Ground Resistance Monitor

Alltec

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In collaboration with:
WCU Corp. for Entrepreneurship and Innovation

Western Carolina University

PROBLEM STATEMENT

- Grounding is an important process that provides a path for fault current to protect people and equipment
- Ground systems are done currently by being checked by a technician that periodically visits the site.
- Develop a device that would measure ground resistance with moderate accuracy.
- The created device would remain on location and provide data remotely and on site. Allowing for time and labor and costs to be potentially reduced.
  - Less travel time and costs
  - Less delay in system malfunction alert time. Potentially preventing a disaster caused by ground system malfunction.

Feature	Requirement	Notes
Battery Life	One year	Comparable to smoke alarms
Connectivity	Primary-wired Relays Secondary-wireless	Wired relays are compatible with off the shelf SCADA systems
Wireless technology	Primary-cellular Secondary-Wi-fi	Cellular is preferred as some sites will not have Wi-Fi
Measurement technique	Non-contact	Allows for isolation of the device from ground transients
Measured resistance range	2-25 Ω	Range sited by grounding standards
Measurement accuracy	±20%	
Maximum wire gauge	00 AWG	Common residential/commercial gauge
Enviromental tolerance-ingress	IP66	Resistant to dust and spray
Enviromental tolerance - temperature	-40 to 50°C	Common outdoor ranges

FINAL DESIGN, APPROACH, PLAN

- The design was divided into two sections that were worked on in parallel.
- The analog section consists of the battery and attendant power management circuitry, the transmission coil and current control circuitry, and the receiving coil and analog-to-digital converter.
- The digital section contains the logic, display, and communication circuitry. It hosts the microcontroller that manages the monitor's functions and the display and wireless systems that communicate results to the user.
- The two sections will send and receive data to each other to create the monitor.

Analog

- The transmitter consists of a split ferrite ring with loops around both halves closing around the ground wire; forming a many-to-one turns-ratio transformer.
- The transmission signal is a known EMF delivered by the transformer. The EMF generates a current that can only vary with the resistance of the ground loop.
- EMF is derived from stored magnetic energy. Closed loop control of inductor current needed for consistency.
- High speed nature of received signal pulse requires external sample and hold circuitry to allow Arduino ADC time to read.

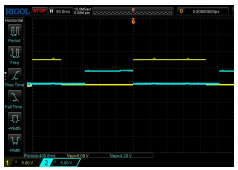
Digital

- Using the Arduino Uno microcontroller, the signal sent from the analog side will be read and through code converted to display current value.
- Current will be deduced by measuring the induced voltage with a known resistance to. In lab testing, the Arduino was done by laptop generated code with a signal sent from the same source. The signal was sent using an ADALM 2000 M2K signal generator and oscilloscope.
- In testing the voltage detector, a sine wave signal was sent from the signal generator monitored on the oscilloscope. The voltage meter then displayed this value in RMS voltage on an LCD 1602 monitor.

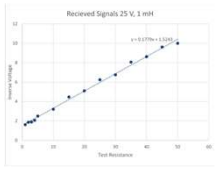
RESULTS

Analog

- Coil pair design has been tested on the bench to the point where the mechanism of action has been proven. The design has proven its ability to generate a linear response to the resistance present on the line using benchtop equipment to control it.
- Driver circuit has failed to produce results. Fragility in design lead to numerous component failures. Final demonstrator drives +9 V rail through transmit coil for preset time from Arduino.
- External sample and hold circuit has performed flawlessly. Peaks of fast transients are held at output over second time-scales. Output clears quickly on application of reset signal.



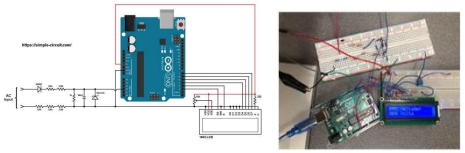
Testing of the sampling circuit



Results of the coil test

Digital

A circuit has been constructed to receive an ac signal. In our product, this will be with the signal sent by the transformer. It will then be used to calculate the current on a line based on the induced voltage measurement. The circuit was tested using the ADALM 2000 as a signal generator.



Schematic and photograph of digital receive circuit with Arduino

SUMMARY AND CONCLUSIONS

- The team made considerable progress in creating individual sections of a ground monitor system. This consisted of many various circuit and code designs.
- The individual sections appear to function alone. Difficulties arose in combining the sections after development and testing to create a cohesive monitor prototype.
- Complications also occurred in circuit design in the steps of transferring circuits as they did not function as they did initially.

FUTURE WORK

- Revisit circuit functionality and wiring to create original operation.
- Further design needed in incorporating the digital and analog aspects into one device.
- Create smaller printed circuit board of combined analog and digital circuit
- Conduct real world testing of prototype with weatherproof exterior.

TEAM & ACKNOWLEDGEMENTS

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References

"Measure Any AC Current with ACS712." Projecthub.arduino.cc, https://projecthub.arduino.cc/SurtrTech/8357625a-305f-41b9-b427-171569f0effc.

Projects, Simple. "Measure AC Voltage with Arduino - AC Voltmeter." SIMPLE PROJECTS, 16 Nov. 2019, https://simple-circuit.com/measure-ac-voltage-arduino-ac-voltmeter/