Solar-Powered Traffic Light

ECE 445 - Team 20

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Roles

Bowen Xiao (EE)
  ● Circuit/PCB design

Richard Przybek (CompE)
  ● Firmware design and development

Colin Tarkowski (EE)
  ● Circuit/PCB design and simulation
Problems

- High energy consumption and costs
- Light pollution due to bright LEDs
- Dangerous encounters between bicyclists and drivers
Objectives

- Automatically switch between solar and grid power based on available sunlight
  - Cannot operate solely on solar power, but will drastically reduce the utilization of grid power

- When the ambient light is sufficiently low, the LEDs will be dimmed via pulse-width modulation (PWM)
  - Will reduce light pollution at night, in addition to the grid power consumption
  - In adverse weather conditions, lights will not be dimmed to ensure proper visibility

- Cyclists will cross the road at the same time as pedestrians, so we have two walk/bike buttons
Project Images

- Traffic light enclosure
- Sensors/MCU box
- Power and light control systems
Control Subsystem
Control Flow

- Photoresistor polling in delay states for switching solar/grid
- Button interrupts escape green light delay
Programmed traffic light
Power Subsystem
Challenges

- Wrong PCB footprints
  - Coupled inductor
  - MOSFET
- Unconnected ground pad

SEPIC controller package [1]

Debugging SEPIC
Results

- Use electronic load to adjust current draw and power supply to adjust input voltage

Testing SEPIC converter with 2 A output current
Results

- SEPIC converter output voltage is between the specified range of 22.8 V and 25.2 V
Results

- 5 V buck converter output voltage is between the specified range of 4.75 V and 5.25 V
Challenges

- LT1161 quad protected high-side MOSFET driver
  - Four timer pins should have been left disconnected based on the desired operation
    - During the design process, we connected a 1 uF capacitor to each of these pins
  - Four sense pins are included and are supposed to be connected to the supply voltage (grid) based on the desired operation
    - Two were connected to the grid and two were connected to solar power, which resulted in faulty switching behavior
Results

- Output voltage (yellow) does not dip when input voltage sources are switched from grid (green) to solar (blue)

Switching network test - 24 V output (yellow), gate of grid control (green), and gate of solar control (blue)
Design - Switching Network

Switching network demonstration
Sensing Subsystem
Challenges - Infrared Sensor

- Difficult to sense distances over 250 cm (8.2 ft) accurately
- Works best from 10-250 cm
IR sensor demonstration
Challenges - Power Monitor

- Power monitor was not found on I2C bus
  - Debug: I2C scanner, oscilloscope, remove optoisolators, hex inverter
  - Possible causes: Overheat, slow optoisolator slew rate, inverted SDAO line

- Workaround: use photoresistor to switch power sources
Results

- Photoresistor is able to differentiate between different light intensities
- Power monitor does not work
  - Use photoresistor instead
- Humidity sensor is able to detect differences in humidity from 0% to 100%
- Button interrupts change state after a delay
Traffic Light Subsystem
Challenges

- Lights were not turning on
  - Floating high side N-channel MOSFETs
  - Lower resistor values for isolation
    - $10 \, \text{k}\Omega \rightarrow 150 \, \Omega$
Results

- Light board works as expected
  - Lights visible from 150 ft
  - Able to dim lights
  - No flickering
Successes

● All objectives were met

● Grid power utilization
  ○ 16.9 W at 100% PWM
  ○ 10.7 W at 20% PWM

● Solar power utilization
  ○ 8.09 W at 100% PWM

● Assuming 12 hours sunlight, 12 hours darkness, and ideal conditions
  ○ Our traffic light uses 0.385 kWh grid power per day
  ○ Average traffic light uses 1.08 kWh grid power per day [4]
Lessons Learned

- Be more careful picking ICs and sensors
- Test ICs/sensors before creating PCBs for them

What we would have done differently

- Different power monitor, one without inverted SDAO
- Find more accurate IR sensor

Recommendations for further work

- Waterproof enclosure/electronics
- Make full scale system with 4 traffic lights


Thank You

Any questions?