ELECTRICAL INSTALLATION DESIGN FOR 13 STOREY APARTMENT BLOCK

MOHAMAD FADLI BIN ABDUL RAHMAN
Faculty of Electrical Engineering
Universiti Teknologi Mara
40450 Shah Alam

ABSTRACT

This project is about designing the electrical installation of 13 storey apartment block which has been prepared with reference to wiring regulations and there are interpretations of particular technicalities. The scopes of the design are calculation of power consumptions, estimate of range of power, lighting installation, MATV (master antenna TV) and telephone. As far as possible all information accords with the requirements of BS 7671: 2001 Requirements for Electrical Installation, the IEE Wiring Regulations. Issued jointly by British standards institution, the Electricity Regulation, Federations of Malaysia, and Tenaga Nasional Berhad (TNB). Besides that every item of equipment, which forms parts of an electrical installation, must be designed and manufactured so that it will be safe to use by consumer.

KEYWORD
MCB (Main Circuit Breaker), RCCB (Residual Current Circuit Breaker), MCCB (Moulded Case Circuit Breakers), SSB (sub switch board), KW (kilo watt), KVA (kilo volt-ampere) and DB (distribution board).

1.0 INTRODUCTION

The 13 storey apartment block is a multi unit dwelling made up of several apartment and it is a high-rise construction. The overall area covers by this building is 1933 m^2 and it consists of several layouts such as apartment, tadika, surau, telephone room, pump room, main switch board (MSB) room, parking area, and playground. The total area of each apartment is 146.2 m^2 and there are 100 apartments in this building block. This apartment consists of bedroom 1, bedroom 2, bedroom 3, bathroom 1, bathroom 2, bathroom3, living room, dining, kitchen, drying yard and utility. The electrical design involve in apartment is lighting and socket outlet. The apartments block also have a parking area and playground which the size of area are 2500 $m^{2.}$ The design needs at both areas are street lighting. Tadika, telephone room, pump room, main switch board (MSB) room and surau cover area of 292.4 m^2, 10.44 m^2, 146.2 m^2, 17.04 m^2 and 292.4 m^2 respectively. The main electrical designs in this area are lighting and socket outlet design. Another required for the layout includes substation design, the cable size needed to optimize the distribution of power to the customer by considering the cost and without sacrificing the protection of the customer. This design was comply with the requirements such as:

- The Regulation for the electrical equipment of building (current edition) as issued by the institution of electrical engineer, London
- The electricity regulation, federations of Malaysia
- The British Standard Electrical Codes of Practice
- Jabatan Bekalan Elektrik dan Gas (JBE&G)

This building also was installed with two lifts which the power of each of lifts is 15kW and it can carry the consumers at least 20 persons or load weight is least than 2000kg at certain times. Whereas, in this project, the pump also was installed in pump room. The power for wet riser pump control panel and suction pump control panel are 70 kW and 10 kW.

When dealing with the design of installation for example small building (such as apartment, surau and tadika) and large building (such 13 storey apartment block), precaution steps must be taken to ensure they do not constitute a hazard to the consumer and damage to the electrical equipments. Considering the maximum demand and diversity is very important in deciding the rating of cables, switches and protective device, the form and size of circuit protective conductor and type of protection to be used.

Before determine the size of cable to be used, it is necessary to measure current of a circuit. This kind of info will be used to choose the size and type of protective device needed. The miniature circuit breaker (MCB) and fuse are commonly used as protective device to protect electrical equipments against overcurrent. For this project, the MCB is preferred to be use because it is easier to do maintenance and more cheap compare with fuses. The factors which affect the ability of a cable to lose heat are ambient temperature, cable grouping and thermal insulation. The earthing system also had to be considered in this installation. The purpose of earthing is to connect all metal part which is intended to carry current to earth. So, all electrical equipments would save from damage cause of the differences potential cannot exist either between different metal parts or between different metal parts or between metal parts and earth. The earthing arrangement of an installation must be such, earth fault and earth leakage currents which may occur under fault conditions can be carried without danger and they are robust and protected from mechanical damage.

Due to the higher electrical load in this building, it need a three phases supply. The loading in this building is too high for the local low- or medium- voltage system to provide and a private sub-station was installed, fed from the high voltage cables from the Electrical boards nearest switching station. The total demand for this building is 700kW. So, from that, the size transformer that suitable to install was 1000 kVA. The electrical installation in this building is similar with to small building (an apartment) but is divided into sections. There is one main intake panel incorporating large fused switches or circuit breaker, each of control a feeder cable to subsidiary distribution in different parts of the building. The subsidiary distribution panels are smaller version of the main intake panel and they control distribution boards for each of sub-station.

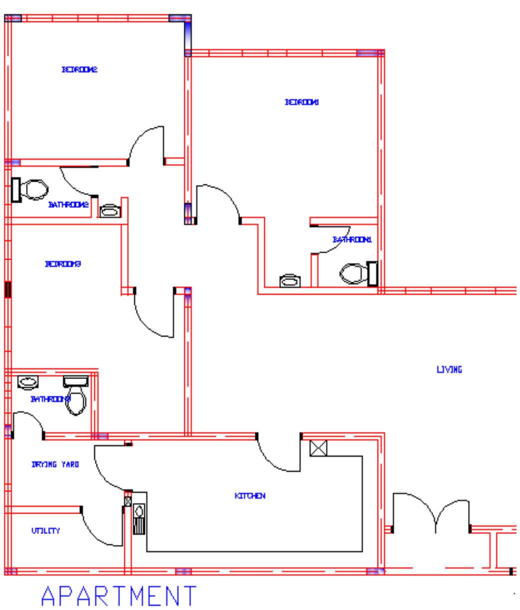


Figure 1: the layout of apartment

2.0 DESIGN METHODOLOGY

2.1 Estimation of power consumptions

Basically, first step must done by the engineer before start to design installation is determine the maximum demand. Installed load is the sum of the rated maximum consumption of all appliances and equipment installed on the on the consumer's premises for connection to the electricity supply. Maximum demand is a total load current which measure from the electrical metal or equipments which will be installed in this building such as water heater, lift, air condition and etc. measurement may be either in kilo volt-ampere (KVA), which automatically includes the effect of the prevailing power factor, or in kilo watt (KW).

Besides considering the maximum demand, the diversity also very important to consider in order deciding the rating of cables, switches and protective device, the form and size of circuit protective conductor and type of protection to be used. The application of diversity in installation permits is by assuming that not all loads will be energized at the same time, a reduction in main or distribution circuit cable sizes. Tabulate diversity in the form of percentages of full load for various circuits in a range of installations as said in The IEE Regulations guidance notes or On-Site Guide. However it is for the designer to make a careful judgment as to the exact level of diversity to be applied.

It would be uneconomical to provide cables and protective device of a capacity for the maximum possible load, they will carry the load are likely to be less that the maximum. Challenge is to make electrical system in building such as:

- Energy efficient with better energy management,
- Safe in all aspects,
- Of adequate power quality with regards to harmonics and overvoltages,
- Able to accommodate modern IT systems,
- Compatible with EMI requirements of electrical systems,
- Able to provide monitoring system to assess condition of electrical installation,
- Comply with all statutory regulations

Because that, the Guide to power demand estimate was referred in order to estimate the maximum demand and diversity. This guide is produce by Tenaga Nasional Berhad (TNB) in their book called as TNB's Electricity Supply Application Handbook in order to gives guidelines to consumers, contractors and consultants for the estimation of maximum demand, voltage level and method of connection. The guide to power demand estimate as show in table 1.

FEATURE	DEMAND IN VOLT-AMPERE PER AREA(VA / M^2)
Lighting Office Others (Store, Corridor)	 25 – 30 10
Air-Conditioning	90 - 130
Gpo (General Power Outlet)	40 - 50
Lifts	10
Amenities Hot Water, Etc	5 - 10

Table 1 the power demand estimate for TNB's Electricity Supply Application Handbook

Inside the TNB's Electricity Supply Application Handbook also has typical values of group diversity factor applied in the computation of final demand. The value of group diversity factor applied in the computation of final demand was showed as in table 2.

CUSTOMER CLASSES	GROUP DIVERSITY FACTORS
Domestic Less than 10 customers More than 10 customers	 0.80 0.75
Commercial or industrial Less than 10 customers More than 10 customers	 0.80 0.75

Table 2 the value of group diversity factor applied in the computation of final demand

2.2 Design Calculations

In every installation the supply divides and subdivides as is necessary to reach the outlets all over the building. Each final subdivision is made as near as possible to the centre of the load in that area, the amount of power to be used governing the type and size of cable and the nature of the equipment. The requirements of IEE Regulation were followed, in order to make sure the design of circuit and the design data made readily available. Basically there are eight stages in such a procedure. These are the same whatever the type of installation, be it a cooker circuit or a submain cable feeding a distribution board in factory. Here the eight basic steps in a simplified form:

1) Determination of design current, I_b
2) Selection of protective device having nominal rating or setting, I_n
3) Selection of appropriate correction factors
4) Calculation of tabulated conductor current, I_t
5) Selection of suitable conductor size
6) Calculation of voltage drop
7) Evaluation of shock risk
8) Evaluation of thermal risks to conductors.

2.2.1 Design current, I_b

The design current is defined as the magnitude of the current to be carried by a circuit in normal service, and is either determined directly from manufacturers' details or calculated using the following formula:

Single phase:

$$I_b = \frac{P}{V} \text{ or } \frac{P}{V \times Eff\% \times PF}$$

Three phase:

$$I_b = \frac{P}{\sqrt{3} \times Vl} \text{ or } \frac{P}{\sqrt{3} \times Vl \times Eff \times PF}$$

Where:

P = power in watts
V = phase to neutral voltage in volts
VL = phase to phase voltage in volts
Eff = efficiency
PF = power factor.

2.2.2 Nominal rating or setting of protection, I_n

The first requirement for I_n is must be greater than or equal to I_b. This condition can be select from IEE Regulations Tables 41B1, 41B2 or 41D. Details from the manufacturer will need to be sought, for types and sizes outside the scope of these tables. Table below show commonly used protective devices.

Device	***Application***	***Comments***
Semi-enclosed re-wireable fuse BS3036	Mainly domestic consumer units	Gradually being replaced by other types of protection. Its high fusing factor results in lower cable current carrying capacity or, conversely, larger cable sizes. Does not offer good short-circuit current protection Ranges from 5A to 200 A.
HBC fuse links BS88 Parts 2 and 6	Mainly commercial and industrial use	Give excellent short-circuit current protection. Does not cause cable de-rating. 'M' types used for motor protection. Ranges from 2A to 1200 A.
HBC fuse links BS1361	House service and consumer unit fuses	Not popular for use in consumer units, however, gives good short-circuit current protection, and does not result in cable de-rating. Ranges from 5A to 100 A.
MCBs (miniature circuit breakers) BS3871, now superseded by BS EN 60898 CBs	Domestic consumer units commercial/ Industrial distribution boards.	Very popular due to ease of operation. Some varieties have locking-off facilities. Range from 1A to 63A single and three phase. Old types 1, 2, 3 and 4 now replaced by types B, C and D with breaking capacities from 3 kA to 25 kA.
MCCBs (moulded case circuit breakers) BS EN 609472	Industrial situations where high current and breaking capacities are required	Breaking capacity, 22 kA to 50 kA in ranges 16A to 1200 A. 2, 3 and 4 pole types available.

Table 3 commonly used protective devices

2.2.3 Correction factors

There are several conditions which may have an adverse effect on conductors and insulation, and in order to protect against this, correction factors (CFs) are applied. These are:

C_a Factor for ambient temperature (From IEE Regulations Tables 4C1 or 4C2). The cable ratings quoted in the IEE Regulations are based on n ambient temperature of 30°C, and so it is only above this temperature that an adverse correction is needed.

C_g Factor for groups of cables (From IEE Regulations Table 4B).

C_f Factor if BS 3036 re-wireable fuse is used (Factor is 0.725)

C_i Factor if cable is surrounded by thermally insulating material (IEE Regulations Table 52A).

2.2.4 Tabulated conductor current carrying capacity It

$$I_t = \frac{In}{Ca \times Cg \times Ci \times Cf}$$

Where;
In is the rating of the protection in ampere (A)
C_i is the thermal insulation factor
C_a is the ambient temperature factor
C_f is the protection by BS 3036 fuse
C_g is the cable grouping factor

When determine the current carrying capacity, I_t the relevant factor always consider to use. When discussing about overload protection, the Regulations permit the omission of such protection in certain circumstances (473–01–04), in these circumstances, I_n is replaced by I_b and the formula becomes:

$$I_t = \frac{Ib}{Ca \times Cg \times Ci}$$

Where;
In is the rating of the protection in ampere (A)
C_i is the thermal insulation factor
C_a is the ambient temperature factor
C_g is the cable grouping factor

Example:

Let the I_n=40A
Since I_n>Ib
Choose I_n = 40A

By using formula

$$I_t = \frac{In}{Ca \times Cg}$$

The value for the Correction factor for ambient temperature (C_a) will be find in Table 4C1 IEE Regulation and the value of Correction factor (C_g) can be find by using the table 4B1

Let C_a =0.87,C_g =0.8

The I_t will be 57.5 A.

2.2.5 Selection of suitable conductor size

During the early stages of the design, the external influences have been considered, and a method of circuit installation is chosen. The table 4A1in IEE Regulations gives examples of installation methods, and it is important to select the appropriate method in the current rating tables. That the correct cable rating table and relevant reference method are selects, the conductor size is determined to correspond with I_t is greater or equal to the corrected value of I_n or I_b as is the case. Table4 show the cable size and it main circuit breaker (MCB) rating.

CIRCUIT	MCB	CABLE SIZE (SQ.MM)	AREA
Light And Fan	6A	1.5	-
S/S/O-Ring	32A	2.5	100m2 Max.10nos
S/S/O-Radial	32A	4.0	50m2 Max.6nos
S/S/O-Radial	16A/20A	2.5	20m2 Max.2nos
Air Cond.	20A	2.5	-
Air Cond.	32A	4.0	-
El And K.Sign	6A	1.5	Stand Alone
S/S/O-15a	16A	2.5	1nos/Circuit

Table 4: Cable size and MCB rating

2.2.6 Voltage drop

In many instances this may well be the most onerous condition to affect cables sizes. Based on the Regulations requirement, the voltage at the terminals of fixed equipment should be greater than the lower limit permitted by the Malaysia Standard and international standard for that equipment, that the safe functioning of the equipment should not be impaired. These requirements were fulfilled if the voltage drop between the origin of the installation and the equipment does not exceed 4 percent of the supply voltage. That means a permitted drop of 9.6V for a single-phase 240V supply and 16.6V for a 415V three-phase supply. Accompanying the cable current rating tables are tabulated values of voltage drop based on the millivolts (mV) dropped for every ampere of design current (A), for every metre of conductor length (m), i.e.

Voltage drop, $Vc = \frac{mV \times Ib \times L}{1000}$

Where

Vc is voltage drop in volt (V)

mV is volt-drop in unit mili-volt per ampere per metre (mV/A/m)

L is length of conductor in metre

I_b is design current in ampere unit (A)

2.2.7 Evaluation of shock risk

When evaluate shock risk, the value of loop impedance that was calculated should not exceed the tabulated value quoted for the protective device in question. The total value of loop impedance, Zs is therefore the sum of these values:

$$Zs = Ze + (R1+R2)\Omega$$

Where:

Zs is the actual loop impedance in ohms

Ze is that part of the earth fault loop impedance external to the circuit concerned

R1 is the resistance of the phase conductor from the origin of the circuit to the point of utilization

R2 is the resistance of the protective conductor from the origin of the circuit to the point of utilization

Provided that, the value of Zs does not exceed the maximum value given for the protective device in question in Tables 41B1, 41B2 or 41D of the Regulations, the protection will operate within the prescribed time limits. It must be noted that the actual value of (R1+R2) is determined from:

$$(R1 + R2) = \frac{\text{Tabulated value of } (R1 + R2) \times \text{circuit length} \times \text{multiplier}}{1000}$$

Note: The multiplier corrects the resistance at 20 ℃ to the value at conductor operating temperature.

2.2.8 Evaluation of thermal constraints

The 'let-through' energy of a protective device under fault conditions can be considerable and it is therefore necessary to ensure that the CPC is large enough either by satisfying the requirements of IEE Regulations Table 54G or by comparing its size with the minimum derived from the formula:

$$s = \frac{\sqrt{I^2 t}}{K}$$

Where:
s is the minimum csa of the CPC
I is the fault current
t is the disconnection time in seconds
k is the factor taken from IEE Regulations Tables 54B to 54F

2.2 LIGHTING SYSTEM

Lamp is the electrical equipment which produces the light. There are three categories of electric lamps; it is incandescent filament lamps, compact fluorescent lamps and high intensity discharge (HID) lamps.

The first and most important decision is the selection of lamps. When choosing the lamp, the criteria such as the type of area, lighting requirements, space dimensions, color requirements, relative lamp efficiency, glare properties, dimming properties, Starting and restarting characteristics, range of wattages, Lamp life costs in lamp replacement, Price and availability must be considered. The requirements of the occupiers, architectural concepts and building constraints also must be take into account when designing the lamp installation.

The procedure to calculate the number of lamp is shown below. All the calculation example of number of lamp used is show in result and discussion topic.

Procedure to calculate number of lamp;

1. Room length and room width must be considered to find the room area. The height of the room also must be considered.
2. By using the equation 1, the room index value is calculated.

   $$\text{Room index} = \frac{LW}{Hm\ (L+W)} \text{ ------(1)}$$

   Where:
   L is length in meter
   W is width in meter
   Hm is height of fitting above the working plane in meter
3. Base on the value of room index that has been calculated in step 2, the coefficient of the utilization from the table of coefficient of utilization of lamp is defined. From the table 5, the desired lumen of the room is defined.
4. By using the equation 2, the installed flux is calculated. In this case the maintenance factor is set to 0.8.

   $$\text{Installed flux, } F = \frac{A \times E}{UF \times MF} \text{ -------(2)}$$

   Where
   E is the average horizontal illumination at working place
   UF is the utilization factor

   MF is the maintenance factor
   A is the area of the working plane in square metres.
5. From the table of the illumination which shown in table 6, the lumen of the desired lamp is select and the number of lamp use is calculated by using the equation 3.

   $$\text{Number of lamps required, } N = \frac{F}{LDL} \text{ ------(3)}$$

GENERAL BUILDING AREAS	IES STANDARDS ILLUMINATION LEVEL	MS 1525 RECOMMENDATION	PANDUAN TEKNIK JKR
HOMES			
Living rooms general	50		50
Casual reading	150		150
Sewing darningsrudies desk and protuged	300		300
Bedroom general	50		50
Bedlead kitchen	150		150
Kitchen working areas			
Bathrooms	100		100
Halls and landings	150		150
Stairs	100		100
Workshops	300		200
Garages	50		50
CIRCULATION AREA			
Corridors, Passageway	100	50	100
Lift	150	100	100
Stairs	150	100	100
Escalator	150	150	100
External Covered Ways	30	50	30
STORE AND STOCK ROOMS	150	100	150
Telecommunication board, switchboard rooms			
Cordless			500
switchboard	300		300
Apparatus rooms	150		150
Teteprinter rooms	500		500

Table 5: Illumination index

Bil	Lighting Type	LDL
1	Pendaflour 1 x 18W	1325
2	Pendaflour 2 x 18W	2650
3	Pendaflour 1 x 36W	2650
4	Pendaflour 2 x 36W	5300
5	Pendaflour 3 x 36W	7950
6	Pendaflour 4 x 36W	10600
7	Tungsten Bulb 40W	325
8	Tungsten Bulb 60W	576
9	Tungsten Bulb 100W	1160
10	Mercury 80W	2500
11	Mercury 125W	4600
12	Mercury 250W	10400
13	Mercury 400W	18000
14	Mercury 700W	32000
15	Metal Halide 400W	22000
16	Metal Halide 1000W	70000
17	Down Light SL	1000
18	PL-L/4P 18W	1200
19	PL-L/4P 24W	1800
20	PL-L/4P 36W	2900
21	PL-L/4P 40W HF	3500
22	PL-L/4P 55W HF	4800
23	PL-S/2P 5W	250
24	PL-S/2P 7W	400
25	PL-S/2P 9W	600
26	PL-S/2P 11W	900
27	PL-S/4P 5W	250

Table 6: lamination lumen

3.0 RESULT AND DISCUSSION

The sample of electrical design of this project is shown in figure 1. Every point of lamp and fan connection is shown in the figure below. The legend for this drawing can be finding in figure 2. All the necessary information for the lamp and fan can be finding in the legend description.

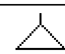
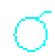
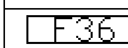
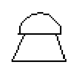
Legend	
	13 A socket outlet
	MATV point
	One way 10 A switch
	Distribution board
	18 W tubular fluorescent lamp
	36 W tubular fluorescent lamp
	Ceiling fan
	Telephone outlet

Table 7: Legend for electrical drawing

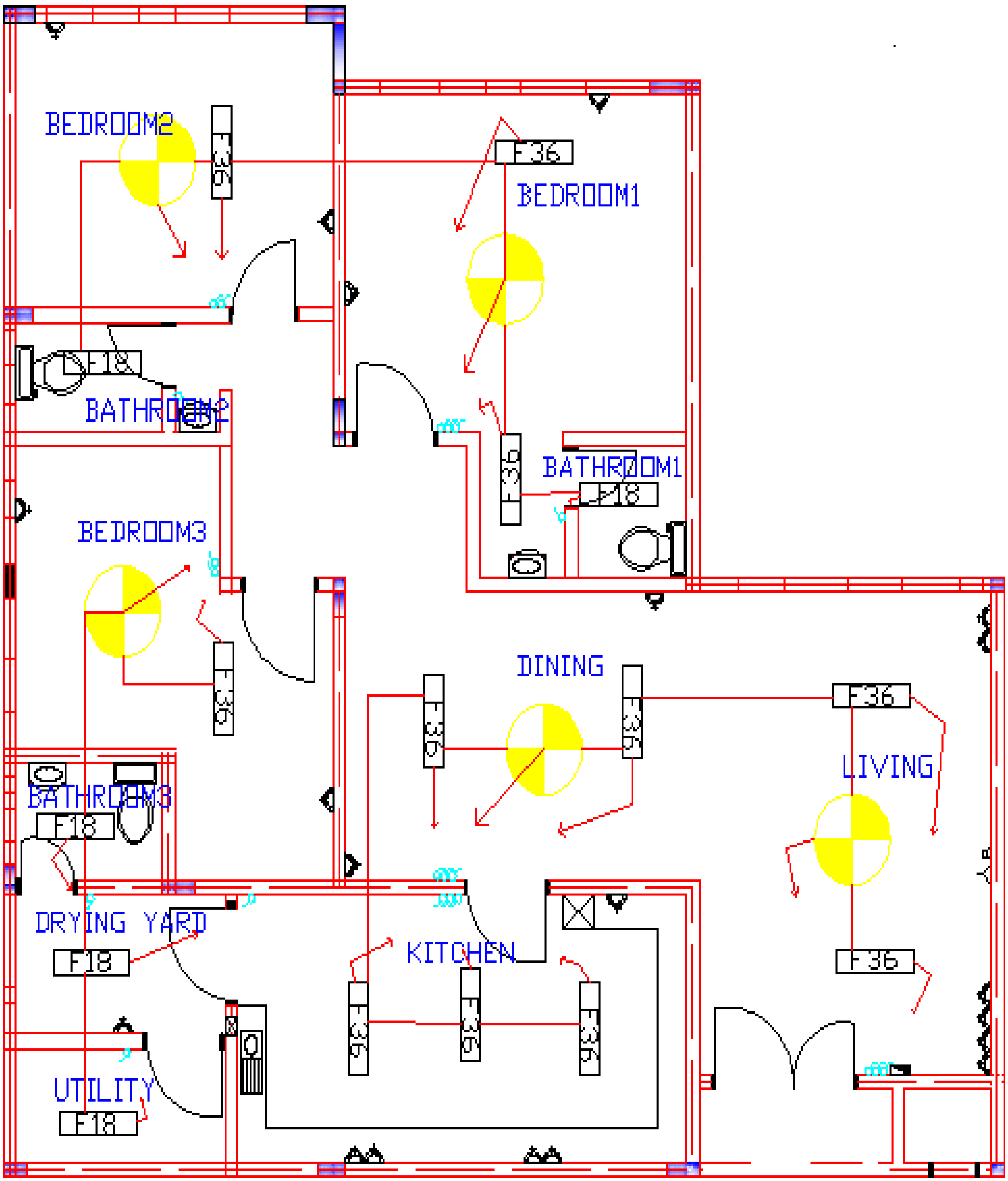


Figure 1: Electrical installation drawing

The estimation of power consumption is showed in table below. Also, it shows how the group diversity factors will be applied in order to determine maximum demand, before design the electrical installation. The total demand for one unit apartment is showed in table 8.

APARTMENT	AREA	LIGHTING	A/C	GPO	AMENITIES	TOTAL
BEDROOM 1	15.75	472.5	1417.5	630		2520
BEDROOM2	11.7	351		468		819
BEDROOM 3	11.7	351		468		819
BATHROOM1	3.24	81				81
BATHROOM2	4.675	116.875				116.875
BATHROOM3	2.16	54				54
KITCHEN	17.544	526.32		877.2		1403.52
DINING	8.1	243		324		567
LIVING	18.36	550.8		734.4	183.6	1468.8
YARD DRYING	3.78	113.4		151.2		264.6
UTILITY	2.5179	75.537				75.537
TOTAL DEMAND (VA)						8189.332

Table 8: the total demand for one unit apartment

The calculation for the illumination results are sorted in Excel tables below. The output data for the number of lighting point will be use in this design are shown below, originally they look like in Excel output table.

NO	LOCATION	ROOM LENGTH, L (m)	ROOM WIDTH, W (m)	ROOM AREA, A (m^2)	ROOM HEIGHT, H (m)	ROOM INDEX (RI)	COEFFICIENT OF UTILIZATION, Uf	SERVICE ILLUMINANCE (Eav), LUX	MAINTENANCE FACTOR (MF)	INSTALLATED FLUX (IF)	TYPE OF LAMP & LAMP WATT	LIGHTING DESIGN LUMEN OF LAMP (LDL)	NUMBER OF LAMPS (N)
1	Bedroom1	4.2	4.2	17.64	3	0.7	0.28	50	0.8	3938	Pendf: 1× 36W	2650	2
2	Bedroom2	3.001	3.899	11.697	3	0.57	0.24	50	0.8	3046	Pendf: 1× 36W	2650	1
3	Bedroom3	3	3.899	11.697	3	0.57	0.24	50	0.8	3046	Pendf: 1× 36W	2650	1
5	Bathroom1	1.199	2.7	3.237	3	0.28	0.33	100	0.8	1226.13	Pendf: 1× 18W	1325	1
6	Bathroom2	1.199	3.899	4.6749	3	0.31	0.33	100	0.8	1770.8	Pendf: 1× 18W	1325	1
7	Bathroom3	1.199	1.8	2.1582	3	0.24	0.33	100	0.8	817.5	Pendf: 1× 18W	1325	1
8	Dining	3	4.2	12.6	3	0.58	0.45	150	0.8	5250	Pendf: 1× 36W	2650	2
9	Living	5.1	3.6	18.36	3	0.7	0.33	50	0.8	3477.3	pendf: 1×36W	1325	2
10	utility	1.199	2.1	2.5179	3	0.25	0.33	50	0.8	477	Pendf: 1× 18W	1325	1
11	Drying Yard	1.8	2.1	3.78	3	0.32	0.33	50	0.8	715.91	Pendf: 1× 18W	1325	1
12	Kichen	3	4.2	12.6	3	0.58	0.33	150	0.8	7159	Pendf: 1× 36W	2650	3

Table 9: Illumination Calculation

Example: Estimate the maximum demand.

The number of the apartments is 100 units. From group diversity factor, 0.75 is choosing. The power factor is consider, 0.85 pf. The maximum demand is showed as below.

Max. demand = number of apartment × total demand in volt-ampere (VA) × diversity × power factor

= 100 × 8189.332 × 0.75 × 0.85

= 522 kW

Example: Design calculation.

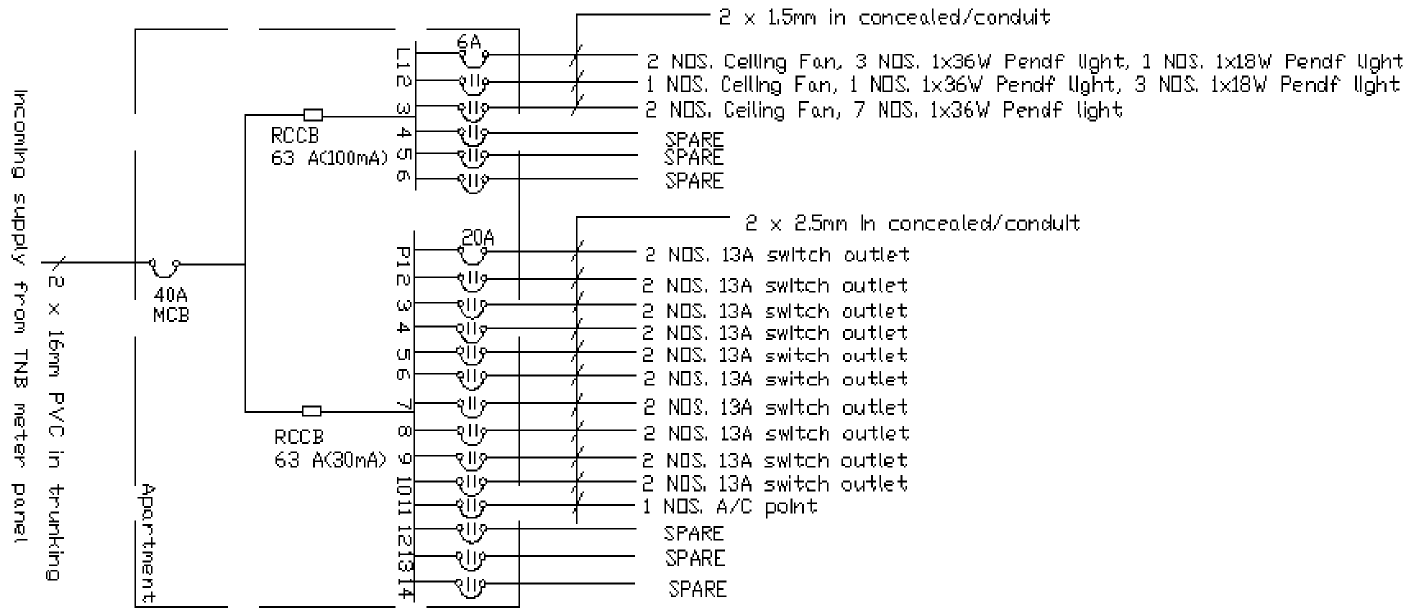


Figure 2: Schematic diagram

This calculation considered the table 4 above.
Let,

The maximum demand for one unit apartment is
Max. Demand = 8189.332 VA× 0.75 × 0.85
= 5.22 kW

By using basic formula, The I_b current can be defined.

$$I_b = \frac{P}{V}$$

So current I_b =21.75A

By referring the Table 41B2 IEE Regulation, the Rating Current for I_n is 40A.

Let the I_n=40A
Since I_n>Ib
Choose I_n = 40A

By using formula

$$I_t = \frac{In}{Ca \times Cg}$$

The value for the Correction factor for ambient temperature (C_a) will be find in Table 4C1 IEE Regulation and the value of Correction factor (C_g) can be find by using the table 4B1

Let C_a =0.87,C_g =0.8
The I_t will be 57.5 A.
After tabulated conductor current carrying capacity, I_t, next, the cable size is determine. The type of cable to use is multicore 70℃ thermoplastic (PVC) insulated and thermosetting insulated cables, non-armoured and the table 4D2A the IEE Regulation will be use.

The cable chosen is 16 mm.sq

The minimum voltage drop of cable which used to supply a load of 21.75 A with a cable length of 30m, and protection by miniature circuit-breaker (MCB), can be calculate by using this formula.

$$\text{Voltage drop, } Vc = \frac{mV \times Ib \times L}{1000}$$

By referring table 4D2B in the IEE Regulation mV is 2.8mV/A/m

$$\text{Voltage drop} = \frac{2.8 \times 21.75 \times 30}{1000}$$

= 1.83 V (<9.6 V, where 9.6 V is 4 percent of 240 V)
So, the size of cable is suitable to use.

The phase conductor of the circuit has been calculated as $16mm^2$, and a twin cable of this size has a $6.0mm^2$ CPC. Then, by using the tabulated values of R1 and R2 given in the on-site guide, 30m of cable would have a resistance under operating conditions of:

$$R1 + R2 = \frac{(R1 + R2) \times 1.38 \times length}{1000}$$

$$R1 + R2 = \frac{(4.23) \times 1.38 \times 30}{1000}$$

R1 + R2 = 0.175
(1.38 = multiplier for PVC from table 6 B) and as Ze is 0.3 ohms, then:
Zs = Ze+R1+R2
= 0.3+0.175
= 0.475 ohms

Refer to table 41B2 from IEE Regulation, only MCB (BS 60898) type C is suitable to use because maximum Zs at 40 A is 0.6 ohms.

Then, the actual earth fault loop impedance is 0.475 ohms and the nominal voltage to earth is 240 V are use to calculate the fault current as below;

$$If = \frac{Uoc}{Zs}$$

$$= \frac{240}{0.475}$$

= 506 A
By referring the appropriate curve for the 40A MCB (type C), obtain a disconnection time t of 0.02s and constant, k is 115. Therefore the minimum size of PVC is given by

$$S = \sqrt{\frac{(If^2 \times t)}{k}}$$

$$= \sqrt{\frac{(506^2 \times 0.02)}{115}}$$

= 0.65 mm2
So, 6 mm2 PVC is acceptable.

Example: Lamp illumination calculation.

The bedroom
The measuring area is 4.2m × 4.2m to provide with an illuminance consistent with good practice. The height of ceiling-mounted fittings likely to be appropriate is 3m. The reflectance of ceiling is 70 percent and of the walls is 30 percent, is the common reflection factor for that area. The value of an illuminance that required for this area is 50 Lux refer from the code of the IES, JKR and the lighting industry federation Ltd. In order to minimize the installation cost, the tubular fluorescent (1× 36W)

was choosing to use. Besides that, this lamp was choosing because it is compatible with daylight, long life and high efficacy. The luminaire tentatively has a downward light output ratio (DLOR) of 50 percent was selected.

Before determine the utilization factor, the first thing must calculate is room index.

$$\text{Room index} = \frac{\text{LW}}{\text{Hm (L+W)}}$$
$$= \frac{4.2\times4.2}{3\ (4.2+4.2)}$$
$$= 0.7$$

The table in appendix 3 shows that for a DLOR of 50 percent, this combination of room index and reflectance means a utilization factor of 0.25 (for R.I is 0.6) and 0.31 (for R.I is 0.8). So,

$$\frac{0.7-0.6}{0.8-0.6} = \frac{UF-0.25}{0.31-0.25}$$

UF = 0.28

A suitable maintenance factor is considered to be 0.8.

$$\textit{Installed flux, } F = \frac{\text{A} \times \text{E}}{\text{UF} \times \text{MF}}$$
$$= \frac{4.2 \times 4.2 \times 50}{0.28 \times 0.8} = 3938 \text{ lumens}$$

From appendix 10, the lighting design lumens output of a 36 W tubular fluorescent lamp is 2650 lumen

$$\text{Number of lamps required, N} = \frac{3938}{2650}$$
$$= 1.49$$
$$= 2$$

4.0 RECOMMENDATION

Domestic electrical installations have been included within the scope of the Building Regulations. All new domestic electrical installations, together with specific alterations and additions to current installations, will have to be inspected and comply with strict electrical safety performance standards. The standards cover the design, installation, inspection and testing of domestic electrical work and the provision of information.

The main reason for the change is the need to reduce the hazards posed by unsafe domestic electrical installations and thereby help to reduce injuries from electrical shocks and burns. It is also hoped to reduce injuries arising from fires in dwellings due to electrical components overheating or arcing.

5.0 CONCLUSION

This project has outlined and illustrated a method to make the design strategies. This project can tell us about the procedure and step taken to becomes the installation designer and learn how to produce the creative and unique installation but without sacrificing the most effective factor i.e. protection. Besides, able to understand and know to use AutoCAD software to draw layout. Domestic electrical installations were simple and only basic design planning was necessary. The most important thing must be consider when doing the installation design is the total current demand and diversity of consumer. From this value, the size of cable, fuse and protective device can be measure. The choice of a cable, the size of fuse and circuit breaker that use in this installation design must higher than calculation value to avoid short circuit and overload. For the future development, this project can be added with the new technology of designing and installation equipment. Some of the design in this project is spare for future installation.

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