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Voltage and wire standards for domestic DC distribution systems

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Home micro-grid concepts have gained interest in the modern world due to the increased distributed generations with renewable energy sources. The present "DC-AC-DC" route from distributed generations to DC loads via inverters may not be rational from the viewpoint of system simplicity and energy efficiency. Considering the increasing prevalence of DC home appliances, establishing reasonable DC distribution standards for domestic buildings is significant. In this study, the Wattage of household electric appliances and the time duration they are being used were collected. The monthly power consumption of each appliance category was calculated. According to the results, the average monthly electricity demand of a Sri Lankan family is 111 kWh. Only eight equipment categories consume nearly 90% of domestic power. Those are refrigerators (22%), lights (16%), fans (16%), rice cookers (14%), TV (8%), irons (7%), washing machines (4%) and water pumps (3%). When considering the average maximum power demand, the most commonly available appliances have less than 1 kW maximum power demand. By considering the power requirements, to minimize the loss, and keep the system's safety at the maximum level, the midpoint grounding system with main wires at +60 VDC and -60 VDC is proposed. Using this topology, 120 V line to line potential difference can be archived with keeping the ground to line voltage within safety extra-low voltage limit as proposed by the European telecom standards. Following the IEE wiring standards, three commonly available wire sizes ($2.5\,mm^2$, $4\,mm^2$, $6\,mm^2$) were selected to analyze the suitability for the system's sub circuits. Voltage drop, power loss, short circuit current, and insulation resistance were considered to select the maximum allowable current for each wire size in a sub-circuit. Since the wire length for a sub-circuit of a domestic distribution system is usually less than 10 m, the voltage drops and the power losses are too small and negligible. The insulation resistance of each wire was tested against high voltages. All the wires show infinite resistance (more than 1 $T\Omega$) up to 2500 V. The most critical factor in wire selection is the short circuit current. According to the results, for a high power sub-circuit that require power up to 2400 W, wire size of 6 mm^2 can be used with 20 A circuit breaker. For sub circuits with power requirement less than 1800 W, 4 mm^2 wires can be used with a 15 A circuit breaker. And for low power sub-circuits, 2.5 mm^2 wire can be used with 10 A circuit breaker to supply power up to 1200 W. Further studies must be carried out to determine the power/voltage losses and increase the whole distribution system's efficiency under these conditions.

Keywords: Electricity, Micro grid, Wire, Voltage level

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