GANDHI SCHOOL OF ENGINEERING

Chidananda Hills, Bhabandha, Berhampur, Ganjam

ECA LABORATORY EXPERIMENTS

EXPERIMENT NO. 01

Aim of the Experiment

To identify star-labelled electrical appliances and compare data across various star ratings.

Apparatus Required

1. Various household appliances (refrigerator, AC, TV, water heater, grinder, etc.)
2. BEE (Bureau of Energy Efficiency) star-label charts.

Theory

BEE Label: Standardized tags indicating energy efficiency.

Star Rating: Ranges from 1 (least efficient) to 5 (most efficient).

Benefits: Higher stars mean lower electricity consumption and costs.

Procedure

1. Locate the BEE label on the selected electrical appliances.
2. Note the number of stars coloured in red / green.
3. Record the manufacturer details and model number.
4. Copy the total annual energy consumption value from the label.
5. Repeat the process for appliances with a different rating.
6. Compare the data to evaluate energy savings.

Observation Table

Sl. No.	Name of Appliance	Brand	Star Rating (1 to 5)	Annual Energy Consumption
1	Refrigerator	LG	5	180 kWh/year
2	Refrigerator	Samsung	4	220 kWh/year
3	Refrigerator	Whirlpool	3	280 kWh/year
4	AC	LG	5	900 kWh/year
5	AC	Voltas	3	1200 kWh/year
6	Grinder	Philips	4	35 kWh/year
7	Grinder	Bajaj	3	45 kWh/year
8	TV	Samsung	5	100 kWh/year
9	TV	LG	4	120 kWh/year

Sl. No.	Name of Appliance	Brand	Star Rating (1 to 5)	Annual Energy Consumption
10	TV	Sony	3	150 kWh/year

Conclusion

Appliances with higher star ratings consume significantly less power annually, which leads to direct savings in electricity bills.

EXPERIMENT NO. 02

Aim of the Experiment

To determine the reduction in power consumption in star mode operation of an induction motor compared to delta mode.

Apparatus Required

Sl. No.	Name of the Equipment	Range	Quantity
01	3-φ Induction Motor	7.5 HP, 415 V	1
02	Star / Delta Starter	7.5 HP, 415 V	1
03	Ammeter	0–30 A	1
04	Voltmeter	0–500 V	1
05	Wattmeter	1500 W	1

Theory

Delta connection: The motor receives the full line-to-line voltage (VL = Vph).

Star connection: The phase voltage drops to VL / √3.

Energy saving: Running a lightly loaded motor (less than 30% load) in star mode saves significant power.

Procedure

1. Ensure the motor is completely uncoupled from any heavy mechanical load.
2. Connect the power measurement instruments to the supply line.
3. Configure the changeover switch to start and run the motor in delta mode.
4. Take readings of voltage, current, power factor and total input power.
5. Stop the motor safely.
6. Switch the configuration to star mode.
7. Record exactly the same parameters under star operation.
8. Calculate the power reduction percentage:

$$\% \text{ Power reduction} = [(P\Delta - PY) / P\Delta] \times 100$$

Observation Table

Type of Mode	Voltmeter Reading (VL)	Ammeter Reading (IL)	Power Factor (cos φ)	Total Power in Watts P = √3 VL IL cos φ	% Reduction in Power [(PΔ − PY) / PΔ] × 100
Star	415 V	2.5 A	0.35	0.63 kW	66.7%
Delta	415 V	2.5 A	0.35	1.89 kW	66.7%

Conclusion

Power consumption in star mode is exactly one-third of the power consumed in delta mode for the same voltage supply.

EXPERIMENT NO. 03

Aim of the Experiment

To compare the power consumption, current and power factor of a conventional tube light with an electromagnetic choke, a tube light with an electronic ballast, and an LED tube light via direct measurement.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	Standard fluorescent tube light with magnetic choke and starter	40 W	1
02	Standard fluorescent tube light with electronic ballast	36 / 40 W	1
03	LED tube light	18 W – 20 W	1
04	AC Ammeter	0–5 A	1
05	AC Voltmeter	230 V	1
06	1-φ Wattmeter	0–150 W	1
07	Line Tester	0–500 V	1
08	Insulated Combination Wire Cutter	150 mm	1
09	Wire Stripper	50 mm	1
10	Connecting Wires	1.5 mm^2	1

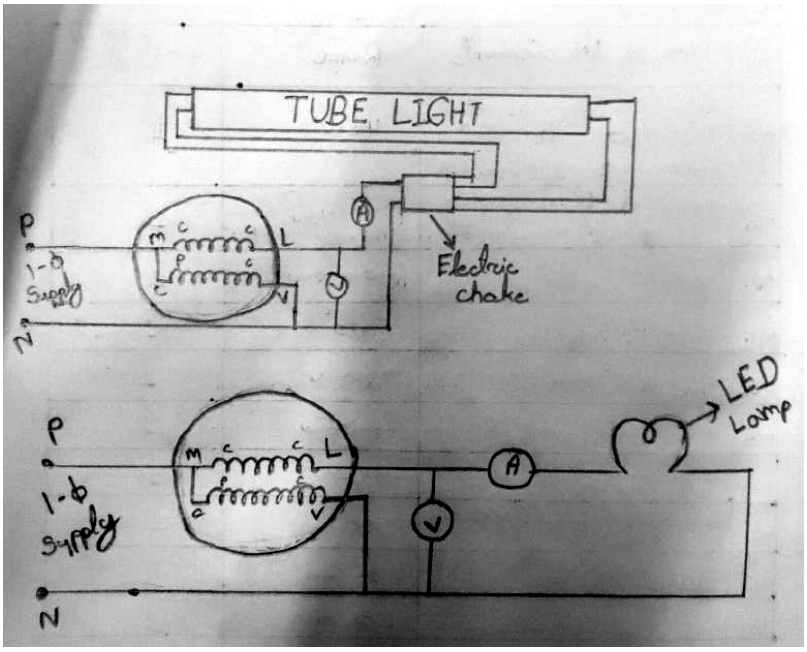


Fig.: Circuit diagrams – tube light with electromagnetic choke, tube light with electronic choke, and LED lamp

Theory

Current: Current is the rate of flow of charge.

$$I = Q / t$$

where Q = charge in coulombs, I = current in amperes, t = time in seconds.

Voltage: Voltage is the potential difference across a circuit element. Its unit is the volt.

Power: Power is the rate of doing electrical work. Its SI unit is the watt.

$$P = W / t = QV / t = (I \times t \times V) / t = VI$$

$$P = VI = I^2R = V^2 / R$$

where P is in watts, V in volts, and I in amperes.

$$1\text{-}\varphi \text{ power} = VI \cos \varphi$$

$$\text{Power factor} = \text{Real power} / \text{Apparent power} = \text{Real power} / VI$$

Procedure

The AC supply is fed through the voltmeter (in parallel), ammeter (in series) and the current coil and pressure coil of the wattmeter, which then connect to each lighting fixture sequentially.

Measure the voltmeter reading, ammeter reading and wattmeter reading in each case.

Observation Table

Sl. No.	Type of Lamp	Voltage (V)	Current (A)	Power (W)	Power Factor (cos φ)
01	TL with electromagnetic choke	230 V	0.44 A	53 W	0.52

Sl. No.	Type of Lamp	Voltage (V)	Current (A)	Power (W)	Power Factor (cos φ)
02	TL with electronic choke	230 V	0.20 A	43 W	0.94
03	LED lamp	230 V	0.09 A	20 W	0.97

Conclusion

- The conventional magnetic choke incurs heavy copper losses (10–15 W) and a low power factor (0.5–0.6).
- The electronic ballast eliminates starter delay, operates at higher frequency, reduces ballast losses to 2–4 W and improves the power factor (> 0.9).
- The LED lamp consumes the least power for equivalent or higher lumen output, with a power factor close to unity (> 0.95).

EXPERIMENT NO. 04

Aim of the Experiment

To determine the reduction in power consumption achieved by replacement of the existing lamps of a classroom / laboratory with energy-efficient lamps.

Apparatus Required

- Measuring tape, lux meter, clamp meter / power meter.
- Sample energy-efficient lamps (LED).
- Room layout drawing, tariff schedule, record sheet.

Theory

Lighting typically accounts for 15–25% of the electricity use of an educational or commercial building, and lamp replacement is the classic no-regret energy conservation measure.

The connected lighting load is the sum of the lamp wattage plus the ballast loss of every fitting.

$$\textit{Annual consumption} = \textit{Connected load (kW)} \times \textit{Operating hours per year}$$

Replacement must maintain the illumination levels recommended by IS 3646 / the National Building Code – about 300 lux for a classroom and 300–500 lux for a laboratory. Any measure is judged by its simple payback period:

$$\textit{Simple payback period} = \textit{Investment} / \textit{Annual savings}$$

Procedure

1. Prepare a layout of the room and mark the position of every light fitting.
2. Count the fittings type-wise and record the wattage of each lamp and its ballast loss.
3. Measure the actual input power of a sample fitting of each type with a power meter.
4. Measure the illumination in lux on the working plane at a grid of points and compute the average lux.
5. Record the daily and annual operating hours of the lighting from the timetable.
6. Calculate the existing connected load and annual energy consumption.
7. Select an equivalent LED replacement that maintains the required lux level; obtain its wattage and cost.
8. Compute the proposed connected load, annual consumption, annual saving and simple payback.

Observation Table

Sl. No.	Fitting Type	Nos.	Watt per Fitting (incl. ballast)	Total Watt	Average Lux	Hours / Day
01	Existing fluorescent lamp	10	50 W	500 W	250	6
02	Proposed LED	10	20 W	200 W	320	6

Assumptions:

- Working days = 250
- Tariff = ₹7 per kWh
- Total replacement cost = ₹3000

Sample Calculations

Connected load (kW) = Total watt ÷ 1000

Existing = 500 ÷ 1000 = 0.5 kW

Proposed = 200 ÷ 1000 = 0.2 kW

Annual energy consumption (kWh) = Connected load (kW) × Hours/day × Working days

Existing = 0.5 × 6 × 250 = 750 kWh

Proposed = 0.2 × 6 × 250 = 300 kWh

Energy saving = Annual energy (existing) − Annual energy (proposed)

= 750 − 300 = 450 kWh/year

Cost saving = Energy saving × Tariff

= 450 × 7 = ₹3,150 per year

Simple payback (years) = Total replacement cost / Annual cost saving

= 3000 / 3,150 = 0.95 years = 11.4 months

Result

Replacement of the existing lamps of the room reduced the lighting load from 500 W to 200 W, saving 450 kWh and ₹3,150 per year with a simple payback of 0.95 years, while maintaining an average illumination of 320 lux.

EXPERIMENT NO. 05

Aim of the Experiment

To collect the electricity bill of a residential consumer and to suggest suitable means for conservation and reduction of the energy bill.

Apparatus / Material Required

- Electricity bills of a domestic consumer for at least 12 months.
- Domestic tariff schedule with the slab structure.
- Appliance inventory sheet of the household.
- Calculator / spreadsheet.

Theory

The domestic tariff is a telescopic slab tariff: the rate per unit rises as consumption crosses each slab (for example 0–50, 51–200, 201–400 and above 400 units), and a fixed charge is levied on the sanctioned load. Reducing consumption so that it falls into a lower slab therefore reduces the bill more than proportionally.

The major domestic end uses are lighting, fans, refrigerator, air conditioner, water heater, water pump and television. The standby load of electronic equipment can be 2–5% of the household consumption.

The main conservation measures are replacement of incandescent and CFL lamps by LEDs, use of BLDC fans, star-rated refrigerators and air conditioners, solar water heating, set-point and thermostat management, and switching off standby loads.

Procedure

1. Collect twelve monthly bills and note the sanctioned load, the slab-wise units and the charges.
2. Plot the monthly consumption and identify the seasonal peaks.
3. Prepare an appliance inventory: appliance, quantity, wattage, hours of use per day.
4. Estimate the monthly consumption of each appliance and compare the total with the metered consumption.
5. Identify the appliances contributing the largest share of the bill.
6. Propose conservation measures for each major end use, with the reduction in consumption of each.
7. Recompute the bill under the slab tariff after the proposed measures and find the saving.

Observation Table

Sl. No.	Appliance	Nos.	Watt	Hours / Day	kWh / Month	Proposed Replacement	kWh / Month After
1	Lamps	5	60	6	54	9 W LED	8.1
2	Fans	4	75	8	72	30 W BLDC fan	28.8

Sl. No.	Appliance	Nos.	Watt	Hours / Day	kWh / Month	Proposed Replacement	kWh / Month After
3	Refrigerator	1	200	8	48	150 W energy-efficient	36
4	Air Conditioner	1	1500	6	270	Inverter AC (1100 W)	198
5	Water Heater / Pump	1	750	2	45	Energy-efficient pump 600 W	36
6	Other	1	1000	2	60	Energy-efficient appliances 800 W	48
	Total	—	—	—	549	—	354.9

Calculation

1. Monthly consumption of an appliance:

kWh/month = (Nos. × Watt × Hours/day × 30) / 1000

Before Replacement	kWh	After Replacement	kWh
Lamps	54	Lamps	8.1
Fans	72	Fans	28.8
Refrigerator	48	Refrigerator	36
A.C.	270	A.C.	198
Water Heater	45	Water Pump	36
Others	60	Others	48
Total	549	Total	354.9

2. Bill = Σ (units in each slab × rate of the slab) + Fixed charge + Electricity duty

Assumptions: Rate = ₹8/unit, Fixed charge = ₹200, Electricity duty = 5%

Before = 549 × 8 + 200 + (549 × 8 × 5 / 100) = 4392 + 200 + 219.60 = ₹4811.60

After = 354.9 × 8 + 200 + (354.9 × 8 × 5 / 100) = 2839.20 + 200 + 141.96 = ₹3181.16

3. Saving = Bill before − Bill after

= 4811.60 − 3181.16 = ₹1630.44 / month

4. % Saving = (Saving ÷ Bill before) × 100

= (1630.44 / 4811.60) × 100 = 33.88%

5. Payback period = Cost of replacement ÷ Annual saving

Annual saving = 1630.44 × 12 = ₹19,565.28

Assume replacement cost = ₹10,000

Payback = 10000 / 19565.28 = 0.51 years = 6.13 months

Conclusion

The domestic electricity bill was analysed. The household consumes 549 kWh per month at an average cost of Rs. 4811.60. The suggested measures reduce consumption to 354.9 kWh per month, bringing it into a lower consumption slab and saving Rs. 19,565.28 per year.

EXPERIMENT NO. 06

Aim of the Experiment

To determine the percentage loading of a given loaded induction motor.

Apparatus Required

Sl. No.	Name of the Equipment	Range	Quantity
01	3-φ Induction Motor (with load)	415 V, 5 HP	1
02	3-φ Power Analyser / Two Wattmeters	0–10 A, 600 V	1
03	AC Voltmeter	0–500 V	1
04	AC Ammeter / Clamp Meter	0–10 A	1
05	Tachometer	0–3000 RPM	1
06	Connecting Wires	2.5 mm²	As required

Theory

Motors working at low load have poor efficiency and poor power factor. The percentage loading tells how much of the rated output the motor is actually supplying. It is found from the measured input power and the rated input power taken from the nameplate.

$$\textit{Rated input power } Pr = \textit{Rated output (kW)} / \textit{Rated efficiency}$$

$$\textit{Measured input power } Pi = \sqrt{3} \times VL \times IL \times \cos\varphi \quad \textit{(or from the wattmeter / power analyser)}$$

$$\%\ \textit{Loading} = (Pi / Pr) \times 100$$

The loading can also be estimated from the slip:

$$\%\ \textit{Loading} \approx [(Ns - N) / (Ns - Nr)] \times 100$$

where Ns is the synchronous speed, N is the measured speed and Nr is the rated (full-load) speed.

A motor loaded below about 50% should be replaced with a smaller motor, or operated in star mode, to save energy.

Procedure

1. Note the nameplate details of the motor: rated output, voltage, current, speed and efficiency.
2. Connect the power analyser (or two wattmeters), voltmeter and ammeter in the motor supply.
3. Start the motor and let it run on the given load.
4. Note the line voltage, line current, power factor, input power and speed.
5. Repeat for different loads if possible.
6. Calculate the % loading by both methods.

Observation Table

Nameplate: Rated output = _____ kW, Rated efficiency = _____ %, Rated speed Nr = _____ RPM

Sl. No.	VL (V)	IL (A)	cos φ	Input Power Pi (kW)	Speed N (RPM)	% Loading (Power)	% Loading (Slip)
1							
2							
3							

Conclusion

The percentage loading of the given induction motor was determined from the measured input power and from the slip. Motors that are found to be under-loaded can be replaced by correctly sized motors to reduce energy consumption.

EXPERIMENT NO. 07

Aim of the Experiment

To use an APFC (Automatic Power Factor Correction) unit for improvement of the power factor of an electrical load.

Apparatus Required

Sl. No.	Name of the Equipment	Range	Quantity
01	APFC Panel / Relay with Capacitor Bank	1-φ / 3-φ, with 3–6 steps	1
02	Inductive Load (motor / choke)	230 V / 415 V	1
03	Power Factor Meter / Power Analyser	—	1
04	AC Voltmeter	0–500 V	1
05	AC Ammeter	0–10 A	1
06	Wattmeter	0–1500 W	1
07	Connecting Wires	1.5 mm²	As required

Theory

Inductive loads such as motors, chokes and transformers draw lagging reactive power, which lowers the power factor. A low power factor increases the line current, the I^2R losses and the electricity bill (power factor penalty).

Connecting capacitors in parallel with the load supplies the reactive power locally and improves the power factor. The capacitor kVAr required to improve the power factor from cos φ1 to cos φ2 is:

$$Qc = P \times (\tan \varphi 1 - \tan \varphi 2) \quad (kVAr)$$

An APFC relay continuously measures the voltage and current (through a CT) and calculates the power factor. When the power factor falls below the set value, it switches ON capacitor steps through contactors one by one; when the power factor rises above the set value, it switches capacitor steps OFF. In this way the power factor is kept close to the target value (0.95–0.99) automatically.

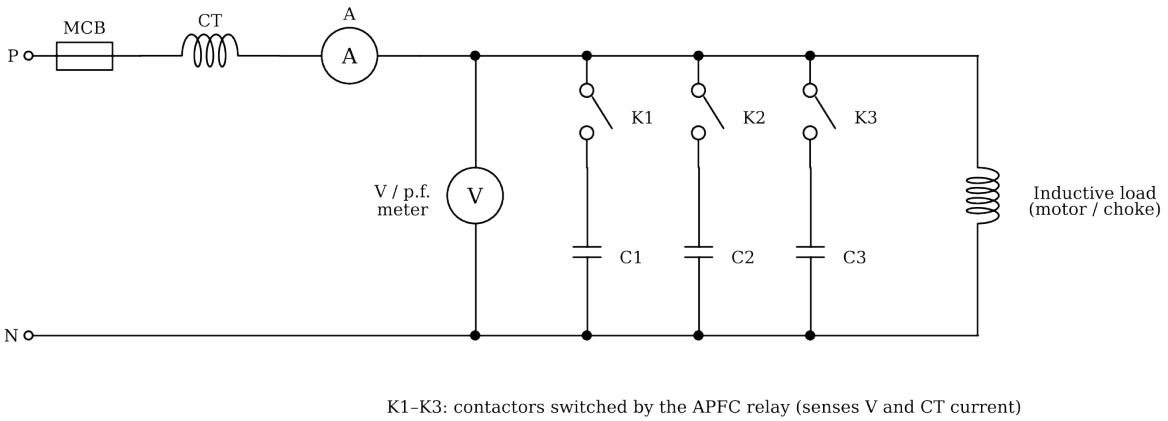


Fig.: Power factor correction using APFC unit

Procedure

1. Connect the circuit as per the circuit diagram.
2. Set the target power factor on the APFC relay (e.g. 0.98).
3. Keep the APFC unit in OFF (manual) mode and switch on the inductive load.
4. Note the voltage, current, power and power factor without correction.
5. Switch the APFC unit to AUTO mode.
6. Observe the capacitor steps switching ON and note the readings after correction.
7. Change the load and repeat the readings.
8. Calculate the reduction in current and the kVAr supplied by the capacitors.

Observation Table

Sl. No.	Condition	V (V)	I (A)	P (W)	cos φ	No. of Capacitor Steps ON
1	Without APFC					0
2	With APFC (Load 1)					
3	With APFC (Load 2)					

Calculation

$$\% \text{ Reduction in current} = [(I1 - I2) / I1] \times 100$$

$$Qc = P \times (\tan \varphi 1 - \tan \varphi 2)$$

Conclusion

The APFC unit automatically switched the capacitor steps and improved the power factor of the inductive load close to the set value. As a result, the line current and losses were reduced for the same active power.

EXPERIMENT NO. 08

Aim of the Experiment

To determine the reduction in power consumption by replacement of fans and regulators in a classroom / laboratory.

Apparatus Required

- Power meter / energy meter (or wattmeter, voltmeter and ammeter)
- Conventional ceiling fan (75 W) with resistive regulator
- Energy-efficient BLDC ceiling fan (28–35 W) with electronic regulator / remote
- Tachometer, record sheet

Theory

Ceiling fans are a large part of the electrical load in classrooms and offices. A conventional induction-type ceiling fan consumes about 70–80 W at full speed. A resistive regulator reduces the speed by dropping voltage across a resistor, so the power wasted in the regulator remains high even at low speed.

An electronic (step-type) regulator reduces the speed with very little loss. A BLDC (brushless DC) fan uses a permanent magnet motor with electronic control and consumes only about 28–35 W for the same air delivery. Therefore, replacing old fans and resistive regulators gives large energy savings.

$$\textit{Annual energy (kWh)} = (\textit{No. of fans} \times \textit{Watt} \times \textit{Hours/day} \times \textit{Working days}) / 1000$$

$$\textit{Annual saving (₹)} = \textit{Energy saving (kWh)} \times \textit{Tariff}$$

$$\textit{Simple payback} = \textit{Investment} / \textit{Annual saving}$$

Procedure

1. Count the fans in the classroom / laboratory and note their wattage and type of regulator.
2. Measure the input power of a conventional fan at each regulator step.
3. Measure the input power of the BLDC fan (or a fan with electronic regulator) at each speed step.
4. Note the daily operating hours and the number of working days.
5. Calculate the existing and proposed annual energy consumption.
6. Calculate the energy saving, cost saving and simple payback period.

Observation Table

Power Input at Different Speed Steps

Speed Step	Conventional Fan with Resistive Regulator (W)	BLDC Fan (W)
1 (Low)		
2		
3		

Speed Step	Conventional Fan with Resistive Regulator (W)	BLDC Fan (W)
4		
5 (High)		

Energy Saving

Sl. No.	Fan Type	Nos.	Average Watt	Hours / Day	Working Days	Annual Energy (kWh)
1	Existing conventional fan					
2	Proposed BLDC fan					

Calculation

Energy saving = Annual energy (existing) − Annual energy (proposed)

Cost saving = Energy saving × Tariff

Simple payback = Total replacement cost / Annual cost saving

Conclusion

Replacement of conventional fans and resistive regulators by BLDC fans with electronic control reduces the power consumption by more than half for the same air delivery, giving a short payback period.