Tennessee
TECH

Automatic Generator Battery Backup Controller

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Capstone 2

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Introduction/Objective

- Objective: To design an automatic generator battery backup controller that is less expensive than the current devices on the market.
- There's a need for cheap automatic generator controllers so that people who depend on solar power and/or don’t have access to the power grid don’t have to buy a $100 ~ $400 device or manually start their generator every time it’s needed.
- The generator should be turned on when solar panels aren’t producing sufficient energy to power a person’s home.
- Components of the project include an Arduino Uno, 5 VDC and 120 VAC relays, a DC to DC regulator, a voltage divider, Arduino compatible screw shield and LCD keypad shield (for improved user interface), mounting equipment, and some wiring.

Generator

- For the generator, three connectors are present: the connector for the coil, the connector for the starter, and the connector for the internal battery of the generator (12 VDC).

- The starter button and the on/off switch work simultaneously to start the generator. If the generator fails to start the first time, attempt to start it a second and third time.

- Once started, the generator can be used to charge the external backup battery when its voltage falls below a certain voltage value.

Arduino

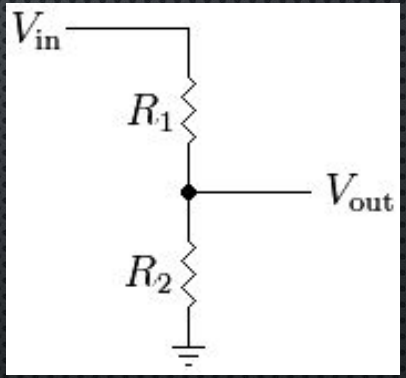
- The Arduino Uno microcontroller acts as the controller/brains for the whole BBC system.
- A screw shield mounts on top of an Arduino, and allows the user to access all of the pins through screw terminals.
- An LCD screen mounts on top of the screw shield, displays control options, and provides an external keypad with several buttons, including a system reset.
- It is important to use a proper power adapter (9 VDC ~ 14 VDC) for the Arduino to avoid damage to it and/or connected components.

DC to DC Regulators

- A DC to DC regulator is a power electronics device that accepts a DC input voltage and then provides a constant DC output voltage.
- This component can take an input voltage range from 12 VDC ~ 24 VDC.
- It converts the battery voltage to a constant 5 VDC to supply power to the 5 VDC relays.
- DC to DC regulators output a constant voltage that does not vary based on input voltage.

Voltage Dividers

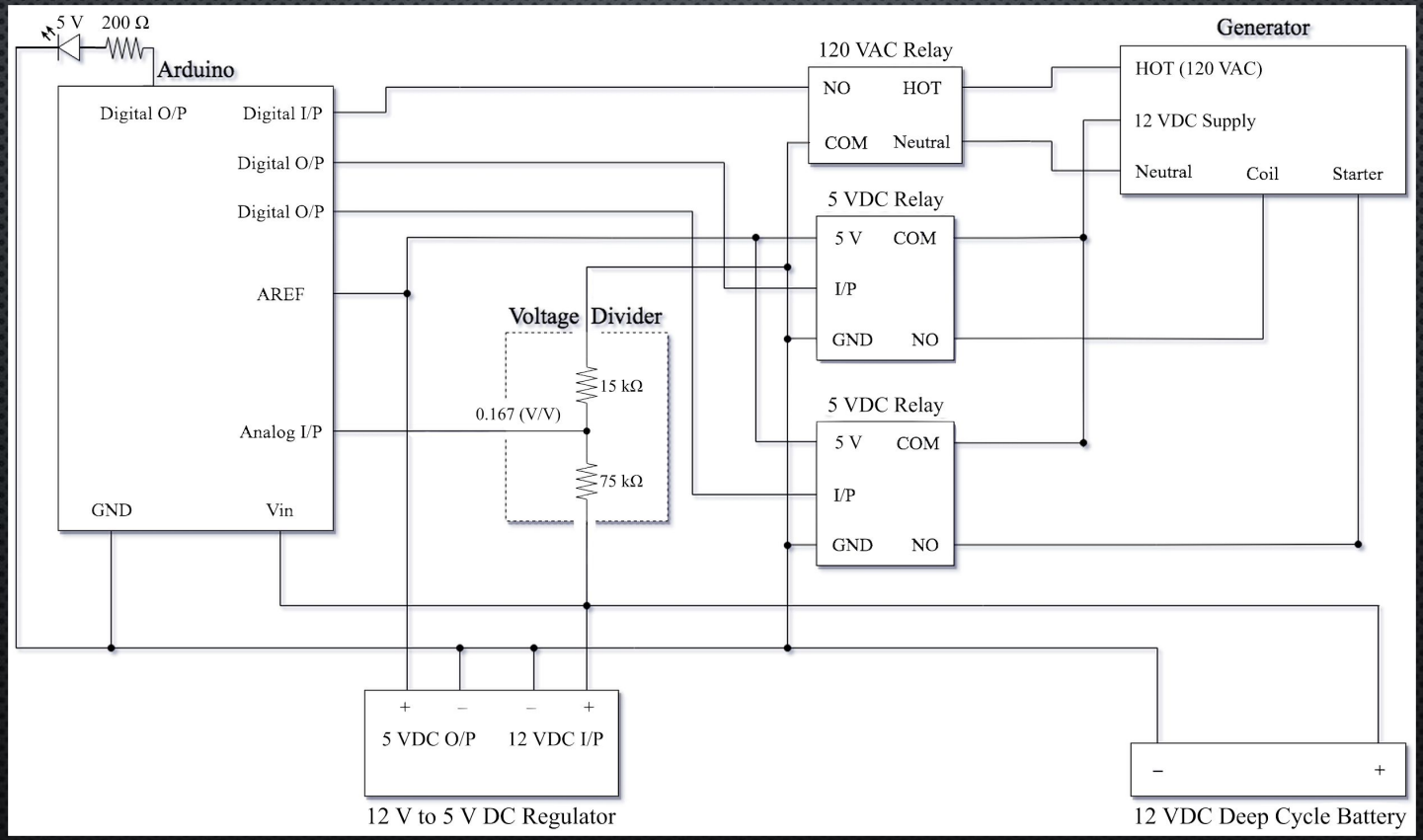
- The output of a voltage divider varies with the input.
- Because the Arduino cannot read more than 5 VDC, a voltage divider was used to lower the external battery voltage to an appropriate level.
- A voltage divider can be made with two resistors. For this project, the resistor values were 75 kΩ and 15 kΩ. The scaled output is as follows: Vout = Vin • 0.167 V/V.
- Voltage dividers output a linearly scaled voltage based on the input.



Relays

- Relays are switches that open or close depending on an input signal. The input signal must be “strong enough” to activate the relay.
- Current through a coil creates an electromagnetic force, pulling an armature down to close the internal circuit.
- A 120 VAC relay was used to read the status of the generator (powered on or off).
- Two 5 VDC relays were used to control the starter and coil of the generator.

Application Overview

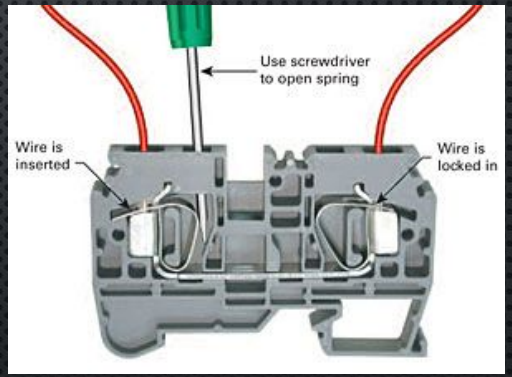


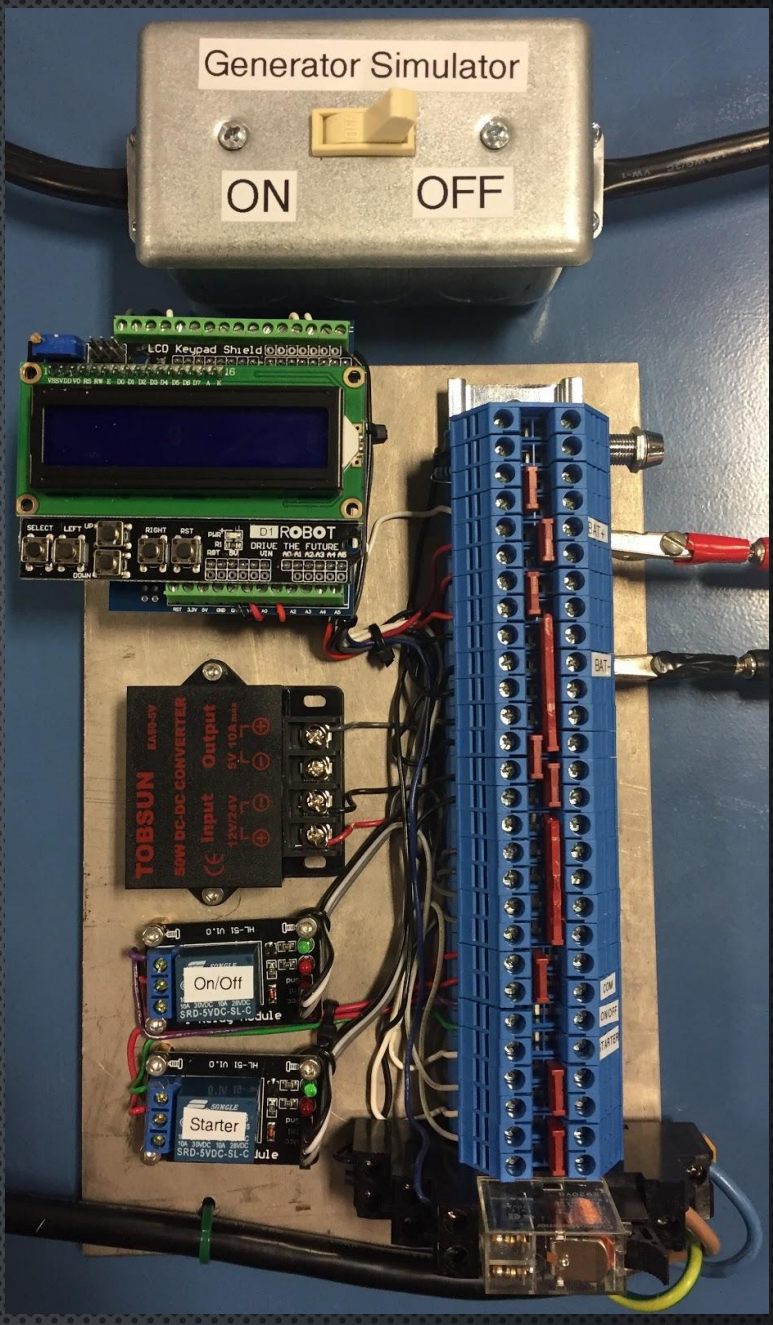
Hardware Design

- For this project, a modular hardware design was implemented.
- The circuit is not enclosed, so the parts can be easily accessed.
- The BBC system can be easily repaired and maintained by replacing individual parts when necessary.

Hardware Construction

- The components were mounted by first drilling holes in a metal plate. We then used nuts, bolts, and standoffs to solidify the placement of the components.
- All electrical connections were made through the terminals, including wires, resistors, and an LED.
- A Tektronix PS283 power supply was used to simulate the external battery.
- A switch connected to a 120 VAC outlet was used to simulate the generator powered on and off.




Generator Simulator
ON
OFF
LCD Keypad Shield
SELECT
LEFT
UP
DOWN
RIGHT
RST
ROBOT
DRIVE THE FUTURE
TOBSUN
50W DC-DC CONVERTER
Input
12V/24V
Output
5V 10A
On/Off
SRD-5VDC-SL-C
Starter
SRD-5VDC-SL-C
BAT+
BAT-
COM
ON/OFF
STARTER

Software Program

The majority of the source code is contained within 4 main functions:

- read_volts(); Monitors the live external battery voltage and displays it on the LCD. Automation status is available to be enabled or disabled while running and is also displayed on LCD. Based the on the battery's voltage level, certain actions are taken to power on or off the generator, using the starter and coil. Monitors LCD keypad for menu changes.

- disp_params(); Allows the user to set the system parameters for BBC system. Will get and put system parameters from and into non-volatile Electronically Erasable Programmable Read Only Memory (EEPROM).

- starter_failure(); Stops the program after 3 failed starter attempts, displays an error to the user, and turns on the red LED.

- check_for_inactivity(); Turns off the LCD screen after 10 seconds of user inactivity.

Software Implementation

- System parameters: Minimum voltage threshold, maximum voltage threshold, starter duration, and between-starter delay time with floor and ceiling values. Provides user configuration/optimization. Persistent through power outages, system resets, and menu changes.
- The program starts with displaying the live voltage reading of the external battery. When the external battery drops below the minimum voltage threshold, the BBC system attempts to power on the generator.
- From the main menu, use “UP” & “DOWN” to toggle the system automation status. Use “LEFT” & “RIGHT” to enter the system parameters menu.
- Use “SELECT” to exit the system parameter menu and to enable the LCD when it’s inactive.
- Accounting for inactivity will save power, keep the LCD from burning out, and prohibit accidental system manipulation.

Prototype vs. Optimized Consumer Cost

- Prototype Cost: $494.36000
  - Assuming all components and testing equipment must be purchased.
- Optimized Consumer Cost: $62.96149
  - Assuming buying components in bulk and not using testing equipment.
- Actual Prototype Cost was free of charge; all components and testing equipment were provided by TTU, the ECE department, and Dr. Baswell.

Category	Component	Quantity	Prototype	Consumer
Microcontroller	Arduino Uno	1 / 1	4.42000	4.42000
	Screw Shield	1 / 1	3.50000	3.50000
	LCD Display	1 / 1	4.11000	3.49000
Regulator	DC to DC Regulator	1 / 1	9.99000	9.99000
Relay	5 VDC Relay	2 / 2	2.14000	2.14000
	120 VAC Relay	1 / 1	15.70000	9.79000
Terminal	DK4N Terminal Blocks	100 / 28	41.21000	11.54000
Mounting	DIN Rail (*1.0m*)	1 / 1	7.86000	1.31150
	5 VDC Relay Board	2 / 2	2.89000	2.89000
	120 VAC Relay Socket	1 / 1	10.48000	6.11000
	Metal Base Plate	1 / 1	variable	variable
	Screws and Bolts	as needed	variable	variable
Power	Tektronix PS283	1 / 1	350.00000	N/A
	120 VAC 60Hz Socket	1 / 1	0.00000	N/A
Connectivity	Test Leads	2 / 2	12.18000	N/A
	Alligator Clips	2 / 2	1.04000	N/A
	75 kΩ ± 5% Resistor	1 / 1	0.10000	0.00784
	15 kΩ ± 5% Resistor	1 / 1	0.10000	0.00904
	200 Ω ± 1% Resistor	1 / 1	0.20000	0.02831
	Jumper Connections	100 / 26	27.98000	7.27480
	Copper Wiring	as needed	variable	variable
Miscellaneous	Red LED (*optional*)	1 / 1	0.46000	0.46000
	120 VAC 60Hz Switch	1 / 1	variable	N/A
Total ($USD)			494.36000	62.96149

Conclusion

- The objective of the project was to design an automatic generator battery backup controller that is less expensive than the current devices on the market.
- The objective was achieved and the project was a success in terms of cost, hardware construction, and software implementation.
- Our product can help those who depend on solar power, especially those in developing nations.
- Since our design is modular, it can be easily repaired and modified.
- The BBC system eliminates the need to manually start and stop a generator, making it possible to never lose power for an individual’s home even when they aren’t present.

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