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Detecting Microwave Signals (X-Band) Using Glow Discharge Detectors

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Abstract - The use of neon indictor lamp glow discharge detectors (GDDs) has a relatively great potential for a number of microwave detecting and imaging applications. This is so because of their many advantages which include but not limited to; low cost, fast response time and wider dynamic range. In this paper we experimentally examine the microwave interaction with these GDDs in that the effect of the distance between the signal source of 10.5GHz and the GDD on the signal peak to peak voltage (Vpp) for peculiar modulation frequencies is analyzed. The most efficient modulation frequency is found to be 200kHz followed by 250kHz. Nonetheless, it is observed that the Vpp is higher when the signal source is closer to the GDD.

Key words: Microwave, Glow Discharge, Neon indictor lamps, X-band, Detection, Plasma

I. INTRODUCTION

The microwave region of the electromagnetic spectrum is very prominent for applications such as communications, defense, and space technology [1]. It is noteworthy that there are challenges in the development of meliorated microwave radiation sources and detection technologies whereby there is need for low cost and ideally sensitive room temperature detectors in the microwave spectral region. In general, there are three room temperature detectors; Pyroelectric detectors, Golay cells and Schottky diodes [2]. A Schottky diode is a faster room temperature detector with a low noise equivalent power (NEP) of 10^{-10} W/Hz$^{1/2}$ [3]. It may be even applied for measurements above 1.5 THz, although it is less sensitive and needs more local oscillator (LO) power [4]. Pyroelectric detectors and Golay cells have a relatively wider spectral response and a low NEP, however they have a long response time and a limited modulation frequency [2]. These detectors are also expensive. However, neon indictor lamp glow discharge detectors (GDDs) have a great potential for microwave detecting applications. They have a lot of advantages that include; low cost, fast response time, wider dynamic range, broader spectral range and ability to operate at higher temperatures. It is stated in [5], that the GDDs' response time is 14–100 ns, their NEP is 10^{-12} W/Hz$^{1/2}$, and their spectral response is from microwave to X-ray. The detection mechanism used in the microwave band is the enhanced cascaded ionization and this is because of the high electromagnetic wave electric fields. Nevertheless, GDDs have a problem of internal noise which is a common characteristic of plasma devices.

Moreover, it is needful to note that plasma produced by gases have a classifiable detection platform for electromagnetic (EM) radiations. The fact that its physical and electrical features can be controlled has motivated research in its applications such as detection. Some of the research can be found in [6-8]. In our paper, the effects of microwave radiations on alternating current (AC) glow discharge are experimentally examined by analyzing the effect of the distance between the signal source and the GDD on the signal peak to peak voltage (Vpp) for peculiar modulation frequencies.

II. MATERIALS AND METHOD

In this section, we thoroughly describe the steps taken to set up the experiment.

To detect microwave signals using GDDs, we needed the following:

- A GDD
- An AC or DC source to bias the GDD
- A microwave signal source and modulation
- A filter
- An amplifier
- An oscilloscope.

The GDD used was a neon indicator lamp of NE-2 series because of its aforementioned advantages. The characteristics of an ac glow discharge is dependant on the gas type and its pressure as well as the material and electrodes' geometry. The GDD used had a distance of about 0.4 mm between the anode and cathode with cylindrical shapes of a diameter (r) = 0.9 mm and height (H) = 3.4 mm. Even so, the electrodes are normally coated with barium azide or barium strontium oxide (because of their higher electron emission coefficients) to lower the required breakdown voltage. Fig. GDD physical dimensions.

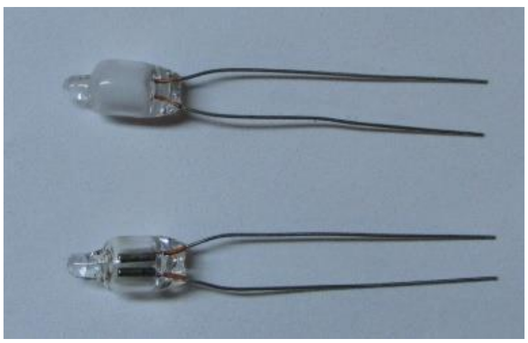

Figure 1. Neon lamps used

The GDD was biased with an AC source. It should be noted that an alternating voltage applied between electrodes can curb the problem with dc glow discharge where electrodes may charge up when one of the them is non-conducting due to the constant current, thereby causing the GDD to burn out. In our experiment, the GDD was biased using an 11kΩ resistor connected in series with the GDD and an AC from a T11500B-FE model transformer of 110V output voltage from Artsanenerji.

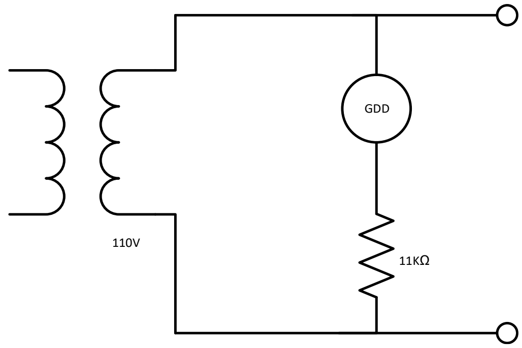

Figure 2. AC biasing circuit for the GDD

An X-band frequency microwave doppler sensor of 10.5GHz was used to transmit a microwave signal to the GDD. The signal was modulated using different frequencies and measurements were taken. 200kHz proved to be the most efficient modulation frequency.

To get rid of the 50Hz AC frequency and other noise, a passive LC high-pass filter was used. Passive LC filters are used for high frequency signals. The figure below shows the filter circuit used. The capacitor was 223pF and the inductor was 332mH

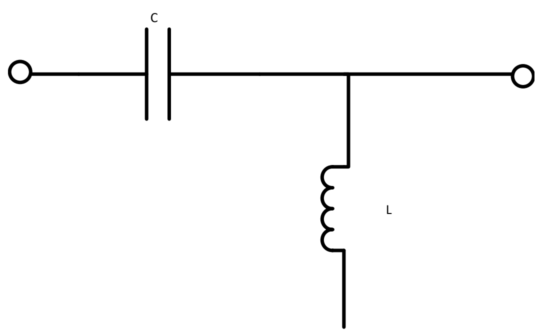

Figure 3. Filter circuit

The signal was then amplified with an amplifier circuit given below. The regulated power supply used was an ATP-3303D model and the op amp used was an LM324N.

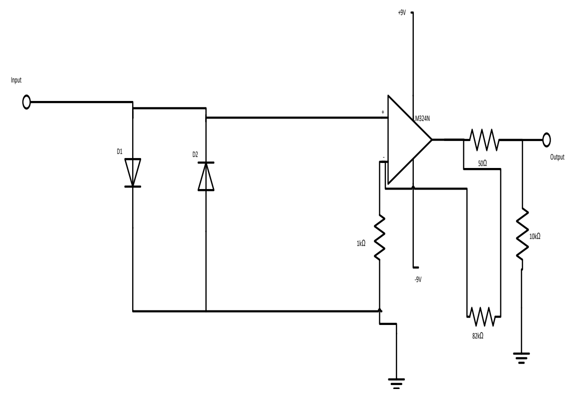

Figure 4. Amplifier circuit

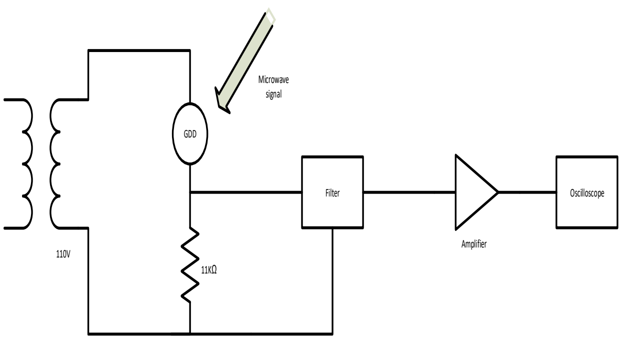

Figure 5. The Schematic diagram for the whole setup

III. RESULTS

In the experiment, the signal was modulated with different frequencies and the respective peak to peak voltages were recorded as shown in the table below. It was observed that 200kHz had the highest peak to peak voltage of 2.8mV followed by 250kHz with 2.6mV. The distance between the GDD and the signal source was arbitrary, and it was 5.4cm. Thus, it can be argued that to detect a microwave (X-band) signal with a GDD, its more efficient to modulate it with 200kHz.

Table 1. Vpp for different modulation frequencies

Modulation Freq (kHz)	Vpp (mV)
10	2
20	1.8
30	2
40	1.8
50	1.4
100	1.6
150	2.4
200	**2.8**
250	2.6
300	1.8

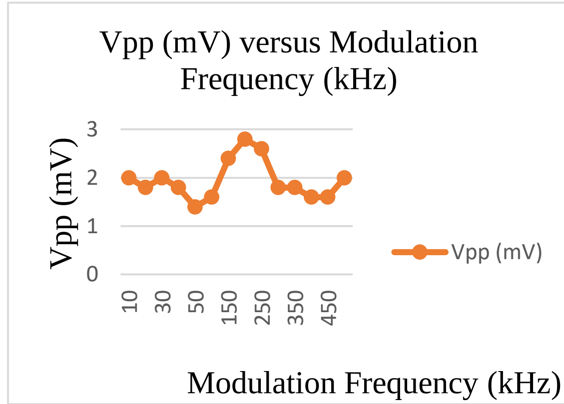

Figure 6. Relationship between Vpp and modulation frequency

After realizing the most effective modulation frequencies (200kHz and 250kHz), the distance between the GDD and the signal source was set at different points to analyze its effect on the peak to peak voltage (Vpp) of the detected signal. It was observed that the Vpp is higher when the signal source is closer to the GDD. The Vpp values observed were not net values but rather they were oscillating between particular ranges, and the highest values were recorded.

Table 2. Vpp for 200kHz and 250kHz at different distances

Distance (cm)	Vpp (mV) for 200kHz	Vpp (mV) for 250kHz
1	3.9	3.5
2	3.6	3.2
3	3.52	2.92
4	3.44	2.56
5	3.12	2.48
6	2.8	2.24
7	2.72	2.2
8	2.64	2.16
9	2.56	2.16
10	2.48	2
15	2	1.8

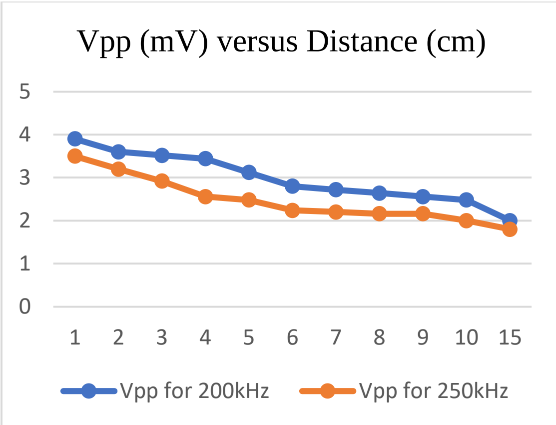

Figure 7. Relationship between 200kHz and 250kHz Vpp and Distance

IV. DISCUSSION

A thorough exposition as well as an experimental examination of microwave interaction with glow discharge detectors (GDDs) to determine the most efficient modulation frequency when detecting microwave signals in the X-band region is presented in this paper, thenceforth, the work presented can be a source of literature to the overall research that is being undertaken today due to the never-ending need for new technologies with reduced cost and improved reliability that need to be employed in microwave detection applications.

V. CONCLUSION

In this paper we have experimentally examined the microwave interaction with a neon indicator lamp GDD in that the effect of the distance between the signal source and the GDD on the signal peak to peak voltage (Vpp) for peculiar modulation frequencies has been analyzed. The most efficient modulation frequency is found to be 200kHz followed by 250kHz. Nonetheless, it has been observed that the Vpp is higher when the signal source is closer to the GDD. Even so, the GDDs' performance need to be studied for higher frequencies like in the terahertz region.

REFERENCES

[1] Abramovich, A., Kopeika, N. S., & Rozban, D. THz Polarization Effects on Detection Responsivity of Glow Discharge Detectors (GDDs). IEEE Sensors Journal, *9*, 10, OCTOBER 2009.

[2] Lei, H., Hongkyu, P., & Xi-Cheng Z. Terahertz Wave Imaging System Based on Glow Discharge Detector. IEEE Journal of Selected Topics in Quantum Electronics, *17*, 1, January/February 2011.

[3] Brown, E. R. A system-level analysis of Schottky diodes for incoherent THz imaging arrays. Solid-State Electron, *48*, 2051-2053, October/November 2004.

[4] Maestrini, A., Ward, J., Gill, J., Javadi, H., Schlecht, E., & Chattopadhyaym, G. A 1.7–1.9 THz local oscillator source. IEEE Microwave Wireless Compon. Lett., *14*, 6, 253–255, June 2004.

[5] Kopeika, N. S. Theory of a fast, sensitive, submillimeter wave glow discharge detector. Int. J. Infrared Milli Waves, *5*, 1333-1348, September 1984.

[6] Kopeika, N. S., Galore, B., Stempler, D., & Heimenrath, Y. Commercial Glow Discharge Tubes as Detectors of X-Band Radiation. IEEE Transactions on Microwave Theory and Techniques, *23*, 10, 843-846, October 1975.

[7] Yaakov M., Oded R. M., & Kopeika, N. S. Very High Sensitivity Heterodyne Detection of X-Band Radiation with Neon Indicator Lamps. IEEE Transactions on Microwave Theory and Techniques, *26*, 1, January 1978.

[8] Kopeika, N. S., Makover, Y., & Schonbach, S. IF Conversion Gain of Glow Discharge Lamps as X-Band Mixers for High LO Power Levels. IEEE Transactions on Microwave Theory and Techniques, *27*, 3, 227-232, April 1979.