48V DC: *The right choice*

DC (direct current) and AC (alternate current) systems were born around the same time in late 1800s and battled head to head in the well-known “War of Currents”. It might have seen that AC has won the power transmission battle, and DC was all washed out, but it wasn’t. Majority of today’s end-use appliances and electronics use DC at various levels of DC voltage. Improvements in power electronics have enabled engineers to develop circuits capable of inexpensively transforming DC voltages.

At the same time, Solar PV which has emerged as a great source of decentralized power produces only DC energy. Batteries which have emerged as a powerful and wide-spread energy storage system can charge/discharge only DC power. When AC power-line is used, AC to DC and DC to AC converters used further increase the power-loss.

All these raises the question, “Why not DC?”

The Choice of DC Voltage

It is of utmost importance to carefully consider what should become a standard for various possible voltages between 0 and 60V DC. There are various possible options: 60V, 54V, 48V, 24V, 12V, 5V etc. Let us examine the pros and cons of choosing one of these voltages:

a. Cable losses: a 2.5 sq mm cross-section loop (the commonly used cross-section for AC wiring) would have less than 2% losses for a 48V system, for 12V system, losses would be almost 22%, clearly proving the sub-optimality of reducing voltage below 48V.

b. Cost of wiring: For a given source power output and percentage power loss, the thickness of cable is inversely proportional to the square of source voltage. This implies that compared to a 48 V system, four times the wire thickness and sixteen times the wire thickness are necessary for 24 V and 12 V systems respectively. Cable/wiring costs are directly proportional to the cost of the copper and varies with the size of the wiring.

c. Use of existing inside-building AC wiring: Currently, for inside-building 230V AC wiring, 2.5 sq mm and 4 sq mm are the most widely used cross-sections. For both these cross-sections, a 100W loop on 48V would work with good efficiency as shown above as long as the loop length is moderate. The same does not hold true for 24V or 12V. Thus, using 48V gives us the opportunity to re-use the existing AC wiring loops present inside homes and offices while keeping losses within acceptable limits.

d. Scale of economics: As explained in point c above, for a limited power system, 48V DC and 230V AC loops can use same kind of copper cables. A common design of this kind will enable standardization of cables/wires and give markets an opportunity to exploit economies of scale. This will in turn mean lower cost and ready availability to end customers.

Reliability While 48V DC for inside building wiring is being explored for the first time, 48V DC is not uncommon in other fields and well accepted documents exist. A lot of standards related to 48V exist in different fields like Electric Vehicles, Ethernet, Telecom, UPS and Batteries.

IEEE802.3af (15.4W/port) and the updated IEEE 802.3at-2009 for Power over Ethernet (PoE) are such widely used standards that are based on 48V. PoE concept is becoming extremely popular as it eliminates the need of a power outlet close to the device. For electric vehicles, leading German carmakers have developed standard LV148 for 48V on-board supply and charging plug owing to the efficiency of 48V network. Other countries like the US have followed it. In field of Telecom, BTS (base transceiver stations) worldwide uses 48V as the primary source of power as the main standard. These standards can be leveraged to learn and create a common platform and align with other areas. Although 48V has been extensively used in some other fields, it was not exploited for electrical purposes till recently, primarily due to two reasons: Affordability and Availability. Integrated circuits, LED and BLDC revolution have addressed both of these limitations.

Availability of appliances A wiring standard is of importance and use only if the compatible equipment exists. Hence, an obvious question is whether 48V DC appliances exist. Answer is a resounding yes. There exist a wide range of low power appliances that work on 48V. Full size BLDC fans of around 30W power rating and 48V input requirement are being produced by TVS Lucas and Crompton Greaves and are readily available. 48V LED tube-lights and bulbs also exist. Electronics use variable voltages and have internal conversions. 19V and 5V are two commonly used voltages. 48V is higher than both and hence, can be easily deployed with simple high-efficiency DC-DC convertors. 48V to 19V or 5V DC-DC conversion is much more efficient than existing 230V to 19V or 5V AC-DC conversion being deployed in case of mobiles, laptops, televisions etc. Speakers, webcams, sensors and a lot of other electronics can also work very easily on 48V.One important aspect to note is that wiring losses become large when larger currents are used. For example, if currents are of the order of 10A (500W power consumption for 48V DC voltage), the wires need to be thicker. Higher power appliances like air-conditioners, mixers, electric-stoves shall use more than 500W and 48V DC may not be appropriate for this. 380V DC could be a good candidate for such higher power consuming appliances. The current standard being presented is focused on 48V LVDC wiring for inside-buildings with an upper limit of 10A on the current. The proposal of IEEE LVDC committee can be a starting point for defining the standard. The standard addresses all important aspects required for a fool-proof deployment.

Efficiency Deploying a DC power-line inside the building and using it to directly power these DC appliances and devices will ensure energy savings in two ways: Use of higher efficiency DC devices and elimination of conversion losses.

Safety While 60V DC in itself is safe, even the smallest variation in the voltage could take it to unsafe levels. Up to 15% variation in voltage is common for any system in practice. The standard voltage needs to be chosen such that despite any fluctuation on the positive side, the SELV limit of 60 V DC is not exceeded. Same holds true for 54V: 15% variation would make it exceed the 60V SELV limit. These considerations leave 48V as the highest voltage level where even with the 15% voltage fluctuation the devices can operate without posing any safety risks. The peak voltage shall not exceed 55V which is well within SELV limit. Even a 48V battery never needs voltage in excess of 57V to charge. So while 48V DC would be the highest safe voltage, use of 24V, 12V or 5V DC would be equally safe.

The discussion on "Why 48V DC" has centered around five major areas: reliability, availability of appliances, efficiency and safety. More emphasis is being placed upon utilizing alternate sources of renewable energy. Solar power is the primary focus as these elements can be deployed almost anywhere in the world. Solar panels produce power at a DC voltage. This has traditionally been converted to AC in order to be integrated into the existing power system. On a 48VDC distribution system, a direct connection can be made with these sources to the DC appliances that operate at 48V DC making them more efficient and easier to use. With many industries lined up to manufacture such appliances, the definite sustainable advantage of a 48VDC system is thus seen.