APPENDIX C
OPERATION OF OPTICAL POWER METERS

An optical power meter is a relatively simple device. It utilizes a photodiode as the light sensing element. This photodiode generates an electric current I (see Figure 1), which is *proportional* to the incident optical power P (i.e. $I \propto P$). The electric circuit within the optical power meter senses the electric current generated by the photodiode, processes it and then displays the corresponding optical power.

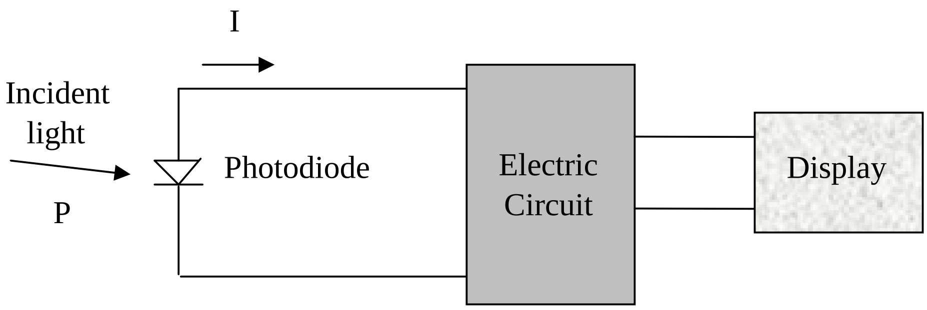

Figure 1: Basic Structure of an Optical Power Meter.

The parameter that relates the generated current to the incident optical power is called the responsivity, R, so that $I = RP$. The responsivity R of the photodiode is a function of the wavelength of the incident light, i.e. $R = R(\lambda)$. A typical photodiode responsivity curve is shown in Figure 2.

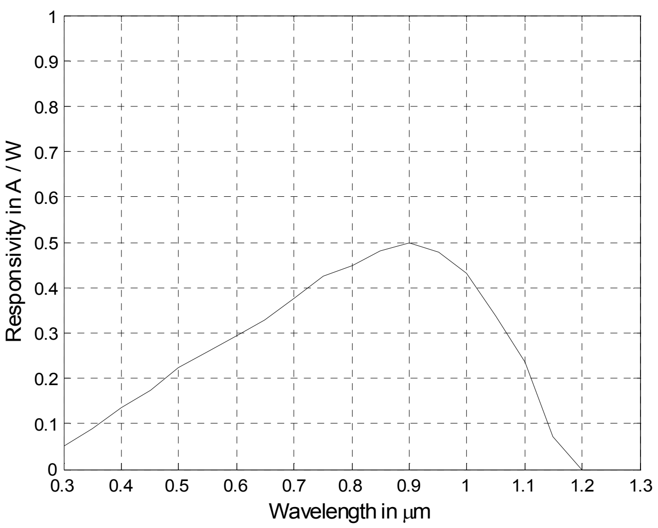

Figure 2: Typical Photodiode Responsivity Graph.

As seen in Figure 2, the maximum responsivity occurs at $\lambda = 0.9\ \mu m$. Notice also that above $\lambda = 1.2\ \mu m$, the photodiode does not detect any optical power. The wavelength $\lambda = 1.2\ \mu m$ is called the *cutoff wavelength*. Different types of photodiodes have different responsivity curves and thus also have different peak responsivity and cutoff wavelengths.

Because the responsivity of the photodiode is a strong function of wavelength, the internal circuit of the optical power meter, which can only sense the current generated by the photodiode, is usually designed to account for the dependence of R on λ. Otherwise, the meter will not be capable of displaying the correct optical power. Optical power meters usually have a wavelength setting. The user needs to select the correct wavelength of the light in order for the optical power meter to display the optical power correctly.

A *calibrated* optical power meter displays the correct value of the incident optical power *at a given wavelength*.

A *non-calibrated* optical power meter does not display the correct optical power. However, a non-calibrated optical power meter remains useful in optical power measurements, because it can be used to measure *relative* optical power. For instance, a non-calibrated optical power meter can be used to measure the loss of an optical element (see Appendix B). Let us assume that at a particular wavelength a non-calibrated optical power meter has a relative error κ. Instead of displaying the correct input and output power levels P_i and P_o, respectively, it will then display κP_i and κP_o, respectively. The ratio of the input to output powers in this case is given by:

$$\eta = \frac{\kappa P_i}{\kappa P_o} = \frac{P_i}{P_o} \qquad (1)$$

According to equation (1), a non-calibrated optical meter gives the correct ratio η. Another way to think of this idea is by finding the element loss in dB. Using equation (1), we have:

$$\begin{aligned} \mathrm{dB}_{Loss} &= 10\log\eta = 10\log\frac{\kappa P_i}{\kappa P_o} = (10\log\kappa P_i) - (10\log\kappa P_o) \\ &= (10\log\kappa + 10\log P_i) - (10\log\kappa + 10\log P_o) \\ &= (10\log\kappa - 10\log\kappa) + (10\log P_i - 10\log P_o) \\ &= 10\log P_i - 10\log P_o \qquad (2) \end{aligned}$$

Equation (2) shows that when taking the difference in the power levels in dB, the error in dB, given by $10\log\kappa$, simply cancels out. Equation (2) clearly shows that the dB error $10\log\kappa$ is the same for both the input and output power measurements. It should be obvious now that the dB error $10\log\kappa$ must be the same for all power measurements performed by the *same meter* at a *particular* wavelength.