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Rf Leakage Detection System for Microwave Based Industrial Heating Appliances

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Abstract: *According to WHO standard the RF leakage beyond +10 dBm are hazardous to human being. The microwave oven is a kitchen appliance which is used in day to day life. But, until 1967 an affordable and compact microwave oven was not readily available for domestic use. The obvious cooking advantages provided by the microwave oven ensured that its uptake would be rapid. It is extensive with up to 90 percent of the western world's households currently owning one. After long use of oven there is leakage of microwave radiations takes place. Microwave leakage can easily cross +10 dBm powers. Public concern over leakage from the microwave ovens was present from the very beginning. Many people believing that radiation leakage was similar to atomic radiation that could lead to serious health problems, including cancer. These radiations are hazardous to human being. Number of people use microwave ovens every year and make them vulnerable to risk. Effort has been taken to design the system which detects the leaked radiations using microstrip antenna. Designed RF circuit amplifies detects radiations. Raspberry pi checks those leaked radiations for the threshold value. If these radiations are found above the threshold value, then using GSM the system informs to their respective owner and manufacturer about leakage. So they can take appropriate action regarding the issue.*

Keywords: *Leakage detection, MAR 3 Amplifier, MCP 3008, Microwave Oven, Raspberry Pi*

I. Introduction

Now a day's public is concerned about radio frequency radiation from mobile phones and towers. This has gained general concern over any device that may be perceived as a "radiation" source. This along with aggressive marketing by companies offering measurement services for microwave ovens has increased concern over microwave oven leakage. Earlier microwave ovens relied on accurate engineering of the oven door and metal-to-metal contact where the door is closed. This type of design allowed higher levels of leakage that increased when the door or oven interface became dirty or distorted. Due to misalignment in hinge it may also cause leakage of the radiations. Microwave oven leakage can have devastating effects. One of the company (Microwave Safe Australia) inspected 12,000 ovens per year in workplaces in which they have provided data that 0.8% of ovens leak microwave radiation in excess of the 5 mW/cm^2 limit. The microwave oven works at 2.4 GHz frequency which is ISM band frequency.

Reports of excessive leakage from apparently undamaged domestic microwave ovens have been investigated by Australian Radiation Protection And Nuclear Safety Agency (ARPANSA). For many years up to now domestic microwave ovens were not considered for checking leakage levels of microwave radiation. They have not been regularly monitored. This shows the need of investigation of oven leakage which is the issue of emission levels versus exposure levels as well as the application of the specific absorption rate (SAR) measurements. Preliminary measurements indicate that under certain circumstances microwave oven emission limits may not prevent the ARPANSA SAR limits from being exceeded.

Occupational health and safety requirements place the responsibility on employers of providing a safe workplace. Because microwave ovens used in food preparation and staff canteen areas need to be in safe working condition. The question has been raised over the possibility that leaky ovens may pose a health risk to workers. Daily exposure to leakage caused by microwave ovens can cause serious eye damage, skin cancer, temporary sterility, cardiovascular problems, and central nervous system damage. Every year millions of people use microwave ovens and put themselves at risk. Due to this problem it is important to perform measurements of electromagnetic energy leakage. This concern has resulted in a number of people claiming that regular leakage tests need to be conducted on microwave ovens that are used in a workplace.

In order to fabricate the microwave leakage detector the antenna is an essential part that needs to be considered. If it is designed properly it can reduce the complexity of the detector circuit. Compared with conventional antennas microstrip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed-line flexibility, beam scanning Omni-directional patterning.

II. System Architecture

The block diagram and architectural representation of the system is shown in Fig.1 and Fig.2 respectively. It has three sections in the system, Radio Frequency Section (named as RF FRONT END), Processing section, Output section.

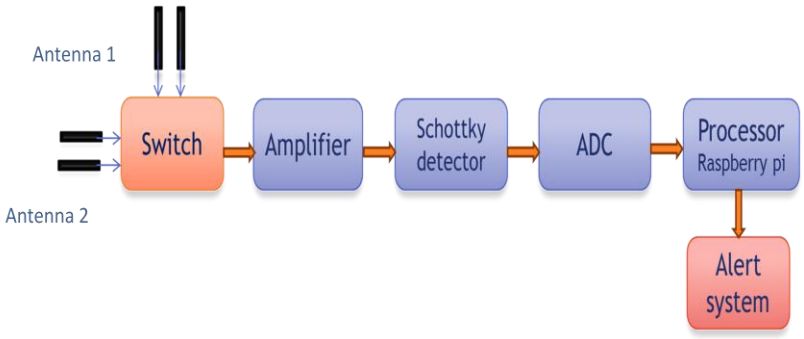

Fig:1. System Block Diagram

Input section consists of patch antenna which works as receiver, receives all the radiation and are then used as input to the system. Processing section consists of MMIC Amplifier, Schottky Detector, Analog to Digital Converter and Raspberry-Pi and the output section consist of GSM, internet, LED and buzzer. The electromagnetic radiation frequency is 2.4 GHz. The gain is variable but for the simplicity we have taken it as -65 dBM. To detect the leakage from oven we need a sensor which can work at 2.4 GHz. There are few antennas which can work at this frequency. The antenna here works as a sensor of the system. Here system uses patch antenna as shown in fig.2 with the gain of 6 dB because of its more advantages and better prospect

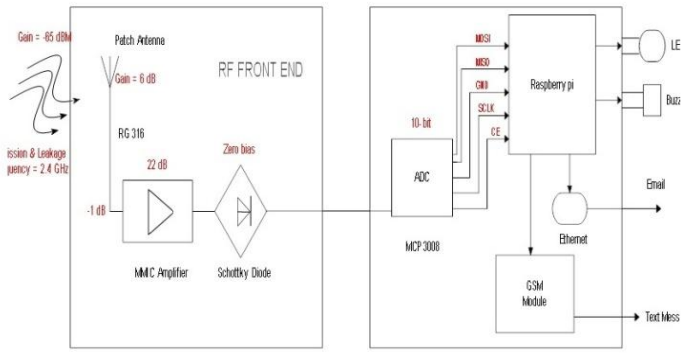

Fig:2 Architectural Representation

The SMA connector connects the path between antenna and MMIC amplifier. The gain of this cable is -1 dB works up to 3 GHz frequency and system works on 2.4 GHz therefore system uses RG 316 cable having impedance 50 ohms, which is used as medium.

Here system uses MAR 3 amplifier whose Maximum gain is 22 dB and it works at 2.4GHz. Input impedance matching is 50 Ohms. For proper functioning of this amplifier DC blocking capacitor is needed at the input as well as at the output. The signal from the MAR 3 amplifier goes to the schottky detector and converted to DC which works at zero bias that requires no external power when attached with antenna for receiving purpose. The signal from schottky detector is then transmitted to 10 bit ADC. System uses MCP 3008 A to D converter which is based on serial peripheral interface (SPI). Clock pin is necessary for ADC.

Raspberry Pi is nothing but the single chip computer. Raspberry Pi don't have mass storage device like hard disk which is present in the laptops. So it requires SD card as a storage device. The Raspberry pi runs on its own software which is located on the SD card. So to mount that SD card on the Pi it requires a SD card slot. Once card is inserted in it then it will be ready to operate for various purposes. When we put card in the slot then the processor fetches the operating system which is present in the memory card. It reads the signal from the ADC. If it is above the threshold level then the system realize that radiation has occurred. Then LED will glow and buzzer will start ringing. To inform the manufacturer and the user the Raspberry Pi will send email through the internet if Ethernet cable is plugged and text message using UART pins which are interfaced to the GSM Module to them**.** So they can take appropriate action regarding that issue

III. Results And Discussions

Co-polar and cross-polar levels of the dual printed dipole antenna measured on spectrum analyzer. The antennas are mounted in two fashions to catch the signal available in the air as shown in fig.3. The left hand figure shows the spectrum at its noise level. The antenna is connected to receiver port of spectrum analyzer. The right hand figure shows received -35dBm level. Antenna is physically close thus co & cross polarization difference is -12dbm only.

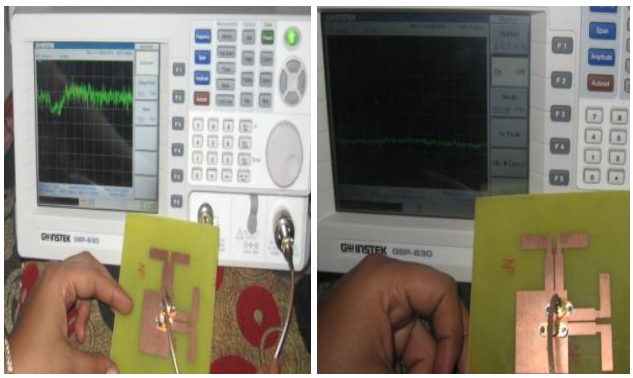

Fig:3 Co-polar and cross-polar levels of the dual printed dipole antenna measured on spectrum analyzer.

Preliminary testing is done with blue tooth and Wi-Fi.
In case of testing with Blue tooth Antenna is connected to spectrum analyzer and blue tooth signal is kept at distance of 2 ft and observed the power of signals.
Minimum power observed = -55dbm
Maximum power observed = – 32dbm
In case of testing with Wi Fi, Wi Fi signal generated by hot spot at distance of 2 ft and observed that signal is continuously hopping and observed the power of signals.
Minimum power observed = –50 dbm
Maximum power observed = – 32 dbm

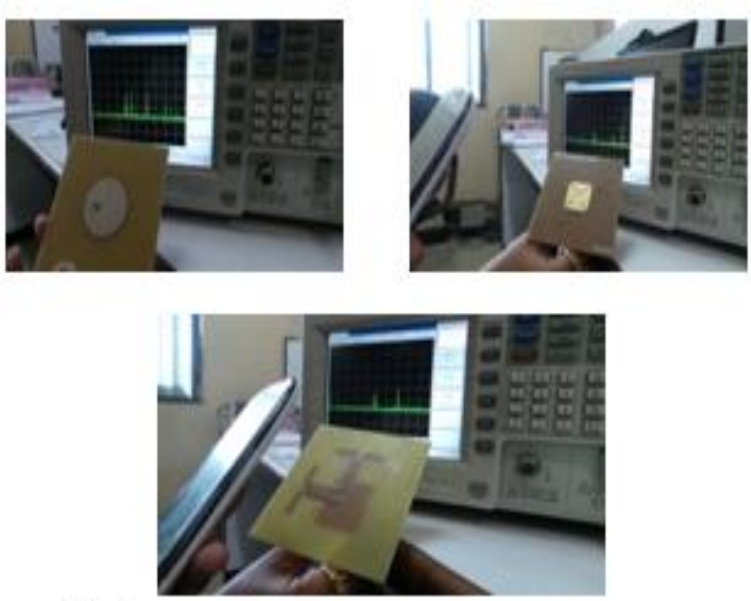

Fig: 4. *Frequency Vs. Power Spectrum with different Antennas*

In both cases power is very far below the 0 dbm as sensitivity of our system starts from 0 dbm so that our system will not respond to these power levels.

Fig: 5. System setup & Voltage Testing

Frequency versus power spectrum with different antennas is shown in Fig.4 and choice of antenna depends on maximum leakage sensing. System setup is shown in Fig. 5.
Circular microstrip linear polarized antenna used as leakage sensor, whose gain is 4.26 and directivity is 6.28. Signal observed on spectrum analyzer
Rectangular microstrip circular polarized antenna with one feed and two slots whose gain is 2.28 and directivity is 6 dB & signal observed on spectrum analyzer in which leakage is less than circular microstrip linear polarized antenna

Dipole based vertical & horizontal polarized antenna with two feeds whose gain is 3 and directivity is 3.25 dB. It is observed that this antenna is receiving signals from all directions (Omni-directional) and leakage sensing is maximum in the case of circular microstrip antenna. So this antenna is used as guard.
Leakage of microwave oven has been detected by schottky detector whose output is given to ADC. ADC continuously monitors the voltage level with the set threshold voltage level. Whenever the measured voltage is above the threshold value LED will start blinking as shown in Fig.6, buzzer will start ringing and email notification is send to the user that the leakage of microwave is above threshold. These indications will help the workers to know about the leakage.

Fig: 6 : Blinking LED

IV. Conclusion

After detecting the leakage from the microwave oven through patch antenna the signal will be given to the Raspberry Pi module. This module will process the obtained information. After that it will send the email to the respective owner and manufacturer of the microwave oven about the leakage. So that they can take corrective action to stop the leakage as radiations are hazardous to human being. LED and buzzer function is added in the system. LED and buzzer help the workers who are working near to the microwave oven about the leakage that has occurred.

In the current system single antenna is used as an input. This antenna may be vertical polarized or circular polarized. With the use of single pole double through switch (SPDT) system can have two antennas with different polarization at the time. This increases the accuracy of the system. Currently the system is for the

single microwave oven. System can also increase the number of microwave ovens under test by increasing the number of antennas. To improve the efficiency of the system array of antenna can be used.

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