Smart Toaster Oven For The Future

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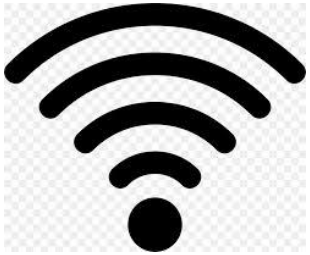
Overview - How is it Smart?

- What Makes a Toaster Oven Smart?
  - Easy user control
  - Connection to networks by things such as wifi, bluetooth, NFC, etc…
  - Safety features to prevent the user from starting fires.



What's Toasting

Toasting is rapid dehydration.

The loss of water in a substance

As we toast food, water is being taken away.

Average Toasting Temperature

On average, most people toast at 350 F.

This will get the perfect toast if left in the toaster oven for the proper amount of time

Motivation

- The love of toast
- The ability to expand upon our limited programming skills
- The ability to improve our circuit design skills
- The opportunity to have creative freedom while constructing and selecting the features for the project.
- The ability to make a common use item more fun and easier to use.

Goals & Objectives

For our toaster oven we will be implement a digital timer through arduino software that is controlled by a number pad as well as a gauge to control the temperature.

As electrical engineers, we will design our own PCB, Control AC power with DC, and sensors in order to make the toaster oven more efficient and innovative.

As an extra design innovation we will also be implementing a smartphone application for the toaster. This website will be able to control certain aspects of the toaster oven such as: powering on or off, toast profiles, and time left on the toast.

Specifications

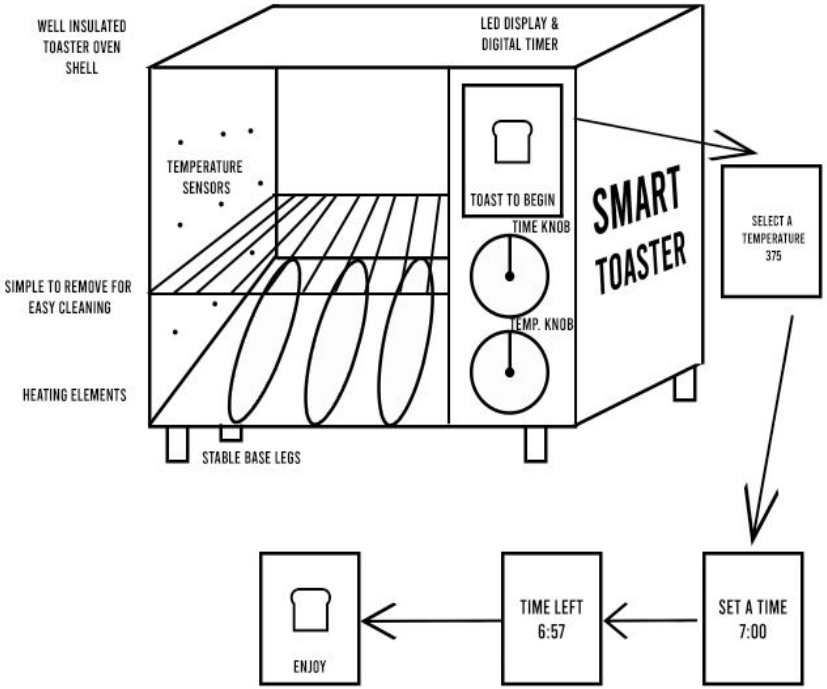
1. The toaster oven should be able to operate with a desired time between 1 second and 1 hour.
2. The toaster oven needs to be able to heat/ preheat to a minimum of 300 degrees.
3. The toaster oven will need to be able to be turned off by a smartphone device within 5 seconds of issuing the command from the smartphone
4. The user will receive a notification from the toaster oven to their smartphone device within 30 seconds of completed tasks.

Current toaster ovens Vs Ours

- Basic toaster ovens are directly AC powered (120 V 60 Hz from the wall outlet).
- Analog dials are used to control temperature and set times
- Since the controls are not digital, it will be less accurate with time and temperature
- Our toaster oven will remove all the dials, give it a way to select options digitally, and provide smartphone control.

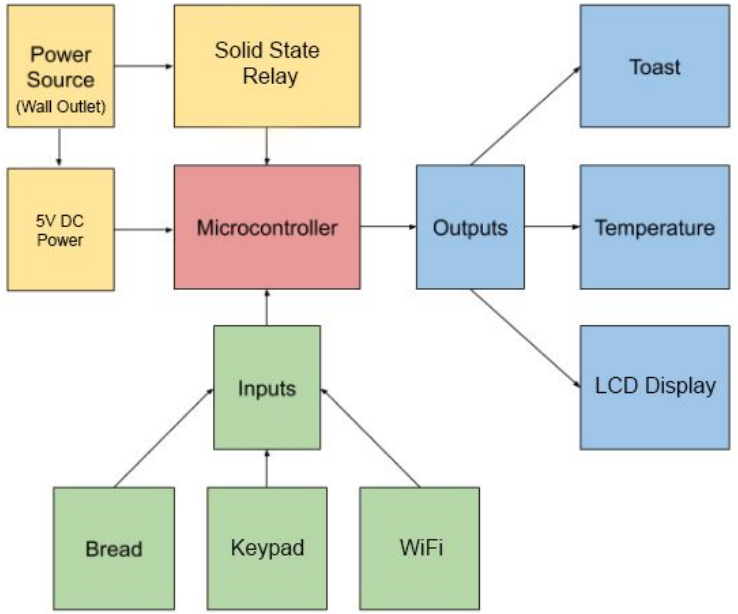
Revamped User Control

- We have selected a keypad for the most user friendly interface.
  - This can turn the toaster on and off, as well as input temperature and time
  - A kill switch is readily available in case anything goes astray
  - Further Time can be added or temperature can be modified after initial toasting
- Furthermore we are working on a website
  - Includes all properties mentioned above



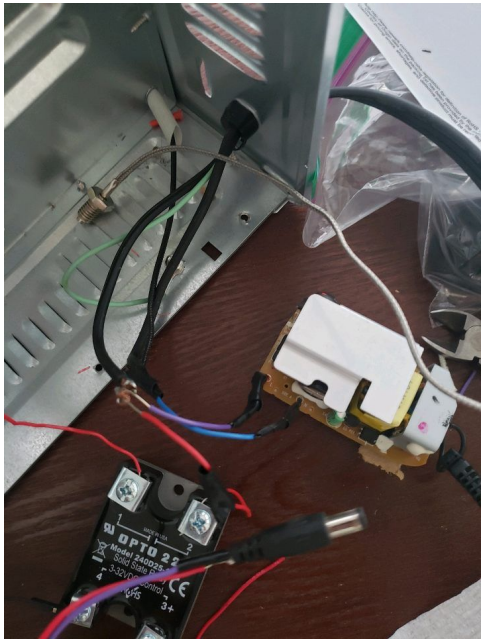
Block Diagram

- AC power comes into SSR as well as the heating elements. DC power opens and controls the circuit in between to allow to control.
- Input commands come from the keyboard or from the wifi into the PCB
- Commands outputted on the LCD display as well as heating element control



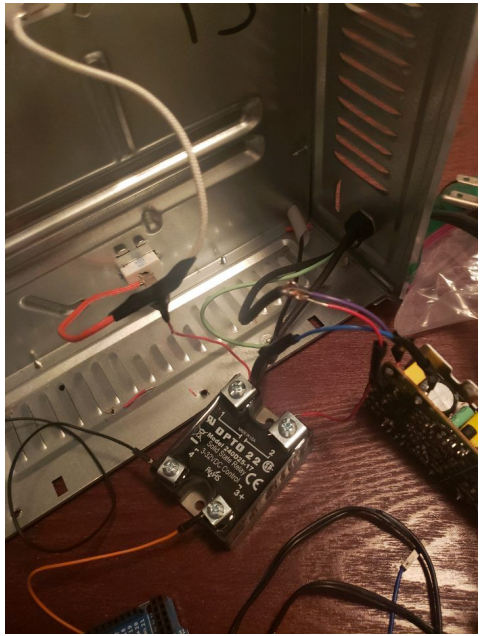
How is the Toaster powered?

- Main power comes from the wall (120V 60 Hz AC)
- Development board is powered through a 12V AC to DC adapter.
- To simplify having to plug multiple devices in, the adapter was rewired along with the AC power coming from the toaster.



How Does the Toaster Heat Up

- Red and white wire show the heating. elements both simultaneously connected.
- Both elements are connected to one socket of the SSR.
- AC power from the toaster is coming into the socket parallel to the heating elements.
- The MCU control the bottom two sockets by applying a DC voltage to open and close the circuit.



Mechanical aspects

- Since we bought a toaster and are remodeling it, many mechanical changes must be made
- This begins by gutting everything out, leaving only the shell of the toaster
- The knobs are of no use to us to that must carefully be removed as well
- The amount of space required for all of the electrical components must remain in mind
    - This is why we are making a toaster oven and not just a toaster
- Electronic components must not be affected by the heating of the toaster oven
- A flat service must be available for the touchpad and display

Mechanical aspects cont.

- In order to get the holes where the knobs were big enough for wires to get through, a Dremell was used to slowly make the holes bigger.
- A solution for a flat service against the toaster oven can easily be accomplished via some tough cardboard cutouts. All the pieces are being held together with a strong adhesive tape that won't easily be heated or mess with any of the electrical components.
- The touchpad was easy to mount, but the display wasn't as sturdy. Therefore we implemented some screws so it can constantly stay in place.
- The cardboard cutout was then placed in front of the holes and held to the toaster via more adhesive tape.

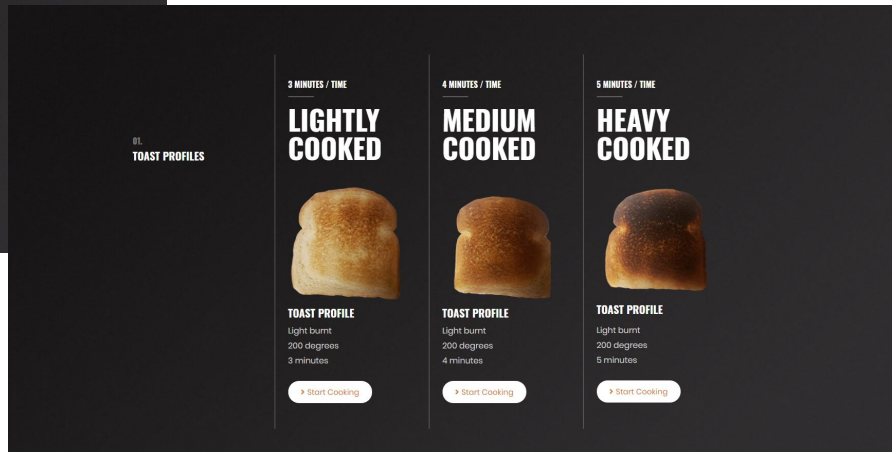
Cell Phone Control

We will be building a website which controls the toaster oven & showcases our senior design project. For the CMS we will be using WordPress.

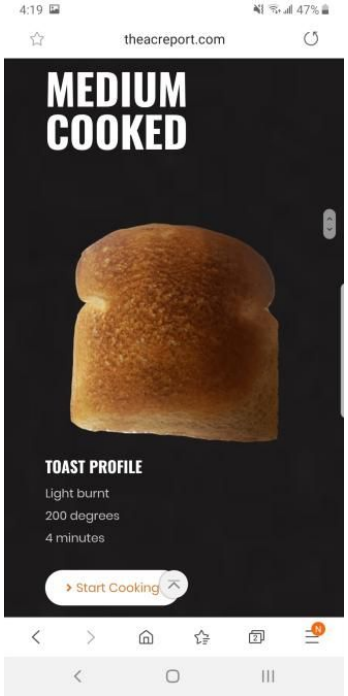
WordPress Elementor

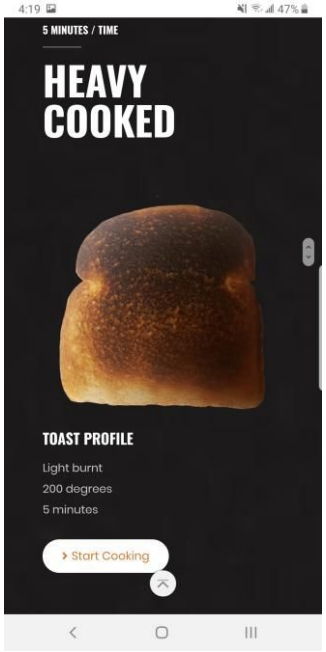
For the page builder, we are going to be using Elementor. It has a lot of customization options and allows for custom code to be inserted on the page.

Theacreport.com



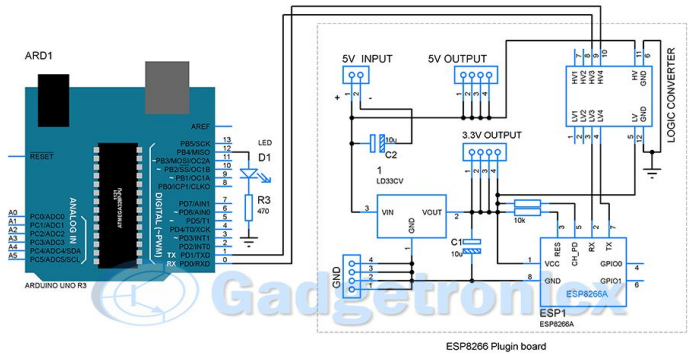
Theacreport.com - Mobile Friendly



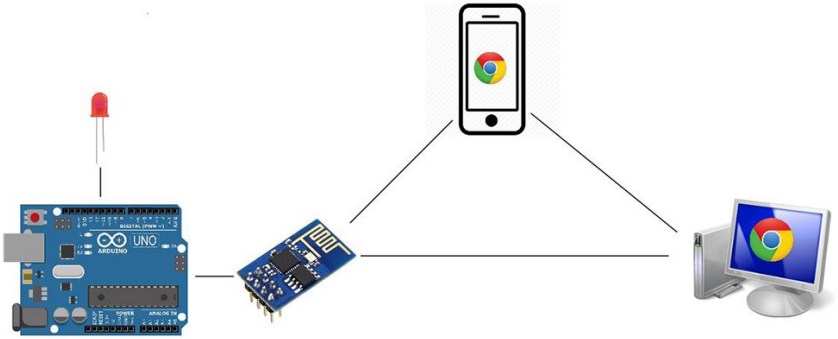


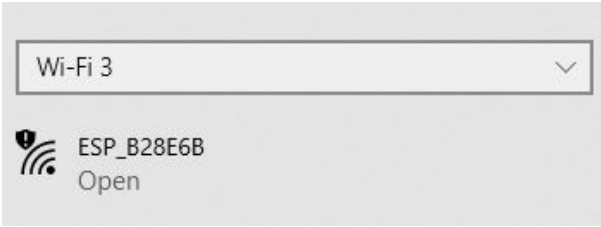
How The WiFi Works

- Assign Static IP Address to ESP8266
- Set the code with in Arduino IDE
- Toast profiles will refer to that IP address on the website.

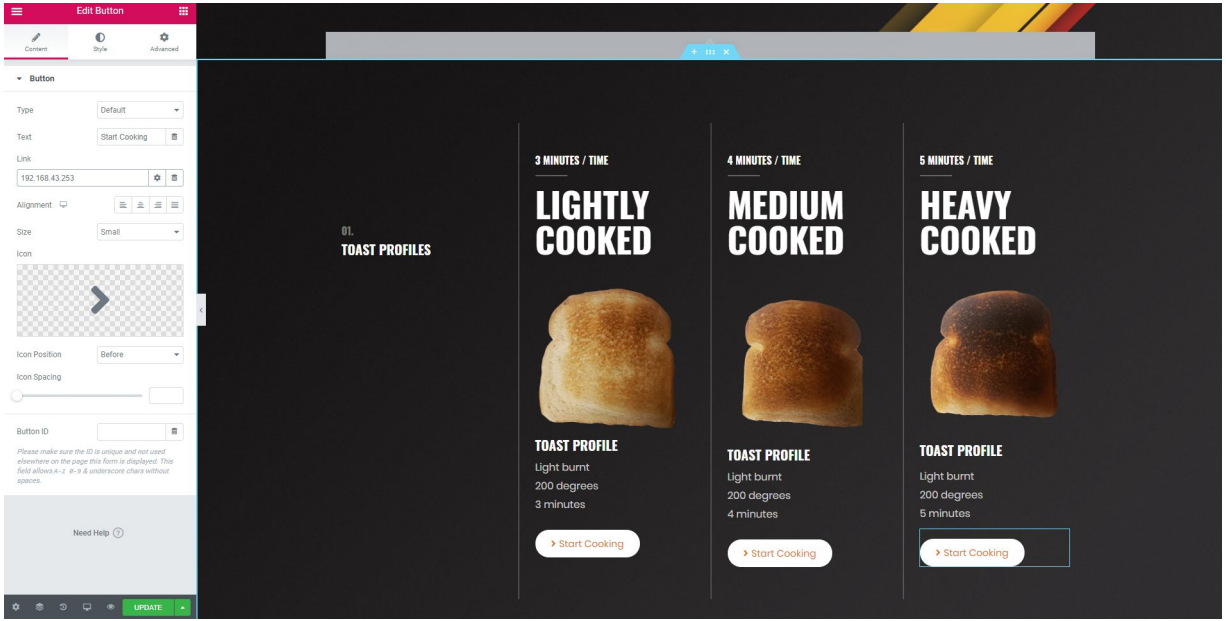


ESP8266 Plugin board





How The WiFi Works



Toast Profiles

Light burnt 200
degrees
3 minutes

Medium burnt
200 degrees
4 minutes

Heavy burnt
200 degrees
5 minutes

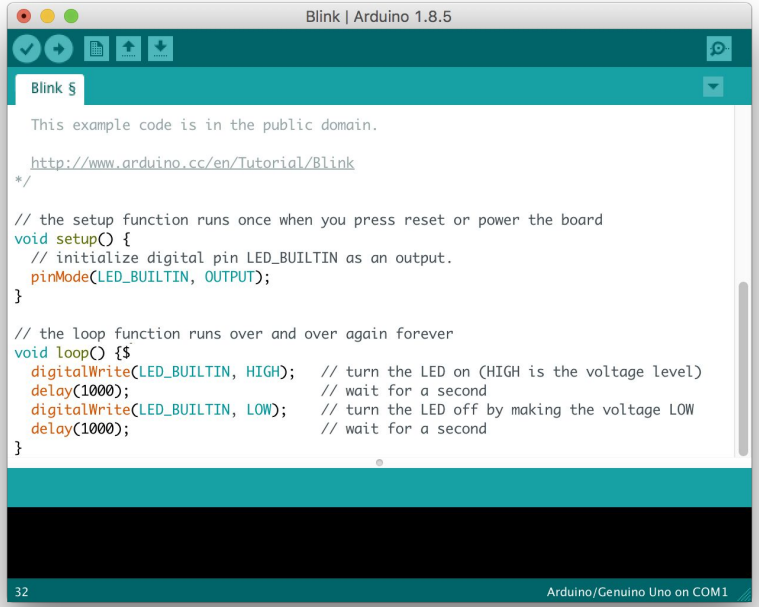
Software Selection

Arduino IDE Code simple and easy to use.

Uses C++, courses we have all taken.

Each part is compatible with arduino and has the libraries available online.

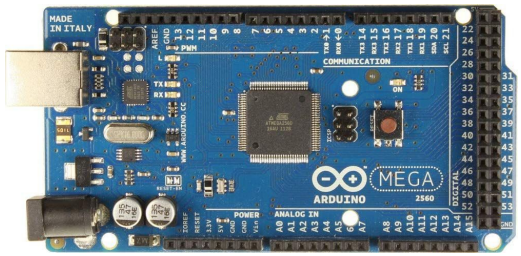
All of us are Electrical Engineers so the coding is a bit on the weaker side; however, all the resources online have made the process fairly straight forward.



Microprocessor Selection

Feature	Atmega328	ATmega2560	MSP430G2553	BCM2837
Voltage Range	1.7- 5.4 V	1.8 - 5.5 V	1.7 - 3.5 V	2.5 - 6.1 V
Temperature Range (Celcius)	-40° - 86°	-40° - 85°	-40° - 85°	-25° - 80°
Low Power	Yes	Yes	Yes	Yes
Power Consumption	200uA at 1MHz	500 uA at 1MHz	330uA at 1 MHz	3500 mW
Clock frequency	20 MHz	16 MHz	16 MHz	1.2 GHz
Analog I/O	Input	Input	Input/Output	Input/Output
Digital I/O	Input/Output	Input/Output	Input/Output	Input/Output
Memory	32 KB Flash	64 KB Flash	16 KB Flash	512 KB Cache
GPIO Pin Count	20	100	24	40
Avg. Board Price	$16.72	$40.40	$18.94	$34.98

MCU Selection: Atmega 2560 processor



Voltage Range: 1.8 - 5.5 V

Temperature Range: -40° - 85°

Power Consumption: 500 uA at 1MHz

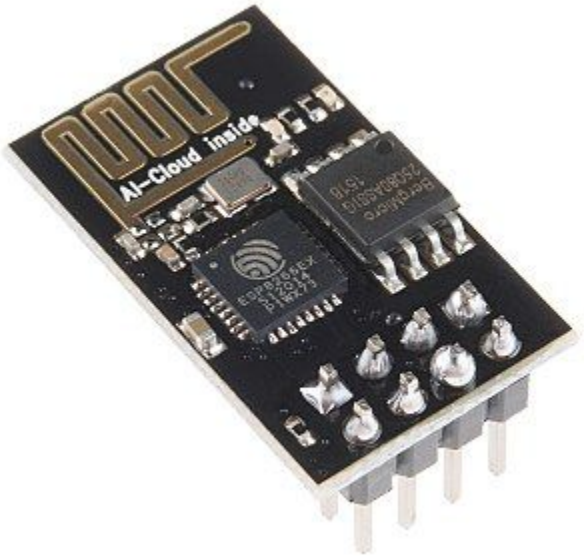
Clock frequency: 16 MHz

Memory: 64 KB Flash

GPIO Pin Count: 100

Avg. Board Price: $40

Wifi chip: ESP8226



1MB Flash Memory

Integrated TCP/IP protocol stack

Power down leakage current of <10uA

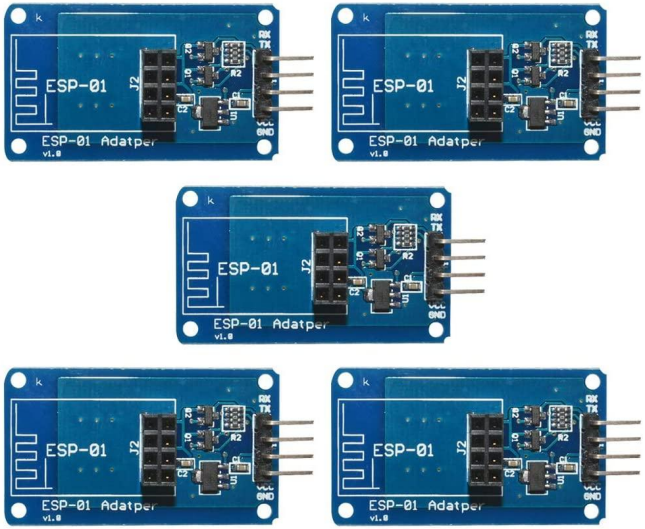
VCC-3.0-3.6V

802.11 b/g/n

2.4GHz

External wifi chip connected through cable so it can be mounted in a place with a better signal

3.3V 5V ESP-01 Serial Adapter Module



A adapter module for ESP-01 Wi-Fi module.

3.3V voltage regulator circuit and onboard level conversion circuit.

Interface logic voltage: 3.3V / 5V compatible(On-board level shift circuit)

It can make 5V microcontroller easy to use with ESP-01 Wi-Fi module.

Ardunio 4x4 keypad

Membrane Switch

Membrane Keypad Switch

Matrix Array 4x4 16 Keys

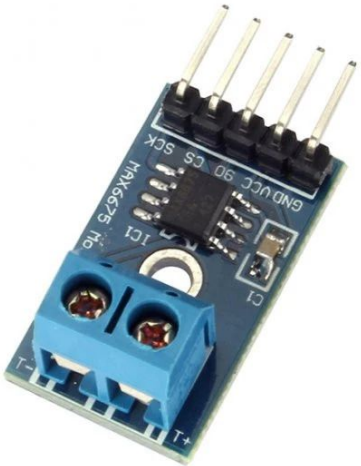
8 pins connector Switch Keypad

Switch Keypad for Arduino/AVR/PIC

Oven Temperature Sensors

Sensor	Pros	Cons
Negative Temperature Coefficient (NTC) Thermistor	Price, Accuracy, and Linear	Out of our temperature range
Resistance Temperature Detector (RTD)	Accuracy, Operating Range, & Linear	Most Expensive
Thermocouple	Widest Operating Range	Low accuracy and nonlinear
Semiconductor-based sensors	Linear	Out of our temperature range with slow responsiveness

Sainsmart max6675 module with k type thermocouple



Temperature Range: 0 to 1024 °C

Avg. Price: $15

Size: 25.0mm x 15.0mm x 13.0mm

Weight: 4g

Type of Sensor: Thermocouple

Sunfounder I2C 1602 LCD display

Display: 4 lines x 20 characters

Backlight: Blue with white character color

Pin Definition: VCC/ GND/SDL and SCA

Working Voltage: 5V

Default Address: 0x27, 0x3F

Black and decker toaster oven

Exclusive Even Toast Technology

120 volts

1150 watts

14.5 x 8.8 x 10.8 Inches

Removable crumb tray

AC 100-240V to DC 12V 1.5A Power Supply Adapter

C Input:100-240V 50-60Hz, DC Output: 12V 1.5A 18W.

DC connector: 5.5mm*2.1mm, totally cable length:120cm.

Over-voltage protection,over-current protection,short-circuit protection

Opto 22 solid state relay 240D25-17

Nominal Voltage Line - 240VAC (Ports 1 and 2)

3-32 VDC Control (Ports 3 and 4)

Turn-on Time: ½ Max Cycle

Turn-off Time: ½ Max Cycle

Operating Frequency: 25 - 65 hz

Can be turned on and off with a 5V DC output from PCB

DSD TECH SH-U09C2 USB to TTL Adapter Built-in FTDI FT232RL

Transfers code without a USB connection.

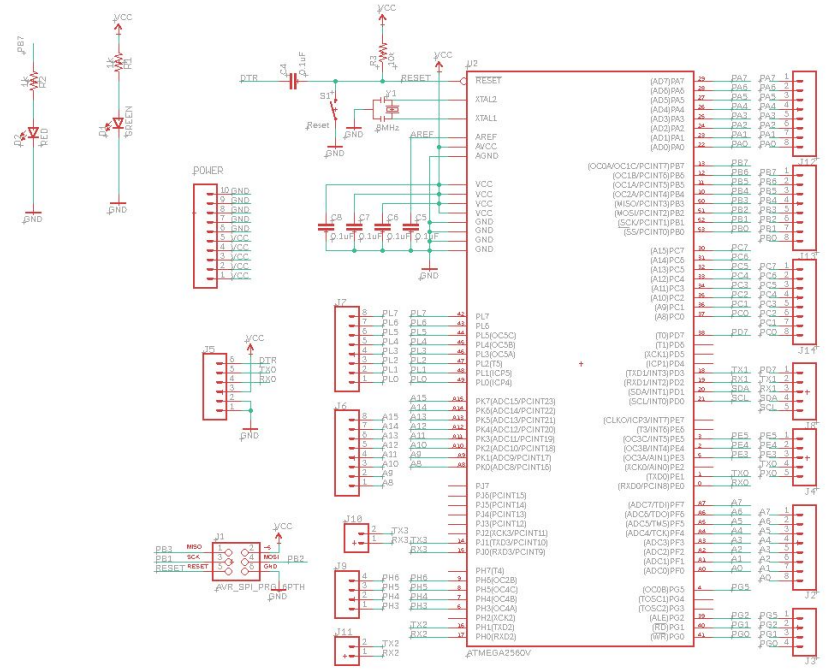
Uses 6 pins that connect to the GPIO pins available on the arduino board

Flash ATmega 2560 with arduino code

Supports 5V, 3.3V and 1.8V Logic TTL levels

Easier to use than ICSP (In circuit serial programmer). Requires another device, more complex.

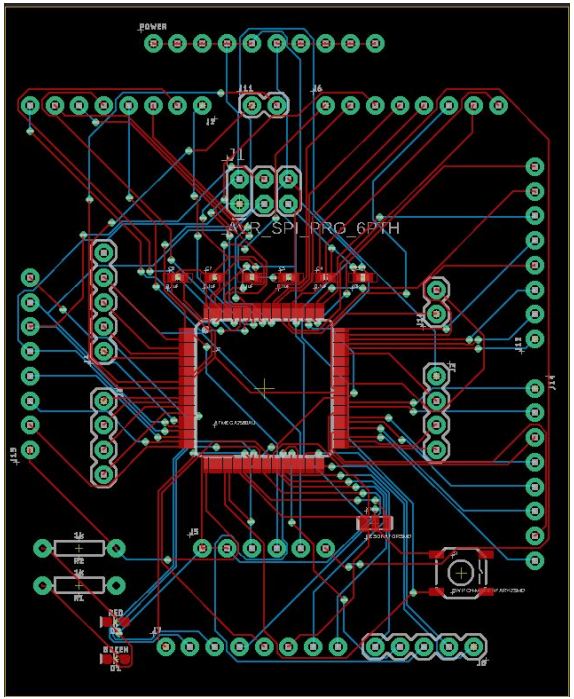
PCB Schematic



Coded through Eagle PCB Software.

Took Junior Design with the man, the myth, the legend The Dr. Richie, so it has not been difficult using eagle tools to design the PCB.

PCB Layout

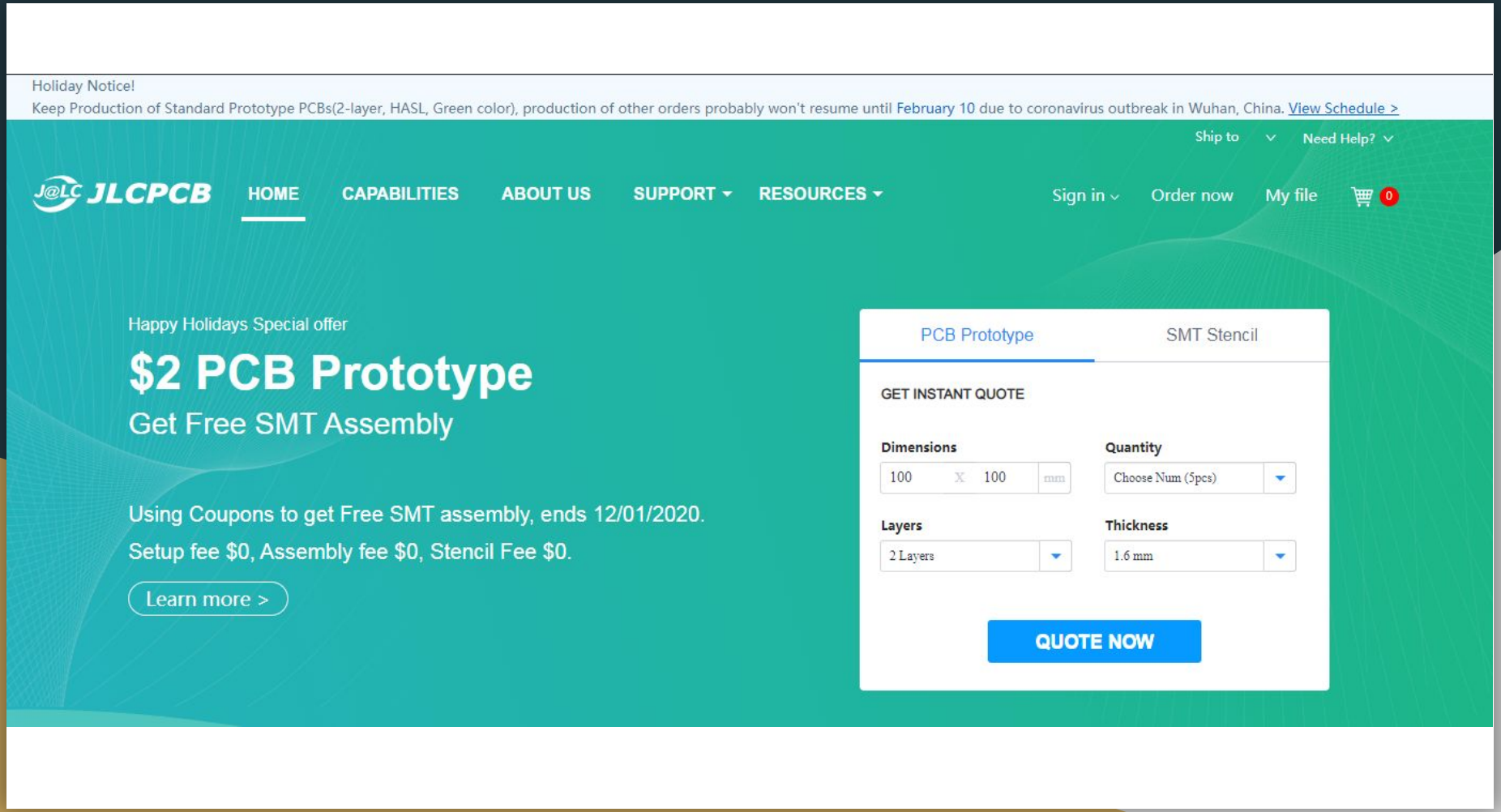


JLCPCB

PCB manufacturer we are using from China.

Verified to be Coronavirus free

*PCB Got Delayed Because of the Virus


Holiday Notice!
Keep Production of Standard Prototype PCBs(2-layer, HASL, Green color), production of other orders probably won't resume until February 10 due to coronavirus outbreak in Wuhan, China. View Schedule >
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Dimensions
100
X
100
mm
Quantity
Choose Num (5pcs)
Layers
2 Layers
Thickness
1.6 mm
QUOTE NOW

Project development over time

- Each part was tested individual and was verified to work
- Code was developed to use each part in conjunction with each other
- PCB was created and parts were soldered
- PCB did not work, moved to development board for the rest of the project
- Mechanical design was done to complete the revamped user control
- Website was developed for smartphone user control
- Wifi with ESP module coded to work with the website

Work Distribution

Name	Ryan Nolan	Alexander Tsangarakis	James Chroma
Primary	WiFi & Website	PCB & Wiring	Coding & Mechanical
Secondary	Coding & Wiring	Coding & Mechanical	Website & WiFi

Budget Estimated

Item	Budgeted Cost
Arduino Board	$20
Toaster Oven	$200
LCD Display	$50
Sensors	$80
PCB	$20
Other Supplies	$125
Total	$495

Development Cost

Item	Budgeted Cost	Purchased From
Arduino Mega Development Board	$0	Already Had
Toaster Oven	$0	Already Had
LCD Display	$9	Amazon
Thermocouple Sensor	$14	Amazon
Solid State Relay	$28	Amazon
PCB	$15	JLCPCB
ATmega 2560 Processor	$30	Mouser Electronics
ESP8266 Wifi Module	$15	Amazon
ESP-01 Serial Adapter	$11	Amazon
3.3 to 5V Shifter	$8	Amazon
4 x 4 Keypad	$7	Amazon
Surface Mount PCB Parts	$20	Newark Electronics
Total	$157	

Single unit cost

Item	Budgeted Cost	Purchased From
Arduino Mega Development Board	$15	Already Had
Toaster Oven	$40	Already Had
LCD Display	$9	Amazon
Thermocouple Sensor	$14	Amazon
Solid State Relay	$28	Amazon
PCB	$15	JLCPCB
ATmega 2560 Processor	$30	Mouser Electronics
ESP8266 Wifi Module	$15	Amazon
ESP-01 Serial Adapter	$11	Amazon
3.3 to 5V Shifter	$8	Amazon
4 x 4 Keypad	$7	Amazon
Surface Mount PCB Parts	$20	Newark Electronics
Total	$213	

Financing

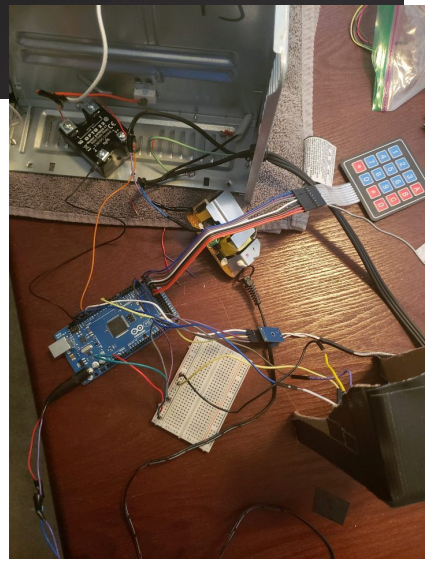
We will be paying out of pocket for this project.

It’s budget friendly and we didn’t want to work with a sponsored project.

Overall Project Issues

- Flashed PCB Board; however, could not upload code to the board
- Due to Covid-19 outbreak group meetups over the Discord.
- Accidently burnt out Atmega2560 MCU as well as the LCD Display
- Faulty ESP Module, would disconnect at random times
- Some parts could not be ordered to arrive in time due to Covid-19
- Entire group made up of Electrical Engineerings, programming was very difficult
- Loss of income

Finished Product



Conclusion

Thank you UCF for the opportunity to learn and grow. Each member of this team will be pursuing different career paths upon graduation.

Alex- Will be moving to California to be stationed at an Air Force Base as a flight test Engineer.

Ryan- I’m moving to Vegas in August to work on my SEO/Web Design startup.

James- Moving back home in Vero Beach, working with father’s company to fix electrical components in homes.