G PULLAIAH COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ENERGY AUDITING AND DEMAND SIDE MANAGEMENT (15A02706)

UNIT-3

LIGHTING AND ENERGY INSTRUMENTS FOR AUDIT

3.1 BASIC TERMS & DEFINITIONS

Term	Definition
Luminaire	It is a device that distributes, filters or transforms the light emitted from one or more lamps
Illuminance	This is the quotient of the illuminous flux incident on an element of the surface at a point of surface containing the point, by the area of that element.
Lux(lx)	This is the illuminance produced by a luminous flux of one lumen, uniformly distributed over a surface area of one square metre. One lux is equal to one lumen per square meter.
Luminous Efficacy (lm/W)	This is the ratio of luminous flux emitted by a lamp to the power consumed by the lamp. It is a reflection of efficiency of energy conversion from electricity to light form.
Colour Rendering Index (RI)	Is a measure of the degree to which the colours of surfaces illuminated by a given light source confirm to those of the same surfaces under a reference illuminent; suitable allowance having

3.2 Some Good Practices in Lighting

Installation of energy efficient fluorescent lamps in place of "Conventional" fluorescent lamps.

Energy efficient lamps are based on the highly sophisticated tri-phosphor fluorescent powder technology. They offer excellent colour rendering properties in addition to the very high luminous efficacy

3.2.1 Installation of Compact Fluorescent Lamps (CFL's) in place of incandescent lamps.

Compact fluorescent lamps are generally considered best for replacement of lower wattage incandescent lamps. These lamps have efficacy ranging from 55 to 65 lumens/Watt. The average rated lamp life is 10,000 hours, which is 10 times longer than that of a normal incandescent lamps. CFL's are highly suitable for places such as Living rooms, Hotel lounges, Bars, Restaurants, Pathways, Building entrances, Corridors, etc.

3,2,2 Installation of metal halide lamps in place of mercury / sodium vapour lamps.

Metal halide lamps provide high color rendering index when compared with mercury & sodium vapour lamps. These lamps offer efficient white light. Hence, metal halide is the choice for colour critical applications where, higher illumination levels are required. These lamps are highly suitable for applications such as assembly line, inspection areas, painting shops, etc. It is recommended to install metal halide lamps where colour rendering is more critical.

3.2.3 Installation of High Pressure Sodium Vapour (HPSV) lamps for applications where colour rendering is not critical.

High pressure sodium vapour (HPSV) lamps offer more efficacy. But the colour rendering property of HPSV is very low. Hence, it is recommended to install HPSV lamps for applications such street lighting, yard lighting, etc.

3.2.4 Installation of LED panel indicator lamps in place of filament lamps.

Panel indicator lamps are used widely in industries for monitoring, fault indication, signaling, etc. Conventionally filament lamps are used for the purpose, which has got the following disadvantages:

- High energy consumption (15 W/lamp)
- Failure of lamps is high (Operating life less than 1,000 hours)
- Very sensitive to the voltage fluctuations Recently, the conventional filament lamps are being replaced with Light Emitting Diodes (LEDs). The LEDs have the following merits over the filament lamps.
- Lesser power consumption (Less than 1 W/lamp)
- Withstand high voltage fluctuation in the power supply.
- Longer operating life (more than 1,00,000 hours)

It is recommended to install LEDs for panel indicator lamps at the design stage.

3.3 Light distribution

Energy efficiency cannot be obtained by mere selection of more efficient lamps alone. Efficient luminaires along with the lamp of high efficacy achieve the optimum efficiency. Mirror- optic luminaires with a high output ratio and bat-wing light distribution can save energy.

For achieving better efficiency, luminaires that are having light distribution characteristics appropriate for the task interior should be selected. The luminaires fitted with a lamp should ensure that discomfort glare and veiling reflections are minimised. Installation of suitable luminaires, depends upon the height - Low, Medium & High Bay. Luminaires for high intensity discharge lamp are classified as follows:

- Low bay, for heights less than 5 metres.
- Medium bay, for heights between 5 – 7 metres.
- High bay, for heights greater than 7 metres.

System layout and fixing of the luminaires play a major role in achieving energy efficiency. This also varies from application to application. Hence, fixing the luminaires at optimum height and usage of mirror optic luminaries leads to energy efficiency.

Light Control

The simplest and the most widely used form of controlling a lighting installation is "On-Off" switch. The initial investment for this set up is extremely low, but the resulting operational costs may be high. This does not provide the flexibility to control the lighting, where it is not required.

Hence, a flexible lighting system has to be provided, which will offer switch-off or reduction in lighting level, when not needed. The following light control systems can be adopted at design stage:

Grouping of lighting system, to provide greater flexibility in lighting control

Grouping of lighting system, which can be controlled manually or by timer control.

Installation of microprocessor based controllers

Another modern method is usage of microprocessor / infrared controlled dimming or switching circuits. The lighting control can be obtained by using logic units located in the ceiling, which can take pre-programme commands and activate specified lighting circuits. Advanced lighting control system uses movement detectors or lighting sensors, to feed signals to the controllers.

Optimum usage of day lighting

Whenever the orientation of a building permits, day lighting can be used in combination with electric lighting. This should not introduce glare or a severe imbalance of brightness in visual environment. Usage of day lighting (in offices/air conditioned halls) will have to be very limited, because the air conditioning load will increase on account of the increased solar heat dissipation into the area. In many cases, a switching method, to enable reduction of electric light in the window zones during certain hours, has to be designed.

Installation of "exclusive" transformer for lighting

In most of the industries, lighting load varies between 2 to 10%. Most of the problems faced by the lighting equipment and the "gears" is due to the "voltage" fluctuations. Hence, the lighting equipment has to be isolated from the power feeders. This provides a better voltage regulation for the lighting. This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.

Installation of servo stabilizer for lighting feeder

Wherever, installation of exclusive transformer for lighting is not economically attractive, servo stabilizer can be installed for the lighting feeders. This will provide stabilized voltage for the lighting equipment. The performance of "gears" such as chokes, ballasts, will also improved due to the stabilized voltage. This set up also provides, the option to optimise the voltage level fed to the lighting feeder. In many plants, during the non-peaking hours, the voltage levels are on the higher side. During this period, voltage can be optimised, without any significant drop in the illumination level.

Installation of high frequency (HF) electronic ballasts in place of conventional ballasts

New high frequency (28–32 kHz) electronic ballasts have the following advantages over the traditional magnetic ballasts:

Energy savings up to 35%

Less heat dissipation, which reduces the air conditioning load

- Lights instantly
- Improved power factor
- Operates in low voltage load
- Less in weight
- Increases the life of lamp

3.4 WATTMETERS

The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements.

3.4.1 Construction of a Wattmeter

The internal construction of a wattmeter is such that it consists of two cols. One of the coil is in series and the other is connected in parallel. The coil that is connected in series with the circuit is known as the current coil and the one that is connected in parallel with the circuit is known as the voltage coil. These coils are named according to the convention because the current of the circuit passes through the current coil and the voltage is dropped across the potential coil, also named as the voltage coil. The needle that is supposed to move on the marked scale to indicate the amount of power is also attached to the potential coil. The reason for this is that the potential coil is allowed to move whereas the current coil is kept fixed. The mechanical construction of a wattmeter is shown in the Fig. 3.1 below.

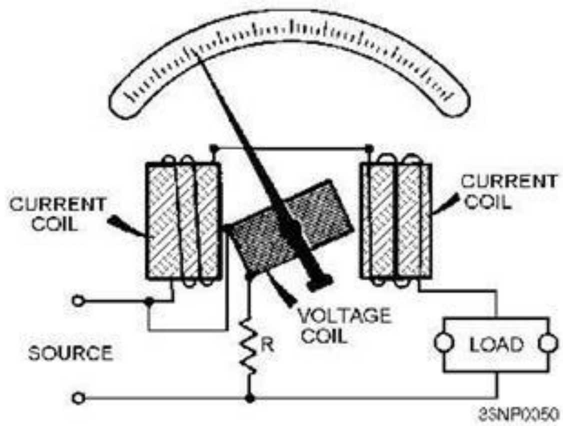


Fig. 3.1: Construction of a Wattmeter

3.4.2 Working of a Wattmeter

When the current passes through the current coil, it creates an electromagnetic field around the coil. The strength of this electromagnetic field is directly proportional to the amount of current passing through it. In case of DC current, the current is also in phase with its generated electromagnetic field. The voltage is dropped across the potential coil and as a result of this complete process, the needle moves across the scale. The needle deflection is such that it is according to the product of the current passing and the voltage dropped, that is, $P = VI$.

This was the case of DC power. We know that the AC power is given by the formula $P = VI\cos\theta$, and we know that this $\cos\theta$ factor is because of the fact that the current and voltage are not in phase. The measurement principle of wattmeter is shown in the Fig. 3.2 below:

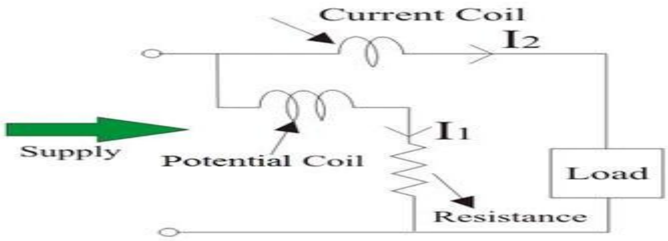


Fig. 3.2 Principle of Wattmeter

3.4.3 Applications of Wattmeter

1. As other measuring instruments, watt meters are also used extensively in electrical circuit measurement and debugging.

2. They are also used in industries to check the power rating and consumption of electrical appliances.

3. Electromagnetic watt meters are used to measure utility frequencies.

4. They are used with refrigerators, electric heaters and other equipment to measure their power ratings

3.5 Data loggers

A data logger (also data logger or data recorder) is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors. Increasingly, but not entirely, they are based on a digital processor (or computer). They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer, and use software to activate the data logger and view and analyze the collected data, while others have a local interface device (keypad, LCD) and can be used as a stand-alone device.

Data loggers vary between general purpose types for a range of measurement applications to very specific devices for measuring in one environment or application type only. It is common for general purpose types to be programmable; however, many remain as static machines with only a limited number or no changeable parameters. Electronic data loggers have replaced chart recorders in many applications

Applications of data logging include:

- Unattended weather station recording (such as wind speed / direction, temperature, relative humidity, solar radiation).
- Unattended hydrographic recording (such as water level, water depth, water flow,

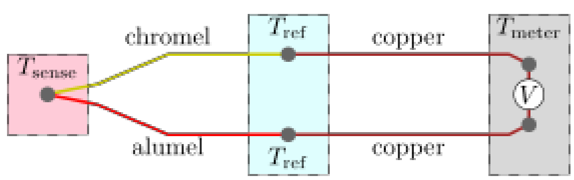
water pH, water conductivity).

- Unattended soil moisture level recording.
- Unattended gas pressure recording.
- Offshore buoys for recording a variety of environmental conditions.
- Road traffic counting.
- Measure variations in light intensity.
- Process monitoring for maintenance and troubleshooting applications.

3.6 Thermocouple

A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature- dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor.

Thermocouples are widely used in science and industry. Applications include temperature measurement for kilns, gas turbine exhaust, diesel engines, and other industrial processes. Thermocouples are also used in homes, offices and businesses as the temperature sensors in thermostats, and also as flame sensors in safety devices for gas-powered appliances.



The standard configuration for thermocouple usage is shown in the figure. Briefly, the desired temperature Tsense is obtained using three inputs—the characteristic function E(T) of the thermocouple, the measured voltage V, and the reference junctions' temperature Tref. The solution to the equation E(Tsense) = V + E(Tref) yields Tsense. These details are often hidden from the user since the reference junction block (with Tref thermometer), voltmeter, and equation solver are combined into a single product.

A thermocouple produces small signals, often microvolts in magnitude. Precise measurements of this signal require an amplifier with low input offset voltage and with care taken to avoid thermal emfs from self-heating within the voltmeter itself. If the thermocouple wire has a high resistance for some reason (poor contact at junctions, or very thin wires used for fast thermal response), the measuring instrument should have high input impedance to prevent an offset in the measured voltage. A useful feature in thermocouple instrumentation will simultaneously measure resistance and detect faulty connections in the wiring or at thermocouple junctions.

Applications

Thermocouples are suitable for measuring over a large temperature range, from −270 up to 3000 °C (for a short time, in inert atmosphere). Applications include temperature measurement for kilns, gas turbine exhaust, diesel engines, other industrial processes and fog machines. They are less suitable for applications where smaller temperature differences need to be measured with high accuracy, for example the range 0–100 °C with 0.1 °C accuracy. For such applications thermistors, silicon bandgap temperature sensors and resistance thermometers are more suitable.

- Steel industry
- Gas appliance safety
- Thermopile radiation sensors
- Power production

3.7 Pyrometers

A pyrometer is a type of remote-sensing thermometer used to measure the temperature of a surface. Various forms of pyrometers have historically existed. In the modern usage, it is a device that from a distance determines the temperature of a surface from the spectrum of the thermal radiation it emits, a process known as pyrometry and sometimes radiometry.

Design

A modern pyrometer has an optical system and a detector. The optical system focuses the thermal radiation onto the detector. The output signal of the detector (temperature T) is related to the thermal radiation or irradiance j* of the target object through the Stefan– Boltzmann law, the constant of proportionality σ, called the Stefan-Boltzmann constant and the emissivity ε of the object.

$$J=\varepsilon\sigma T^4$$

This output is used to infer the object's temperature from a distance, with no need for the pyrometer to be in thermal contact with the object; most other thermometers (e.g. thermocouples and resistance temperature detectors (RTDs)) are placed in thermal contact with the object, and allowed to reach thermal equilibrium. Pyrometry of gases presents difficulties. These are most commonly overcome by using thin filament pyrometry or soot pyrometry. Both techniques involve small solids in contact with hot gases

Applications

Pyrometers are suited especially to the measurement of moving objects or any surfaces that can not be reached or cannot be touched. Thermocouples were the traditional devices used for this purpose, but they are unsuitable for continuous measurement because they melt and degrade.

- Salt bath
- steam boiler
- hot air balloon
- gas turbine

3.8 Lux meter

The lux (symbol: lx) is the SI derived unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square metre. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface. It is analogous to the radiometric unit watt per square metre, but with the power at each wavelength weighted according to the luminosity function, a standardized model of human visual brightness perception. In English, "lux" is used as both the singular and plural form.

A candela is a fixed amount, roughly equivalent to the brightness of one candle. While the candela is a unit of energy, it has an equivalent unit known as the lumen, which measures the same light in terms of its perception by the human eye. One lumen is equivalent to the light produced in one direction from a light source rated at one candela. The lux takes into account the surface area over which this light is spread, which affects how bright it appears. One lux equals one lumen of light spread across a surface one square meter.A lux meter works by using a photo cell to capture light. The meter then converts this light to an electrical current. Measuring this current allows the device to calculate the lux value of the light it captured.

3.9 Tong Tester(clamp Meter)

In electrical and electronic engineering, a current clamp or current probe is an electrical device with jaws which open to allow clamping around an electrical conductor. This allows measurement of the current in a conductor without the need to make physical contact with it, or to disconnect it for insertion through the probe. Current clamps are typically used to read the magnitude of alternating current (AC) and, with additional instrumentation, the phase and waveform can also be measured. Some clamps meters can measure currents of 1000 A and more. Hall effect and vane type clamps can also measure direct current (DC).

An electrical meter with integral AC current clamp is known as a clamp meter, clamp-on ammeter or tong tester. A clamp meter measures the vector sum of the currents flowing in all the conductors passing through the probe, which depends on the phase relationship of the currents. Only one conductor is normally passed through the probe. In particular if the clamp is closed around a two-conductor cable carrying power to equipment, the same current flows down one conductor and up the other; the meter correctly reads a net current of zero. As electrical cables for equipment have both insulated conductors (and possibly an earth wire) bonded together, clamp meters are often used with what is essentially a short extension cord with the two conductors separated, so that the clamp can be placed around only one conductor of this extension.

A relatively recent development was a multi-conductor clamp meter with several sensor coils around the jaws of the clamp. This could be clamped around standard two- or three- conductor single-phase cables to provide a readout of the current flowing through the load, with no need to separate the conductors. The reading produced by a conductor carrying a very low current can be increased by winding the conductor around the clamp several times; the meter reading divided by the number of turns is the current, with some loss of accuracy due to inductive effects. Clamp meters are used by electricians, sometimes with the clamp incorporated into a general purpose multimeter.

` It is simple to measure very high currents (hundreds of amperes) with the appropriate current transformer. Accurate measurement of low currents (a few milliamperes) with a current transformer clamp is more difficult. The range of any given meter can be extended by passing the conductor through the jaw multiple times. For example a 0–200 A meter can be turned into a 0–20 A meter by winding the conductor 10 times around the jaw's core

3.10 Applications of PLC

Principle of Programmable Logic Controller:

Programmable Logic Controllers are used for continuously monitoring the input values from sensors and produces the outputs for the operation of actuators based on the program. Every PLC system comprises these three modules as shown in Fig. 3.3.

- CPU module

- Power supply module
- One or more I/O module

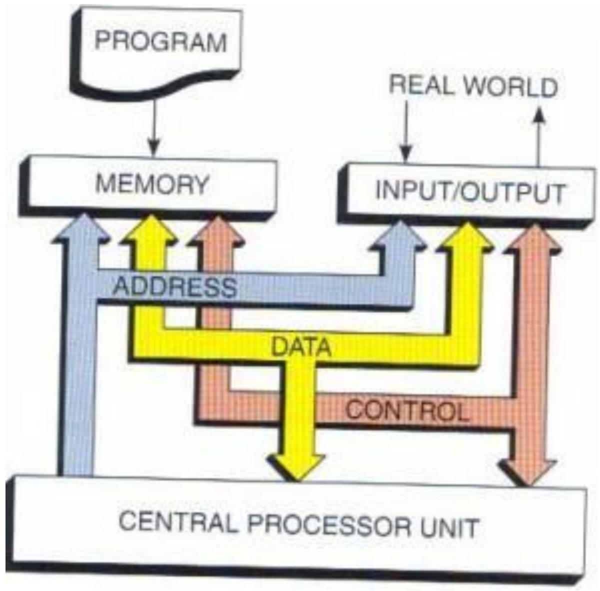


Fig. 3.3: PLC system

Applications of Programmable Logic Controller (PLC)

The PLC can be used in industrial departments of all the developed countries in industries like chemical industry, automobile industry, steel industry and electricity industry. Based on the development of all these technologies, functionality and application, the scope of the PLC increases dramatically.

3.10.1 Application of PLC in Glass Industry

From the year 1980 the Programmable-logic controllers are in use in the glass industry, and they are assembled bit by bit. PLCs are used mainly in every procedure and workshop for controlling the material ratio, processing of flat glasses, etc.

With the development of PLC and increasing demand in the real world, the control mode of the programmable-logic controller with an intelligent device is applied in the glass industry. In making of a float glass, PLC itself cannot finish some controlling tasks because of the complexity of the control system and processing of huge data. For the production of glass, we make use of bus technology to construct the control mode of a PLC with a distributed-control system. This control system deals with analog controlling and data recording; the PLC is also used for digital quality control and position control. This type of control mode is a big advantage for PLC and DCS for improving reliability and flexibility of the control system.

3.10.2Applications of PLC in Cement Industry

Along with the best-quality raw materials, the accurate data regarding process variables, especially during mixing processes within the kiln, ensures that the output provided should be of the best possible quality. Nowadays a DCS with bus technology is used in the production and management industry. By using this existing DCS control system, the PLC is in user mode of SCADA. This mode comprises PLC and configuration software. This SCADA mode comprises the PLC and host computer. The host computer consists of slave and master station. The PLC is used for controlling the ball milling, shaft kiln and Kiln of coal.

IMPORTANT QUESTIONS

1. Write a short notes on the Tong testers & Data loggers

2. Write short notes on the a) Pyrometers b) wattmeter c) Thermocouples

3. Explain in brief about Lighting Energy Audit.

4. Discuss about Applications of PLC's.

5.Write a short notes on Energy Instruments & lux meters.

6.Enumerate the following : Lighting control

7.Illustrate important points that to be considered for good lighting design and practice