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PICO-WATTS POWERED MULTIFUNCTIONAL ACTIVE SENSOR FOR DETECTION OF HARMFUL ELECTROMAGNETIC RADIATION

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ABSTRACT:

Electronics devices and components including computers, tablets, and many home appliances produce electromagnetic emission and it should be at certain low levels. Health is always a concern for today's technologies that have high-frequency signal emission. To protect health from harmful electromagnetic and radiation environments, it is desirable to design multifunctional sensors that can be used to monitor both earth and space environments. This work involves the simulation and design of multifunctional sensors and electronic modules suitable for both space and earth environments. The sensors will incorporate microcontroller-based hardware-software solutions for various sensing applications. The sensors will be tested using customized program codes. Preliminary work has shown that it is possible to have multifunctional sensor that can detect two types of harmful environments. Work to be done include designing newer materials, making sensor system compact, and developing the sensor driving electronics. In addition, methods to fabricate the sensors in-house would be developed and fine-tuned for repeatable production. It is envisage that the product of this work will be the development of compact multifunctional sensors that will alert users of hazardous environments caused by ionization, radiation and electromagnetic emission. The multifunctional sensors to be developed may be used for space technology, satellites, medical, handheld mobile and IoT

devices. Several government agencies, such as NSF, NASA, Department of Defense, EPA, might be interested in funding further developments of this work.

KEYWORDS: *Radiation sensor, Microcontroller, Sensitivity, Electronic device, TID, Single Event Upset.*

INTRODUCTION:

Earth is home to all lives in the solar system. Health conditions are determined mostly by diseases that can spread from one person to another, even though there are some isolated diseases of non-transmitted diseases. Most of the non-transmitted diseases like cancer are major area of research in health. Causes of cancer in the body, that have been identified, include various electromagnetic emissions and ionizing radiation. Ionizing radiation can weaken the working of the human organs and can deliver intense impacts, for example, skin redness, baldness, or severe radiation disorder. These impacts are increasingly extreme at higher doses and higher dose rates. Food and environmental effects have been identified to produce many such diseases today. Like the frequent happening radioactive materials found in soil, water, and air. Radon, as per the U.S. EPA, is known to be the second leading cause for Lung disease. It is an active component present all through the earth's crust. It can diffuse through the dirt to the climate, where it aggregates in buildings by discharging a few Alpha particles, which can irradiate the breathing tracts of people. The significance of the multifunctional sensor can be employed to address various environmental effects of electromagnetic emission and radiation as shown in figures 1-5.

Solutions to detect these dangerous environments at early stages can save lives through the application of the multifunctional sensors and the electronic modules. Many sensors are already developed and available today [REMM, Aaronia, (2018)], but still just a few multifunctional sensors in the market, that can work on more than one type of detection tasks at the same time. These sensors have other advantages such as being very compact and modular with signal driving electronics, hence, the need of multifunctional sensors for detecting hazardous environments.

PRELIMINARY TEST METHODS AND RESULTS:

A number of materials were identified that have the potential to design the multifunctional sensors for this research work. We selected two materials primarily to design the sensors based on the multifunctional concept. The initial test carried out was sensing both ionizing air and X-ray radiation in way that both environments could be sensed at the same time. Figure 6 shows the sensor and its pre-, at- and post- Total Ionizing Dose (TID) results when radiated in ionizing air of X-ray. The sensor was then redesigned and coated with a non-static material to prevent ionization effect; thus only X-ray radiation could be detected. Figure 7 shows the sensor with a non-static

coating, and its pre-, at- and post- TID results when radiated in same ionizing air environment of X-ray. The ionizing air detected was 0.75e10pA. The second material did not produce very good results from the sensor with a non-static coating, shown in figure 8. Results showed unwanted notches due to radiation discharge currents in the sensor. This sensor could be very good for detecting and measuring TID effects for radiation environments.

FUTURE DESIGN CONSIDERATIONS:

There are a number of areas to expand this research. Two important works to be done is in the area of materials selection and characterization. These materials will be tested to determine their responses under influence of radiation, ionic or electromagnetic emissions.

Simulation techniques for designing the multifunctional sensors would be developed and this technique will help in analyzing the equivalent electronic design and circuit configuration to create sensor modules. Also, various circuit design approaches will be considered to create the best suitable sensor electrodes that can detect electromagnetic emissions. Microcontroller-based circuits would be developed and programmed to process the data from the sensor module at various signal components from radiation, ionization and electromagnetic environments for monitoring and detection purposes [Binzaid, S. et al., 2009]

For various samples design and continue research work, fabrication methods will be optimized within the Lab. Techniques to create scalable smaller sensors, perform various electrical tests, process to collect data of electrical parameters and performance analysis methods for various applications would be developed. So, the sensor module with its built-in signal conditioning electronic circuit can be verified for safe operation in harsh environment [Verbeeck, J., 2018]. Figure 9 illustrates the system block diagram of the microcontroller-based solution for the multifunctional sensor where a single multifunctional sensor can be used to process signal to determine various types of harmful energy and provide alerts if the tolerance limits are exceeded.

CONCLUSION:

It is obvious that health is always a concern for today's technologies that have high-frequency signal emission. The power lines spread around homes create sensitive electromagnetic harmful networks. Electronic devices and components including computers, tablets, and many home appliances produce electromagnetic emission. Hospitals and industries have many microelectronic and micro-controlling systems. The circuits in systems may malfunction, and even cause a catastrophicfailure due to electromagnetic emissions, and ionizing radiation effects (SEE, SEU, SEB etc.) can occur [McLean, B., et al, 1987, Ratti, L., 2013, Binzaid, S. et al., 2009, Verbeeck, J. 2018, Babulal, S. et al., 2016]. In order to protect them from such failures and harmful incidences,

it is needed to design sensors that are compact and multifunctional. They can be designed for systems to monitor both on earth surface and in space applications.

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WEB Resources: NOAA, "Space Weather and Safety", National Weather Service, USA.gov.

Figure 1a: Electromagnetic field Satellite home

Figure 1b: Power-line noise issue

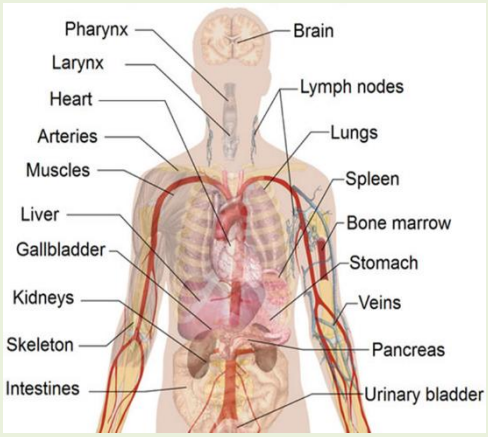

Figure 2: Human organs open to electromagnetic field

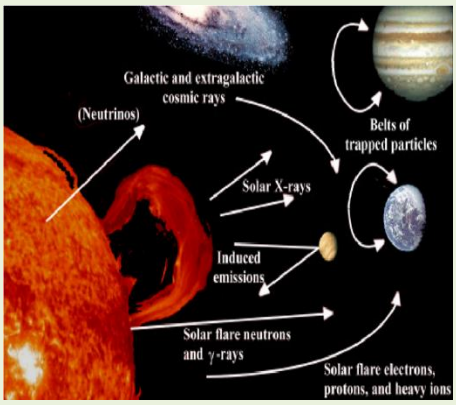

Figure 3: Solar flare causes abrupt change in space weather

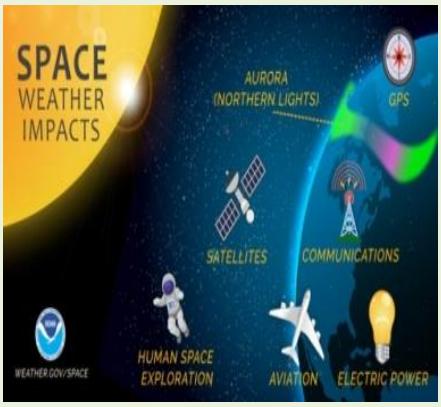

Figure 4: Serious risks during a solar-flares event

Figure 5: Ruptured line-Power Transformer

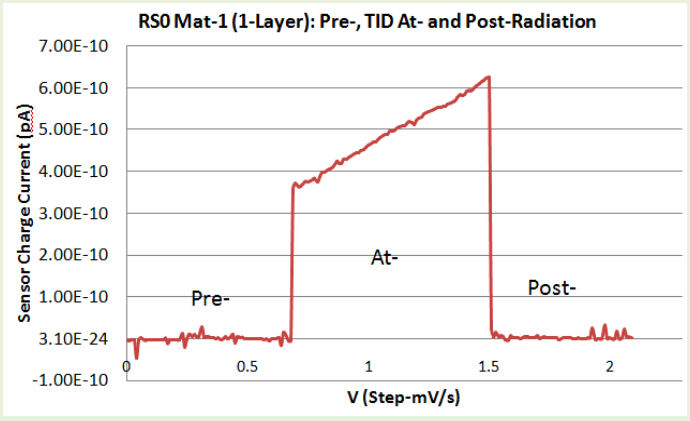

Figure 6: The first material used for the sensor and results of pre-, at- 3.75-6.25E10pA and post- TID results as radiated in ionizing air environment of X-ray

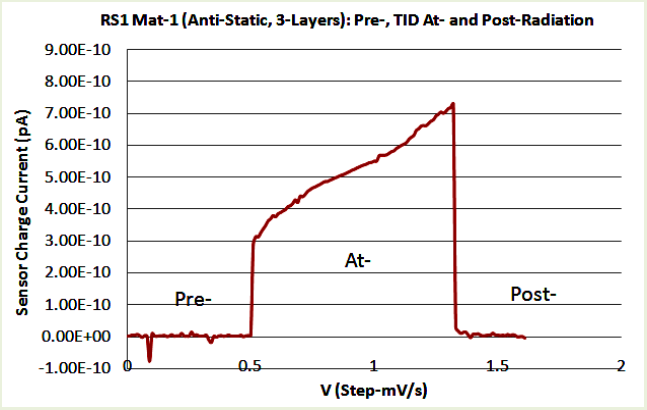

Figure 7: The second material used for the sensor with non-static coating and results of pre-, at 3.0-7.0E10pA and post- TID results as radiated in ionizing air environment of X-ray

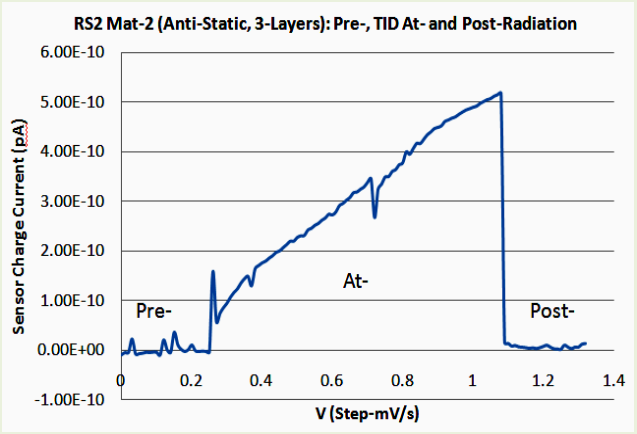

Figure 8: The third material used for the sensor with a non-static coating and results of pre-, at- 0.5-7.0E10pA and post- TID results as radiated in ionizing air environment of X-ray

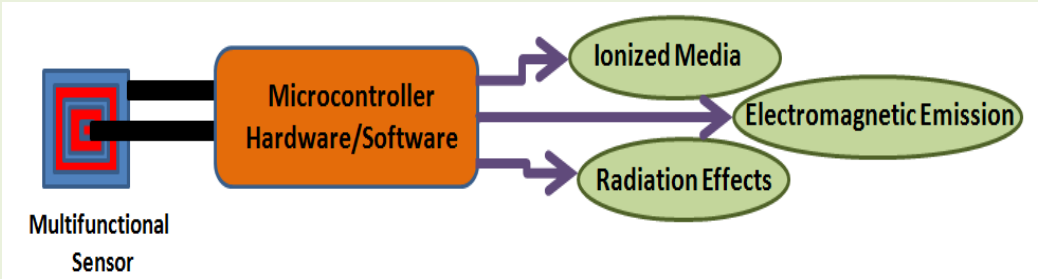

Figure 9: Multifunctional Sensor Microcontroller based hardware-software solution