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Measuring Voltage and Wire Continuity

PROJECT PLAN V3

Contents

1 Introduction

1.1 Project statement

Our project is to develop a device that can detect the presence of a voltage up to 600V AC and DC and determine wire continuity in a 3-phase system. Our device will display to the user whether there is a voltage between 3V and 600V present in each of the wires in the three phase system. This is beneficial because it removes the necessity for users to manually check the voltage values of a system with a multimeter, which would require multiple measurements. Our device will also state if any of the wires are broken (if the power is turned off). Users will be able to determine when components need to be repaired without having to access the three phase system themselves, increasing convenience and safety. Our device should be a unique design that does not infringe on designs that other companies have developed. This will allow our clients to use our product as they please without having to deal with the complications that come with working with other company's products.

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.

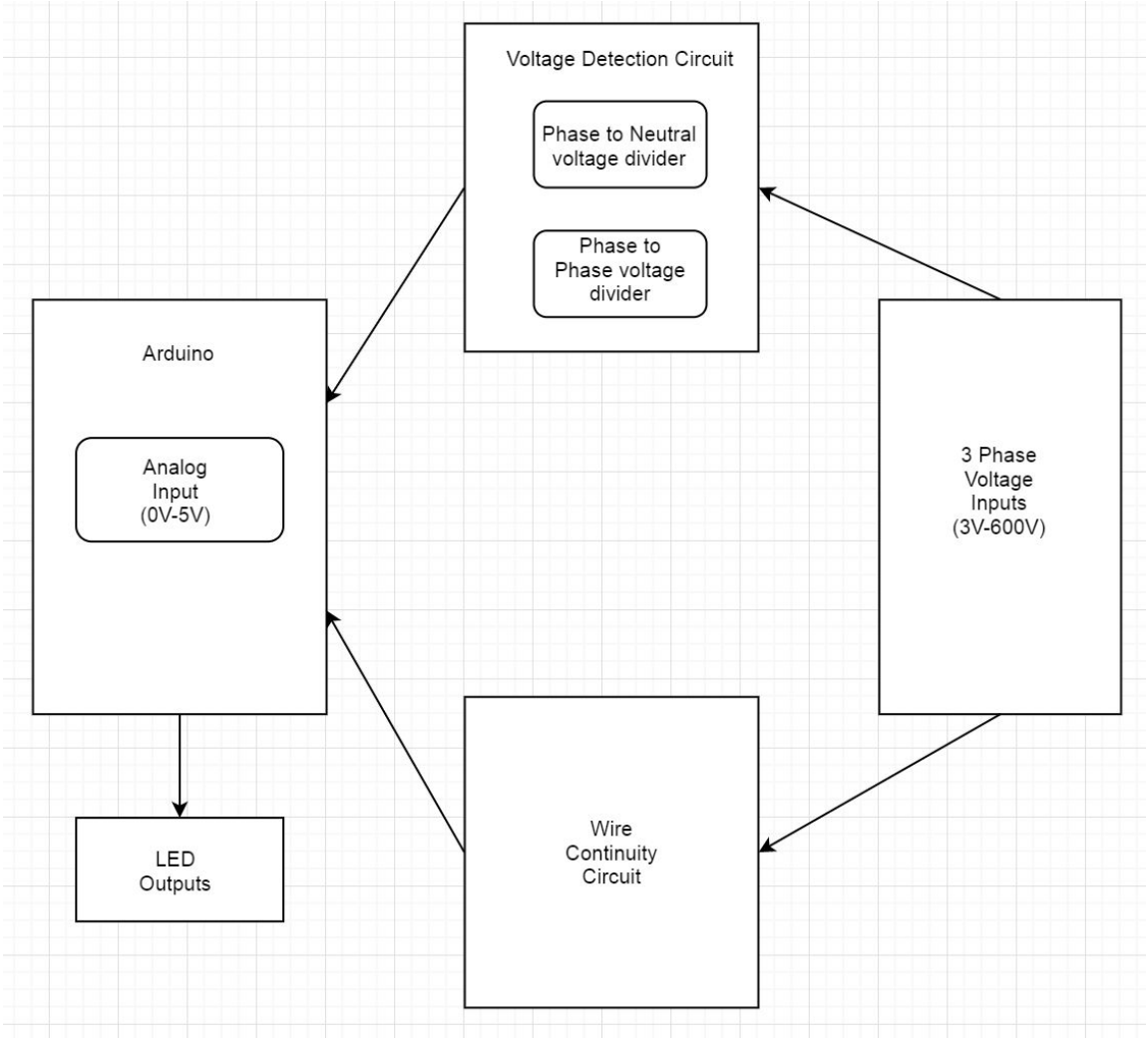
1. Develop a device that can measure the voltage in a 3-phase system.
2. The device would be permanently mounted in an electrical cabinet.
3. The device would be able to determine that the wires connected to the test are not broken.
4. The device would report the presence or absence of voltage.
5. The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

3 Design

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 the voltage detection circuit. the wire continuity circuit will

take inputs from the arduino, detect a reflection of that input and send the reflection back to the arduino. 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, which would be 0V-5V through the analog input pin. 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 devices 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, and is small. 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 while the arduino has the capability built in. There are also other microprocessors like the arduino, such as the TI Launchpad, but we decided on the arduino due to its large amount of libraries and online help.

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. We have created two circuits to measure this, and they are described in detail in section 2 of the design document.

To measure wire continuity we will send a signal through a directional coupler which will be used to measure the reflection of the signal. The reflection should be different for an open circuit (fails wire continuity test) and a closed circuit (passes wire continuity test).

3.4 Validation

To validate our project we will simulate our project parts individually using programs like pspice and simulink. Next, we will build our project using lab equipment at ISU to simulate a three phase system at lower voltages and test our prototype. Validation will be complete when Grace Engineering can view our test results and is satisfied with the prototype.

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 be able to test for wire continuity
- 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 will use IEEE standards in our development. We review IEEE standard documents as part of

5 Challenges

The biggest challenges we have had for measuring voltage are keeping the power dissipated in our circuits to the required amount and measuring phase to phase voltage. Power has been an issue for us because the voltages are very high, but there aren't many good ways to avoid using big resistors. We are allowed to have up to 5V of power dissipated in our circuits, so we can keep resistors in the range of hundreds of kiloohms, but we still needed to select an op amp with high input impedance to reduce the chance that circuit impedance could affect output. Additionally, measuring phase to phase has been a challenge. For strictly AC voltages, we have created the circuit that uses transformers to induce a proportional waveform relative to the ground on the device. However, it is much trickier to measure the phase to phase DC voltage while still keeping the device isolated from potentially damaging voltages. We are still investigating how we will measure phase to phase DC voltage.

The biggest challenge for testing wire continuity has been finding a way to measure a reflection. We finally found a method using a directional coupler that we can send a signal through to the power line. The signal will not be coupled but the reflection will be. The coupled signal will be sent to the arduino which will analyse the signal and determine if the wire continuity test passes or fails.

6 Timeline

Timeline - Suspense	Action	Status	Progress	Tasked to
4 Jan	Send schedule for next semester to Grace and Nathan to set up meetings	on time	not started	everybody
1/12/18	Try to get directional coupler and start running tests to see different systems reflections	on time	not started	wire continuity
Jan- Feb	Decide on final voltage reading circuit	on time	not started	voltage
Feb - March	Build and prototype voltage readuing circuits with arduino	on time	not started	voltage
Feb - March	Start testing coupler with arduino	on time	not started	wire continuity
March - April	Finish testing wire continuity	on time	not started	wire continuity
April	Build and test final device to give to Grace	on time	not started	everybody

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 the presence of voltage using LED's. We will use a directional coupler to measure a signal reflection which we will use to test wire continuity. 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