Session 1620

Designing an EMS Emergency Beacon

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Abstract

This paper presents the details of an undergraduate senior design project in our design technology course[1-3]. The main idea of this design is to have a keypad that could be carried on board an ambulance to communicate with the units available on houses in neighborhoods so that in an emergency situation ambulances can easily identify where the emergency call is coming from. As the ambulance is approaching the neighborhood where the emergency is taking place, the attendant could push a code that is unique to the house where assistance is needed, which would activate a beacon located in front of the house. This would greatly limit the time spent on finding the house which is ordinarily spent on trying to read numbers that are not always where they are suppose to be. In this design, each of the houses has its own unique three-digit code that can easily be changed. The data lines are the only portion of the system that is shared between the ambulance and the houses.

Introduction

This project is mainly a digital circuit with a little analog involved in the design[4-5]. A keypad is used in conjunction with an encoder to send a BCD signal to a home unit. If the information from the keypad matches the code of the home unit a flashing beacon will be activated. The keystone of this design lies in the 7485 chip, which is a four-bit magnitude comparator. This chip offers the features needed for this design. Sequencing and latching circuitry allow the beacon to only become active when the correct code is entered in the correct order. Another feature that is desired is that all of the systems be independent and have the ability to change the code easily. Each of the houses has its own unique three digit code that can easily be changed. The data lines are the only portion of the system that is shared between the ambulance and the houses. This is obviously necessary for data transmission. The concept of the design is illustrated in figure 1.

The Design Process

I. The Keypad and the 74C922

The first question that arises is what type of keypad to use with this project. A 16-button SPST 4X4 Matrix type keypad is an appropriate choice, mainly because the IC 74C922 is a 4X4 Matrix keypad encoder. The 74C922 has an internal key debounce and key scanning circuits, which will eliminate the need for an additional circuitry. This debounce circuit is controlled by an external capacitors connected to the oscillator (OSC) pin and the key mask bounce (KBM) pin. The only stipulation is that the KBM capacitor be a value ten times (10X) that of the OSC capacitor. The values of .01uF (OSC) and .1uF (KMB) are chosen merely for convenience.

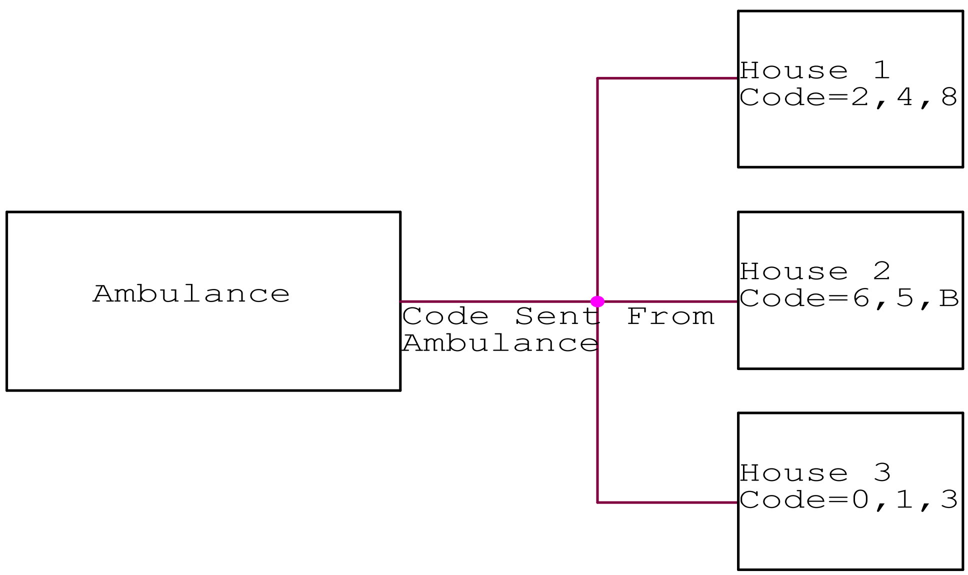

Fig. 1: Block Diagram of Design

The 74C922 connects to a switch matrix that is four columns by four rows. When none of the keys are pressed the column outputs are at logic low "0." However, when none of the keys are pressed the row inputs are pulled to logic high "1" by internal pull-up circuits. When a key is pressed the encoder converts this into a four-bit nibble, which is sent out onto the data bus lines. The final circuit is shown in figure 2. The NOT Gate is for Enabling Purposes.

II. 7485 Comparator

After the encoded signal is placed onto the data bus, the BCD signal is split onto three separate four-bit buses. Each of these buses is wired into a four-bit magnitude comparator, which is the keystone of this design. This comparator takes two four-bit straight binary or BCD and compares them mathematically. The final result is shown on the three different outputs, A=B, A>B and A<B. The output A=B is the only output that is of concern for this project, mainly because if the codes do not equal each other, an output is not desired.

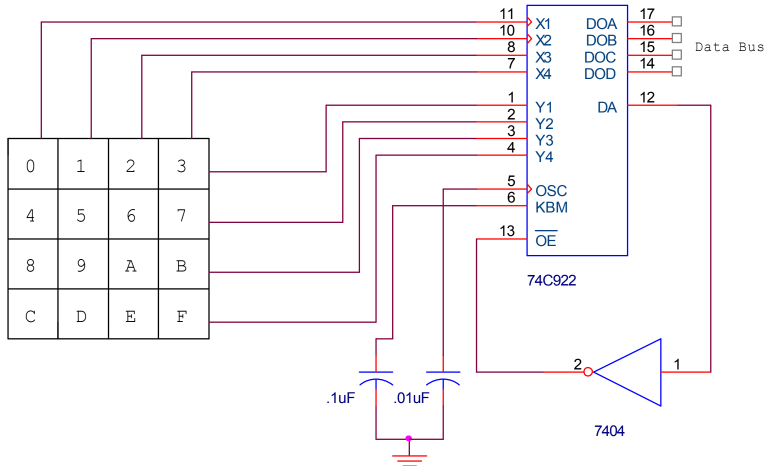

Fig. 2: Key Pad with Encoder

III. Coding

DIP switches are used to produce the twelve-bit code (three digits, four bits for each digit). The code can easily be changed by changing the position of the DIP switch to give the corresponding BCD input to the comparator. After the DIP switches set the code, it is then inputted to comparator at the "A" input. This code is compared with the code from the keypad encoder, which is given to the "B" input, and either gives a HIGH or LOW at the A=B output. An example of the encoding system is shown in Figure 3.

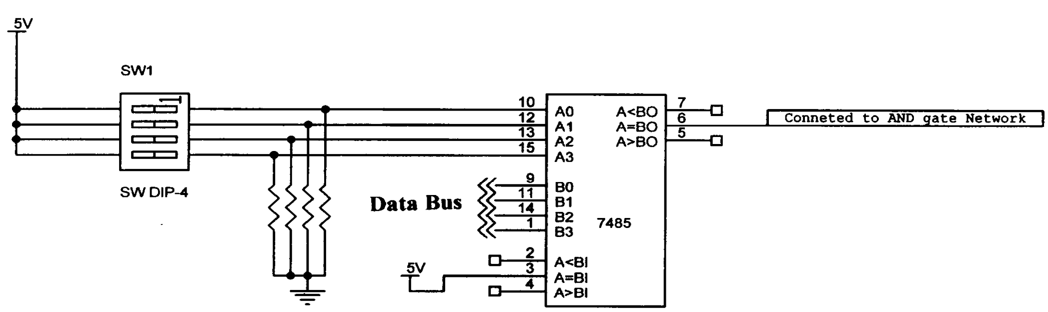

Fig: 3: Coding Circuit

IV. Sequencing

The next problem that presents itself is how to ensure that the beacon will only come on when the correct numbers are pushed in the correct order. A way of accomplishing this is to design an AND Gate network. This network consists of three AND Gates cascaded together to give one final output.

An AND Gate only gives a HIGH output when both inputs are HIGH. This network works by connecting the output of the first AND Gate to one of the inputs of another AND Gate. The second input connected to the output of one of the 7485 chip, this allows the output to only be activated when the keys are pushed in the correct order. Figure 4 shows the schematic of the AND Gate network. The 5 volts connected to the input of the first gate is to ensure that when the input goes HIGH, the output also goes HIGH.

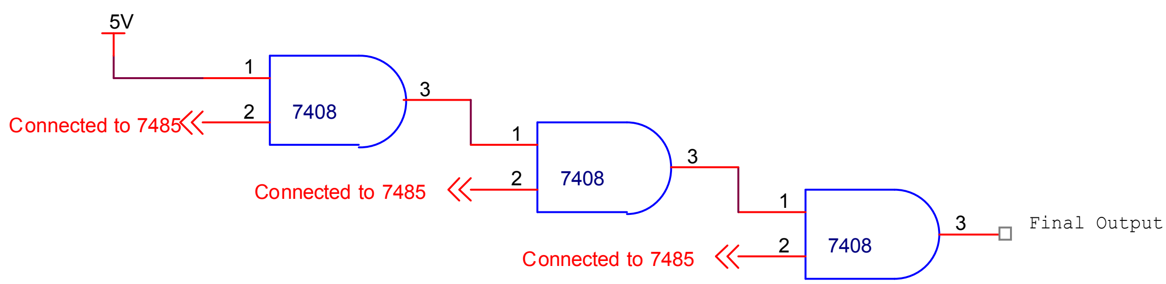

Fig: 4: AND Gate Network

V. Latching

However, this is not the final problem that must be overcome. When a key is pressed on the keypad, the BCD code goes to the comparator, where it is compared with another code, then if the codes match the A=B, output becomes active HIGH. Then, the same process happens with the other two numbers in the code and the A=B outputs go to the AND Gate network where the final output is activated. But, this is not what happens. As soon as a key is released the outputs of the comparators return to their LOW state. Thus, the final output never becomes active.

Using latches to hold the output HIGH even after the key is released solves this problem. A J-K Flip-Flop would seem to be the first choice to hold the output HIGH, but an NOR Gate latch fits this design better mainly because the NOR latch does not need an external clock to trigger the response needed. Figure 5 shows a NOR latch and its corresponding truth table.

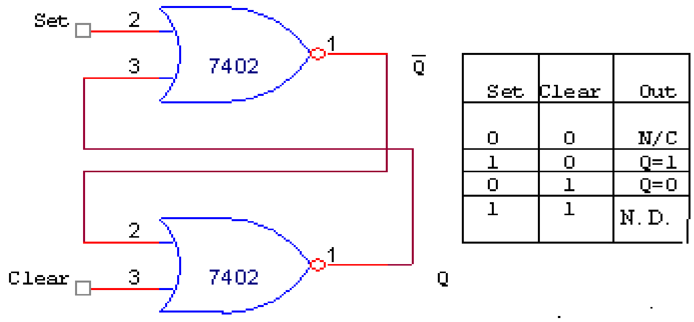

Fig. 5: S-R Flip-Flop

Each AND Gate output is connected to the Set pin of the NOR latch and the Q output is then connected to the input of the next AND gate. Using these latches allow the outputs of the AND Gates to remain HIGH after the key is released. Thus, allowing the final output to become active. A push button switch controls the reset. The reset switch is connected to the Clear pin and 5 volts. When the switch is closed the Clear input is sent HIGH, this resets the output (Q) LOW.

VI. Final Output

The final output is a flashing LED. The flashing LED is chosen for this design solely to grab the attention of the approaching ambulance. A regular LED could be used, but the ambulance could miss this. In this design, a regular LED would turn on and stay on until the unit is reset. The flashing feature attracts more attention.

VII. Power

Each of the home units has a separate power supply controlled by a LM7805 Voltage Regulator. This regulator takes the 9 Volts, supplied by a battery, and regulates it down to 5 Volts. The regulator has a capacitor connected to the input as well as the output. These capacitors are incorporated in the design for stability. The power design is shown in Figure 6. The final schematics for this design are shown in figure 7.

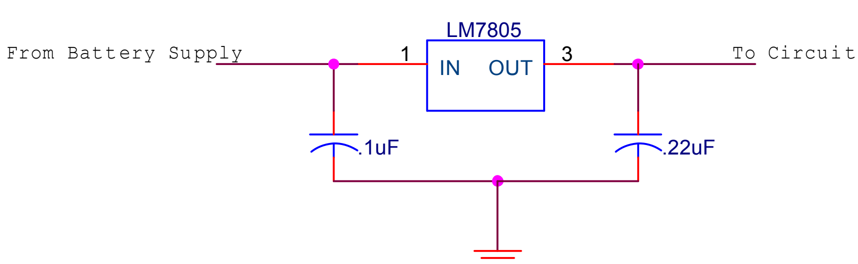

Fig. 6: Voltage Regulator

When wiring this circuit together it is paramount to remember to tie all of the grounds together. If the grounds are not tied together, the circuits will not have a common reference and the transmitted BCD will be "floating" compared to the home units. Tying the grounds together gives all the circuits a common reference.

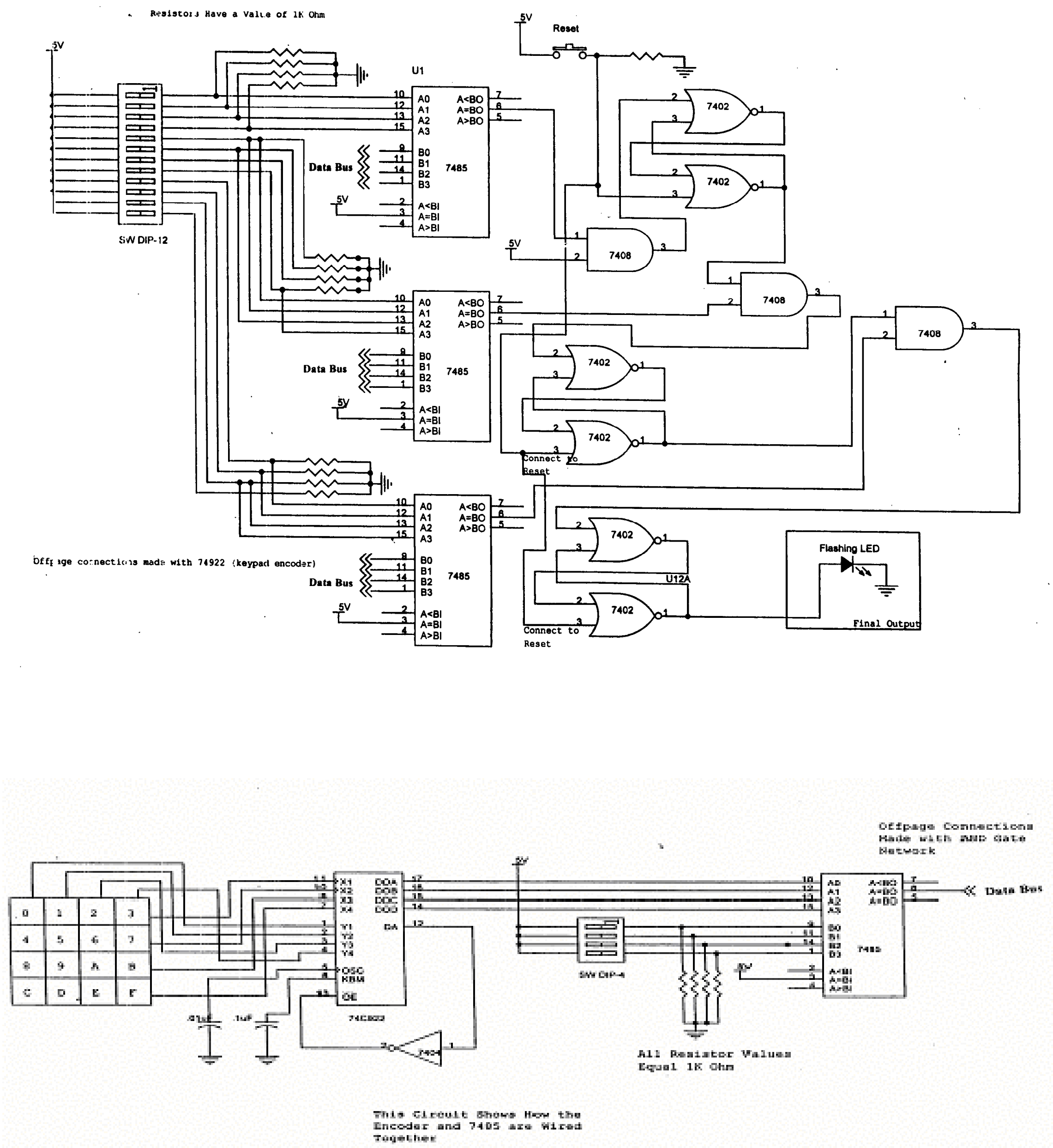

Fig. 7: Final Schematics for the Design

Conclusion

This design has the capability to be developed further. One possibility would be to have the control lie in the hands of the 911 operator, who would activate the home unit from 911 dispatch through the telephone lines. Another possibility would be to have the beacon activate as soon as 911 is dialed from the home. However, the ultimate hope is to make this design an infrared transmitter and receiver. The keypad could be carried on the ambulance and would transmit the code via infrared waves to the home unit that would receive and decode this information. This design is a wonderful learning experience, especially for familiarization with logic and switching circuits. It also gives the student an opportunity to design and debug the project.

References

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