Al-Mustaqbal University

College of Engineering & Technology

Biomedical Engineering Department

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Lecture No.:-4

Lecture Title: [Types of Lasers]

Types of Lasers

Lasers may be classified according to several criteria:

1. Based on the mode of operation:

• Pulsed system (single pulsed or repetitively pulsed).
• Continuous wave system.
• Single pulsed Q-switched system.
• Mode locked system.

2. Based on the mechanism in which population inversion is achieved or the number of energy levels which participate in the lasing process;

• Three level system.
• Four level system.

3. Based on the active medium state (gain medium);

• Gas laser.
• Solid state laser.
• Semiconductor laser.
• Tunable dye laser.

4. Based on the characteristics of the laser radiation;

- Fixed frequency.
- Tuneable

5. Based on the excitation mechanism (pumping) method of the active medium;

- Optical pumping.
- Electrical pumping.
- Laser pumping.

6. Based on the laser output power or the power delivered by the laser;

- Low.
- Medium.
- High.

7. Based on the spectral range of the laser wavelength (Emission range):

- Ultra-Violet (UV) spectrum.
- Visible spectrum.
- Infra-Red (IR) spectrum.

8. Based on the efficiency of the laser system

9. Based on the applications

- Industrial and Commercial
- Medical
- Scientific
- Military

Continuous and Pulsed Lasers

A CW laser is one whose power output undergoes little or no fluctuation with time. It exhibits a steady flow of coherent energy. Helium neon and argon gas lasers are typical examples. They are said to operate in the "CW mode."

A larger group of lasers has output beams that Undergo marked fluctuations; that is, the beams' power changes with time in a very noticeable fashion. They are said to operate in the "pulsed mode." Nd:YAG solid crystal lasers and CO2 gas lasers, are operated in the pulsed mode.

The total energy of the pulse and the total pulse duration remain essentially the same from shot to shot for such a laser. But the maximum output power reached during one pulse may be very different from that of the next. For this reason, such lasers often are classified according to energy per pulse and pulse duration.

Characterization of Pulsed Laser Outputs

Pulsed lasers may be divided into two further subclasses

1. Single pulsed lasers (produce one pulse of light per laser operation).
2. Repetitively pulsed lasers (produce a train of pulses at equal spacing whenever the laser is in operation).

Single Pulsed Lasers

Figure (1) gives the power of a single laser pulse as a function of time. The maximum power of the pulse is Pmax. The total duration of the pulse at the base line is difficult to determine because the pulse dies out slowly toward zero power. The most convenient method of measuring the temporal length of the pulse is at the half power point (1/2 Pmax).

Pulse duration or pulse width is the duration of the pulse at one-half the maximum power. This relationship sometimes is referred to as the full width at half maximum (FWHM) and is represented by Δt1/2. (others often use simply t, or T, for the pulse width).

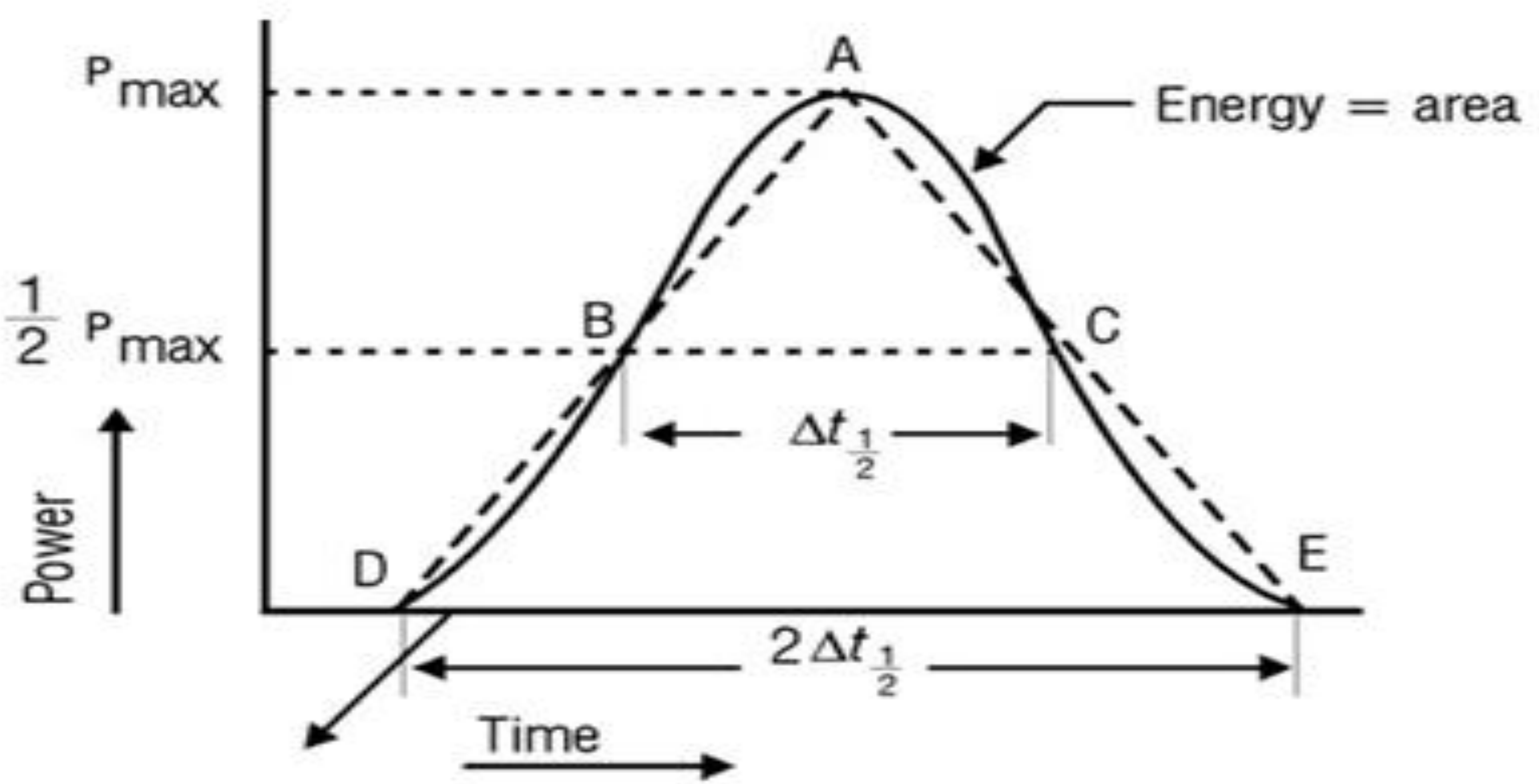

Figure (1): Single pulsed laser

Since "power" is defined as “energy divided by time”, energy is the product of power and time. The total energy of the pulse is represented by the area under the power curve. The area of triangle ADE in the Figure (1) can be determined from:

A = 1/2 bh

where: b = Length of triangle base and h = Height of triangle.

The base of the triangle in the figure is 2Δt1/2; therefore one-half the base is the pulse duration, Δt1/2. The height of the triangle is the maximum power of the pulse Pmax. Substitution of these quantities into the above equation yields;

$$E = (\Delta t1/2)(Pmax) \qquad (1)$$

The energy content of a laser pulse is the product of the maximum power and the pulse duration. In most practical situations, measurements of pulse duration and energy can be made. Measurements of pulse power cannot be made; therefore, the most useful form of Equation 1 is that for maximum power given in Equation 2:

$$P_{max} = \frac{E}{\Delta t_{1/2}} \qquad (2)$$

- Example: The output pulse from a Q-switched ruby laser has a duration of 5 ns and an energy of 1 J. Find the maximum power. Answer: Pmax=200 MW