To thoroughly characterize a Q-switched laser system, certain beam parameters must be known. Several of these parameters can be easily measured and used to calculate the rest.

**Measured Parameters:**
- Average Power
- Repetition Rate
- Pulse Duration

**Calculated Parameters:**
- Energy per Pulse
- Peak Power

Average power is measured using a direct reading power meter. Since average power is measured while the laser is Q-switching (pulsing), the repetition rate at which the measurement was taken should be noted. Repetition rate is measured by observing the output pulse train on an oscilloscope, and determining the number of pulses per second. Pulse duration is determined by viewing the laser output on an oscilloscope and applying the full-width-half-maximum (FWHM) criteria (See Figure 1).

![Figure 1. Typical Pulse from a U.S. Laser Q-switched laser](image-url)
CALCULATIONS:

Energy per pulse:
Energy per pulse is determined by dividing the average power by the repetition rate. The resultant quantity is the energy, in Joules, contained in EACH laser pulse.

\[ E = \frac{P_{av}}{R_{rate}} \]

Where:
\( E \) = Energy in Joules
\( P_{av} \) = Average power in Watts
\( R_{rate} \) = Repetition rate in pulses per Second.

Peak Power per Pulse:
Peak Power per pulse is determined by dividing the energy per pulse by the pulse duration.

\[ P_{pk} = \frac{E}{D_{pulse}} \]

Where:
\( P_{pk} \) = Peak power in Watts
\( E \) = Energy per pulse in Joules
\( D_{pulse} \) = Pulse duration at the full-width-half-maximum points.

Example 1:
A laser is operated at a 5 kHz repetition rate, at an average power of 2 Watts. Using this information, we can calculate the energy per pulse as follows:

\[ E = \frac{2}{5000} = 0.0004 \text{ Joules} = 0.4 \times 10^{-3} \text{ Joules (0.4 millijoules) per pulse}. \]

Example 2:
In the previous example we determined that the 2 Watt average power laser operating at 5 kHz has a pulse energy output of 0.4 millijoules. In addition, assume that we measured the pulse duration to be 150 nanoseconds \((10^{-9} \text{ seconds})\). With this information, the peak pulse power can be calculated as follows:

\[ P_{pk} = \frac{0.4 \times 10^{-3}}{150 \times 10^{-9}} = 2.667 \times 10^{3} \text{ Watts (2.67 kilowatts)}. \]