DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

NORTHEASTERN UNIVERSITY

ECE G287 **OPTICAL DETECTION** **Spring 2004**

Homework Set 3

Due: Wed. Feb. 25

Here we explore some detector circuits. This will probably be a good review of your undergraduate circuits course. You may use any software you like to prepare the plots. We will draw a set of characteristic curves in Problem 1, and then use them in circuits in the other problems.

Problem 1: Detector I–V Curves

Part a: Consider a photodiode, with $I_0 = 1$ nanoampere, a quantum efficiency of 80%, and a light source at a wavelength of 633nm. Plot the I–V curves for incident optical powers of 0 to 6mW, in 1mW steps, from -10 Volts to + 1 Volt.

Part b: Now, assume that the quantum efficiency increases slightly with reverse voltage, so that the photocurrent increases linearly with reverse voltage from 80% at a voltage of zero, to 88% at -10 Volts.

Part c: Draw a circuit model of this detector, with component values appropriately labelled.

Problem 2: Bias Tee

Now consider the detector from Problem 1. Assume that we have a nominal power level of 3mW, with an AC signal having a peak–to–peak value of 2pW. The maximum safe reverse voltage is 10 Volts, and the maximum safe current is 10 mA.

Part a: Find a good operating point for linear behavior.

Part b: What is the AC current associated with the signal? What is the AC voltage?

Part c: How could your answers to Part b be changed if the maximum safe reverse voltage were 20 Volts?

Part d: How much do you expect the answers to change if you use the detector in Part b, instead of that in Part a?

Problem 3: Transimpedance Amplifier

Now, suppose we use a transimpedance amplifier with this detector, using a feedback resistor of 10kOhms.

Part a: Draw the loadline for this situation. What is the voltage responsivity (change in voltage out divided by change in optical power in).

Part b: Suppose that the transimpedance amplifier has a transfer characteristic (output voltage divided by input current), which is linear except that it is limited to the range $\pm 10V$. Extend the "loadline" in these limiting cases.

Problem 4: Measuring Pulse Energy

Now, let's suppose that we use a configuration like the bias tee in Problem 2, but in parallel with the load resistor, we install a large capacitor. Let it be large enough to create a time constant of about a second.

Part a: Draw the equivalent circuit, showing the diode, DC voltage, photocurrent source, one resistor and one capacitor.

Part b: What is the voltage responsivity (voltage out divided by energy in) of this "pulse energy monitor?"