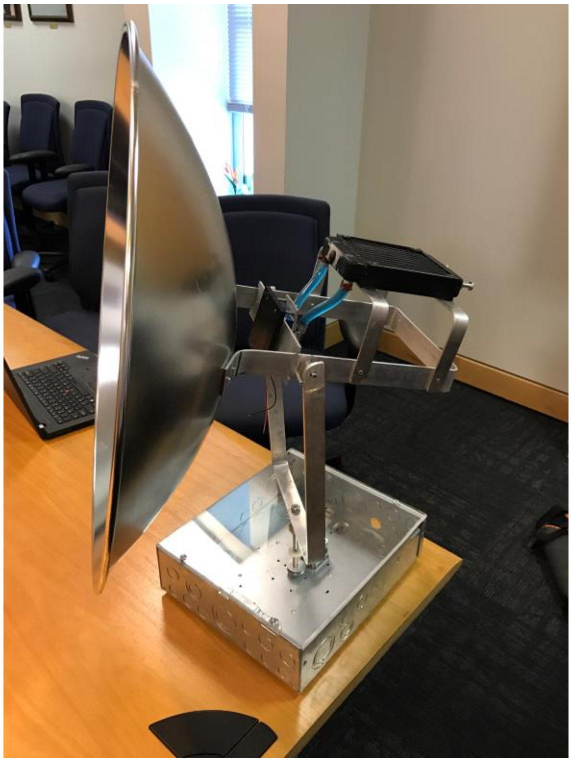
Solar Thermal Generator

Operations Manual 2017



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Introduction

This project is an entrepreneurial-based undertaking sponsored by FAMU-FSU College of Engineering, specifically through Dr. Michael D. Devine. Currently, there is no effective and simple way to generate power in remote locations, such as campsites and national parks. In order to supply power to everyday electronic devices a gas generator is traditionally used. However, due to their tremendous weight, noise factor, and environmental impact, it has become increasingly problematic to use these generators responsibly in isolated locations.

While portable photo-voltaic technology is viewed as the current solution to this dilemma, it is important to recognize that there exist more promising alternatives, specifically in solar-thermal technology. Currently, photo-voltaic cells are only able to harness specific wavelengths within the spectrum of visible light to generate power. Additionally, if the sun is obscured by the geographic location or weather conditions, a photo voltaic cell would be unable to produce any energy. However, thermoelectric generators possess the capability to utilize the heat from the entire spectrum of visible light as well as UVA, UVB, and infrared rays. This allows the process of thermal-electric power generation to continue even while the sun is not in full radiation.

The overall goal for this project is to develop a convenient and portable device that transforms solar thermal energy into usable electricity. In order for the device to be applicable as a charging station, it would be required to generate 20W of electricity. Other features include a convenient assembly and disassembly process as well as a low environmental impact.

The basic idea for this project was conceived for the sole purpose of being able to generate electricity for the myriad of electronic devices used by an average outdoorsman aiming to be environmentally responsible. Currently, there is no effective and simple way to generate power in remote locations, such as campsites and national parks. In order to supply power to everyday electronic devices a gas generator is traditionally used. However, due to their tremendous weight, noise factor, and environmental impact, it has become increasingly problematic to use these generators responsibly in isolated locations. Although photo voltaic cells were initially considered for the design, a more interesting process involving thermoelectric power generation was sought as the more promising solution. The concept transformed further with a trivial amount of experimentation using a small parabolic dish to concentrate the heat provided by the sun to a fixed point. The system should run autonomously at the push of a button to intelligently track the sun that will mechanically align itself and charge electronic devices as well as the provided battery. The finished product is ideally portable and will be used as light and heater applications in a relatively remote location where a power grid is unavailable or unreliable. Ideally, the effective design must be simple to use for your average consumer.

Warnings and Safety Regulations

⚠ WARNING: DEVICE IS OPERATED AT HIGH TEMPERATURES. RISK OF BURNING AND LOSS OF VISION/EYE DAMAGE CAN OCCUR IF OPERATED IMPROPERLY. INORDER TO AVOID PHYSICAL HARM, PLEASE FOLLOW THE FOLLOWING SAFETY GUIDELINES.

Safety Equipment

1. Tinted safety goggles.
2. Heavy duty work gloves or thermal protective gloves
3. Long sleeves and closed toed shoes

Safety Procedure

1. Before handling or operating device, put on tinted protective eyewear and heavy duty work gloves.
2. Do not look directly at the focal point of the dish or directly into reflective surfaces when the dish is in sunlight. Focused rays from the dish and reflectors can cause severe eye damage and may cause temporary or permanent blindness.
3. During setup, operation and general handling, do not allow any exposed skin to make contact with device components. Device is operated at high temperatures and contact can result in severe burns.

Components

The project has the following major components:

- Parabolic Dish
- Dish mount
- Thermal Electric generator
- Heatsink
- Radiator
- Boost Converter
- Arduino
- Stepper motors and servos for dish control
- Battery charger and NiMH battery cells
- Project box and base

  Note: The internal components of the base are depicted in Figure 1

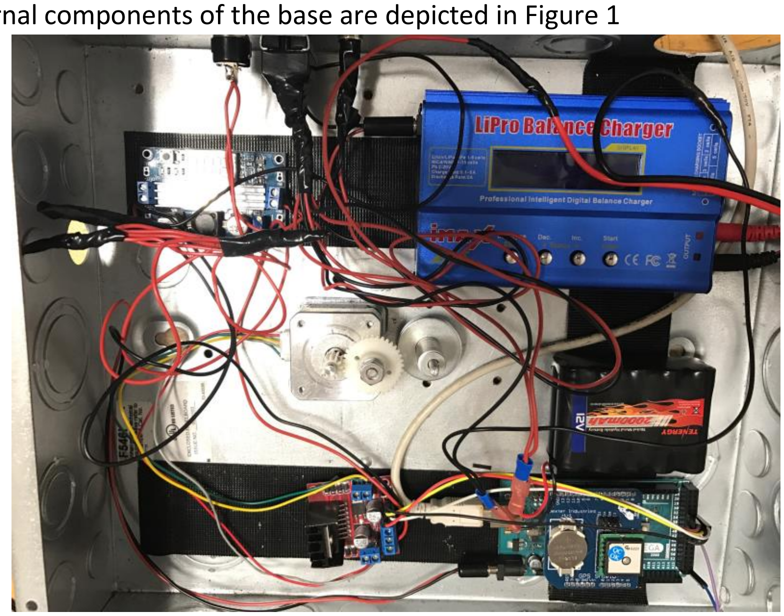

Figure 2

The component most likely to fail is the dish mount. The mount was handmade and if it were to fail it would be beneficial to have a mechanical engineer design a suitable replacement. If another group takes over this project, that may be the first thing we would recommend investing time into.

The TEG has a very specific temperature range that it is effective in. if it overheats on the cool side, it will not produce the energy that is required. If the cooling system fails, it will need to be replaced with new water, new hoses and in the future a fan may be helpful in removing more heat form the chips.

The battery will also need to be replaced if the cells fail. This will be due to normal wear. Nickel Metal Hydride batteries were chosen for this design due to their functionality and range of safe operation.

The rest of the components are relatively reliable and the code will be provided from the Arduino so if that needs to be replaced it can be recoded and implemented. The entire system is meant to be modular so that components can be easily replaced if necessary.

Initial Setup

In order to set up the device the user will have to reset the dish to the starting position (arrows must line up from dish to base) and the dish must be in its fully downright position.

1. Manually point dish if necessary with power off (it should be able to reset with the button on the top but if power is lost at any point, this will not work properly)
2. Point entire device south (do not only turn the dish) using the compass onboard
3. Be sure the switch is off for battery charging
4. Turn the device on to use the battery as the source – the dish should automatically adjust to point towards the sun

Operation

In theory, the operation of the device should be automatic but due to time constraints and many mechanical issues that were involved, the device is not automatic. It requires the user to manually change the power source (battery or TEG) and also requires that the user switch the power supply when appropriate. If the dish only functions from the battery, it will eventually die and never use the energy the TEG is collecting. When the time is appropriate, the device must be switched to use the TEG as the source for electricity. The procedure is as follows:

1. Hold down the hold button
2. Flip the power switch from battery to external
3. According to user preference and energy being collected, the battery charger can now be enabled and charging can begin
   Note: The aforementioned buttons and switches are depicted and described in Figure 2

Figure 2

The power input from the TEG's is located on the far left of the base. The red switch located in the middle of the box is the power supply in which the up position supplies power from the external source while the down position supplies power from the battery source. The switch on the far right of the base is the power supply for the battery charger. The up position of this switch turns the battery charger on while the down position of the switch turns the battery charger off.

It should be noted that the device is set to trickle charge the battery at 1/8C so it will take approximately 5-7 hours to charge the battery depending on how much it must be charged. Also, the battery is not regulated so deep discharge cycles can occur if caution is not taken. When the device is using the battery as the source, the boost converter will attempt to boost the output until the battery voltage drops below ~4V (very deep discharge).

Troubleshooting

Some minor problems that may occur and their solutions are as follows:

- The battery has completely died
  If the battery completely dies, there is a good chance that it will be damaged from deep cycling. To attempt to charge the battery, external supply can be given (through the dish input plug on the device between 5-12V) and the device can be turned on to use external supply (red switch) and the batteries can be charged. If the cells are badly damaged, the battery can be replaced with a suitable replacement.
- The dish is not pointing the correct direction
  Turn the device off (red switch to middle position) and manually reset the dish by lining up the arrows on the base and the dish. Also, be sure the dish is in its fully downright position. External power may need to be supplied if the battery has completely died (See battery died). Repoint the device south. With external power supplied if necessary, turn the device back on to use either the battery or external supply.
- The device has stopped responding
  Try the reset procedure. It is as follows
  1. Try using the reset button, then turn the power button off.
  2. Follow the setup procedure

3. Turn device back on to use battery as source then switch the source as outlined in the Operation section

More advanced problems may occur.

As stated in the components section, the mechanical design is flawed in many ways. If this project is being taken on by future students, a great effort should be invested in redesigning the dish control, gearing, and mount. This project could greatly benefit from the addition of a mechanical engineer.

There is a good chance the single TEG employed will not supply enough power. This may be fixed by adding an additional TEG, using a more polished dish, and/or improving heat dissipation. In order to complete proof of concept procedures, an external supply was used for most of the demonstrations or was used to charge the batteries then the batteries were used for testing procedures. It would be helpful to add additional batteries or as stated use lithium batteries that can be charged more rapidly, last longer, and do not suffer as badly from memory effect.