Characterizing Asteroid Infrared Emission for HAIV

Design Document
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Project Statement

Our client and his team have been able to generate infrared and visible spectrum images of an asteroid and were able to simulate what images would look like if the asteroid was a great distance away. The parameters for their simulations are all theoretical and they desire to have more real-world parameters. They have also generated comparison images between visible spectrum image of an asteroid versus the infrared spectrum image. The problem is that they do not have any proof of how their simulated images or theoretical parameters compare to real values; we intend to provide this proof of concept and keep it very well documented so that our work can become of later use to them.

System Level Design

System Requirements

Our system includes rotating stage, heat lamp, IR camera, and most important thing is asteroid. The rotating stage is controlled by the user and will show different angle of asteroid for heat lamp to heat it. And we will set the temperature of the heat lamp, otherwise, it will heat the object too much. For the IR camera, it will give us the thermal image that we need.

Functional Decomposition

First of all, we need a power supply which is connected to the rotating stage. This will give us a place to set the asteroid, and then the rotating stage will connect to stepper motor which helps rotating the stage. And we will need wireless transmitter to send data. Another thing that we will need is a heat lamp which is controlled by main system, either turning it on or off.

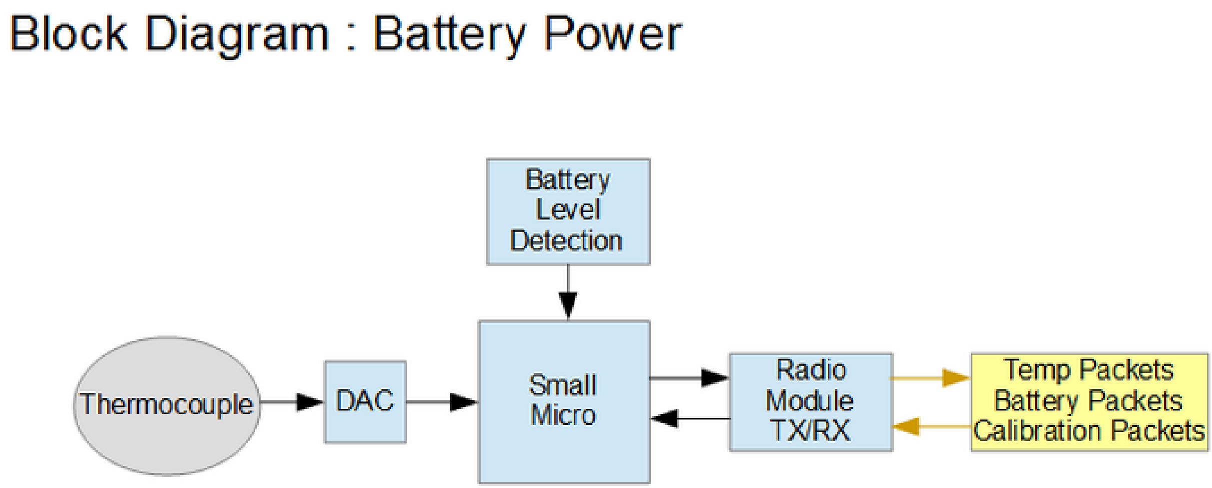
System Analysis

The battery powered subsystem is mainly part of a temperature feedback loop that will be used to control the temperature of the specimen. The thermocouple will be attached to the specimen and shielded with thermal tape to allow for the most accurate reading. The analog to digital converter (ADC) will be in the range of 10-bit to 24-bit. This will give us a higher resolution for high quality readings. The reason why we need a wireless transmitter is because the subsystem will be attached to a rotating stage and we will need to be sending live data readings to the main system so it can keep track of the temperature of the specimen. The easiest way to do this will be to use a low power radio module; this eliminates the need for a brush-contact system.

The main system will be powered with a rectified and regulated AC source. The microprocessor on this board will need to be slightly larger, faster, and more powerful than the small subsystem microprocessor as it will be handling all peripherals of our experiment apparatus. The stepper motor and stepper motor driver combination will give great control over orientation of the object in testing. Another feature the main system will have is control over the heat lamp, either turning it on or turning it off. This will serve two purposes : the first ensuring that the specimen will not be overheated and the second being user control because we may not want it on 100% of the time after we have heated the specimen. The user interface will be another component of the main system and is described later in this document.

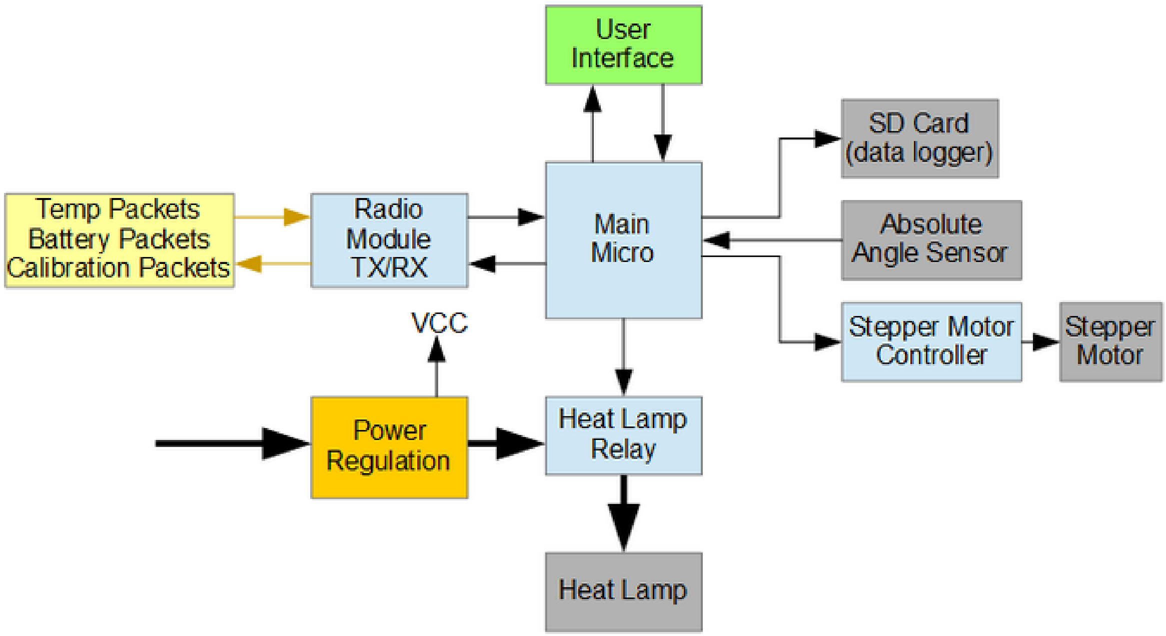
Block Diagrams

This first block diagram is of the battery powered portion of our system.



The second block diagram consists of the main portion of our system

Block Diagram : Main Power



Details Description

I/O Specifications

The I/O of our design will all be transmitted over the bluetooth module to the User Interface. This is a stand-alone piece of hardware and serves only the function to heat an object so that a human controlled camera can take thermal or visible images.

Inputs to the stage will mainly consist of experiment setup parameters and start and stop commands given by the user interface.

Outputs of the device will be to constantly readout the current temperature of the sample. We are in the process of deciding whether a data logging SD card will be necessary for this application. We understand that it wouldn't hurt to implement this, but it may be an expandable feature if it cannot meet our timeline.

Interface Specifications

Our interface will involve using an Android app that can easily communicate with the system via bluetooth. The app will be able to receive data such as temperature, angle of rotating stage, condition of lamp and battery level.

Then it would have the option of saving captured data to a memory card. We will also have the app able to control the temperature level, the angle of stage, turning the lamp on or off, and powering the system up or down. We will be implementing this as an Android app due to the simplicity of doing it on this platform and due to the abundant resources available on the internet.

Hardware & Software Specifications

We are going to use a total of two microcontrollers in this design. The small battery powered micro must be power efficient in order to maintain a decent battery life for this subsystem. We have decided to use an ATMega 328 3.3V core voltage at 8MHz. It can be slower since it only has a couple of operations to perform and does not need to be polled at a very fast rate.
The other microcontroller will need to be faster, and we have not quite decided on what type we will use in the end, but it will be at least 16 MHz to be able to control all peripherals effectively.

Simulations and Modeling

As we are building a largely mechanical device, we will be making use of 3D modeling software to create all parts necessary to build the stage.

Another software that we will employ is National Instruments Multisim and Ultiboard. Multisim is a great schematic capture tool that can forward annotate parts and electrical connections to Ultiboard. Ultiboard is the software where we will spend some time creating small PCBs largely in part for the small battery powered subsystem.

Implementation Challenges

One challenge we will encounter is creating a structurally sound piece of equipment. As we are not mechanical engineers, we will be learning new software and concepts in order to create the case for our system. We are not only creating a case, but a piece of equipment with many moving parts.

Another challenge we may face is the fact that our client has no experience with electrical circuitry at all, and they do not care. We may find out that although we are making progress in the right direction, they may view it differently as they may not understand what we are doing exactly. They may see it as we are working on something, but not producing any results. Once change we are are going to make to our plan is to shift around and update our timeline to accommodate.

Testing Procedures and Specifications

Initial testing will mostly consist of heating various materials that we plan to build the apparatus with to ensure they can withstand the heat. This will be our first test in finding heating limit of our device. The second test will be to find the highest temperature our thermocouple will either withstand or measure. The third test will be to determine the hottest temperature we can heat an object via shining light on it. All of these tests will be taken into consideration when coming up with a heat rating of our apparatus.

A safety test should be performed on the AC switch outlet so that we can make sure that it or the relay switch will not explode when more than 500 Watts is being drawn from the outlet. The last thing anyone needs is a fire in their lab that destroys their sample.

In the end we will test our final product by sending data packets to tell the device to heat an object to maybe around 50 C. We will also use something else besides the expensive meteorite sample. This is to ensure that we do not damage the sample nor will we damage the apparatus since we will not heat to a very high temperature. This will also ensure that nothing will go horribly wrong in case of a bug in the system.

Other Documents

See project plan