SAKER
Medium Voltage Measurements

What is Medium Voltage?

In the IEC culture there is the so-called low and high voltage ranges and according to IEC60038, the threshold between the two ranges in AC installations is 1000Vrms. However it is normal in the ANSI universe of electrical distribution companies and several industry segments to refer to electric power installations and equipment for voltages up to 38 kV as medium voltage systems although strictly speaking ANSI C81.1 defines includes voltages up to 69kV in the medium voltage class. Each country or economic region however may define other voltages for historical reasons, like Canada does in its CAN3-C235-83. Eventually the voltages selected in each particular area reflect a strong historical influence from industry manufacturers. The tables below show the precise values as defined by IEC and ANSI standards.

Three wire, V	Four wire, V		Three wire, V	Four wire, V
2400			13800	13800Y/7970
4160	4160Y/2400			20780Y/12000
4800				22860Y/13200
6900			23000	
	8320Y/4800			24940Y/14400
	12000Y/6930		34500	34500Y/19920
	12470Y/7200		46000	
	13200Y/7620		69000	

Standard nominal three-phase system voltages per ANSI C84.1. In blue nominal system voltages for Canadian standard CAN3-C235-83.

Nominal system voltage, V	Highest voltage for equipment, V
3000—3300	3600
6000—6600	7200
10000—11000	12000
15000	17500
20000—22000	24000
30000—33000	36000
35000	40500

AC three phase systems with nominal voltage above 1kV and not exceeding 35kV as defined in IEC 60038:2009

In informal literature the term high voltage can be misleading with some parties referring to it as greater than 600V, others 1000V and others 100kV. For the sake of clarity we at SAKER like to talk about medium voltage because it is a more unequivocal and specific term that clearly defines our area of interest and focus.

Where the growth in the use of MV comes

It has been acknowledged, with forecasts anticipating the problem, that the most serious problem of the 21st century will be the lack of energy. Continuously growing consumption and decreasing energy resources of electric power increase its price. As a result this stimulates the technical development on the side of transmission and distribution of electric power. At the side of consumption, industry being the biggest, the same is stimulated by the profit from huge energy savings when modern power electronics is applied. Also the requirement to reduce green house gas emissions drives the investments of European Union, and other economical areas, into renewable sources of energy. The fastest growing are the ones with the ultimate generation resource (solar and wind). They are the most expensive, but well stimulated by subsidized redemption prices, which have secured so far high return on assets. The imperative need for their drastic cost reduction represents further stimulus for technical development in power electronics. Power semiconductors play leading role in the progress of power electronics, since they are essential to satisfy the constantly growing demands on cost, performance and reliability.

As the new so called Green Economy unfolds, Design Engineers are quickly transitioning to focus ever more effort upon maximizing the efficiency and power of their designs, which inevitably leads to a world-wide explosion of demand for high voltage power semiconductor devices.

The array of semiconductor devices available coupled with different topologies (cascaded…) enable new products with increasing powers and efficiencies, such as medium voltage drives, static frequency converters for railway supply, statcom, wind power inverters or modules for traction applications.

Medium voltage and semiconductor manufacturers

The need to develop new power electronic applications in medium voltage is backed up by research and development of high voltage semiconductors by different manufacturers, like ABB, Dynex, Infineon or Cree and it has seen a steep rise in the last decade. Be it diodes, thyristors, IGCTs, SiC mosfets or IGBTs. ABB for example specializes in IGCTs with even 10kV modules available.

The main stream of power semiconductor industry takes evolutionary steps to gradually increase the voltage and current ratings of Si devices. It is obvious that Si will continue to enjoy its dominance in high-power devices because of its excellent properties and advantageous cost, and it is indeed defending its dominance by improvements in ratings, up to 10 kA, cost reduction (using up to 12” wafers) and circuit topologies.

Wide bandgap semiconductors like SiC and GaN strive to profit from their much better electrical strength and thermal conductivity in order to compensate for their much higher cost. The blocking voltage of available devices is nonetheless increasing and most interestingly the switching frequency compared to medium voltage IGBTs is many times higher, something that affects size and efficiency. Indeed the industry push is so relevant that from a few years back some manufacturers have samples available for 3.3kV, 6.5kV and 10kV SiC mosfets with 15kV modules on research.

While the low-voltage sector is nowadays dominated by the MOSFET, the range 1kV – 3.3 kV belongs to the IGBT, which has also penetrated into the 4.5 and 6.5 kV classes, the traditional domain of IGCTs. Typical example is the medium voltage drives, namely the voltage source inverters, where the region below 10 MVA is rather covered by IGBTs while above 10 MVA by IGCTs.

What are the uses and applications of Medium Voltage?

The uses of medium voltage are many and definitively going up. Medium-voltage class voltages have been used historically and primarily for subtransmission and primary distribution. Medium voltages often supply distribution transformers which step the medium voltage down to low voltage to supply end-use equipment. Also a large traditional use has been in industries for medium voltage motors of 13800 V and below.

However power electronics applications have been making its way into medium voltage enabled by new system topologies and semiconductors. Also new distribution grid architectures are laid out around medium voltage, be it AC or DC, to allow for new sources and consumers of energy.

Some uses and applications of medium voltage are listed below,

- Medium-Voltage DC Distribution Grids

The first motivation for developing dc systems on high-voltage level was the higher efficiency of long-distance transmission of electrical energy since the reactive-power demand of the overhead lines or power cables vanishes and only active power has to be transferred so conduction losses are reduced.

But not only in transport but in generation too advantages are found and implementing MVDC technology into collector grids of wind and photovoltaic parks have been the result of intense study for a while, the main advantage being that the grid-side inverter of the generators as well as lossy grid filters and bulky 50/60Hz transformers can be eliminated.

Also domestic power generation based on PV and battery energy-storage systems in homes are operated with an internal dc link as well as battery-charging stations for different loads like electrical vehicles, LED-based lightning, computer and consumer electronics.

- AC medium voltage Drives

Energetic efficiency has spawned a huge development effort around medium voltage motor drives, so that its speed and torque can be regulated according to production needs and cost savings can be reaped. Where in the past motors where just operated in on/off mode by means of soft starters now complex drives from 3.3kV to 11kV based mainly on IGBTs or IGCTs arranged in cascaded topologies reign the market.

- MV DC-DC converters

The expansion of renewable energies such as photovoltaic and wind requires a rising number of converters between generator and consumer of electrical energy. With higher blocking voltages available in semiconductor devices, converters which can feed directly into the medium voltage grid become a reality. An increase of the voltage level not only reduces the current and thereby the copper weight heavy power frequency transformers can be omitted.

Also applications like traction require converters that operate in harsh environments regarding temperature cycling and power demand.

- Electric ships

Ship installations have undergone considerable developments over the years. Initially built with a steam-powered propulsion system, size, environmental and safety requirements have encouraged the progressive electrification of ships. First based on AC networks now the attention is turning into medium voltage DC for its advantages in undesirable harmonics and no need of heavy transformers. There is even a standard IEEE Std 1709, entitled "Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships"

- Photovoltaic energy

The presence of 1500V photovoltaic arrays is widespread nowadays. As mentioned before, going up in voltage lowers the current and thus the copper loss and cost of the total installation. Furthermore since eventually all power generated is transferred to the grid, it pays to have a higher starting voltage from which to feed a medium voltage DC-DC converter tied to the distribution grid.