Solar-Powered Game Camera Support Systems

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Game cameras provide an automated capability for monitoring wild animals, remote property, etc. Ideally, the camera can operate in all outdoor weather conditions and can operate for many seasons independent of user input. The current market for game cameras is based on simple motion sensors that take photographs whenever triggered. This method leads to a large percentage of images being completely unrelated to what the camera operator wants to photograph. These cameras are powered by batteries that limit operational lifetime and alternative triggering approaches. The problem for this senior capstone project was a solar system design that could power an image recognition system and provide long life. An external company defined the requirements for the image recognition system. The number of subsystems that interconnect to support this expanded functionality is challenging. The subsystems that make up this solar-powered camera system include a charging circuit, a heating circuit, a trigger circuit, a solar array, and batteries, Along with the challenges presented from designing the subsystems, there were a number of lessons learned as a result of the project. Of the lessons learned, the most notable were the challenge of getting parts for a prototype, the level of funding determines the products maximum potential quality, and there is a lack of education on industry practices. After all of the experience from building the subsystems for the camera and dealing with learning a number of lessons along the way, the senior design program allowed the growth of a team as engineers.

A main technical problem of the game camera system was the array of solar panels for recharging the battery. Selecting which panels to use for the array began with calculating how much power our system would require. Calculations showed that the average power draw from the trigger and heating circuitry, combined, was 0.372W. From the wattage requirements, the current draw was calculated based on a 12 volt system. The technical information about 12-volt batteries showed that the battery would require ~14V for optimal charging. Therefore, the solar array needed to provide at least 14V to the battery to allow for recharging. Many different combinations of panels could provide the required voltage and provide different currents. The final selection resulted in six panels, each providing about 200mA. The measured voltage of the panels, while in direct sunlight, was about 2.5V. The panels were connected in series, providing a total measured voltage of approximately 14.5V. Each solar panel measured 6cm x 6cm and weighed 11.49g.

Batteries are the weakest part of rechargeable systems due to their limited lifetime. Along with limited lifetime, batteries do not operate as efficiently in low temperatures and some battery technologies are damaged in low temperatures. The game camera needed a wide operating temperature. To keep the game camera as solid as possible, the team researched a number of battery technologies to find the most appropriate. While searching, the team looked for a battery with enough power for a four-day runtime, the widest possible operational temperature range, the longest calendar lifetime, and the smallest size. First the team had to research different battery technologies and find the strengths and weakness or each. After compiling a list of the battery technologies that will work, the search began to find which battery technology would be the superior option. After looking at Lead Acid, Nickel Cadmium (NiCd), Lithium Polymer (LiPo), and other battery technologies, the team selected Lead Acid as the best battery technology for the application within budget constraints.

To help simplify the final assembly of the component systems onto a single board a number of steps were taken. First all of subsystems were assembled in prototype boards and the functionality of each was tested thoroughly. The heater circuit was powered with an adjustable voltage source to verify it responded to temperature changes. The motion sensor was tested and the output was verified using an oscilloscope. The solar array was taken outside on days that met our testing requirements and metrics about the array performance were recorded. After all of the subsystems were tested independently, each subsystem was paired with another and again tested. Finally the two pairs of subsystems were assembled together and final verification of the assembly commenced. Going through many iterations of component testing helped us to avoid problems later on. If we had run into a problem after an assembly stage we knew that the problem would likely be found in how the systems were connected together.

The lessons we learned from this project were the influence of budget on prototype quality, the extreme cost associated with building one of something, and the gap in knowledge between educational institutions and industries. The motion sensor choices were narrowed down to two sensors with similar power, detection, and size characteristics. However, the sensor with a $15 single-unit cost had an operational temperature range of 0°F-120°F and the sensor with $75 single-unit cost had a range of -30°F – 120°F. Also, the cost for the latter sensor dropped to $10 unit cost if 100,000 were ordered. The selection of batteries also was influence by budget. Commonly available lead acid batteries were used, even though higher performance Lithium Polymer batteries are available. The unit costs were similar, but the Lithium Polymer batteries had to be shipped from overseas which gave a prohibitive cost for a low-volume purchase. A final major lesson was the gap between the classroom and industry. When looking into building the boards for each subsystem, the team realized none of them had any classes teaching them how to layout components on a PCB. The team realized the soldering irons in the lab were not taught in the classroom, they were learned independently. The simulation software in the labs had been introduced but the operation never showcased. A large number of the skills needed to complete the project were not learned in the classroom, they were learned in life.

David C. Macke Jr is a Masters student in Electrical Engineering at Misouri S&T. David is the reorganizing president of the Missouri S&T IEEE AESS Student Chapter and Chief Engineer in the chapter's Autonomous Rescue and Reconnaissance UAV. Along with actively participating in the AESS Student Chapter, David is the IEEE Region 5 Student Representative and is active with the MO Beta chapter of Tau Beta Pi.

Adam Reab graduate in May 2012 with his B.S. in Electrical Engineering from Missouri S&T. The focus of his studies has been in the power field however, he has taken courses in circuitry analysis and electronic design. The electrical engineering curriculum has taught him a great deal about the field and he is currently a member of the electrical and computer engineering honors society, Eta Kappa Nu.

Tyler Allen graduate in May 2012 with his B.S. in Electrical Engineering from Missouri S&T. His main focus is in Power Engineering and has completed a course in Power Systems Design and Analysis. He is currently enrolled in Power Systems Engineering and Electromechanics. Tyler is involved in the MSM Spelunkers and has held the position of President and Vice President of the club. He is also involved in Eta Kappa Nu, an honors society for Electrical Engineers.

Jeffery Keener graduate in May 2012 with his B.S. in Electrical Engineering from Missouri S&T. Jeff is an active member of Phi Kappa Theta Fraternity and the Missouri S&T Lacrosse club team. He served as Vice President of the Fraternity from November 2010 to November 2011, and served as the web master and publications officer of the lacrosse team for the 2011 and 2012 seasons.

DR. Steve E. Watkins is Professor of Electrical and Computer Engineering at Missouri University of Science and Technology, formerly the University of Missouri-Rolla. His interests include educational innovation. He is active in IEEE, SPIE, and ASEE including service as the 2009 Midwest Section Chair. His Ph.D. is from the University of Texas at Austin (1989).

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The Project

Design/Build Subsystems
- •Solar Array
- •Charge Controller
- •Heater Circuit
- •Motion Sensor
- •Battery

Game Camera

Used for observation of various different objects, game cameras are most commonly used by
- •Hunters
- •Ranchers
- •Game Wardens
- •Remote Property Surveillance

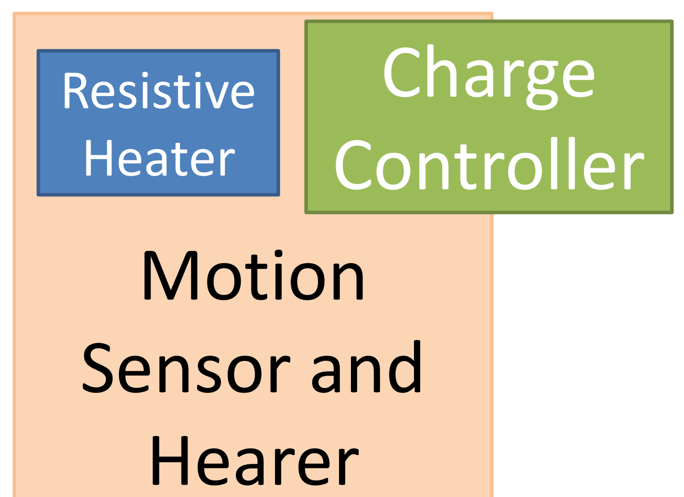
Solar Array

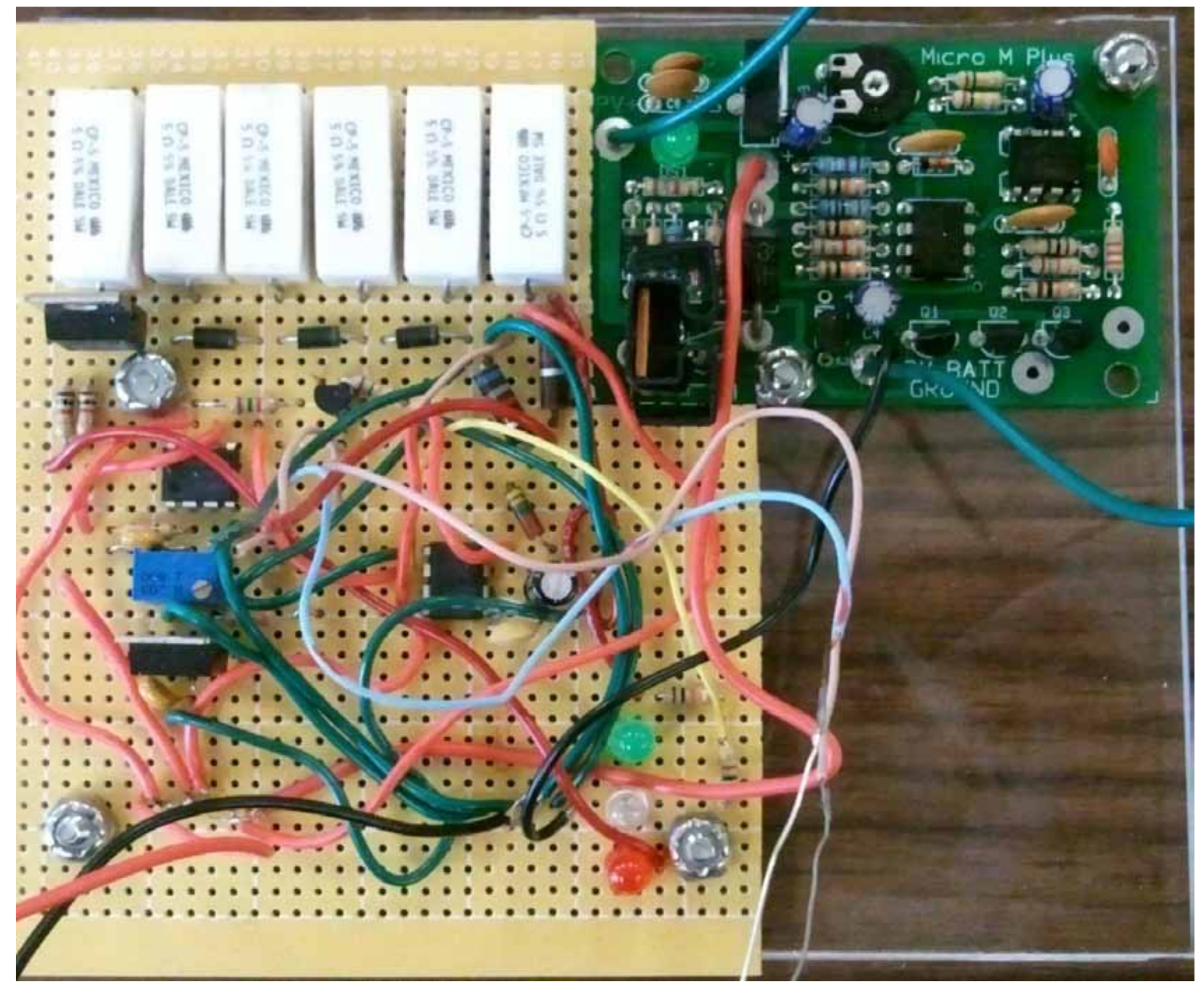
200mA @ 14.5 Volts

18cm x12cm

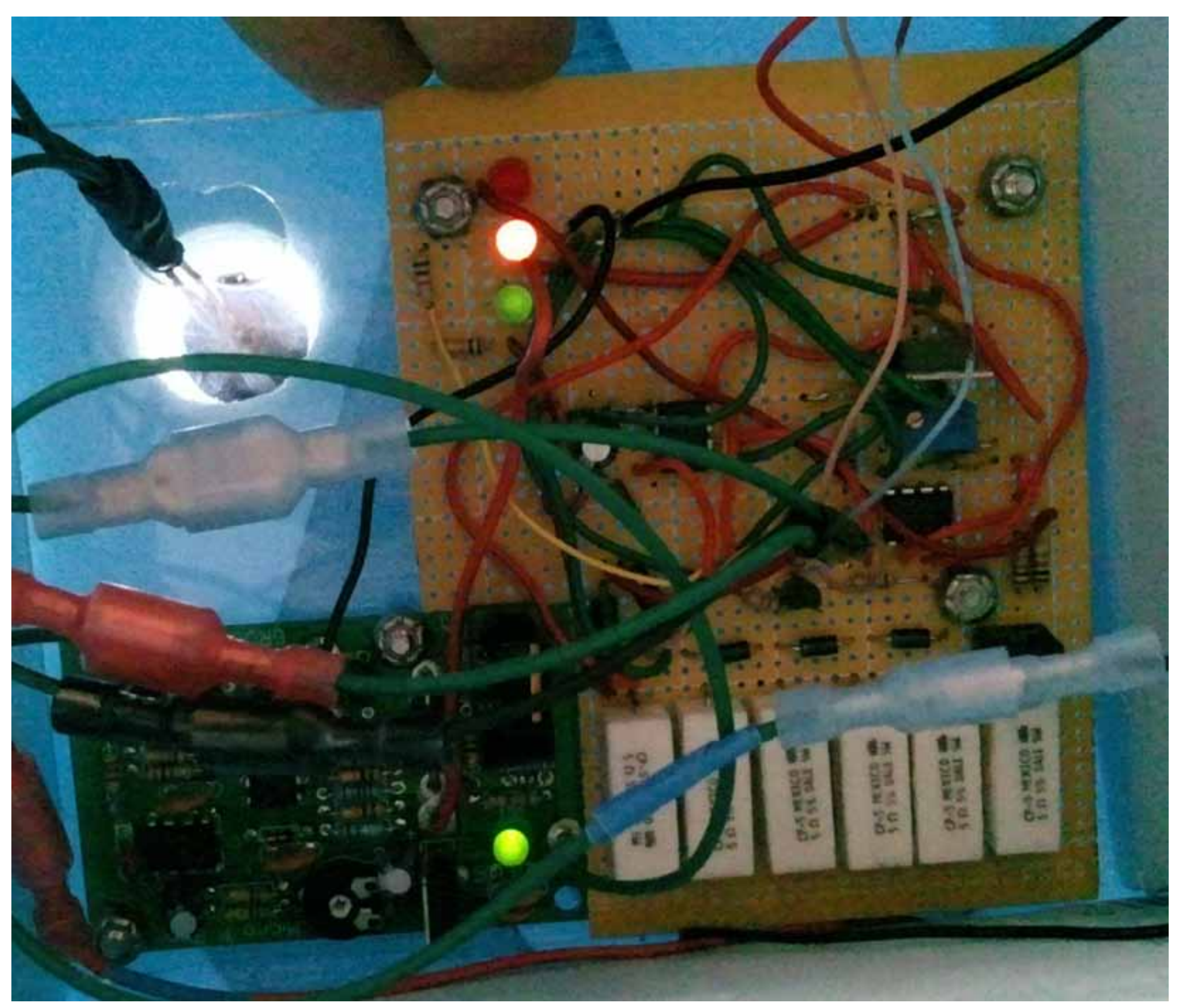
Assembled Subsystems

Systems
- •Heating
- •Charging
- •Motion





Technical Accomplishments



The System:
- • Runtime:
  - 5.5 Days without solar
  - 12 months with solar
- • Operating Temperature:
  - -30°C to +50°C
- •Storage Up to 32Gb
- •Sensor Range: 0.01-12m
- •12 Megapixel Camera
- •14.5 Volt Solar Array

Testing Procedure

1. Prototype Individual Circuits
2. Test Circuits
3. Assemble Circuits on Perf Board
4. Test Circuits
5. Merge two assembled circuits
6. Test functionality of combined circuits
7. Merge the two paired circuits
8. Test functionality of all sub circuits
9. Assemble into camera enclosure

Design Lessons

- •Prototypes can cost >10x production cost
- •A Prototype's maximum quality is determined by funding
- •Gap between Classroom and Industry
- •Component layout software experience
- •Lacking hands on education with circuit assembly
- •Methods of searching for parts suppliers.