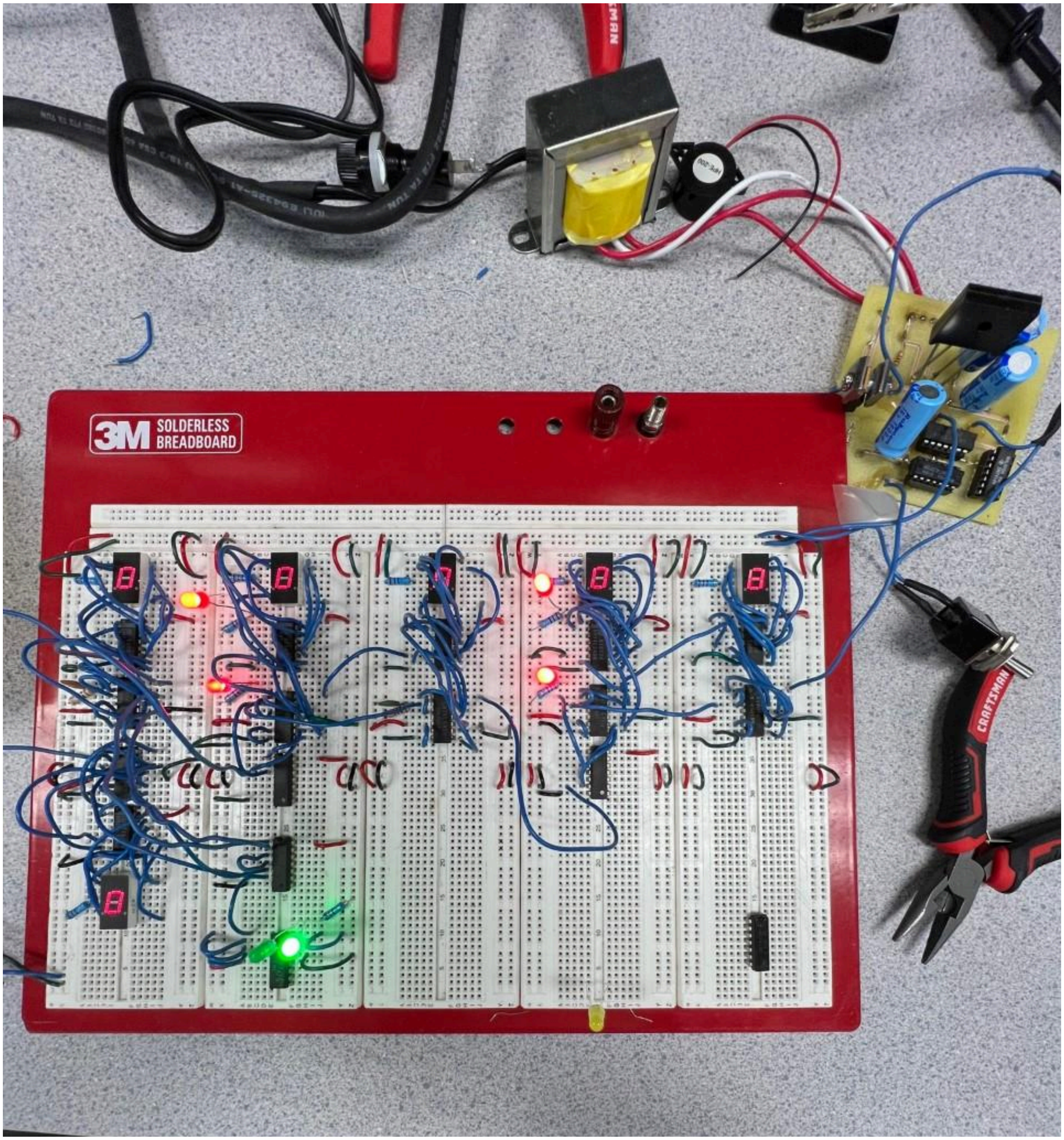
Lab 13 - Full Clock Project



Jason Cardente, Daniel Cardone, Ethan Herron, Jackson Staheli, Nick Vaughan, Henry Warfield (2/27/23-3/03/23)

Objectives:

- Create a working clock with the seconds, minutes, and hours

Materials List:

- [ ] Multisim
- [ ] Ultiboard
- [ ] Autodesk Inventor
- [ ] Makerbot
- [ ] Variac 130VAC
- [ ] Breakout box
- [ ] 10:1 Transformer
- [ ] 1kΩ Resistor (4)
- [ ] 1N749 Zener Diode (2)
- [ ] 7414 Schmitt Inverter (2)
- [ ] 1N4001 Diode (2)
- [ ] 7448 BCD to 7-Segment Decoder (12)
- [ ] M74 7-Segment Display (12)
- [ ] 7408 AND Gate (6)
- [ ] 7490 MOD-10 Counter (14)
- [ ] 7476 JK Flip-Flop (2)
- [ ] 1000uF Capacitor (3)
- [ ] 0.01uF Disc Capacitor (4)
- [ ] 1kΩ Resistor (4)
- [ ] 220Ω Resistor (22)
- [ ] Red LED (8)
- [ ] Green LED (4)
- [ ] LM7805 Voltage Regulator
- [ ] MDA970-1 Bridge Rectifier

Procedure:

1. To create a power supply we first had to create a circuit in multisim that could produce 5V DC output using a rectifier and regulator, the finalized version of which is shown below.

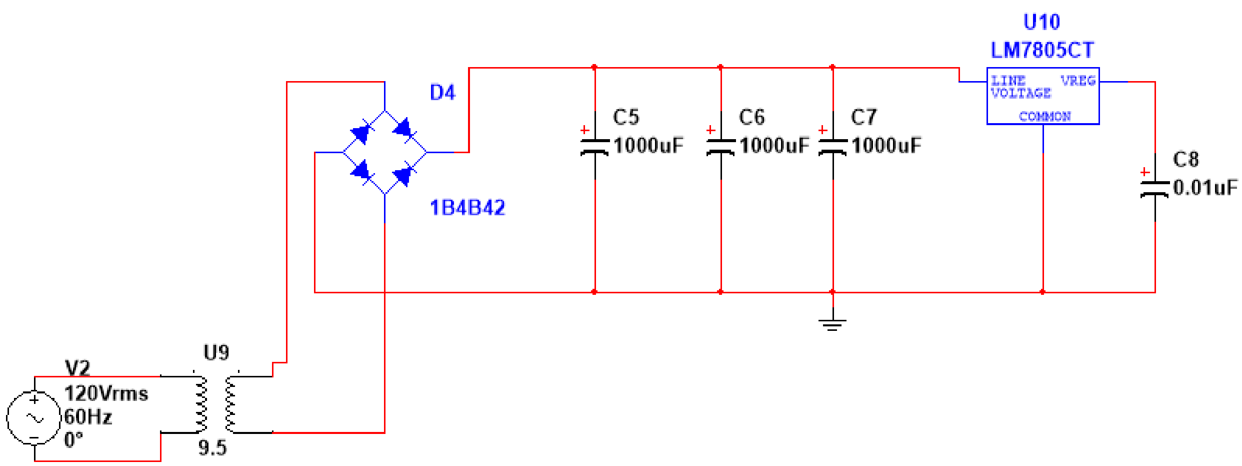


Figure 13-1: Finalized 5V Power Supply

2. We then needed to create another circuit in multisim that could produce a 60 pps (pulse-per-second) output which can be shown in figure 13-2.

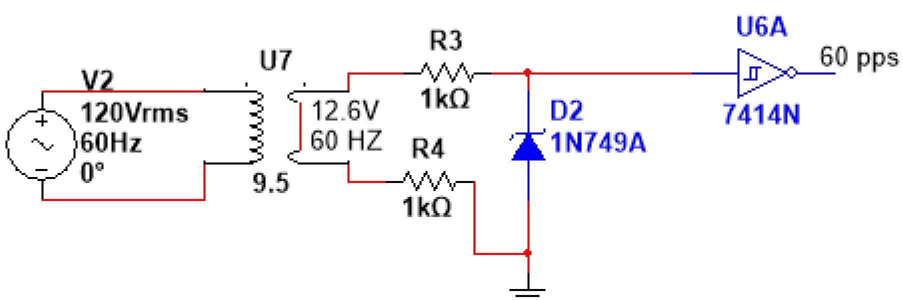


Figure 13-2: Finalized 60 pps circuit

3. Once we had the 60 pps, we could use a divide by 10 counter to make the signal become 6 pps and this can be shown in figure 13-3.

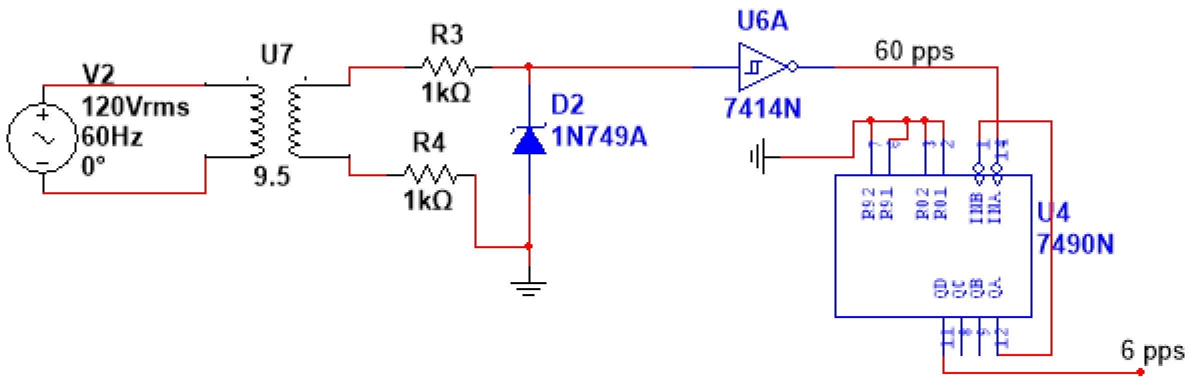


Figure 13-3: Finalized 6 pps circuit

4. Now that we were able to create a 6 pps signal, all we needed was a divide by 6 counter to make the signal become 1 pps which can be shown in figure 13-4.

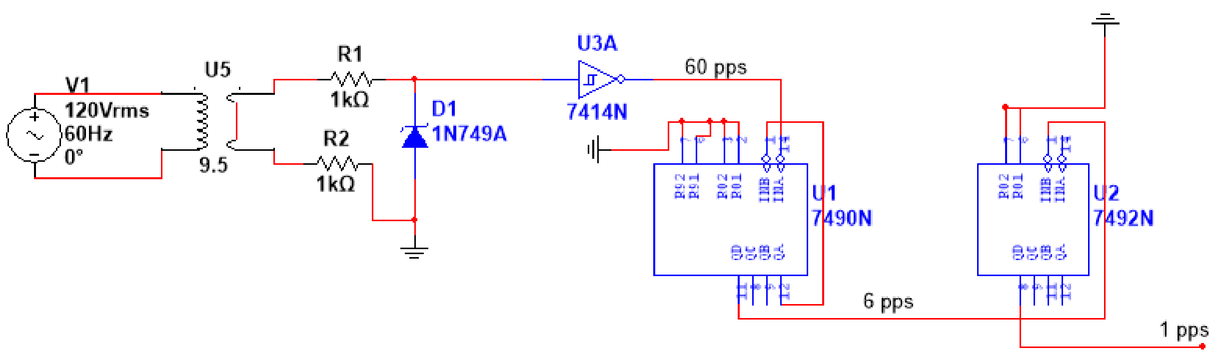


Figure 13-4: Finalized 1 pps circuit

5. Once we had both the 1 pps signal circuit and the 5V power supply circuit we were able to combine the two to create the 1 pps 5V power supply circuit which can be shown in figure 10-5.

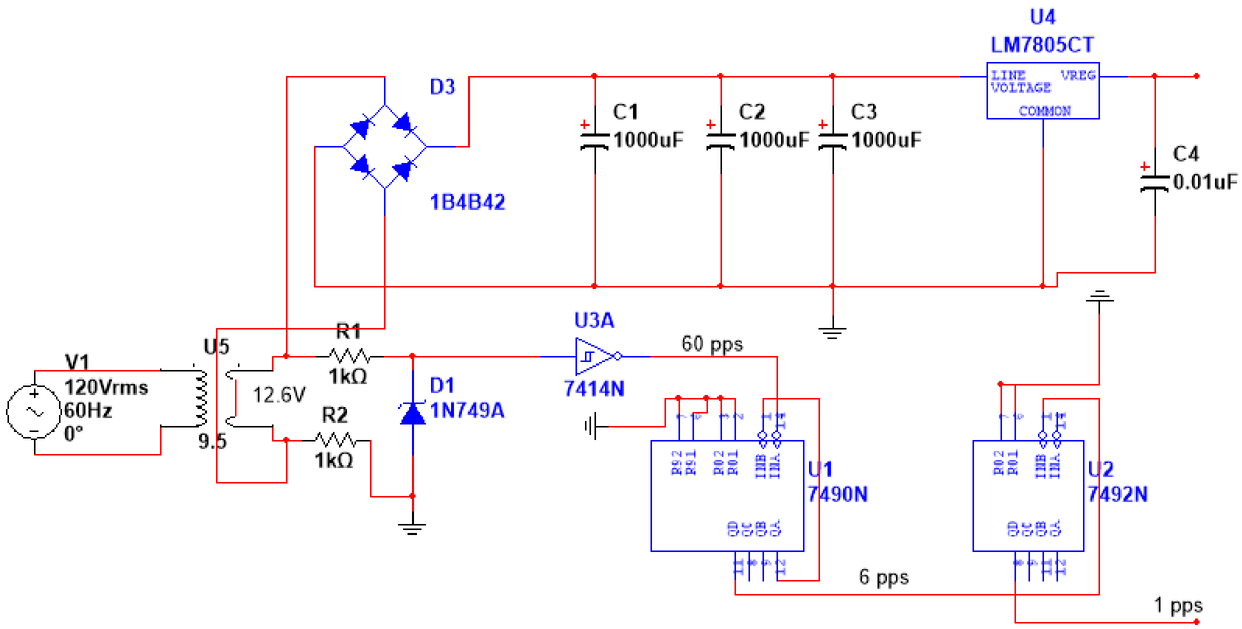


Figure 13-5: Finalized 1pps 5V power supply circuit

6. We then created the circuit on a breadboard to make sure it works before we started our Ultiboard.
7. We then created an Ultiboard for this circuit to be able to print and use and this can be shown in figure 13-6.

Figure 13-6: Finalized Ultiboard

[Ultiboard File Link]()

8. To create a digital clock that would show minutes and seconds we first created a circuit in multisim that could take in the output from the 1PPS DC Power Supply we made and display that output onto a 7-Segment display for both digits of seconds. This finalized circuit is shown below.

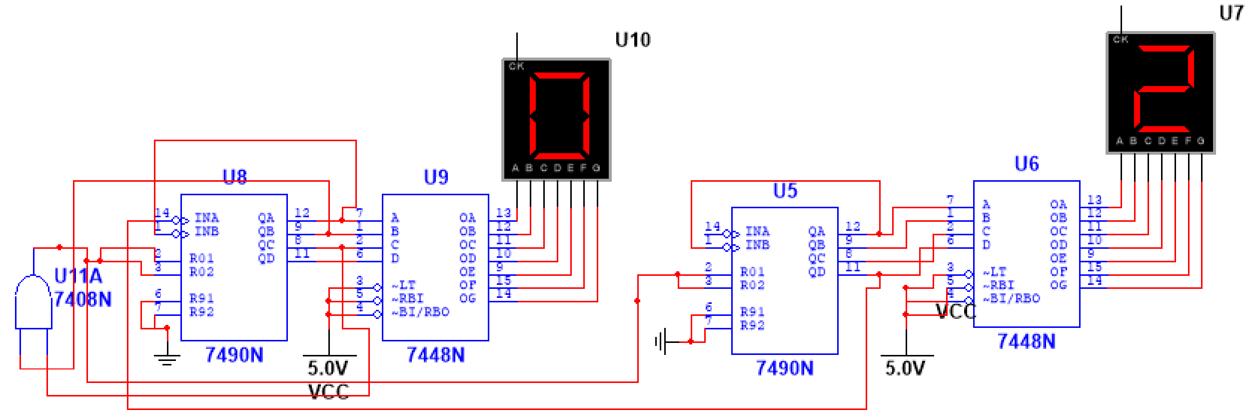


Figure 13-7: Seconds Counter

9. Once we had the completed circuit for the seconds, we recreated the same circuit to represent our minutes, connecting the output D of our last seconds counter to the CP_0 of our minutes counter.

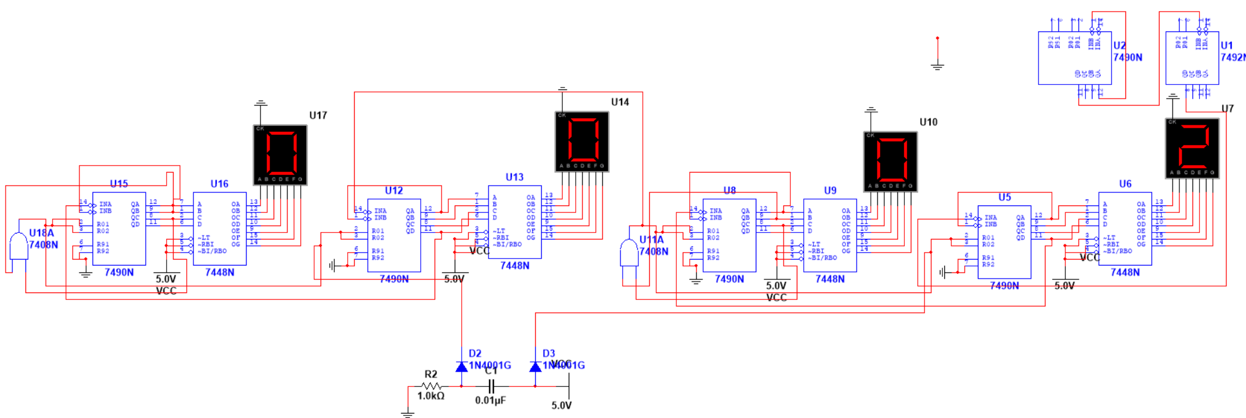


Figure 13-8: Seconds & Minutes Counter

10. Once both circuits are constructed and connected, the final circuit will display a clock that can count up until 59:59, as shown below.

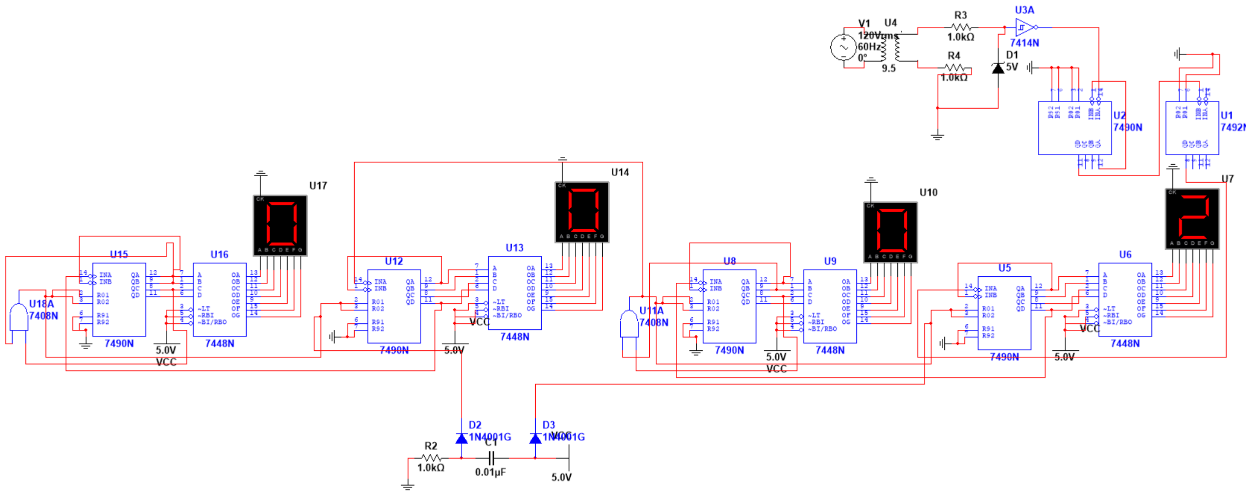


Figure 13-9: Complete Seconds & Minutes Clock

11. Using our seconds and minutes clock, we added the hours by using a Mod-10 and a Mod-3. Input A of the MOD-10 was connected to the AND gate of the tens digit in minutes and the Input A of the MOD-3 was connected to Output D of the MOD-10. Both of these were tied to a reset circuit, which took an AND gate that had its inputs tied to Output A (1) and Output B (2), with that output connected to the input of another AND gate, with the other input going to Output A of the Mod-3. This allows the circuit to reset only when it hits 13.

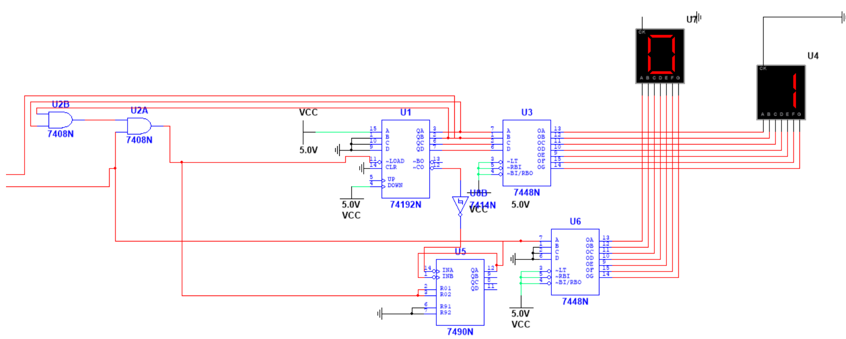


Figure 13-10: Hours Counter

12. We then created an indicator to show whether our clock was showing AM or PM, so we used a JK flip flop to accomplish this. This JK flip flop will give us a Q and a Q Not, which we connected to LEDs, so only one will be on at a time. The clock pulse was tied to the output of the reset circuit so the lights that are on will change when the clock is reset when it hits 13.

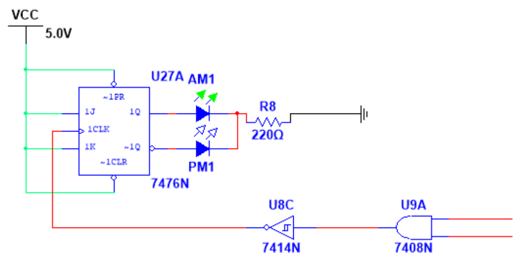


Figure 13-1: AM/PM Indicator

13. The complete circuit can be shown below, which includes the clock displaying seconds, hours, and minutes, along with an AM/PM indication.

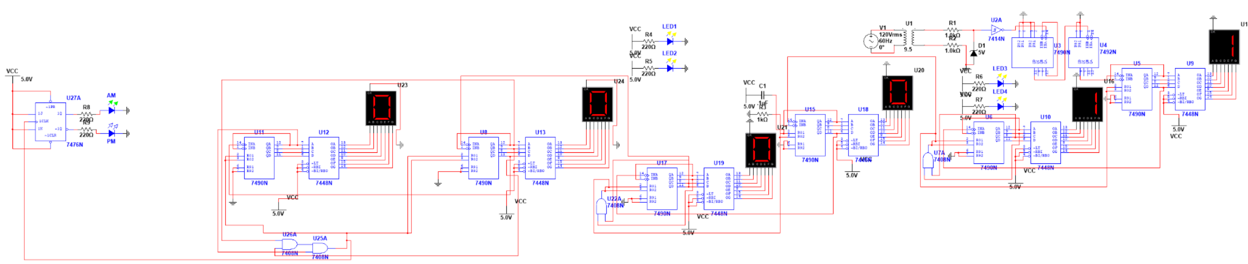


Figure 13-12: Seconds, Minutes, and Hours counter with AM/PM indicator

14. Using this circuit, we then transferred all of the decoders, displays, and AND gates to one board, and all of the counters to another board, and created test points on all of the connections between the two separated circuits. We then transferred these files both to ultiboard.
15. Using the autoplace tool and autoroute tool, we were able to create the ultiboard files for both of these and printed them onto circuit boards. The ultiboard files can be found below.

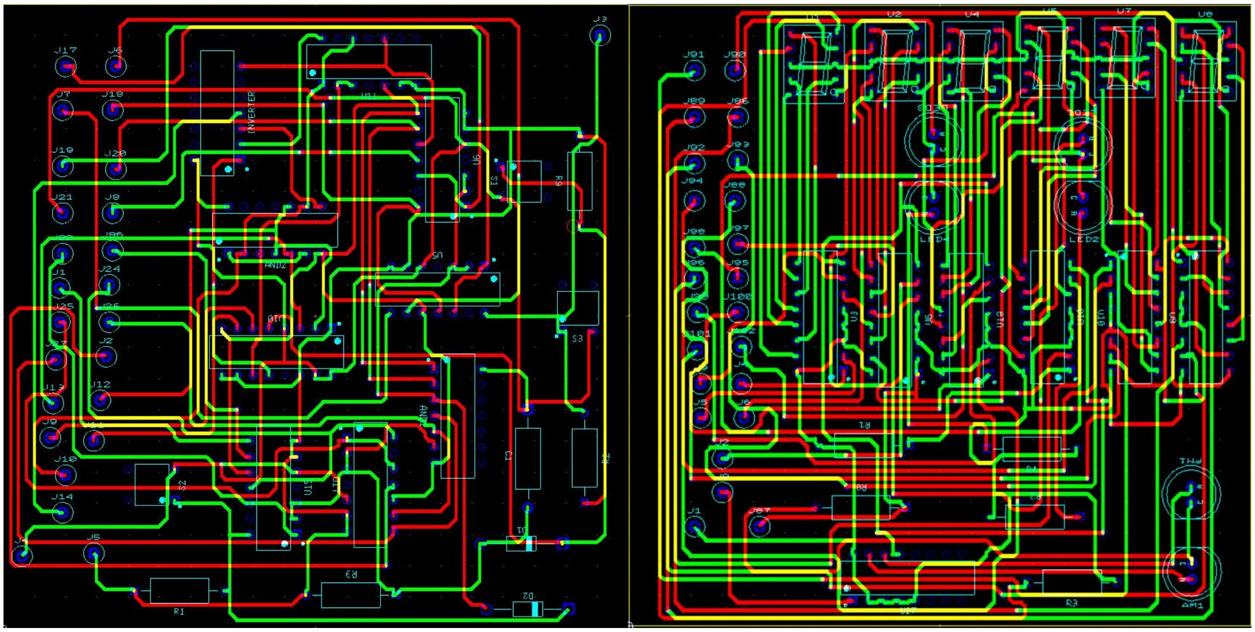


Figure 13-13: Finished Ultiboard for Counter (left) & Displays (right)

[Ultiboard Files]

16. Using Autodesk Inventor, we constructed a box and a lid that would hold our clock, with holes for the displays, set buttons, AM/PM indicator, the fuse, power cord, and an ON/OFF button. The files can be found below in Figure 13-14.

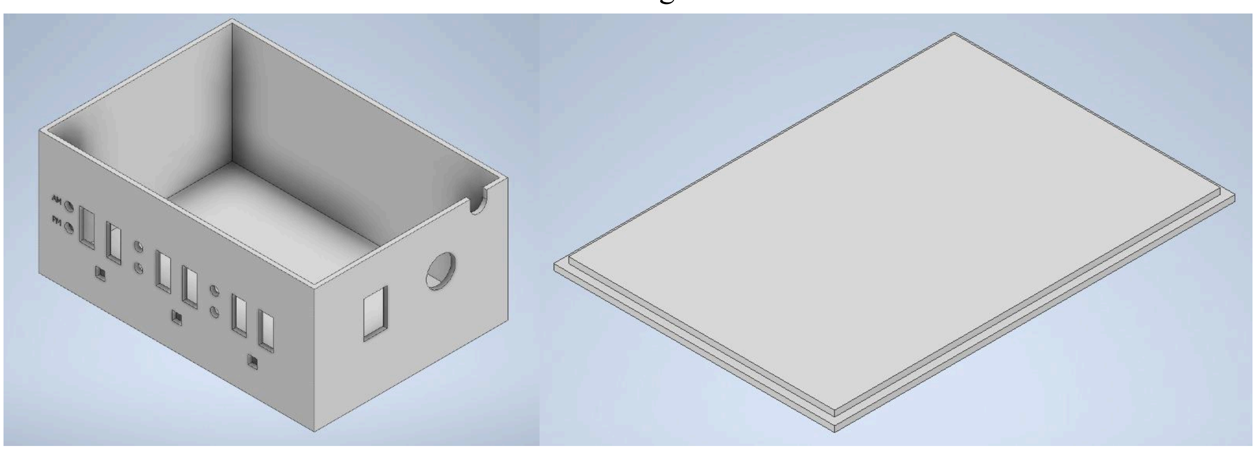


Figure 13-14: Finished CAD File for clock enclosure

[Clock Enclosure Files]

Discussion:

We had no difficulties to note while completing this week of the project.

Conclusion:

To turn the power supply into 1pps, you would need to use divide-bys. Starting with 60 pps, we used a divide-by 10 to get 6pps, then a divide-by 6 to get 1pps. To go from 60 pps to

6pps, we put the wave output into the clock input of the divide-by-10, and then put the Q_3 output received into the clock input of the divide-by-6, and the output of that gave us 1pps.

To continue this display of counting for more than the first second digit, you feed in the final output, D, into the CP_0 of the next counter so that it will start counting once the first counter reaches 9. Once this second counter reaches 6, it is reset to 0 using an AND gate on outputs B & C (0110). This output is connected to the reset of the counter, along with the clock input of the next counter for the first digit in minutes. This is repeated for the minutes.

These counters are used as divide-by 10s and divide-by 6s, to further reduce the PPS. The first counter (1st second digit) is used as a divide-by 10 counter which will give our second digit of seconds a 0.1 PPS. After this, for the first digit in minutes, a divide-by 6 is used in order to get a 1 pulse-per-minute for the first digit of minutes. Lastly, another divide-by 10 counter is used to get 1 pulse per 10 minutes, 0.1PPM, for the second digit of seconds. After this, we have a divide-by 6 counter which will give us 1 pulse-per-hour for the hours.

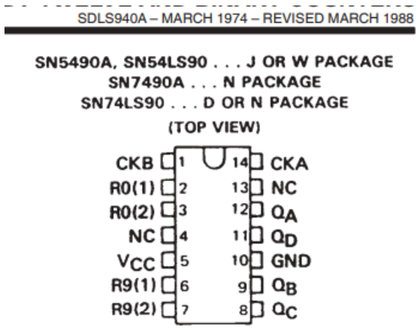
To create the hours of our digital clock, we used a MOD-10 and a MOD-3, which would let us get up to 12 hours. These chips were connected as the other ones were. The reset only triggered one three conditions. The first two conditions were that Output 1 and Output 2 must be high on the Mod-10, which would be a 3, then the last condition was that Output 1 must also be high on the Mod-3, which would have a 1 in the tens place. This creates a 13 which is impossible in a 12-hour AM/PM clock, so the circuit would reset.

Along with this reset, we added an indicator to show the difference in AM/PM. This was done by using a JK flip flop as it had two opposite outputs and only displayed a 0 or a 1. The clock input was connected to an AND gate that turns on when 12 is hit on the hours.

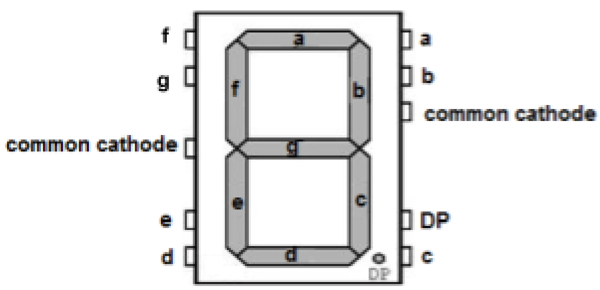
The 74192 used for the ones-digit on hours has a load function, which we set to 1. This will start the circuit with 1 in the hours, and everytime it reaches 13, it will load back to one. After completing the circuitry for the clock we designed a circuit board for the counters and a circuit board for the decoders and displays using multisim and ultiboard. After agreeing on the circuit board dimensions, we designed a 3D printed case in Autodesk to house the circuit boards and display the clock values and set buttons.

Datasheets:

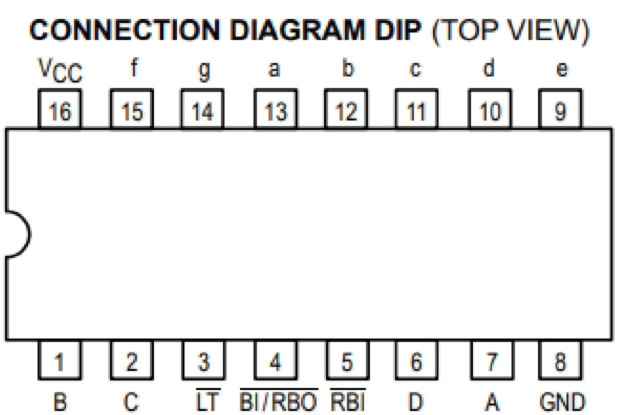
☐ **7490 Counter Datasheets**



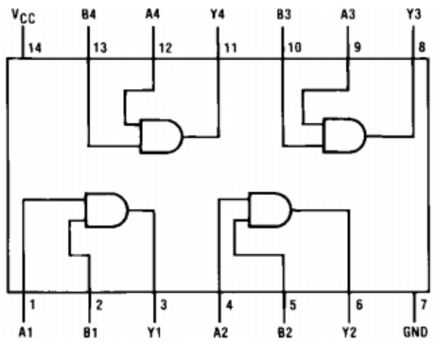
☐ **M74 7-Segment Display**



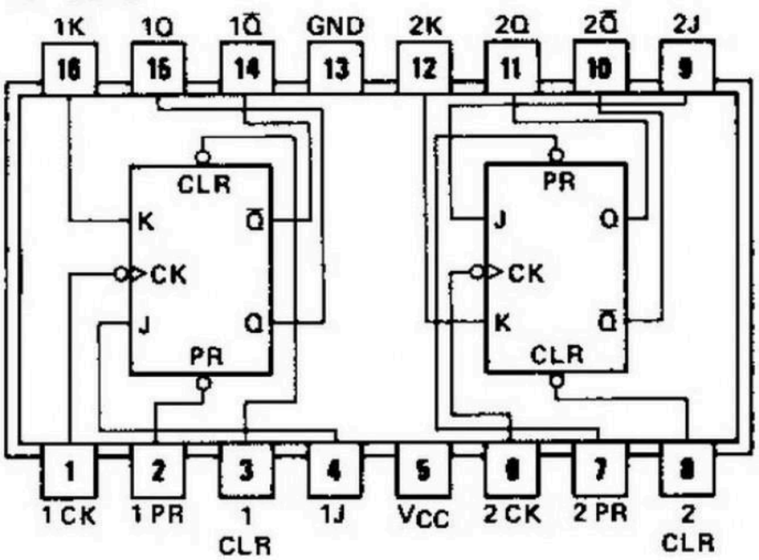
☐ **7448 BCD to 7-Segment Decoder**



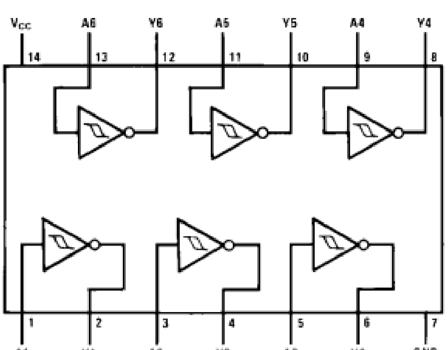
☐ **7408 AND Gate**



☐ **7476 J-K Flip-Flop**



☐ **7414 Datasheet Inventor**



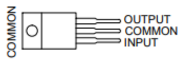
$Y = \overline{A}$

Input	Output
A	**Y**
L	H
H	L

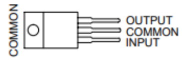
H = HIGH Logic Level
L = LOW Logic Level

☐ LM7805 Voltage Regulator

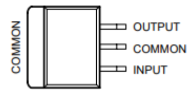
KC (TO-220) PACKAGE
(TOP VIEW)



KCS (TO-220) PACKAGE
(TOP VIEW)



KTE PACKAGE
(TOP VIEW)



description/ordering information

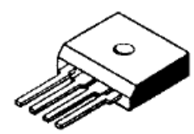
This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

ORDERING INFORMATION

T_J	$V_{O(NOM)}$ (V)	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
	5	POWER-FLEX (KTE)	Reel of 2000	µA7805CKTER	µA7805C
		TO-220 (KC)	Tube of 50	µA7805CKC	µA7805C
		TO-220, short shoulder (KCS)	Tube of 20	µA7805CKCS	

☐ MDA970-1 Bridge Rectifier

- High Dielectric Strength
- Simple, Compact Structure for Trouble-free Performance
- High Surge Capability — 100 Amps



Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MDA970A1	MDA970A2	MDA970A3	MDA970A5	MDA970A6	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 31 50	 62 100	 124 200	 248 400	 372 600	Volts
Average Rectified Forward Current T_A = 25°C T_C = 55°C	I_O	 4.0 8.0					Amp
Nonrepetitive Peak Surge Current (surge applied at rated load conditions, T_J = 150°C)	I_{FSM}	100					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150					°C