ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 4, Issue 3, March 2018

Study and Review of Cables Used In Solar Installations

[1] Darshan Nakhate, [2] ShubhamPardhi, [3] Dr. S.S Ambekar
Dept. of Electrical Engineering, KDK College of Engineering

***Abstract*: -- Planning and installation of a PV power plant involve a lot of calculation and design of electrical circuitry. For a rooftop or ground mounted efficient solar power plant, it becomes very essential that all energy generated get transferred to load as the efficiency of PV cell is relatively very less and installation is a costlier process. The power transmission to cables needs good design, selection, and careful handling. Cables are subjected to thermal, mechanical and electromagnetic stresses. For a long-lasting electrical circuit with exposure to the harsh environmental condition like temperature fluctuations and UV rays, it becomes necessary to protect the cable network. This paper reviews the conductor and cables used in solar installations, it also gives the specification difference in normal DC power and DC cables used in solar system.**

I. INTRODUCTION

In order to connect the components of a solar energy system, it is needed to use correct wire sizes to ensure low energy loss and to prevent overheating and possible damage. Four components are to be connected together: the solar panels, the charge controller, the batteries, and the inverter. The charge controller prevents the batteries from overloading; the wires that connect the panel to the charge controlled must be correctly sized to minimize transmission power loss. Likewise, the further away the panels are, the larger the wire gauge should be. The inverter converts the DC power collected by the panels into AC power, which is the accepted by most of the appliances. The solar systems are installed in outdoors, so the cables used for this type of application needs to be UV radiation resistant and suitable for wet locations. In case of solar tracking panels, the cables used need to be flexible as the panels will be moving along with the sun. Cables used in solar generation are to be designed to withstand long-term exposure to sunlight. To maintain long-term performance and reliability, solar cables have been developed to resistant UV, ozone, and water absorption, as well as provide excellent flexibility for sub- zero conditions and deformation resistance during prolonged exposure at high temperatures. Considering the fact that the solar power systems are installed in extreme weather conditionsand the need to save time and ensure reliabilitypre-connectorizedcable solutions have been developed,. Ideal for utility-scale generation systems, these solutions enable fast, easy connections, simplifying installation while removing the inconsistencies associated with field termination. For connecting combiner boxes to inverters DC feeder cables are now offered as all-in-one metal-clad cables that increase reliability and eliminate the need to install conduit. PV cables are also being engineered in a full array of colors to easily identify source, output, and inverter circuits without the need for time-consuming marking tape or tagging cables.

II. SIGNIFICANCE OF DC CABLES

DC cables are used predominantly in solar projects and hence, issues around their usage are still not understood very well unlike AC cables, which are used extensively across the power sector. Moreover, intense commercial pressure is forcing project developers and contractors to reduce capital cost resulting in the selection of inferior products and/or sub-optimal design.DC cables connect modules to inverters and are further segmented into two types.

A. String Dc Cables

String DC cables are used to interconnect solar modules and also to connect modules with string combiner boxes or array combiner boxes. Cables used for interconnecting modules come pre-connected with modules and the cables required to interconnect strings and to connect with combiner boxes are procured separately. These cables carry current around 10 Ampere (A) and a small cross section (2.5 mm2 to 10 mm2) is sufficient for this purpose.

B. Main DC cables

These cables are used to connect array combiner boxes with inverters, they carry higher current of around 200–600 A in utility scale projects and also require a larger cross section (95 mm2 to 400 mm2). Except for the cables which are pre-connected with modules, DC cables account for only around 2 per cent of solar project cost, but can have a significant impact on the power output. Improper design and/or poor cable selection can lead to safety hazards, which mainly are reduced power output, and other performance issues. According to the studies conducted in this field it is believed that power output loss in DC cables can be as high as 15 per cent but it is time consuming and arduous to empirically isolate and quantify the role of DC cables in poor performance. Also, a higher voltage drop typically leads to heating up of cables and fire accidents. In case of DC cables power loss is measured in terms of

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 4, Issue 3, March 2018

voltage drop from module to inverter. The voltage drop implies proportionate loss of power as current in the cables remains the same.

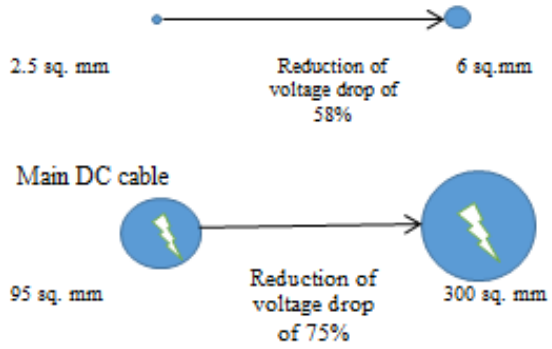
III. DC CABLE DESIGN AND SELECTION

According to studies conducted the power loss inDC cables can be as high as 15% but it is time consuming at the same timeit is difficult to empirically isolate and quantifythe role of DC cables in poor performance. Additionally the higher voltage drop leads to heating up of cables and fire accidents.
The measuring of power loss in DC cables is done in terms of voltage drop from module to inverter. Since the current DC cables remains constant, the voltage drop implies proportionate loss of power. Therefor there is need to minimize the voltage drop, which can be done in following ways.

- Approaches to minimize voltage drop

As mentioned earlier voltage drop is proven to be one of the critical parameters for design andselection of dc cables.
Voltage drop => V=IR
Where, I is current carried by DC cable
R is resistance offered by DC cable

a. Using larger sized cable
String DC cable



b. Reducing Cable length

string dc cable
15km

10km

- Reducing string DC cable length from 15 km to 10 km reduces percentage voltage by 33%.

c. increasing operating voltage

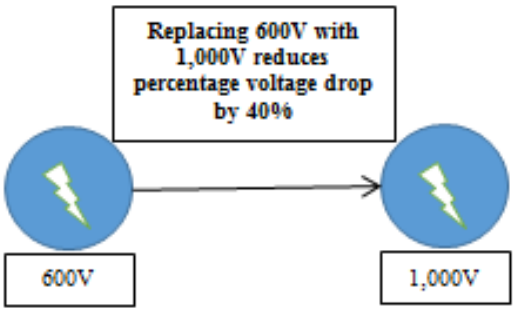


Figure 1: Approaches for limiting voltage drop

IV. LT AND HT CABLES (AC CABLES)

AC cables with a higher voltage rated capacity are known as HT and LT cables. These are used to connect inverters to transformer and transformer to the on-site substation. At present, cables of 1,000 V rating are typically used for this purpose but the trend is now shifting towards the use of 1,500 V cables. HT cables are used for power transmission at high voltage from on-site substation to transmission grid substation.Voltage rating of these cables can range from 11,000 V to 33,000 V, depending on the capacity of project. LT and HT cables are widely used in the power sector including both conventional and renewable energy power generation plants. DC cables are used primarily in solar projects. Aluminium is widely used in AC cables, which have a life of over 35 years and have been widely used throughout the world. In AC cables, flow of current is mostly continuous, whereby the cablereaches steady state with minimal thermal stress. Operation in a solar plant is discontinuous because of ever changing irradiation. Figure 2 shows the type of cables used in a solar PV plant.

V. CABLE SPECIFICATIONS

There is a need of a cabling system engineered to optimize efficiency and to minimize losses in order to economically generate electricity from renewable sources, which allows more of the generated power to reach substations where it is transmitted to the grid. Firstly, the cables used at the point of solar power generation offer a higher voltage range of up to 2,000 V to optimize efficiency as compared to the standard 600 V rating for conventional applications. In case of Medium-voltage, cables used between transformers and substations are being re-engineered to provide better efficiency over the life of the cable through cooler operation and lower line loss. Solar cables are UV and weather resistant and can be used within a large temperature range because of which they are laid outside. Single-core cables with a

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 4, Issue 3, March 2018

maximum permissible DC voltage of 1.8 kV and a temperature range from –40°C to +90°C are the primary choice here. A metal mesh encasing the cables is provided to improve shielding and overvoltage protection, so that their insulation is not only able to withstand thermal but also mechanical loads .The

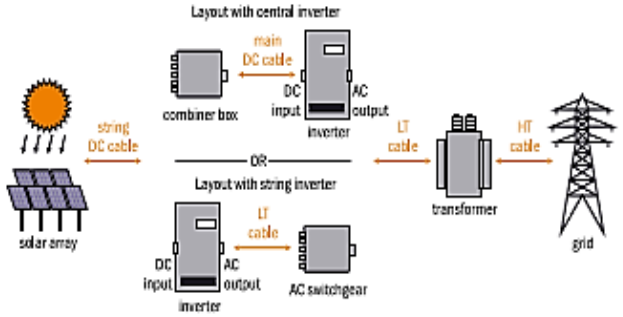


Figure 2: Type of cables used in Solar PV Plant

cross-section of the cables should be proportioned such that losses incurred in nominal operation do not exceed 1 per cent. String cables generally have a cross-section of 4mm2–6 mm2.

VI. CONNECTING TECHNOLOGIES

Developing connecting technologies was the dire need in the past years, as inadequate contacting can cause electric arcs. Secure connections are required that will conduct current fault-free for as long as 20 years. The contacts must also show permanently low contact resistance. Since many plug connectors are required in order to cable a PV plant, care should be taken that every single connection should cause as little power loss as possible, so that losses do not accumulate. Given the precious nature of the solar power acquired from the PV plant, as little energy as possible should be lost. Screw terminals and spring clamp connectors are gradually being replaced by special, shock-proof plug connectors, which simplify connection between modules and string cables. Crimp connection (crimping) has proven itself to be a safe alternative for attaching connectors and bushes to the cables. Crimping is used not only in the work carried out by fitters on the roof but also in the production of preassembled cables in the factory. An alternative plug connector design has been developed to allow the connection to be fixed in place without the need for special tools: in this instance, the stripped conductor is fed through the cable gland in the spring-loaded connector. Subsequently, the spring leg is pushed down by thumb until it locks into place. The locked cable gland thus secures the connection permanently. Plug connectors and sockets with welded cables are also available in the market. However, such connections cannot be used during installation work on the roof, but only during production in the factory. Another development is preassembled circular connection systems for the AC range. These are intended to reduce the high levels of installation work required when several inverters are used within one plant. Aluminium has recently gained significance as an electrical conductor because of the sharp increase in copper prices. It is possible to save around 50 per cent by using aluminium cables, particularly for underground cables at low- and medium-voltage levels. Since, alumninium cables are thicker than copper cables they have poor conductivity as compared to copper. Careful attention must be paid to the default breakaway torque of their screw connections, as, in comparison to copper, aluminium tends to creep under roofs which are very heavy. If the screw connections are too tight, the cable loosens over time if the screw connections are too tight possibly resulting in an electric arc, not to mention the associated risk of fire and all the consequential damage.

VII. DIFFERENCE BETWEEN NORMAL DC POWER CABLE DC CABLES IN SOLAR SYSTEMS

As reviewed earlier solar cables are meant to sustain exposure to extreme weather conditions unlike the normal DC cables.Normally DC cables are used for batteries and as power cables in case of routers for example MX240 router, exceptionally there are many cases where DC cables are exposed to extreme weather conditions as in the case of solar cables, mainly in case of marine battery cables (Figure 4) and welding cables. Considering general usage of DC cables following are the major difference in characteristics acquired by normal DC cables and solar cables:

Table 1 Comparison of DC cables

Properties	Normal DC cable	Solar Cable
Temperature	Upto 60o C	-40oCto 120oC
Insulation	PVC	XLPE/XLPO
Expected life	5 to 10 years	20 to 25 years

The most important parameter is the wire section. Inappropriate wire sizing could result in excessive heating and even fire due to large current. Properly connected and sized wiring won't require any maintenance for years. Exterior modules and other PV components connection wires and cables should be used with UV radiation resistible insulation. Standard wire and cable insulation cracks under years of exposure to atmospheric conditions and UV radiation. The temperature range is also important. Exterior cables should allow for temperature range from -45°C to up to +80°C or even more. Application of such cables will enable efficient system operation for the next two decades or longer. Standard, usually stranded wires and cables are used for interior

ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 4, Issue 3, March 2018

connections. A simple rule to follow in small systems is 1 mm2 wire area/1 A current. Its application will prevent wire overheating and curb loss within required limits.

Figure 3: Solar cable

Figure 4: Marine battery cable

VIII. CONCLUSION

Solar cables of different sizes and construction designs are available to meet the efficiency requirements of solar PV systems. The international standard EN 50618 specifies the performance requirement of solar cables. It is necessary to evaluate solar cables before actual installation to ensure its desired life span of 25 years. The industry has seen a variety of cable designs and practices, many of which may not necessarily support long-term solar needs. Application specific cables and contractor certification are paramount to ensuring the economic viability of solar power systems.

REFERENCES

1. Report on 'DC cabled design and performance issues' by BRIDGE-TO-INDIA_india-solar-excellence November-2016 edition.

2. www.electricalindia.in /blog /post/ id/ 5972 /solar-cables-for-photovoltaic-systems.

3. www.kei-ind.com/cable-and-wire/solar-power-cable.

4. Presentation by V.K Gupta, Chief manager-renewables at 'Copper Alliance' presented at 'International copper', WRETC