# FrankenClock

Final Report for E155

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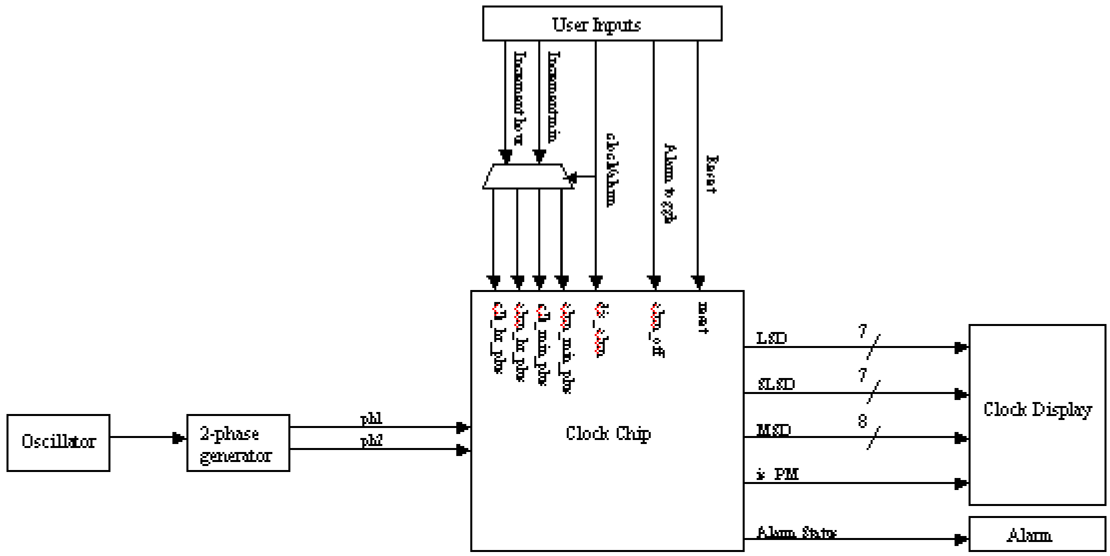
**Abstract**

Our team designed and constructed a fully packaged 24-hour alarm clock using a chip that we designed in E158: Introduction to CMOS VLSI Design in the spring of 2003. The design allows the user to set the clock and alarm time and displays the appropriate time on a four digit, seven segment LED display. It is powered with an external DC adapter. The alarm is an ear-splitting piezoelectric buzzer. The user can turn the alarm on or off and can even reset the clock using a convenient button. This wondrous device lives in a skillfully crafted wooden home.

## Block Diagram



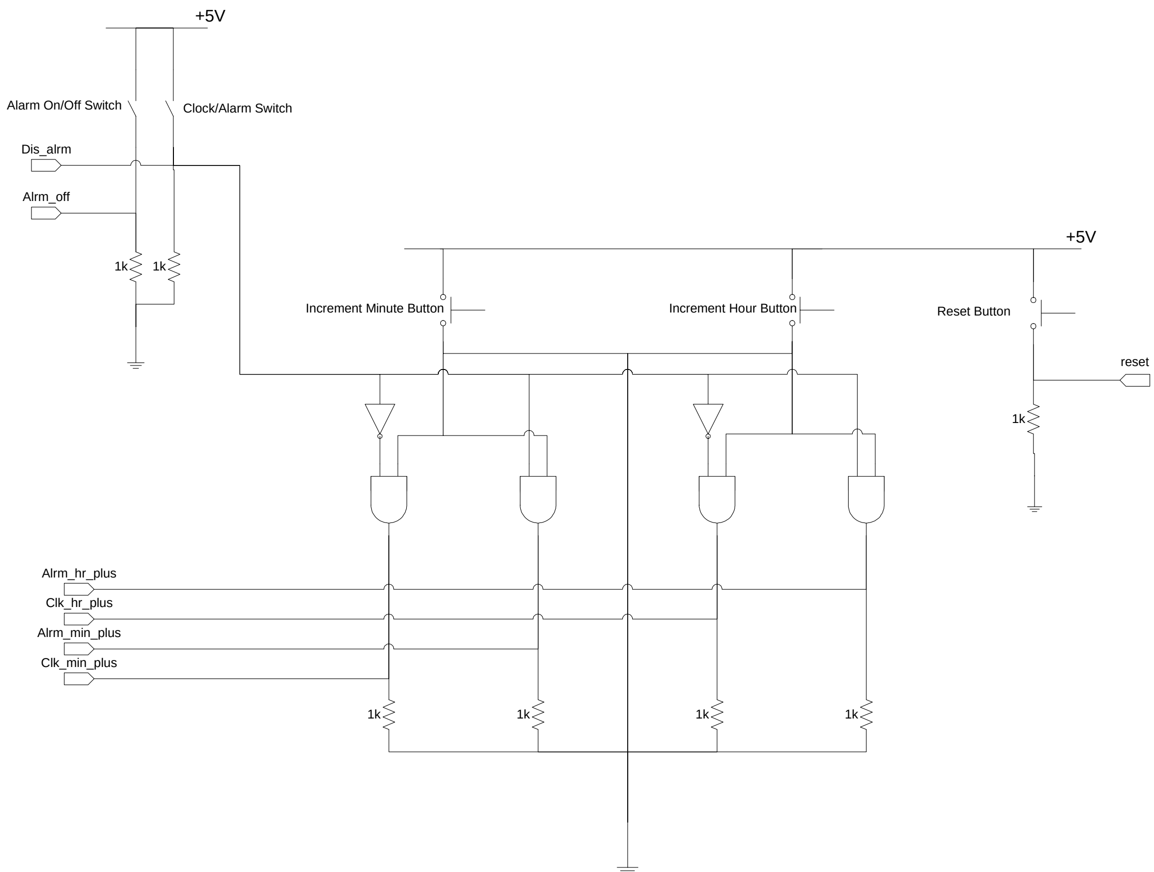

The clock chip performs all of the basic functions of an alarm clock. The chip needs a 2-phase non-overlapping clock at 32.768kHz to function properly. In addition to clock signals, it has four inputs for incrementing the clock and alarm times, two each for hour and minute. It also has inputs for selecting whether the alarm or the clock time is displayed, a reset, and an alarm toggle. The chip has 24 active-high outputs, 23 of which control the clock display, the other setting off the alarm. (Bissinger, Reynolds. “Digital Alarm Clock” 2003. ECF Press.)

The user inputs consist of three push-button switches for the *Increment Hour, Increment Minute*, and *Reset* user options. There are also two switches, *Alarm On/Off* and *Clock/Alarm.* The illustrious firm of Microprocessor Laboratory, Inc provided all of the buttons and switches. The *Clock/Alarm* switch controls a demultiplexer that will route the *Increment Hour* or *Increment Minute* signal to the correct pin on the clock chip. We have a 32.768 kHz temperature-compensated crystal oscillator from Dallas Semiconductor (DS32kHz) that drives a 2-phase clock generator that provides the clock signals for the chip.  The displays are dual seven segment common cathode LEDs.  The alarm is a 3-24V piezoelectric buzzer, which can be purchased from Marvac Electronics.

A full schematic of the clock can be found in Appendix A.

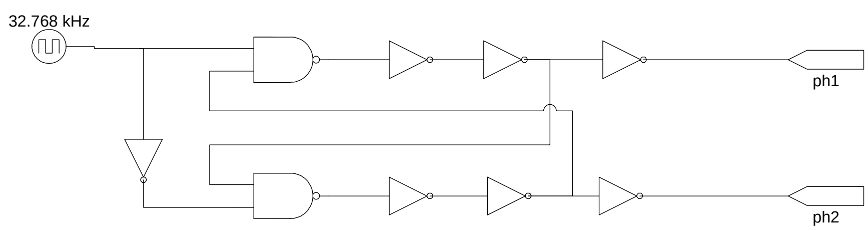
## User Inputs

Two switches control whether the alarm is on or off and whether the clock or alarm is displayed by sending high or low signals to the appropriate pins on the chip. The *Clock/Alarm* switch also controls which increment pins on the chip see the user input. We have some simple TTL logic acting as a demultiplexer to handle this process. ClockChip debounces the buttons and switches due to the amazing forethought of its designers. The buttons are sampled every 250 ms.



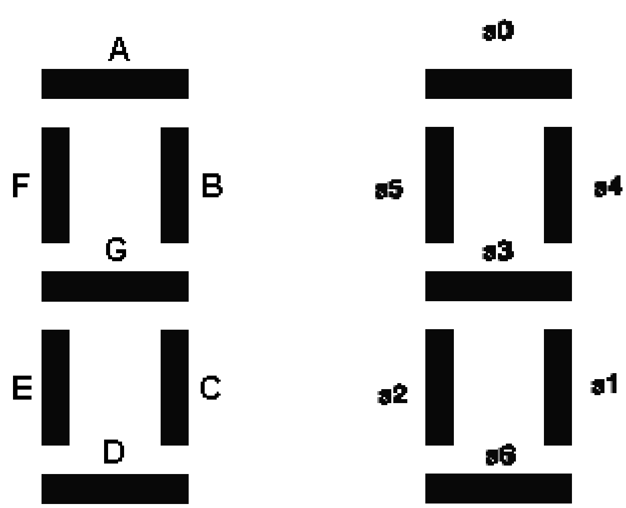
## 2-Phase Clock Generation

One 74LS00 quad NAND and one 74LS04 hex INV are employed to generate a two-phase, non-overlapping clock. For the seventh inverter, one of the extra NAND gates is used, tying one input high. Our non-overlap for this setup is about 25ns. Our estimate for the FO4 inverter delay for the 0.6 micron process that the clock chip is fabricated with is 200ps. This gives us about 125 gate delays before any overlap, which is more than enough to ensure safe operation.

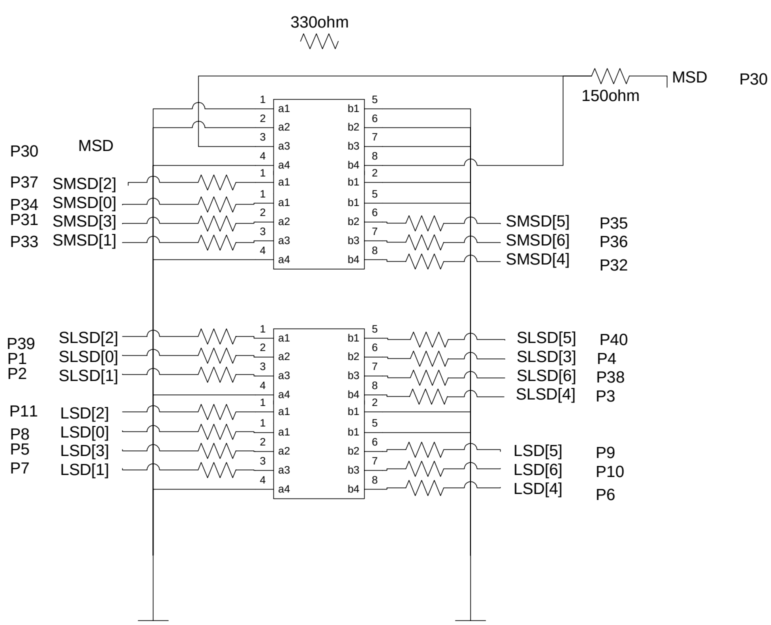



## Time Display

The seven segment displays map as follows. The display on the right shows how the clock chip maps the seven segments. On the left is the mapping of the segments on the common-cathode displays we are using.



We are using two dual seven segment common cathode LEDs (with dots, which we aren't using) to provide the time like a beacon in a storm of asynchronicity.  The chip provides a high voltage, and hence a current when the appropriate segment is to be on. All segments not used are grounded to keep them driven off.  330 Ohm resistors are placed between the chip and the display to limit the current driven into the LED's by the chip.  At the supply voltage of 5V this will limit the current to 15mA.  Betwixt the seven segment displays lie two LEDs acting as a colon.  To the right of the displays a lone red LED sits, waiting for 11:59am to pass so it may light up the PM mask under which it lives for a glorious 12 hours.



## Box Construction

One of the most invigorating aspects of this project is the box that houses FrankenClock. The exoskeleton is constructed using patented super glue and measure-as-you-go technology. It is a fine specimen of architecture and quite an aesthetic achievement. Using the finest woods the HMC machine shop's scrap bin offers, it truly celebrates the fine art of woodcraft.

In addition to structural and aesthetic wonder that is the box, the display is a work of art. The finest matte black paint was applied to a piece of the clearest plastic to shield prying eyes from the inner workings of FrankenClock. A piece of balsa wood was painstakingly hand-carved to fit this window onto time.

The final touches to FrankenClock come in the form of button ports and switch mounts. Each of the three buttons is masterfully ensconced in the side of the box. With our habitual attention to detail, space for even the largest of fingers is provided around each button to provide easy access and ample pushing room. The switches are mounted like regal gargoyles on the top front in the center. This allows the user only the easiest access to the switch that turns the alarm off.

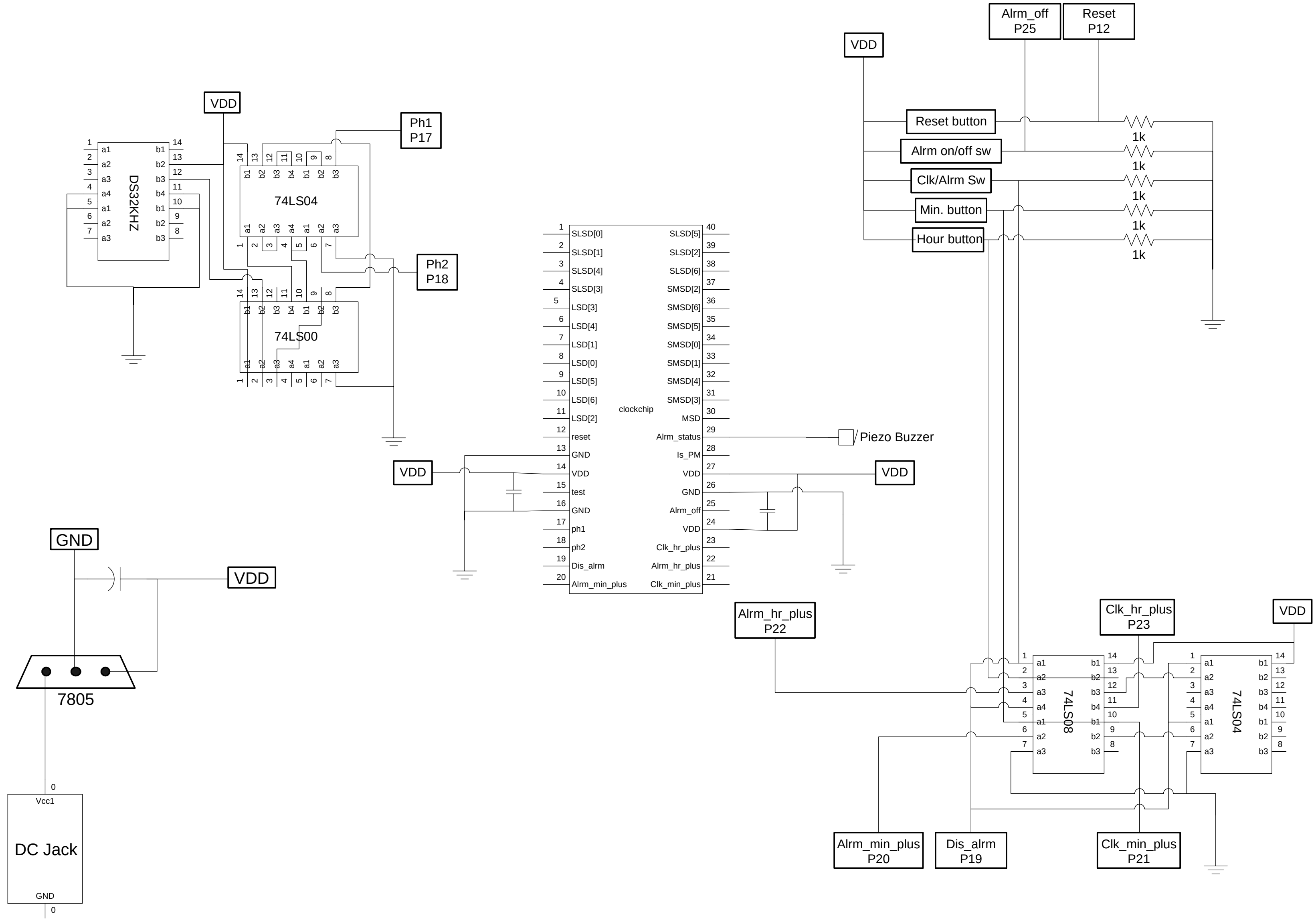
## Results

The project turned out well. We achieved all of our objectives and didn't even hallucinate due to sleep deprivation. By far the most difficult part of the construction of the final project was the soldering. If we were to build FrankenClock2, we would use perfboard with built-in soldering pads or design a custom PCB. The majority of the hours spent in construction were spent hunched over a solder station, solder sucker in hand. Although we had originally envisioned a clean acrylic box or perhaps a shiny metal box, we decided wood would be easier to construct and would have a nice finish.

## Parts List

| | | |
|---|---|---|
| 2 Common Cathode Displays | Engineering Stockroom | -- |
| 1 ClockChip© | MOSIS/E158 | -- |
| 3 Red LEDs | MicroProcessor Laboratory | -- |
| 1 DC Jack | MicroProcessor Laboratory | -- |
| 2 Dual Position Switches | MicroProcessor Laboratory | -- |
| 3 Momentary Push Buttons | MicroProcessor Laboratory | -- |
| 1 7805 Voltage Regulator | MicroProcessor Laboratory | -- |
| 2 150-ohm Resistors | Engineering Stockroom | -- |
| 2 330-ohm Resistors | MicroProcessor Laboratory | -- |
| 4 330-ohm 10 Resistor Networks | MicroProcessor Laboratory | -- |
| 5 1 kOhm Resistors | MicroProcessor Laboratory | -- |
| 1 6”x10” Piece of Perfboard | Marvac Electronics | $6.00 |
| 1 10uF Electrolytic Capacitor | MicroProcessor Laboratory | -- |
| 2 0.1uF Capacitors | MicroProcessor Laboratory | -- |
| 1 Generic 3-24V Piezoelectric Buzzer | Marvac Electronics | $5.00 |
| 1 DS32kHz Temperature-Compensated Crystal Oscillator | Dallas Semiconductor (MAXIM-IC) | Free Sample |
| 1 74LS00 Quad NAND | Engineering Stockroom | -- |
| 2 74LS04 Hex Inverters | Engineering Stockroom | -- |
| 1 74LS08 Quad AND | Engineering Stockroom | -- |
| Lots of Wire | MicroProcessor Laboratory | -- |
| Lots of Solder | MicroProcessor Laboratory | -- |
| Lots of High Quality Scrap Wood | HMC Machine Shop | -- |
| 1 Piece of Plastic (1.5”x4”) | Home Depot | $3.00 |
| 1 Can Matte Black Spray Paint | Pegasus Hobby | $5.00 |
| 1 Tube Purple Hobby Glue | Pegasus Hobby | $5.00 |

# Appendix A



VDD
Ph1
P17
Ph2
P18
DS32KHZ
74LS04
74LS00
a1
a2
a3
a4
b1
b2
b3
b4
clockchip
SLSD[0]
SLSD[1]
SLSD[4]
SLSD[3]
LSD[3]
LSD[4]
LSD[1]
LSD[0]
LSD[5]
LSD[6]
LSD[2]
reset
GND
VDD
test
GND
ph1
ph2
Dis_alrm
Alrm_min_plus
SLSD[5]
SLSD[2]
SLSD[6]
SMSD[2]
SMSD[6]
SMSD[5]
SMSD[0]
SMSD[1]
SMSD[4]
SMSD[3]
MSD
Alrm_status
Is_PM
VDD
GND
Alrm_off
VDD
Clk_hr_plus
Alrm_hr_plus
Clk_min_plus
Piezo Buzzer
VDD
Alrm_off
P25
Reset
P12
Reset button
Alrm on/off sw
Clk/Alrm Sw
Min. button
Hour button
1k
1k
1k
1k
1k
GND
VDD
7805
Vcc1
DC Jack
GND
Alrm_hr_plus
P22
Clk_hr_plus
P23
VDD
74LS08
74LS04
Alrm_min_plus
P20
Dis_alrm
P19
Clk_min_plus
P21