ECE445

Spring 2013

Design Review

Power Budget Automation System

Team 40

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I. Introduction

1. Statement of Purpose

This project is to build a home power budget control system to save energy for the user. Energy is invisible to us, but we were using it every single day. We might be aware of the money we overspend each month. However, the energy we wasted daily might not be as obvious. This project can help the users to understand their power usage behavior and decide a power budget plan that fit for them.

2. Objectives

2.1 Goals

- User interface with the system through the controller
- Wireless communication between sensors unit and controller unit
- Home electricity automation
- Power budget saving
- Notification helps alerting user if user reach the power usage limit setting

2.2 Functions

- Sensor system can turn light on/off depend on room's occupancy
- IR sensor detecting room's occupancy
- Automatically turn off the power when the electric devices aren't used
- LCD display current power consumption, alert user, and allow remote control.

2.3 Benefits

- Reduce wasted energy
- Enable remote control to power outlet
- Save money by reducing power usage
- Allow user to manage home power usage

2.4 Features

- User remotely control through the controller system
- Learning ability on controlling
- User-friendly display and notification
- Easy and safe installation process

II. Design

1. Block Diagrams

The system will be the controller unit and sensor unit.

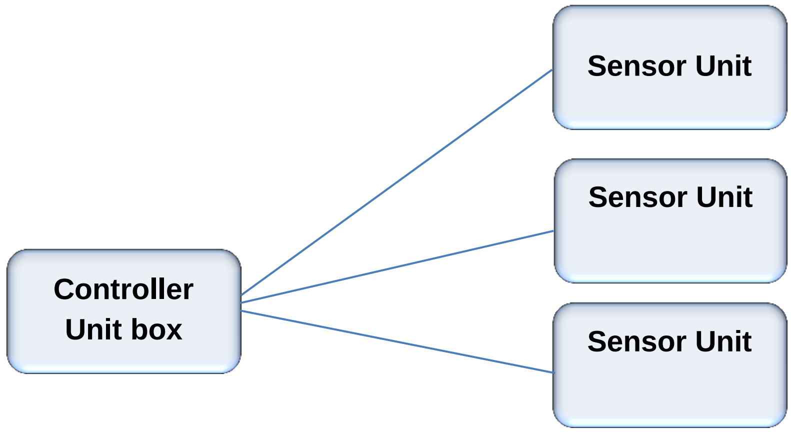

Figure 1: Top level system layout

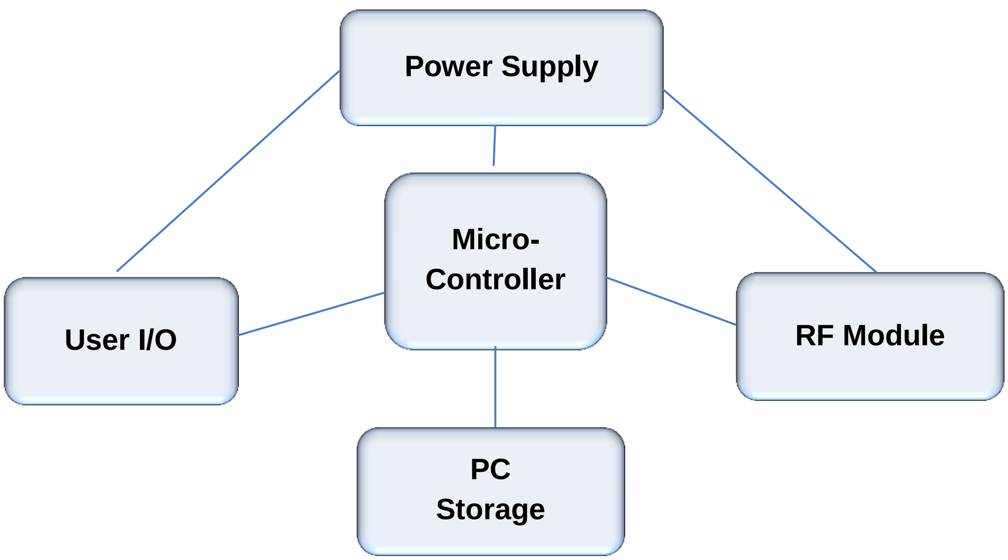

Figure 2: Block Diagram of Controller Unit

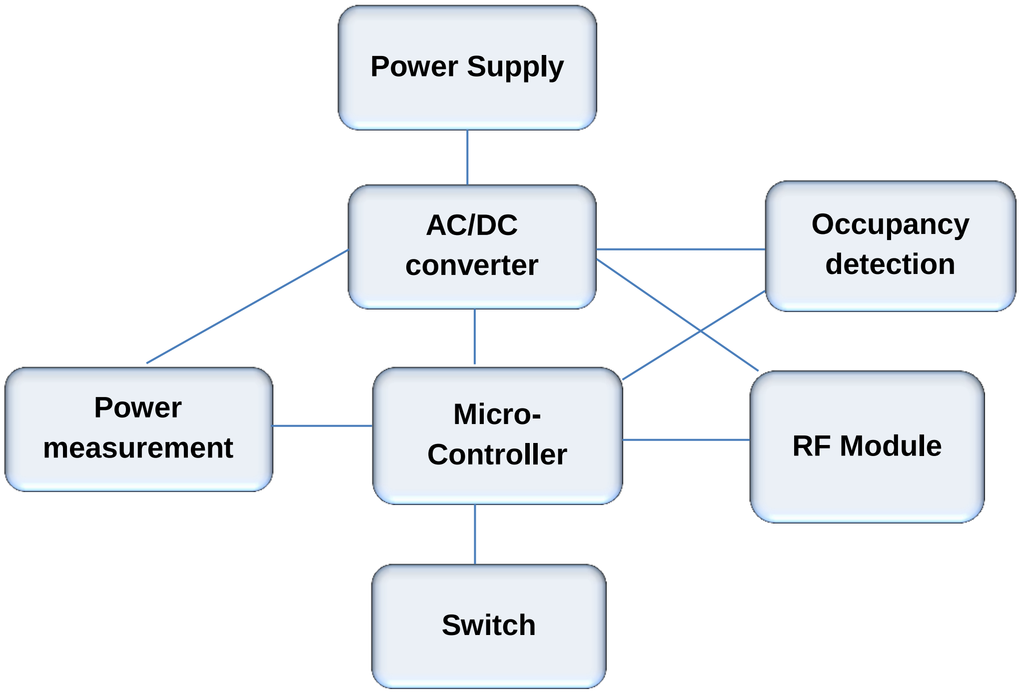

Figure 3: Block Diagram for Sensor Units

2. Block Descriptions

2.1 Controller Unit

The unit will consist of a microcontroller, RF module, power supply, and user I/O. Microcontroller in the big box will process all the data receive from small box and also commanding small box from user's input. RF module enables wireless communication between microcontroller and sensors. Power supply will be the energy source for microcontroller's operation. User I/O display information of power usage and allow user to control the power.

Case Design

The case will be designed to be small and portable. It's intended to let the user to carry around the house. The body should also be insulator to prevent electrical shock.

User I/O

A basic character LCD will be used for display and buttons for user input. Information such as power usage will be display on the LCD and user can interact with the system through the buttons. The LCD and buttons will connect with the microcontroller through a serial connection.

Microcontroller

The microcontroller receives input signal through RF transceivers and store data. When motion has been detected from the sensor system, the microcontroller will send signal to give command to start the power for particular areas. It also analyzes the users 'setting to generate a power budget management. The implemented microcontroller will be TI MSP 430. Furthermore, the MSP430 connects to the LCD through a serial connection.

Power Supply

The power supply will be a small power circuit that provides a stable constant 3V to the MSP 430, LCD display, and RF module. Small batteries will be used as the initial energy source.

RF Module:

The module transmits and receive radio signal for communication between controller and sensor system. These CC1101 transceiver and CC1150 transmitter modules operate in the 434 MHz which is comply with a TI MSP 430 microcontroller through SPI interface. They are an inexpensive option for high performance and price ratio of wireless transceivers implemented with PLL. We use transmitter to send command signal from controller to the switches and use transceiver to receive data signal for power consumption value and motion detection

Storage module

We use the MMC or SD card to communicate we use the MMC or SD card communicate with MSP430 via SPI interface that allow for simultaneous bidirectional data transfer. The memory storage will be used to memory the power consumption and compared to the user's setting power budget.

2.2 Sensor Units

Power Supply and AC/DC converter

The power supply 120 V from AC line and convert to will be a small power circuit that provides a stable 3V-5V to power the circuit including the MSP 430, RF module, sensor device .

Microcontroller

MSP 430 microcontroller will be used to control the unit. This device is powered by the AC/DC converter, which provides a constant 3V. The microcontroller will receive input data from IR sensors/ Current sensors to output control signals to relays. Moreover, it will analysis data, which collects from power measurement, to send to controller unit via RF transmission. The main reason for using this sort of microcontroller is the low power consumption and low cost of this device.

RF module

We use the same wireless module for each unit. They will transmits the data of power usage and receive the command from the controller for the relay.

Occupancy Detection

The sensor module will detect motion and occupation. It is able to provide consistent and reliable reading. The sensor output an analog voltage will give signal to RF module as activation for starting power.

Switch

It is used as a relay which can be controlled by DC voltage. The primary reason for using this device is high rate current adoption at 120VAC. This relay is connected to microcontroller via serial data port. The relay works as a switch (on/ off) power when it receive command signal from microcontroller.

Power Measurement module

The module is a wattmeter which output a voltage that's proportional to the average power consumption in the load. Figure 26 in page 24 showed the schematic. The output voltage to power measured ratio is 0.5V/1kW. It allows power detection from 0W to 6.6kW. The module will be between the grid and the load separated with an isolation transformer. The output voltage is then sent to the MCU for ADC and data processing.

3. Flowchart and Schematic

3.1 Flow chart

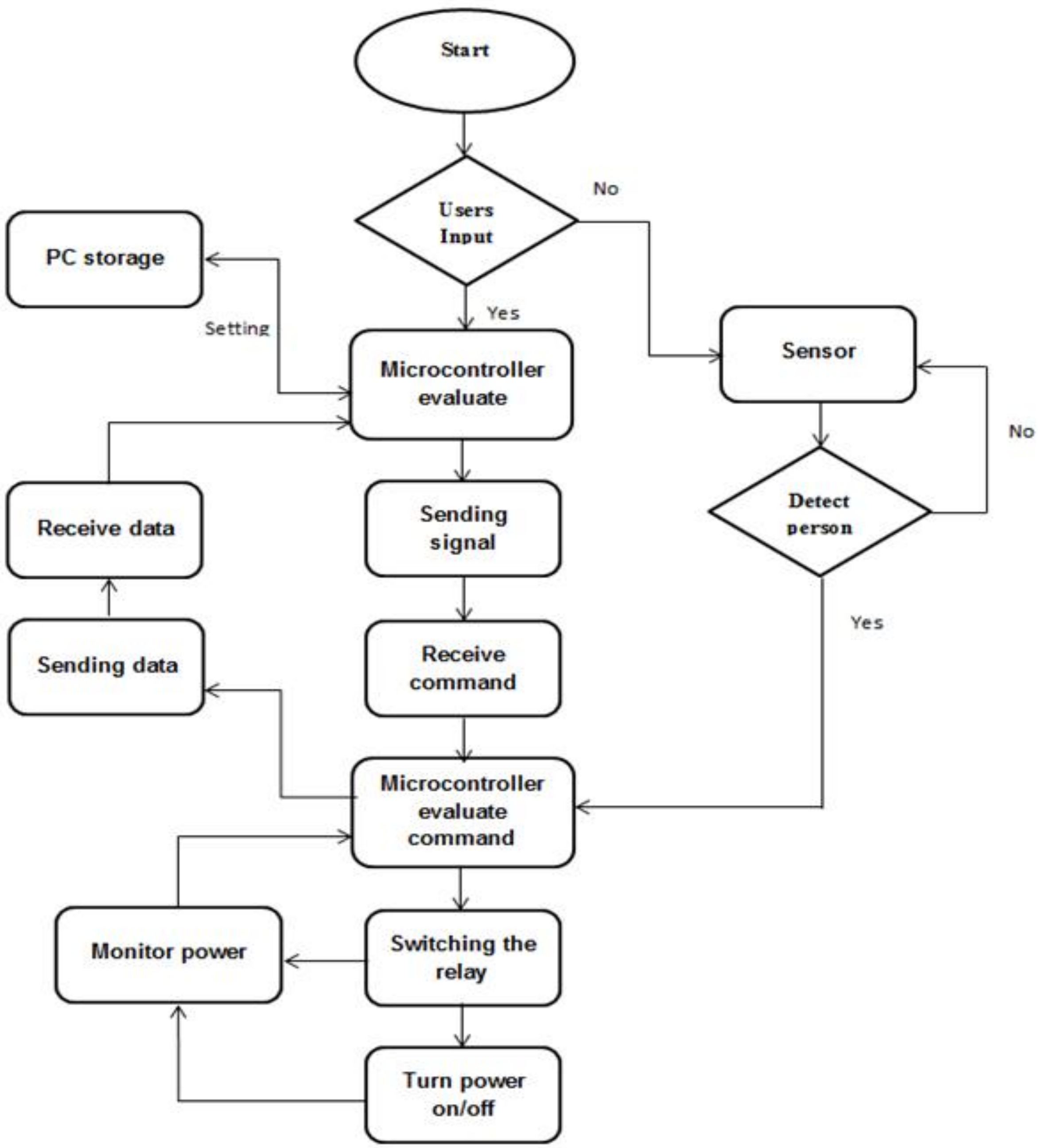

Figure 4: Performance flow chart

3.2 Schematic

User I/O

The output interface consist the LCD 16x2 of Lumix U01602D/A and buttons which allow the user to interact with the controller.

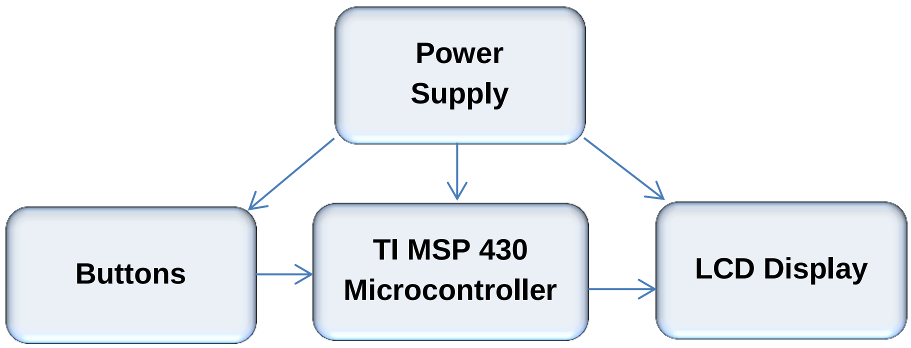

Figure 5: User I/O flow chart

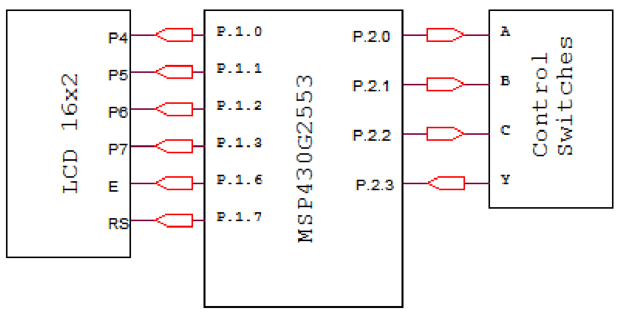

Figure 6: User I/O Pin with MSP430 microcontroller connection

LCD

The LCD can work within a range from 2.2V to 5V supply voltage and within a range from 4.2V to 4.8V driving voltage. The supply voltage 5V for the display is connecting to pin 2. The pin 4,5,6,7,E ,RS will get the signal from pin (p1.0;1.1;1.2;1.3;1.6;1.7 respectively) of microcontroller to be able to display information. LED backlight can be used to help LCD brighter where pin 15 and 16 are LED cathode and anode

Button

The button will connect the multiplex DM74151 which logically send the signal microcontroller. There are 6 buttons which connect in serial to the multiplexer DM74151, then logically send the signal to pin TI MSP 430 microcontroller. Pin 1,2,3,4 and 12,13,14,15 are data input signal. Pin 9,10,12 are set as data select. Pin 5,6 are output.

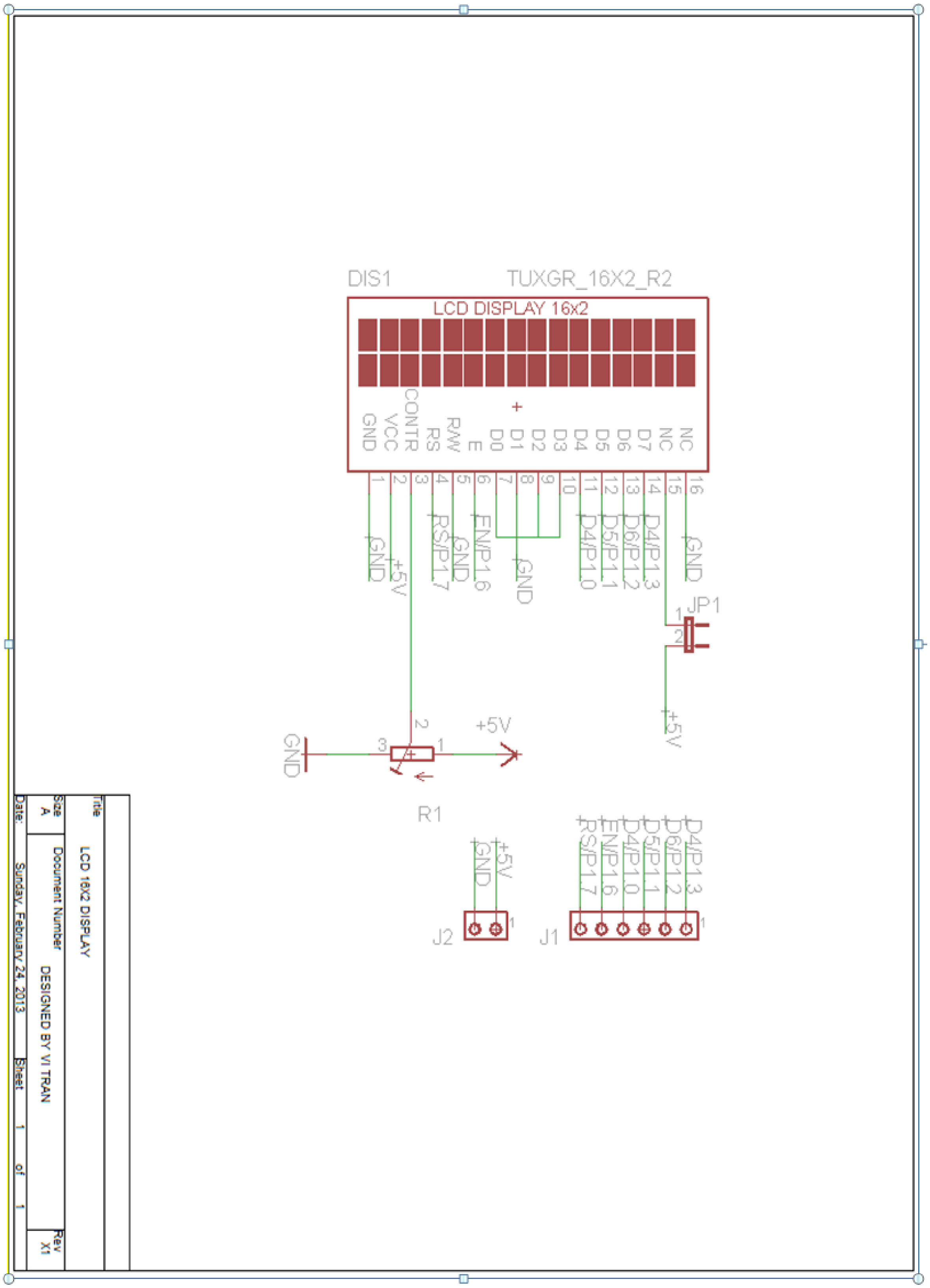

Figure 7: Liquid crystal display diagram

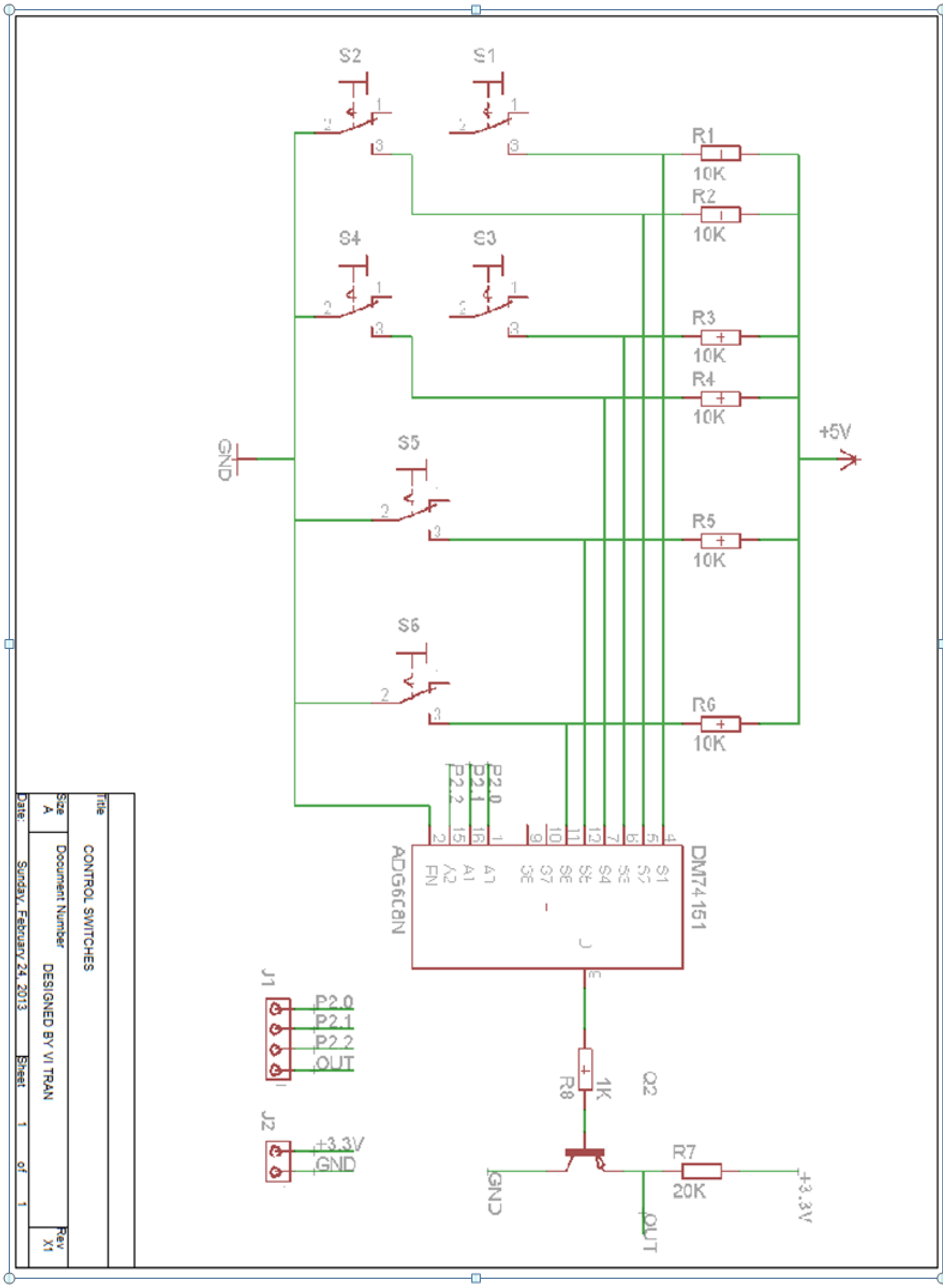

Figure 8: Push Buttons diagram

Microcontroller

The microcontroller operates with 3.3V supply voltage. It receives signal from PIR sensor, RF transceiver and power measurement module through P2.0, P1.5, P1.3; and give output signal through P1.5, P1.4 to RF transmitter and switch

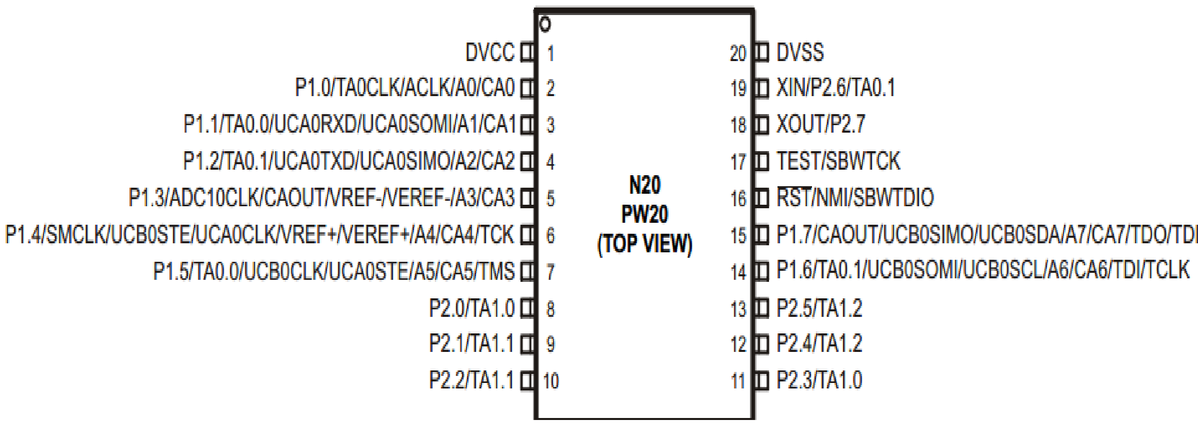

Figure 9.1: 20-Pin MSP430G2553 Layout[1]

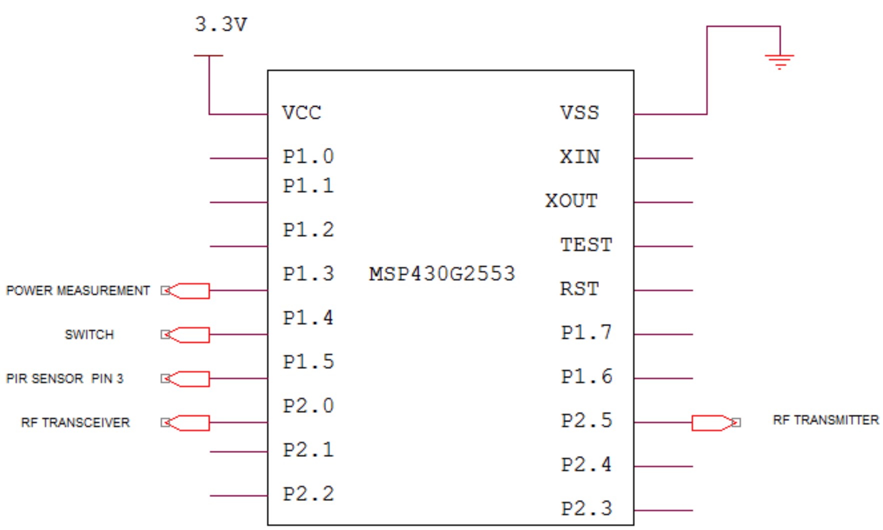

Figure 9.2: Microcontroller connection pin for the sensor units

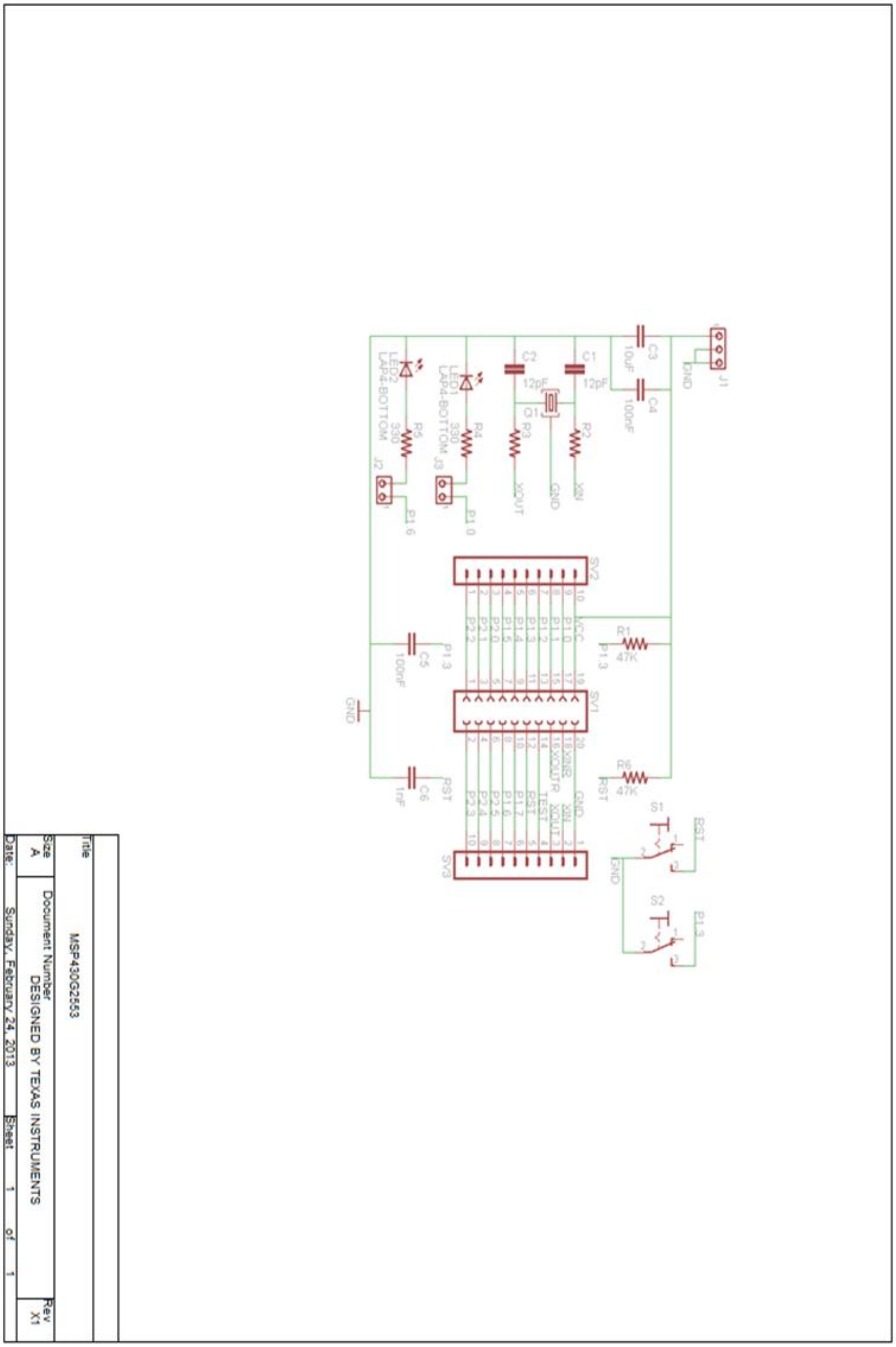

Figure 10: TI MSP430 chip circuit diagram [1]

AC/DC converter module

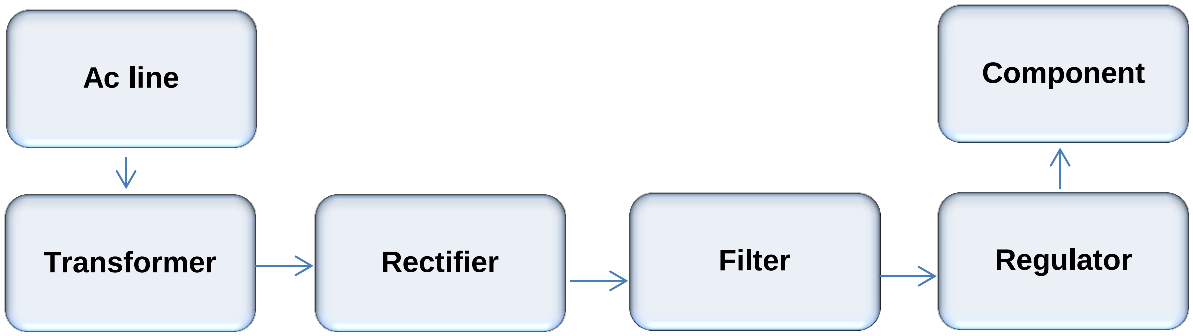

Figure 11: AC/DC converter flow chart

To provide the proper supply voltage for components, we use a step down transformer with ratio 5:1 from 120Vac to 24Vac. Then apply a full-wave rectifier MB1S to convert alternating current which periodically reverses direction to direct current which flow in one direction. The no-load output voltage of a single phase full-wave rectifier is:

$$V_{peak} = V_{rms*}\sqrt{2} \qquad \text{(eq.1)}$$

$$V_{dc} = \frac{V_{peak} * \sqrt{2}}{\pi} \qquad \text{(eq.2)}$$

$$V_{peak} = V_{rms*}\sqrt{2} = 24 * \sqrt{2} = 33.94V$$

$$V_{dc} = \frac{V_{peak} * \sqrt{2}}{\pi} = \frac{33.97V * \sqrt{2}}{\pi} = 15.28V$$

By connecting voltage regulator (LM7815,LM7805), the circuit is able to maintain and supply a constant voltage level (15V, 5V, 3.3V) for each component in the sensor unit.

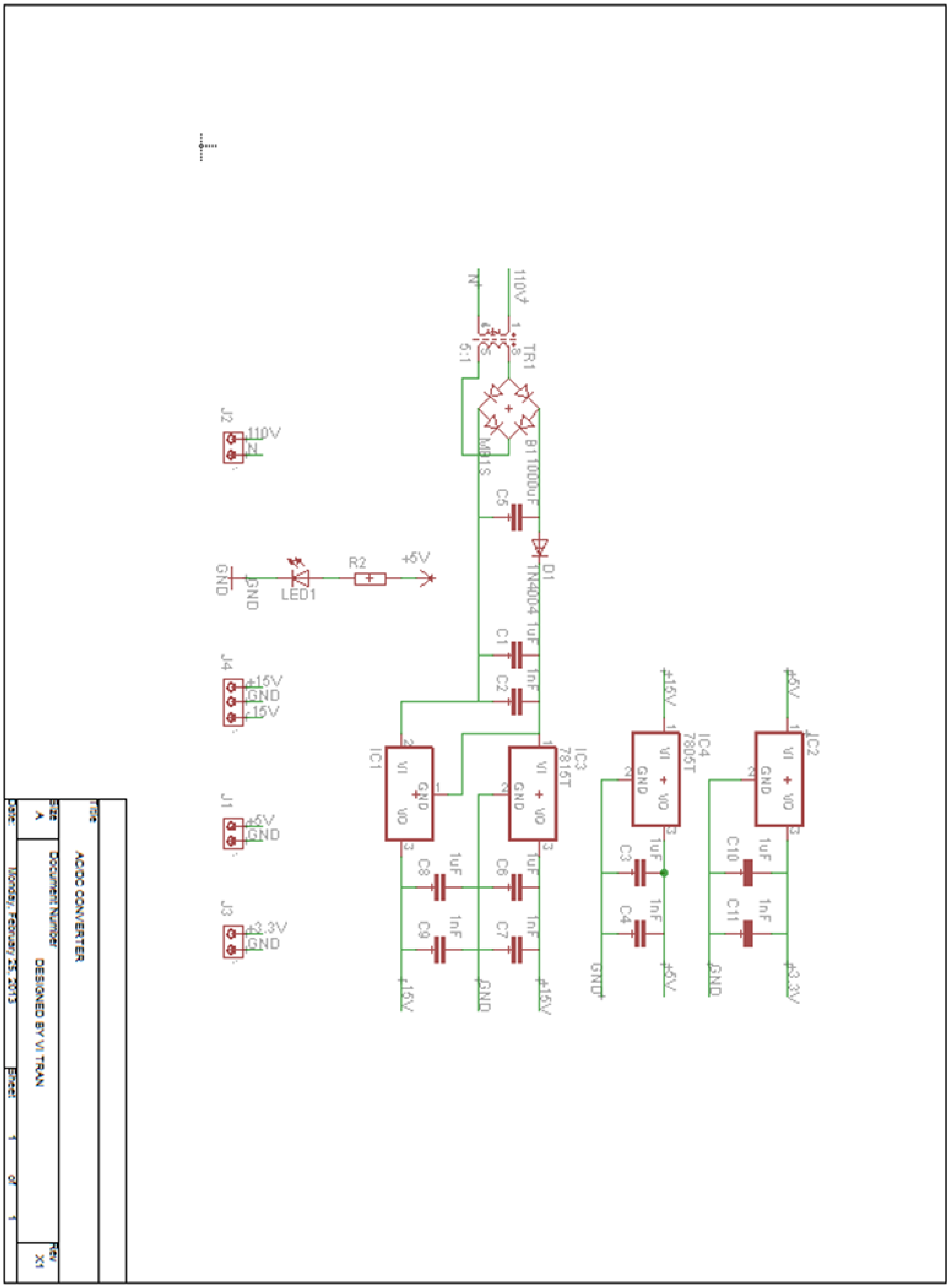

Figure 11: AC/DC converter circuit diagram [2]

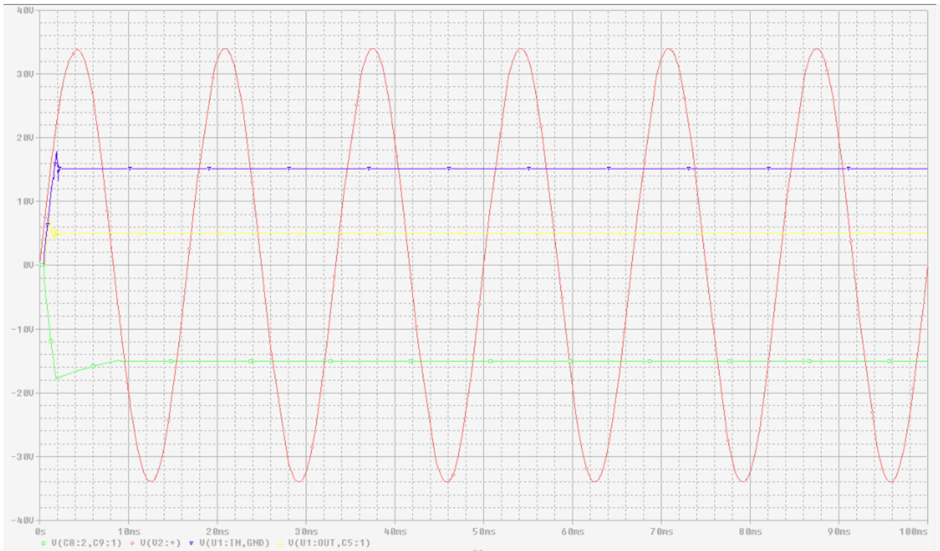

Figure 13: AC/DC converter Output voltage simulation

The simulation shows constant output voltage ±15V, + 5V output voltage from sinusoid input voltage. A transformer 5:1 ratio is used to step down voltage from 120V RMS to 24V RMS. The positive voltage is generated by using rectifiers bridge, the serial voltage regulator, which is LM7805, LM7915, and LM7915, is used to generate a DC voltage

Relay

The signals from P14 of MSP430 microcontroller are used to trigger the switches to turn on/off power. When Relay is used for this circuit due to the maximum AC voltage is 120V and current is 10A; moreover, it can be controlled by 5V DC. The 2N3903 NPN is use as general purpose amplifiers because it can operate at high switching frequency.

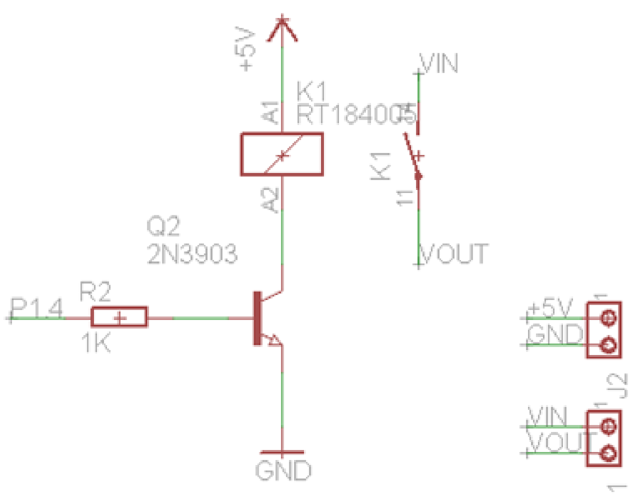

Figure 14: Switches circuit diagram

Occupancy Detection module

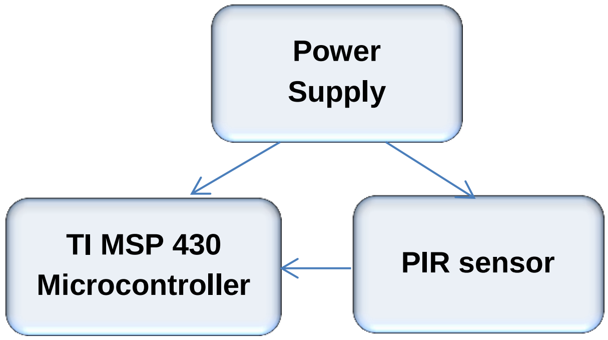

Figure 15: Motion detection flow chart

For the occupancy detection function, we implement PIR (passive infrared) motion sensor form Parallax manufacture. The PIR is a pyroelectric device that detects motion by comparing the amount of infrared radiation that reaches a pair of detectors. When the two detectors receive different values, the sensor indicates it as movement of an object as far away as 20 feet in reduced sensitivity mode. The Parallax PIR sensor has an analog on/off output. When movement is on, the sensor is detecting moving. When movement stops, the output turn off (after a fixed delay) The output of the sensor will be directly connected to TI MSP430 microcontroller, and operates as a trigger for power.

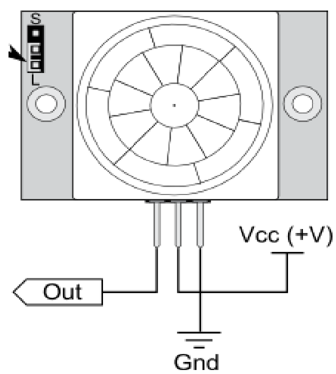

Figure 16: Basic Wiring [3]

The PIR sensor module has a 3pin connection and a Fresnel in the front part to focus the infrared light on to the sensor element
Voltage operates in 3V to 6V range.
Source current is up to 12mA at 3V and 23mA at 5V
View angle is 110 degree
Operating temperature 30^0 to 120^0 F
Pin 1: connects to ground (0V)
Pin 2: connects to supply voltage 5VDC from
Pin 3: (PIR signal) high 1= movement;
    low 0 = no movement;
    connect to PIN 1.5 of MSP430 microcontroller

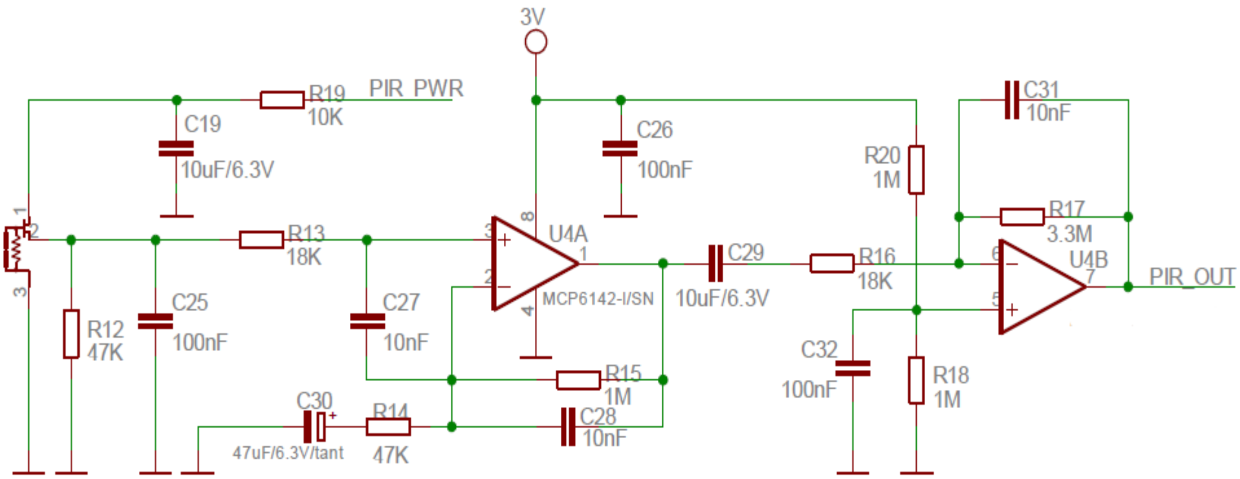

Figure 17 : PIR motion sensor circuit diagram[3]

Figure 18: Testing PIR motion sensor

(Yellow line: supply voltage 5Vdc; Blue line : output signal)

For testing PIR sensor, we connect a module to 5VDC supply voltage (by checking with voltage multimeter and oscilloscope) When the PIR detect motion, the output pin go to high 2.92 which is decent for an input of a microcontroller.

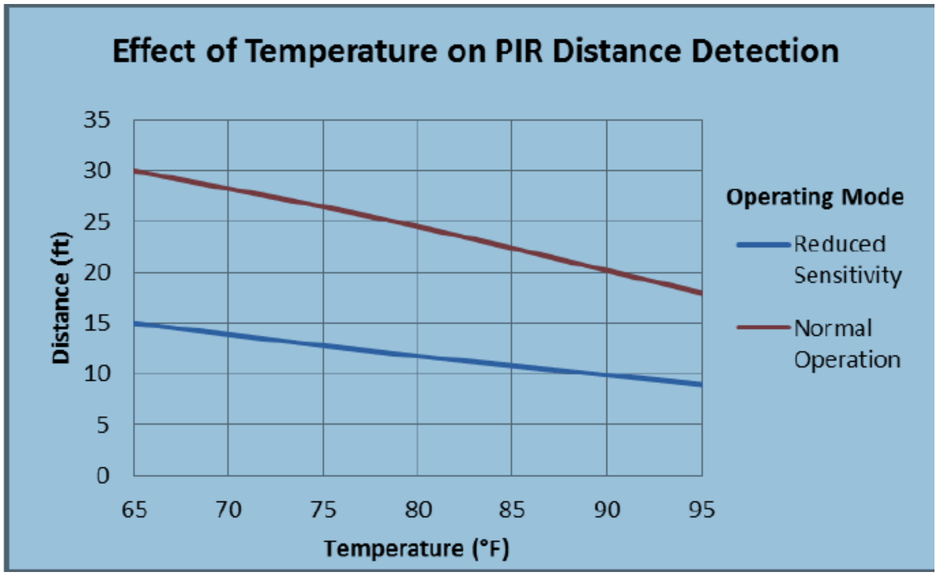

Figure 19: Effect of temperature on PIR distance detection[3]

The PIR sensor's range is also effective by environmental condition including room temperature and light sources. The graph below depict the approximate effect of known temperature on the PIR sensor's detection range

RF Module

For wireless communication , we implement the RF module CC1101 transceiver and CC1150 transmitter provided from Texas Instruments. It is a low cost low power sub 1GHz transceiver designed for low-power wireless application and easily programmed to operate in frequency range 387-464MHz. it is capable of communicating with TI MSP 430 through SPI interface. It has high sensitivity (at 433 MHz, 1% packet error rate).

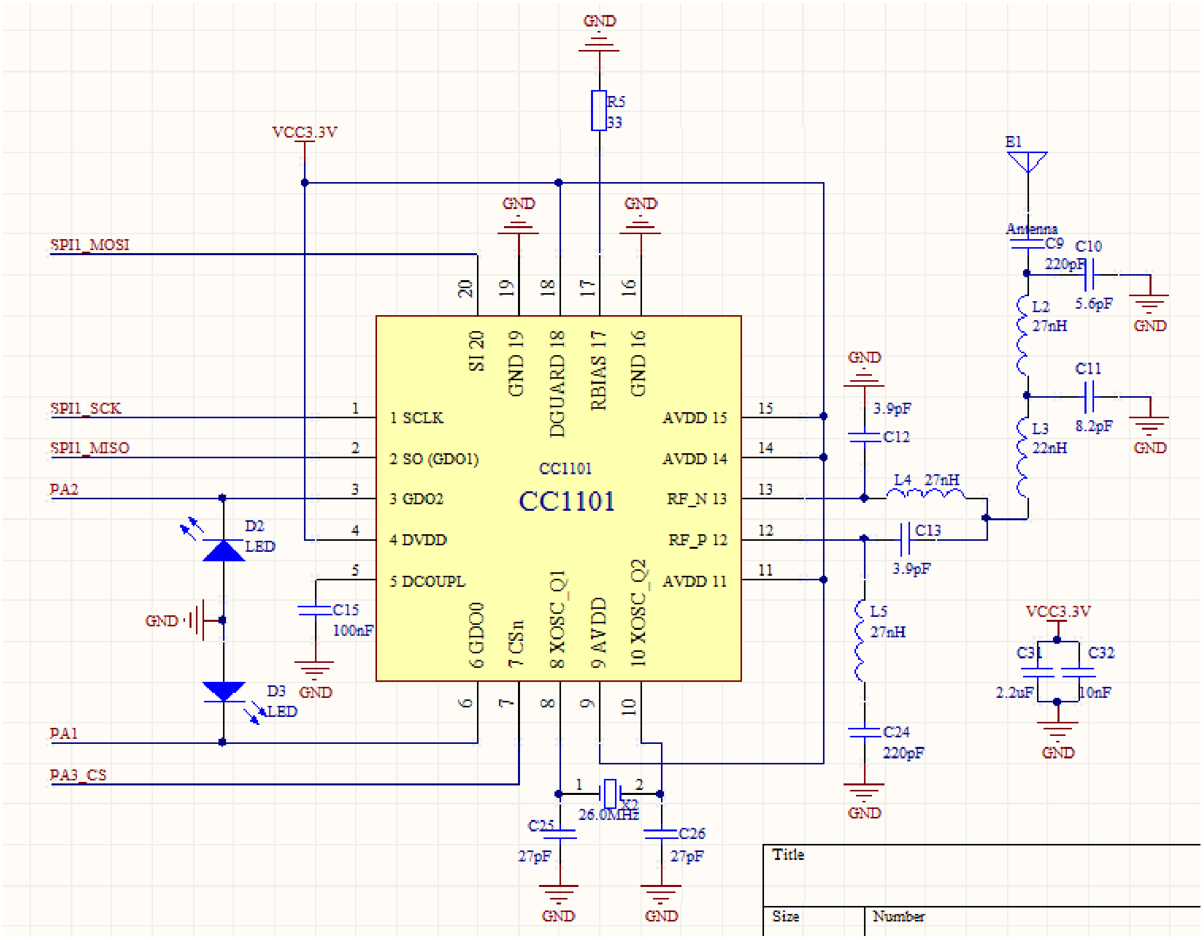

Figure 20: RF transceiver circuit diagram [4]

We do the simulation on the output signal of the transceiver, i.e. pin12 and pin13 of CC1011. As shown in the schematic of the simulation circuit below, the circuit before probe2 serves as a differentiator, taking in one positive and one negative signal, and outputting a signal indicating the difference of the two input signals.

The circuit between probe2 and probe1 is basically a low pass filter, filtering out signals above about 434MHz to reduce the impact of noise. 434MHz is chosen is this circuit to ensure filtering out higher-frequency noise signal while maintaining the transmitting signal at the same time. The curve is the signal at probe1 with input at probe2.

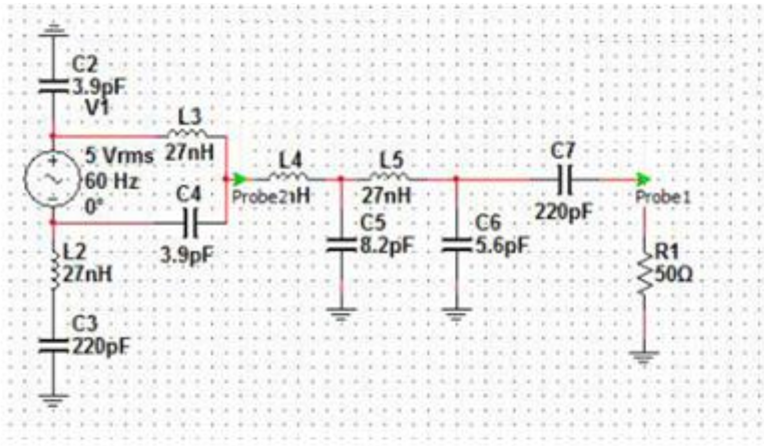

Figure 21: low pass filter circuit diagram

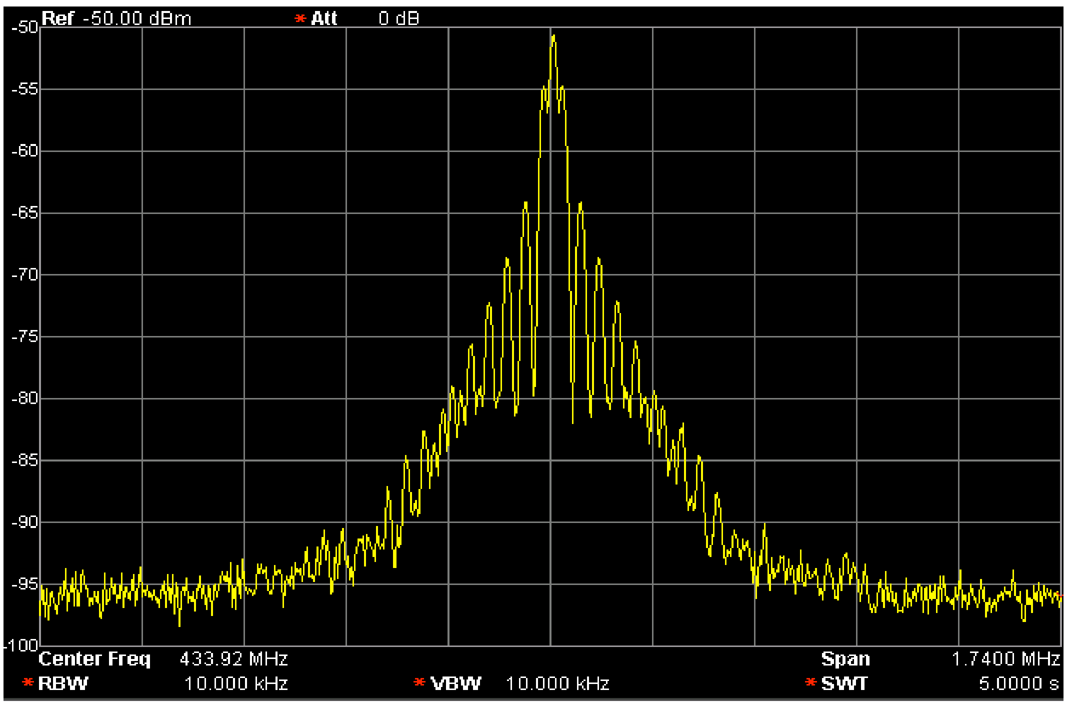

Figure 22.1: spectrum analysis

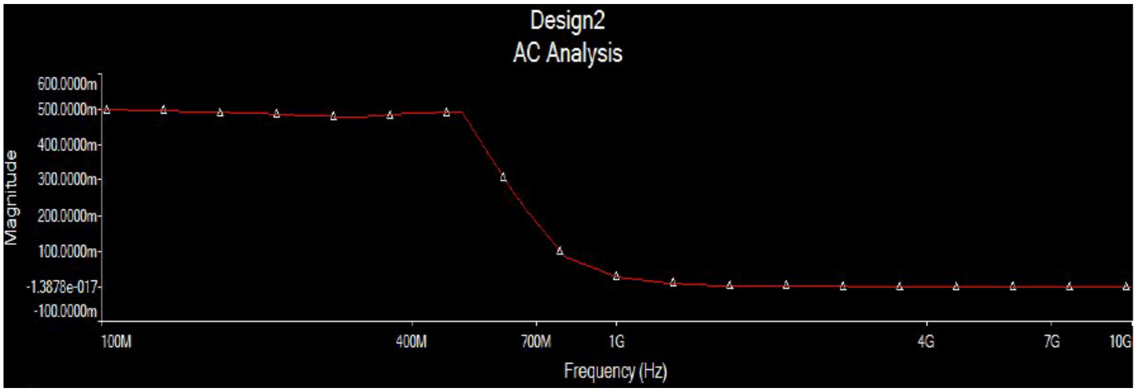

Figure 22.2: Analog signal frequency

In the simulation, we see the peak signal at approximate 433.92 Mhz ±10 Mhz and the spectrum analyzer integrates the power taking into account the frequency step

Low pass filter Calculation:

We use the RC low pass filter to eliminates all frequencies above the cut off while passing those below unchanged . This filter has a purpose to pass the desired frequencies signals and block the unwanted high frequencies signals. Below is the schematic of the RC low pass filter

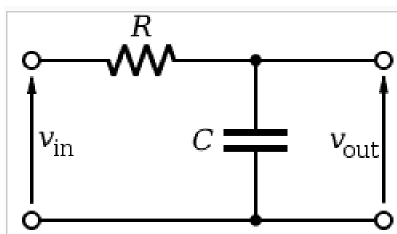

Figure 23: a low pass RC filter [5]

The cutoff frequency can be calculated as: $f_c = \frac{1}{2\pi RC}$ (ep 3) [5]

The fundamental frequency is the frequency where the filter changes its behaviors from passing the low frequency and stopping the high frequency

Memory storage

We use MMC card to save data from power measurement and user's setting.

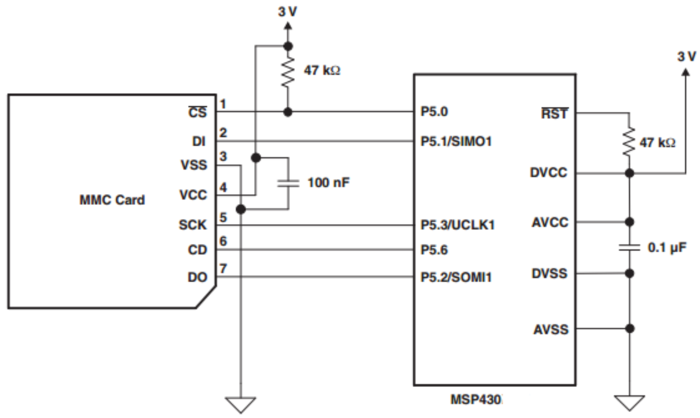

Figure 24 Connection between MSP430 and MMC card[1]

Power measurement

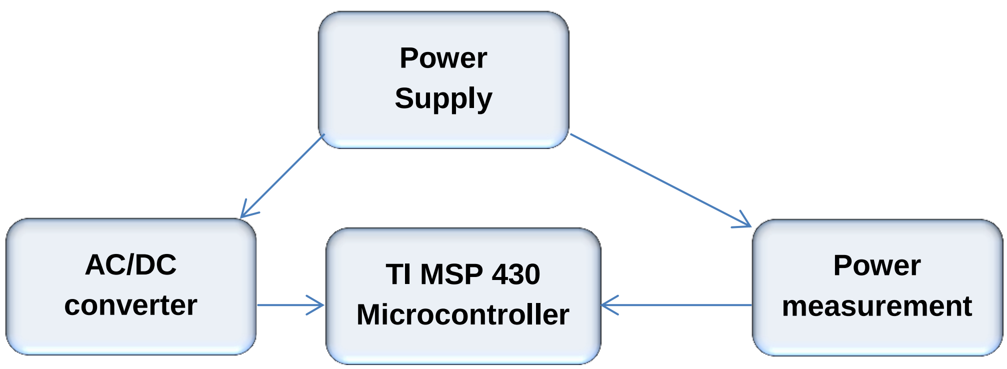

Figure 25: power measurement module flow chart

The circuit use voltage divider to reduce the load voltage signal and the first operational amp to reduce the load current voltage signal from the .005ohm current sensing resistor. Then the AD633 multipliers multiply these two signals. The last op-amp compute integrate the product and output a voltage signal that every .5mV represent 1 W in the load.

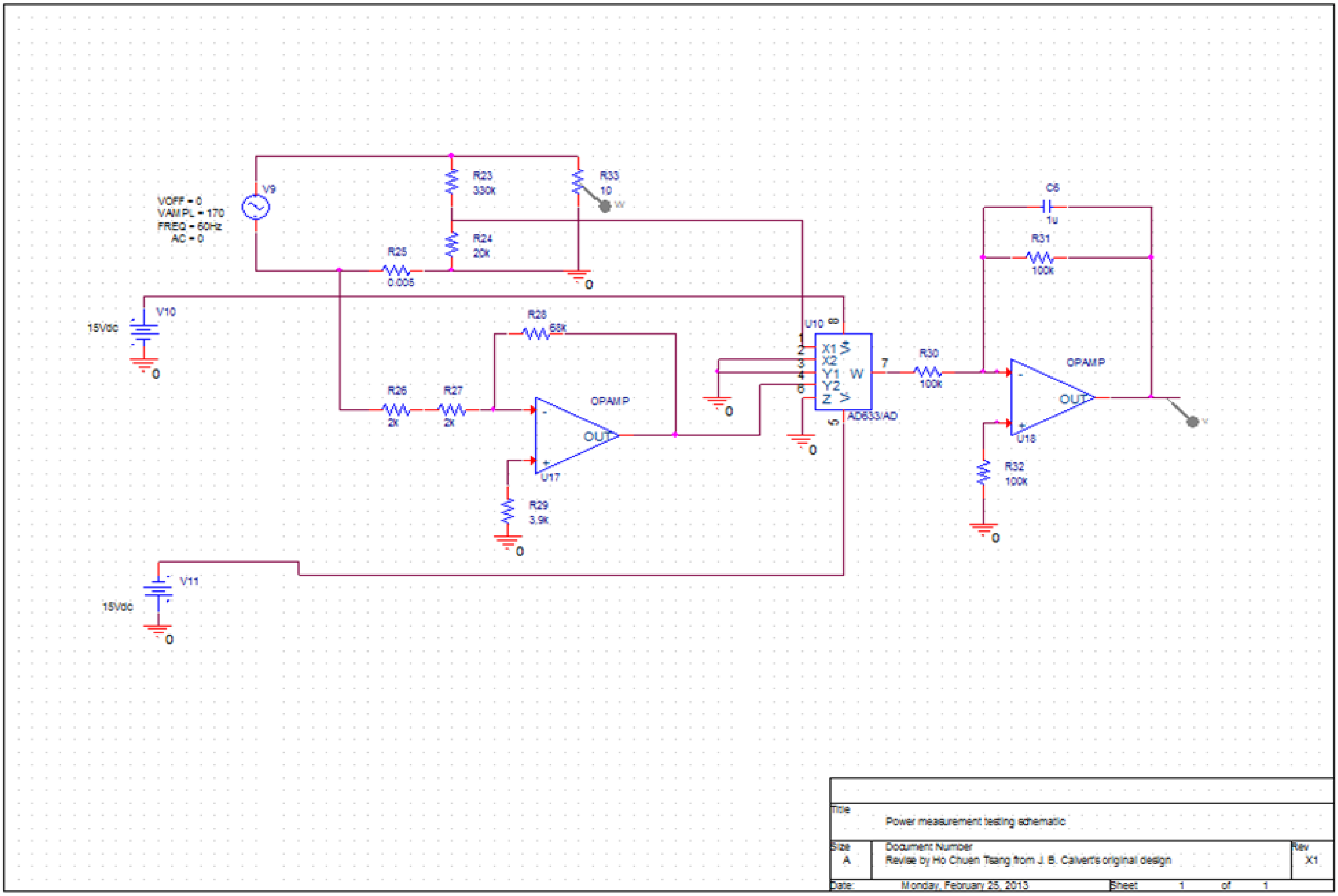

Figure 26: Power measure circuit diagram

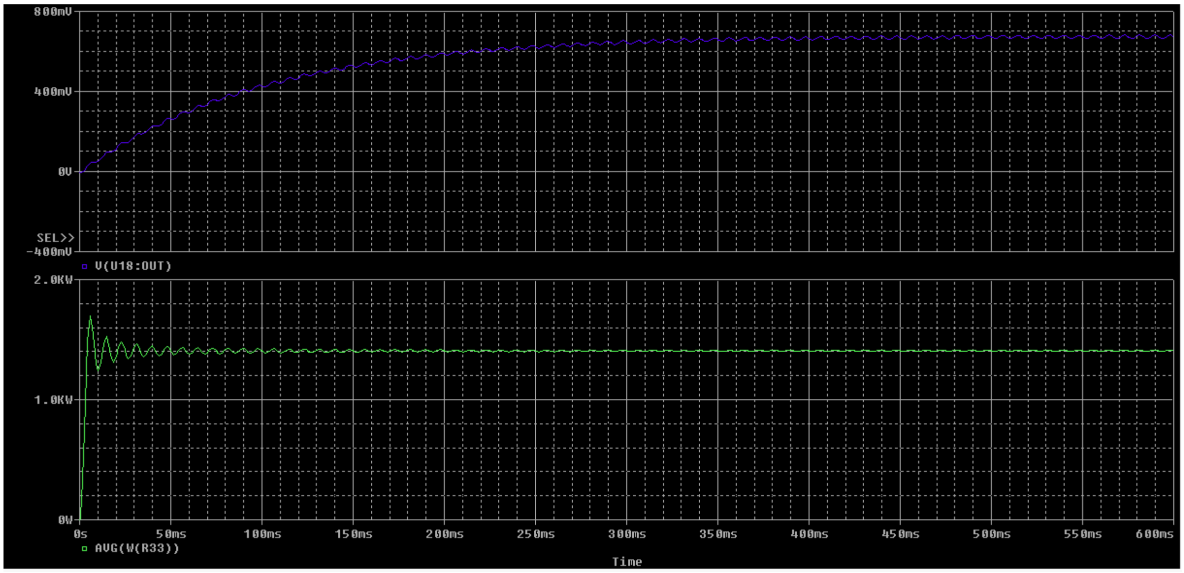

Figure 27: Out measured voltage

This simulation has a 10ohm load which dissipates 1.4kW average power shown in the bottom plot. The output voltage should be .5mV per W. And the top plot shown the output voltage is stabilize at .7mV after about .4 second.

Power management

For the feature "learning ability" of the device, we focus on programming the microcontroller to accumulate the measured information each hour, process and save on the MMC card then use it to match with default mode or user's budget plan. When the data reaches closed to the reference setting; the device will send notification to the users and temporarily shut down the power of the areas which are set as low priority. The process is also saved as a new reference for the updated schedule.

IV. Requirement and Verification

1. Testing Procedure

User I/O module

Requirement	Verification
LCD interface input voltage 5V $\pm$10% to power on	LCD interface Adjust the input voltage in range of 4.5V to 5.5 then test with multi-meter and check the LCD works properly (clear numbers, letters, and characters)

Power supply

Requirement	Verification
Power supply 1. The power supply 120V with variation 20mV pk-pk. 2. 2 AA batteries generate 6V $\pm$ 8% 3. Efficiency at least 80% AC/DC converter 1. Able to convert from supply voltage 120Vrms: 5V $\pm$ 10% for microcontroller , RF 3V + 10% for sensor 15V $\pm$ 10%V for op amp 2. Ripple voltage is equal or smaller than 100mV 3. Output voltage is within 10% of the desired voltage	Power supply 1. A AC source is connected directly input to simulate potential change in voltage. The peak to peak voltage is measured 2. Connect the batteries to volt meter over a period of 5 minutes and check the output staying in the acceptable range 3. Measure the output current and voltage from the supply , calculate and compare with the input voltage and current AC/DC converter 1. Probe the input with a voltmeter and amp meter; observe display signal waveform through oscilloscope. Check out put of the power supply 2. Measure output voltage on DMM and check voltage output on oscilloscope 3. Measure the voltage at the terminal connecting to microcontroller and other component.

Occupancy detection module

Requirement	Verification
1. Function correctly in power supply range 3V + 10%	1. Connect to power supply (3,4,5V)and read output change indicating device working
2. The sensors need an accurate reading in room temperature in range 50°F-90°F condition.	2. Changing the temperature in door or close to the sensor. Move in front of sensor ,then use oscilloscope to check if sensors give output signal corresponding to the movement
3. Be able to generate voltage output at least 0V when there is no movement and 2.5V $\pm$ 10% when detecting motion distance between 5-20 feet	3. Connect to power supply and vary signal when changing distance between sensor and people. Use oscilloscope to check the waveform signal

RF module

Requirement	Verification
RF module 1. Able to transmit and receive data in the frequency range 387-464 MHz , especially at 434MHz $\pm$ 10MH z signal 2. Certify to recognize bit patterns from microcontroller signal with less than 1% error 3. Communicate within 20 meter $\pm$ 5 meter range indoor	RF transceiver 1. Set spectrum analyzer to read around the 434 MHz frequency. Pulse control signal through microcontroller. Compare with spectrum analyzer that 434 MHz signal is propagating. Send difference signals at different frequencies. Use oscilloscope to observe which one is verified the most 2. Continuously transmit data from microcontrollers, use parity bit method to check the error 3. Digital signal will be sent from the microcontroller to the transmitter. A distance test will measure the signal strength and noise ratio of the receiver to determine the maximum RF transmission distance. Transmit data and then measure the output vs. distance. Change the distance between 2 module and check the point at which the data output cannot be recognized will be the maximum distance.

Microcontroller

Requirement	Verification
1. Function correctly under voltage range of 1.8V- 3.6V 2. Communicate to RF module accurately transmit data rate from 0.6 to 600kbps with 1% error rate. 3. Be able to receive the digital signal under 0 – 3V $\pm$ 10% from sensor	1. Connect to the power supply at 1V-4V and verify the correct input with function generator and output with oscilloscope 2. Code the microcontroller to transfer data. We connect the digital pin out of the microcontroller to the oscilloscope. 3. Use the digital output pin of the microcontroller to the digital high (5V) and digital low (0V), and see the LED response to check if it is on or off

4. The delay time between data input less than 200ms	4. A duty cycle pulse is generated by function generator and is inputed into the microcontroller. Connect probe 1 to the input signal pulse, probe 2 to the output from the microcontroller, then check the periodic output waveform in the oscilloscope. The time difference of both input and output signal is observed.

Switch module

Requirement	Verification
Relay 1. Operate at 120V AC $\pm$ 10%, with the maximum current is 10A$\pm$ 10%.	1. Use multi-meter to check input and output voltage ,current
2. The delay times with respect to control signal is smaller than 400ms	2. Use an oscilloscope to testify voltage waveform before apply the control signal, then apply a control signal to check switching delay time and switching frequency.

Power Measurement

Requirement	Verification
1. Able to measure load in range from 1W to 6kW.	1. Value of components in the circuit already simulated in OrCad which can measure load with range from 1W to 6kW. The actual circuit will be test with oscilloscope by placing different value resistor as load. Test will then be taken to see if the average power rescale from the output voltage is showing the average power which measured across the load resistor with a wattmeter in the lab
2. The average power measured after rescaling the output voltage must not excess 5% error.	2. The second requirement will be also test with the above method for the whole range of load resistor to make sure error is under 5%. compare to the average power measure across the load

3. The ripple of the output voltage needs to be less than 4%. 4. The response time for the output voltage to reach 3dB ± 10%less than 5 second 5. The peak power dissipate in each resistor is less than 80% of the P.R.	3. The ripple of the output voltage can be measure with the oscilloscope. 4. When testing the first 3 requirement, see if the output voltage is stable after few second 5. Measure resistor's voltage and current with the oscilloscope. Then find the peak instantaneous power dissipate and make sure it's less than 80% of their P.R

2. Tolerance Analysis

For the power measurement block, the allowed error of average power measurement will be tune to be less than ±2.5% for appliance with load range from 1W to 6kW. It will be verified through comparing the actual average power across the load with the average power measured from rescaling the output voltage. The oscilloscope will be used for this comparison.

VI. Cost and Schedule

1. Cost Analysis

1.1 Labor

Member	**Hour Rate**	**Total Hours Invested**	**Total** = Rate *hour *2.5
Hai Vo	$35/hour	180	$15,750
Vi Tran	$35/hour	180	$15,750
Benny Tsang	$35/hour	180	$15,750
		540	$47,250

Table 1: Labor Cost approximate

1.2 Part

Description	Part number	Quantity	Manufacturer	Cost / Unit	Total cost
Voltage regulator	LM7805	3	Fairchild Semiconductor	$0.67	$1.81
	LM7815	3	Fairchild Semiconductor	$0.67	$1.81
	LM79155	3	Fairchild Semiconductor	$0.67	$1.81
	UA78M33	3	St microelectronic	$0.62	$1.86
BJT	2N2222	3	St microelectronic	$0.15	$0.30
NPN	2N3903	1	National Semiconductor	$0.51	$0.51
	DM74151N	1	C&K Components	$0.80	$4.80
Relay	T77S1D10-05	3	TE CONNECTIVITY	$2.25	$6.65
16x2 character LCD	U01602D/A		Lumix	$15.00	$15.00
16 bit Microcontroller	MSP 430g2553	4	Texas Instrument	$5.00	$20.00
RF Transceiver	cc1101	3	Texas Instrument	$1.53	$4.59
PIR motion sensor	555-2870	3	Parallax	$4.99	$14.97
current sensing resistor	OAR5R040JLF	8	DigiKey	$0.89	$7.12
relay	655-T7751	3	DigiKey	$2.28	$6.84
RF transmitter	cc1105	3	Texas Instrument	$1.73	$5.19
Op-amp	LF411	4	Texas Instrument	$0.84	$3.36
Analog Multiplier	AD633JN	3	Sparkfun	$3.50	$10.50
push button switch	COM-00097	6	Sparkfun	$0.35	$2.10
isolation transformer	DA102MC	3	Sparkfun	$1.56	$4.68
					$111.10

Table 2: Parts cost approximate

1.3 Grand Total

Section	Total
Labor	$47,250.00
Parts	$111.10
Total	$47361.10

Table 3: Grand total cost

2. Schedule

Week	Description Task	Team Member
1/14	Initial Post Finding partners	Hai Vo, Vi Tran , Benny Tsang
1/21	Finding partners	Hai Vo, Vi Tran , Benny Tsang
1/28	1. Project Page Update 2. Work on RFA 3. Working on proposal paper	1. Hai Vo 2. Benny Tsang 3. Vi Tran
2/4	**Proposal due** 1. Data mining on transceivers, Sensors 2. Data mining on microcontroller, sensor, replay 3. Data mining on AC/DC converter, power supply	1. Hai Vo 2. Vi Tran 3. Benny Tsang
2/11	**Mock Design review** 1. - investigate LabView 2. - Power measurement circuit design 3. - PIR sensor circuit design	1. Vi Tran 2. Benny Tsang 3. Hai Vo
2/18	**Sign-up Design Review** 1. - Write simple detector for microcontroller - Work on I/O module circuit (LCD & switches) 2. - Testing &Debugging PIR sensor - Work on RF module 3. - run simulation for power measurement circuit - Work on ADC in MCU	1. Vi Tran 2. Hai Vo 3. Benny Tsang
2/25	**Design Review** 1. - Write code to communicate with sensors - Testing & verify PIR sensor 2. - Testing controller system - verify I/O module circuit 3. - implement power measurement circuit and its verification - Write code for ADC and start work on data storage	1. Hai Vo 2. Vi Tran 3. Benny Tsang
3/4	1. - PCB of I/O module in eagle. 2. - Testing & Debugging RF transceiver circuit - PCB of RF and PIR module 3. - PCB of Power measurement in eagle	1. Vi Tran 2. Hai Vo 3. Benny Tsang
3/11	**Individual Progress Report** 1. - Testing/Debugging/soldering power measurement circuit 2. - Testing/Debugging/soldering I/O circuit 3. - Testing/Debugging/soldering PIR and RF circuit	1. Benny Tsang 2. Vi Tran 3. Hai Vo
3/18	**Spring break (no access to lab)** 1. - Program MCU for ADC and data storage 2. - Program MCU for I/O and communication 3. - Program MCU for RF and PIR	1. Benny Tsang 2. Vi Tran 3. Hai Vo
3/25	**Mock-up Demos sign up** 1. - Working on final report 2. - Improve UI interface 3. - Final integration	1. Benny Tsang 2. Vi Tran 3. Hai Vo
4/1	**Mock-up Presentation** 1. - have power measurement and MCU verification met 2. - have I/O, switch, and power supply verification met	1. Benny Tsang 2. Vi Tran

	3. - have case, IR, and PIR verification met	3. Hai Vo
4/8	1. - Debugging power circuit 2. - Debugging microcontroller code 3. - Debugging communication circuit	1. Benny Tsang 2. Vi Tran 3. Hai Vo
4/15	**Demo and presentation sign-up** 1. - Final product test (software) 2. - assemble everything together 3. - Final product test (software)	1. Benny Tsang 2. Vi Tran 3. Hai Vo
4/22	**Demo and Presentation** 1. - Demo & Presentation (power), Final Paper 2. - Demo & Presentation (UI), Final Paper 3. - Demo & Presentation (communication), Final Paper	1. Benny Tsang 2. Vi Tran 3. Hai Vo
4/29	**Presentation, Checkout, Final Paper, Lab Notebooks** 1. - Presentation 2. - Checkout part 3. - Finish final paper	1. Benny Tsang 2. Vi Tran 3. Hai Vo

VII. Safety

Since parts of devices connect directly to the power from the grid, the main safety goal is to prevent any potential of electric shock to the users. Electric shock from the wall power to users can be fatal, so we will install a protection fuse on the AC line input to avoid short circuit. Since the sensor unit is plug into the wall, it's important we make sure the case of our sensor unit is isolated from the circuit. Warning should also be given to users that they should never open the case to inspect the circuit inside under any circumstances. Another important safety concerns will be the circuitry. We want to make sure it won't catch on fire. That mean we not just only consider a working circuit, but also its state when fail.

VIII. Ethical Issue

This project will be deal with wall power. It's our responsibility to make sure our product does not ignore safety to the public. It's consistent with the 1st code of the IEEE code of ethics:

1. to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

The intent of this project is to help the user to save money by reduce energy consumption. To achieve such goal, our system will also need energy to run. It's important to be honest about our system's energy consumption. It's stated in the 3rd code:

3. to be honest and realistic in stating claims or estimates based on available data;

While working on this the project, we will learn about ways of measuring power, wireless communication, and programming MCU. As we apply this knowledge into our project, we are learning their corresponding application and potential consequences as the 5th code:

5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

There were colleagues working on different project in the lab with us. It's for our best interest to keep a good relationship with them. It's also for the best of us to seek help from them or provide support to them which form an efficient and friendly environment for us to work. These are consistent with 7th and 10th code:

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Every project have their limit and tolerance. It's important to state them honestly as the 3rd code said to avoid injury which mention in 9th code:

9. to avoid injuring others, their property, reputation, or employment by false or malicious action;

IX. Reference

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