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Electric Field Sensor for Lightning Early Warning System

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Abstract

Electric field mills are used popularly for atmospheric electric field measurements. Atmospheric Electric Field variation is the primary signature for Lightning Early Warning systems. There is a characteristic change in the atmospheric electric field before lightning during a thundercloud formation. A voltage controlled variable capacitance is being proposed as a method for non-contacting measurement of electric fields. A varactor based mini electric field measurement system is developed, to detect any change in the atmospheric electric field and to issue lightning early warning system. Since this is a low-cost device, this can be used for developing countries which are facing adversities. A network of these devices can help in forming a spatial map of electric field variations over a region, and this can be used for more improved atmospheric electricity studies in developing countries.

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Abstract

- A Low cost , simple device to measure Electric field at a point
  –>Source can be AC/DC
  –>Non-contacting measurement of Electric field
- A varactor based device whose output voltage changes in proportion to the applied Electric fields >50 Hz
- Static Electric field changes are the primary signature of an arriving storm hence this can be used for early detection of natural disasters like lightning
- By using a network of these, mapping and tracking of storm also possible

Device

- Varactor is used on reverse bias-capacitance varies linearly with applied terminal voltage
- Modified form of model proposed by Maceij A. Noras[1][2], but with wider amplitude range

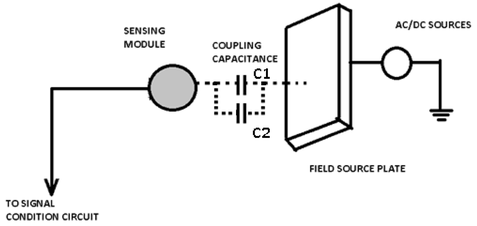

Figure 1: Schematic figure of the non-contacting measurement device

- Sensing module is directly exposed to the electric field environment
- This forms a capacitive coupling between the sensing plate and the source of field.
- Hence the source of AC field always induces voltage in sensing module. This measurement can be done for a field of frequency as low as Hz.
- DC can also be measured using special techniques.

Working

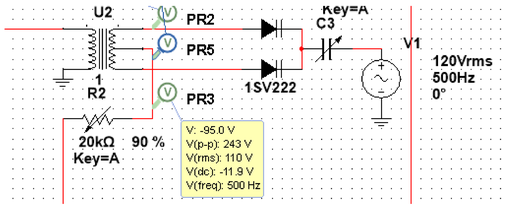

Figure 2: Circuit diagram of the electronic part of device

- A higher frequency modulation signal is applied at the transformer primary. The arrangement of transformer makes the varactors reverse biased for each half cycle of sinusoid alternatively.
- The sensing plate is placed at cathode of both varactors. The capacitor C3 is coupling capacitor. Whenever a voltage is induced due to field in sensing plate, both of the varactors perform their function.
- In the circuit shown , the AC voltage source is equivalent to the voltage induced through coupling capacitor. Hence at transformer secondary we have an AM modulated waveform and current flows through resistor whose envelope is the induced electric field.
- The importance of modulating wave is on measurement of DC field. The probe PR3 shows the induced voltage which is in turn proportional to field.

Applications

- Static Electric field variation is the primary signature of arrival of heavy storms, and sometimes, natural disasters like earthquakes
- Can be used to provide timely warning in lightning early warning systems for protection of life and equipment.
- A network of them could be used to provide a spatial map of Electric field variations over a region
- This can be used for accurate tracking of storms.

Advantages

- No mechanical parts like EFM – hence cheaper in fabrication, maintenance and technical support
- Since it is a low cost device(<10 USD), can be used in developing countries for disaster preparedness
- Resolution, compactness and simplicity

Testing

- Device was designed and developed; and E field signals tested using a guard ring capacitor
- Sinusoidal Electric field of varying frequency and amplitudes were used (using signal generator) to analyse the response of device (using DSO).
- Frequency response was studied using the fft tool of MATLAB.
- Static electric field variations prior to and during thunderstorms were studies using data from different ObservatorieSonnblick, Austria; NCESS, Trivandrum, and GHRC datasets from KSC Field mill Network, NASA.

Results

- The output amplitude of the sensor varies directly w.r.t. applied input Electric field/voltage at >50 Hz.

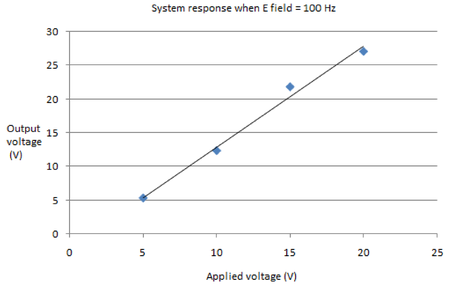

Figure 3: Sensor voltage varies in proportion to applied Electric field

Other results

- There is very slight interference due to the Weinbridge oscillator used in the sensor circuit. This shifts in direct proportion to variation in oscillator frequency.

Conclusions

- This device can be used for the detection of static electric field changes that occur prior to lightning as it can detect frequencies >50 Hz.
- Thus this can be employed as a powerful tool for disaster prediction and preparedness in non-affluent economies and data-sparse regions.

Acknowledgements

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