ECE 445 Spring 2017

Lava Lamp 2.0

The Inductioning

TEAM 44

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Final Presentation
5/2/2017

OUTLINE

- INTRODUCTION
- OBJECTIVES
- DESIGN
- BLOCK DIAGRAM

- MCU
- TEMPERATURE SENSOR
- LED CIRCUIT
- LED & MCU POWER SUPPLY
- INDUCTION POWER SUPPLY
- INDUCTION HEATING

- CONCLUSIONS
- FUTURE WORK

INTRODUCTION

INTRODUCTION TO A LAVA LAMP

- Water
- Wax
- Heating source
- Density difference

COMPARING LAVA LAMPS

	CLASSIC	LAVA 1.0	LAVA 2.0
Flow time:	2 hours	25 minutes	10 minutes
Brightness:	25W incandescent	2 color LED’s	3 ultra-bright white LED’s & 3 color LED
Interactivity:	None	1 button, 1 lever: 5 colors & variable brightness	2 buttons: 7 colors & 5 brightness levels
Safety:	None	Temperature control	Temperature control + cool globe

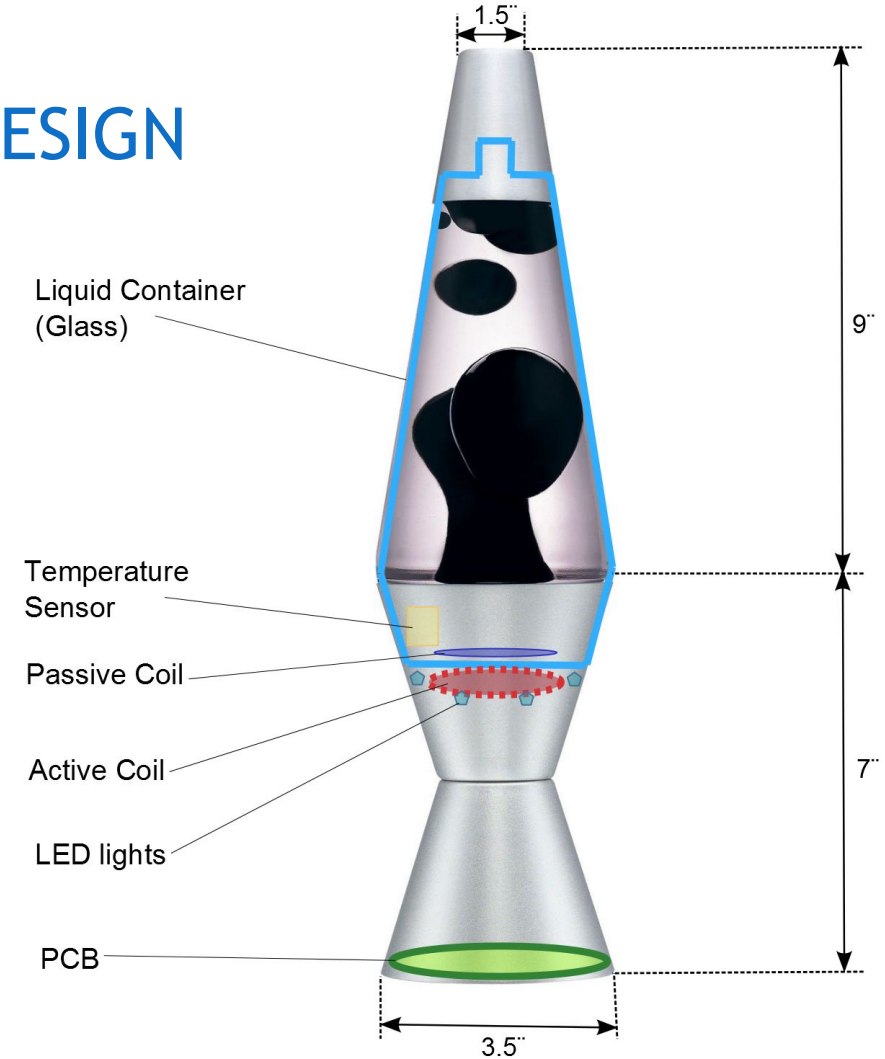
OBJECTIVES

OBJECTIVES

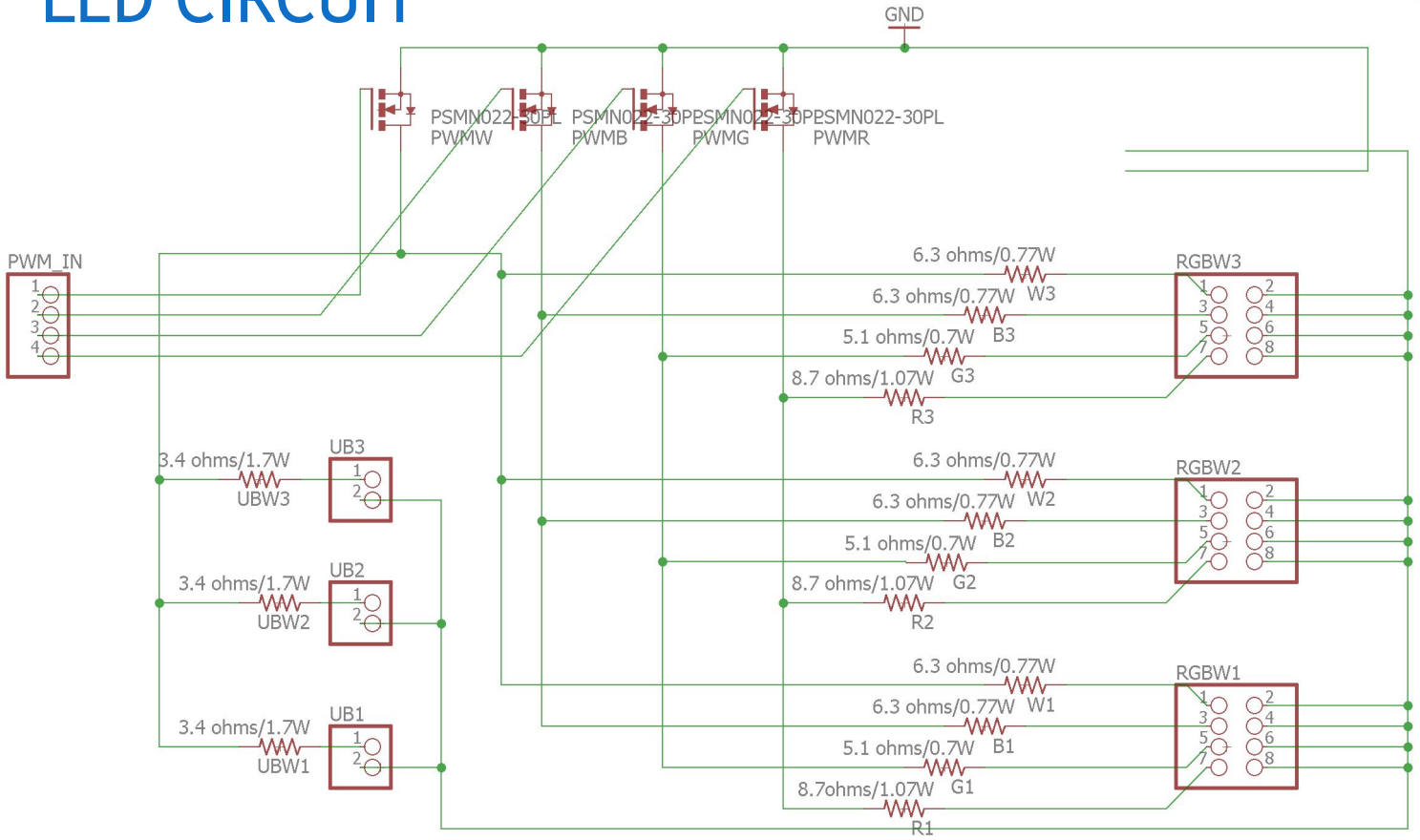
- OPERATION ⟹ 50°C within 10 minutes
- BRIGHTNESS ⟹ 3000 lux at 1 ft.
- INTERACTIVITY ⟹ 7 Colors, 5 Brightnesses
- SAFETY ⟹ 45°C outside the globe

DESIGN

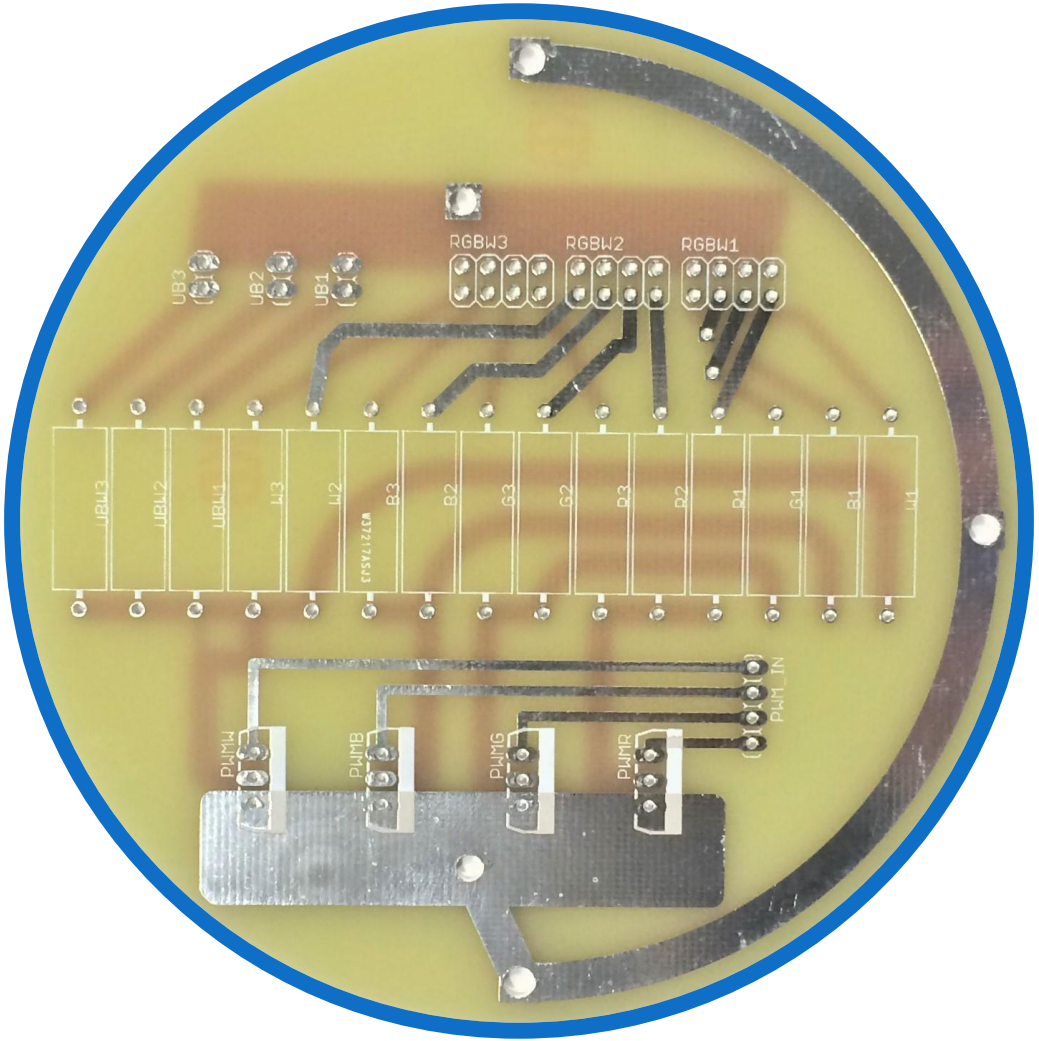
PHYSICAL DESIGN



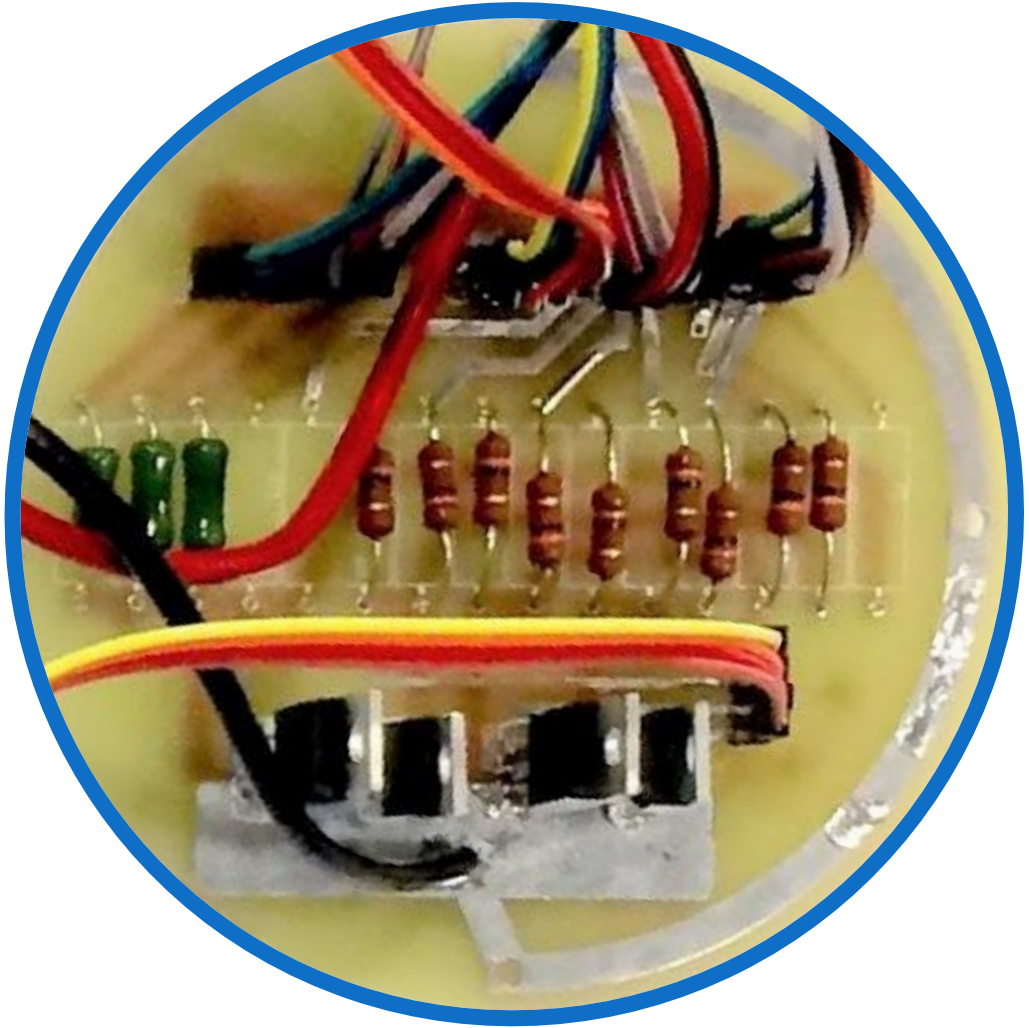
LED CIRCUIT


GND
PSMN022-30PL
PWMW
PSMN022-30PL
PWMB
PSMN022-30PL
PWMG
PSMN022-30PL
PWMR
PWM_IN
1
2
3
4
6.3 ohms/0.77W
6.3 ohms/0.77W W3
5.1 ohms/0.7W B3
8.7 ohms/1.07W G3
R3
RGBW3
1
2
3
4
5
6
7
8
3.4 ohms/1.7W
UBW3
UB3
6.3 ohms/0.77W
6.3 ohms/0.77W W2
5.1 ohms/0.7W B2
8.7 ohms/1.07W G2
R2
RGBW2
3.4 ohms/1.7W
UBW2
UB2
6.3 ohms/0.77W
6.3 ohms/0.77W W1
5.1 ohms/0.7W B1
8.7ohms/1.07W G1
R1
RGBW1
3.4 ohms/1.7W
UBW1
UB1

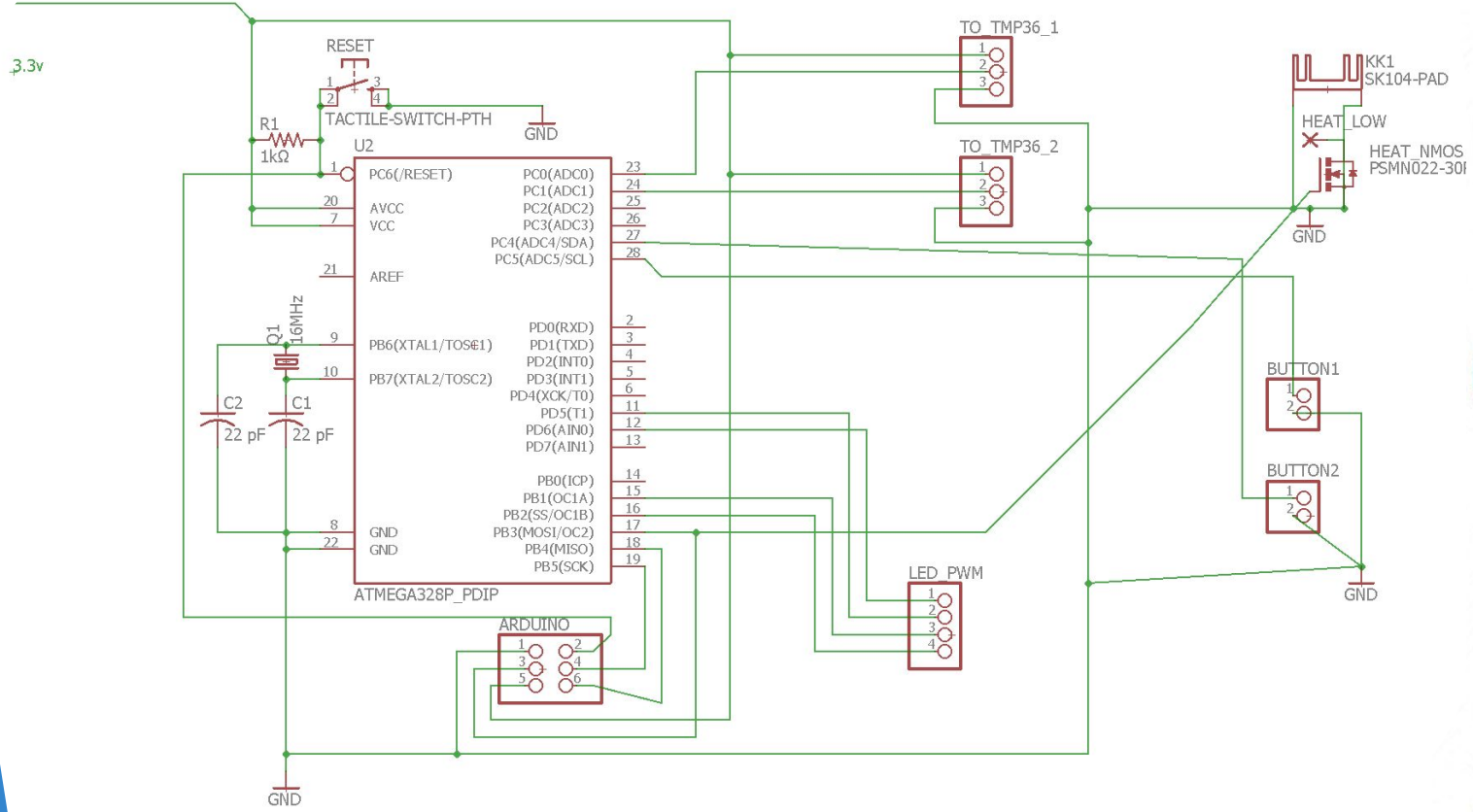
LED PCB


RGBW3
RGBW2
RGBW1
UB3
UB2
UB1
UBW3
UBW2
UBW1
W3
W2
B3
B2
G3
G2
R3
R2
R1
G1
B1
W1
PWM_IN
PWMW
PWMB
PWMG
PWMR

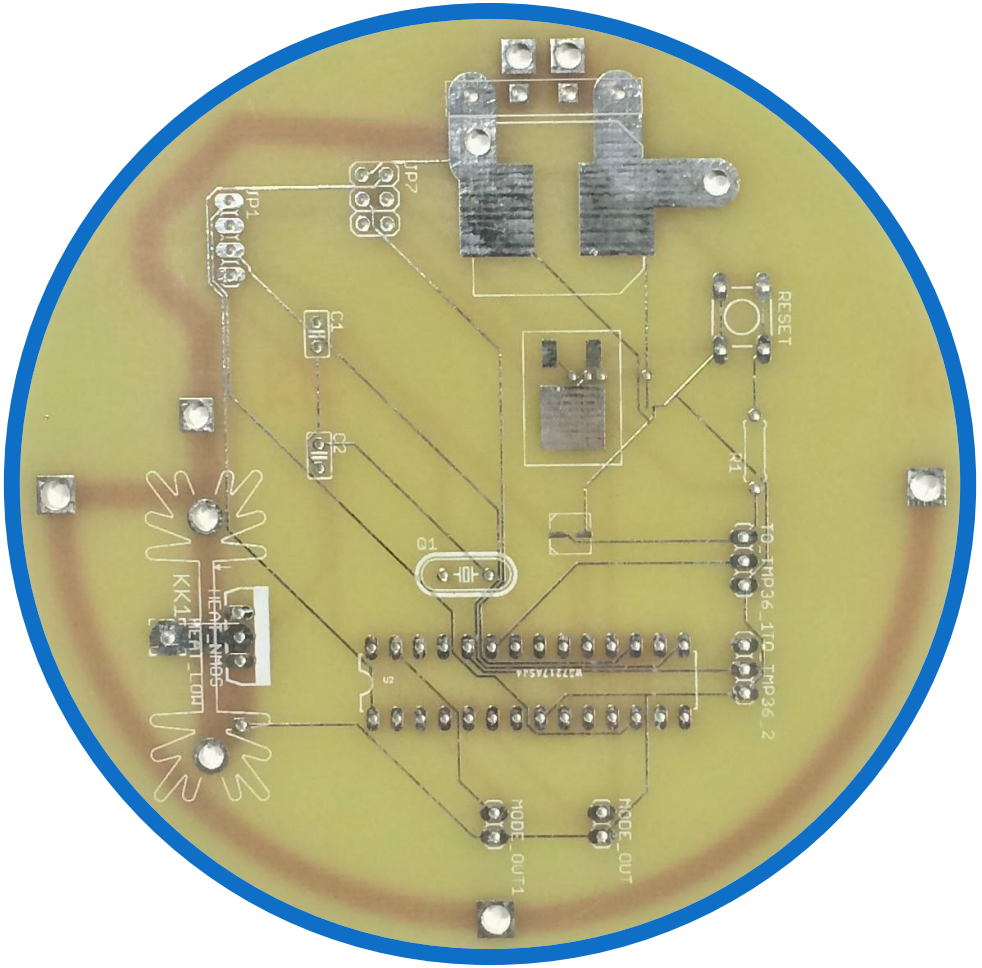
LED PCB



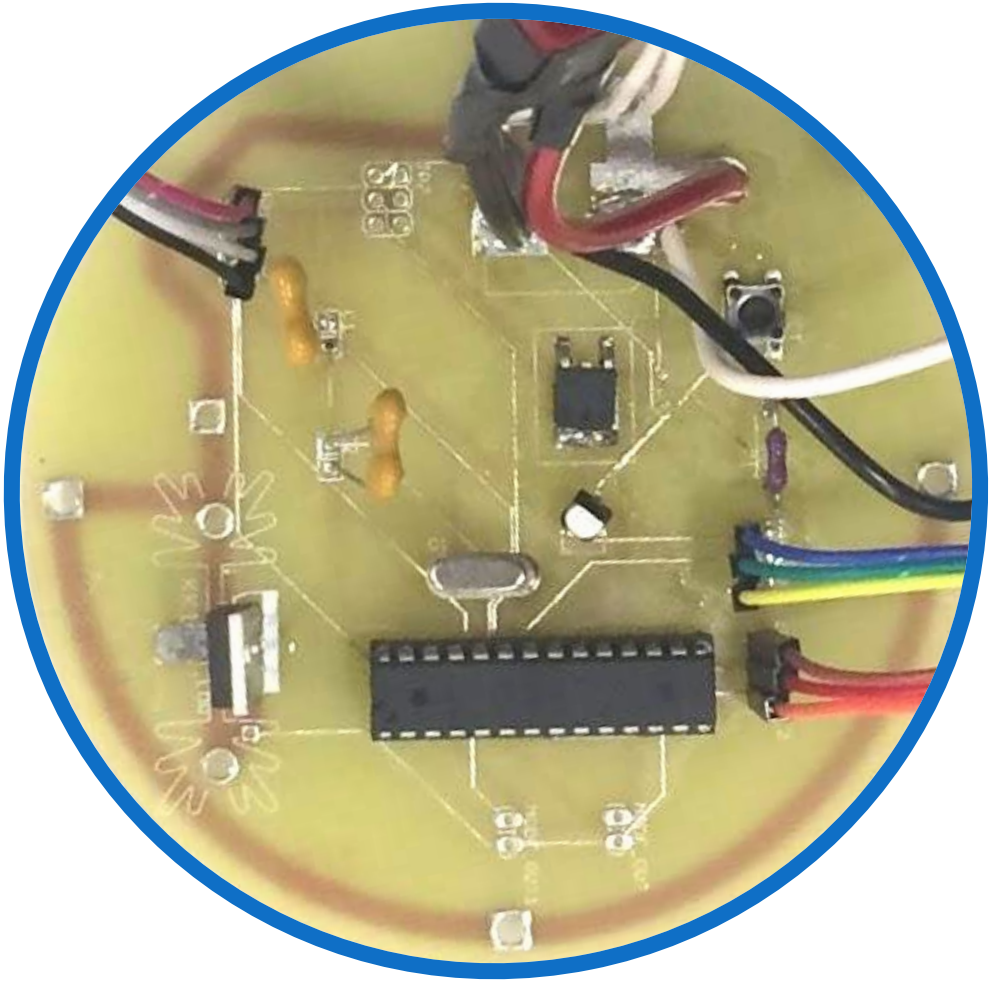
MCU CIRCUIT


3.3v
RESET
TACTILE-SWITCH-PTH
GND
R1
1kΩ
U2
PC6(/RESET)
AVCC
VCC
AREF
PB6(XTAL1/TOSC1)
PB7(XTAL2/TOSC2)
GND
GND
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
ATMEGA328P_PDIP
Q1
16MHz
C2
22 pF
C1
22 pF
ARDUINO
TO_TMP36_1
TO_TMP36_2
KK1
SK104-PAD
HEAT_LOW
HEAT_NMOS
PSMN022-30I
GND
BUTTON1
BUTTON2
GND
LED_PWM

MCU PCB

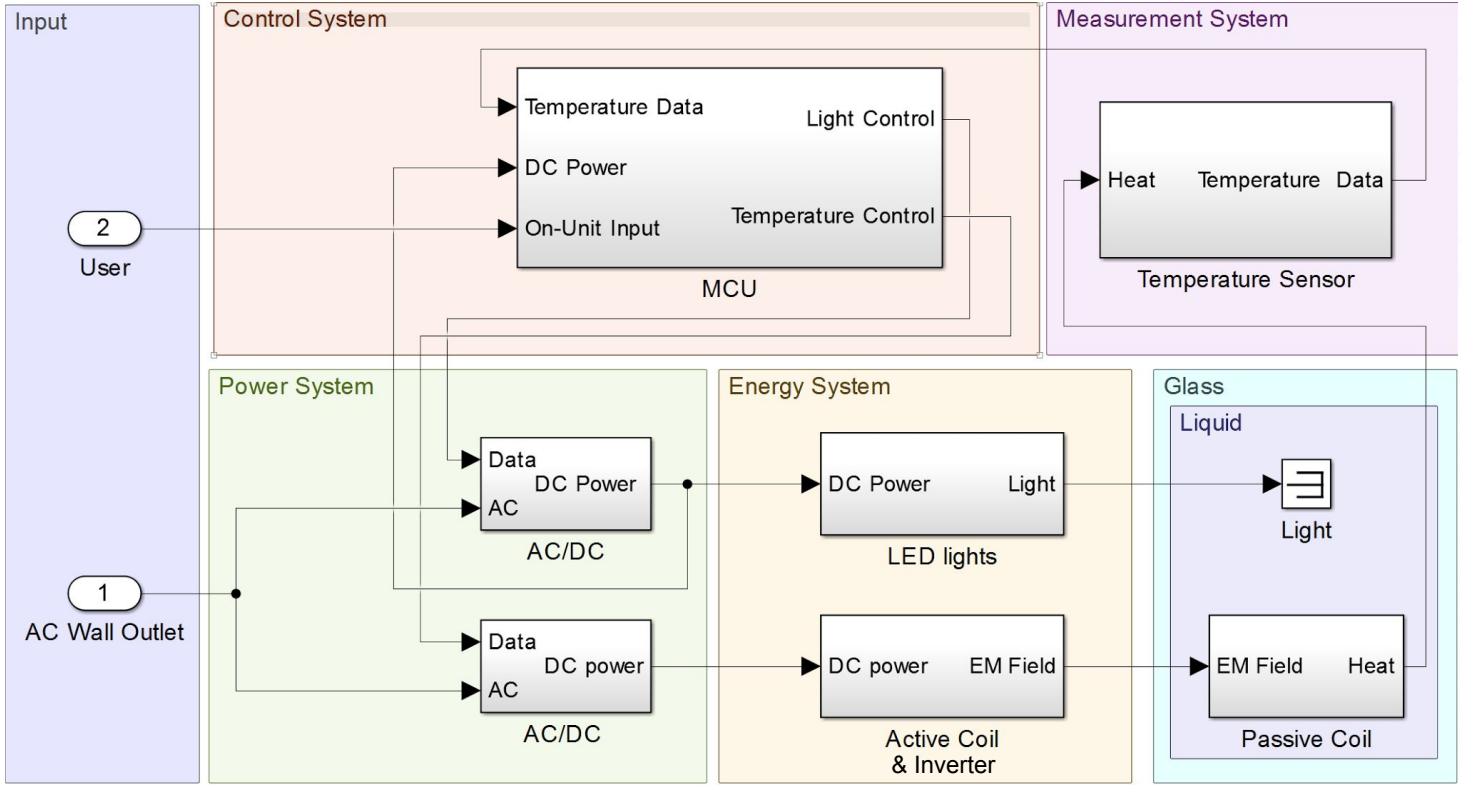

JP7
JP1
C1
C2
Q1
RESET
R1
TO_TMP36_1
TO_TMP36_2
KK1P
HEAT_CMD
HEAT_LOW
MODE_OUT1
MODE_OUT

MCU PCB

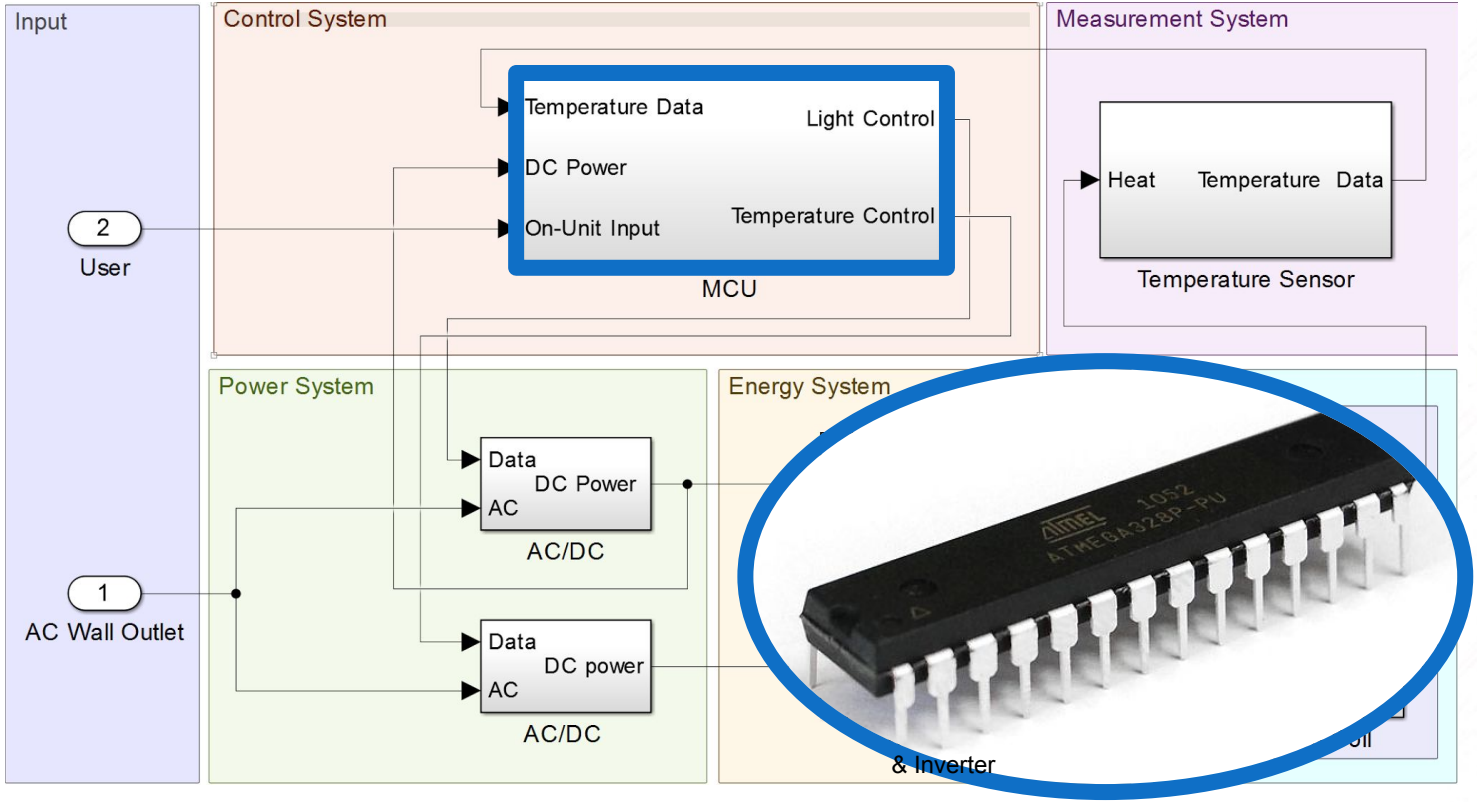


BLOCK DIAGRAM

BLOCK DIAGRAM



MICROCONTROLLER UNIT (MCU)



MCU INPUTS & OUTPUTS

PIN	TYPE
Button 1	Input
Button 2	Input
Lava Temperature Sensor	Input
Heat Temperature Sensor	Input
Red LED PWM	Output
Green LED PWM	Output
Blue LED PWM	Output
White LED PWM	Output
Heat Output	Output

INPUTS:


×2

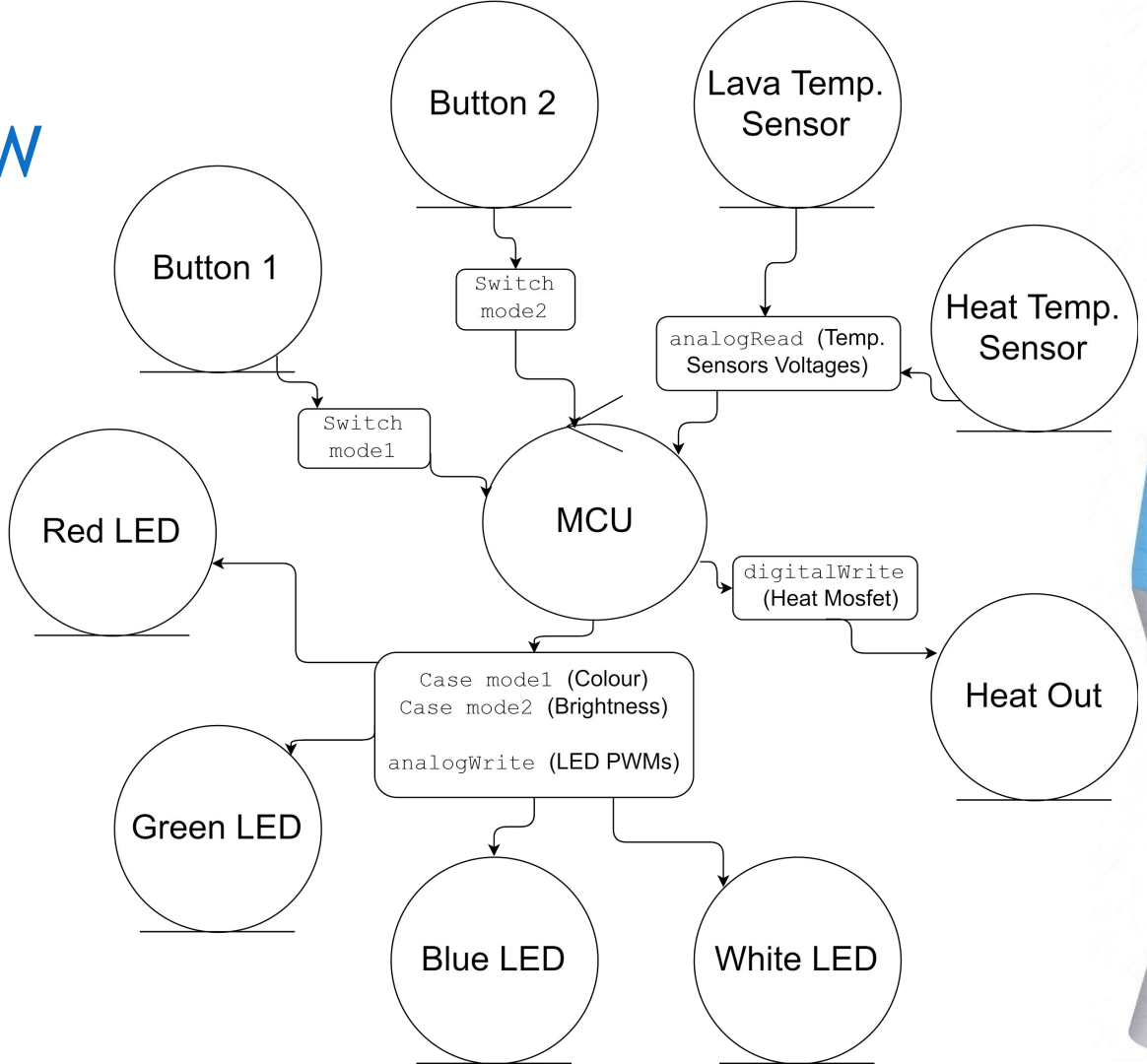

×2

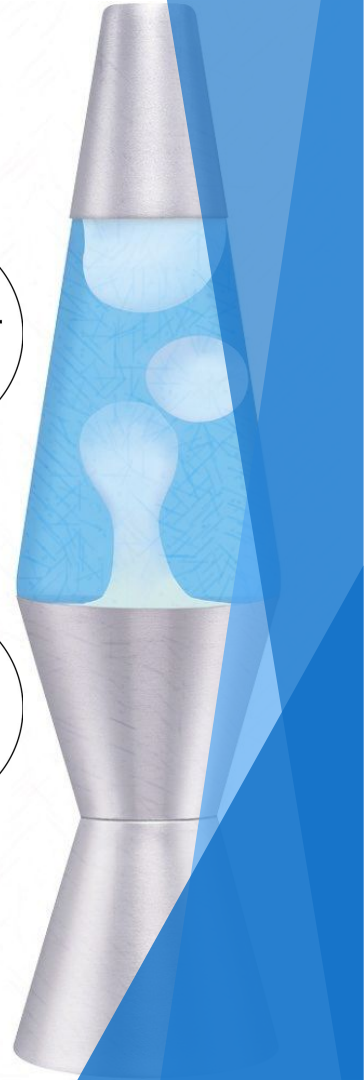
OUTPUTS:

×4


×1

MCU FLOW CHART



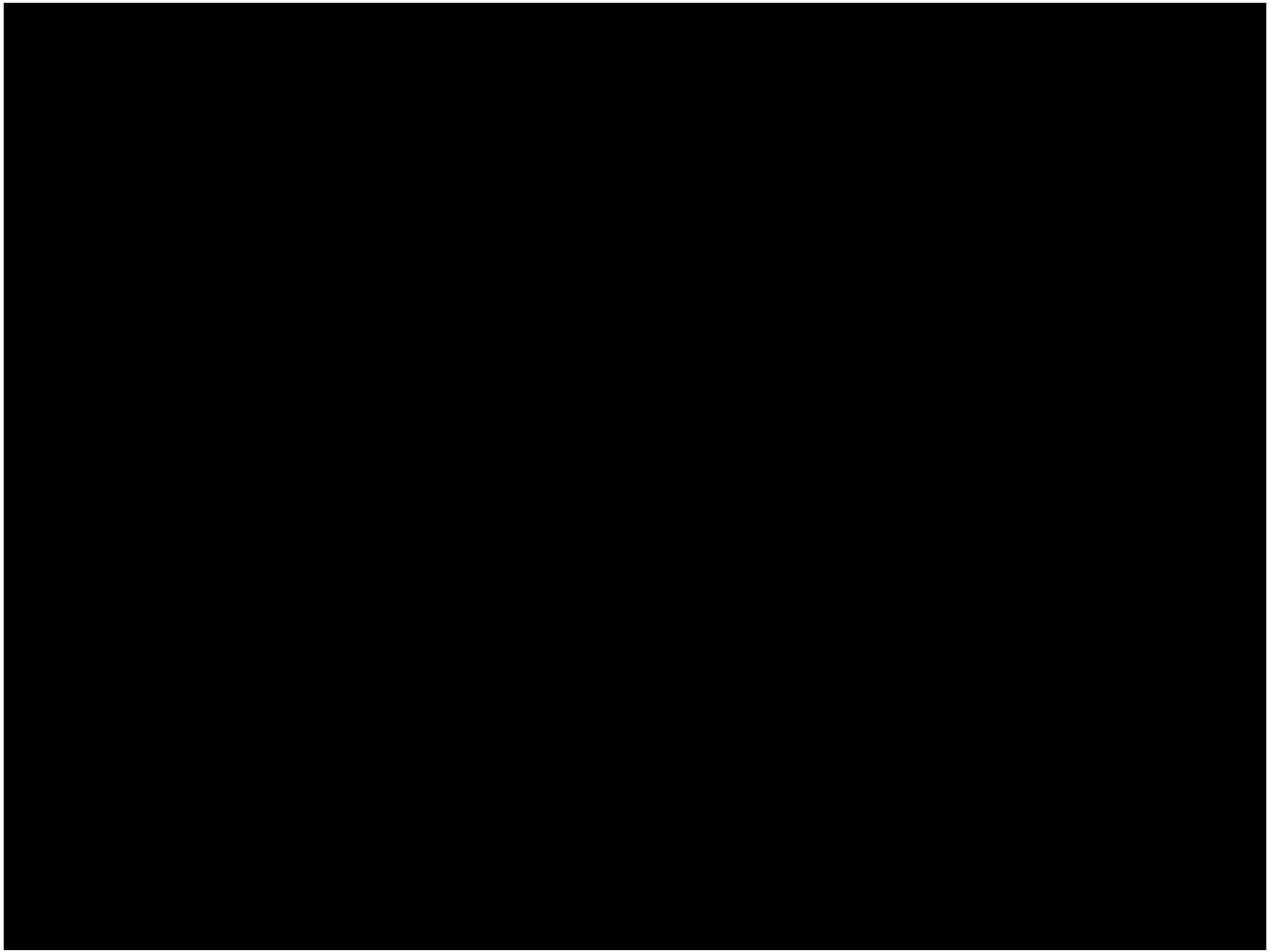


MCU CODE

```
////////////////////////////////////////////////////////////////////////////
//                                                                        //
//                              Main Loop                                 //
//                                                                        //
////////////////////////////////////////////////////////////////////////////
void loop()
{
  //Light
  userInput();  //Read User Input (button1, button2)
  calcLEDs();   //Calculate LED PWM Signals
  setLEDs();    //set LED PWM Signals;
  //Heat
  tempInput();  //Read Temperature Sensors
  calcHeat();   //Calculate Heat PWM Signals
  setHeat();    //Set Heat PWM Signals
}
```

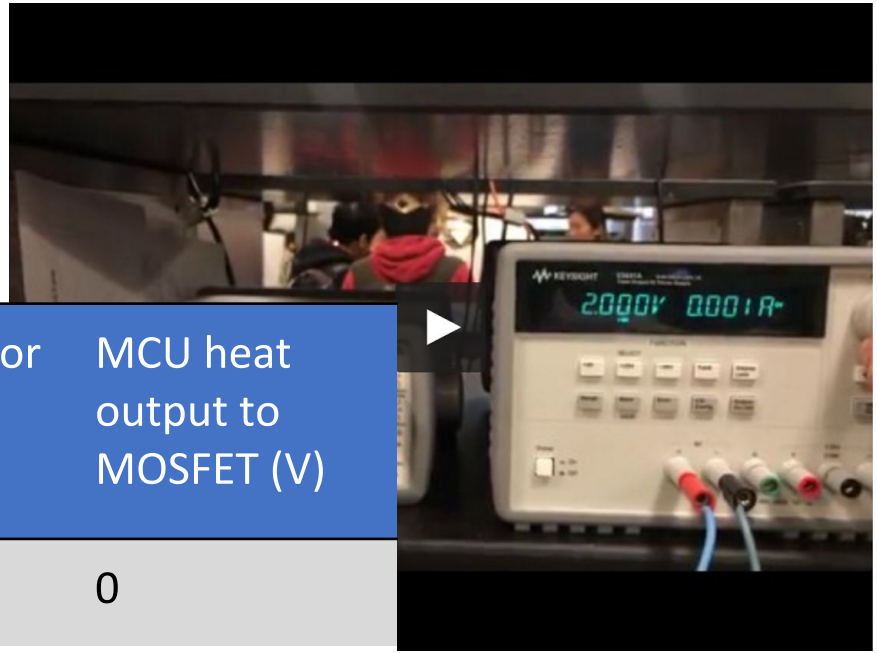
MCU REQUIREMENTS

- [x] LED light control



MCU UNIT REQUIREMENTS

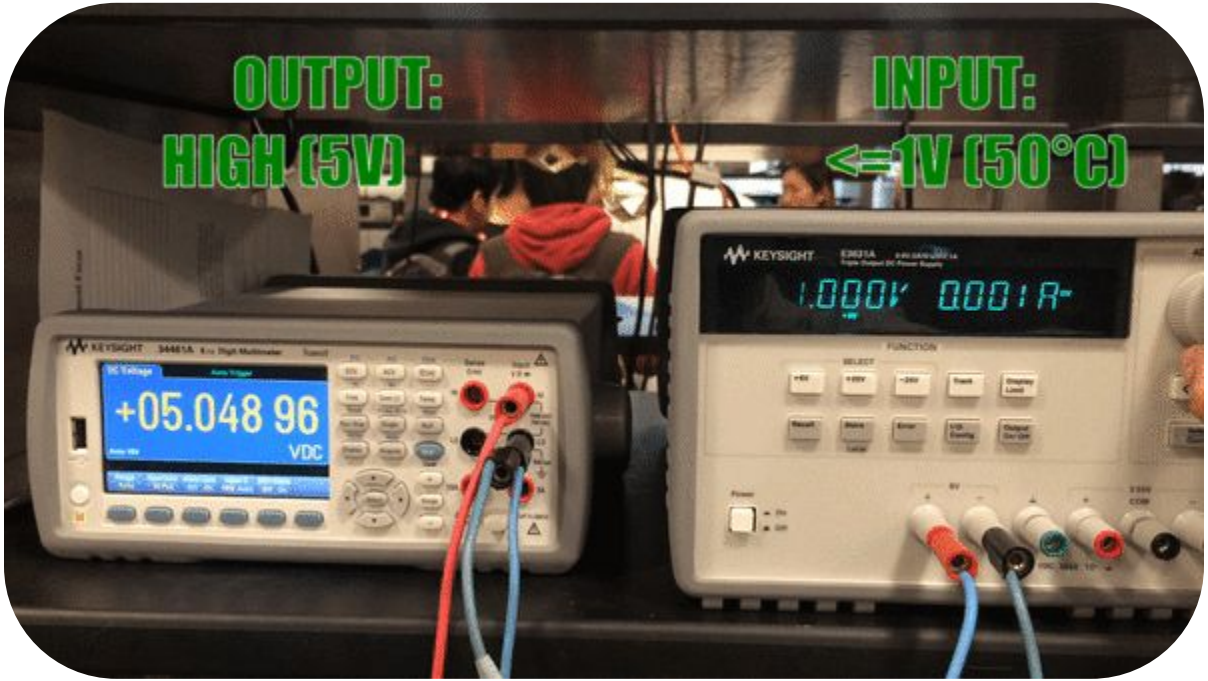
- [x] Heat control



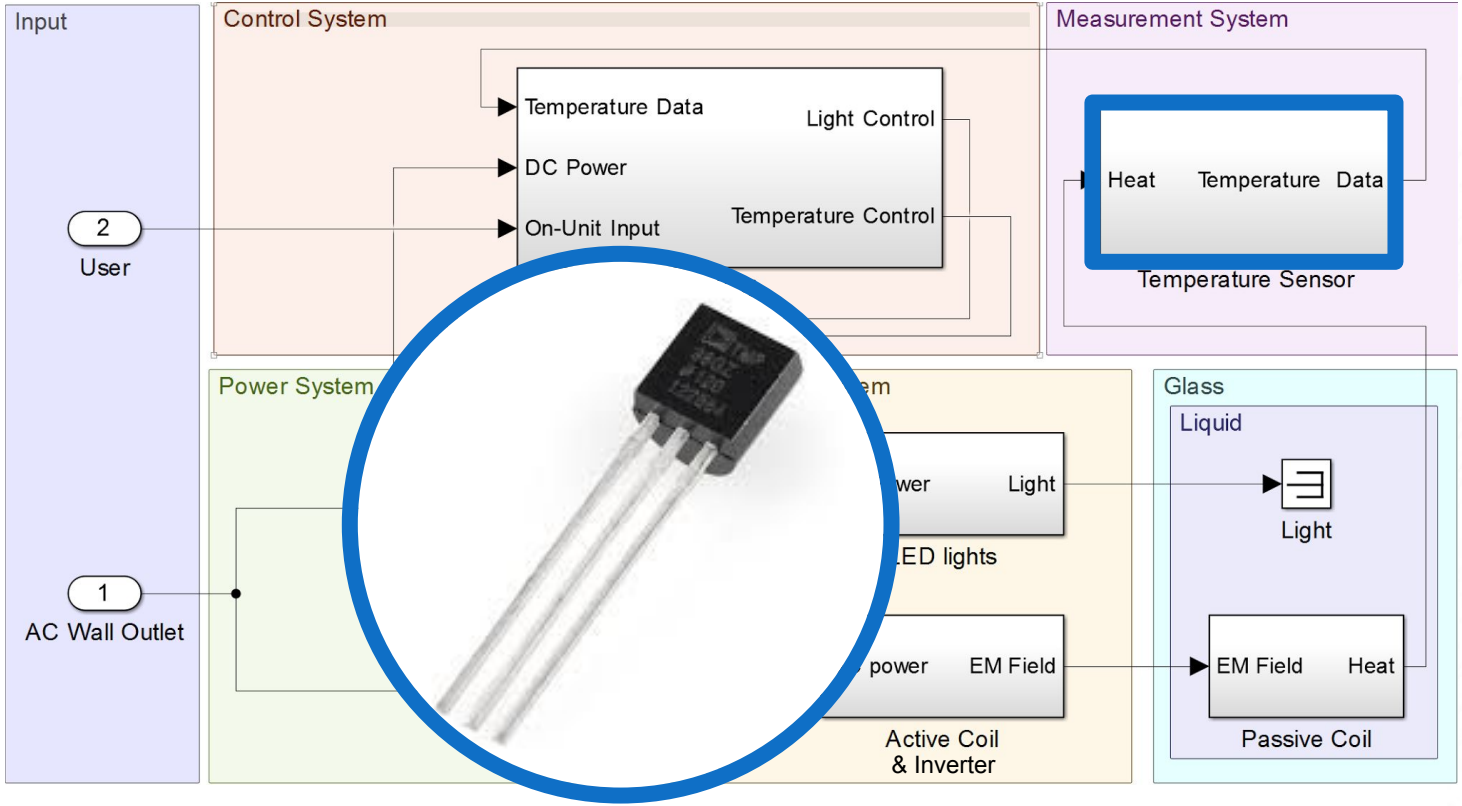
Temperature (°C)	Temp. Sensor Voltage (V)	MCU heat output to MOSFET (V)
>50°C	>1.0	0
<=50°C	<=1.0	5

MCU REQUIREMENTS

- [x] Heat control



TEMPERATURE SENSORS

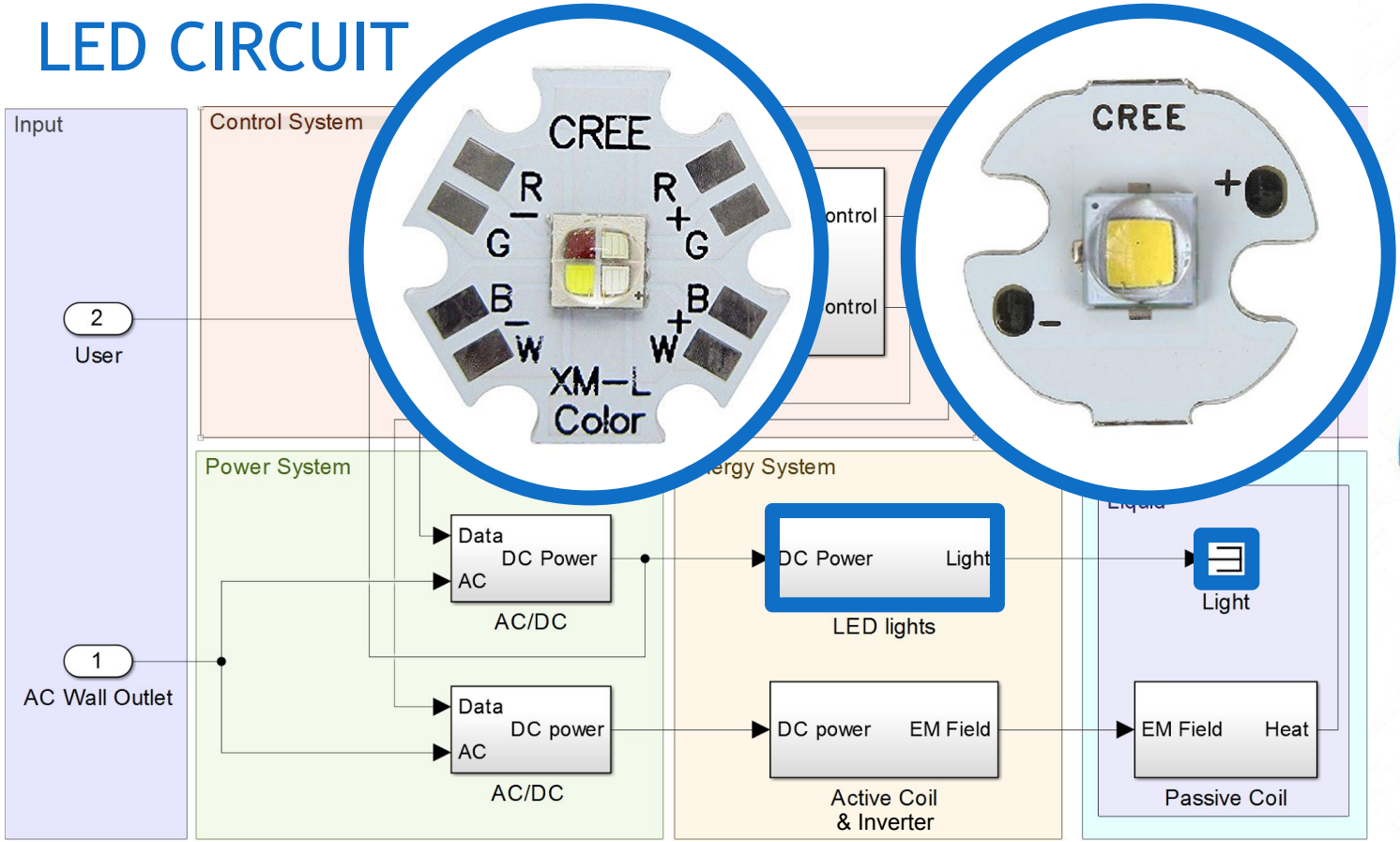


TEMPERATURE SENSORS VERIFICATIONS

$$Voltage[V] = 0.75 + (Temperature[°C] - 25) * 0.01$$

☑ Measurement once every 15 sec.	▶ TESTED
☑ Output readable by MCU	▶ 0.1 to 1.75V (-40 to 125°C)
☑ Precision of ±2°C	▶ Equivalent to ±0.02V

LED CIRCUIT

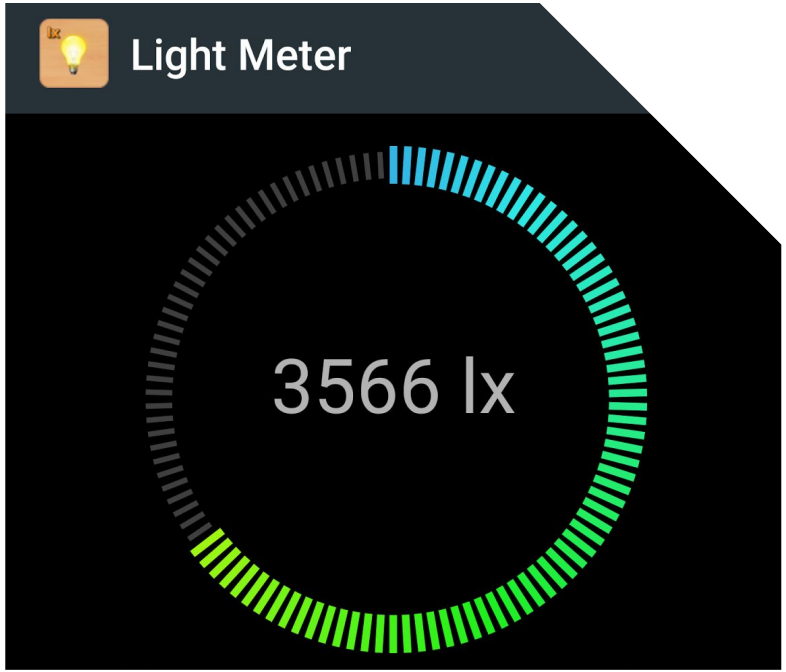

Input
2
User
1
AC Wall Outlet
Control System
ontrol
ontrol
Power System
Data
DC Power
AC
AC/DC
Data
DC power
AC
AC/DC
ergy System
DC Power
Light
LED lights
DC power
EM Field
Active Coil
& Inverter
Light
EM Field
Heat
Passive Coil
CREE
R
G
B
W
XM-L
Color
CREE

LIGHTING REQUIREMENTS

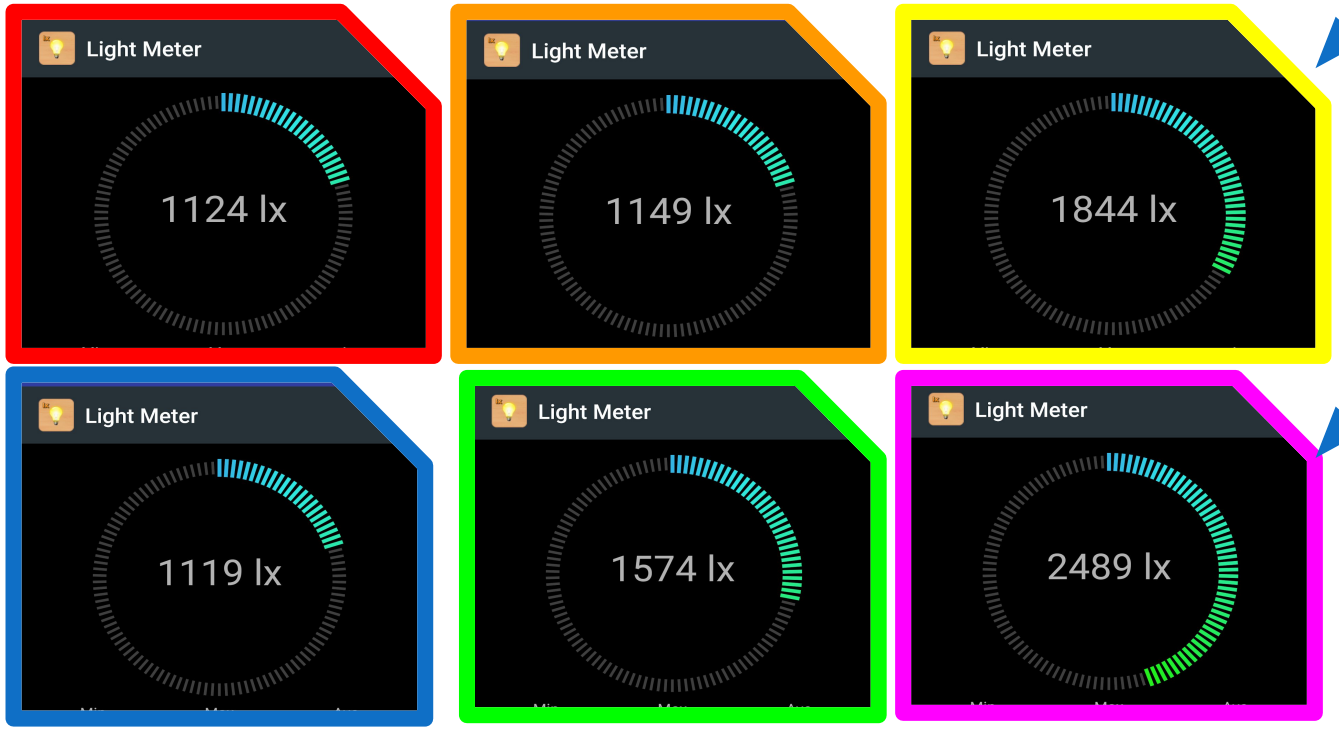
- [x] Produce 3000 lux

1 foot away from

light source



LIGHTING REQUIREMENTS



LIGHTING REQUIREMENTS

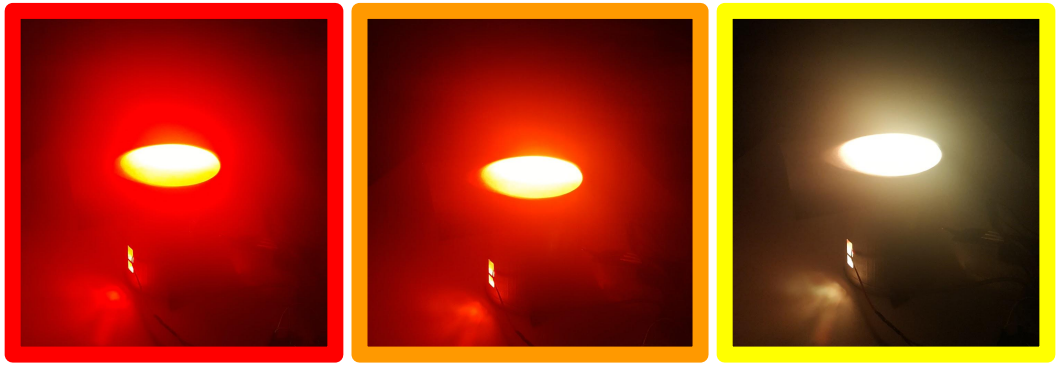
- [x] Control illuminance at 5 increments

LIGHTING REQUIREMENTS

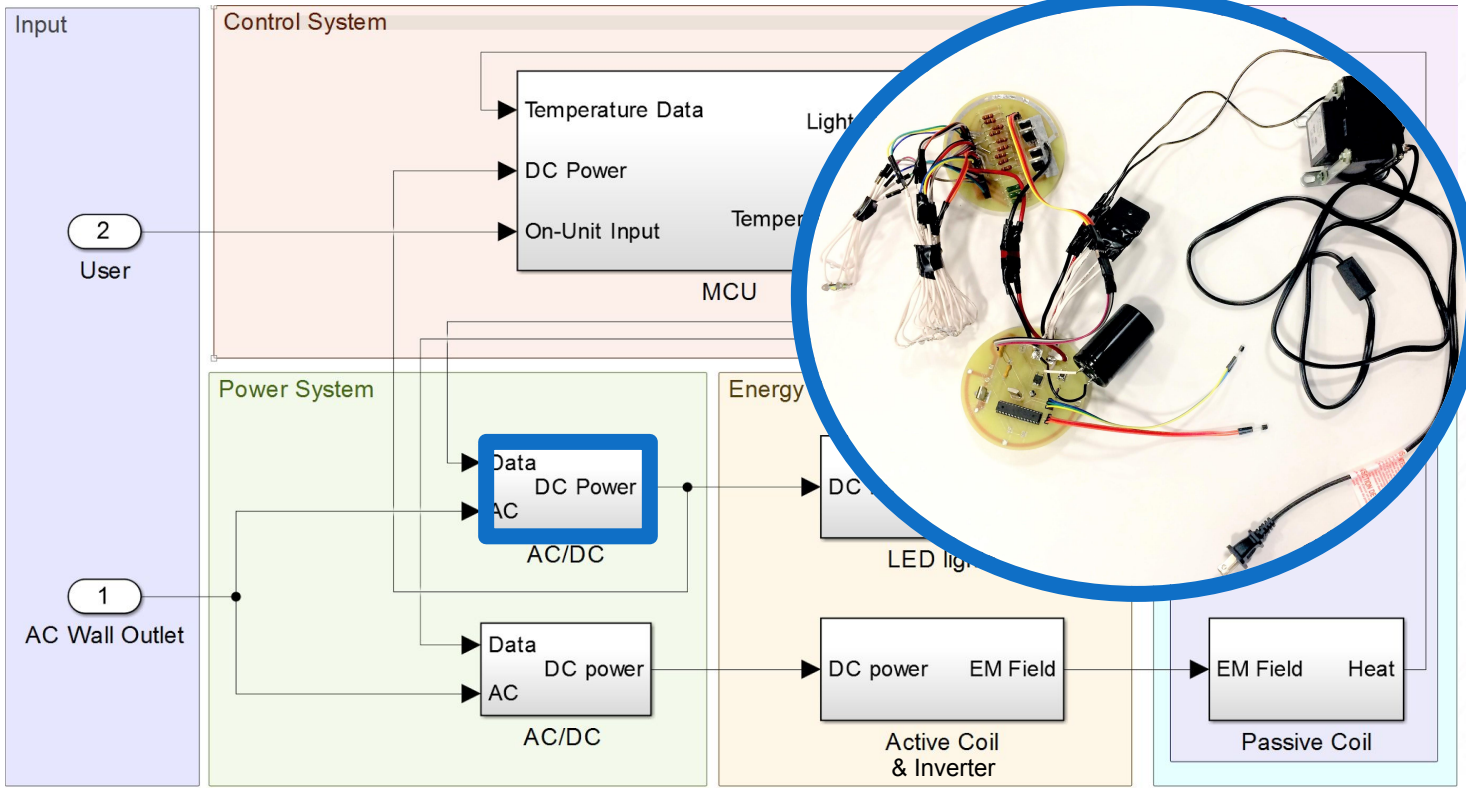
☑ Switch between

- Red
- Orange
- Yellow
- Green
- Blue
- Violet
- White

LIGHTING REQUIREMENTS

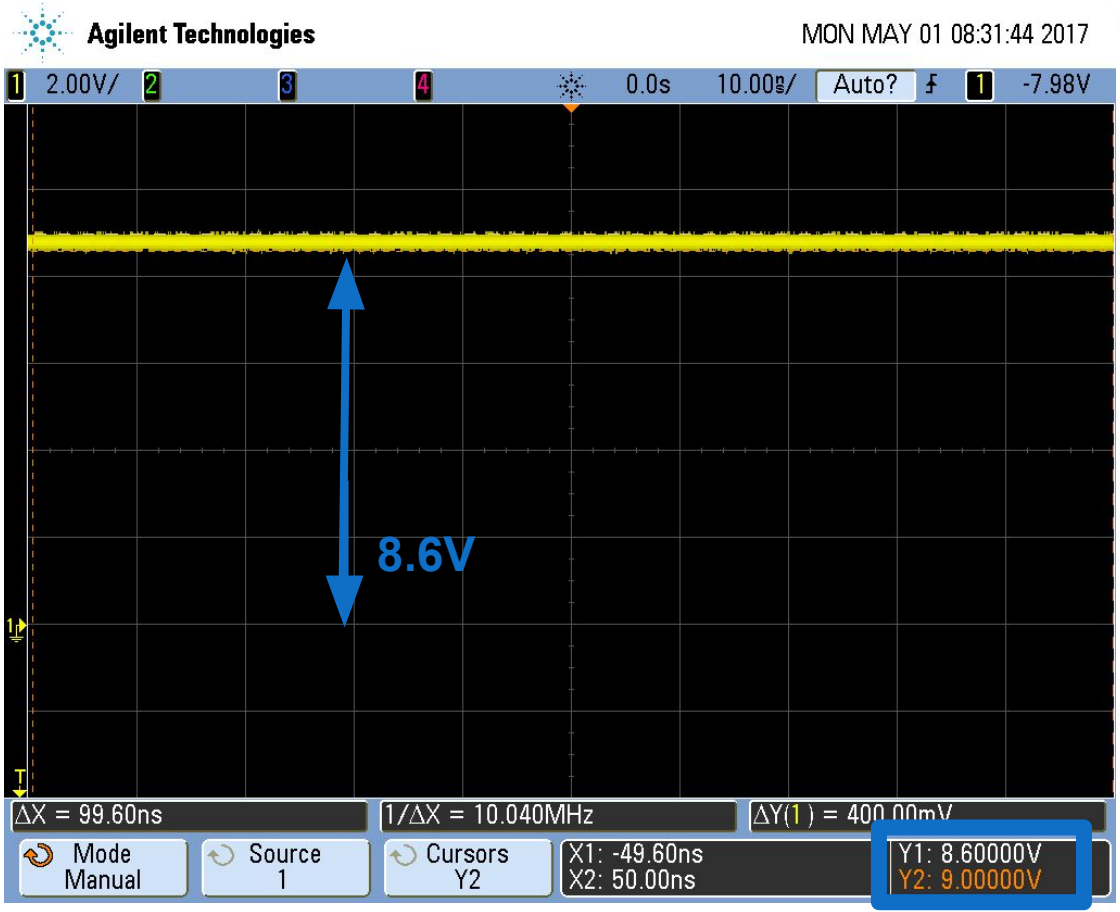


LED AND MCU POWER CIRCUIT



LED AND MCU POWER REQUIREMENTS

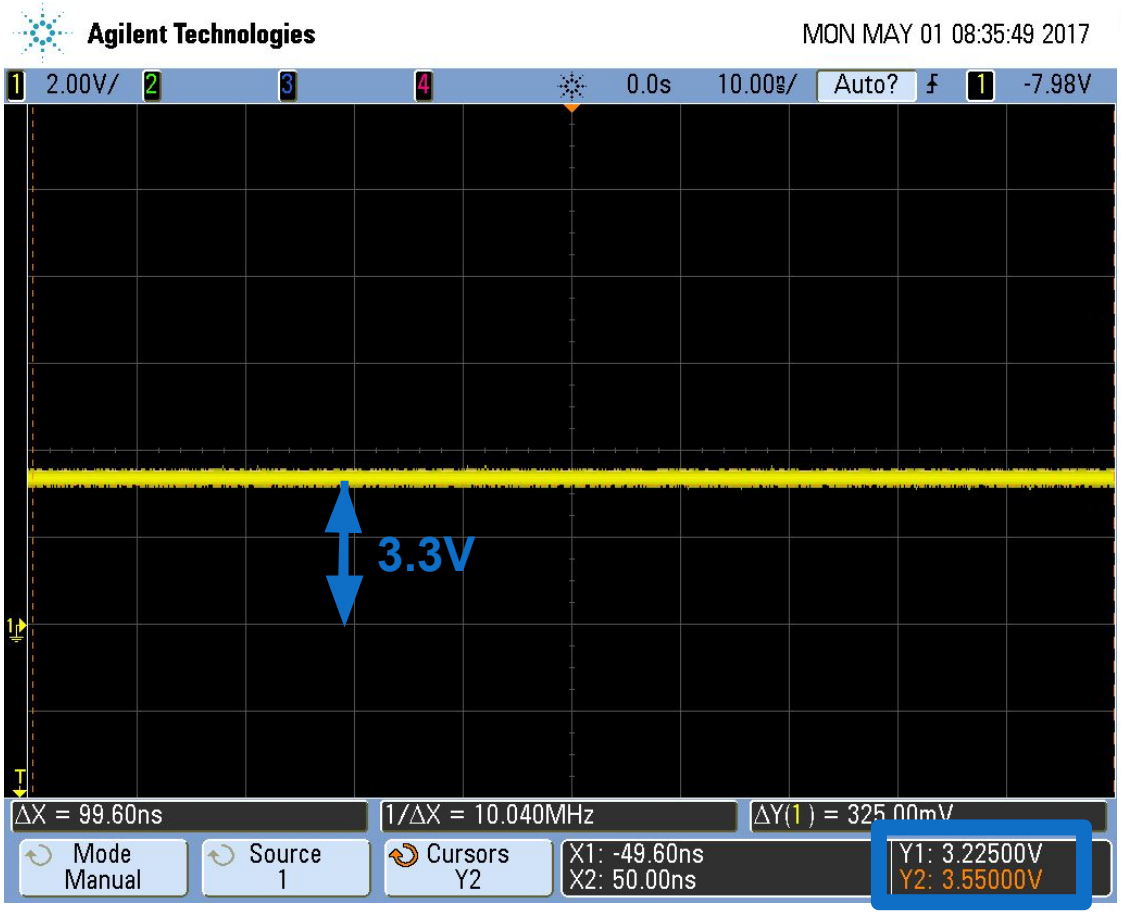
- [x] Supply 8.6V DC to LED circuit



LED AND MCU POWER REQUIREMENTS

- [x] Supply 3.3V

DC to MCU

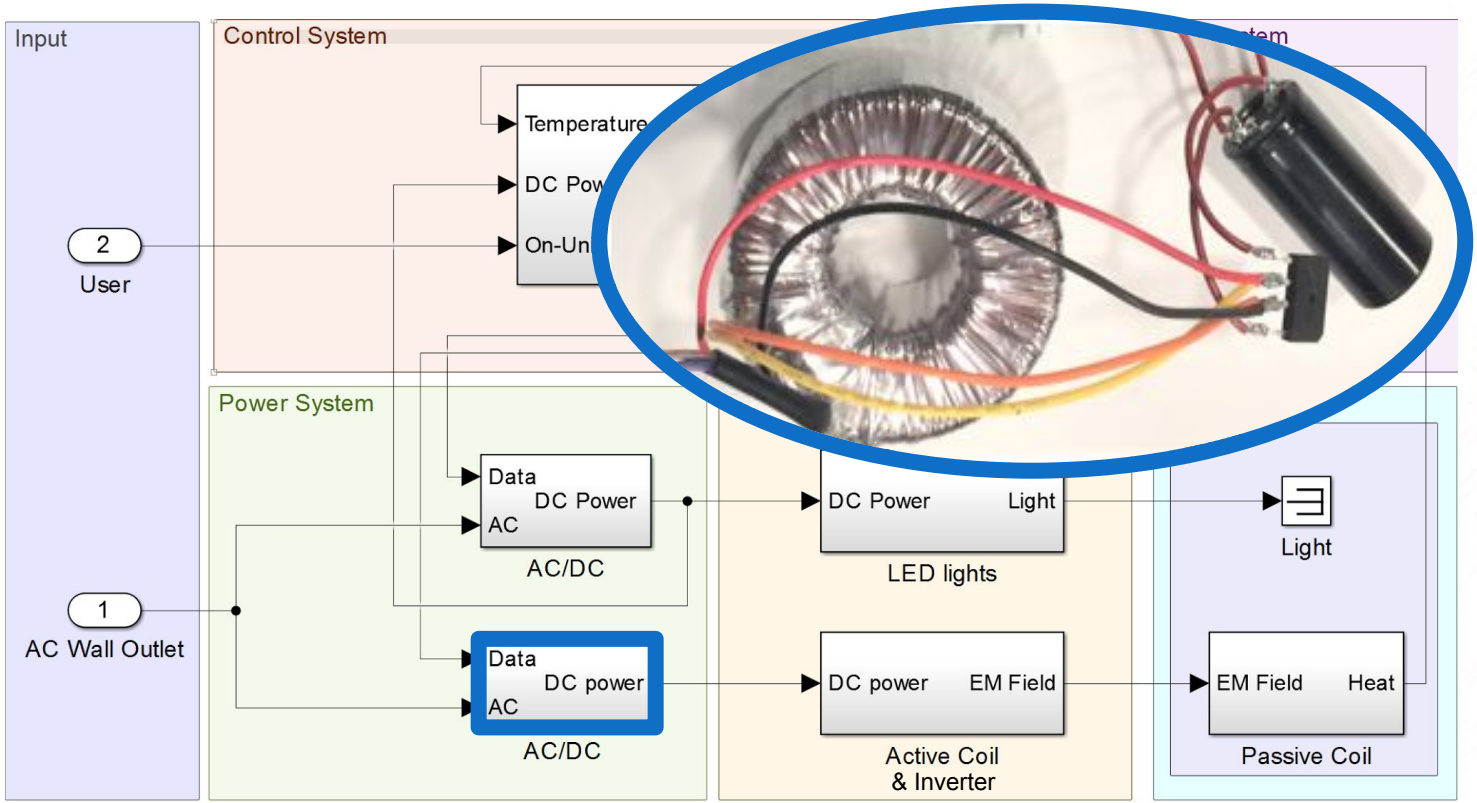


ADDITIONAL POWER REQUIREMENTS

- LED circuit operates within 10A and 60W

All on	5.11A	12.734W
White	1.8A	5.7W
R/G/B	1.03A	2.55W
O/Y/V	2.1A	5W

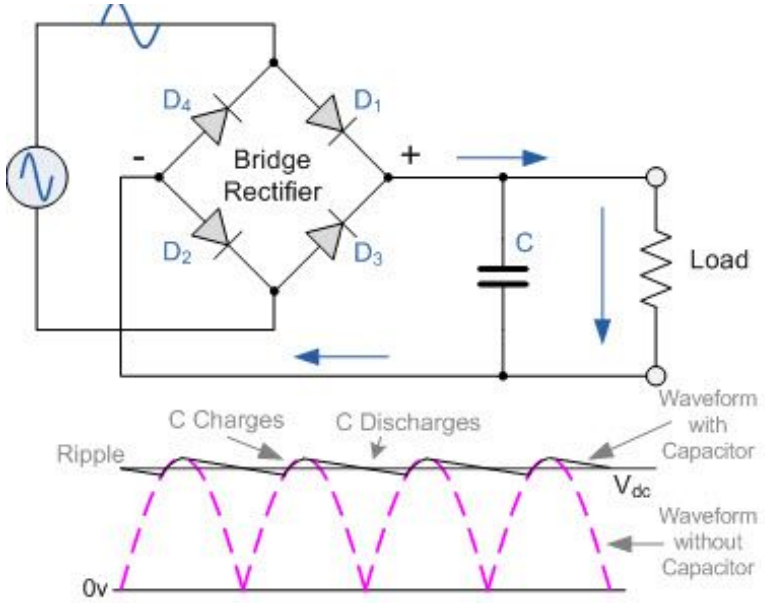
INDUCTION POWER CIRCUIT



INDUCTION POWER SUPPLY

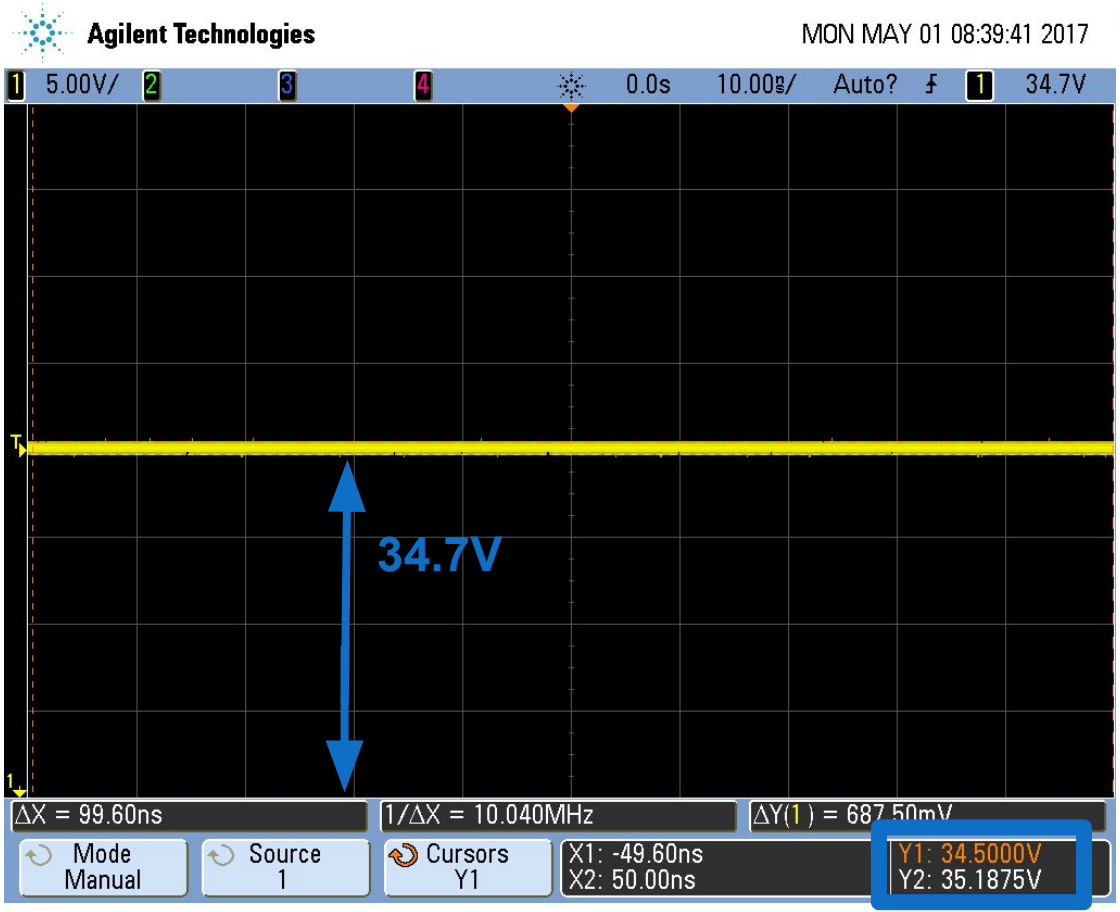
- 115:24 turn transformer
- Full-bridge rectifier
- Filter capacitor
- Equation for filter cap value:

$$C = \frac{i\,t}{\Delta V}$$

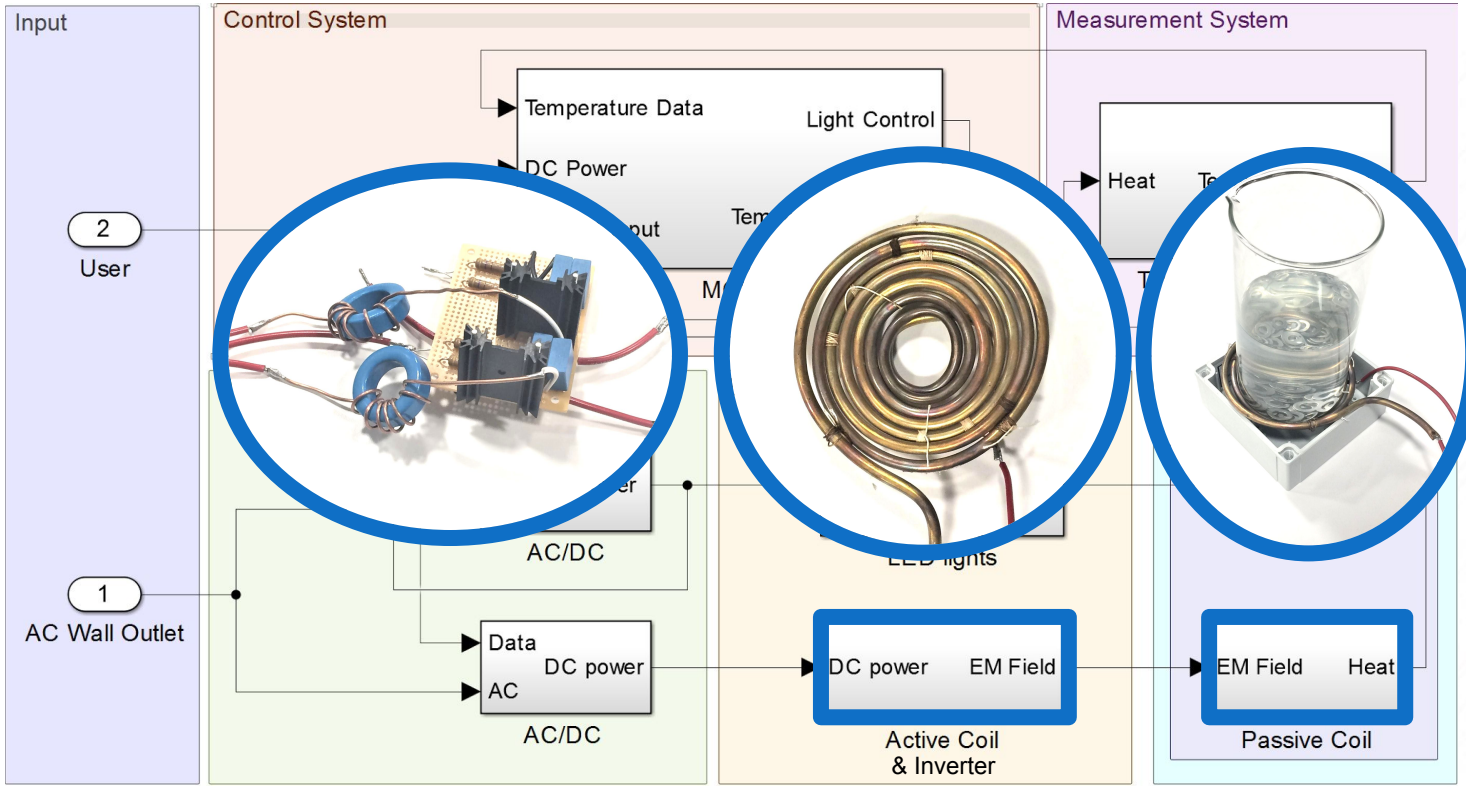


INDUCTION POWER REQUIREMENTS

- [x] 120V AC to 34V DC



INDUCTION

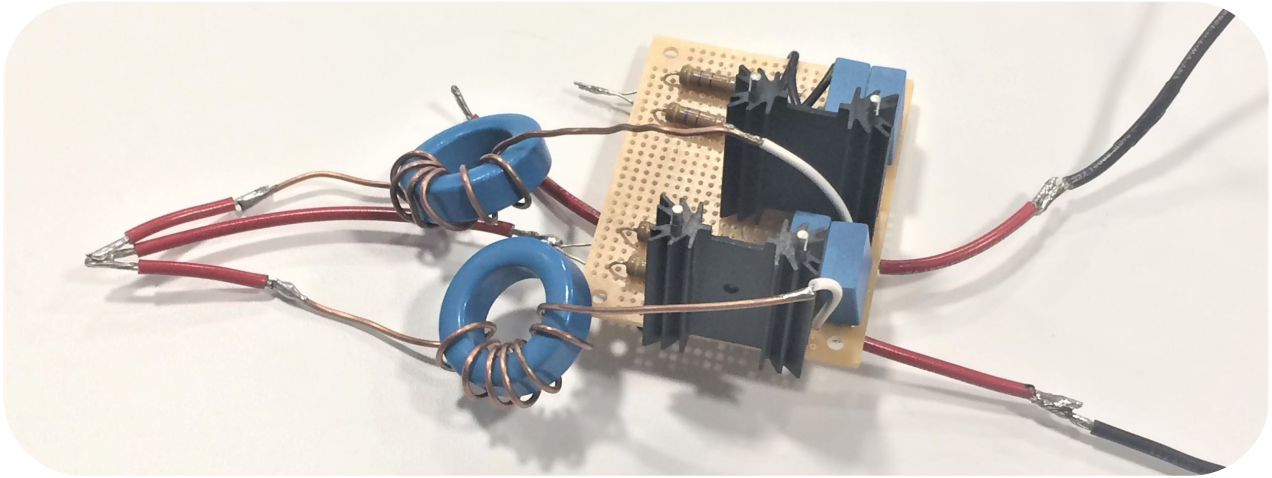

Input
Control System
Measurement System
2
User
1
AC Wall Outlet
Temperature Data
Light Control
DC Power
Heat
AC/DC
Data
DC power
AC
AC/DC
DC power
EM Field
Active Coil
& Inverter
EM Field
Heat
Passive Coil

HAND-BUILT INDUCTION DRIVER

- Built as a ZVS driver
- Frequency determined by:

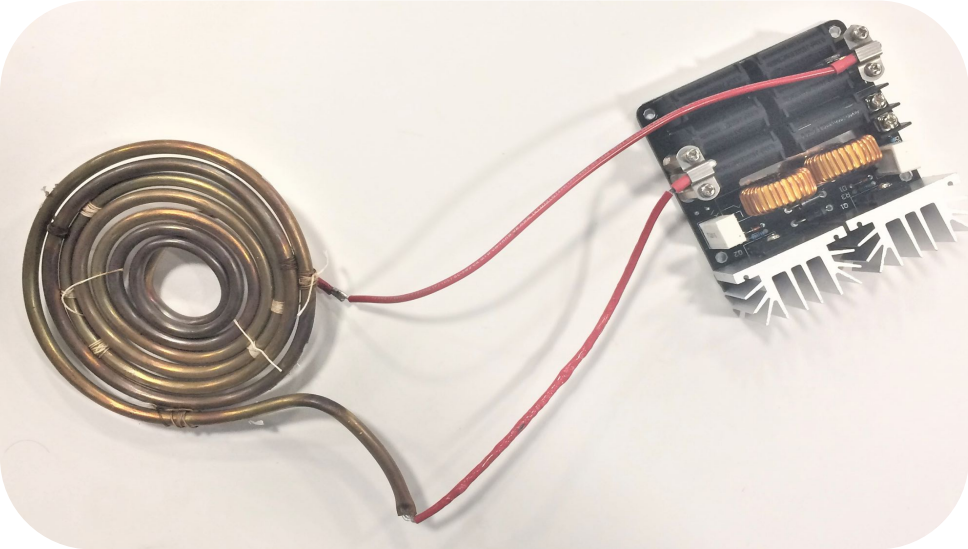
$$f = \frac{1}{2\pi\sqrt{LC}}$$

- Damaged MOSFETS prevented further testing

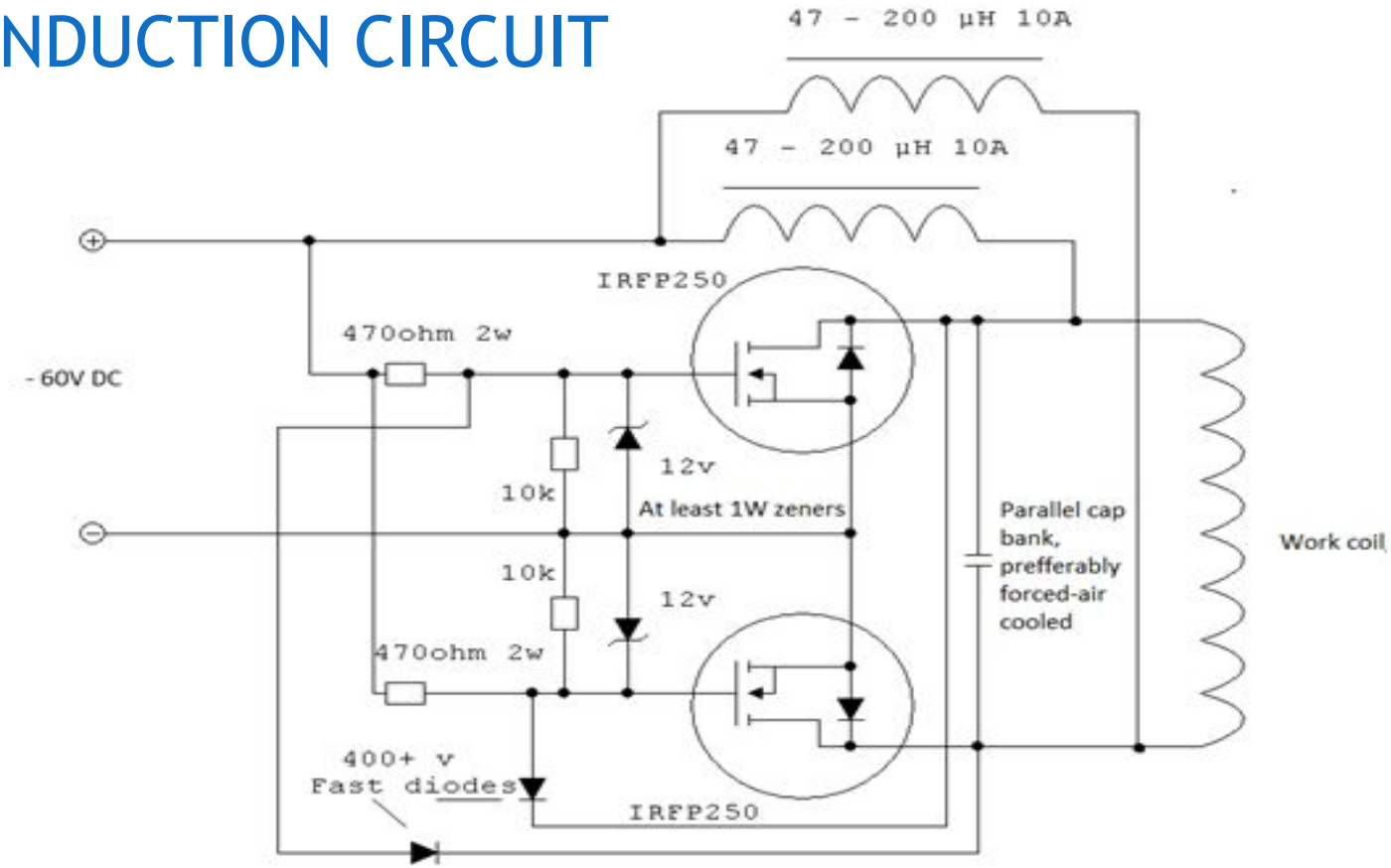


PRE-BUILT INDUCTION DRIVER

- Same basic design as hand built driver
- Built more robustly (capable of producing 1000W)
- Used to conduct induction tests



INDUCTION CIRCUIT

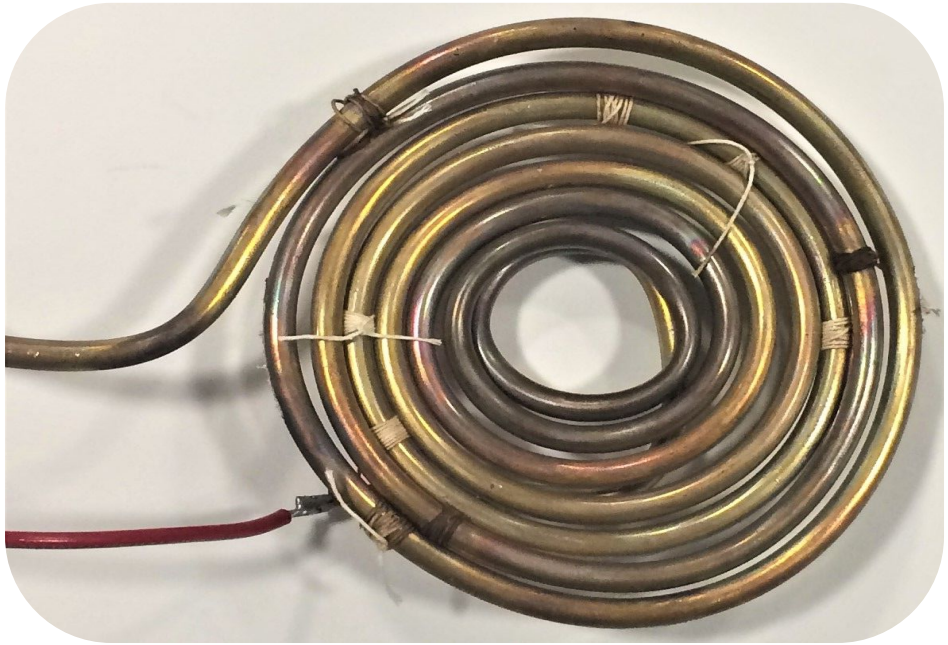


INDUCTION REQUIREMENTS

- Heat water to 50°C within 10 minutes

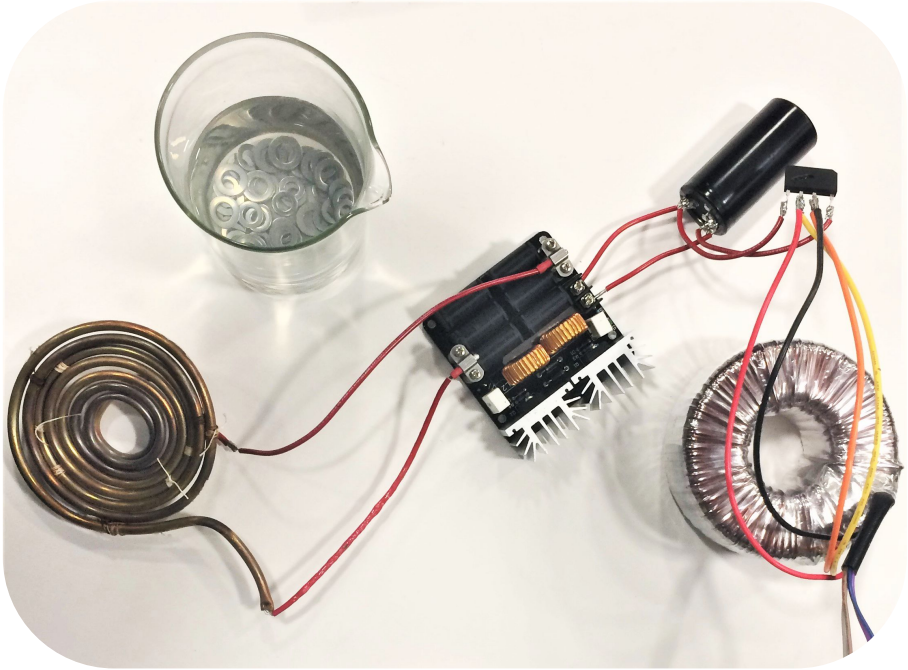
INDUCTION REQUIREMENTS

- Make sure active coil does not exceed 44°C



INDUCTION REQUIREMENTS

- Surface temperature of glass does not exceed 44°C



CONCLUSIONS

- ✗ OPERATION → 50°C within 10 minutes
- ✓ BRIGHTNESS → 3000 lux at 1ft
- ✓ CONTROL → 7 Colours, 5 Brightnesses
- ✗ SAFETY → 45°C outside the globe

FUTURE WORK

- Integration of components into one working unit:
  - Power supplies
  - PCBs
- Better active coil to prevent overheat
  - Research in coils
- Updated physical design

Thanks Everybody!

Questions