Application Note
High Voltage Systems

Tektronix® + Elektro-Automatik

Introduction

In today's technologically-driven world, the demand for efficient, reliable, high-capacity power transmission and distribution has never been greater. One of the most significant advancements addressing these needs is the development and implementation of high voltage direct current (HVDC) systems. Unlike traditional alternating current (AC) systems, which have been the backbone of electrical infrastructure for over a century, DC high voltage systems offer unique advantages that are becoming increasingly essential in various applications across multiple industries.

Higher voltage systems reduce resistive losses in the electrical distribution system. Power losses due to resistance are proportional to the square of the current ($P_{loss} = I^2 \times R$). By reducing the current through higher voltage, these resistive losses are minimized, leading to more efficient power transmission. Furthermore, lower current results in less heat generation in the wiring and components. Excessive heat can be detrimental to the performance and reliability of electrical systems, so reducing heat through higher voltage operations can enhance the safety and longevity of electrical components. High voltage systems can also help in reducing electromagnetic interference (EMI) with signaling and communication systems. Lower current flows result in weaker electromagnetic fields, which reduce potential interference issues.

The adoption of HVDC systems is evident in several key areas like railway, aviation and renewable energy systems.

Railway

Many railway systems worldwide use standardized high-voltage levels for electrification. Common voltages include 1500 V DC, 3000 V DC, 15000 V AC and 25000 V AC. The use of 3000 V DC is prevalent in several countries and offers a good balance between efficiency and infrastructure requirements, allowing trains to operate at high speeds and carry heavy loads over long distances. Many suburban and interurban rail systems use 3000 V DC to provide reliable and efficient service. This approach enhances the performance of suburban and interurban rail networks, as well as light rail and tram systems.

Using higher voltages reduces the amount of current required to deliver the same amount of power. This reduction in current allows for the use of thinner and lighter conductors, which can significantly reduce the cost of electrical infrastructure, including catenary wires and substations. Higher voltages improve the overall energy efficiency of the railway system by minimizing energy losses during transmission and distribution. This contributes to lower operational costs and reduced environmental impact.

Aviation

As the aviation industry continues to innovate towards more electric and hybrid-electric aircraft, the adoption of HVDC systems is set to play a central role in achieving these goals. These systems not only contribute to the operational efficiency and safety of current aircraft but also pave the way for next-generation aviation technologies.

In the rapidly evolving aviation industry, the pursuit of efficiency, performance and sustainability has led to significant advancements in electrical power systems. Among these innovations, HVDC systems are emerging as a pivotal technology. These systems offer substantial benefits that align with the critical demands of modern and future aircraft.

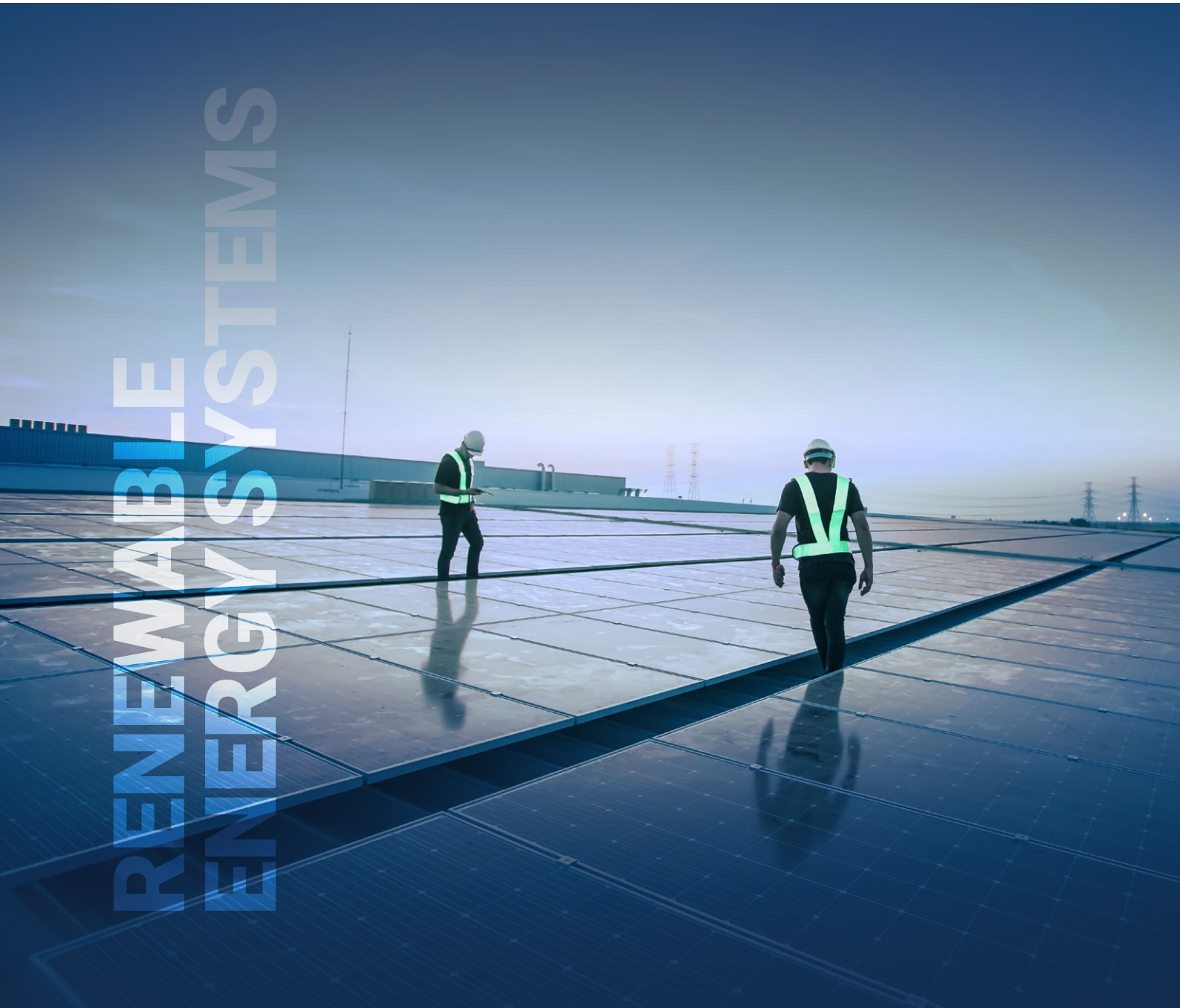
High voltages within an aircraft are typically needed for systems that require high power density and efficiency, like the electric environmental control systems (eECS) which manages the aircraft's air conditioning, pressurization and temperature control. Higher voltages allow for more efficient operation of compressors, fans and other components. Electric propulsion systems for hybrid or fully electric aircraft also benefit from high voltage systems between 1000V DC and 3000V DC, which are essential to generate the necessary thrust for flight. Furthermore, high voltage systems are used to charge large batteries that power various aircraft systems, especially in hybrid and electric aircraft.

One of the most critical factors in aviation is minimizing the weight of the aircraft. Higher voltages allow for the transmission of power using lower current. Since power is the product of voltage and current, increasing the voltage allows for the same power to be delivered with a lower current. Lower current means that thinner and lighter wires can be used, significantly reducing the overall weight of the aircraft. So, using high voltages in aviation helps in reducing the weight of the aircraft to meet the power requirements of modern and next-generation aircraft systems. This facilitates the transition to more environmentally friendly and efficient aircraft.

Renewable Energy Systems

The growing emphasis on renewable energy sources has further propelled the use of HVDC systems. Large-scale photovoltaic installations and advanced battery energy storage systems (BESS) benefit from the efficient power transmission and reduced energy losses provided by HVDC. Some large-scale photovoltaic installations use high voltages to minimize losses when transmitting power from solar panels to inverters or storage systems.

Advanced BESS use HVDC for the efficient storage and retrieval of energy, particularly in systems integrated with renewable energy sources. Additionally, HVDC transmission technology is revolutionizing the way power is transmitted over vast distances, enabling the integration of remote renewable energy sources into the grid and facilitating cross-border power exchanges.



Test equipment from EA

EA Elektro-Automatik supports the high-voltage industries of tomorrow with outstanding test equipment to shorten development processes and to be able to develop high-quality systems. EA's portfolio covers the entire range, from low-voltage equipment to devices that provide 2000V DC.

The devices can be connected in series to meet the demand for higher voltages of up to 3000V DC. To ensure the necessary safety here, the use of the so-called serial connection box (SCB) is necessary.

The SCB protects the devices in series connection from exceeding the specified insulation voltage, ensuring safe operation. In addition, EA's systems can be used flexibly with the help of the SCB. The devices can be used individually or connected in series. For example, two parallel-connected groups can be connected in series to create systems with high voltage and high power to meet corresponding market requirements.

With high-performance criteria and a broad application spectrum, EA has established itself as a development partner in forward looking industries. Work with us, and we will address your individual needs and challenges.

Serial Connection Box

If you need further information or want to contact us visit **www.elektroautomatik.com**

Large product range

EA-10000 series

EA-10000 Industrial series

Service for you worldwide

At EA Elektro-Automatik 450 qualified associates, in a facility of 19000m², research, develop, manufacture and market high-tech equipment for laboratory power supply, high power mains adaptors and electronic loads with or without power feedback. The sales and service network includes branches in China, Singapore and USA, offices in Spain and Korea as well as an extensive partner network. Since 2024 EA Elektro-Automatik has been part of the Tektronix Group, which has increased sales and service coverage globally.