New Normal in Power Electronics

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In the midst of COVID-19, we have been introduced to many new concepts, such as the 3Cs (closed spaces, crowded places, and close-contact settings) and social distancing. Some other activities have included frequent hand washing, gargling, and staggered commutes. When I think of it, concepts such as telecommuting and telework have been around for a long time. It has been only recently, however, that their importance has been recognized in the real world.

The use of power electronics equipment to control electric power has progressively spread throughout the world as an increasing number of devices have gradually become electrified over the decades. When I think back, the oil crisis in the 1970s created a strong demand for power saving and the broad introduction of semiconductors and microcomputers in the 1980s led to their widespread use in home appliances and electric railways. All of this created a new way of life unique to Japan. It is against this backdrop that research and development into power electronics equipment has placed the highest priority on improving energy-saving efficiency and enhancing capacity to support a wider range of applications.

Volume 1, No. 4 of Fuji Electric Journal was published in June 1924 and contains an article on mercury-vapor rectifiers. In this type of rectifier, mercury is sealed in an electrode-equipped glass container. It converts power from AC to DC by using the rectifying action of the arc discharge between the electrodes. Thyristor turn-on is referred to as "firing." This name originated from the fact that arc discharges were called "electric arc." Prior to this, there were only rotary converters that integrated an AC motor and DC generator. As a result, the development of mercury rectifiers without rotating parts was a real breakthrough. I had used a mercury rectifier once when I was a student. It emitted heat and ultraviolet rays due to the arc discharge, but this also caused large voltage drops. Therefore, it is now considered normal to use diode rectifiers.

Today's power electronics use low-loss power devices such as IGBTs and power MOSFETs and perform digital control using embedded microcontrollers. The latest power devices are designed to reduce switching loss. This enables higher switching frequencies that make it possible to reduce the size of filters and smoothing circuits and achieve faster and more stable control. At the same time, control digitization not only made it possible to shorten development cycles, but also played an important role in customizing processes to meet various needs.

Power electronics is defined as the application of any technology that converts voltage, current, or frequency without substantial loss (i.e., without affecting the power). This definition may sound reasonable to experts, but to engineers in other fields and the general public, I think it would be easier to explain it as the interface of electric power. This type of explanation helps to clarify that power conversion from DC to AC is necessary for grid connections using solar cells and batteries. At the same time, however, the word "power electronics" is rarely used when discussing new energies and energy creation. It is similar to how words like "hubs" and "routers" are not often used in discussions about cloud computing and IoT. Since it expected that communication data will increase in the future, these types of devices will need to provide higher performance and capacity. At the same time, however, their interfaces are such that they will need to perform various functions behind the scenes. Many general users tend to think of USB as a connector standard, but they are unaware of the chips connected to these types of devices.

In most cases, information interfaces have a fixed standard. This means that it is relatively easy to replace them with equivalent products from other manufacturers. On the other hand, power electronics are customized for their particular connection. This means that it is not easy to replace them with the products of other manufacturers. In particular, it is difficult for devices that use chemical reactions, such as batteries and fuel cells, to conform their characteristics to standards. To compensate for this, power electronics play an important role.

At the same time, there is great demand for miniaturization. For people familiar with the DC power supplies of the past, it must seem amazing that recent smartphone chargers have become so small, yet

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still contain a 10-watt isolated power supply inside them. To the average user, however, the charger is just a distraction that occupies a port on a power strip. Likewise, many laptop chargers that used to weigh nearly 1 kg are now only 300 g or so. Any interface for power should ideally be just a cable.

The requirements of power electronics equipment have been changing drastically. In the past, high efficiency and capacity were enough, but now there is increasing demand in terms of miniaturization, controllability reliability, noise, lifetime, and IoT. The many challenges that need to be resolved in this field can only be solved using power electronics. In this respect, a new normal has already started for power electronics. I look forward to seeing the future developments.

(Translated by Fuji Electric)

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