C-5

Invention of Crystal Oscillators

The research achievement of the temperature - independent crystal oscillator by Issac Koga (1899－1982) is well known globally. More than 25 years after this development, it was certified as an IEEE Milestone which is a certification of history-making achievements that have made significant contributions to the development of societies and industries.

The discovery of the piezoelectric effect which led to the development of the crystal oscillator was made by Pierre Curie when he was single (in 1880－1881, just before he started the study of radiation with Madame Curie as a married couple). For the crystal plate used in those days, the frequency of vibration, when power was applied, depended in a large part on the temperature, so for a long time, this was a major bottleneck. It was Issac Koga's group that made it possible by eliminating this barrier to develop the crystal devices widely used today. Through rigorous analyses of piezoelectric elastic waves, they found the fact that when cutting a crystal plate from rock crystal at some specific angle (called R cut), changes in oscillation frequency of the said plate were as small as 10^{-7}/C, i.e., a double-digit drop from the previous one, a temperature - independent crystal oscillator (1932–1933). Almost a half century after the research carried out by Pierre Curie, eventually, a crystal oscillator without a constant temperature reservoir came into the world, and thereby applications to a wide range of products became possible.

Crystal oscillators that operate independent of the operation temperature support the digital information society as an indispensable electronic component for our lives being set in telecommunications equipment, e.g., smartphones, personal computers including watches, audio-video equipment such as flat-screen televisions and Blu-ray Discs, electronic equipment such as car electronics, and infrastructure systems such as mobile communication/optical communication networks.

C-6

Seminal Study of Electric Discharge Tubes and the Generation of Ultra-high Frequency

In 1940, Masaharu Hoshiai (1898–1986) discovered the ultra-high frequency (wavelength: 0.1 mm) generation method with quite a seminal method using a special electric discharge tube having a confined electric discharge channel. Consequently, he won the IECE's Akiyama/Shida memorial award for his achievement. Incidentally, a Lecher wire and crystal detector were used for this detection. The special electric discharge tube used at the point of

the discovery was named a *Hoshiai tube*. After that, in 1944, he won the award of the then agency of industry and technology (then AIST) for his achievement of the radio terrain clearance indicator. Also, in May 1953, he again won the IEICE's Akiyama/Shida memorial award for the achievement of this study about the measurement of permittivity properties in the superhigh frequency.