Solar Powered mobile device charger with remote monitoring and control

Members

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Sponsors

Water Missions International, Progress Energy, Overstreet Foundation

Description

According to the World Health Organization, an estimated 780 million people lack access to safe drinking water in 2010 and that number is rapidly growing[1]. It appears that lack of funding and motivation of getting filtration systems and pumps installed in areas of need is not the problem as to why so many people remain deprived of this essential need; It is estimated that 30% of all hand pumps installed in sub-Saharan Africa over the past two decades have failed prematurely and that water points in some areas such as the Chikwawa and Phalombe districts of Malawi are even less than 50% functional[2].

Water Missions International is a nonprofit engineering ministry providing sustainable safe water solutions to developing countries. Often times, these water treatment systems include solar panels to power the pumps. Water Missions' engineers typically oversize the solar panel array, so that there will be enough power to run the water treatment system under different weather conditions. A few months ago, an operator of one of Water Missions' systems wired a power strip, in parallel with the pump, and plugged in cell phone chargers to start charging cell phones. Surprisingly, his set up worked and his business has been quite successful, charging dozens of phones per day. The charging business is so successful that it is actually is bringing in more income than the water sales.

As a result of the success and the opportunity the additional revenue source has to help the water treatment systems be financially sustainable, our group was contacted by Water Missions International. They are interested in designing a product to make this setup safer, introduce more features to it and consider making it into a product that can be deployed on many of Water Missions' projects.

The information provided by our group will ultimately be used to determine what will be included on the circuit board before it is manufactured and distributed. Since Water Missions International is a nonprofit who must fundraise every dollar that is spent, affordability of these units while meeting the requirements is very important. While looking at the possible solutions, being cost-effective and creative is highly encouraged during the solution creation process.

[1] http://www.who.int/water_sanitation_health/publications/2012/jmp_report/en/index.html
[2] http://blog.watermissions.org/index.php/2012/04/empower-solar-energy-charging-mobile-phones

Goals

1. Design a scalable and modular kiosk system that allows users to charge cellular devices via power systems designed for other primary uses, such as water filtration systems.
2. Design a means by which to monitor and control per port usage, in order to determine system demands (and possibly to support a fee system).
3. Design a means by which to remotely monitor, control, and diagnose the system via cellular connectivity.
4. Design features that support a fee system by which users can pay via cellular devices and an human interface that manages human to kiosk interaction
5. Build a working prototype that meets all specifications.
6. Deliver requested documentation to Water Missions including but not limited to.
    a. Circuit Board Design
    b. Software
    c. Functional Prototype
    d. Material cost breakdown for each part

Specifications and Requirements

- Charge attached devices with a fluctuating supply voltage range of 12-240 VDC.
  Goal: (12-300 VDC)
- There will be 10 USB 2.0 type A sockets for charging at 5 V DC (up to 0.5 A each)
- There will be an additional port where a hub can be plugged into to another 10 USB type A sockets. The hub will have an additional port where another hub can be plugged into, so they are daisy-chained. This hub's circuit board will also be required to be designed and priced as an option.
- There will be 2 cigarette lighter socket ports for 12 V outputs (up to 5 A each).
- There will be some type of resettable fuse to protect too much current from being drawn from each USB and cigarette lighter port
- Each port will have an LED to indicate the status of whether the port is charging or not
- There will be two leads for an external battery (12-24V) that can be attached. This battery will power the unit when solar power is not available but will not allow the mobile devices to be charged through it.
- If power is lost while this unit is operating and the external battery is not attached, when power is available again, the unit will automatically resume its normal functionality (as well has having the correct date and time)

- The cumulative energy (kWh) used in charging the mobile devices' batteries will be logged at a configurable interval with a date and time stamp
- The cumulative energy used and a date time stamp will be sent through an integrated Quadband GSM device (SMS or GPRS, you can help decide) to a configurable cell phone number/domain at a configurable interval (daily, weekly or monthly at noon). Multiple energy and date and time stamps will be sent per message/packet.
- The Quadband GSM device can receive commands through SMS to configure and control the unit. The following commands are required:
    - Command to turn all charging ports on or off
    - Command to send a custom text message (for entering the code to add credit to prepaid SIM card in the unit)
    - There will be a prepaid option of adding energy credit to the unit. This amount of energy credit is added by a SMS command. The unit will be powered on as long as the energy credit is more than the value of the energy sold. Once the unit's credit is used up, then the unit disables charging and sends a SMS notification (up to 4 phone numbers). When more credit is added, then charging is enabled, until the credit is used up again, then charging is disabled.
    - Command to enable an alert to send an SMS to a configurable phone number (up to 4 different phone numbers) when available energy (kWh) credit is below a configurable value. If there are not any phone numbers entered, SMSs are not sent.
    - Command to configure the energy credit difference when a low notification notice is sent
    - Command to query how much energy credit is available on the unit
    - Command to query the cumulative energy used with date time stamp on the unit
    - Command to update the interval (in minutes) how often the cumulative energy used is logged into memory
    - Command to query the date and time
    - Command to update the date and time
    - Command(s) to update where the SMS sends to (up to 4 different phone numbers) or GPRS connects to (APN settings, domain, protocol, etc)
    - Command to update the reporting frequency of cumulative kWh (daily, weekly or monthly)
    - Command to update the unit's ID number
    - Each command will have a success or failure reply message.
    - Each command will need a correct password entered before the command is run. This password will precede the command and be in the same SMS. There

will be a different password for querying data and configuring the unit. Unrecognized SMS will be ignored.
    - Command to update the passwords
    - Command to query all the settings on the unit
- There will be a way to determine and troubleshoot the unit when there are configuration issues and the unit can't connect to the cell phone network
- There will be a ON and OFF switch for the unit
- There will be a LED to show when the unit has power (on when there is power, off when there is not any power)
- There will be a LED to show when charging ports are enabled because there is sufficient energy credit (on when enabled, off when disabled)
- The unit will be operated within the temperature range 0—45°C
- The unit will be stored in within the temperature range -20—60°C

Block Diagrams

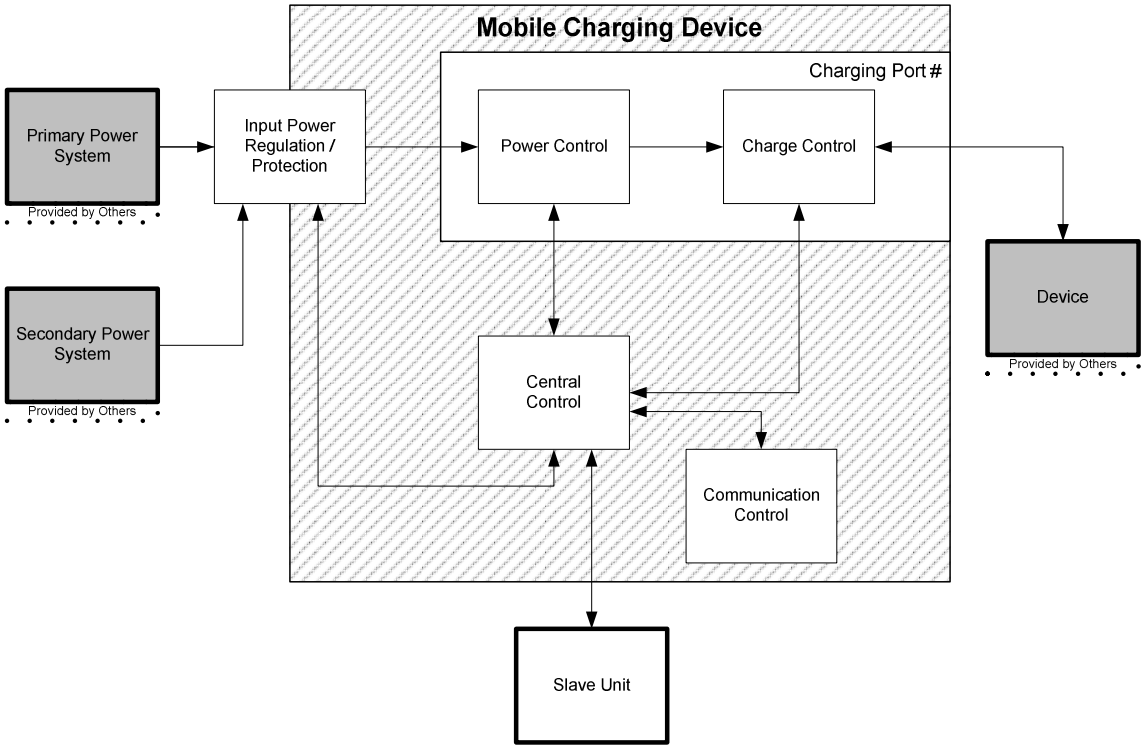

Figure 1: System Block Diagram

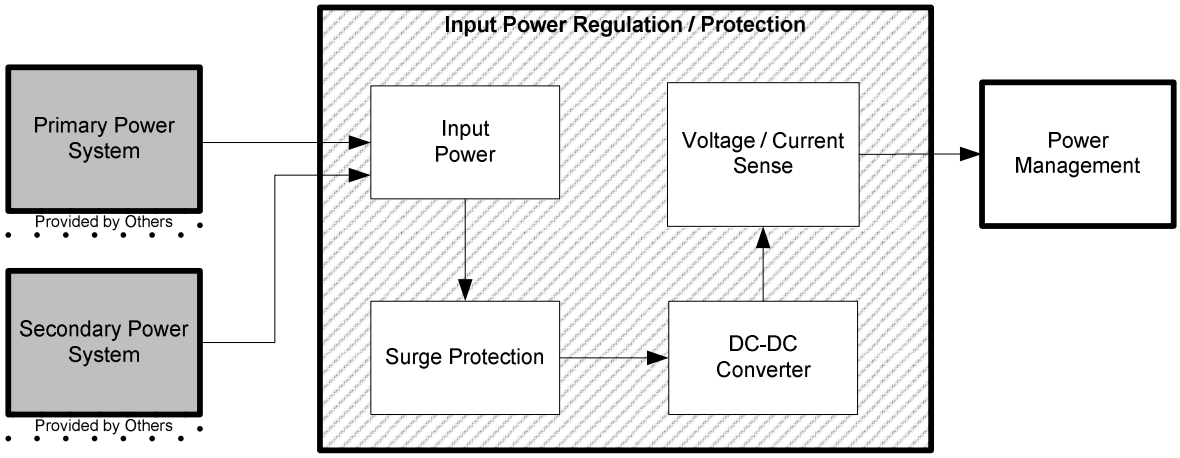

Figure 2: Input Power Regulation / Protection Block Diagram

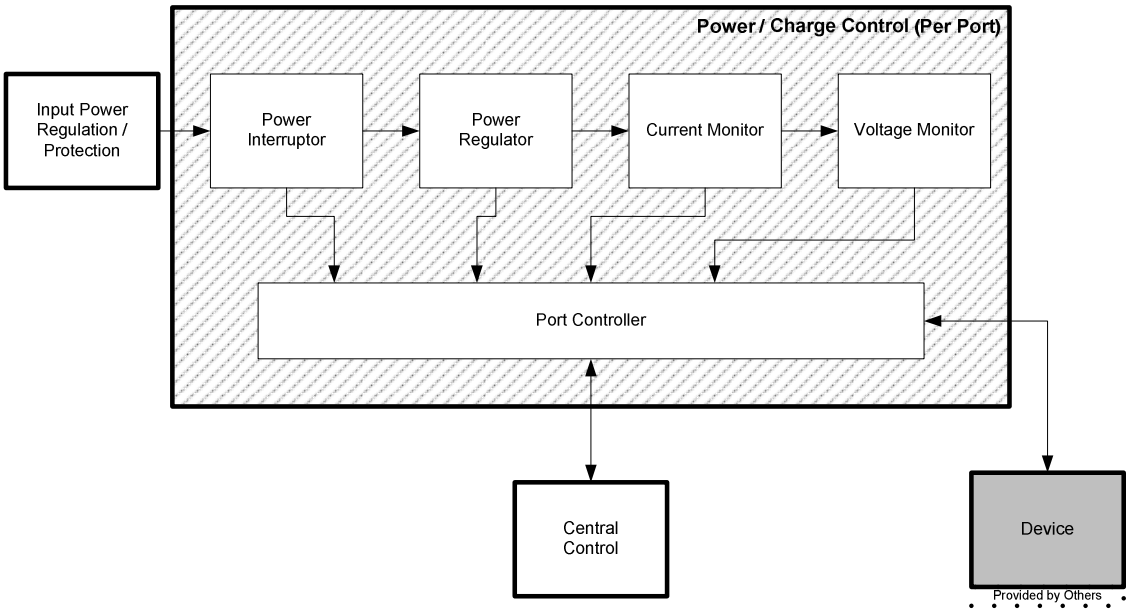

Figure 3: Power / Charge Control Block Diagram

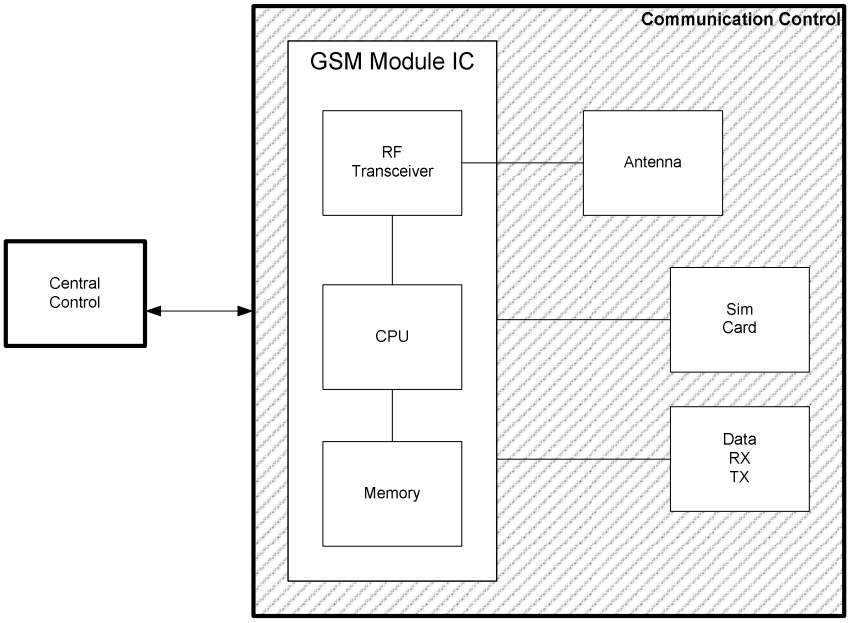

Figure 4: Communication Control Block Diagram

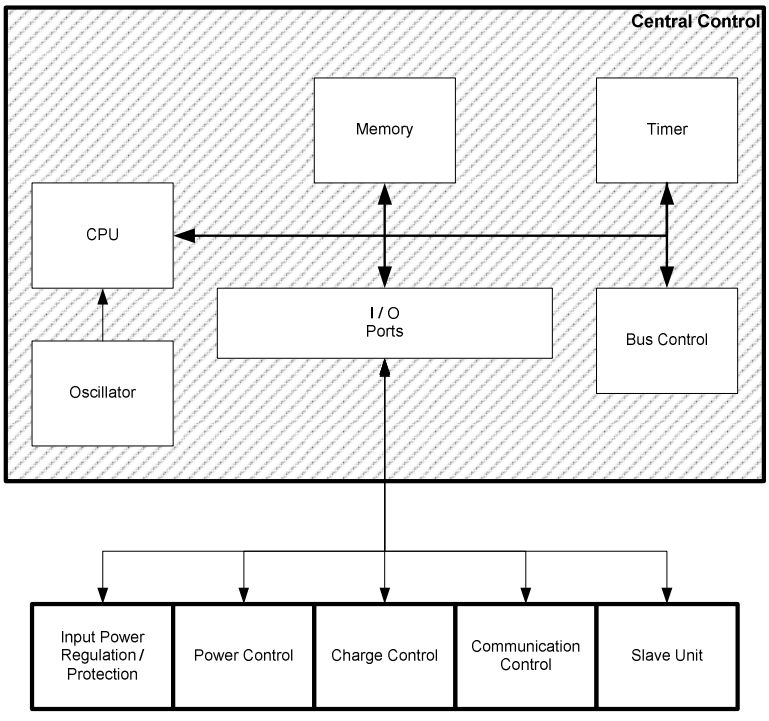

Figure 5: Central Control Block Diagram

Budget & Financing

Mobile Charging Device	
Components	$300.00
PCB	$200.00
Enclosure	$100.00
I / O Parts	$200.00
Test Equipment	$100.00
Misc.	$100.00
Total	$1000.00

It is our intent to seek financing from Progress Energy. Water Missions International is a non-profit organization that has not expressly committed their financial support, but has committed their staff support. In the case that Progress Energy is not able to co-sponsor this project; our team members will provide financing as available.

Milestones

Date	Task
9/10/2012	Turn in Initial Project and Group Identification Document <15 pages, Assign blocks to Team members
9/17/2012	Re-evaluate block diagram from Dr. Richie's input, Research blocks that are assigned to each individual
9/24/2012	Present project to Water Missions clarify restriction ,AC/DC outputs
10/1/2012	Decide on modules we will use from research Split up research among team members
10/8/2012	Continue with research, present any problems with individual findings, provide help where needed
10/15/2012	Decide on how modules will work together and update block diagram , bread boarding , testing
10/22/2012	choose products to use, find resources for these products, set up accounts to purchase them
10/29/2012	Find parts, part numbers, prices
11/5/2012	Update budget and Present to funding organization
11/12/2012	Purchase parts, modules, or any other peripheral parts to be used in project
11/19/2012	Test parts with various techniques including software programming implementation
11/26/2012	Start implementing project plan from block diagram,
12/3/2012	Re-evaluate progress going into Senior Design 2, start building power controls

12/10/2012	design pcb board, set up communications board and start programming it to communicate with other modules
1/7/2013	design slave unit depending on needs , try to keep it as close to the orginal unit as possible
1/14/2013	test power systems to meet our needs and devise plan to correct any problems
1/21/2013	start putting units together and begin testing phase
1/28/2013	Testing Phase, device plan to fix problems as they arrise
2/25/2013	Final Testing, completion of compliance matrix
3/4/2013	Product Testing with Water Missions International engineers
3/18/2013	Present Project to UCF evaluation team