

Environmentally Controlled Window Shade

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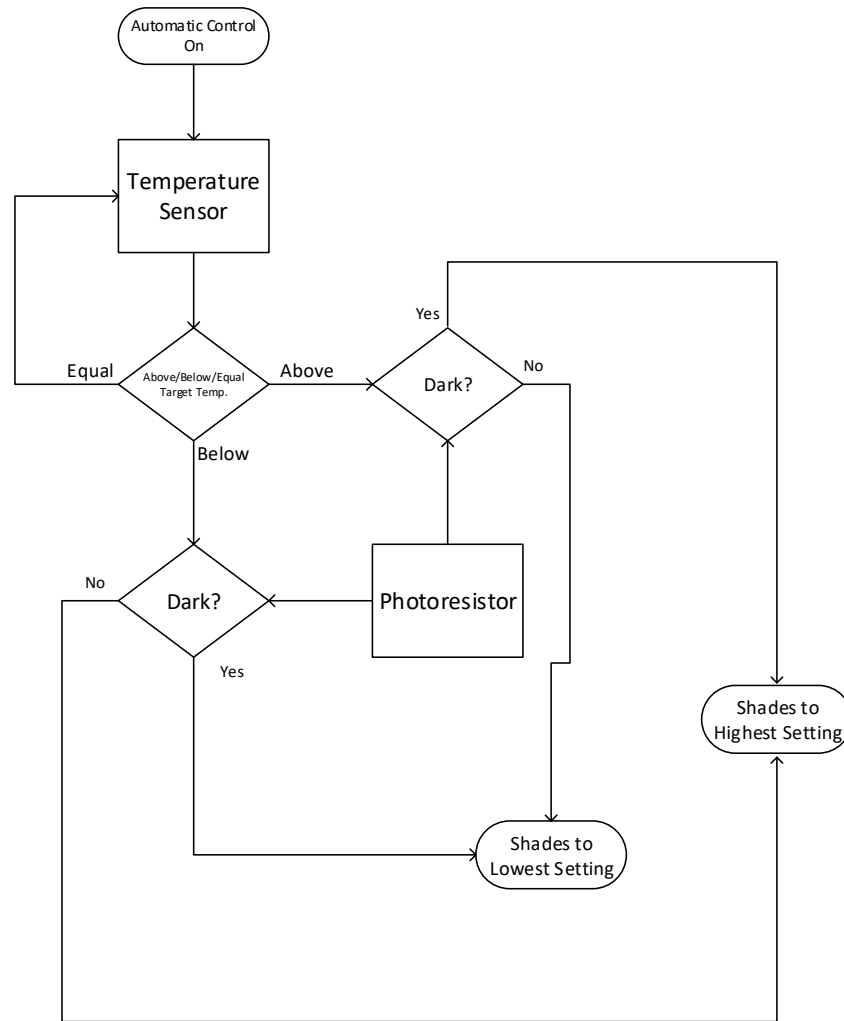
Background Information

- Blinds can reduce heat gain from windows by as much as 45% in the summer
- 1,300 kWh/m² of heat through south facing windows in Laramie each year, assuming every day is sunny
- 10.57 cents/kWh in Wyoming in January 2017
- \$61.8345 per m² per year

Project Purpose

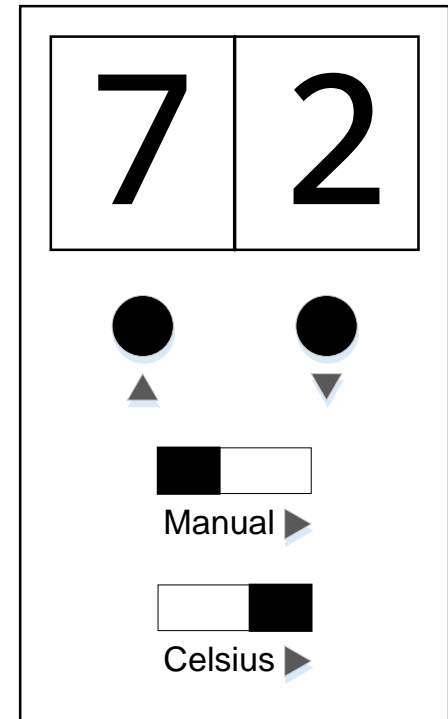
- Create a low-cost, automated, environmentally controlled window shade
- Adjusts on indoor temperature and the sunlight outdoors to achieve maximum power savings

Basic Operation



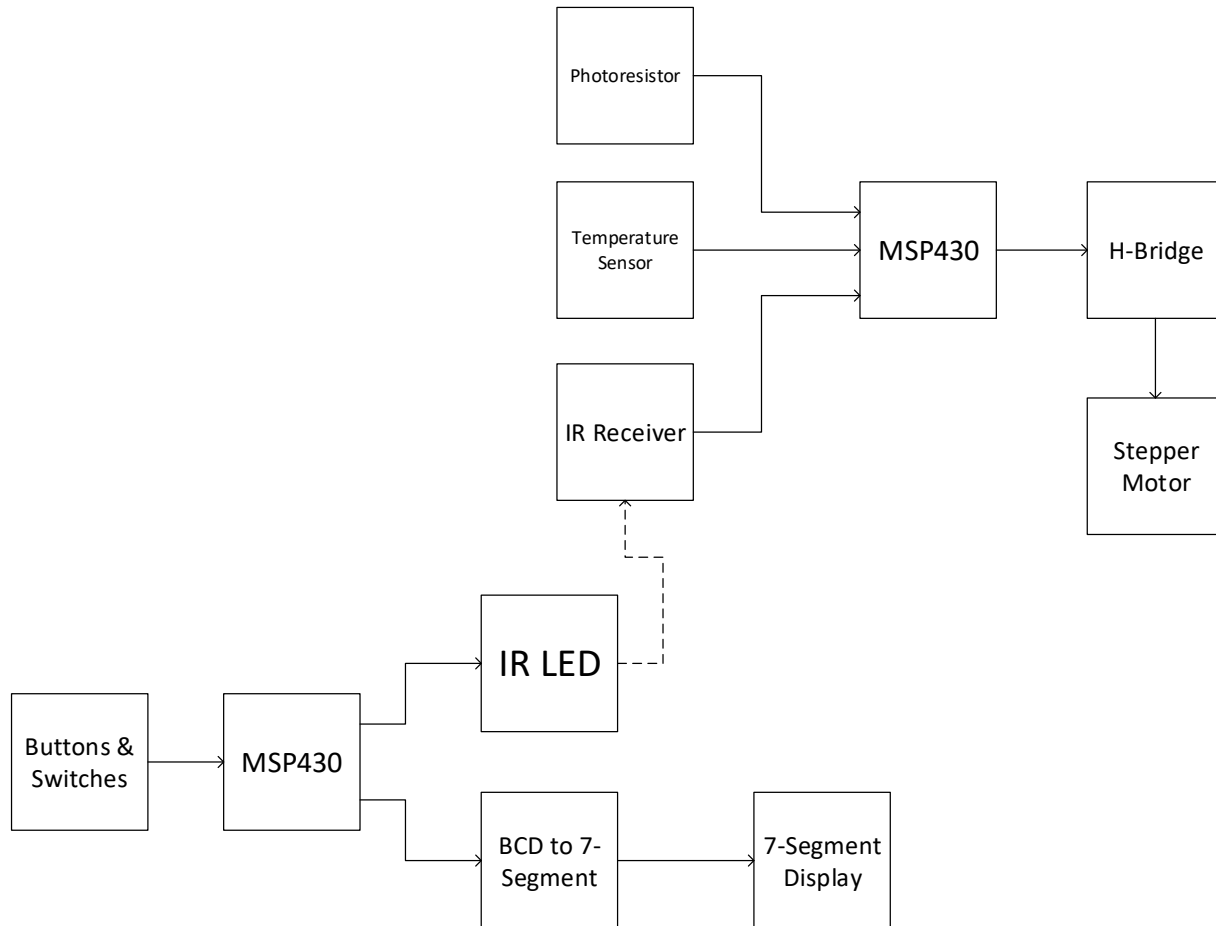
Remote Controlled

- Display temperature
 - Celsius or Fahrenheit
- Set desired temperature
- Manual control of the device
- Multiple communication types considered



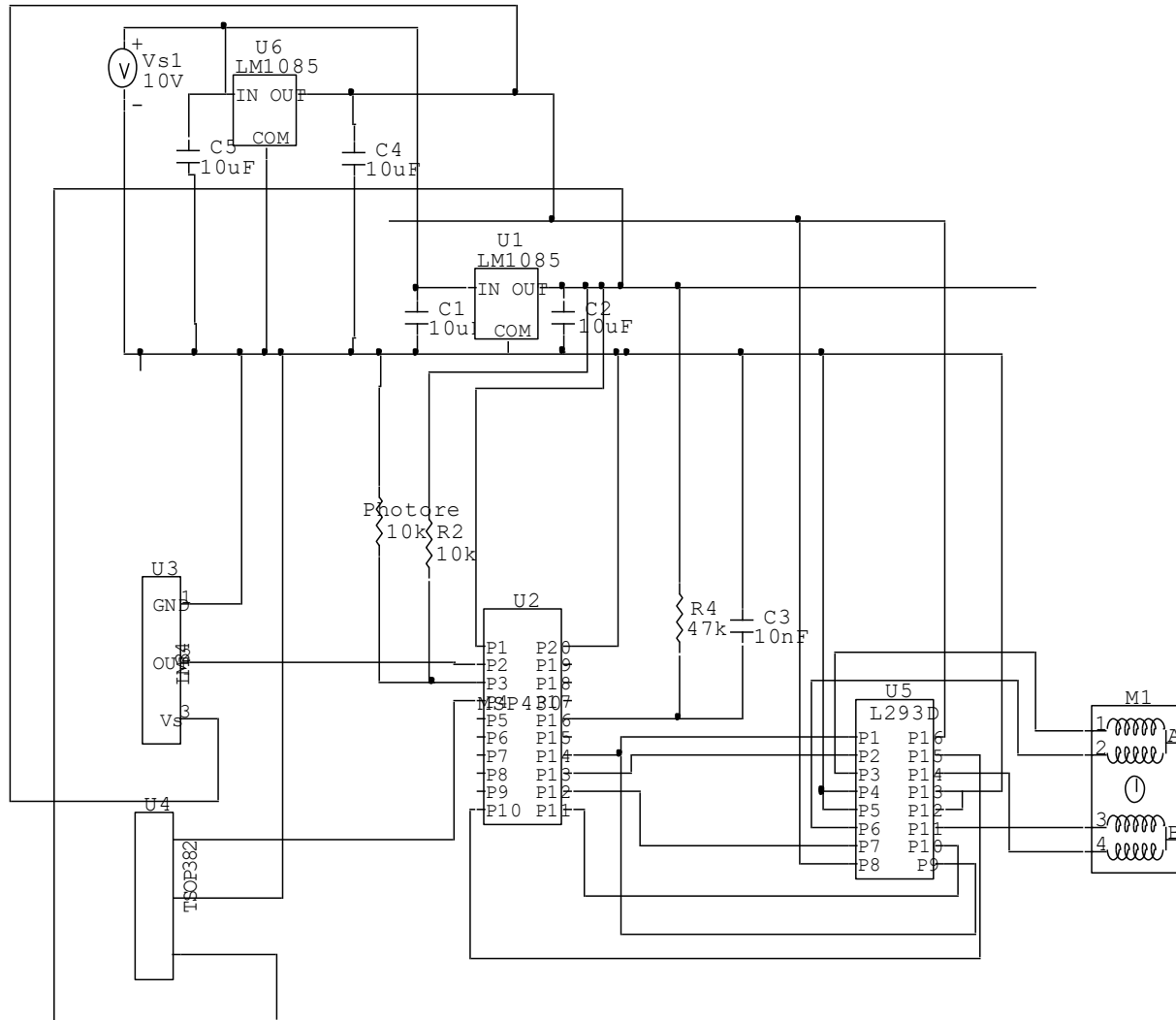
Example Remote
Control Interface

Functional Block Diagram



Input/Output Block Diagram

Main Device Schematic



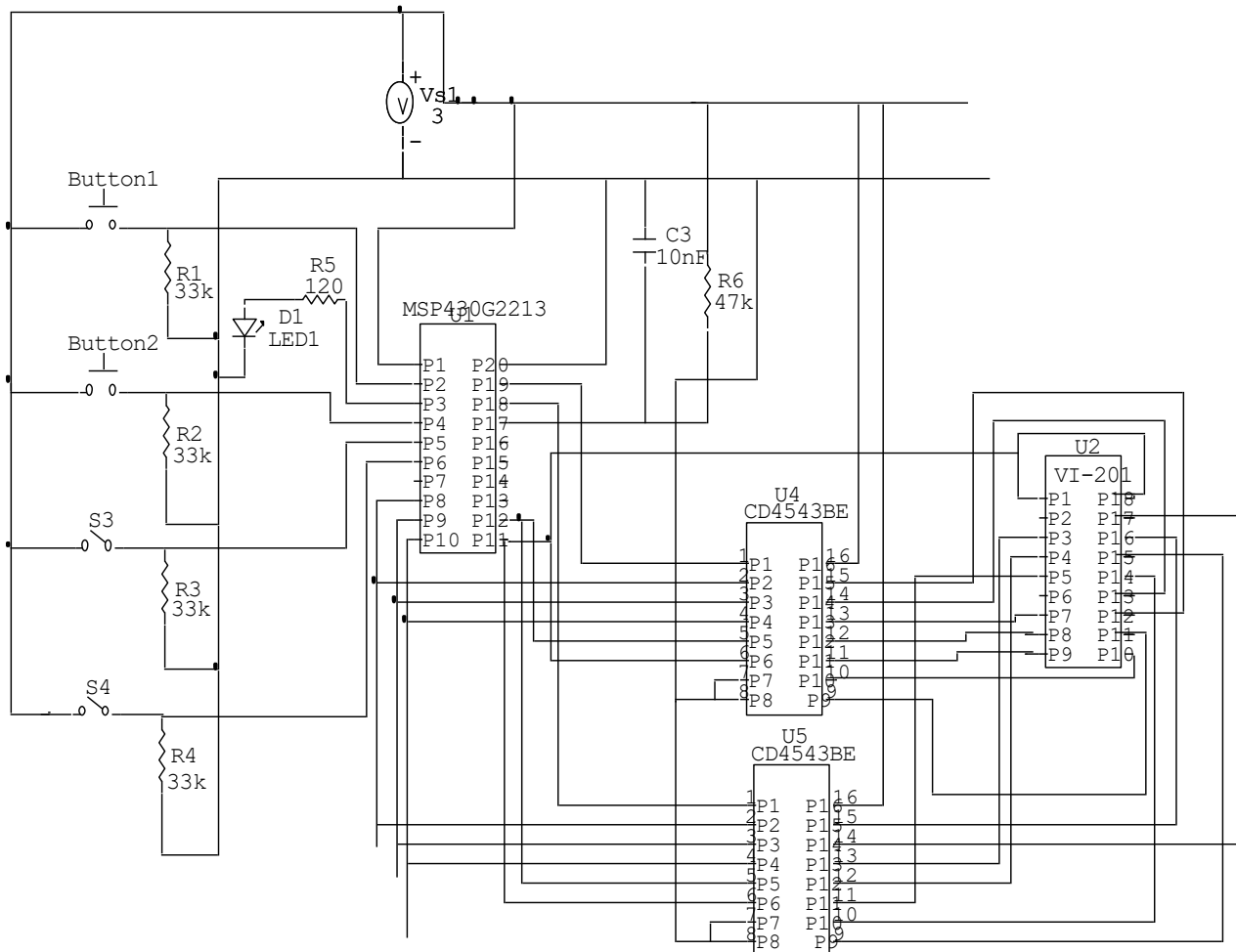
Code

- Written in C
 - msp430gcc to compile
 - Debugging done with mspdebug
- Programmed to be low cost
- Programmed to use as little power as possible

Main Device Code

- On startup
 - Uses timer to time VLO Clock
 - Initialize
 - Watchdog Timer
 - ADC
 - Timer
 - Digital I/O
- Low power mode
 - 2 Interrupts
 - 1 Interrupt from another interrupt

Remote Control Schematic



Remote Control Code

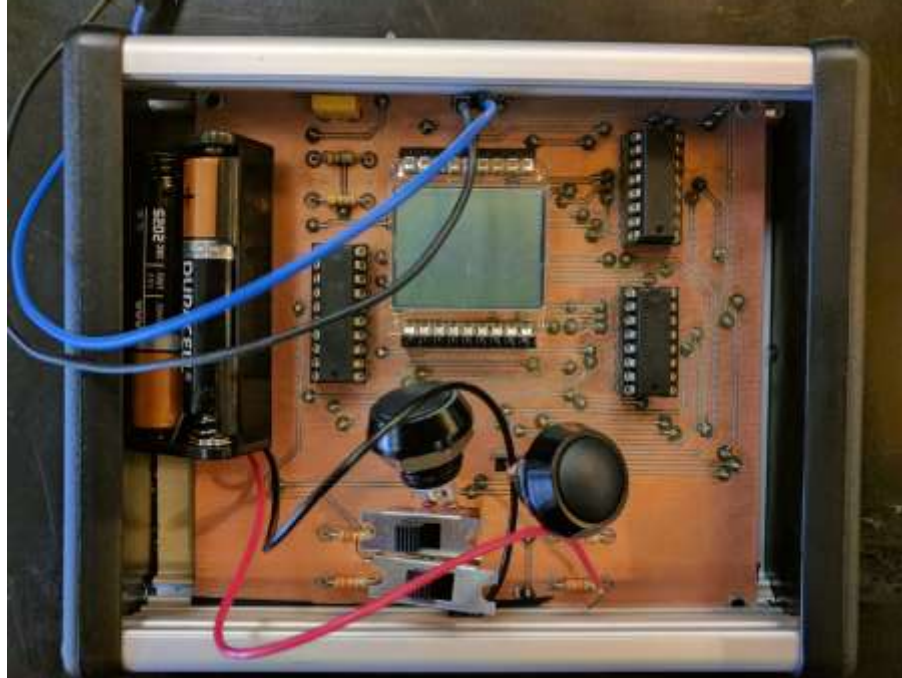
- Initializes
- Low power mode until interrupt
 - Send IR
 - Turn on display
- Modified NEC IR Protocol
 - 38 kHz frequency on IR
 - Pulse Width Modulated Signal
 - Header
 - 8 bit address
 - 4 bit command followed by inverse

```
// send the data
// first, finish the command
// get the inverse
inverse = (~command) & 0xff;
// this should get the full command
full |= predata;
full <<= 8;
full |= command;
full <<= 8;
full |= inverse;

// send the header stuff
TAOCTL = MC_1 | TASSEL_2;
__delay_cycles(phead);
TAOCTL = MC_0 | TASSEL_2;
__delay_cycles(shead);
TAOCTL = MC_1 | TASSEL_2;
// send the predata
for(i = 0; i < 32; i++)
{
    __delay_cycles(pulse);
    TAOCTL = MC_0 | TASSEL_2;
    if((full >> (31 - i)) & (unsigned long)1)
    {
        // send a one
        __delay_cycles(sone);
    }
    else
    {
        __delay_cycles(szero);
    }
    TAOCTL = MC_1 | TASSEL_2;
}
// done sending. finish out the last pulse
__delay_cycles(pulse);
TAOCTL = MC_0 | TASSEL_2;
}
```



Packaging



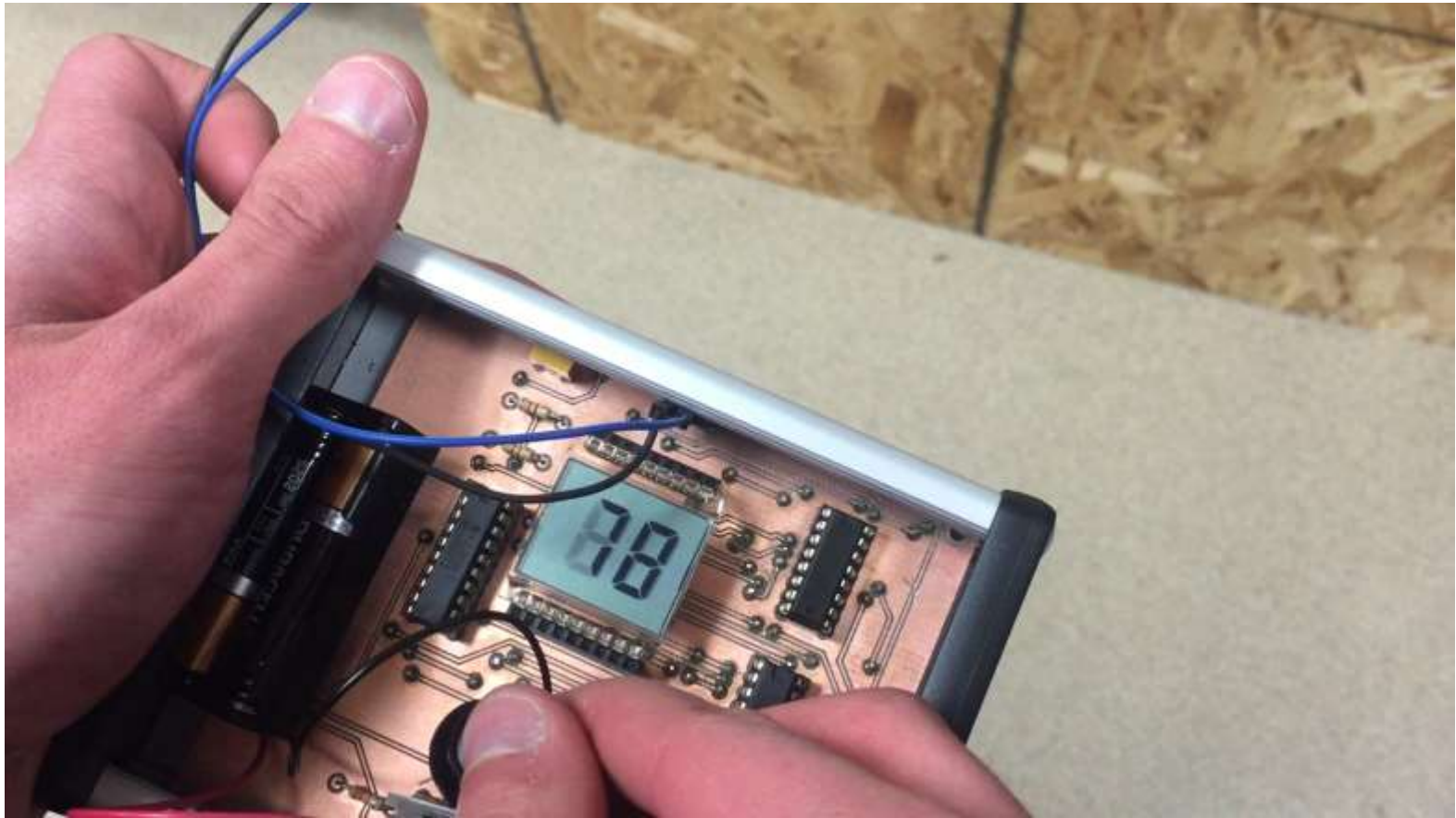
Results

Photoresistor Demonstration



Results

Changing Desired Temperature



Cost Analysis

Stepper Motor	1 x \$4.50
MSP430G2113	2 x \$1.74
CD4543BE	2 x \$0.51
VI-201	1 x \$4.32
TSOP382	1 x \$1.07
L293D	1 x \$3.54
Photocell	1 x \$0.95
IR LED	1 x \$0.22
Motor Coupler	1 x \$40.00
Packaging	\$34.87
Total:	\$93.97

Conclusion and Lessons Learned

- It works
- Packaging could be greatly improved
 - Lid for remote
- Better motor needed
- Several bugs to fix
- Potentially should have used libraries in code to save time

References

- <http://energy.gov/energysaver/energy-efficient-window-treatments>
- <http://www.susdesign.com/windowheatgain/>
- <https://www.eia.gov/state/print.php?sid=WY>