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A New LVDC Wiring System Design and Modification for Conventional Residential LED Lighting Application

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***Abstract*—This paper proposes a new low voltage direct current (LVDC) wiring system design and the modification of conventional residential LED lighting application. Nowadays, the residential lighting system used the supply from the authorized energy supplier to power up all the electrical appliances at home. In Malaysia, the voltage distributed to residential area is 230V AC. The motivation of this study is the application of 12V low voltage direct current (LVDC) can improve the efficiency of performance of electrical appliances that run on DC. As we know, the electrical appliances that driven by DC requires AC/DC converter to operate. But the conversion process of the converter creates losses due to the switching of the device. This study focused on the consideration of wiring design of DC system in residential for LED lighting application especially the size of cable. Maximum number of load than can supports in a point with particular breaker rating is discussed.**

Keywords*— *DC, residential lighting, LED, green technology, wiring design, cable sizing.

I. INTRODUCTION

Nowadays, the rigid development on LED lighting makes brings the development in DC system as well. The advantages of using LED as lighting has big potential to replaced CFL as residential lighting [1-3]. Furthermore, for residential application DC system are said better than AC system. Moreover, LED is DC driven device and the development in LED technology improved it efficiency and thermal problem to be better performance cooling methods using seebeck effect method [4-9]. The losses evaluation on DC and AC system for residential have been observes and the loss calculation result shows the total losses in DC system are 15% lower than the losses in AC system [4].

II. CASE STUDY DESCRIPTION

This study are conducts the design for residential in LED lighting application. Figure 1 shows the typical Malaysian double storey house plan layout. It has about 22 total lighting points in a house and each point controlled by one switch.

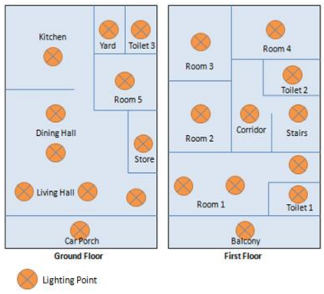
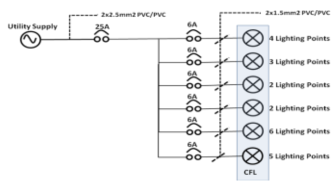
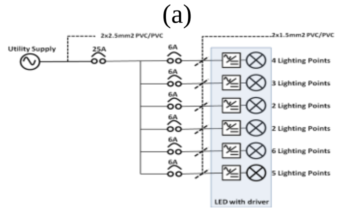


Figure 1: Typical Malaysian double storey house plan layout

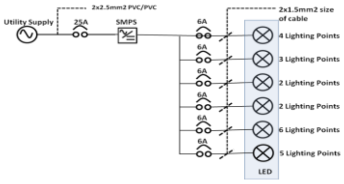
Figure 2(a), 2(b) and 2(c) below shows single line diagram of residential conventional lighting system which operates in 240V AC system. Driver that used at LED lamps makes the 240V AC system differs to each other. Existing of the driver prevents the LED lamps to operate efficiently because the conversion process of the converter creates losses due to the switching of the device. The new proposes system that applies 12V DC for residential LED lighting application single line diagram shows in figure 2(d). It shows that the proposes system has reduced the number of driver used for conversion process.



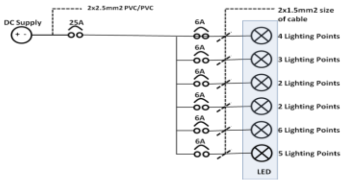
(a)



(b)



(c)



(d)

Figure 2: Single line diagram of four different system

A. *Case 1: Conventional System Design*

Single line diagram for conventional system shows in figure 2(a) and 2(b) which applies CFL and compact LED lamp as the standard device for lighting. The calculations that represent the design of conventional residential lighting system that refers as case 1 are shown below. Long time ago, the standard maximum power that sets for lighting is 100w which is applicable for incandescent lamps. However, the 100w incandescent lamps are equivalent with 25w CFL and 12w LED lamps which are current standard type of lamps used in residential [10]. From the calculation below, the maximum number of load can be supported at one miniature circuit breaker (MCB) are 30 lamps. The suitable size of cable for 6A MCB rating is 1.0mm^2 which are the minimum size of cable. However, the current standard has sets the minimum size of cable for lighting purposes is 1.5mm^2 [11-13].

So, the number of current requires for each CFL in this case are:

$$I(Lamp) = \frac{P}{V} \tag{1}$$
$$I(Lamp) = \frac{25x1.8}{230}$$
$$I(Lamp) = 0.1957A$$

Each lamp requires 0.1957A. Hence, the number of lamps can fit at 6A rating of circuit breaker are:

$$N = \frac{I(Breaker)}{I(Lamp)} \tag{2}$$
$$N = \frac{6}{0.1957}$$
$$N = 30.67$$

While the number of current requires for each compact LED lamp in this case are:

$$I(Lamp) = \frac{P}{V}$$
$$I(Lamp) = \frac{12x1.8}{230}$$
$$I(Lamp) = 0.09391A$$

Each lamp requires 0.09391A. Hence, the number of lamps can fit at 6A rating of circuit breaker are:

$$N = \frac{I(Breaker)}{I(Lamp)}$$
$$N = \frac{6}{0.09391}$$
$$N = 63.89$$

B. *Case 2: Conventional System Design Modification*

Case 2 discussed about the conventional residential lighting modification as shown in figure 2(c). In order to modify the conventional AC lighting system to a new DC lighting system, the same breaker that used in conventional system still can be used for the 12V DC system if the breaker used is dual rated circuit breaker. The same cable can be used for the 12V DC system too since the standards size of cable refers for designs can be used for DC system. There is only one additional equipment that need to be added in the system is the switching mode power supply (SMPS) which functions as the 230V AC to 12V DC converter. Calculation that performs below shows the maximum number of loads can be supported under a 6A MCB.

So, the number of current requires for each compact LED lamps in this case are:

$$I(Lamp) = \frac{P}{V}$$
$$I(Lamp) = \frac{12}{12}$$
$$I(Lamp) = 1.0A$$

Each lamp requires 1.0A. Hence, the number of lamps can fit at 10A rating of circuit breaker are:

$$N = \frac{I(Breaker)}{I(Lamp)}$$
$$N = \frac{6}{1.0}$$
$$N = 6$$

C. *Case 3: Proposed System Design*

The new 12V DC microgrid wiring system design conventional residential LED lighting application which refers as case 3 shown in figure 2(d). From the figure, the number of converter used has been eliminates from the system. The loads directly connected to the supply. The new proposed system design is almost the same with the conventional with CFLs. Conventionally, the LED lamp that operates in AC requires converter for every loads but not in the proposed system.

Table 1 below shows the load calculation for two different voltage levels of DC system which is 12V DC and 48V DC.

Table 1: Load calculation for two different voltage levels of DC system

12V DC Proposed System	48V DC Proposed System
Load rating: 12w MCB rating: 6A Size of cable at load: 1.5mm^2 MSB rating: 25A Size of cable at supply: 2.5mm^2 Current consumes by each load: $I_{consumption} = \frac{P}{V}$ (3) $I_{consumption} = \frac{12}{12}$ $I_{consumption} = 1.0A$ At 6A MCB, the maximum number of load can be are: $N = \frac{6}{1.0}$ $N = 6$	Load rating: 12w MCB rating: 6A Size of cable at load: 1.5mm^2 MSB rating: 25A Size of cable at supply: 2.5mm^2 Current consumes by each load: $I_{consumption} = \frac{P}{V}$ $I_{consumption} = \frac{12}{48}$ $I_{consumption} = 0.25A$ At 6A MCB, the maximum number of load can be are: $N = \frac{6}{0.25}$ $N = 24$

III. Case Study Discussion

Table 2 has concludes the wiring design for three systems. As the conclusion, in order to make modification or change the residential lighting system there is not that complicated. Most of the components in the existing system can be used. Refers to Table 2, case 1(a) and case 1(b) differs in term of the the load rating. Since case 1(b) apply compact LED lamps operating in AC the current flow in the circuit will be lower than in case 1(a) refers to the previous calculation. Hence, it affects the number of maximum loads can be supported in a breaker where case 1(a) can brings until 30 while case 1(b) can bring 63 loads. Case 2 has almost the same condition with case 3(a), the difference between case 2 and case 3(a) is case 2 is not connect directly to DC supply as in case 3(a). In case 3, the first condition are using 12V DC supplies. The maximum number of loads can be increased by increasing the voltage level to 48V. At 48V voltage level, the number of maximum loads increased to 24 loads. Furthermore, the maximum number of loads still can be increased by increasing the rating of the breaker.

Table 2: Comparison of conventional system and it modification and the proposed system

System	Case 1		Case 2	Case 3	
	(a) 230V AC	(b) 230V AC	230V AC	(a) 12V DC	(b) 48V DC
Load Rating (watts)	25	12	12	12	12
Size of Cable at Load (mm^2)	1.5	1.5	1.5	1.5	1.5
MCB Rating (A)	6	6	6	6	6
Maximum Load at each MCB	30	63	6	6	24

IV. Summary

This paper has suggested the modification of conventional residential lighting system which applies 230V AC to a new 12V DC system for LED lighting application. Besides, the new LVDC system wiring design has been proposes for two different voltage levels which are 12V DC and 48V DC. This study can be supports by the previous studies which examine the comparison between AC lighting system and DC lighting system for residential application. From the previous study, DC lighting system has many advantages than the AC lighting system [9]. Hence, this paper shows clearer picture in order to convert the conventional lighting system to DC system.

Acknowledgment

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