

plasma-diode experiments

Plasma diode detector using a neon glow lamp — today's answer to the slotted-line standing-wave detector

The use of the plasma in glow lamps and specially designed discharge tubes for microwave detection is not new.¹⁻⁴ In most cases, means are provided for focusing the microwave energy on a selected point of the discharge, with the detector output appearing as a variable component of the lamp current. The plasmas operate at quite high power levels as far as biasing is concerned (20 mA and 250 volts).

This type power supply is out of line for the experimenter working with transistors and ICs.

The drawback of the conventional kind of plasma detector is its high noise. Relying on Maxwell's displacement current, research workers have, however, constructed glow-lamp microwave detectors that are free from the annoying lamp-current noise. In certain cases they are even more sensitive than the old standby, the crystal diode. These new detectors operate in the gigahertz region up to 100 GHz (3-mm wavelength).

starvation-current mode

A recent research and development project at Sercolab revealed that worthwhile detector sensitivity can be achieved in a "starvation current" glow-lamp mode, with the demand on supply power reduced to about 0.1 per cent. This kind of operation brings the glow-lamp microwave detector within every experimenter's reach, since the entire power supply consists of a few 9-volt transistor batteries. With capacitively coupled microwave energy, the glow-lamp detector combines an acceptable signal-to-noise ratio with a broad frequency range, a wide dynamic range, and the feature of being almost indestructible — something that can't be claimed for its competitor, the crystal diode.

By Dr. Harry E. Stockman, Sercolab, P.O. Box 78, Arlington, Massachusetts 02174

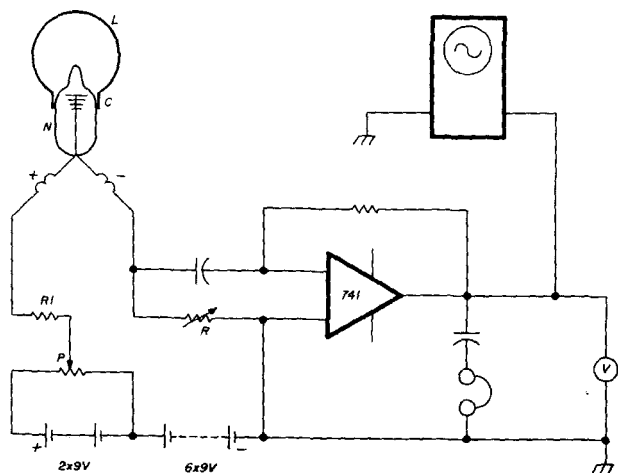


fig. 1. Experimental circuit for evaluating plasma diodes in the "starvation-current" mode. LC is the loop antenna; N is a neon lamp. Other components are discussed in the text.

Its characteristic of being able to take a heavy overload without showing any defect in operation makes the glow lamp a handy microwave detector. Furthermore, it's inexpensive. A brand-new neon lamp costs only 25 cents, (Radio Shack's NE 2 and NE 2H are good examples.)

Today, triode and tetrode glow lamps, such as the TRJ 250, are being used successfully as microwave detectors, providing the desired coupling internally.* Alternatively, an external capacitor plate can be attached to a diode, cemented to the glass envelope. In the detector described below, a diode lamp with protruding terminal wires is used with an external rf-electrode arrangement that forms a loop antenna. A dipole antenna with capacitor plates provides an alternative.

test setup

Fig. 1 shows a simple test rig. In the starvation mode, only the tip of the cathode electrode glows. The capacitor plates, C, of the loop antenna, L, are loosely coupled to the discharge. (We are looking into the glow lamp, /V, in the plane of the two electrodes.) Each lamp terminal wire is formed into two solenoid turns around any temporary 3-mm (1/8-inch) core, thus providing an rf choke.

Potentiometer P is a small 25k trimpot. Variable resistor R is 250k. The values are not critical. R1 is a 5k safety resistor. A 741 IC is the detector — output amplifier; but two 741s in cascade are better, meaning that we may use a 1458 IC.

The output indicators are a scope, an electronic voltmeter, and earphones. Eight 9-volt batteries are

*The TRJ 250 tube and other glow lamps suitable for microwave detection are obtainable from General Instrument Signalite Division, 1933 Heck Avenue, Neptune, New Jersey 07753.

used, held together with a rubber band. The lamp-supply current amounts to only 0.1 mA, so the life of the major part of the battery is almost the shelf life.

the antenna

The experimenter can readily make up an assortment of loop antennas by clipping metal strips from a coffee can, or better, from a neatly polished, somewhat thicker, copper sheet. The width of the strips may be 6 mm (1/4 inch).

The quickest way to obtain a properly tuned system is to try out different-size loops for a given wavelength. The inductance can be reduced somewhat by flattening the loop. The loop position relative to the glow lamp is shown in **fig. 1**. This is only one of several possible positions. Actually, the best results were obtained with the loop folded 90 degrees out of the paper (**fig. 1**), so that its axis is parallel with the direction of the electrode system. The loop is then moved up, down, and lengthwise for optimum coupling to the plasma. For the loop orientation with respect to the transmitter, the rules are about the same as for everyday shortwave work.

test equipment and adjustments

Two low-power laboratory oscillators were available for the tests — one 1.2 GHz (25-cm wavelength) and a 2.4 GHz (12.5-cm wavelength). Each was amplitude modulated with a 1000-Hz tone.

In adjusting the *receiver*, the P and R controls are set in a combination that does not promote CR relaxation oscillations, which are common in neon-lamp hookups. The adjustment of the controls is such that maximum detector audio output is provided.

Once the proper control setting has been found, the detector will remain stable. If, after a long time of operation, the lamp goes out, potentiometer P voltage is temporarily increased to make the lamp fire. Then it is decreased to its previous value. Most lamps fire in the 60-70 volt range. The extinguishing voltage is then some 10 volts or less.

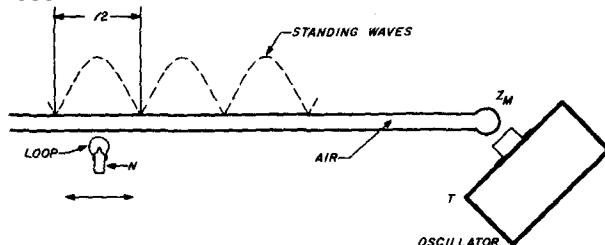


fig. 2. Plasma detector of fig. 1 implemented for plotting standing waves on a transmission line. Loop must be moved along the line at a constant distance from the line for consistent data.

uses

Among practical uses of this detector is the determination of the oscillator wavelength. The glow-lamp detector is placed at the side of the transmitter with just enough coupling for the modulation tone to be heard in the earphones. A meter stick is then placed vertically on the bench, and a reflector is moved up and down along the stick. Readings are taken at every sharp null on the meter or in the earphones. A suitable reflector may be made from heavy aluminum foil cemented to the back of a writing-pad cardboard.

A bigger reflector is better. One with a quarter-meter side is a deluxe article. The average distance between the nulls is one-half the wavelength. Really, doing it this way we're too close to the transmitter, and if the experiment is repeated in the horizontal plane, with a larger distance between transmitter and receiver, better accuracy results.

In another experiment, we may rig up a two-wire line in air with a wire distance of 13 mm (1/2 inch), using one end for coupling and the other end either open or closed. Another arrangement is to put a bit of TV downlead on a wooden table, similarly arranged at the ends.

Fig. 2 shows how the excited end of the line is formed into a loop, coupled through the mutual impedance, Z_M , to the oscillator. With the line removed, the transmitter is tuned for minimum direct pickup by the receiver. Then, with the line in position, Z_M is assigned the compromise value that gives a clear standing-wave pattern with only sufficient rf power for good deflections on the voltmeter.

The detector is then moved along the line and the readings are tabulated, whereupon the standing-wave pattern can be plotted. Loop L must be moved at a constant distance from the line.

The two-wire air line gives sharp nulls, and the wavelength obtained agrees quite well with that measured in the preceding reflector experiment. The TV cable nulls are not equally sharp, and the measured wavelength is smaller than the true wavelength because the insulation dielectric constant is larger than unity.

references

1. G. Burroughs and A. Bronwell, "High-Sensitivity Gas Tube Detector," *Tele-Tech*, vol. II, August 1952, pages 62-63.
2. N.S. Kopeika and N.H. Fartiat, "Video Detection of Millimeter Waves with Glow-Discharge Tubes," *IEEE Transactions on Electron Devices*, vol. ED-22, No. 8, August 1975, pages 534-548.
3. N.S. Kopeika et al, "Commercial Glow-Discharge Tubes as Detectors of X-Band Radiation," *IEEE Transactions on Microwave Theory and Technology*, vol. MTT-23, October 1975, pages 843-846.
4. N.S. Kopeika, "A New Type of 10-GHz Receiver," 73, September 1978, pages 222-223.

ham radio