The Electrical Tester

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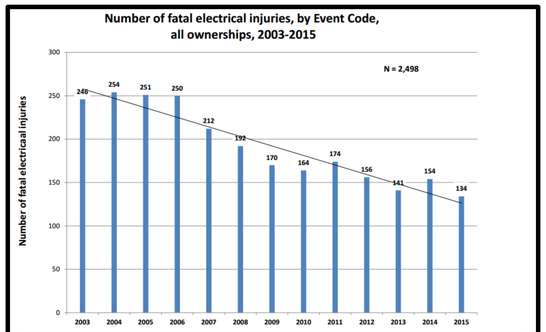
Introduction

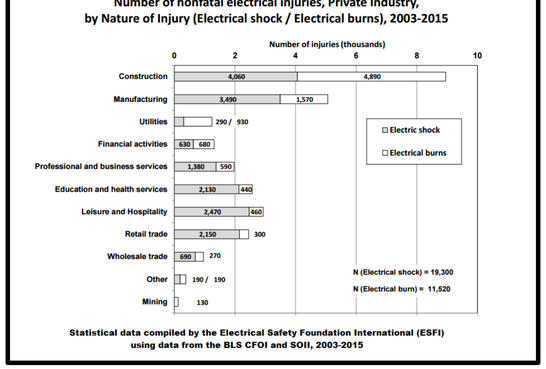
The Electrical Tester is a non-contact, A/C voltage detector glove with memory designed for individuals working near electrical circuits where the potential for electrical fault is present.

Motivations

- Improve workplace safety and productivity
- Reduce number of annual fatal and nonfatal electrical injuries across all industries [1]



Number of electrical fatalities in selected industries, by EVENT, Private industry, 2003-2015														
Industry Sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Construction	132	122	107	126	108	89	89	76	69	66	71	74	81	1,210
Professional and business services	23	29	38	21	25	27	24	20	23	30	20	19	18	318
Trade, transportation, and utilities	17	30	29	32	19	19	18	19	16	16	13	17	9	254
Natural resources and mining	16	20	27	27	24	13	9	18	24	21	14	16	9	238
Manufacturing	22	22	17	14	17	19	15	11	20	11	9	12	7	196
Other services	7	5	10	6	5	5	5	-	5	-	5	-	-	54
Leisure and hospitality	4	3	5	5	-	3	-	3	4	-	3	6	-	37
Information	3	6	4	3	-	-	-	4	3	1	-	-	-	24
Financial activities	5	-	-	5	3	-	-	4	1	3	-	3	-	24
Total	246	254	251	250	212	192	170	164	174	156	141	156	134	2,500



Statistical data compiled by the Electrical Safety Foundation International (ESFI) using data from the BLS CFOI and SOII, 2003-2015

- Improve existing technology by providing continuous, passive monitoring with event triggered data collection
- Assist in determination of event liability via time stamped data collection

Design

The design incorporates the following components:

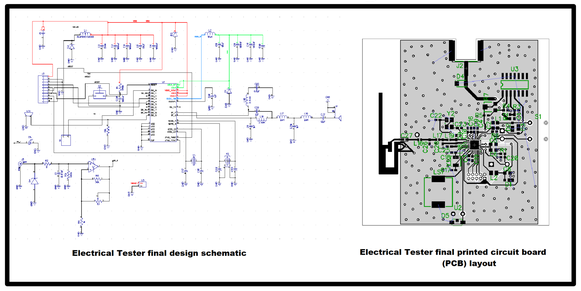
- Glove offering resistance from flames, arc flash and cuts
- Antenna for sensing A/C voltage
- Circuit for A/C voltage amplification
- TI-CC2650 Microcontroller for system alerts and data collection
- Bluetooth Low Energy (BLE) wireless data transfer to Android Studio application
- Interchangeable 3.6V lithium ion battery
- Two alert system using LED and Speaker

Early prototype of The Electrical Tester

Design Considerations

- Sensitivity
- Affordability
- Size
- Dexterity
- Durability
- Life cycle
- Power consumption
- Marketability

Electrical Tester Schematic and PCB Layout

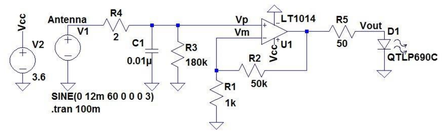


Electrical Tester final design schematic

Electrical Tester final printed circuit board (PCB) layout

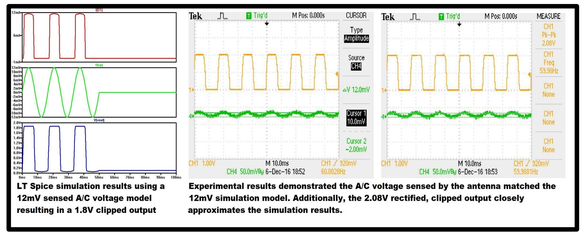
Circuit Testing

The Electrical Tester's ability to amplify the small A/C voltage detected by the system antenna and used to activate the microcontroller is the most critical aspect of the circuit design. Simulation and laboratory test results are as displayed below:



The Electrical Tester LT Spice circuit schematic

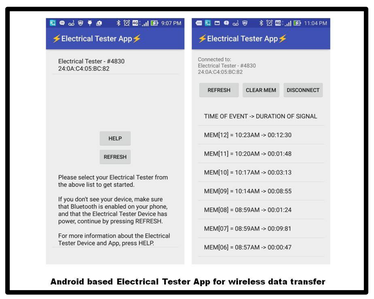
Experimental results closely approximate simulation results indicating the amplifier circuit design functions as intended.



LT Spice simulation results using a 12mV sensed A/C voltage model resulting in a 1.8V clipped output

Experimental results demonstrated the A/C voltage sensed by the antenna matched the 12mV simulation model. Additionally, the 2.08V rectified, clipped output closely approximates the simulation results.

Data Collection



Android based Electrical Tester App for wireless data transfer

- BLE wireless data transfer
- On chip, non-volatile memory storage
- Analog-to-Digital conversion
- Battery powered
- Android based application
- Time-stamped data

Future Improvements

The design process resulted in a functioning prototype, however several key improvements are suggested for future versions of The Electrical Tester. These include, but are not limited to the following:

- Reduce power consumption
- Decrease PCB layout area
- Test flexible PCB suitability
- Increase sensitivity range
- Decrease component costs
- Improve Glove-PCB integration
- Develop App to be more user friendly

Conclusion

The project mission was to design a low-cost, non-contact, A/C voltage detector glove with wireless data transfer capabilities to record event data. To this end, a functioning glove has been designed, tested and demonstrated to work in coordination with an Android based application developed to wirelessly retrieve event data.

The estimated per unit cost is $78 with an overall project budget of less than $1000. Both of these numbers can be reduced with bulk production costs driving component and fabrication costs down. Additionally, the design and development of The Electrical Tester provided team members fundamental experience participating in an interdisciplinary design project.

References

1. **Electrical Safety Foundation International using data from the BLS SOII, 2003-2015, http://www.esfi.org/resource/workplace-fatalities-and-injuries-2003-2015-571**