Ali Baba, the well-known second-hand gold and jewel merchant, is worried. His advisers have been telling him that basing his cave security on vocal commands like "Open Sesame" is just too passé and, besides, is fraught with danger. After all, any passer-by could so easily overhear him chatting to his door. Even if they didn't pick up the secret password and steal his treasure, they would be bound to question his sanity, and what ambitious businessman can afford to be saddled with that sort of a reputation in these hard times?

The security advisers' advice is to get right up-to-date and install a proper electronic locking system, complete with the latest electronically activated flame-throwers to incinerate anyone who enters the wrong combination into the lock.

Ali has agreed, in spite of his nostalgic love for the old system. It was very kind to him in days gone by, after all, but in his position, he can hardly argue with their point about the chance passer-by...

As an expert in digital electronics employed by Baba Black Sheep Ltd. (a wholly-owned subsidiary company which was originally set up by Ali as a philanthropic gesture to provide gainful employment for unemployed thieves), you have been allocated the task of designing the part of the system which recognises the combination.

Your subcircuit will have

- 8 input lines, divided (logically) into 2 groups of 4. You may assume that each group of 4 wires will continuously carry one (BCD\(^1\)) digit of the input combination.

- A 1-bit active-high output line to the door-opening mechanism. This will have the value TRUE when the input combination is 37, and FALSE otherwise.

You need not perform any minimisation of the Boolean Expressions generated during your analysis, nor do you need to specify the chips to implement the design.

(Part B)

Oops! Just after you finished the combination-recognition circuit, Ali hired a new security adviser, who has told him that he's just plain CRAZY to build the combination permanently into the hardware. If anyone else should ever finds the piece of paper Ali has written the

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\(^1\) BCD: Binary-coded decimal. Numbers encoded using four bits for each digit. Bit combinations 0000 - 1010 are used to encode the decimal digits 0 - 9. Bit combinations 1011 - 1111 are unused. Hence 57 is encoded as 0101 0111, and not 00111001.
combination on, (his memory isn't quite as reliable as it used to be) Ali's security system would be completely undermined. Then, not only would Ali lose his equity, but all his gold would flood the market, which would fuel a new inflationary spiral and make life a misery for Ali's old mum (Mum Baba), who is on a fixed income.

Furthermore, the sudden appearance of such a large amount of cash would assuredly come to the notice of the Grand Vizier, and the subsequent investigation into the cause of Ali’s sudden poverty and his previous source of wealth could prove extremely embarrassing, and prevent his return to prominence as a philanthropist and patron of the local Gilbert and Sullivan Society.

The new instructions from on high (although Ali has retained the rustic cave-front because it's good for business, and has even enhanced it by installing fake spider's-webs and water-drips in the entrance-passage-roof - though NOT near the merchandise - he himself occupies a modern air-conditioned office further up the hill, accessible only by high-powered magic carpet) are to make a more versatile combination-recognition circuit. Specifically, it should be possible to load a new combination into it.

Worse (from both your point of view and Ali’s) one of your former colleagues (delicate enquiries have shown the colleague to be former in just about every important respect, having substituted for the wax in the production, by the lost wax process, of the original bronze version of Ali's hottest-selling item of recent times, the critically-acclaimed limited-edition statue curiously entitled "Terrified Traiterous Electronics Whiz"), is no longer in a fit state to supply the circuit design for controlling the closing of the door. Your circuit will therefore also have to issue this command to the door circuitry.

So your contribution to the new system has the following specification:

Inputs:
- 8-bit combination (2 4-bit BCD digits, as before)
- 1-bit input from New-Combination switch
- 1-bit ENTER signal

Outputs:
- 1-bit output to flamethrower activation device
- 1-bit output to door-opener
- 1-bit output to door-closer

When the user hits the ENTER button, the flamethrower will be activated if the value of the input combination does not match the stored value. If, however, the input combination does match, then one of two actions is taken, depending on the value of the New-Combination switch. If it is False, the door will open and, after staying open for one clock cycle, shut again. If it is true, the circuit will load a new combination when the user hits the ENTER button. Subsequent operation will use this new combination instead of the old one.

No marks are allocated to designs for the flamethrower.

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