Measuring the Sensitivity of the OMH-6709B Optical Measurement Head

TECH NOTE

The OMH-6709B is the latest edition to a family of Optical Measurement Heads used with the OMM-6810B. It offers a large dynamic range for very stable fiber optic power measurements in the near-IR.

The OMM6810B uses a transimpedance amplifier with several gain stages to convert the signal from the InGaAs photodiode sensor to voltage:

$$V_{ximp} = R_f I_D = R_f r_D(\lambda) P_{opt}$$

with Rf is the feedback resistance of the gain stage, and r(l) the responsivity of the photodiode. Unfortunately DC drift in the amplifier and noise from the photodiode and amplifier will limit maximum sensitivity. A zeroing procedure helps eliminate the effects of the DC drift but the noise of the system can only be minimized.

The 6709B uses a cooled InGaAs chip with zero bias. There are several contributions to noise but in the zero-bias configuration with no optical input, the noise is dominated by thermal (Johnson) noise. To estimate the NEP of the receiver, take into account noise from the amplifier, Dark current noise, etc.

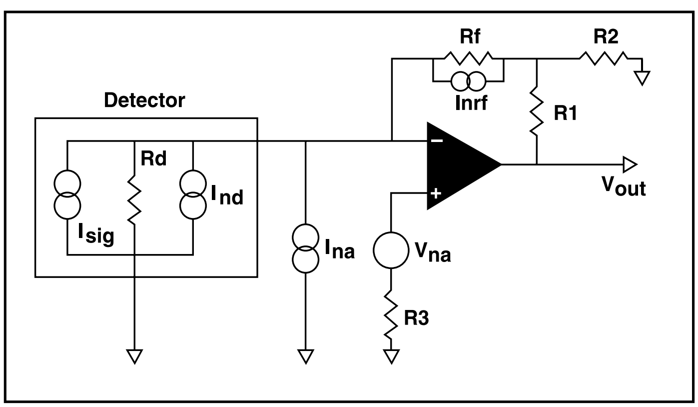

Figure 1. OMH-6709B Receiver Circuit.

Cooling of the InGaAs Photodiode sensor drastically increases the shunt resistance Rd of the detector, which reduces the current noise associated with the detector.

$$\bar{i}^2_{nd} = 4kT/R_d$$

At an operating temperature of -5°C, Rd can be as high as 200M Ω. In the highest gain range the feedback effective resistance is 9G Ω. See Table 1 for RMS current values.

SOURCE	RMS CURRENT A^2/Hz
Rd	$8.23x10^{-29}$
Rf	$1.83x10^{-30}$
InA*	$6.4x10^{-32}$

*Table 1. RMS Current Values. *Manufacturer's specification.*

Total current noise is calculated as the root sum square of these values.

$$\bar{i}^2_{noise} = \bar{i}^2_{na} + \bar{i}^2_{nd} + \bar{i}^2_{nRf}$$

$$\bar{i}^2_{noise} = 8.42 X 10^{-29} A^2 / Hz$$

The voltage noise associated with the amplifier is:

$$\bar{V}^2_{nd} = 8.6 X 10^{-15} V^2 / Hz$$

Now use the root sum square method to get the total voltage noise at the output of the receiver:

$$\bar{V}^2_{total} = 6.82 X 10^{-9} V^2 / Hz$$

$$NEP^2 = \frac{1}{r^2 R_f^2}\left(\bar{V}^2_{total}\right)$$

$$\Rightarrow NEP = \frac{1.02 X 10^{-14}}{r} W / \sqrt{Hz}$$

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Considering a 10 Hz bandwidth the NEP of the 6709B can be estimated at (reference 1mW)

$$\Rightarrow \text{NEP} = -104 \text{ dBm}$$

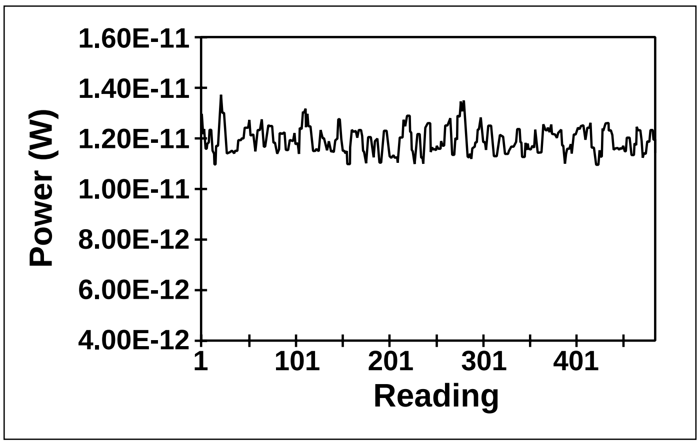

Figure 2. RMS Power OMH-6709B.

Figure 2 is a typical RMS power output curve for the OMH6709B. The detector was covered and the instrument was allowed to warm up. The zeroing function was not used here. Mean power is 11.9 pW and RMS noise is .05 pW (-103) dBm. Readings were taken over GPIB for 60 seconds on slow update rate. If the zero is on the mean, optical power is affected, but the RMS noise is relatively unaffected at .03 pW (-105 dBm). Operationally measurements should be made at least 10 dB above the noise floor. ILX specifies a conservative -90 dBm maximum sensitivity for the OMH6709B.