



Team PICA

Kendrick
Wiersma

Team PICA

Power Information Collection Architecture

Kendrick Wiersma

Calvin College Engineering Department

15 April 2011





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Team Introduction

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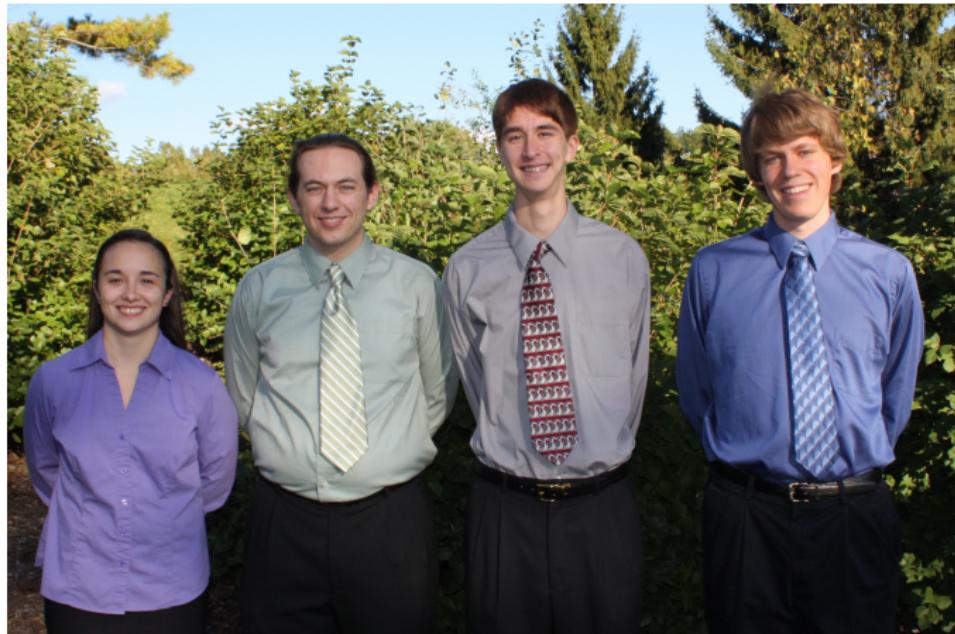


Figure: Amy Ball (EE), Kendrick Wiersma (EE), Nate Jen (EE), Avery Sterk (EE)



Problem Statement and Project Goal

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Problem Statement

Traditional power metering devices provide a consumer with a single measurement over a long period of time. This situation does not allow consumers to actively monitor their own power usage making it more difficult to proactively conserve power.



Problem Statement and Project Goal

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Problem Statement

Traditional power metering devices provide a consumer with a single measurement over a long period of time. This situation does not allow consumers to actively monitor their own power usage making it more difficult to proactively conserve power.

Project Goal

Provide instantaneous information about a consumer's power consumption to both the consumer and the power company in such a way that the data has meaning to each. Thus enabling the consumer to take a more proactive approach to conserving power.



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From this...





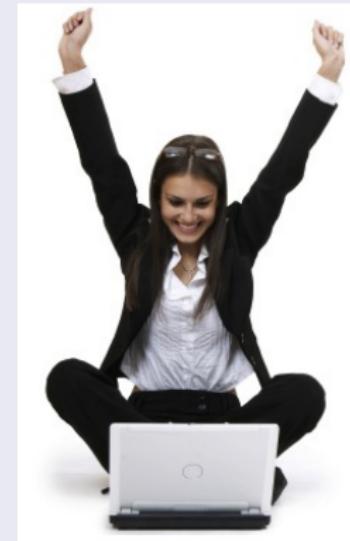
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From this...



To This...





Smart Metering

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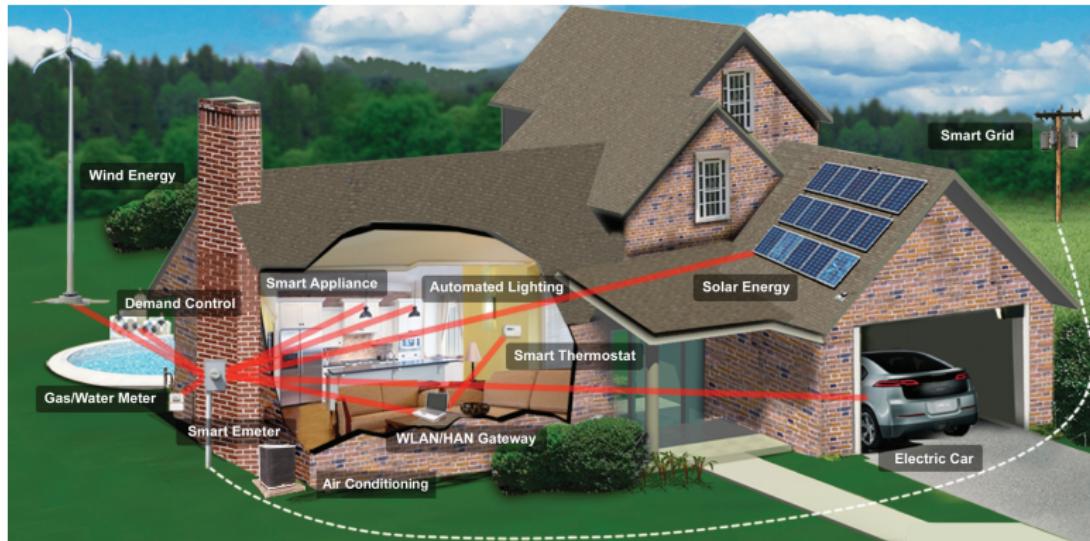


Figure: Smart metering diagram. (Image copyright Texas Instruments.)



AMR vs. AMI

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Automated Meter Reading (AMR)

Provides one-way communication from the meter to the utility company. Removes the need for an employee to visit the meter each month and manually collect readings. AMR systems are not considered smart meters.



AMR vs. AMI

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Advanced Metering Infrastructure (AMI)

Provide two-way communication with the utility company and other nearby meters (such as gas, water, heat, etc.). Allows for collection and distribution of data to and from the customer. Allows the supply system (electric grid) to respond to changes in demand.



AMR vs. AMI

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Our Choice

Team PICA chose to implement an Advanced Metering Infrastructure System.



The PICA System

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The Three PICA Subsystems



The PICA System

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The Three PICA Subsystems



E-Meter



The PICA System

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The Three PICA Subsystems



E-Meter



Base Station



The PICA System

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The Three PICA Subsystems



E-Meter



Base Station



Smart Breakers



E-Meter

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Purpose

- Accumulate kilowatt-hours of energy used



E-Meter

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Wiersma

Purpose

- Accumulate kilowatt-hours of energy used
- Monitor voltage (1-3 phase)



E-Meter

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Wiersma

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- Monitor voltage (1-3 phase)
- Monitor current flow (1-3 phase)



E-Meter

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Purpose

- Accumulate kilowatt-hours of energy used
- Monitor voltage (1-3 phase)
- Monitor current flow (1-3 phase)
- Display data on integrated LCD screen



E-Meter

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Purpose

- Accumulate kilowatt-hours of energy used
- Monitor voltage (1-3 phase)
- Monitor current flow (1-3 phase)
- Display data on integrated LCD screen
- Transmit data to consumer and utility company



E-Meter Hardware

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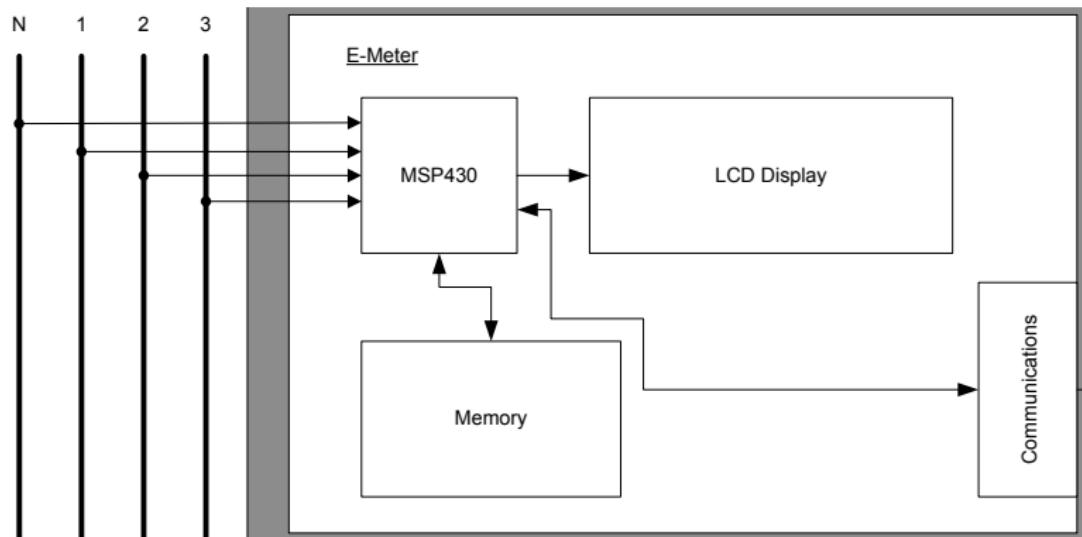


Figure: E-Meter hardware diagram.



E-Meter Hardware

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- Centered on TI MSP430F47197



E-Meter Hardware

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- Centered on TI MSP430F47197
- Uses 3 current transformers, 1 for each phase attached to MSP430 ADC



E-Meter Hardware

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- Uses 3 voltage shunts, 1 for each phase attached to MSP430 ADC



E-Meter Hardware

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- Centered on TI MSP430F47197
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- Uses 3 voltage shunts, 1 for each phase attached to MSP430 ADC
- SynchroSystems 160-segment 4-mux LCD on the MSP430 internal LCD driver



E-Meter Hardware

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- MAX233A RS232 serial driver for serial communications



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- MAX233A RS232 serial driver for serial communications
- Xbee wireless communications device



E-Meter Software

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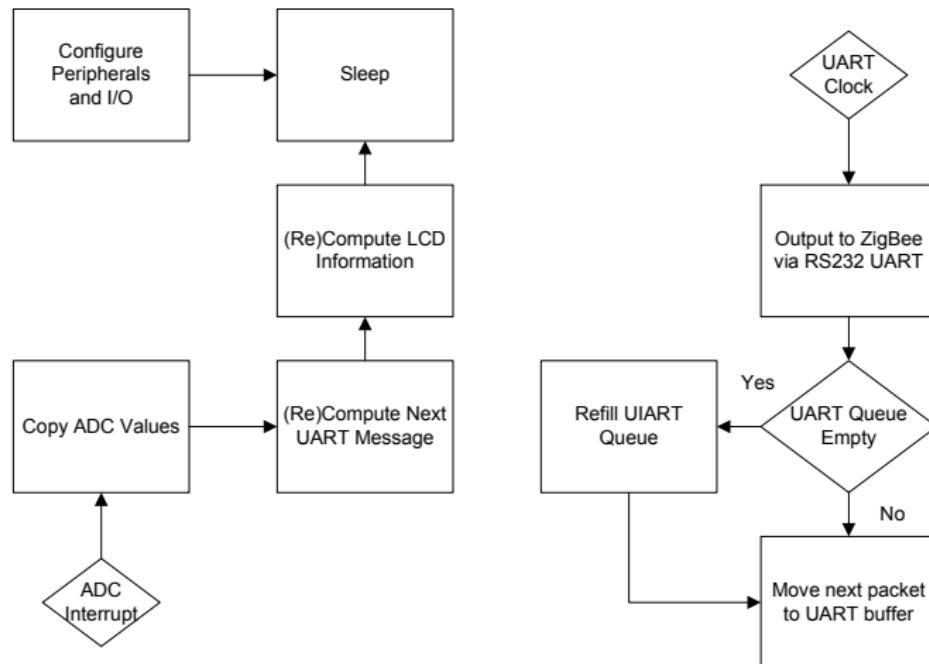


Figure: E-Meter Software Flowchart



Base Station

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Purpose

- Aggregate data from other systems and process for display to user



Base Station

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Purpose

- Aggregate data from other systems and process for display to user
- Host webpage interface to the PICA system



Base Station

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Purpose

- Aggregate data from other systems and process for display to user
- Host webpage interface to the PICA system
- Control Xbee network



Base-Station Hardware

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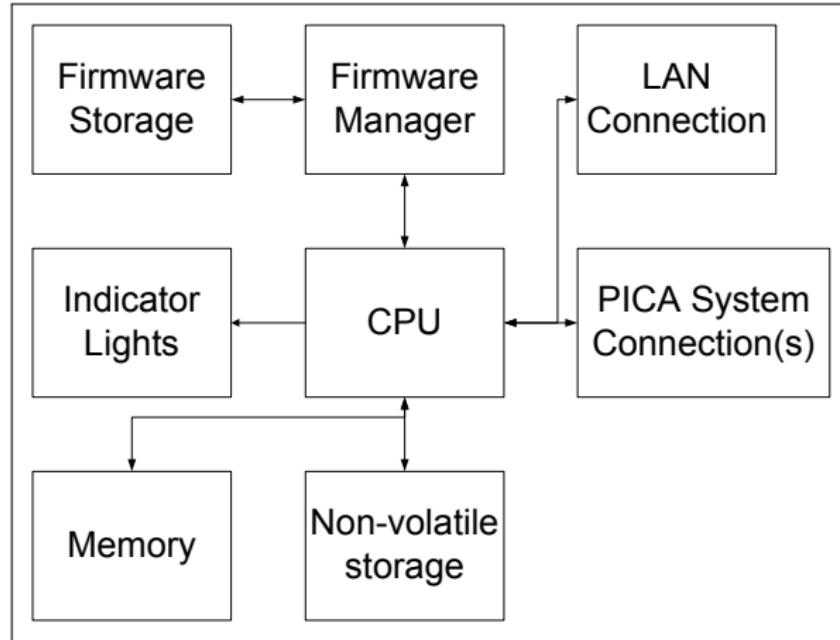


Figure: Base station hardware block diagram.



Base-Station Hardware (continued)

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- Centered on synthesizable LEON3 SPARC V8 from Gaisler Aerospace (GPL)



Base-Station Hardware (continued)

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- Centered on synthesizable LEON3 SPARC V8 from Gaisler Aerospace (GPL)
- Built on Digilent ML-509 Xilinx Virtex 5 development board



Base-Station Hardware (continued)

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- Centered on synthesizable LEON3 SPARC V8 from Gaisler Aerospace (GPL)
- Built on Digilent ML-509 Xilinx Virtex 5 development board
- Serial connection to Xbee collector



Base-Station Software

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- Run a custom compiled Linux kernel based on 2.6.35 (GNU)



Base-Station Software

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- Run a custom compiled Linux kernel based on 2.6.35 (GNU)
- Use Apache as a webserver (Apache License)



Base-Station Software

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- Run a custom compiled Linux kernel based on 2.6.35 (GNU)
- Use Apache as a webserver (Apache License)
- Build a custom app to read data from the serial port, process the incoming data and format it for webpage.



Base-Station Dropped

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Project Component Dropped

Due to time constraints on the design team, a separate hardware base-station has been dropped from the project. As a replacement, the team will design the software to run on a standard x86 Linux PC.



Solid State Breakers

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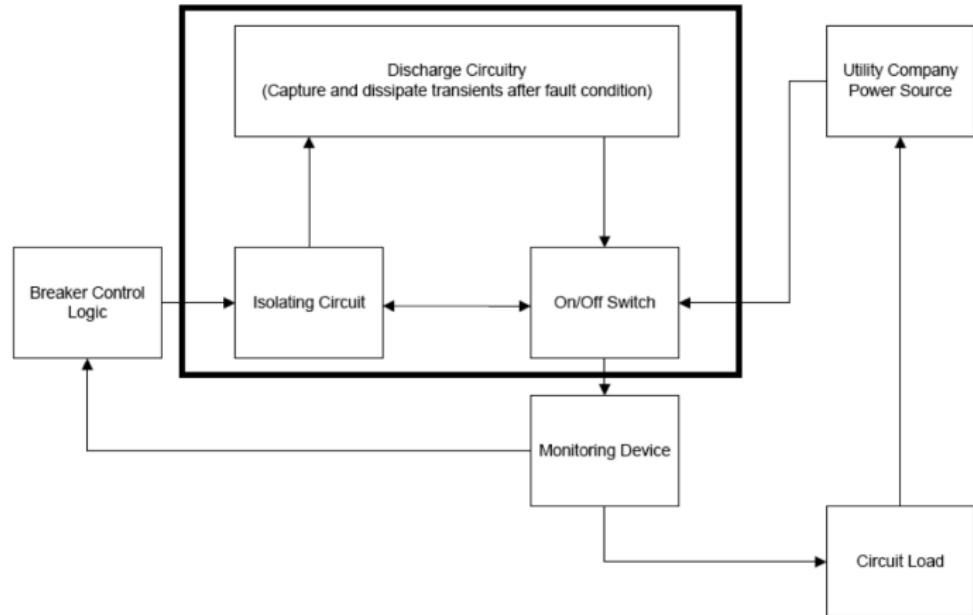


Figure: Block diagram of the smart breakers.



Smart Breakers (Continued)

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Purpose

- Replace a traditional air-gap circuit interruptor with solid-state components



Smart Breakers (Continued)

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Purpose

- Replace a traditional air-gap circuit interruptor with solid-state components
- Monitor current passing through solid-state interruptor



Smart Breakers (Continued)

Team PICA

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Purpose

- Replace a traditional air-gap circuit interruptor with solid-state components
- Monitor current passing through solid-state interruptor
- Automatic detection of over-current situation



Smart Breakers (Continued)

Team PICA

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Purpose

- Replace a traditional air-gap circuit interruptor with solid-state components
- Monitor current passing through solid-state interruptor
- Automatic detection of over-current situation
- Automatic detection of over-voltage situation



Smart Breakers Hardware

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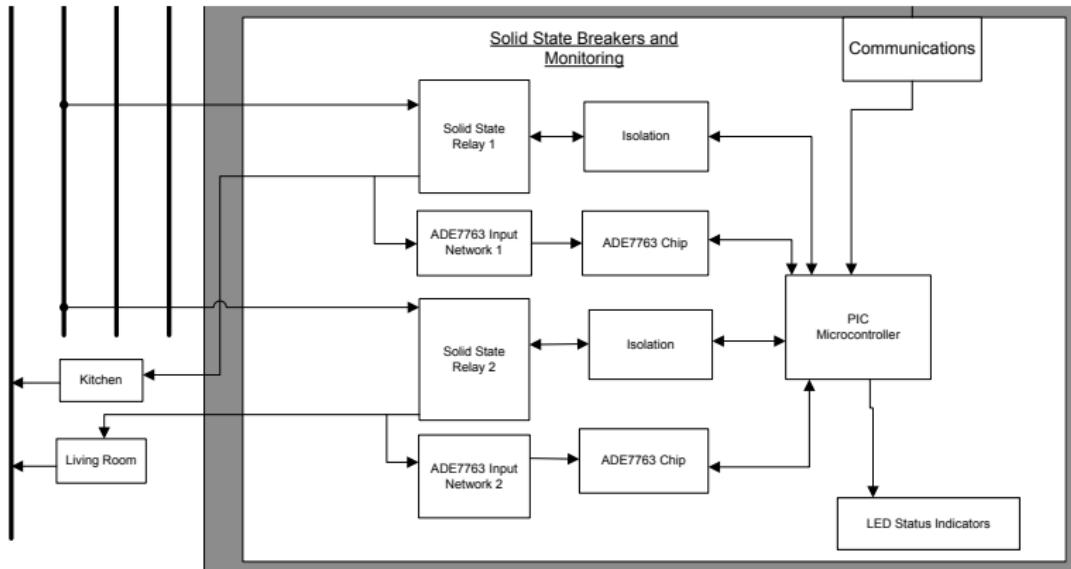


Figure: Smart breakers hardware diagram.



Smart Breakers Software

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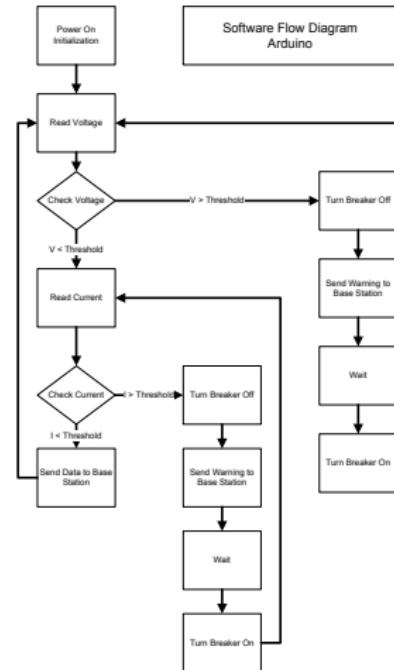


Figure: Arduino software flowchart.



Smart Breakers Software

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Software Design

- Written using Arduino Sketchup IDE



Smart Breakers Software

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Software Design

- Written using Arduino Sketchup IDE
- SPI interface to ADE7763 (SPI Arduino Library)



Smart Breakers Software

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Software Design

- Written using Arduino Sketchup IDE
- SPI interface to ADE7763 (SPI Arduino Library)
- Serial interface to Xbee radio (Xbee Arduino Library)



Power Supply

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Purpose

- Even though the PICA system monitors power it still needs to power itself



Power Supply

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Purpose

- Even though the PICA system monitors power it still needs to power itself
- One generic supply for both subsystems



Power Supply

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Purpose

- Even though the PICA system monitors power it still needs to power itself
- One generic supply for both subsystems
- Switched mode power supply for efficiency



Power Supply Hardware

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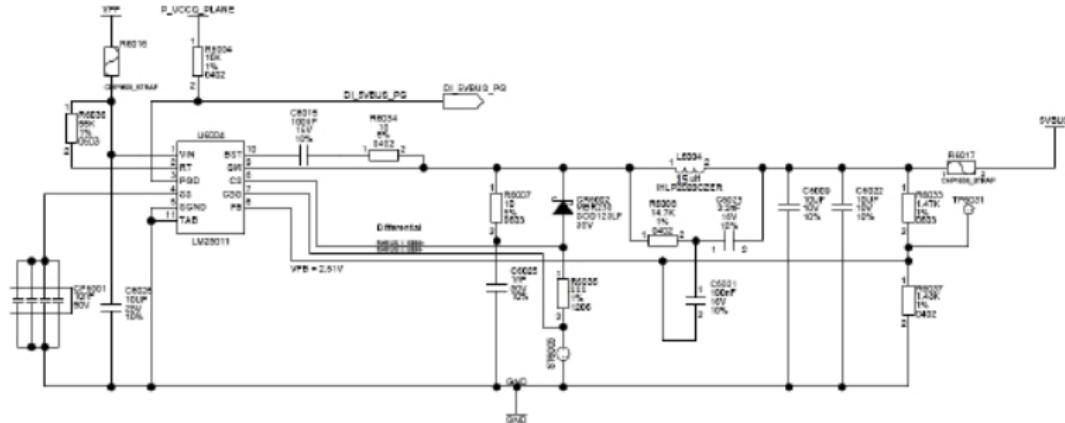


Figure: Schematic for the PICa power supply.



Finances

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Project Finances

- Originally requested \$1000 from the Calvin Engineering Department



Finances

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Project Finances

- Originally requested \$1000 from the Calvin Engineering Department
- Granted \$700 for the project



Finances

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Wiersma

Project Finances

- Originally requested \$1000 from the Calvin Engineering Department
- Granted \$700 for the project
- To date our team has only spent approximately \$250



Questions and Answers

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