L.2: A low cost, sensitive and high dynamic range CW laser power meter

A CW laser power meter with a large dynamic range and high sensitivity based on a single photodiode was developed in Laser Physics Applications Division of RRCAT. The principle of operation of the power meter was based on the conversion of incident laser light to a proportionate current by a photodiode followed by a current to voltage converter circuit, an offset balancing circuit, analog to digital converter (ADC), a atmel 89C4051 microcontroller and a LCD display. The analog voltage was digitized by an ADC, converted to power and displayed on a 2 lines × 16 characters alphanumeric LCD.

Typically photodiodes can easily measure the laser powers from micro to milli watt range. However, the laser power less than few nano watts are difficult to detect due to the presence of large back ground signal. The inherent noise in the circuit also poses serious limitation in the measurement of low powers. Photo diode based commercial power meter can measure power from about 10 pW to 300 mW. These power meters employ two photo diodes. The first photodiode measures the background light and the second photo diode records sum of the signal and the background light. The output signal is the difference signal from the two photo diodes. We developed a power meter with a large dynamic range and high sensitivity which is based on a single photodiode. The high sensitivity was achieved by incorporating an offset balancing circuit to compensate for the DC and low frequency noise of electronic circuit and to reduce the background noise due to stray light.

The power meter circuit requires ± 15V and 5V DC for its operation. These input voltages are sourced by a commercial power supply powered from 230V AC mains. The large area PIN photo diode S3590-01 from Hamamatsu with the operational amplifier and the feedback resistor converts the incident laser signal on the photodiode to an electrical signal. The feedback resistor of the current to voltage converter of the power meter (100Ω, 10KΩ, 1MΩ, 100MΩ or 5GΩ) is automatically selected by the auto ranging circuit depending on the input laser power level. The output of the current to voltage converter stage was applied as one of the inputs to a difference amplifier stage employing the operational amplifier. The difference amplifier is important part of offset balancing circuit. The second input to the difference amplifier is an offset compensating voltage variable from +5V to -5V. The offset compensating voltages are obtained from the variable voltage reference. The output of the difference amplifier was digitized by a slow dual slope ADC and was displayed on LCD. The current to voltage converter and offset balancing stage are fabricated with passive surface mount device components.

The power meter was calibrated with a commercial device. The absolute power was displayed on LCD panel by monitoring the power meter signal and the calibration factor. Micro controller was used both for the automatic adjustment of gain and to display the absolute laser power.

The dynamic range of the power meter was measured with a 200mW CW laser at a wavelength of 532 nm. The laser power incident on the photodiode was estimated by a commercial OPHIR NOVA power meter. The laser power incident on the power meter was scaled down by neutral density filters. The actual laser power incident on the power meter was obtained from the transmission factor of the neutral density filters. The laser power recorded by the power meter was displayed on the LCD. Fig. L.2.1. shows the laser power recorded by the power meter as a function of input laser power. The experimental data was fitted to a straight line passing through the origin. The minimum and the maximum CW laser power measured in the linear regime were about 1 pW and 80 mW respectively which correspond to the dynamic range of 8×10^{10}.

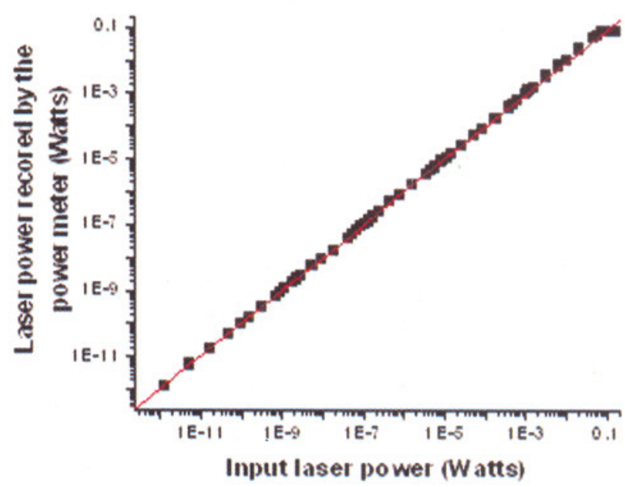

Fig. L.2.1. The plot of laser power recorded by power meter as a function of input laser power.

The response of the photodiode depends on the incident wavelength. Therefore, for the measurement of the laser power at any other wavelength, the power meter should be calibrated with the commercial power meter.

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