Polarization and Detector Linearity

We think that a certain microwave detector is linear in electric field, but we are not certain; it could be linear in intensity or not linear at all. Indeed, it could be linear in electric field at low power and linear in intensity at high power. Devise an experiment that uses a polarizer rotating in front of the detector, and measure the detector output as a function of the angle of rotation of the polarizer (which is proportional to time). How "should" the detector respond if it is linear in electric field? If it is linear in intensity? Hints: The microwave source emits a polarized wave. The detector is sensitive to polarization; that is, it acts as if it has a built-in polarizer. (Check these claims.) Plot the waveform you acquire and compare it with expected waveforms, or devise a means for plotting output versus input, where input could mean electric field or power. Note: If a microwave detector is linear in amplitude but rectifies the signal, then its output would be the magnitude of a cosine function, rather than a cosine function.

You may find expressions for the wave transmitted by polarizers in your physics II text. One such expression is for the amplitude of the transmitted field, whereas another is for the intensity.

Perform a similar experiment with the optical polarizer. This detector is not sensitive to polarization. Devise an experiment to ascertain whether the optical detector is linear in intensity.

The source in this experiment is a HeNe laser. Its output is not linearly polarized but rather is composed of two wavelengths, each linearly polarized at right angles to the other. To begin with a polarized beam, therefore, you will need to place a polarizer in front of the laser. To ensure that the output power is very nearly constant with time, the axis of that polarizer must be oriented by trial and error to lie at 45° to the directions of polarization of the two wavelengths. To that end, set the oscilloscope's timebase to 2.5 s/div and monitor the detector output while rotating the polarizer incrementally (with the rotating polarizer removed).

Be careful; because $\cos 2\mathrm{x} = 1 + 2\cos^2 x$, you can always express a cosine function in terms of a cosine-squared function, and vice versa. How many transmission maxima do you expect in each complete rotation of the polarizer? If the detector responds to intensity, rather than electric field, do you expect the output to go below zero?

Suggestions: Perform the microwave experiment at various powers. Examine the drift of both the laser and microwave sources.

Note: The purpose of rotating the polarizer is simply to vary the input power rapidly, so that the input power does not drift appreciably during a measurement. You will have to understand the polarizer in order to perform the experiment, but the experiment is about the sources, and not about the polarizer. You could in principle take measurements by hand, by varying the input power, and plot detector response versus input power or field, but it would be tedious and potentially be subject to error, because of drift. Thus, the analysis of the data consists of comparing the data with what you would expect to see if the detector was linear with field or with intensity, and figuring out which theoretical calculation agrees best. Perform the microwave experiment at a range of voltages.