

High Power Linearity of the OMM-6810B and OMH-6780B/6790B/6795B Detector Heads

PURPOSE

This technical note discusses the optical power linearity test procedure used by ILX Lightwave, and presents the results of high power linearity testing on the ILX Lightwave OMH-6780B Power/WaveHead 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.

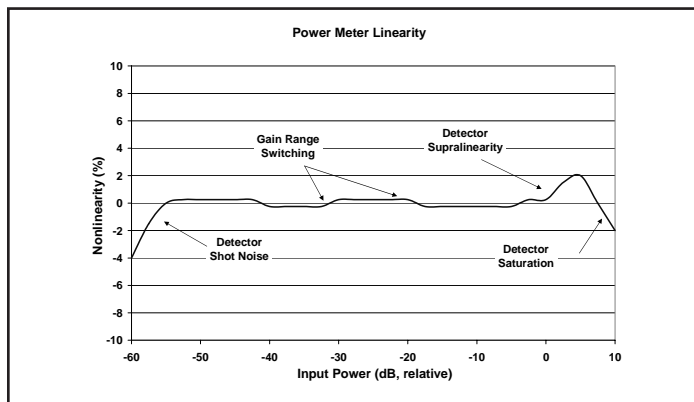


Figure 1 Non-linearity Contributors

ILX Lightwave 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 ILX Lightwave Application Note.

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.

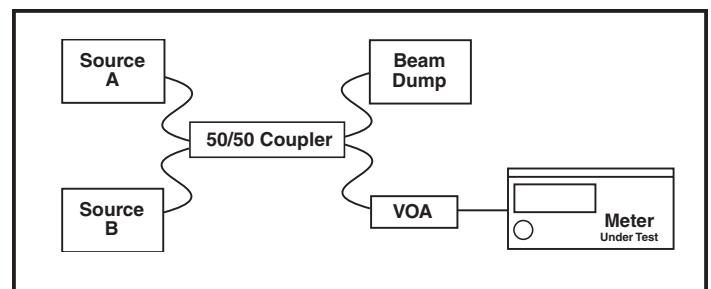


Figure 2 Linearity Test Configuration

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). The sources are nominally set equal to each other with the VOA adjusted to the lowest power to be tested. The individual power levels are then measured, recorded and labeled P1A and P1B. Next, both lasers are switched on simultaneously, and the combined power is recorded and labeled P1C_{ACTUAL}. In the table, P1A and P1B are summed mathematically and called P1C_{IDEAL}.

Next, each laser is separately switched on and the VOA adjusted to power level P1C_{IDEAL}; the new power levels measured and labeled P2A and P2B. Then both lasers are switched on



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Table 1 Power Increment Schedule (Example Values)

Test Point	Source A Setting (μW)	Source B Setting (μW)	Combined Power Ideal (μW)	Combined Power Actual (μW)	Nonlinearity (dB)	Cumulative Nonlinearity (dB)
P1	1.0	1.0	2.0	2.006	-0.013	-0.013
P2	2.0	2.0	4.0	3.995	0.005	-0.008
P3	4.0	4.0	8.0	8.008	-0.004	-0.012
P4	8.0	8.0	16.0	16.0	0.0	-0.012

simultaneously; the combined power is recorded and labeled $P2C_{ACTUAL}$. The result 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 test range. The worst-case cumulative dB delta is called the worst-case linearity performance of the power meter.

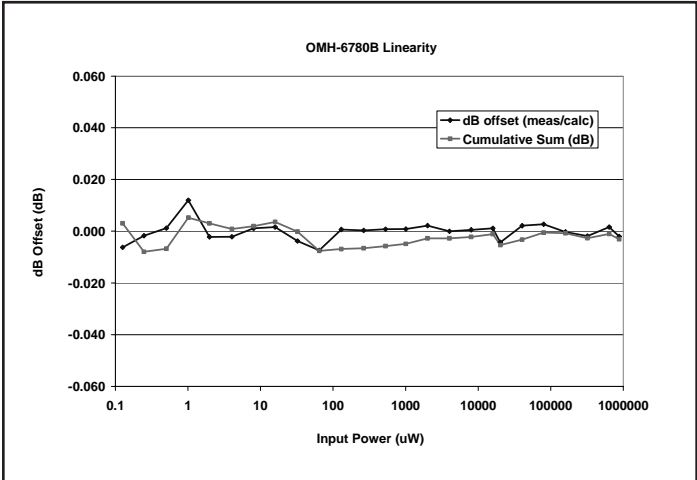


Figure 3 Linearity Test Data for OMH-6780B Measurement

RESULTS

As shown in Figure 3, the linearity performance of the OMH-6780B Power/WaveHead is clearly well within the ILX Lightwave specification of ±0.05 dB. Data was taken from approximately 100 nW to 1.0 W in 3.01 dB steps. This test was run with two 1.0 W SDL 920 nm FP pump lasers.

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-6780B Power/WaveHead 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 ±0.012 dB.

The linearity of the OMH-6790B/6795B Power/WaveHeads was verified using the same super position method.