# CHAPTER TWO

# Meaning Of Flicker

## 2.1 Definition of flicker

A precise definition of lamp flicker can be found in the international electro technical vocabulary (IEV 161-08-13) (1) which we quote the impression of unsteadiness of visual sensation inducted by a light stimulus whose luminance or spectral distribution fluctuates with time. Thus flicker can be considered of physiological quantity rather than simply a physical quantity since the impression of visual sensation may vary from person to person.

Physically flicker can be considered as variation in the lamination intensity of electric lighting devices cause by the fluctuation in its supply voltage.

Flicker is a symptom of voltage fluctuation which can be caused by disturbances introduced during power generation transmission or distribution, but are typically caused by the use of large fluctuating loads, i.e. loads that have rapidly fluctuating active and reactive power demand.

## 2.2 Voltage fluctuation

Voltage fluctuations can be described as repetitive or random variations of the voltage envelope due to sudden changes in the real and reactive power drawn by a load. The characteristics of voltage fluctuations depend on the load type and size and the power system capacity. Voltage fluctuation, or variation in the voltage the electrical outlet, can be system. For most consumers, power generated by many large generators comes to them through a high-voltage electrical transmission network, or grid. Power flows through this grid at voltages around 100 or 200 kV to a substation where the voltage is reduced by a transformer to a lower voltage, typically 12 to 25 kV. It then flows through an underground or overhead distribution system until it reaches a distribution transformer, where it is reduced further to the consumer voltage (typically 120/240 V in a single-phase service or 120/208 V or 347/600 in a three-phase service). The power then flows through a service conductor to the customer meter and distribution panel and through the building electrical system to the outlet or light fixture the voltage at the outlet is determined by two factors: the generator output voltage and the voltage drop, or loss, in the transmission and distribution system. Rapid variations in the generator output voltage occur very infrequently. BC Hydro manages voltages at different points in the grid to maintain maximum efficiency and proper flow of power, and changes to voltage and power flow are carried out slowly in a controlled manner. For any line, the voltage at the load end is different from that at source. This can be demonstrated from the per phase equivalent circuit in figure 2.1a. The relationship(2.1 below ) illustrates how the value of the voltage difference ΔV, defend in (figure 2.1b), Can be drive from the phasor diagram and simple geometrical rules

$$E - \frac{Vo}{Vo} = \frac{\Delta V}{Vo} = Rs\,\frac{P}{Vo^2} + Xs\,\frac{Q}{Vo^2} = Rs\,\frac{P}{Vo}^{2} + \frac{Q}{Ssc} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.1)$$

Where:

E= the source voltage.

Vo= the voltage at the load terminals.

Io= current.

Zs,Xs,Rs= equivalent impedance ,reactance and resistance of the line respectively.

Ssc= short-circuit power at the point of load connection.

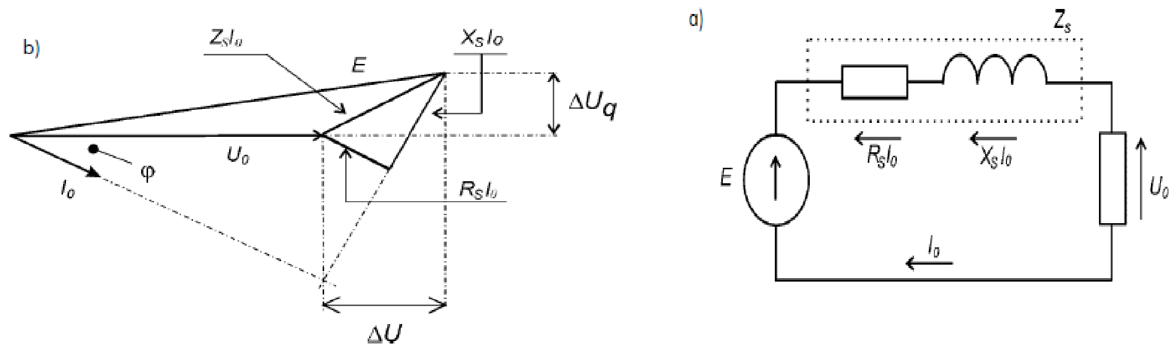



**Fig [2.1] per phase equivalent circuit of supply net work (a)And phasor diagram for resistive-inductive load E≥Vo (b)**

Assuming that the equivalent resistance of the line is negligibly small compared its reactance (Xs>10Rs), which holds true of practical MV and HV supply systems, the following relationship defined the relative value of voltage of change at load-end of the line:

$$\frac{\Delta V}{Vo} = Q/Ssc \quad \text{..........}(2.2)$$

Depending on its cause, voltage ΔV can take the form of voltage drop having a constant value over a long time internal, a slow or rapid voltage change, or voltage fluctuation. Voltage fluctuation defined as a series of (r.m.s) voltage change or a cycle variation of the wave form envelope (see fig [2.3]).

## 2.3 Background on flicker research

Flickering phenomenon disturbs human beings,the most sensitive part to this phenomenon is the eye.to study this phenomena we have to know informations about visual system and measurements which produces light.

## 2.3.1 The response of the eye

Like other human senses,the eye has amazing capabilities without concious thought our eye can adapt to light levels varying by afactor of 10000 from bright sun light to faint star light .despite that enormous dynamic range we can detect variation in brightness of less than 1% even more impressive dedicated parts of the brain filter the incoming information, removing background clutter and extracting the most important features. our eyes are also extraodinarily sensitive to rapid change.as the light level gradually drops by a factor of 100 at dusk, we may be almost unaware of the ghange, but a1%step change in ambient light level due to a sudden change in voltage will almost certaimly attract our attention

Fundamental constraints on the response of the eye limit our perception of very rapid events .the mechanisms of converting light into nerve impulses take a finite time to occur ,so the brain has averaging mechanisms that smooth out the time delay between nerve impulses, presenting us with a constant picture.

Gaps shorter than about 50 milliseconds are filled in,as our processing system ignores them as it would variation in nerve impulses,and averages them out.

We are,therefore,quite insensitive to changes that occur at frequencies above about 20 cycles per second.our television and electric lights run at 60 cycles per second,fast enough that they do not appear to flicker

## 2.3.2 Visible Light

our eyes are sensitive to a very narrow band of frequencies within the enormous range of frequencies of the electromagnetic spectrum. This narrow band of frequencies is referred to as the visible light spectrum.Visible light - that which is detectable by the human eye - consists of wavelengths ranging from approximately780 nanometer ($7.80 \times 10^{-7}$ m) down to 390 nanometer ($3.90 \times 10^{-}$

$^{7}$ m). Specific wavelengths within the spectrum correspond to a specific color based upon how humans typically perceive light of that wavelength. The long wavelength end of the spectrum corresponds to light that is perceived by humans to be red and the short wavelength end of the spectrum corresponds to light that is perceived to be violet. Other colors within the spectrum include orange, yellow, green and blue. The graphic below depicts the approximate range of wavelengths that are associated with the various perceived colors within the spectrum.

## 2.4 Lamp characteristics

A lamp is a device that converts electrical power into the light. However, the conversion methods are essentially different for the different lamp types. The characteristics of the different lamp types are therefore also different.

### Incandescent lamp:

Incandescent lamp or incandescent light globe is an electric light which produces light with a wire filament heated to a high temperature by an electric current passing through it, until it glows

Incandescent bulbs are manufactured in a wide range of sizes, light output, and voltage ratings, from 1.5 volts to about 300 volts. They require no external regulating equipment, have low manufacturing costs, and work equally well on either alternating current or direct current. As a result, the incandescent lamp is widely used in household and commercial lighting,

Incandescent bulbs are much less efficient than most other types of electric lighting; incandescent bulbs convert less than 5% of the energy they use into visible light with standard light bulbs averaging about 2.2%. The remaining energy is converted into heat. The luminous efficacy of a typical incandescent bulb is 16 lumens per watt, compared with 60 lm/W for a compact fluorescent bulb or 150 lm/W for some white LED lamps. Incandescent bulbs typically have short lifetimes compared with other types of lighting; around 1,000 hours for home light bulbs versus typically 10,000 hours for compact fluorescents and 30,000 hours for lighting LEDs.

## 2.5 Permissible flicker

The permissible amount of flicker voltage cannot be stated concisely for several reasons. There is first the human element; one individual may think objectionable a flicker not perceptible to another. The lighting fixture used is of considerable importance. The in candescent lamps (smaller wattage) is more sensitively to change in supply voltage (change its luminous flux more quickly) than lamps with heavier filaments. The character of the voltage change is also take place, cyclic voltage changes are more objectionable than non-cyclic. On non-cyclic changes the annoyance due to the flicker is affected by the rate of change, duration of change, and frequency of occurrence of the flicker. Scientific studies have been carried out in many countries to analysis flicker problem .The most complete analysis is found in the report "The Visual Perception and Tolerance of Flicker," prepared by Utilities Coordinated Research, Inc. and printed in 1937. Fig [2.3] shows the cyclic pulsation of voltage at which flicker of 115 volt tungsten-filament lamp is just perceptible. Derived from 1104observations by 95 persons in field tests of 25-watt, 40-watt, and 60-watt lamps conducted by Commonwealth Edison Company. Figures on curves denote percentages of observers expected to perceive flicker when cyclic voltage pulsations of Indicated values and frequencies are impressed on lighting circuits. Plotted points denote medians of observation- at various frequencies, number of observations in each case being indicated by adjacent figures.

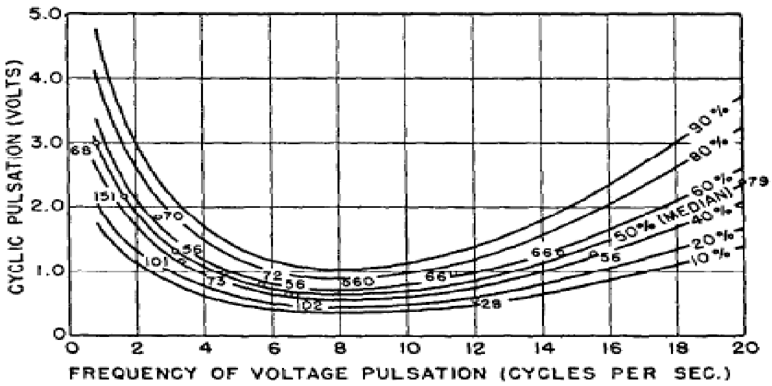
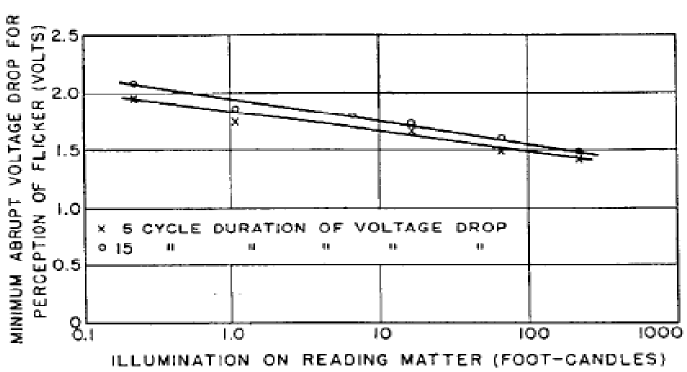



**Fig [2.2] cyclic pulsations of voltage at which flicker of 115-volt tungsten filament lamp is just perceptible.**

At the rate of variation was 8 cycles per second, The Flickers as low as 1/3 volts was perceptible in 10 percent of the observations. The flicker was perceptible in 90 percent of the observations when the voltage change had to be over one volt at the same frequency.

Fig [2.3] shows the minimum abrupt, voltage dip to cause perceptible flicker in a 60-watt, 120-volt tungsten-filament lamp, as a function of intensity of illumination. Curves are shown for 5 and 15 cycles (60 cycles per second basis) durations of voltage dip. Abrupt voltage dips of 1.5 to 2.0 volts were perceptible.




**Fig[2.3] -Minimum abrupt voltage drop for perception of flicker of 60-watt, 120-volt coiled-coil tungsten-filament lamps.**

Each point represents the means of the observation of 44 persons.

In fig [2.4] the curve shows quite clearly that whereas an abrupt change of about 11/2 volts is perceptible, a change of 5 volts or more is necessary before voltage variations requiring several seconds for completion can he perceived.

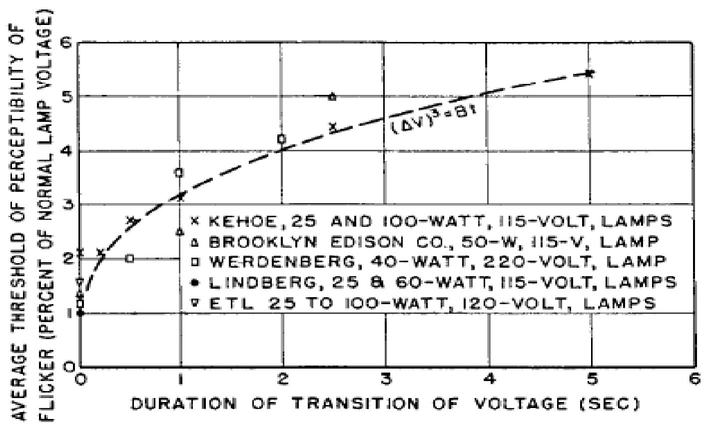



**Fig [2.4] : Effect of duration of transition of voltage on average Threshold of perceptibility of flicker of tungsten-filament lamps.**

Figures from [2.2] to [2.4] show the perceptibility for various classes of flicker, a perceptible flicker is not necessarily an objectionable one, these are not working limits.

Fig [2.5] shows the recommended maximum allowable cyclic variation of voltages as set up by various authorities for their own use (it show quite clearly that The individual judgment enter the problem).

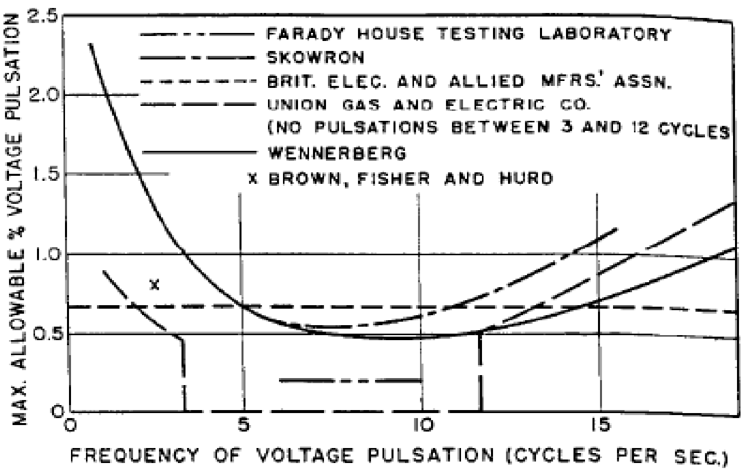



**Fig [2.5] recommended maximum allowable cyclic variation of voltage.**

The large variations are permissible for non-cyclic than for cyclic variations, but that the amount of tolerable dip depends upon the frequency of occurrence and the class of service. Here again, judgment is an important factor as well as technical facts. The maximum allowable fluctuations practiced by one operating company are shown in Table [2.1]. This is a very comprehensive set of standards and has proved satisfactory in practice.

**Table [2.1] maximum allowable voltage fluctuation**

| Class of Service | Volts on 115 Volt Basis | | | |
|---|---|---|---|---|
| | Infrequent | Frequent | Very* Frequent | Extremely Frequent |
| A. *On a substation bus feeding only power lines.................... | 6 | 4 | 3 | 3 |
| B. *On a power line primary whose entire output is not taken by the one customer and read at the customer's premises........... | 8 | 6 | 4 | 4 |
| C. On a power line whose entire output is taken by one customer and read at the customer's premises | No | definit | e Limi | t |
| D. On a substation bus feeding distribution circuit and on distribution circuit primaries.......... | 6 | 3** | 2 | 2 |
| E. On a distribution circuit secondary: | | | | |
| (a) At the secondary customer causing the fluctuation..... | 6 | 6 | 4 | 3 |
| (b) At the secondary customer not causing the fluctuation.. | 6 | 5** | 3** | 2 |

## 2.6 The range of annoyance flicker:

In general, voltage fluctuation and lamp flicker happen due to sudden current due to the motor start the nature of the load, as in the compressor, welding machine, shovel, pump, iron bunch, etc. And the range of the resulting annoyance depends on the range of voltage change during the cycle of each fluctuation, and the number of fluctuation. Fig [2.2] show quite clearly that, the number of voltage fluctuation above the line is not permissible (un-permissible fluctuation region) for lighting. For example, if the rated voltage is 120 volt, then the maximum number of fluctuation per hour most not exceed than 3 once if the voltage dip of each fluctuation cycle is 5 volt. And the sinusoidal portion of the curve is used for compressor and similarly characteristic machine.