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Measuring Voltage and Wire Continuity

PROJECT PLAN V1

Contents

1 Introduction

1.1 Project statement

Our project is trying to make analyzing a 3 phase voltage system more convenient. Our device will mounted in a cabinet and connected the wires of a three phase system. It will then display to the user whether there is any voltage in the system and if any of the wires are broken. This is convenient because it removes the necessity for people to check the voltage values of a system with a multimeter, which cumbersome as it requires multiple measurements. Additionally, our device will be able to report if any of the wires are broken, regardless of whether the power is turned on. This is very helpful for people who want a lightweight and non intrusive way to monitor the wires in their system.

1.2 purpose

Currently technicians measure three phase voltage using some sort of multimeter. This is a perfectly functional way to do it, but it isn't very convenient because it requires the technician to hold the probes manually and take multiple readings. Additionally, there isn't any clear way to detect broken wires in a three phase system without running some kind of power through the system or using a device like ours.

1.3 Goals

1. Develop a concept solution during the fall semester.
2. Design and test a prototype device during the spring semester.

2 Deliverables

The only expected deliverable for this project is a working prototype with adequate documentation on how it works and how to use it.

1. Develop a device that can measure the voltage in a 3-phase system.
2. The device would be permanently mounted in an electrical cabinet.
3. The device would be able to determine that the wires connected to the test are not broken.
4. The device would report the presence or absence of voltage.
5. The device would be able to provide indication locally as well as communicate via Ethernet/IP.

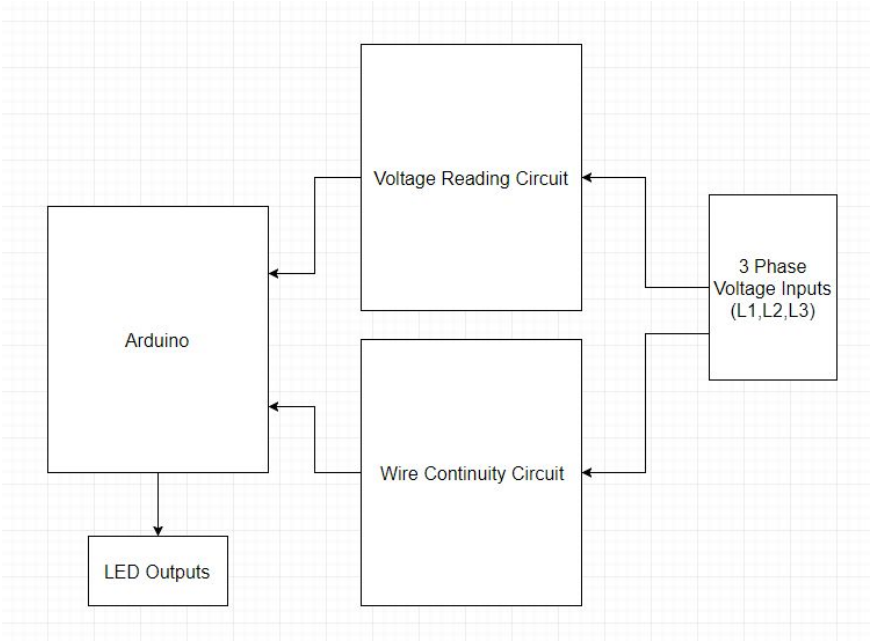
3 Design

Describe any possible methods and/or solutions for approaching the project at hand. You may want to include diagrams such as flowcharts to, block diagrams, or other types to visualize these concepts.

3.1 Previous work/literature

We were provided a patent for a similar produce developed by another another company. That company used some proprietary methods to measure the voltages which involved oscillators measuring signal frequencies which corresponded to the wire voltages. We also looked online for some guidance on reading voltages using Arduino and found some relevant documents (1). It gave us a lot of good ideas on how to accomplish this task, such as using a diode bridge, smoothing capacitor, and voltage divider. However, there is still more research to be done as we can't rely on having a ground reference while we measure the voltage.

3.2 Proposed System Block diagram



Above is an extremely basic system block diagram of our device. It will take in inputs from the three phase system and wire them to two circuits, one for reading voltage and one for measuring wire continuity. The voltage reading circuit will isolate the arduino from the high voltages using capacitor voltage dividers and possibly a zener diode. It will then convert the phase to phase AC waveform into a positive voltage that the arduino can read. The wire continuity solution will also need to isolate the Arduino from high voltage, but the details of that are still tentative.

3.3 Assessment of Proposed methods

There are several methods which could be used to measure 3 phase voltage, we have decided to use an arduino because it is easy to work with, does not take a lot of power, is small and lightweight, and it can do what we need it to do. An alternative we could have used instead of an arduino is a raspberry pi, but for this system we would need to convert our analog signal to a digital signal and we do not need to do that for an arduino. The Arduino can measure 0-5V DC through its analog input, so we will need to make sure that it is isolated from the high voltages of the 3 phase system. To accomplish this, we plan to use capacitor voltage dividers and zener diodes. We will have several capacitor voltage dividers with different conversion ratios that step down the AC voltage before it is converted to DC. The arduino will control a switch that will determine which capacitor divider to use based on the reading it receives from each divider starting with the largest conversion ratio. If no voltage is detected, the arduino will switch to a divider with a smaller ratio. We will use zener diodes to insure that the voltage connected to the arduino is no greater than 5V. The voltage could be greater than 5V if our device is turned on before it is connected to the 3 phase system (all capacitor voltage dividers would read no/low voltage so the arduino would switch to a very small ratio in an attempt to find the correct one). Using a zener diode will prevent any such high voltage spikes from damaging the arduino.

3.4 Validation

Validation for our project will happen in multiple steps. First, we will create detailed circuit mockups with matlab simulink and test to ensure that our design basically meets the requirements. Then, we will use lab equipment at ISU to simulate a three phase system at lower voltages and test our prototype. Finally, we will travel to Grace Engineered products in Davenport and use their testing rig to ensure that our device works on a real system. If they choose to pursue developing our product after the design project, they will need to validate it so that it meets UL standards for this kind of a product.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

- **Product will be permanently mounted in an electrical cabinet**
- **Product must report the presence or absence of voltage down to a 3V minimum**
- **Product must display results locally as well as communicate via Ethernet/IP**

4.2 NON-FUNCTIONAL

- **Legal: product design must not infringe on existing copyrights of similar products that are owned by other companies**
- **Accuracy/Reliability: product must be consistently accurate in measurements to avoid misleading technicians**
- **Security: certain documentation that contains sensitive data about our clients must not be available to everyone (not on our group website)**

4.3 STANDARDS

We haven't really started work in labs or with writing code, but we will plan to use IEEE standards in our development.

5 Challenges

A challenge we have faced when designing our solution for measuring voltage is isolating the microcontroller from high voltages. We will use a series of capacitor voltage dividers to step down the voltage to levels that are safe for our microcontroller. The capacitors will step down the AC voltage before it is converted to DC. The 3 phase system being measured is 3-600V while the Arduino can only measure 0-5V DC through its analog input. The arduino will control a switch to use different voltage dividers with different ratios. We will also use zener diodes to ensure that the voltage connected to the microcontroller does not exceed 5V. The zener diodes will prevent high voltage exposure when the device is turned on before it is connected to the 3 phase system.

6 Timeline

Time Line

Phase	Task Step	Task Description	Team Member(s) Assigned	Status	Start Date	Duration (days)	Must End Date
Define-Measure	1	Measure the voltage in a 3-phase system (up to 600V)	All		8/28/17		TBD
	2	Create a conceptual solution for the device to be able to determine that the wires connected to the test points are not broken	All		8/28/17		TBD
	3	Create a conceptual solution for the device to be able to report the presence or absence of voltage as well as the health of the wires	All		8/28/17		TBD
	4	Provide e indication locally as well as communicate via Ethernet/IP	All		8/28/17		TBD
	5						
Report	6	**Final Design Presentation**		**Planned**			
	7	Design Expo					
	8	Final Presentation					
	9	Final Report					
	10	Project Closeout					

6.1 First Semester

During the first semester, we will research our product and develop a plan for implementation that fits our client's requirements. For specific deliverables and approximate due dates, see the timeline above.

6.2 Second Semester

During the second semester, we will develop prototypes and a working product based on the research and plans that we made during the first semester. For specific deliverables and approximate due dates, see the timeline above.

7 Conclusions

Our project is to create a device to measure a 3-phase voltage and test the wires to see if they are damaged or broken. Our current plan is to use an Arduino to take the 3 voltage inputs, do some calculations to come up with the 3-phase voltage, and output that voltage onto a display similarly to how a multimeter will do it for a single phase circuit. Our goal is to create a design for our project in the first semester, and then second semester create a device using the design that covers our deliverables.

8 References

1. **http://www.instructables.com/id/To-build-a-voltage-regulator-and-measure-AC-voltag/**

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here. (Currently Empty)