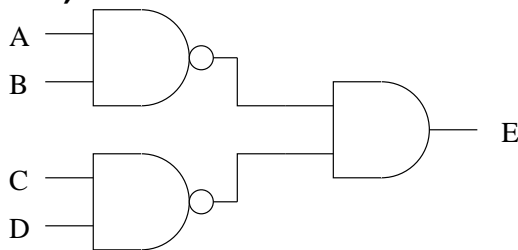
If both gates' outputs are in Z state, then point E is electrically connected only to the 10k pullup resistor and is therefore at 5V (and therefore logic 1); otherwise, at least one gate output will be logic 0, and then E will be logic 0 too.

Putting these facts together, E is 1 when (either A or B is 0) and (either C or D is 0). Thus, the logic function of the circuit can be expressed as:

$$E = (\overline{A} + \overline{B}).(\overline{C} + \overline{D}) = (\overline{A.B}).(\overline{C.D})$$

A simpler way to come to the same conclusion is by remembering that a pull-up at the junction of two or more open-collector outputs acts as an AND (and is called a WIRE-AND). Thus, visually, we have two NAND gates followed by one AND.

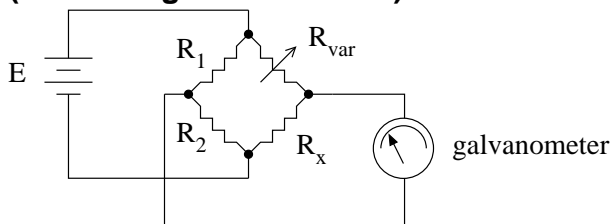
An equivalent circuit using regular logic gates (e.g. two 00 and one 08) is:



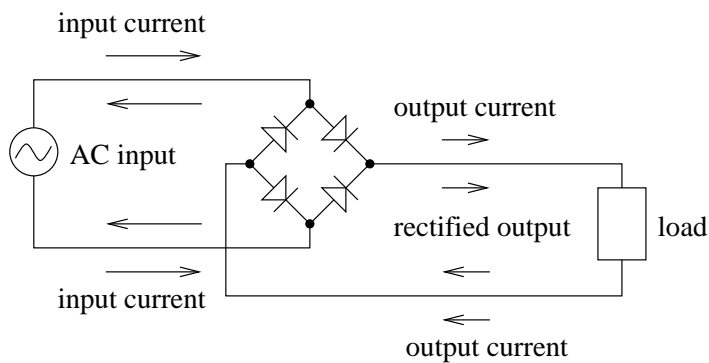
Question 3. (Electronic Wiring)

1. Sketch a circuit that is commonly drawn **diagonally**.

Two such 'diamond-shaped' circuits are the Wheatstone bridge (containing four resistors)



and the full-wave rectifier (four diodes).



2. Name the circuit you just sketched.

Wheatstone bridge or **full-wave rectifier**.

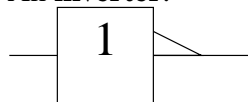
3. When would a **multi-element** circuit component be drawn in a **detached** representation?

When its elements are used in separate areas of the schematic, as often happens when they are needed in different functional blocks (modules) of the circuit. For example, the 74LS279 contains four SR latches, which in the fire alarm project may be used for the Remote Latch, the Special Alarm Enable latch, and elsewhere.

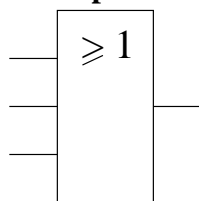
Question 4. (Logic Symbols)

Draw the IEEE standard symbol for:

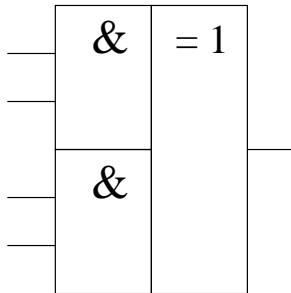
1. An **inverter**.



2. A **3-input OR** gate.

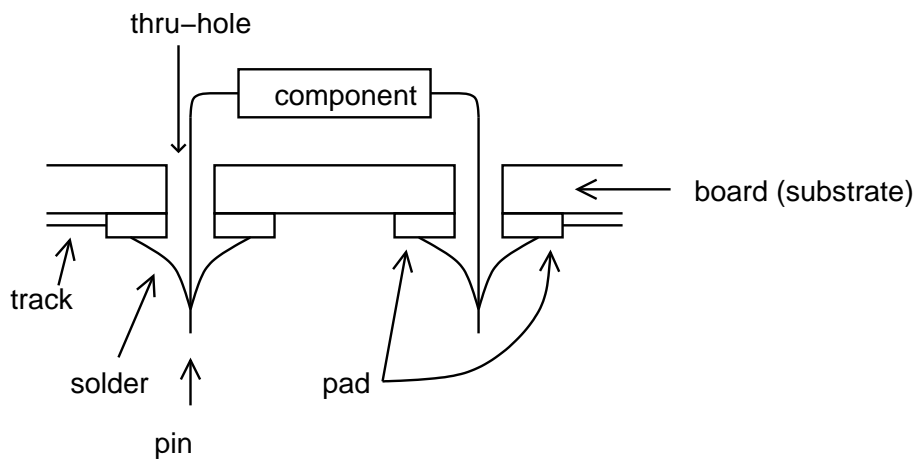


3. A **single** device consisting of *two 2-input AND* gates followed by *one 2-input XOR* gate.



Question 5. (Interconnection of Circuits)

1. What does it mean to **color-code** the wiring in your circuits?
Use one color for each signal. Every wire that carries signal A has the same color. As far as possible, use different colors for different signals. If you run out of colors, then you may reuse the same color for different signals, but only at a safe distance from all other uses of that color. You must not reuse red or black as they are dedicated to VCC and GND.
2. Give two (2) ways in which a **breadboard** (proto-board) is **less reliable** than a **printed circuit board** (PCB).
 - (a) **Wires easily fall out of a breadboard when it's moved suddenly, but tracks stay on a PCB.**
 - (b) **On a breadboard, a circuit of moderate complexity produces a dense forest of wires which makes it difficult to debug and fix the circuit.**
 - (c) **Cheap breadboards' binding posts fall apart.**
 - (d) **Breadboards have significant and extensive stray capacitances (due to the long wide metal strips used in every row and column) so they attenuate badly at high frequencies.**
3. Carefully draw a **thru-hole** connection, labelling all the constituent parts.



Question 6. (Computer Aided Design of Circuits)

1. What are the advantages of CAD packages (such as Protel) for schematic design over drawing a circuit diagram on paper?

Some CAD advantages:

Neater; easier to modify; automatic electrical rule check, netlist, bill of materials; already in electronic form, so cheap and easy to produce many exact copies and to distribute them to colleagues.

2. Does CAD have any disadvantages, and if so, what are they?
 - (a) **Need a computer, a possibly expensive CAD program, and electric power, to create, view and edit the schematic;**
 - (b) **Significant skill and work are required to draw new devices in CAD.**
3. Why is the placement of components important? What should the designer aim to achieve when placing components?

Components with many interconnections are often logically related in the same module (or subcircuit) so it makes good sense to place them near each other. In any case, they are best placed close together so that those interconnections don't get in the way of other connections in the circuit.

Whereas, components with few or no interconnections have no reason to be in each other's immediate vicinity.

4. The 74LS05 IC contains six gates of what kind?
Open-collector inverters.
5. What is the spacing between the pins of a 74LS05?
One-tenth of an inch, because ICs are an American invention from the days when metric was rarely used in the USA even by technical professionals.
6. When describing a track, what does the word “mitred” mean?
Changing direction by 45 degrees for a short distance (then by minus 45 degrees to the original direction) to avoid an obstacle.
7. In what situation are bus tracks mitred?
Typically when there are IC pins in the way to which a bus track should not connect.