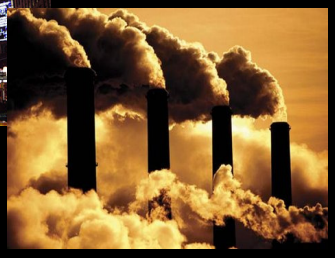
We are in the midst of a crisis

A crisis of…

Over-population

Over-consumption



Over-pollution

BP Oil Spill 2010

Japan Nuclear Disaster 2010

Our current behavior is unsustainable and we need to improve the situation.

Greener, more energy efficient buildings

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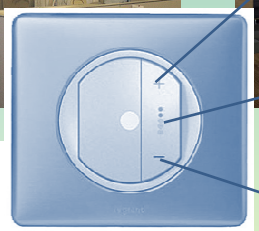

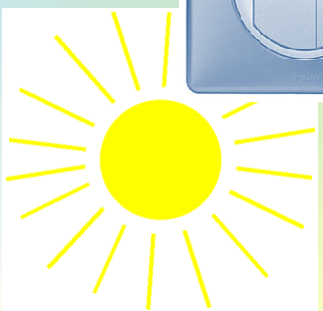

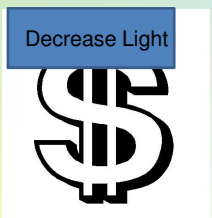

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393 billion kWh of electricity for lighting

$71 billion on electricity for lighting

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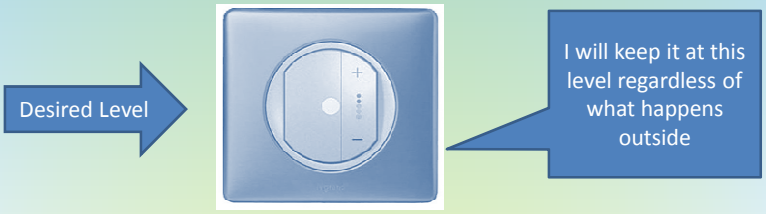
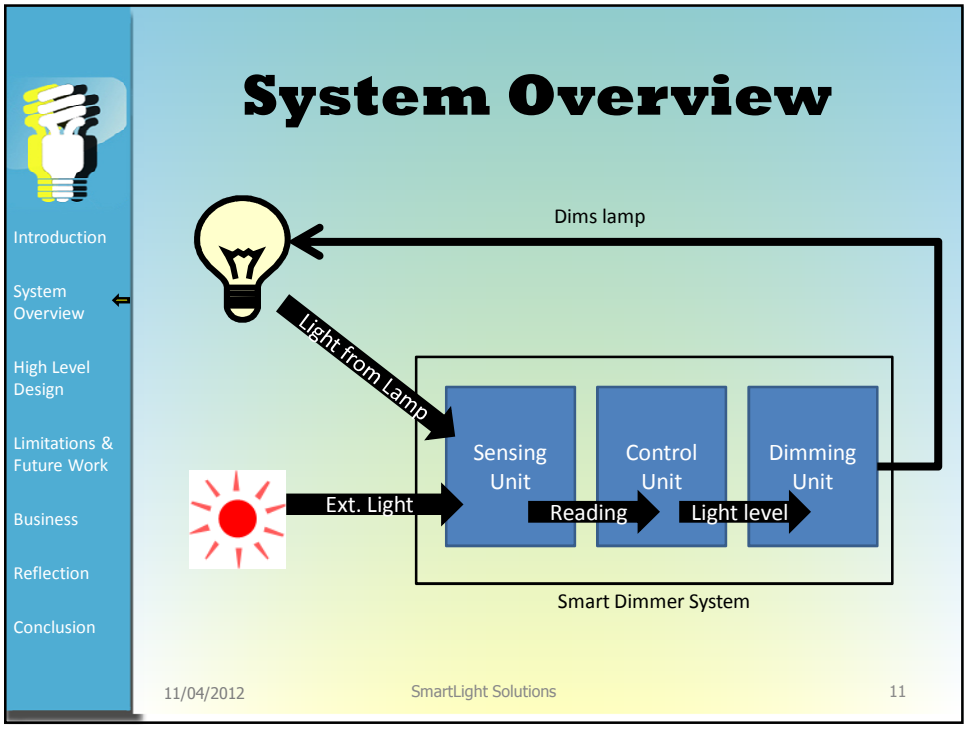
System Overview

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Dims lamp
Light from Lamp
Sensing Unit
Control Unit
Dimming Unit
Ext. Light
Reading
Light level
Smart Dimmer System
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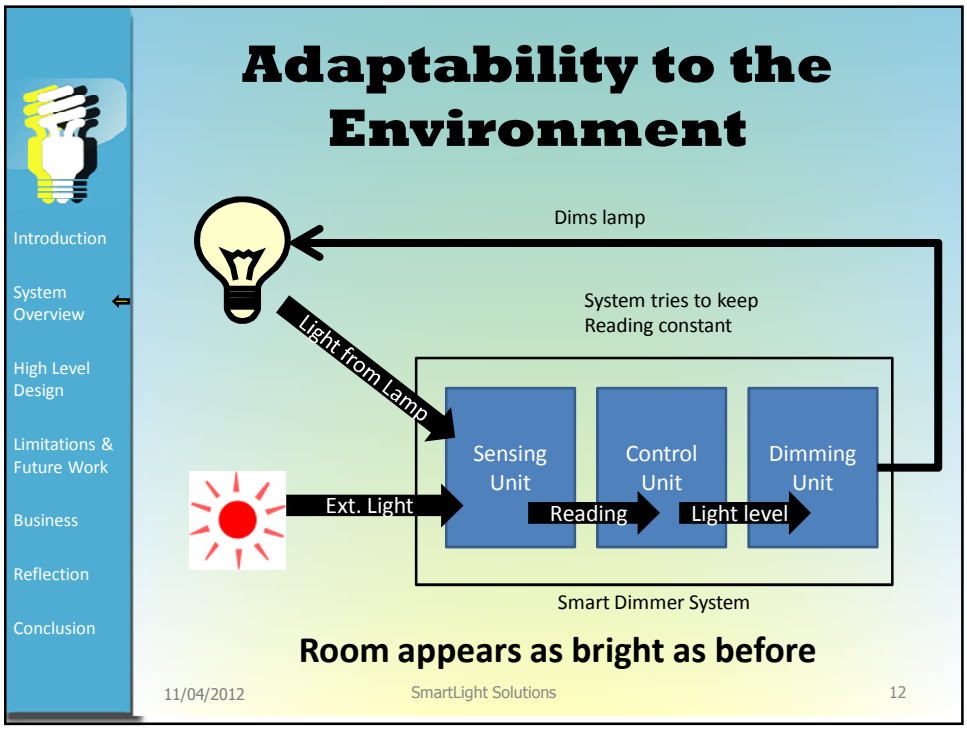
Adaptability to the Environment
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Dims lamp
System tries to keep Reading constant
Light from Lamp
Sensing Unit
Control Unit
Dimming Unit
Ext. Light
Reading
Light level
Smart Dimmer System
Room appears as bright as before
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High Level Design

Sensing Unit

Control Unit

Dimming Unit

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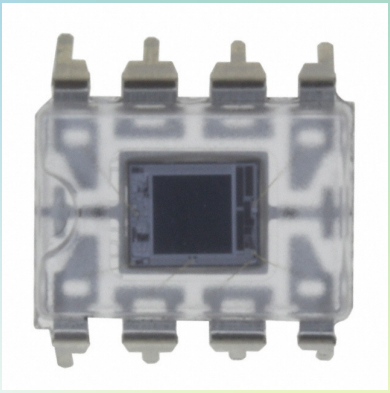

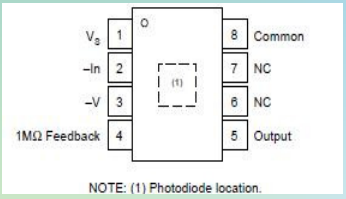

NOTE: (1) Photodiode location.

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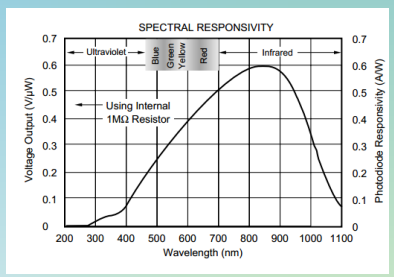
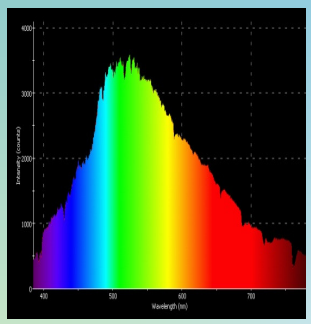
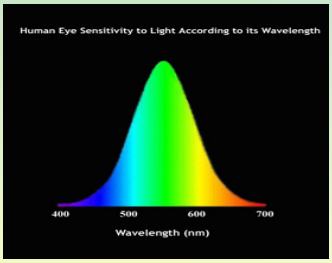


Sensor's Response



Spectrum of Sunlight



Human Eye's Response

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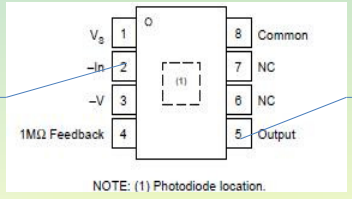
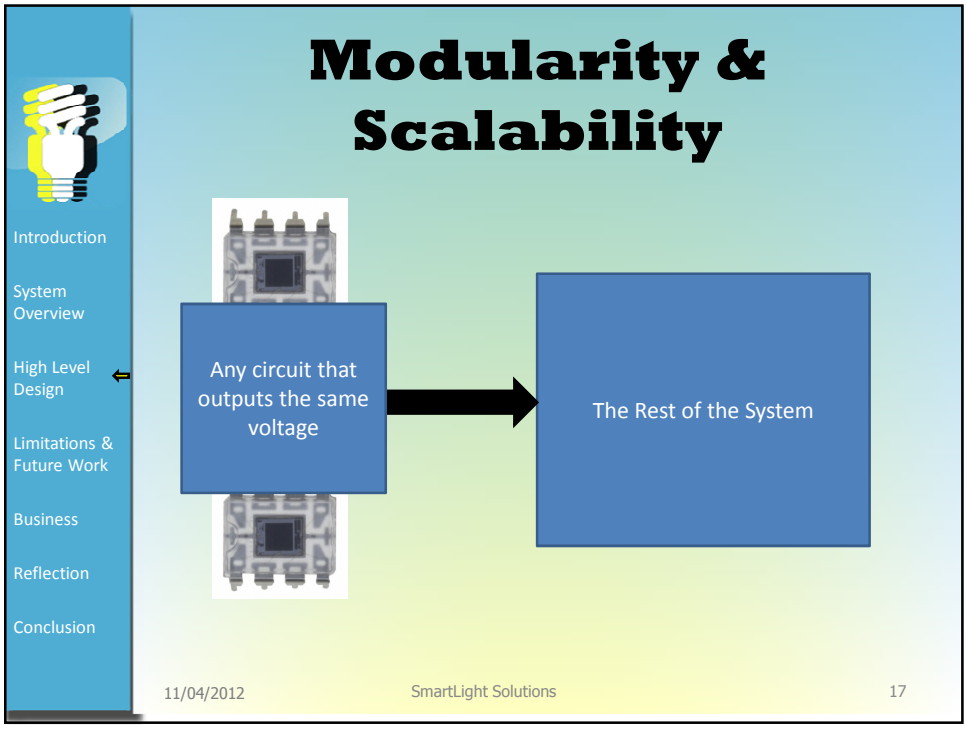
Changing Sensor Responsivity



NOTE: (1) Photodiode location.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Any circuit that outputs the same voltage
The Rest of the System
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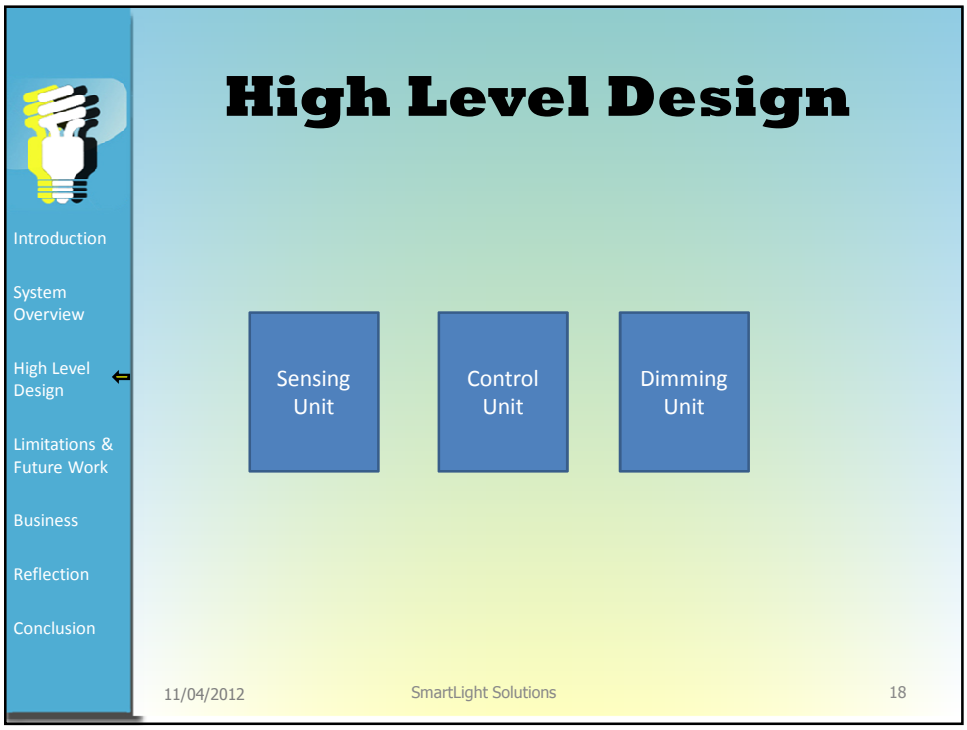
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Dimmer Unit Design

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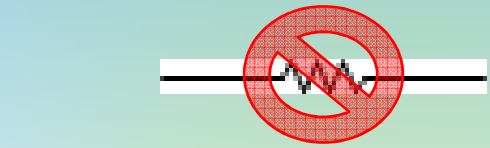

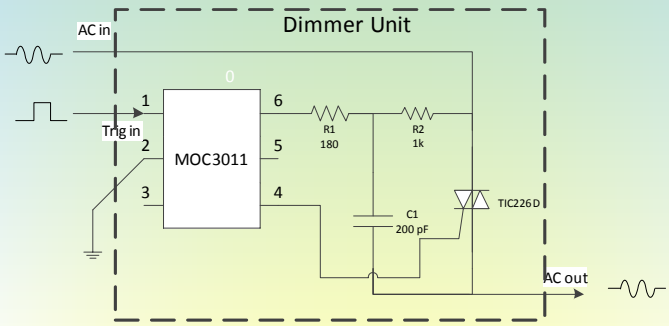

Dim by Power Switching

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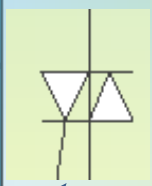

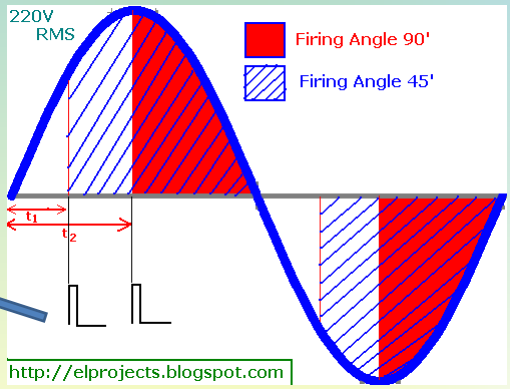

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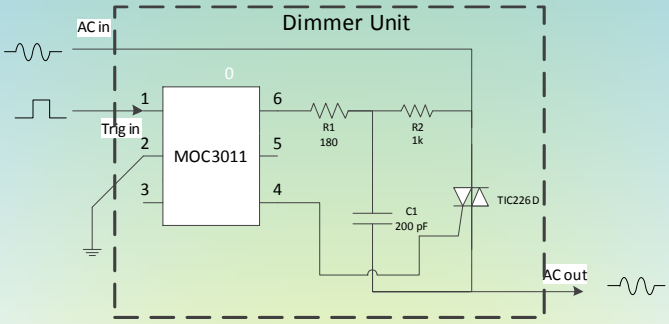

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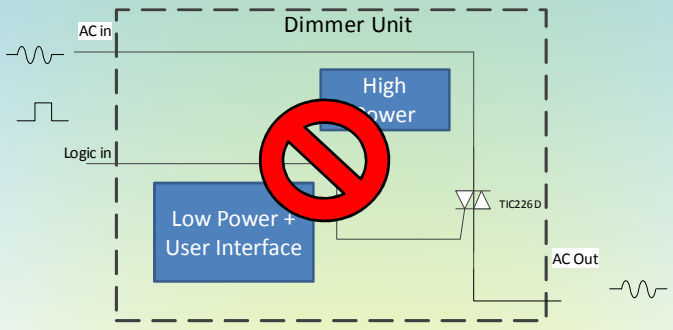
Why is Opto-Coupler needed?



Isolation Between High and Low Power

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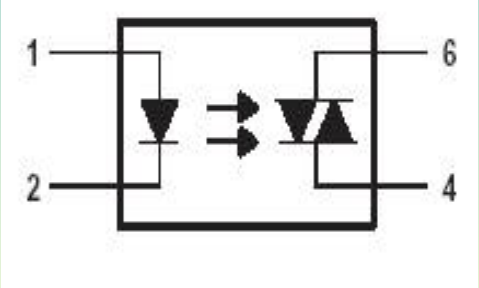
Low-Powered Circuit (Logical)



High Powered Circuit

High Level Design

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Sensing Unit

Control Unit

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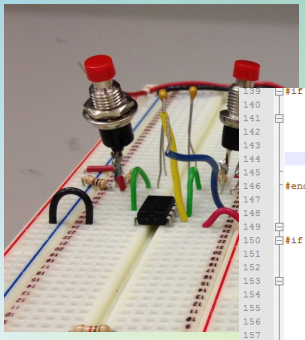
Control Unit



```
#if ADCTESTING
    if(ADIF && ADIE)//ADC interrupts
    {
        currGPIO = GPIO;
        ADIF = 0;
        return;
    }
#endif

    if(GPIF && GPIE)
    {
#if 0
        //*************** IF DELAY IS SHORT ******************//
        if(dimDelay < SHORT_DELAY)//then delay and toggle triac immediatly
        {
            for (i=0;i<dimDelay;i++)//do this many steps
                _delay(DIM_INCR - 3); //step size increment (in instruction c
            //pulse the triac
            GP5=1;
            __delay_ms(1);
            GP5=0;
            //mark as done
            dimDone = 1;
        }
#endif
```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Control Unit

I/O

- Input
  - Signal from Push Buttons
  - 12 VAC
  - Sensor Output
- Output
  - Dim Level Signal

What kind of Signal?

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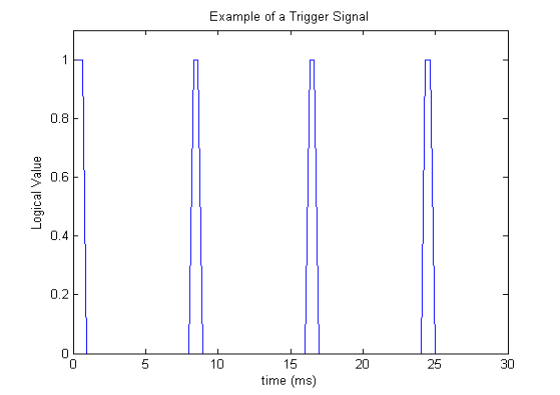

Timed Logical Signal with period of 1/120 s

Integration

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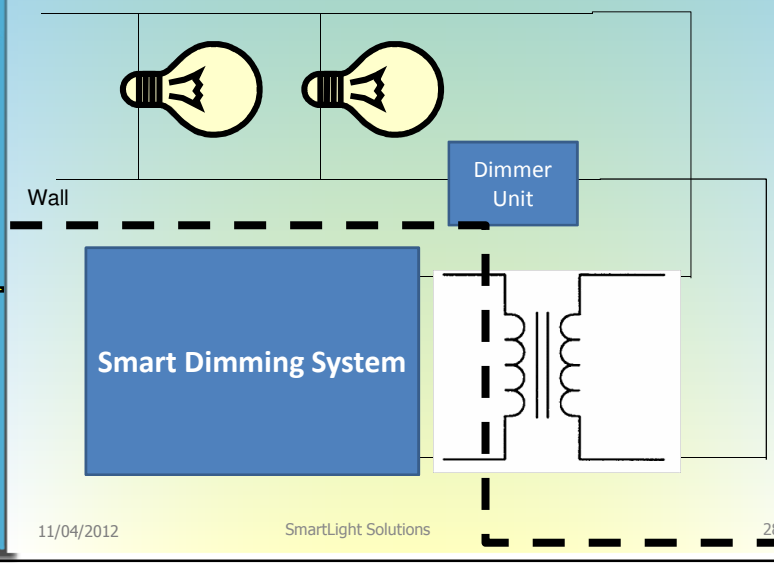

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Current Issues

- Directionality
- Shadows
- Logarithmic Range

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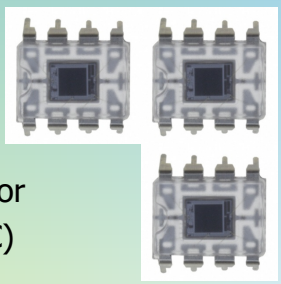
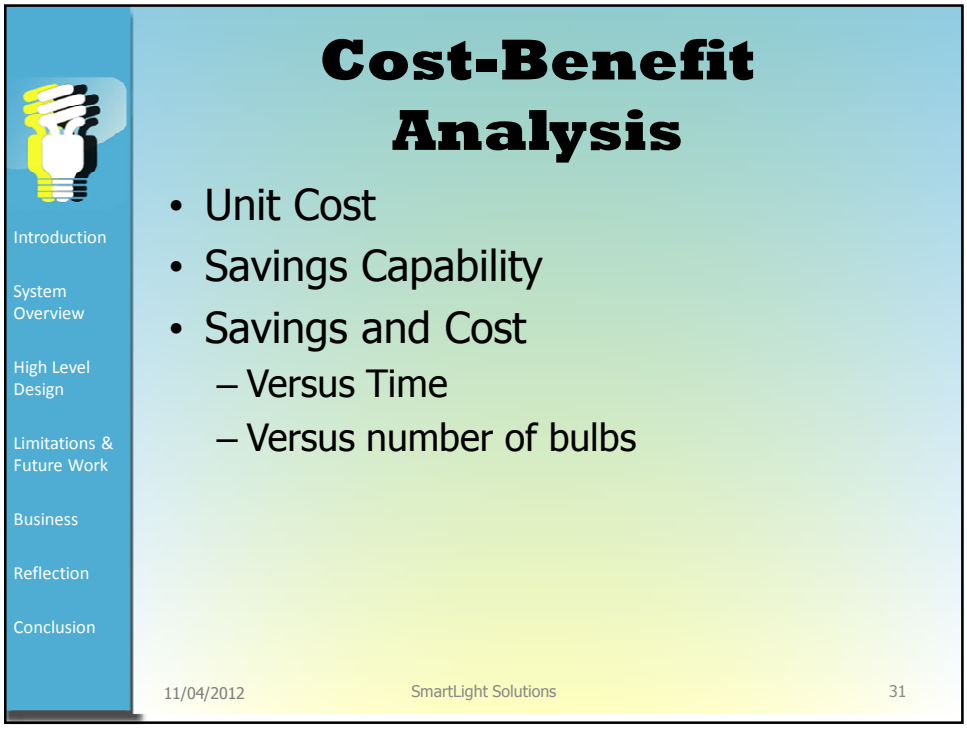
Future Work



- Multiple Sensor System
  - Needs averaging circuit
- Self-Calibrating system
  - Needs JFET as variable resistor
  - Microcontroller upgrade (DAC)
- Shadow Sensing
  - Motion sensor
  - Detection algorithm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Cost-Benefit Analysis
• Unit Cost
• Savings Capability
• Savings and Cost
– Versus Time
– Versus number of bulbs
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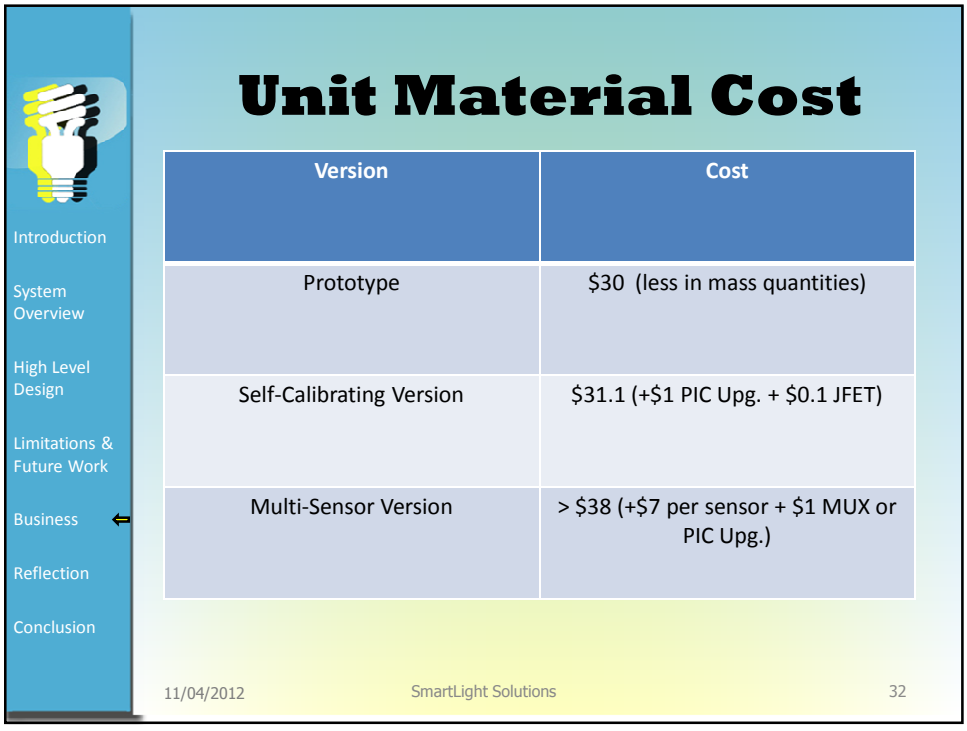
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Unit Material Cost
Version
Cost
Prototype
$30 (less in mass quantities)
Self-Calibrating Version
$31.1 (+$1 PIC Upg. + $0.1 JFET)
Multi-Sensor Version
> $38 (+$7 per sensor + $1 MUX or PIC Upg.)
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Savings Capability

- **On average, 30-34%** of energy is saved per day compared to leaving it fully on 24/7

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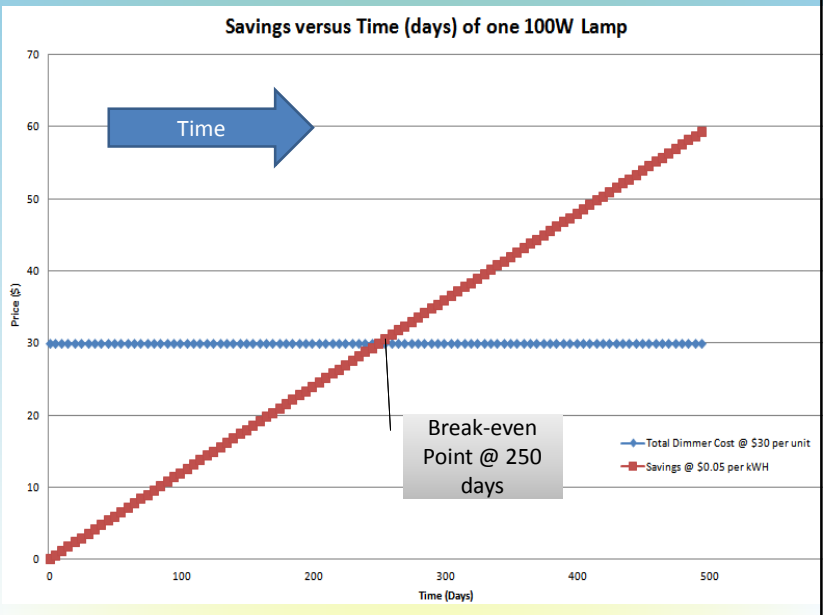

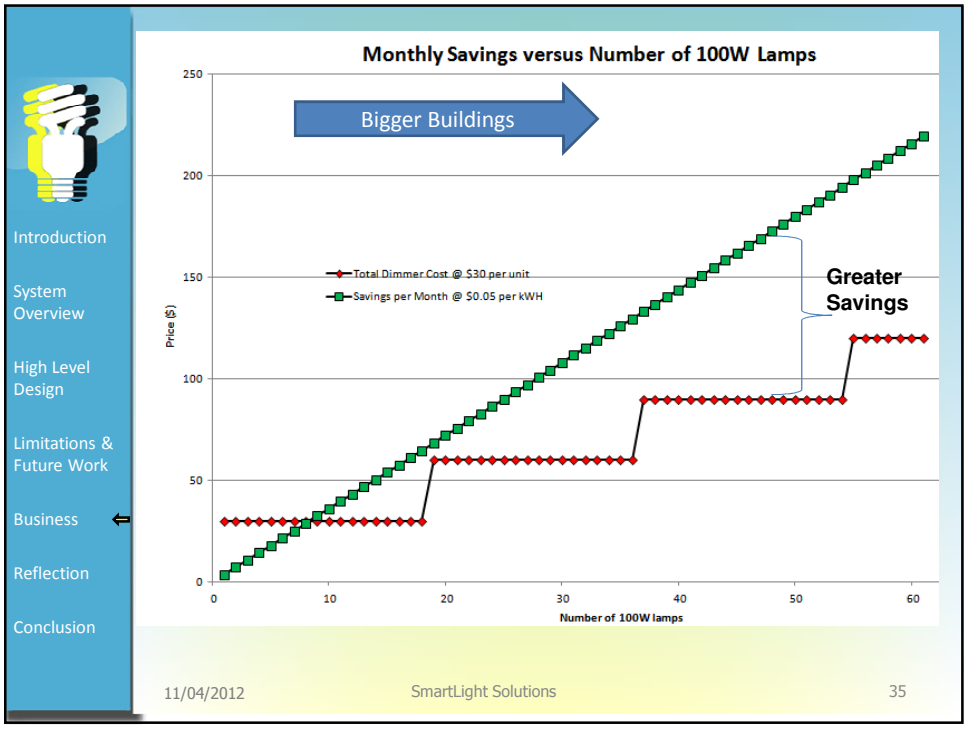
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Monthly Savings versus Number of 100W Lamps
Bigger Buildings
Total Dimmer Cost @ $30 per unit
Savings per Month @ $0.05 per kWH
Greater Savings
Price ($)
Number of 100W lamps
0
50
100
150
200
250
0
10
20
30
40
50
60
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Market Plan
• SWOT Analysis
• Target market
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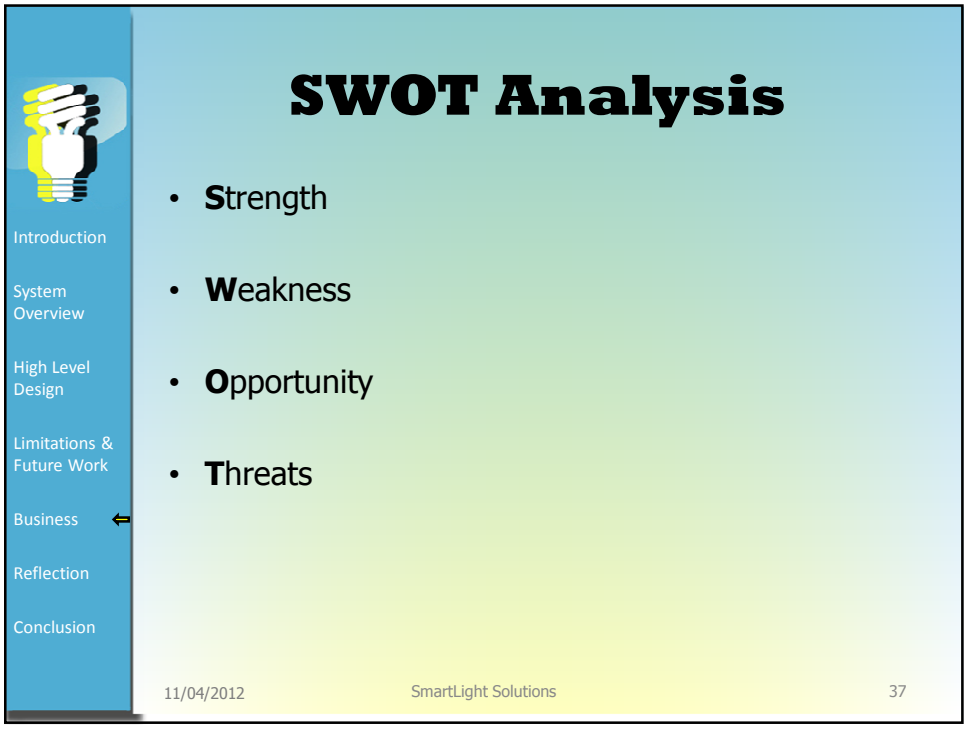
SWOT Analysis
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Weakness
Opportunity
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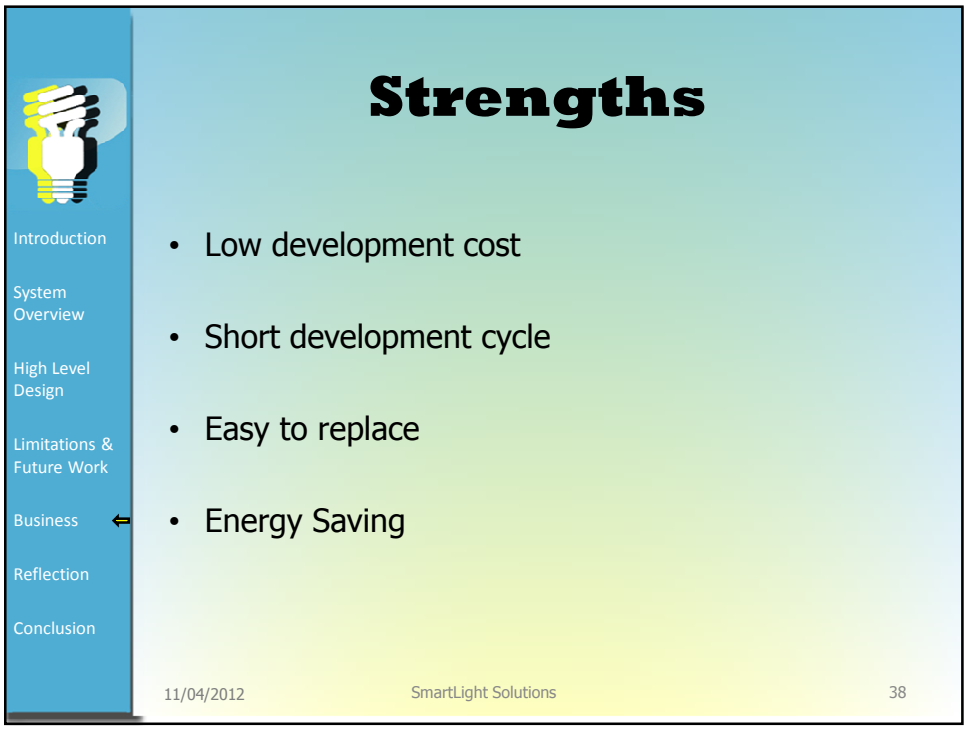
Strengths
Low development cost
Short development cycle
Easy to replace
Energy Saving
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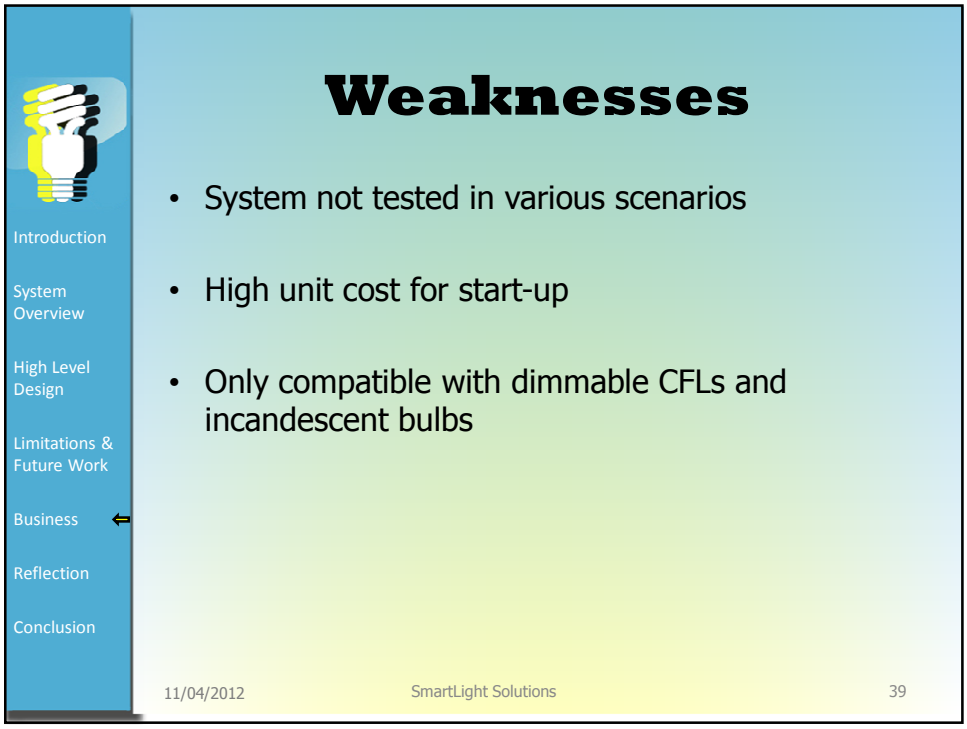
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Weaknesses
• System not tested in various scenarios
• High unit cost for start-up
• Only compatible with dimmable CFLs and incandescent bulbs
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Opportunities
• Easy entry into competition
• Increasing environmental concerns
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Threats
Premature Market
Competitive in the future
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Target Market
Household
Window-walled buildings
Office Buildings
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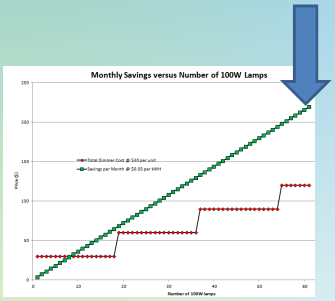
Office Buildings

- Financial capability
- Motivation
- Benefits more immediate



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Budget

Description	Expenditure ($)
RP Purchase, 3 TRIAC	2.81
Digi Key Order 32130862	27.52
RP Purchase. Lux Meter/Transformer	140.48
RP Purchase. PIC programmer.	85.06
Digi Key Order 32387999 (10 x PIC12F675)	21.09
Canadian Tire Purchase. Demo materials.	53.21
Home Depot Electrical Boxes	19.20
Lee's Electronics Purchase Demo props	15.23
Digi Key Order 32539158 (extra light sensors + upg. PICs)	31.16
Home Depot Electrical Box Extention	10
Lee's Electronics Fuse + Opto-Couplers	10.64
Lamp Shades	15.10
Total Spending	**431.50**

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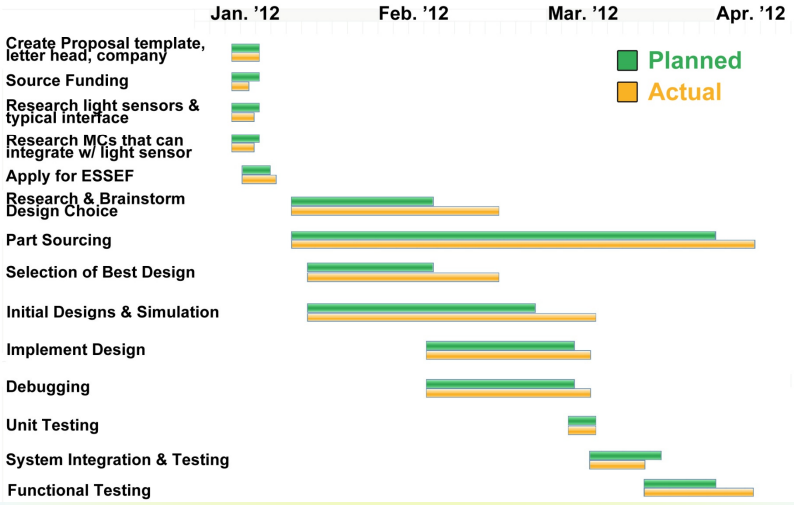
Timeline (Gantt Chart)



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Acknowledgements

We would like to thank:

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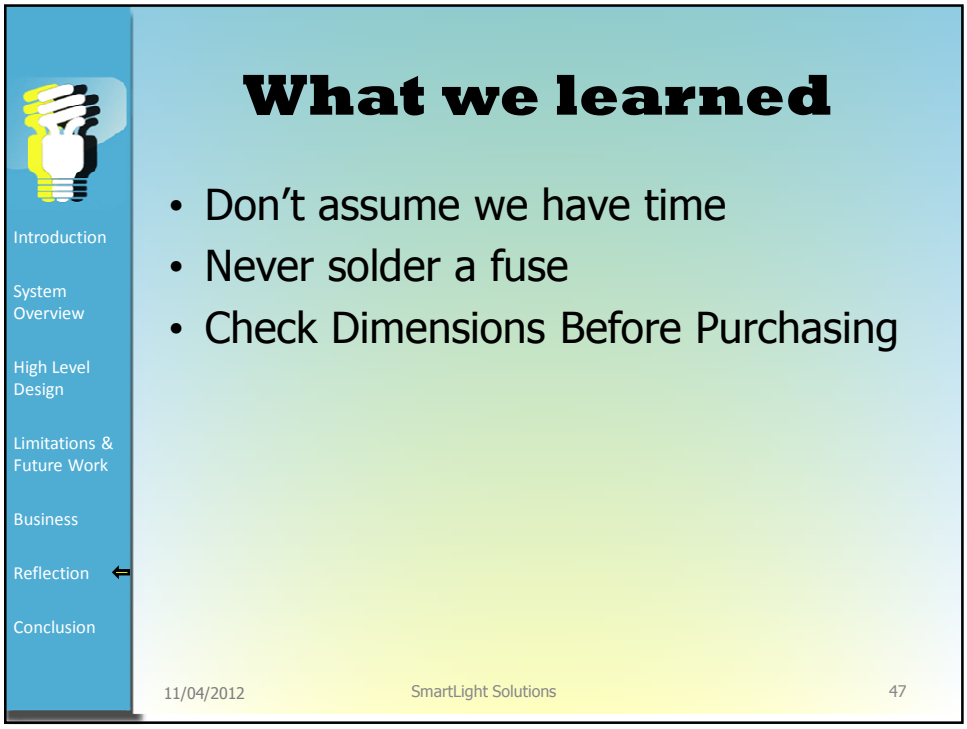
- Dr. Ash Parameswaran
- Fred Heep

Honourable mentions:

- Dr. Albert Leung
- Helpful Home Depot Employee


What we learned
• Don't assume we have time
• Never solder a fuse
• Check Dimensions Before Purchasing
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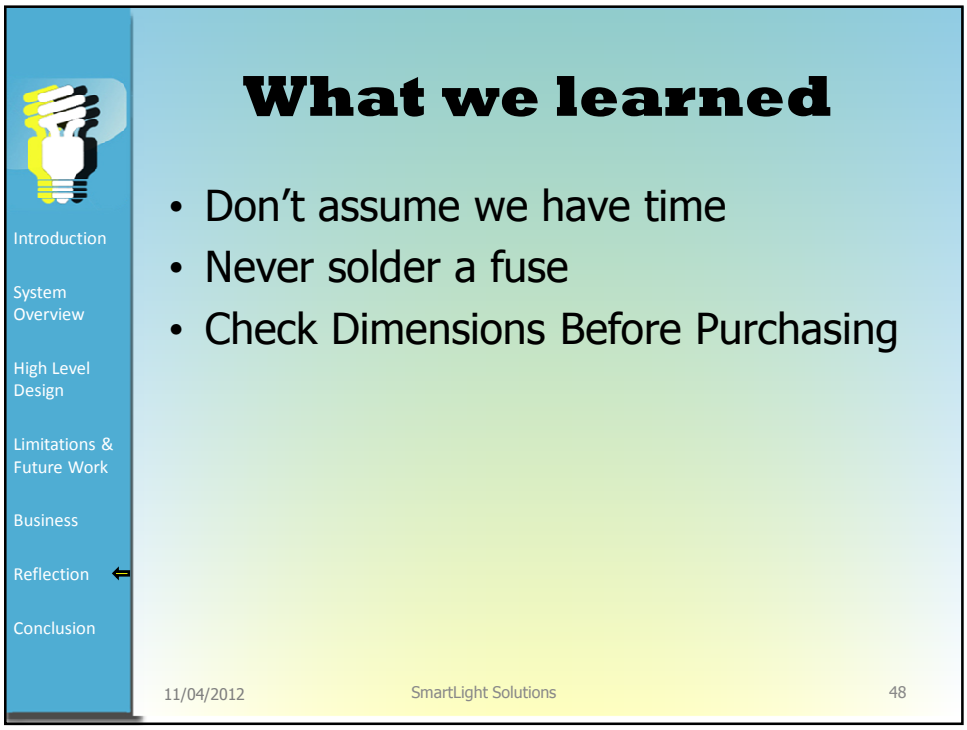
What we learned
• Don't assume we have time
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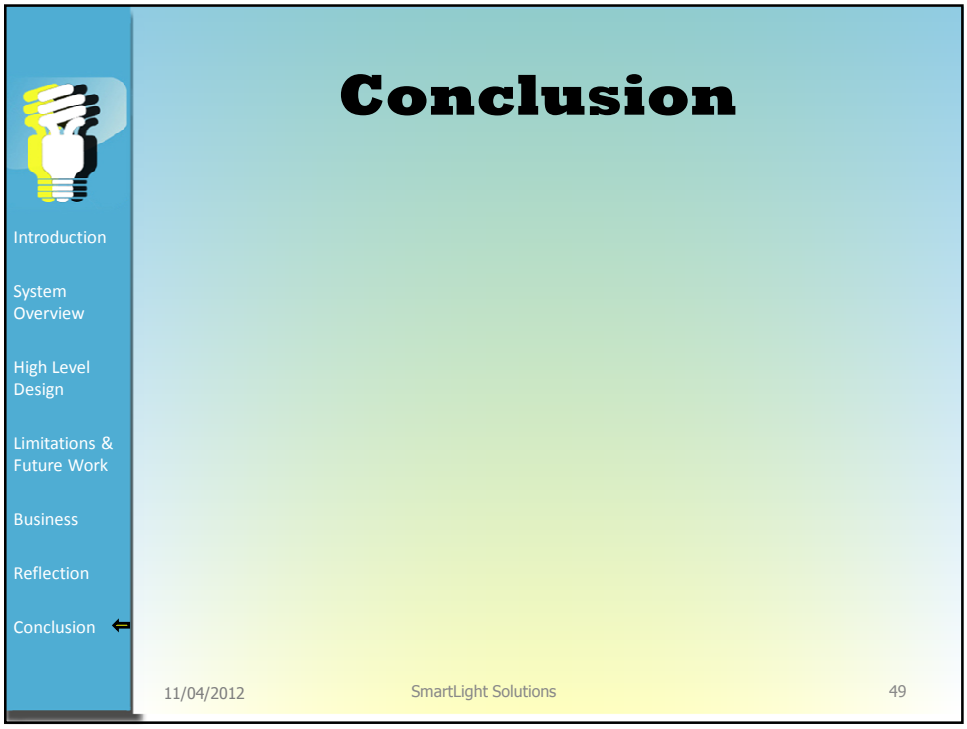
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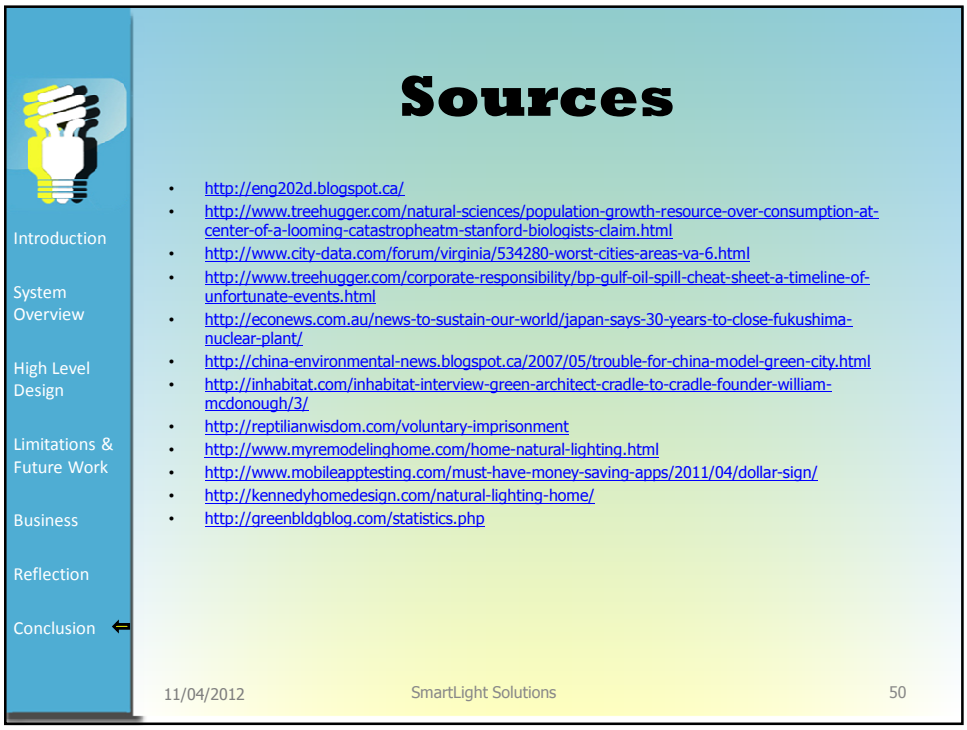
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Questions?

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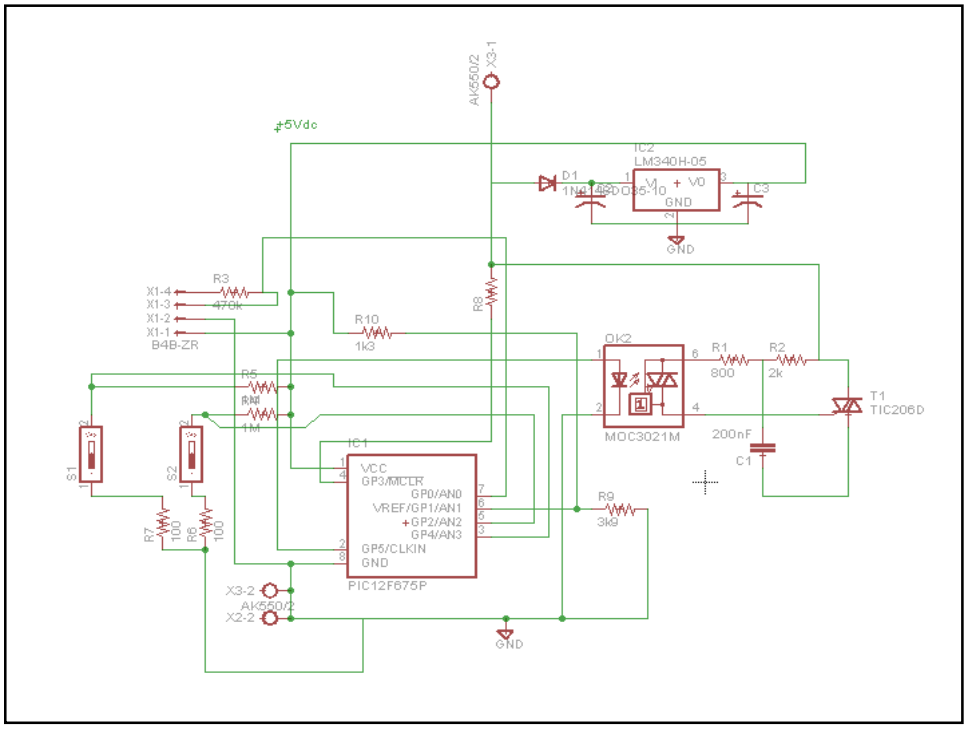
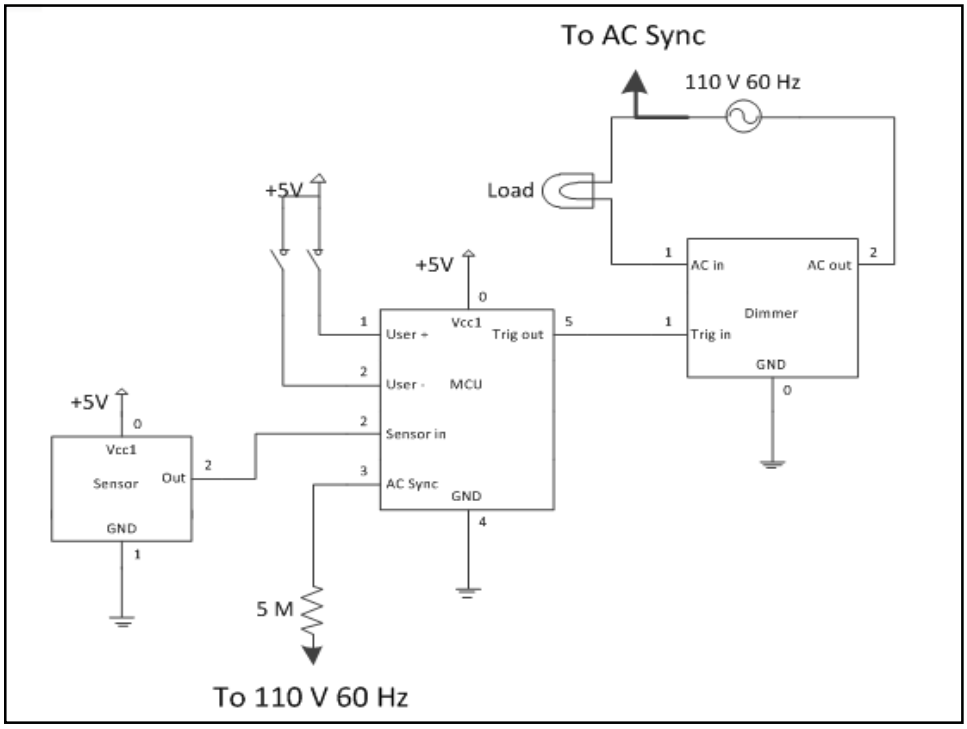
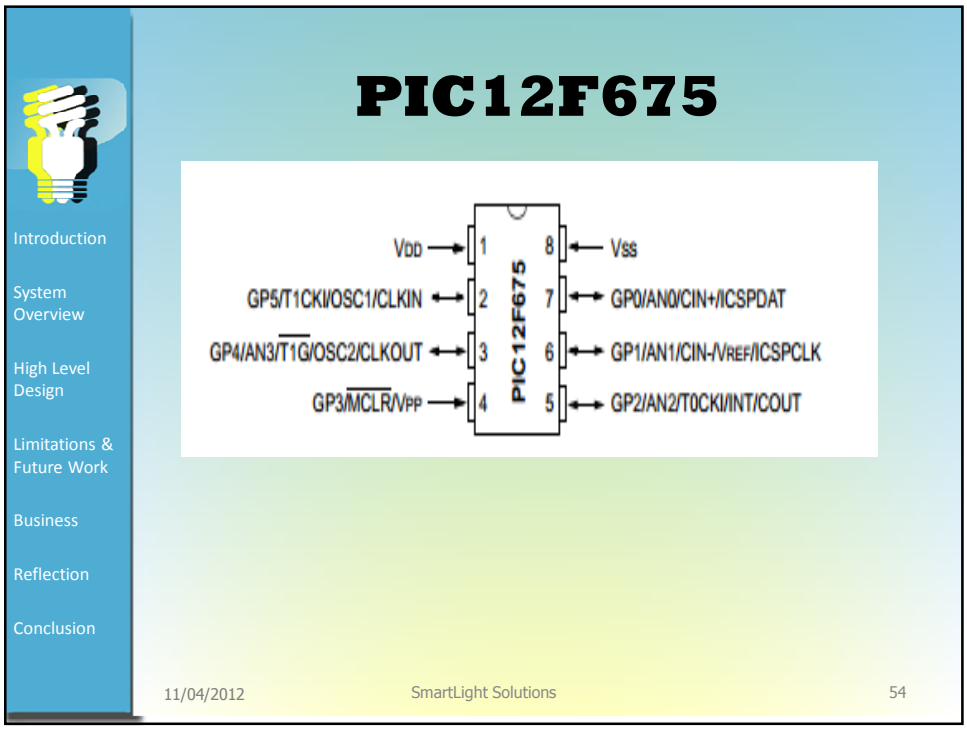



To AC Sync
110 V 60 Hz
Load
+5V
+5V
+5V
AC in
AC out
Dimmer
Trig in
GND
Vcc1
User +
Trig out
User -
MCU
Sensor in
AC Sync
GND
Vcc1
Sensor
Out
GND
5 M
To 110 V 60 Hz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VDD
GP5/T1CKI/OSC1/CLKIN
GP4/AN3/T1G/OSC2/CLKOUT
GP3/MCLR/VPP
PIC12F675
VSS
GP0/AN0/CIN+/ICSPDAT
GP1/AN1/CIN-/VREF/ICSPCLK
GP2/AN2/T0CKI/INT/COUT
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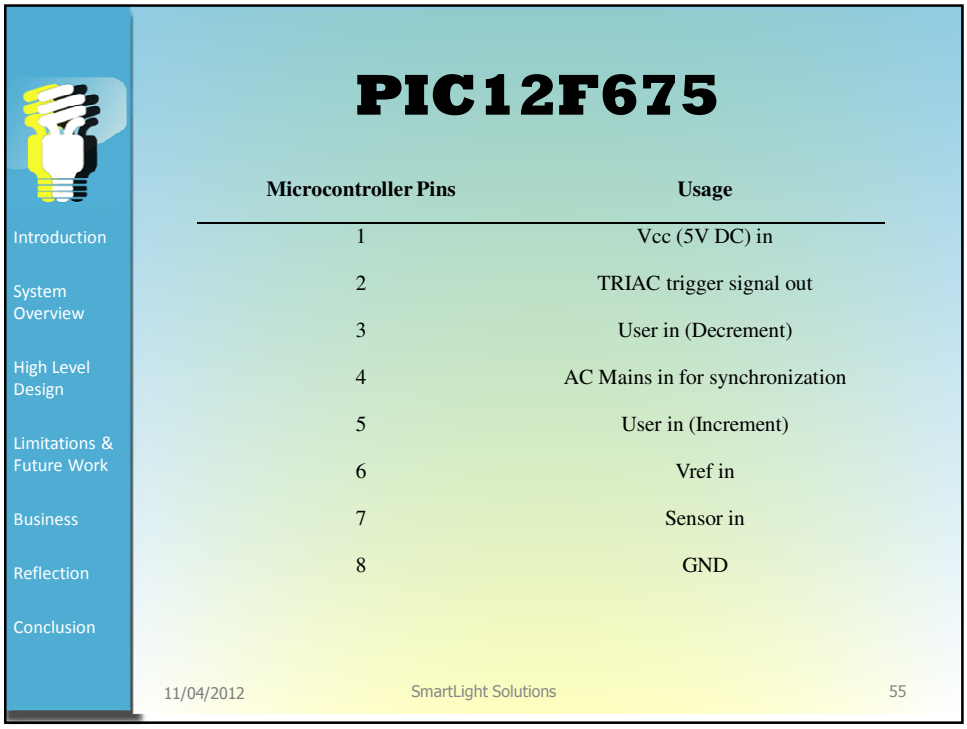
PIC12F675
Microcontroller Pins
Usage
1
Vcc (5V DC) in
2
TRIAC trigger signal out
3
User in (Decrement)
4
AC Mains in for synchronization
5
User in (Increment)
6
Vref in
7
Sensor in
8
GND
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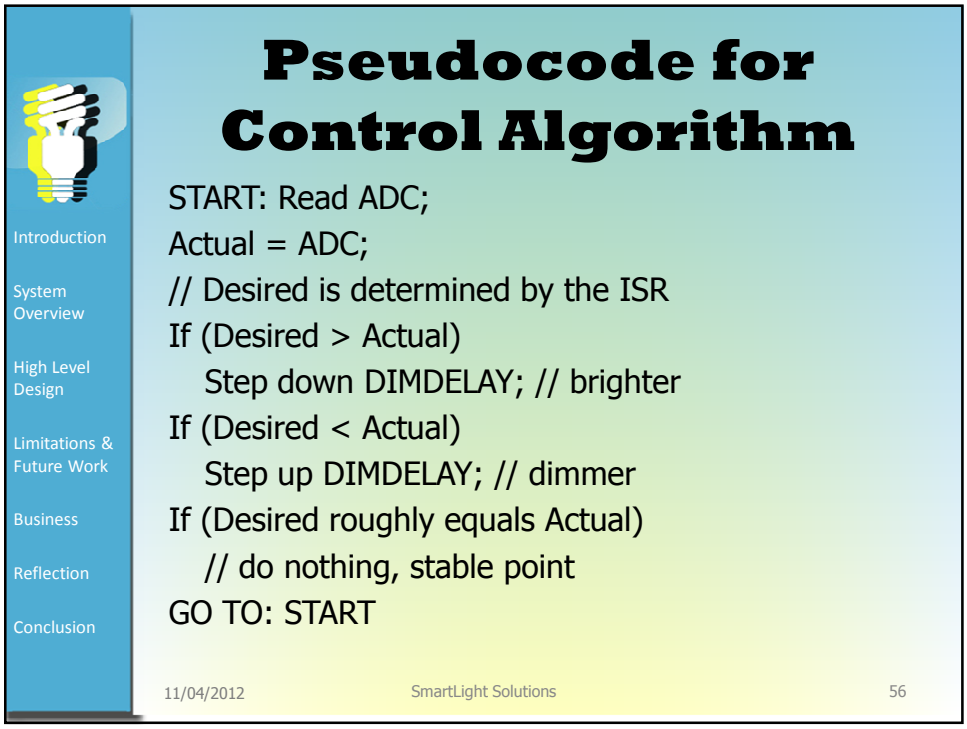
Pseudocode for Control Algorithm
START: Read ADC;
Actual = ADC;
// Desired is determined by the ISR
If (Desired > Actual)
Step down DIMDELAY; // brighter
If (Desired < Actual)
Step up DIMDELAY; // dimmer
If (Desired roughly equals Actual)
// do nothing, stable point
GO TO: START
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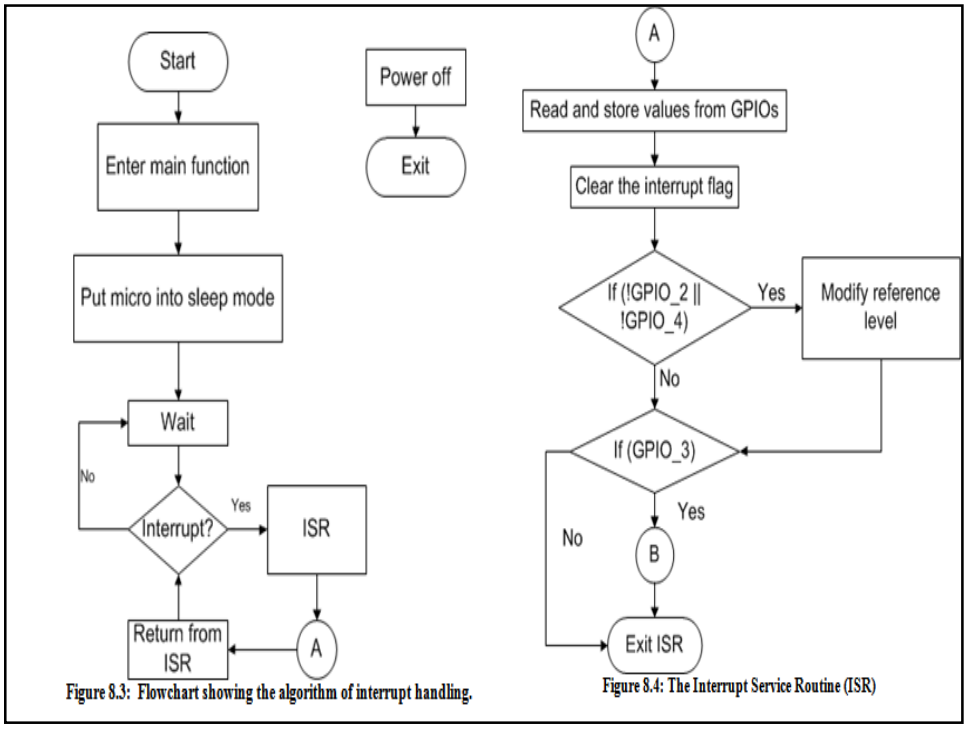


Figure 8.3: Flowchart showing the algorithm of interrupt handling.

Figure 8.4: The Interrupt Service Routine (ISR)

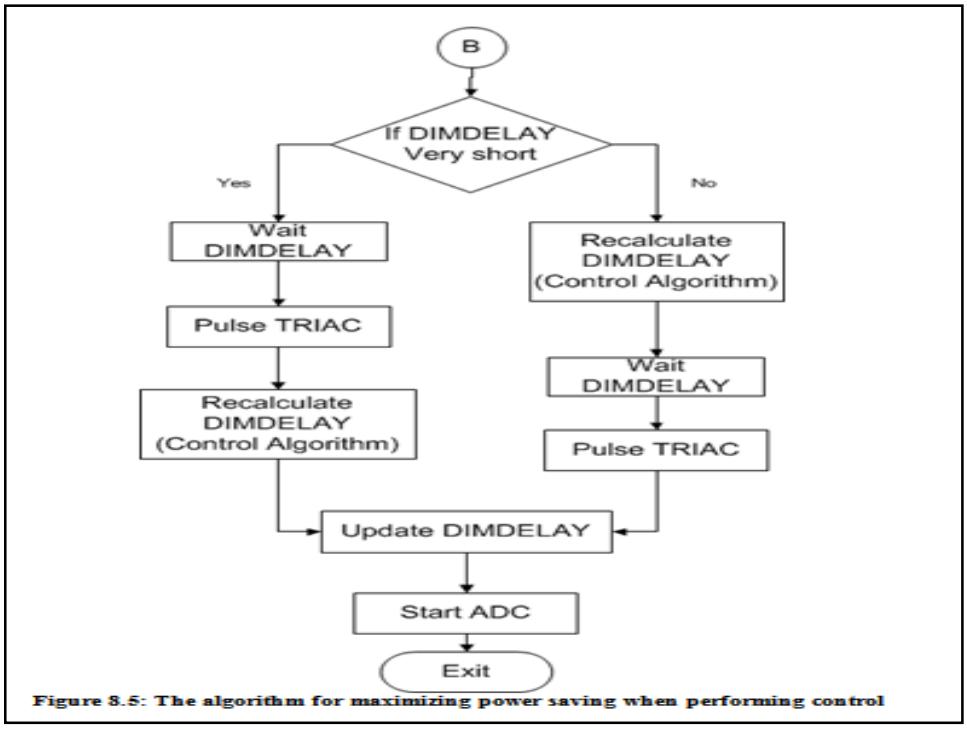
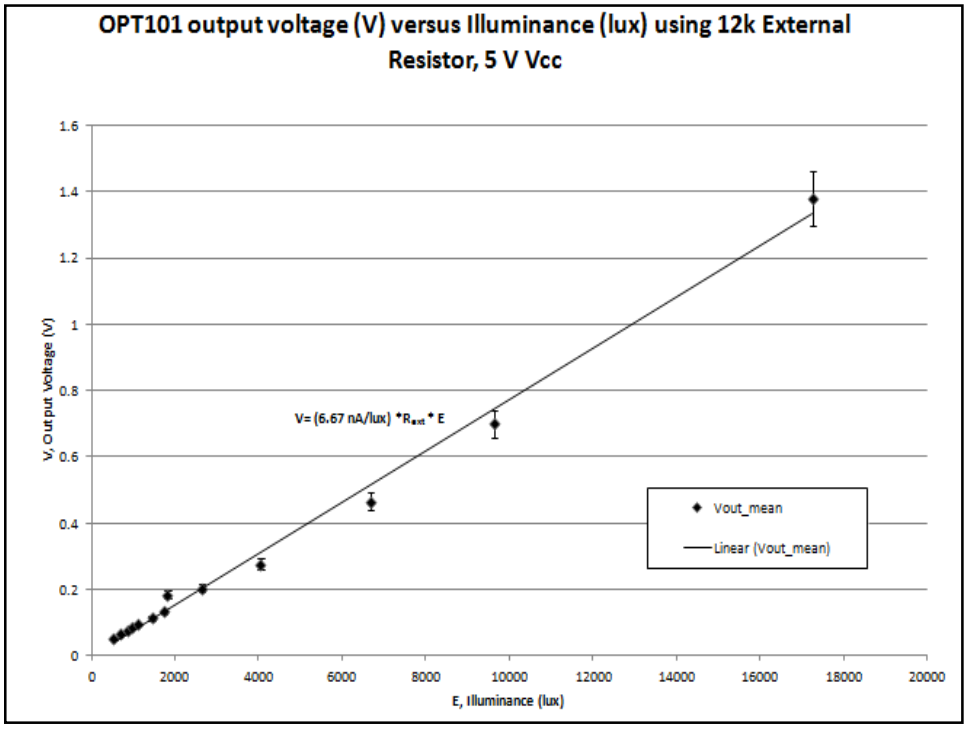
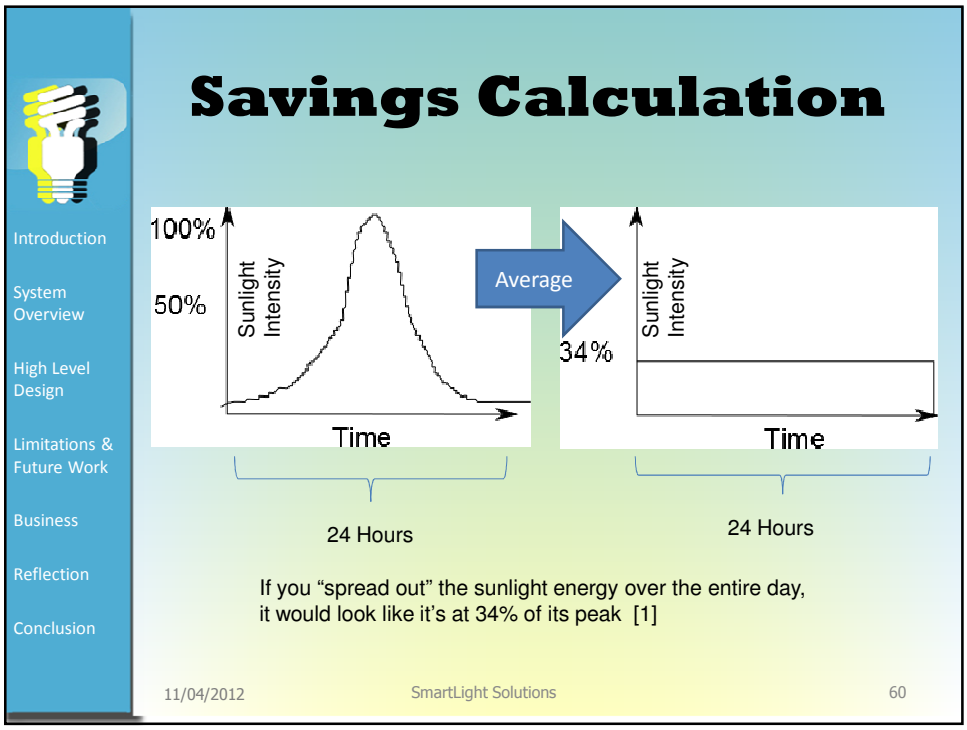


Figure 8.5: The algorithm for maximizing power saving when performing control


OPT101 output voltage (V) versus Illuminance (lux) using 12k External Resistor, 5 V Vcc
V, Output Voltage (V)
E, Illuminance (lux)
V= (6.67 nA/lux) *R_ext * E
Vout_mean
Linear (Vout_mean)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000


Savings Calculation
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100%
50%
Sunlight Intensity
Time
Average
34%
Sunlight Intensity
Time
24 Hours
24 Hours
If you "spread out" the sunlight energy over the entire day, it would look like it's at 34% of its peak [1]
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Savings Calculation

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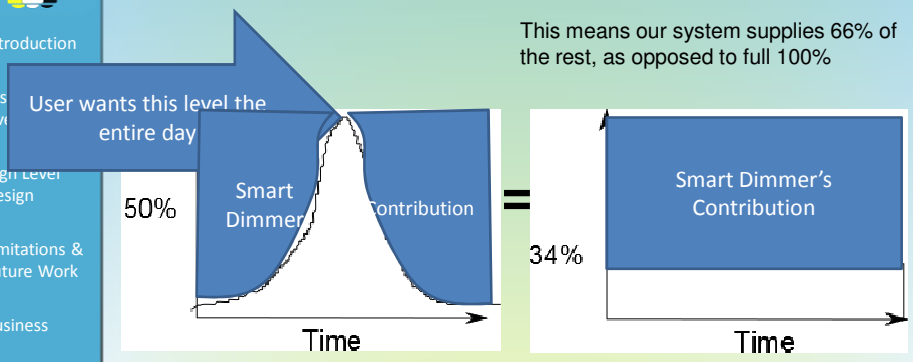
But, on average, it looks like the sun is at 34% all the time.

This means our system supplies 66% of the rest, as opposed to full 100%



Spreadsheet Formula

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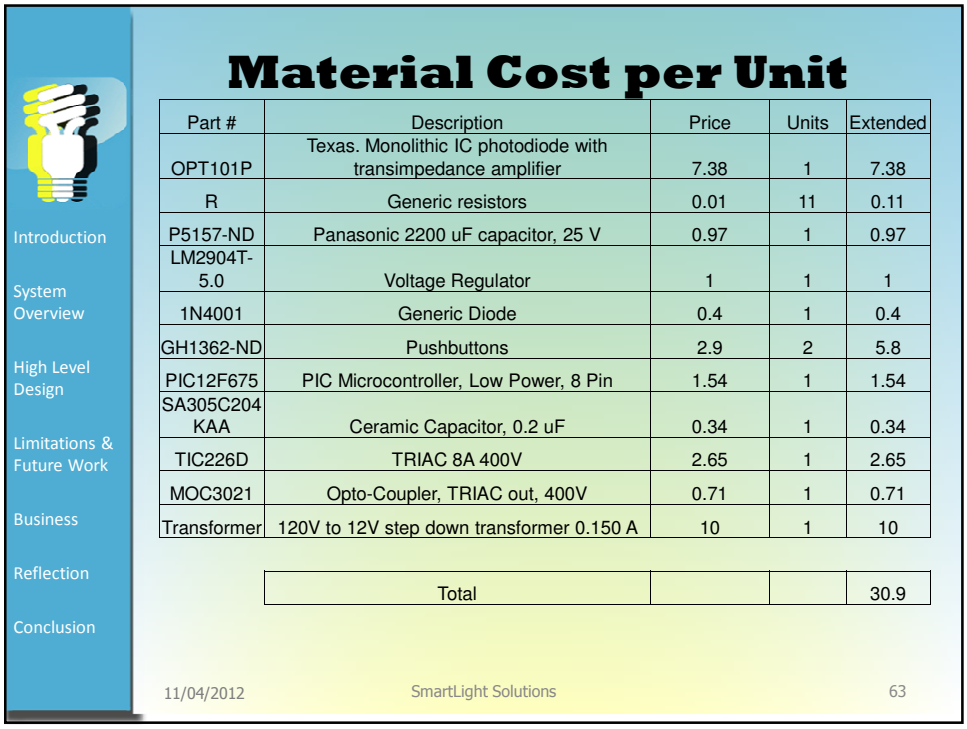
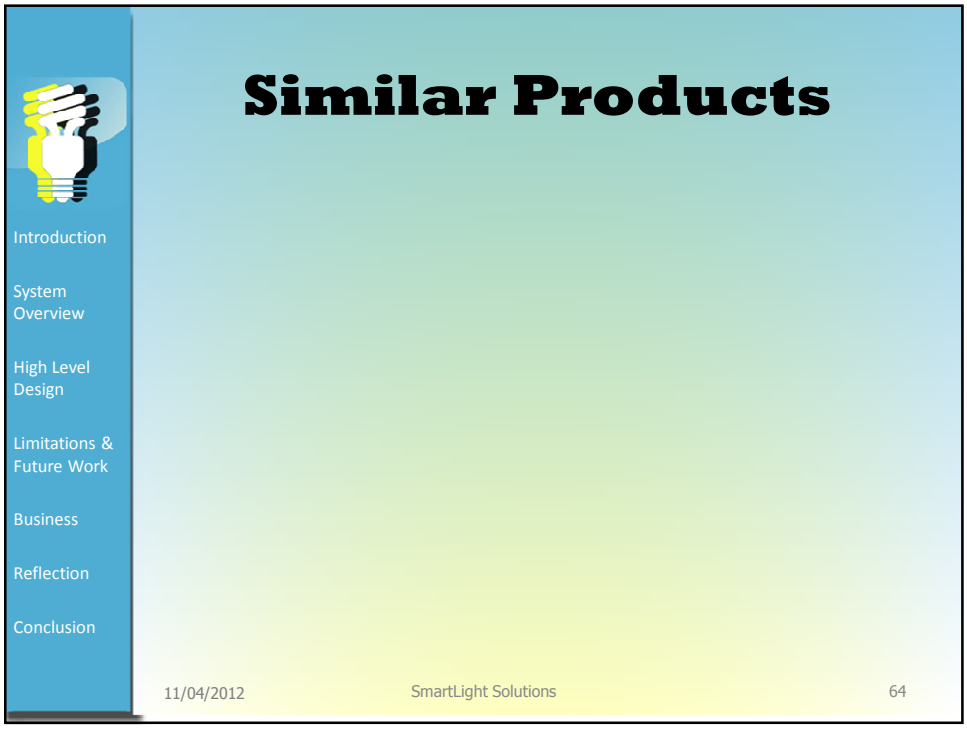
Savings(n, hr) =

(100 W) x (n) x (1/1000 kW/W) x (hr) x ($0.05 per kWh) x (0.34) ← this is where 34% comes in

Each socket only handles 15A, so about 18 100W bulbs so

Cost (n) = 30*(n/18) ← integer division



Part #	Description	Price	Units	Extended
OPT101P	Texas. Monolithic IC photodiode with transimpedance amplifier	7.38	1	7.38
R	Generic resistors	0.01	11	0.11
P5157-ND	Panasonic 2200 uF capacitor, 25 V	0.97	1	0.97
LM2904T-5.0	Voltage Regulator	1	1	1
1N4001	Generic Diode	0.4	1	0.4
GH1362-ND	Pushbuttons	2.9	2	5.8
PIC12F675	PIC Microcontroller, Low Power, 8 Pin	1.54	1	1.54
SA305C204 KAA	Ceramic Capacitor, 0.2 uF	0.34	1	0.34
TIC226D	TRIAC 8A 400V	2.65	1	2.65
MOC3021	Opto-Coupler, TRIAC out, 400V	0.71	1	0.71
Transformer	120V to 12V step down transformer 0.150 A	10	1	10
	Total			30.9