NET1LAB HYBRD CLASS

Circuit Design Project

Final Circuit Design

Due - 04/18/2008

Group #5

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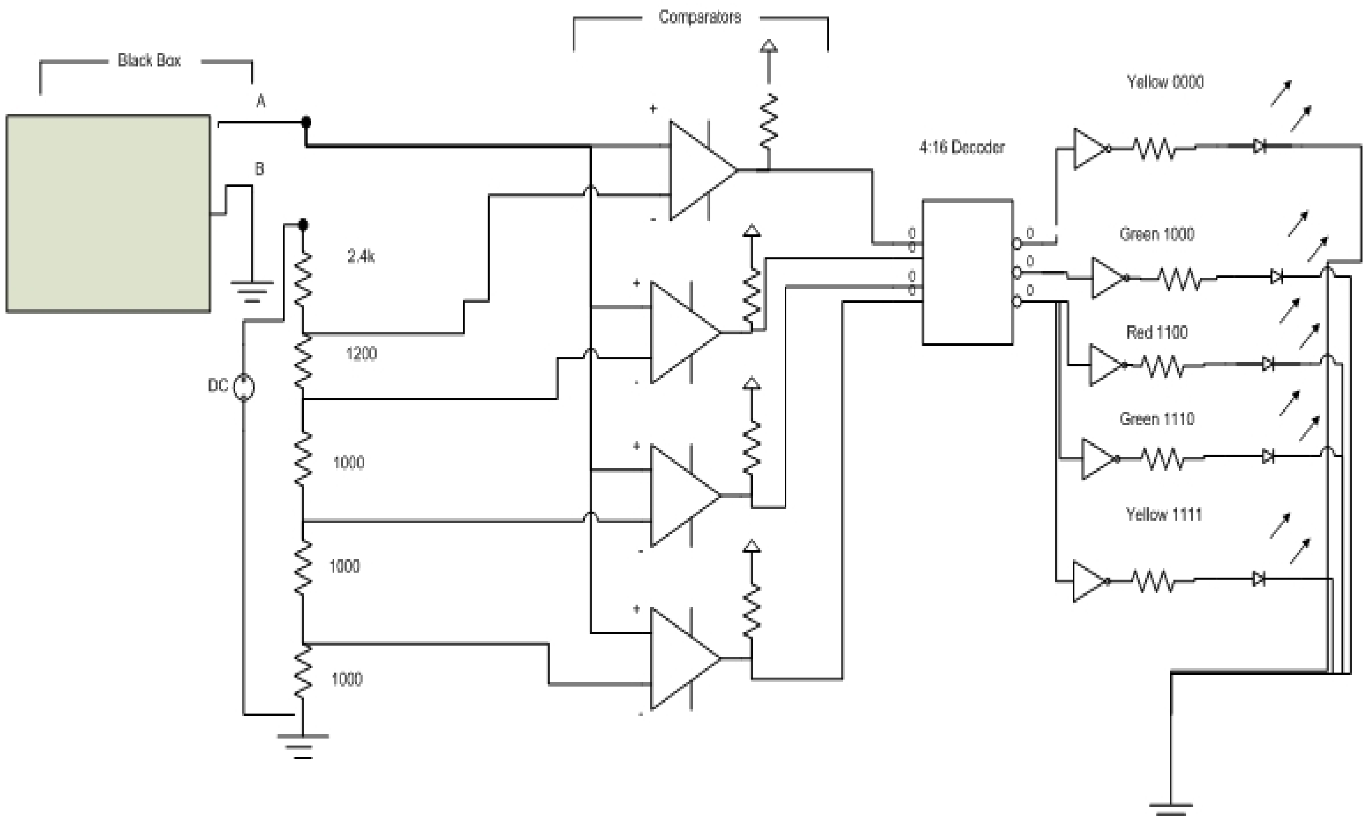
Our Circuit



Black Box
A
B
DC
2.4k
1200
1000
1000
1000
Comparators
4:16 Decoder
0
0
0
0
0
0
0
Yellow 0000
Green 1000
Red 1100
Green 1110
Yellow 1111

After the practical implementation of our circuit design on a breadboard, we have made a few adjustments to our initial circuit design to optimize performance, but we still maintained most of our initial circuit design ideas, as we found our initial circuit model to be quite efficient. The result is we have built a circuit that we have tested with various configurations, and we certify and guarantee that it will work perfectly under all stated criteria and constraints. This achievement was possible through the ingenuity and hard work of Donald King, Marlon McKinnie and Tolulope Kupoluyi with assistance from Dr. C. Kim.

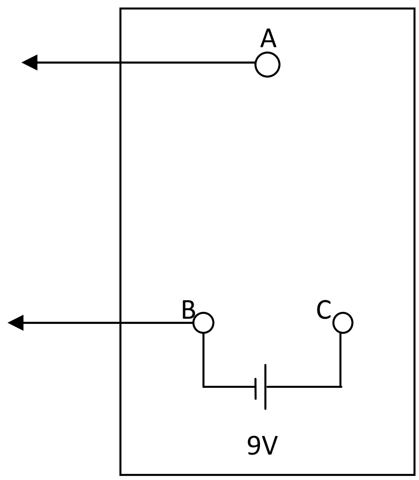
Apparatus:

Below is a final compilation of the parts we used and their quantity. It should be noted that we used as few components as possible in keeping with the given criteria.

- Quad Comparator Chip (LM339) - 1
- 4-line to 16-line decoder/demultiplexer (74LS154) - 1
- Inverter Chip (7404) - 1
- Light Emitting Diodes (LEDs) – 5
- 12V Power Source
- Resistors

Final Circuit Design:

Our final circuit design plan gives a detailed breakdown of the circuit we constructed starting from the two outputs from the black box. A diagram of the black box is given below showing the outputs from terminal A and terminal B.



The internal configuration of the black box is made up of three resistors, one 9V power source and three terminals. Five different arrangements of the internal components of the black box were given, each with an indicating LED color. Each different configuration produces a different voltage at terminal A, while terminal B always has a fixed voltage of 9V. Because none of the terminals in the black box is grounded, it was necessary to ground the output from terminal B. The table below shows the given configurations, the voltages produced at each terminal and the indicating LEDs.

	Configurations	**V at Terminal A**	**V at Terminal B (GND)**	**Color of LED**
1	1-1-1	4.50	0.00	RED
2	2-0-1	6.00	0.00	GREEN
3	1-0-2	3.00	0.00	GREEN
4	3-0-0	9.00	0.00	YELLOW
5	0-0-3	0.00	0.00	YELLOW

We took the output from terminal A and branched it out into four wires (all the wires carry the same voltage) to provide inputs for our four comparators. Because we had only one input to the comparators to work with, it was necessary to introduce a new power source into our circuit design to provide the other inputs. This new power source has a value of 12V. Because the next part of circuit involved comparators, we needed different voltages to be fed into each of the comparators. To solve this problem, we applied the principle of the voltage divider. In series resistance, while the current through each resistor is the same, the voltage across each resistor differs according to the value of the resistor. With the resistors connected in series, the voltage at each node is different. Because we required 4 inputs, we required four different nodes and therefore five resistors. The node voltages we derived were **7.6V, 5.4V, 3.6V and 1.8V**. We then fed our four inputs into the (-) terminals of the comparators, while we fed the outputs from terminal A to the (+) terminals of the comparators. Since one quad comparator chip contains four comparators, we needed only one chip.

A comparator is an electronic chip of transistors that compares two input voltages at its (+) input terminal and (-) input terminal and returns an output by either closing its switch (**Ground**), or opening it. The principle of the comparator is if the voltage at the (+) terminal is greater than that at the (-) terminal, the switch is opened and the output is not connected to ground, but if the voltage at the (-) terminal is greater than that at the (+) terminal, then the switch is closed and the output is grounded. In addition, the comparator can only compare voltages at least 1.5V below its supply voltage. Therefore we used a separate voltage of 16V to power our comparator. It should be noted that the comparator has a maximum supply voltage of 38V.

So by comparing both input voltages, the comparator decides whether to connect its switch to ground (close) or not (open). Based on our circuit, we have included a table that summarizes this portion of our circuit depending on which configuration the connected black box contains.

Configuration	**V at terminal A (+)**	**Comparator 1**	**Comparator 2**	**Comparator 3**	**Comparator 4**
1-1-1	4.5v	Closed	Closed	Open	Open
2-0-1	6.0v	Closed	Open	Open	Open
1-0-2	3.0v	Closed	Closed	Closed	Open
3-0-0	9.0v	Open	Open	Open	Open
0-0-3	0.0v	Closed	Closed	Closed	Closed

The outputs from the comparator were then connected to our 4:16 decoder. A 4:16 decoder is an electronic chip that decodes four inputs A, B, C and D, into one of 16 mutually exclusive outputs. Because we have five different configurations to test for, we will only need to use 5 of the 16 possible outputs. We have provided a small truth table to show which of the 16 outputs will be used.

Configuration	**Inputs**	**Output Bit**	**Color of LED**
1-1-1	1, 1, 0, 0	0011	RED
2-0-1	1, 1, 1, 0	0111	GREEN
1-0-2	1, 0, 0, 0	0001	GREEN
3-0-0	1, 1, 1, 1	0000	YELLOW
0-0-3	0, 0, 0, 0	1111	YELLOW

From the table above, the ‘inputs’ to the decoder are the outputs from the comparators. Each ‘output’ represents 1 of the 16 possible outputs that can be gotten from the decoder. An input of ‘0’ going into the decoder represents a **grounded** output from the comparator, while an input of ‘1’ going into the decoder represents a **non-grounded** output from the comparator which has passed through the inverter. Whichever one output the decoder chooses for the combination inputs, it gives a value of **Active Low**. This output needs to be converted to a **High** to power the LEDs; therefore an inverter is used to invert the output from the decoder.

For the final part of the circuit, the three required LEDs are connected with resistors to the decoder and grounded at the other end. Which ever output that is processed by the decoder is connected to the equivalent LED, and therefore the LED turns on. We included an LED to represent each configuration in our circuit to demonstrate the accuracy of our circuit and to ensure that our design was as easy as possible to understand. Providing an LED for each configuration improves the overall clarity of the circuit.

Additional Instances:

Due to the versatility of our circuit design, it is possible to use the circuit to test several other configurations. As long as different configurations of resistors and other components are present in the black box, they will all produce different binary configurations in the 4:16 decoder. At present, only 5 mutually exclusive outputs are in use, therefore there are still eleven other possible configurations that could be tested with our circuit design. A possible use for our circuit is a traffic light, for which only a timer would be added.

Summary & Questions:

Why do you think you have the best circuit?

We think we have the best circuit because we were able to solve the problem statement with as few components as possible, which was one of the stated criteria of the project. While we only used three chips, other groups used more chips, making our circuit more cost effective and compact. Our circuit is also very easy to implement and understand; making it more marketable and attractive. A major reason why our circuit is the best is it provides the possibility to test more configurations without adding more parts. Because we used only 5 outputs from our 4:16 decoder, it is possible to test for several other configurations without adding any parts, while other groups would need to add parts to their design and even change their circuit logic. I think these reasons set our circuit design apart from the others as the best.

Why did you choose to demo your circuit first?

We chose the earliest time to demo our circuit because we were very confident in our circuit design, and we had tested it with various configurations with excellent results. We think other groups were not as confident in their circuit design, therefore they chose to demo after us. This is another reason why we had the best circuit design. We built it with care and precision; therefore we were sure it would work perfectly.

Was this group work?

Yes, it was group work. Each member of our group made a great contribution to each level of the project development. It improved our group work skills, and also helped us learn a lot from each other. It is very clear to see it was group work because each of our group members knew how the circuit worked and was involved in the circuit implementation.