



Investigation of DC Networks State of The Art for Household

Arjun Sharma

*Lecturer (SG), Department of Mechatronics,
Advanced Technical Training Centre (ATTC), Bardang, Sikkim*

ABSTRACT

There are well established set of standards for household AC networks but DC Networks are far behind in this respect. In available literature there are multiple studies and recommendations are available for household DC Networks but demands more accurate analysis and feasibility oriented critique view. There are evolutionary changes in electrical power consumption of household devices, inclination towards non conservative energy resources like solar PV cells and expenditure on power converters for DC and switching to DC Networks for household use is pretty much dependent on these factors. Rapid reduction in cost of solar cells and upcoming improvements in DC power generations indicates future of a DC Networks parallel to well established AC networks for households. A hybrid system for AC/DC Networks is also taking shape for coming future , IEC and IEEE are very much involved in developing the standards for DC Networks. In this script future scope and potential of DC Networks are investigated and presented.

I. INTRODUCTION

Why DC Networks are preferred in modern days data centers ? is a broadly discussed question amongst the power system community. Non conventional energy resources like wind turbine, solar cells, fuel cells are easily can be integrated with DC Networks unlike Alternate Current Networks [1,2]. Due to less conversion loss in case of DC Networks its efficiency is higher than AC Networks which gives lead to DC networks and broadly used in data centers. History suggests decades ago Thomas Edison conceded defeat from George Washington and Nicola Tesla in the “War of Current” and the established Alternating current as primary mode of electricity transmission [3]. Since last decade bunch of inventions and evolvments are taking place in Direct Current transmission and it is acquiring a parallel space. Improving capacity of long distance high voltage DC transmission is playing a pivotal role in this regard. The power generation is changing and since past decade rapid growth in non-conventional energy generation and solar power generation is playing crucial role, as photovoltaic cell generates DC power which is directly used for charging the batteries and running Direct Current equipments. Batteries are balancing the variability of solar power generation and easy to run home appliances. The DC power can be converted in AC with the help of converters and with the optimization in power circuits and converter the efficiency of DC to Ac conversion is improving. In this script growing market and technological advancement of DC networks is investigated and presented in a way to get better understanding of the same. It has been observed that the DC power transmission less losses are experienced. By

the direct use of DC power with help of DC networks the conversion losses can be avoided and as per a study loss of 120-170 million Euro per year can be avoided across European Union only [4].

II. DC NETWORKS

There are three major constituents in a DC network as in figure 1. Power generation system, power distribution or transmission and thirdly the load. DC networks are adopted in well established manner in data centers. Data centers uses LVDC - low voltage DC and analytics shows there are 25% reduction in the power consumption due to use of DC networks in the data centers.

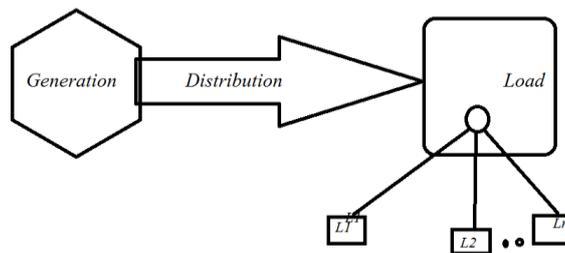


Fig 1 General structure of DC networks

How many constituents of a DC networks are compatible to direct current decides the reduction losses and minimization of cost. As DC power generation is growing rapidly and optimization of PV cells are creating a platform for DC networks. Improving LVDC standards and its compatibility with loads like home appliances are opening a new room of opportunity for the future growth of DC networks.

Figure 2 depicting the cost reduction for household rooftop solar photovoltaic. The decreasing cost and less investment requirement of rooftop setup of photovoltaic cells is indicating the emerging trends of DC appliances and DC networks. Most of the available household devices are compatible with AC and there is an additional requirement of power converters to run available appliances with DC powers and which is a demoralizing factor as cost shoots up and future demands availability of DC compatible household appliances.

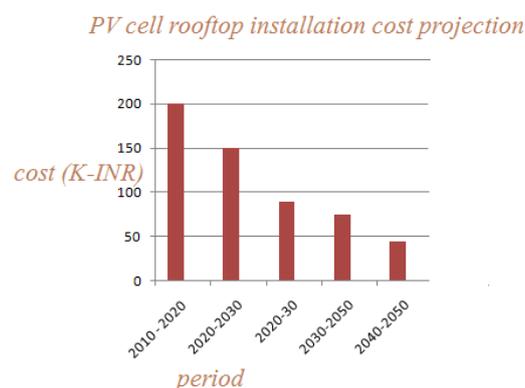


Fig 2 : Cost projection of PV cell installation

In the following section optimum voltage level required for DC networks, general model of DC networks for household systems and standards are discussed.



III. OPTIMUM VOLTAGE LEVEL FOR DC NETWORKS:

Selection of an optimum voltage level for power transmission and operation appliances is a tricky task for community working on DC networks. The level of power transmission plays decisive role in the selection of voltage level and level of required for transmission can be estimated if the sufficient information about connected load and capacity is known, for example for data centers 400V DC is preferred. Secondly after load analysis it is required to estimate the electrical energy required to fulfill the requirement of entire system so that losses can be reduced and a cost effective system can be designed. Mathematical modelling of entire system proves helpful for estimating the priorly mentioned parameters.

Presently the optimum voltage level is a much debated issue and there are various suggestions of voltage levels are presented with specific logics. For example higher voltage level 350 to 450 V DC voltage level is suggested by considering the compatibility and operating range of available devices, less than 238 V DC and in-between 463 to 617 is suggested for single phase and three phase respectively. Voltage level suggested according to compatibility of existing grid system is less than 220 V DC [5]. Available suggestions indicates that separate optimum voltage level needs to be estimated according to the available infrastructure and operational equipments.

IV. GENERAL MODEL OF HOUSEHOLD DC NETWORKS:

There are various models are available in literature for household DC networks, there are multiple factors as discussed in previous sections are important to consider for designing a general model. There are two dominant models are existing for household systems. First one is Hybrid Alternated and Direct current model and second one is pure DC model.

In hybrid system AC transmission and LVDC low voltage direct current works in parallel manner and power supply is selected between AC and DC with the help of a switch over or by automated switch over system. As for hybrid system appliances installed are compatible with AC system so DC input needs to be converted in AC and for that converter systems are needed. Hybrid system is an alternated solution to incorporated DC infrastrure in existing alrenating current system due which it demands least modification. Hybrid system is a promising solution that provides another option of power and which is proving as a solution of current power demand . A systematic general model of hybrid system is shown in figure 3. In this proposed model PV cells are intalled over rooftop and it is connected with AC grid via a converter systems wich further transfers power in main line.

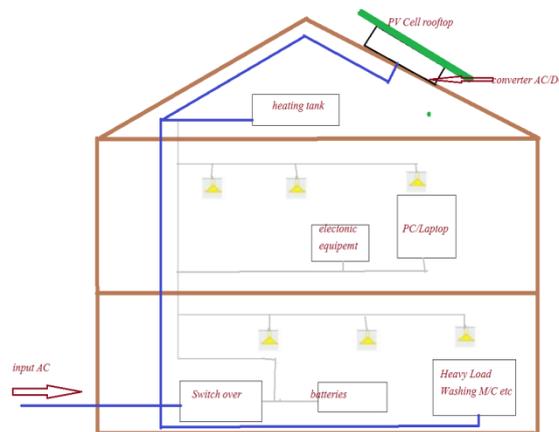


Fig 3 : Hybrid AC/DC network for household

Second optional system is powering the complete system with DC power. There are various voltage levels are available for selecting as per devices available. Different voltage levels are discussed in previous section. But the most important requirement for developing a complete DC power household network is availability of DC power electronic components and devices with optimum cost, reliability and efficiency. A general model of DC network for household system is shown in figure 4.

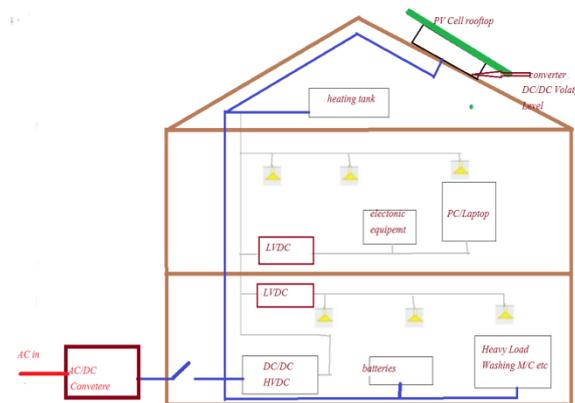


Fig 4 : DC network for households

Standards and Policies:

IEEE and IEC- International Electrotechnical Commission and The European Telecommunications Standards Institute (ETSI) has proposed various standards for DC networks for data center and a lot of work is in progress for developing the standards for household DC networks. There are several voltages recommendations are also available for implementation of DC networks infrastructures. Some policies are also recommended for DC networks, few of them are as follows;

- a. For a transparent standards for DC networks supports needs to be provided to work carried out by IEEE , ETSI and IEC.
- b. For reducing the power consumption and solving the problem of increasing energy demand DC network implementation encouraged in households.
- c. Enhance the support for distributed power storage and battery systems.
- d. Clear standardization of operating DC networks and available DC voltages.



V. CONCLUSION

DC networks are the promising solution for increasing demand of electrical energy and a parallel DC systems needs to develop to minimize the burden on AC energy systems. As electricity generation from non conventional energy resources are growing rapidly with the development and optimization of PV cells. The parallel DC infrastructure is demanded. Few challenges are there like need of development of DC power electronic devices, optimization of desired voltages levels and standardization of DC networks for household implementation. Presented analysis is evident that the DC networks will be dominant and provide energy solutions for household needs in coming future.

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