

OVERVIEW

This technical note discusses the optical power linearity test procedure and presents the results of high power linearity testing on the OMH-6790B / 6795B Power/Wave Heads used with the OMM-6810B Optical Multimeter.

BACKGROUND

The industry standard method for calibrating optical power meters is with a broadband light source and monochromator. The tuning range of the monochromator allows the meters to be calibrated over a wide wavelength range, but since the power output of the broadband source is typically very low and not adjustable, the power meter is calibrated at only a single optical power. In order to know the power measurement accuracy over the full dynamic range, the linearity of the power meter must be characterized, and stated in the specifications. The linearity specification of a power meter indicates how linear the absolute power measurement is over a wide power range.

The total system linearity is a product of the photodetector properties and the electronic gain circuits in the power meter. Photodetectors, by nature, are typically very linear over at least 6 decades, bounded on the low end by shot noise and on the high end by supralinearity effects and saturation. Non-linearity in the power meter gain circuits becomes especially obvious when the meter switches gain ranges. Figure 1 shows the combined effects of detector and gain circuit non-linearities.

ILX measures and verifies high power linearity during the design phase of our power meters and clearly documents the specification. Our NIST traceability is also thoroughly documented and is explained in a separate Application Note.

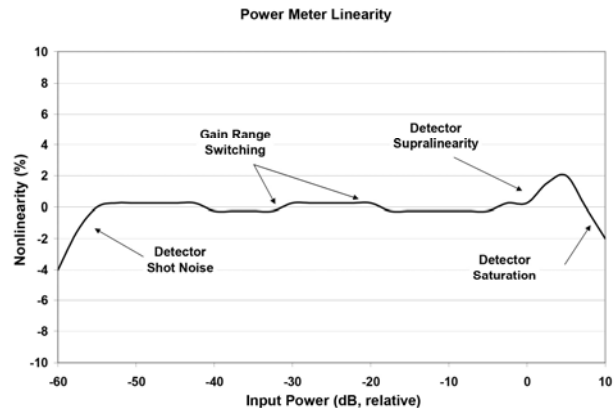


FIGURE 1 – Non-linearity Contributors

MEASUREMENT SETUP

The linearity test conducted by ILX Lightwave is based on the principle of power superposition. This method is self-calibrating and does not require a standard reference meter, so it is easy to duplicate the results in most laser laboratories. Figure 2 illustrates the linearity test configuration.

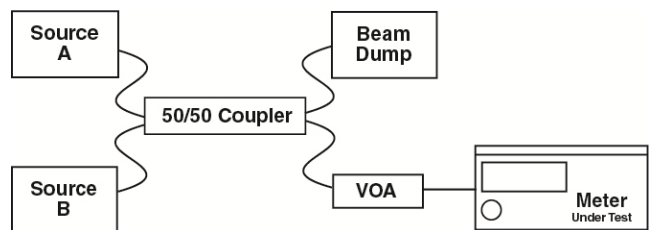


FIGURE 2 – Linearity Test Configuration

The test procedure is described numerically in Table 1, and is performed as follows: two separate stable sources of the same wavelength, labeled A and B, are combined in a 50/50 coupler and input to the meter-under-test through a variable optical attenuator (VOA).

Each laser is switched on separately and the VOA adjusted to the lowest power to be tested, and the individual power levels recorded and labeled P1A

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and P1B. Next, both lasers are switched on simultaneously, and the combined power is recorded and labeled P1CACTUAL. In the table, P1A and P1B are summed mathematically and called P1CIDEAL.

Next, each laser is separately switched on and the VOA adjusted to power level P1CIDEAL; the new power levels measured and labeled P2A and P2B. Then both lasers are switched on simultaneously; the combined power is recorded and labeled P2CACTUAL. The effect of this method is that the power is doubled (increased by 3.01dB) at each step.

The difference between the ideal and actual power values is the nonlinearity, and is calculated as:

$$\text{Nonlinearity} = 10 \cdot \log(\text{Combined Sum} / \text{Ideal Sum})$$

The total nonlinearity of the meter is the cumulative sum of all of the errors from each 3.01dB step over the range test. The worst-case cumulative dB delta is called the worst-case linearity performance of the detector head.

LINEARITY TEST RESULTS

As shown in Figure 3, the linearity performance of the OMH-6790B power/wave head is clearly well within the ILX Lightwave specification of ± 0.05 dB. Data was taken from approximately 0 to 500 mW in 3.01 dB steps. This test was run with two 1.0W SDL 920nm FP pump lasers.

Table 1 – Power Increment Schedule (Example Values)

Test Point	Source A Setting (uW)	Source B Setting (uW)	Combined Power Ideal (uW)	Combined Power Actual (uW)	Nonlinearity (dB)	Cumulative Nonlinearity (dB)
P1	1.1	1.1	2.1	2.130	0.002	0.002
P2	2.2	2.1	4.3	4.313	0.015	0.017
P3	4.2	4.3	8.5	8.471	-0.009	0.008
P4	8.4	8.3	16.7	16.714	-0.005	0.003
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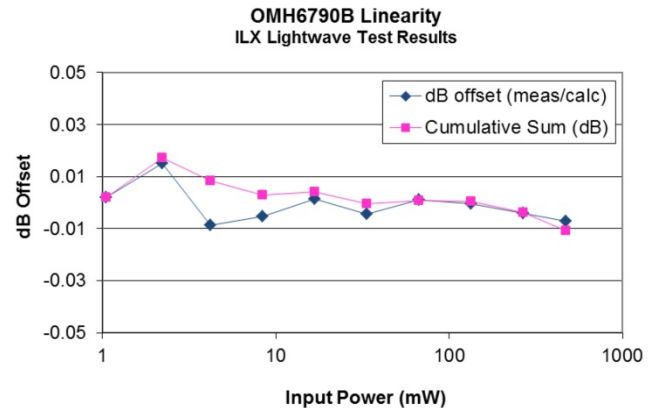


FIGURE 3 – Linearity Test Data for OMH-6790B Head

CONCLUSION

Photodetectors are, by nature, very linear over a wide range of optical input powers, but the power meter electronics can affect the overall system linearity. The power meter linearity must be characterized and specified to know the measurement accuracy and linearity over the full dynamic range.

The linearity specification for the OMM-6810B Optical Multimeter and OMH-6790B Power/Wave Head is ± 0.05 dB. Tested with the power superposition method, the actual results for this particular power meter indicate the linearity over the full dynamic range is within ± 0.017 dB.

The linearity of the OMH-6795B Power/Wave Head was verified using the same superposition method.

