Electrical Installations and loads

Task 1: Understanding wires and protective devices

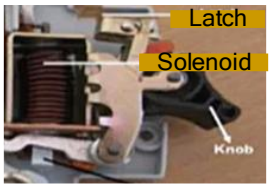
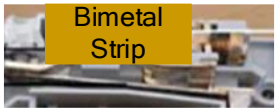
Using the wires provided, please fill in the following table:

Wire size (mm^2)	Number of strands (please count)	Diameter of one strand (mm)	Total area (mm^2)	Resistance per meter length($\times 10^{-3}\Omega m^{-1}$)
1	**1**	**1.13**	**1.0029**	**16.7514**
1.5	**7**	**0.53**	**1.5443**	**10.8787**
2.5	**7**	**0.67**	**2.4680**	**6.8071**
4	**7**	**0.85**	**3.9722**	**4.2294**

Please note that the resistivity of Cu is 16.8 nΩ·m

Task 2: Understanding the protective devices

Using the following-coloured parts of the CB, write down the operation of each part:

	**Latch** – mechanically holds the contacts closed. Allowing current to flow. When tripped latch releases, causing contact to separate **Solenoid**- Solenoid creates a big magnetic field when a large current passes through it, which move plunger and move the latch, which open the circuit then.
	Made of two distinct metals, it heats up when current flowing through it. It designed in a way that after a certain predefined current it bends such that the latch will trigger, which cause to open the circuit.
	When the MCB contacts released, an electrical arc can form. This arc chutes is designed to dissipate this arc safely.

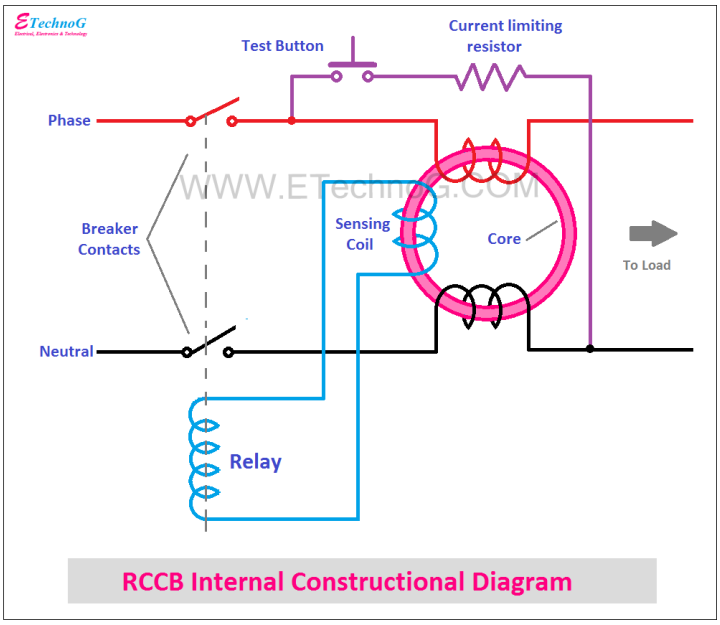
Write 'True' or 'False' under each of the following statements related to an MCB (Miniature Circuit Breaker) or MCCB (Moulded Case Circuit Breaker):

The circuit breaker should continuously carry the normal load current	**True**
The circuit breaker must detect fault conditions and promptly interrupt the fault current	**True**
The circuit breaker should not be damaged during the arc quenching process that occurs when interrupting fault currents	**True**
After a fault is cleared, an automatic or manual mechanism should be available to restore the circuit's operation	**True**

Perform the following calculation for a single-phase circuit powering a 5 kW oven:

Possible voltage to which the over is connected	230V
Possible power factor ($cos\phi$) of the oven. Please remember that an over carries a resistive element and current and voltage waveforms are in-phase. That is $\phi = 0$	1
Using the equation $P = VIcos\phi$, calculate the current drawn by the oven	21.74A
Using available MCB sizes (look on the internet) select an MCB such that the MCB rating is greater than the load current	32A

- Describe the operation of an RCCB with a diagram

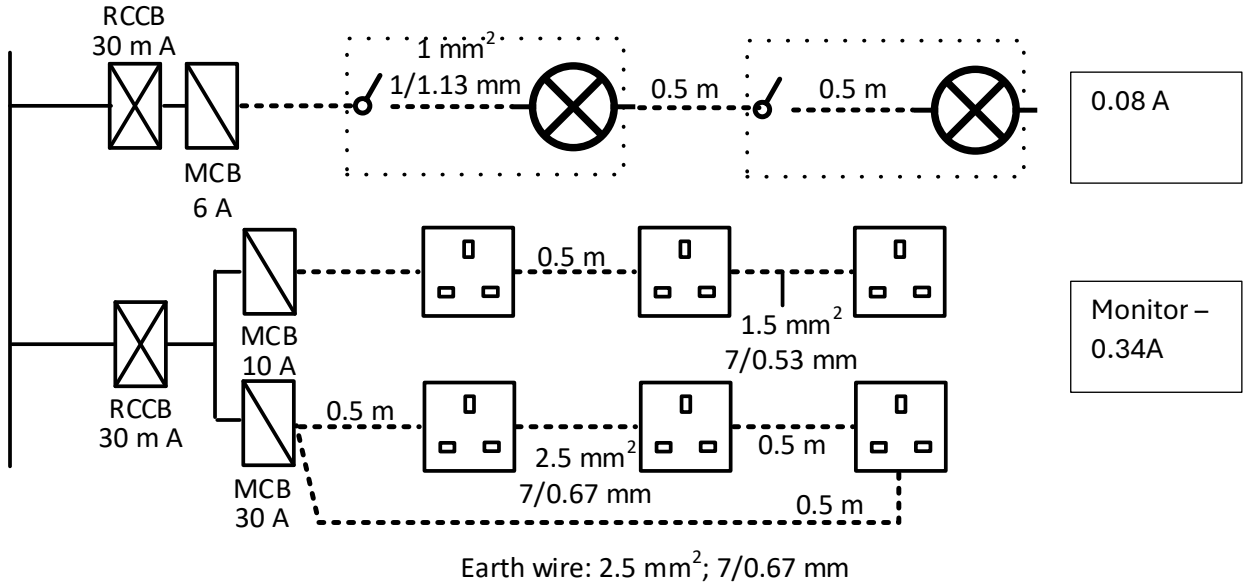


An RCCB works by comparing the current in the phase and neutral wires, which pass through a common sensing coil. Under normal conditions, both currents are equal, so their magnetic fields cancel out. If a leakage occurs (like current flowing to the ground through a person), the balance breaks. This imbalance induces a current in the sensing coil, triggering the relay. The relay then trips the breaker, cutting power—usually in under 30 ms—preventing electric shocks and hazards.

Task 3: Wiring System

In this experiment, you will utilize the existing electrical installation to connect the circuits depicted in the following figure.

- Circuit 1: A radial lamp circuit.
- Circuit 2: A radial socket outlet circuit.
- Circuit 3: A ring socket outlet circuit.

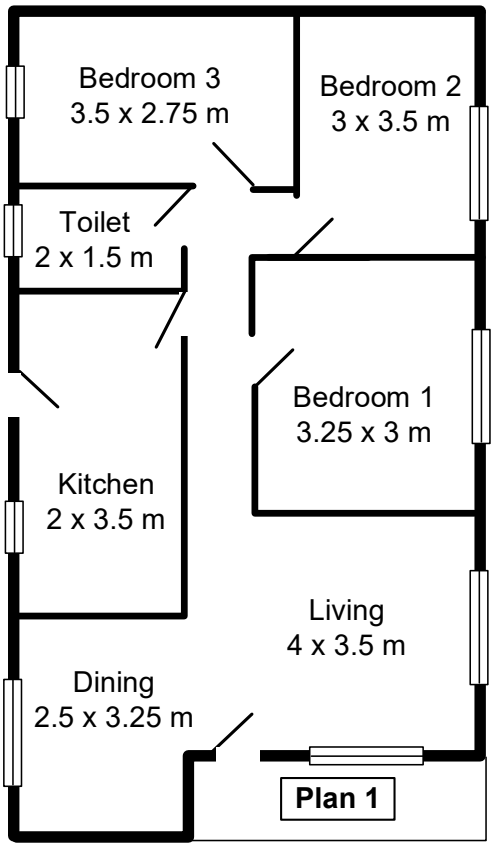


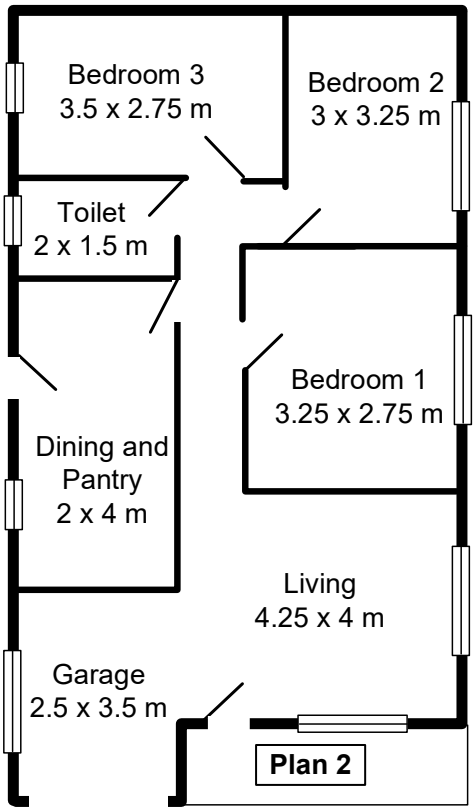
- Based on the details provided in the diagram, your observation of the laboratory setup components, and verification of the provided wiring, connect both circuits.
- Present these completed circuits to the instructor for inspection.
- Test the functionality of the connected circuits by connecting the different appliances given abd measuring the current.
- Subsequently, disconnect the main power supply to the distribution board (DB).

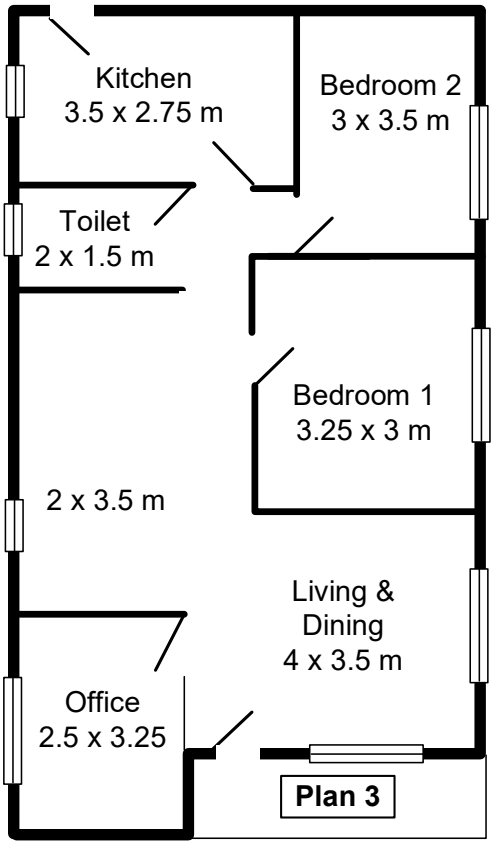
Task 4: Design the Electrical System

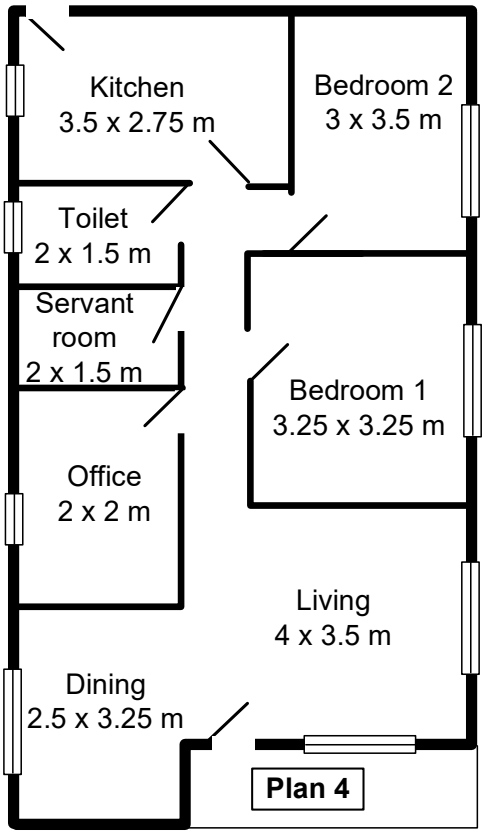
Objective: To apply electrical wiring principles to design a safe and functional electrical system for a residential building.

Material: Floor plans









Activity Steps:

Step 1: List the appliances/items in each room

Room	*Description of electrical items in each room (lamps, fans, socket outlets, special appliances)*

Step 2: Implementing the plan with electrical items

Implement the plan assigned to your group in https://floorplanner.com/projects

- Implement the plan on the 'floorplanner. '
- Plan the layout of electrical outlets, switches, and lighting fixtures on the floor plan.
- Using the Place Sign and Symbols tab, indicate the locations of switches, plug sockets, lamps, and fans.

Step 3: Develop an Excel sheet with the following subheadings

For each sub-circuit that you designed, develop an Excel sheet with the following subheadings:

- Circuit No ✅
- Ring/ Radial ✅
- Description ✅
- Diversity factor ✅
- Maximum demand (A) ✅
- Rating of the MCB (A) ✅
- Length of the circuit (m) ✅
- Min Current Carrying Capacity ✅
- Ambient temperature factor ✅
- Grouping factor ✅
- Initial wire selection (mm2) ✅
- Voltage drop ✅
- Check whether the VD < allowable value ✅
- If required, Second wire selection & Voltage drop

Propagate the Excel sheet for each circuit

Step 4: Create a detailed wiring diagram showing the connections between the electrical components and the distribution panel.

DATA:

TABLE A: Diversity factors

Final circuit	**Household installations**	**Small shops, stores, offices and business premises**	**Small hotels. Boarding houses, guest houses**
Lightning	66% of TD	90% of TD	75% of TD
Cooking appliances	If FL < 10 A 10 A + 5A if a SO is incorporated If FL > 10 A 10 A + 30% of FL + 5A if a SO is incorporated	X + 0.8Y+0.6Z	X + 0.8Y+0.6Z
Motors	N/A	X + 0.8Y+0.6Z	X + 0.8Y+0.6Z
Instantaneous water heaters	X+Y+0.25Z	X+Y+0.25Z	X+Y+0.25Z
Thermostatically controlled water heaters	100% of FL	100% of FL	100% of FL
Standard or final circuits with SOs	X+0.4(Y+Z)	X+0.5(Y+Z)	X+0.5(Y+Z)
SO other than Standard circuits	X+0.4(Y+Z)	X+0.7(Y+Z)	X+0.7W+0.4Z

where TD is the total current demand; FL is the full load; SO is the socket outlet; X is the largest appliance/circuit; Y is the second largest; Z is the remaining; W is the SOs in living and dining rooms

TABLE B: Final circuits using square socket-outlets

Type of circuit	**Over current protective device**	**Minimum live conductor cross sectional area (mm^2)**	**Maximum floor area served (m^2)**
Ring	30 or 32 A	2.5	100
Radial	30 or 32 A	4.0	75
Radial	20	2.5	50

TABLE C: Current carrying capacities and associated voltage drops for single-core p.v.c insulated cables, non-armoured, copper conductors enclosed in conduit or trunking:

Cross sectional area (mm^2)	2 cables single phase ac or dc		3 or 4 cables three phase ac	
	Current (A)	Drop in mV/Amp-meter	Current (A)	Drop in mV/Amp-meter
1.0	13.5	44.0	12.0	38.0
1.5	17.5	29.0	15.5	25.0
2.5	24.0	18.0	21.0	15.0
4.0	32.0	11.0	28.0	9.5
6.0	41.0	7.3	36.0	6.4
10.0	57.0	4.4	50.0	3.8
16.0	76.0	2.8	68.0	2.4
25.0	101.0	1.8	89.0	1.5
35.0	125.0	1.3	110.0	1.1

Ambient temperature 30^0 C

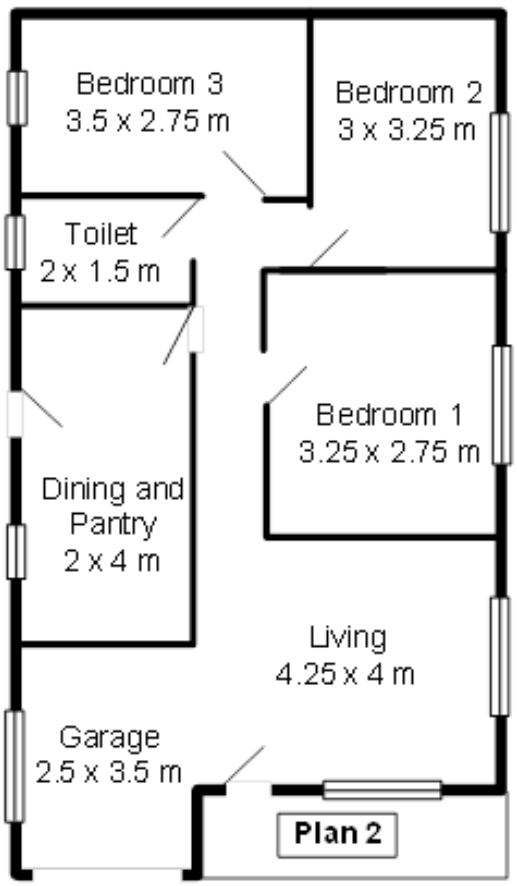
TABLE D: Ambient temperature factor

Ambient temperature °C	25	30	35	40	45	50	55	60
Factor	1.03	1	0.94	0.87	0.79	0.71	0.61	0.50

TABLE E: Grouping factor

Number of circuits	1	2	3	4	5	6	7	8
Factor	1.0	0.8	0.7	0.65	0.6	0.57	0.54	0.52

Step 1: Description about each part of the house



Living Room
Six 10W LED lamps
Two 10W wall lamps
Four 13 A plug sockets
One 75 W ceiling fan

Dining and Pantry
Two 5W LED lamps
Two 10W LED lamps
One 15W LED lamp
Four 13 A plug sockets
One 75 W ceiling fan
One 2kW Oven
One 2kW Rice Cooker
150W Fridge

Bedroom 1
One 10 W LED lamps
One 13 A plug sockets
One 75W Fan

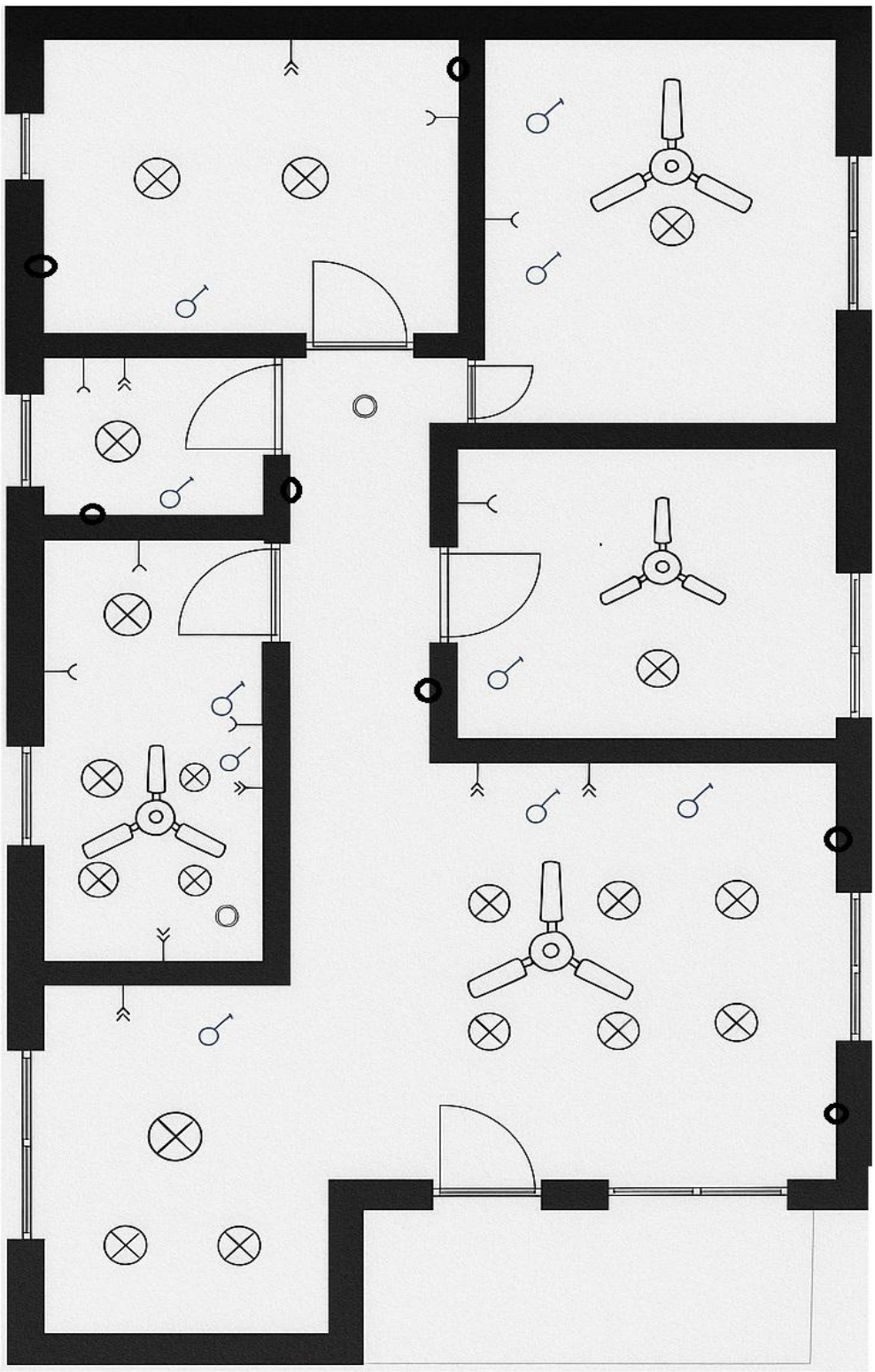
Bedroom 2
One 10 W LED lamps
One 13 A plug sockets
One 75W Fan

Bedroom 3
Two 10 W LED lamps
Two 13 A plug sockets
Two 5W LED lamps
One 1.2kW A/C

Toilet
One 10W LED lamp
One 5W LED lamp
One 1 kW instantaneous water heater
Two 13A plug sockets

Garage
Two 10W LED lamp
One 15W LED lamp
Two 13A plug sockets

Step 2: The plan with electrical items



Step 3: Wiring calculations

1. Description of circuit sub-divisions

Circuit No	Ring / Radial	Description
		Lighting
1	Radial	• One 10 W LED lamps in bedroom 1 • One 10 W LED lamps in bedroom 2 • Two 10W and 5W LED lamps in bedroom 3
2	Radial	• Two 5W LED lamps in the dining & pantry • Two 10W LED lights in dining & pantry • One 15W LED lamp in the dining & pantry
3	Radial	• One 10W LED and One 5W LED in Toilet • Two 10W LED and 5W wall lamp in the Corridor
4	Radial	• Six 10W LED lamps and two 5W wall lamps
5	Radial	• Two 10W LED lamps and one 15W lamps
		Socket Outlets
6	Ring	• One 13A socket in bedroom 1 • One 13A socket in bedroom 2 • Two 13A sockets in bedroom 3 • Two 13A sockets in toilet
7	Ring	• Four 13A sockets for dining & pantry • Four 13A sockets in living room • Two 13A sockets in garage
8	Radial	• A dedicated socket for 150W fridge in the kitchen
9	Radial	• A dedicated socket for 2kW oven in the kitchen
10	Radial	• A dedicated socket for 2kW rice cooker in the kitchen
11	Radial	• A dedicated socket for 1kW instantaneous water heater in the toilet
12	Radial	• A dedicated socket for 1.2kW A/C in the bedroom 3
		Ceiling fan circuits
13	Radial	• One 75 W ceiling fan in living room • One 75 W ceiling fan in dining & pantry • One 75 W ceiling fan in bedroom 1 • One 75 W ceiling fan in bedroom 2

2. Diversity factors, Max current and MCB rating demand in each circuit

Circuit Number	Calculation considering the Diversity factors	Max current demand/A	MCB rating/A
1	$0.66\left(\frac{4 \times 20\ W + \ 2 \times 5\ W}{230\ V}\right)$	0.26	6
2	$0.66\left(\frac{1 \times 15\ W + \ 4 \times 10\ W + 2 \times 5\ W}{230\ V}\right)$	0.19	6
3	$0.66\left(\frac{3 \times 10\ W + 2 \times 5\ W}{230\ V}\right)$	0.11	6
4	$0.66\left(\frac{6 \times 10\ W + 2 \times 10\ W}{230\ V}\right)$	0.23	6
5	$0.66\left(\frac{1 \times 15\ W + \ 2 \times 10\ W}{230\ V}\right)$	0.10	6
6	-	-	32
7	-	-	32
8	$\frac{150\ W}{230\ V}$	0.65	6
9	$\frac{2000W}{230\ V}$	8.70	10
10	$\frac{2000\ W}{230\ V}$	8.70	10
11	$\frac{1000\ W}{230\ V}$	4.35	10
12	$\frac{1200\ W}{230\ V}$	5.22	6
13	$\frac{4 \times 75\ W}{230\ V}$	1.30	6

3. RCCB Selection

RCCB	Assigned circuits to the RCCB
40A, 30mA	1
	2
	3
	4
	5
	6
40A, 30mA	9
	10
	11
	12
40A, 30mA	7
	8
	13

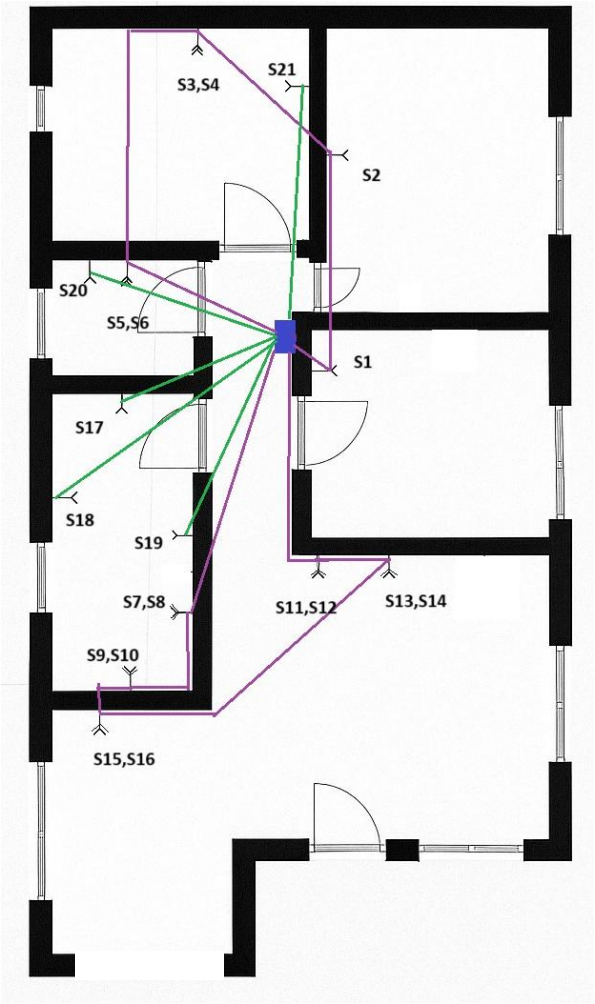
4. Wire Sizes

$$CCC > \frac{\boldsymbol{MCB\ Rating}}{\boldsymbol{C_t \times C_g}}$$

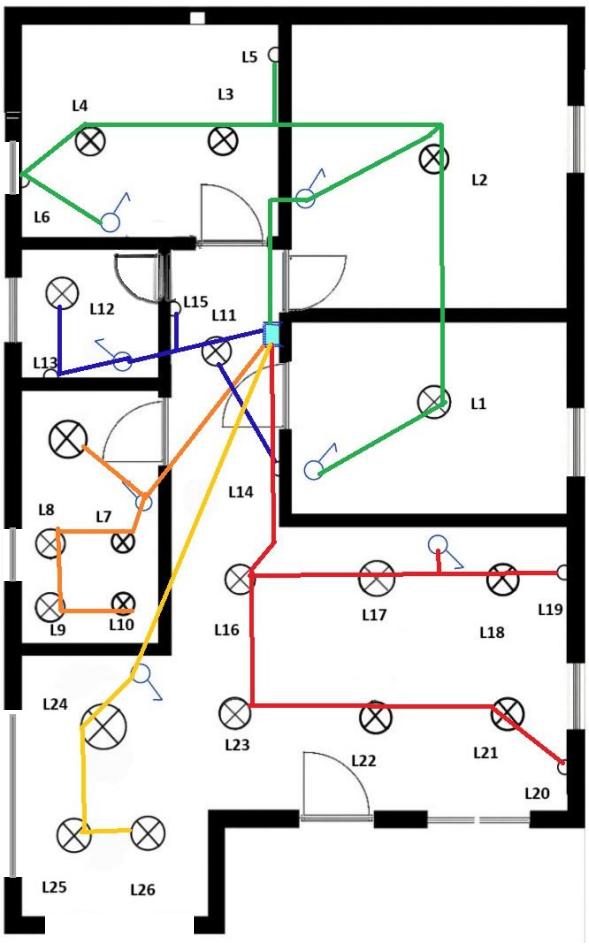
- Allowable voltage drop is 3%. Therefore, allowable voltage drop $= 230\ \text{V} \times 0.03$
  $= 6.9\ \text{V}$
- Ambient temperature factor was taken as 0.94 at 35 °C

Circuit Number	Number of circuits in the conduit	C_g	Minimum CCC / A	Maximum wire length /m	Voltage drop / V	L and N Conductor size (mm^2)	Protective conductor size (mm^2)
1	3	0.7	$\frac{6}{0.94 \times 0.7} = 9.119$	25	$44 \times 10^{-3} \times 25 \times 0.26 = 0.28$	1.0	-
2	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	9	$44 \times 10^{-3} \times 9 \times 0.19 = 0.07$	1.0	-
3	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	11	$44 \times 10^{-3} \times 11 \times 0.11 = 0.06$	1.0	-
4	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	15	$44 \times 10^{-3} \times 15 \times 0.23 = 0.15$	1.0	-
5	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	10	$44 \times 10^{-3} \times 10 \times 0.10 = 0.04$	1.0	-
6	3	0.7	-	21	-	2.5	2.5
7	2	0.8	-	27	-	2.5	2.5
8	3	0.7	$\frac{6}{0.94 \times 0.7} = 9.119$	4	$44 \times 10^{-3} \times 4 \times 0.65 = 0.11$	1.0	2.5
9	3	0.7	$\frac{10}{0.94 \times 0.7} = 15.198$	5	$29 \times 10^{-3} \times 5 \times 8.70 = 1.26$	1.5	2.5
10	3	0.7	$\frac{10}{0.94 \times 0.7} = 15.198$	4	$29 \times 10^{-3} \times 4 \times 8.70 = 1.01$	1.5	2.5
11	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	4	$44 \times 10^{-3} \times 4 \times 4.35 = 0.77$	1.0	2.5
12	3	0.7	$\frac{6}{0.94 \times 0.7} = 9.119$	5	$44 \times 10^{-3} \times 5 \times 5.22 = 1.15$	1.0	2.5
13	2	0.8	$\frac{6}{0.94 \times 0.8} = 7.979$	25	$44 \times 10^{-3} \times 25 \times 1.30 = 1.43$	1.0	2.5

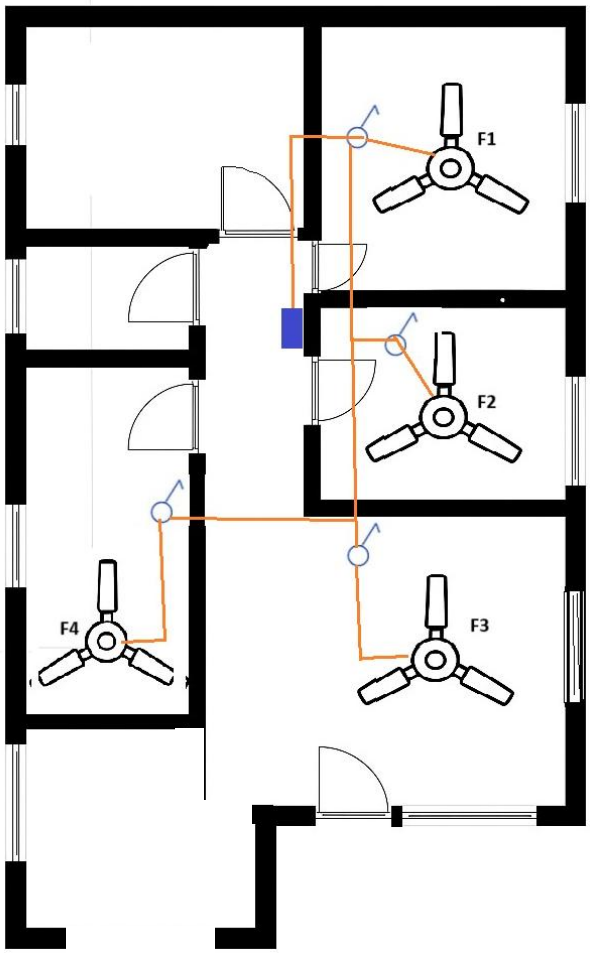
Step 4: Wiring diagrams



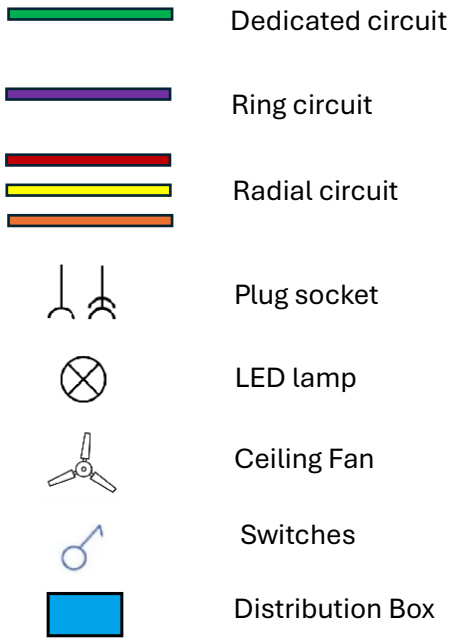
Sockets outlet layout



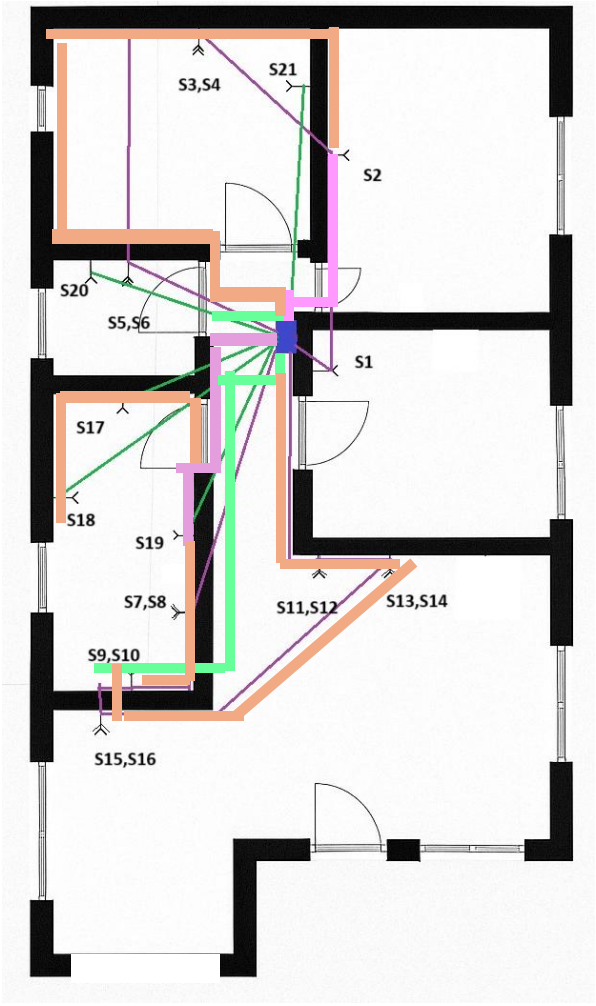
Lamp layout with switches



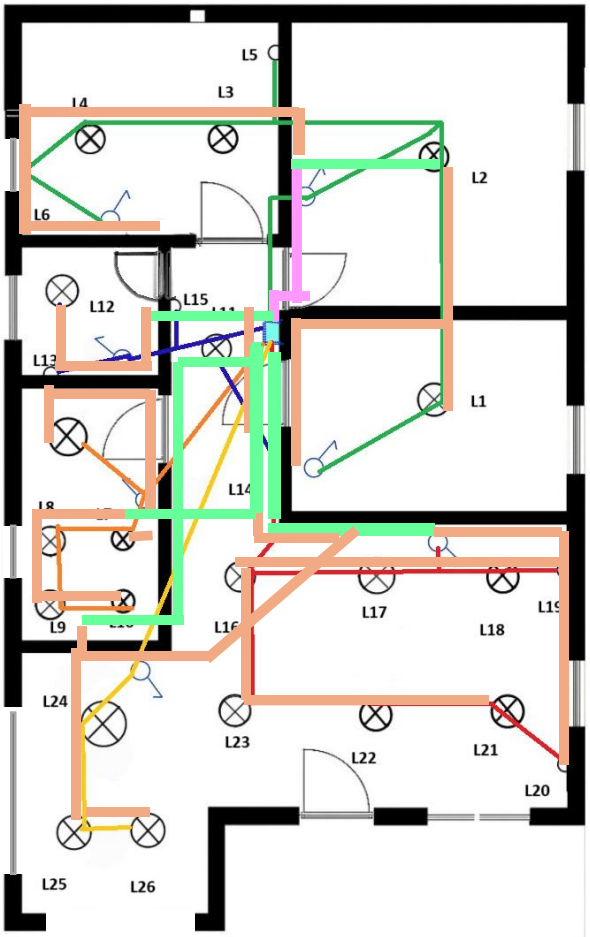
Fan layout



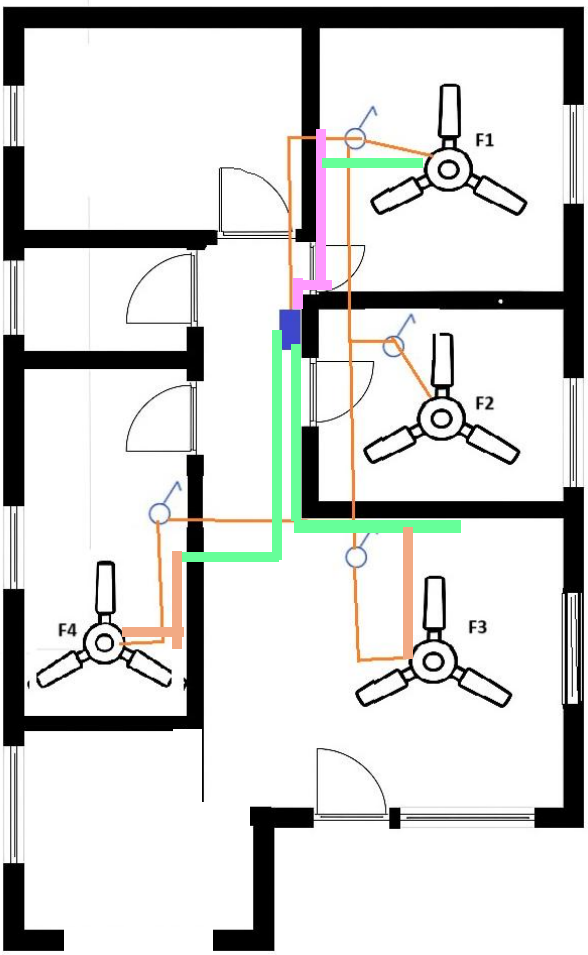
Conduit layouts



Conduit layout for sockets outlet



Conduit layout for lights



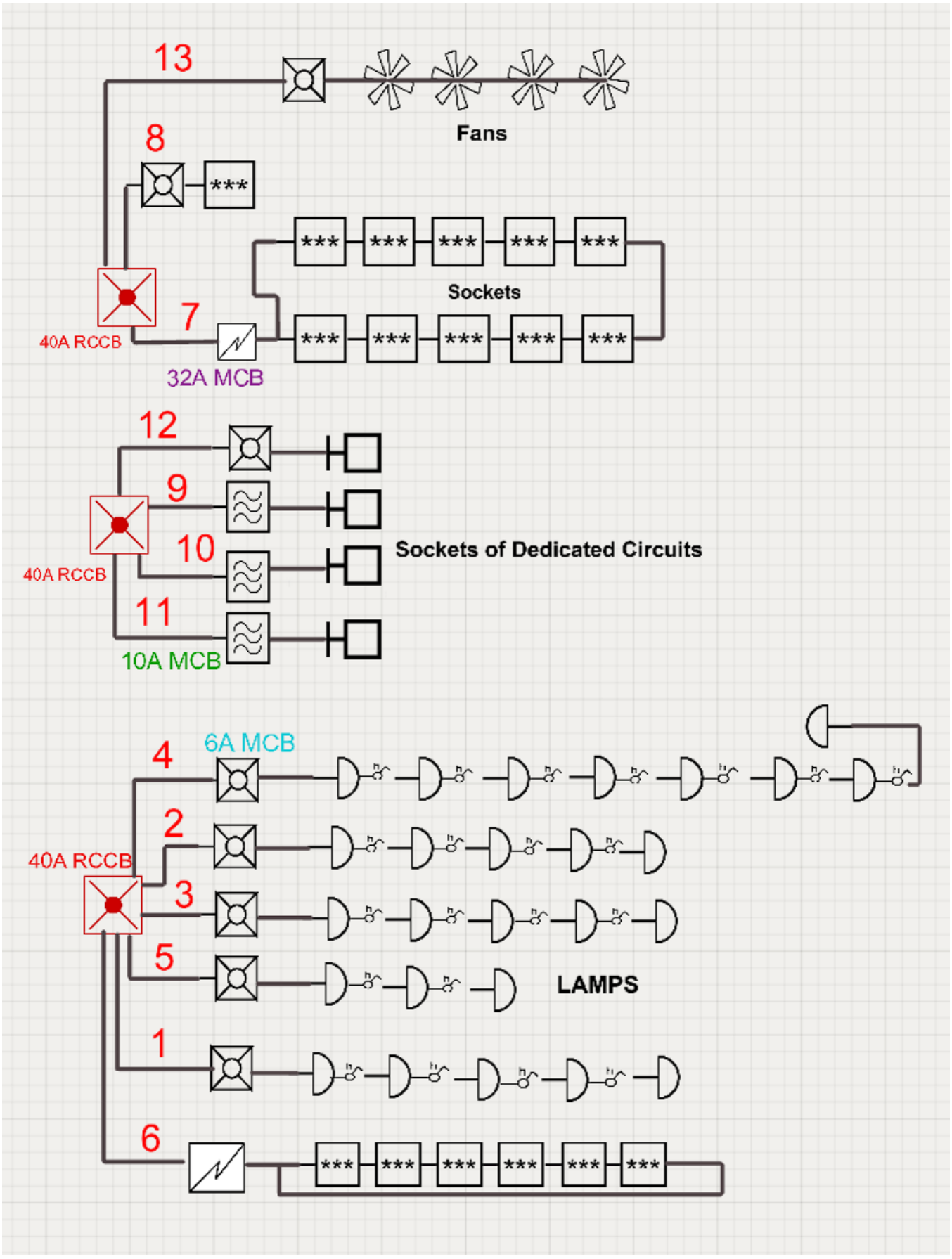
Conduit layout for fans

1” Conduit

¾” Conduit

1/2” Conduit

9. Diagrams


13
Fans
8
***
***
***
***
***
***
Sockets
40A RCCB
7
32A MCB
***
***
***
***
***
12
9
10
11
40A RCCB
10A MCB
Sockets of Dedicated Circuits
6A MCB
4
2
40A RCCB
3
5
LAMPS
1
6
***
***
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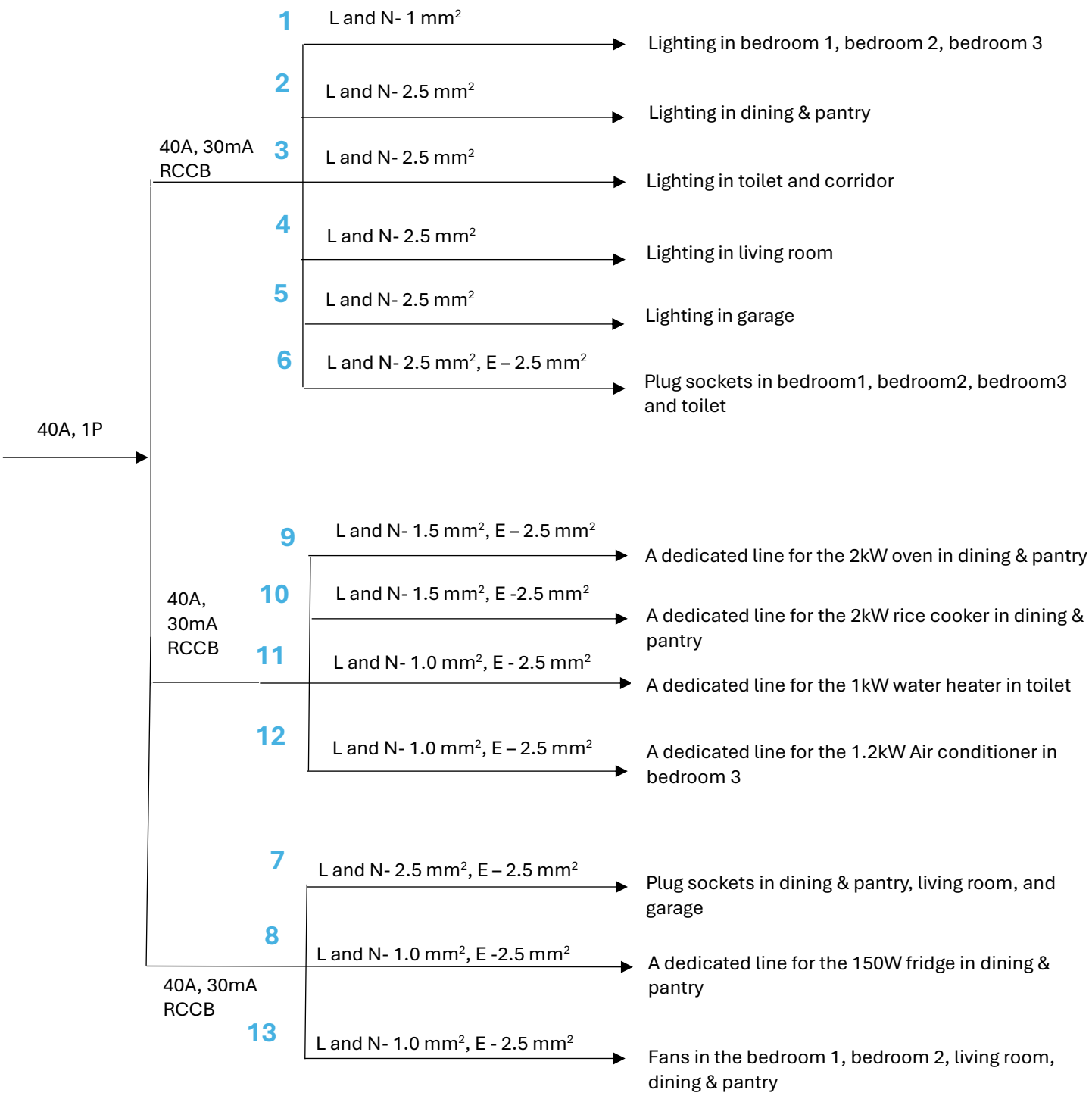
40A, 1P
40A, 30mA RCCB
40A, 30mA RCCB
40A, 30mA RCCB
1
L and N- 1 mm²
Lighting in bedroom 1, bedroom 2, bedroom 3
2
L and N- 2.5 mm²
Lighting in dining & pantry
3
L and N- 2.5 mm²
Lighting in toilet and corridor
4
L and N- 2.5 mm²
Lighting in living room
5
L and N- 2.5 mm²
Lighting in garage
6
L and N- 2.5 mm², E – 2.5 mm²
Plug sockets in bedroom1, bedroom2, bedroom3 and toilet
9
L and N- 1.5 mm², E – 2.5 mm²
A dedicated line for the 2kW oven in dining & pantry
10
L and N- 1.5 mm², E -2.5 mm²
A dedicated line for the 2kW rice cooker in dining & pantry
11
L and N- 1.0 mm², E - 2.5 mm²
A dedicated line for the 1kW water heater in toilet
12
L and N- 1.0 mm², E – 2.5 mm²
A dedicated line for the 1.2kW Air conditioner in bedroom 3
7
L and N- 2.5 mm², E – 2.5 mm²
Plug sockets in dining & pantry, living room, and garage
8
L and N- 1.0 mm², E -2.5 mm²
A dedicated line for the 150W fridge in dining & pantry
13
L and N- 1.0 mm², E - 2.5 mm²
Fans in the bedroom 1, bedroom 2, living room, dining & pantry

Approximate Costs (in rupees)

*Note that the costs are given in LKR

1 mm^2 wire (100 m)	Rs. 5000 – single core	Ceiling roses	Rs. 275
1.5 mm^2 wire (100 m)	Rs. 20000 – two core	13A socket	Rs. 900
2.5 mm^2 wire (100 m)	Rs. 30000 – two core	Switches	Rs. 300 per gang
Earth wires (100 m)	Rs. 15000	MCB	Rs. 800
Fan	Rs.13000	Conduits 1”	Rs. 750 per m
Main switch	Rs. 2500	Conduits 3/4”	Rs. 500 per m
		Conduit ½’’	Rs. 400 per m
RCCB	Rs. 4800	Holder	Rs. 225
Bends, Plastic boxes, junction boxes	Rs. 100	LED lamp	Rs.2000 – 5W wall lamp Rs.1000 – 5W Rs.1500 – 10W Rs.2000 – 15W

Workmanship fees – Rs.750 per point

Bill Of Quantities (BOQ)

1. <u>For ring plug circuit</u>

	For circuit 6&7 (48m)
For plug sockets	14400
Cost for L and N wires	14400
Cost for Earth wires	7200
Cost for conduit (Took 60% of wire length)	17550
Cost for bends, plastic boxes, junction boxes	800+800=1600
Workmanship fees	6000
Total	61150

Total cost for ring plug circuits = 61,150

2. For radial plug circuits

	For circuit 8(4m)	For circuit 9 (5m)
For plug sockets	900	900
Cost for L and N wires	400	1000
Cost for Earth wires	600	750
Cost for conduit (Took 60% of wire length)	1200	1500
Cost for bends, plastic boxes, junction boxes	400	400
Workmanship fees	750	750
Total	4250	5300

	For circuit 10 (4m)	For circuit 11 (4m)	For circuit 12 (5m)
For plug sockets	900	900	900
Cost for L and N wires	800	400	500
Cost for Earth wires	600	600	750
Cost for conduit (Took 60% of wire length)	1200	1200	1500
Cost for bends, plastic boxes, junction boxes	400	400	400
Workmanship fees	750	750	750
Total	4650	4250	4800

Total cost for radial plug circuits = 23,250

3. For lightening circuits

	For circuit 1 (25m)	For circuit 2 (9m)
For lamps	7000	7000
Cost for L and N wires	2500	900
Holders	1125	1125
Switches and sunk boxes	1500	1500
Ceiling roses	1375	1375
Cost for conduit (Took 60% of wire length)	7500	2700
Cost for bends, plastic boxes, junction boxes	600	800
Workmanship fees	750x5 = 3750	750x5 = 3750
Total	25,350	19,150

Average cost for lightening circuits = 22,250

Total cost for lighting circuit = 111,250

4. For Fan circuit

	For circuit 12 (25m)
For Fans	13000 x 4 = 52000
Cost for L and N wires	2500
Cost for Earth wires	3750
Switches and sunk boxes	1500
Cost for conduit (Took 60% of wire length)	7500
Cost for bends, plastic boxes, junction boxes	400
Workmanship fees	750x4= 3000
Total	52650

Total cost for fan circuits = 70,650

Total cost

Description	Cost (rupees)
Main switch	2500
Trip switch	14400
MCB's	10400
Radial plug socket circuits	23250
Ring plug socket circuit	61150
Lightening circuits	111250
Fan circuit	70650
Total Cost	**293,600**

Total cost = 293,600 LKR

REFERENCES

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