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***Question 2.7**: Are there any actual cases which evaluate and compare the centralized and the de-centralized control concepts in voltage control?*
Which method would be superiors and in terms of what criterion?

In Japan, a voltage control device installed in the distribution system adopts an independent control method (ADVCS: Autonomous Decentralized Voltage Control System), and the control amount is determined individually. Also with the expansion of introduction of renewable energy like PV, the voltage fluctuation in the distribution system is expanding. As a method of suppressing voltage fluctuation, Centralized Voltage Control System (CVCS) is being developed to govern the voltage control equipment in a batch.

As a voltage control device, Load Ratio control Transformer (LRT) on the distribution substation and Step Voltage Regulator (SVR) on the distribution line are used in Japan. Each device performs autonomous control based on the measured current and voltage at the point where the device is installed. The average length of distribution lines is different for each electric power company. In TEPCO, the length of 6.6kV distribution line is about 3 km and the length of the 100/200V distribution line is about 50 to 100 m. The 6.6 kV distribution line is divided into 3 to 6 sections according to the distribution of the load, and switches for dividing the section are installed.

CVCS is a culculation system that performs optimum control of each voltage controller based on measurement data at each point of the distribution line provided from DAS. Form of the CVCS can be divided into three stages according to the introduction situation such as ITSW.
Case 1: Previous method.
This is the case where the remote control function and the measurement/communication function are installed in the LRT, and ITSW is installed only in the most upstream point of each distribution line. Therefore, the voltage of whole distribution network can't be obtained by ITSW. In this case, the voltage of the distribution line is estimated based on the ITSW measurement data. The LRT is controlled by CVCS based on the estimated voltage and measurement voltage, and SVR is controlled by ADVCS. Therefore, the control range of the CVCS is limited to the primary side of the SVR
Case 2: ITSWs are installed into all the sections, on the other hand some SVRs are replaced with IT-SVRs. In this case, the voltage of whole distribution network can be obtained with the measurement data from ITSWs, and the voltage estimation is no longer needed. Therefore, it becomes possible to control using only measurement data.
The CVCS control flowis as follows. If the average voltage value per minute measured by the ITSW deviates from the target range, the deviation amount is summed for each deviating node. Furthermore, the summed amount is checked every five minutes, and when the summed amount of any of the nodes exceeds the threshold value, the control amount at the voltage regulator is calculated and the control command is transmitted. The reason for setting the control period to five minutes is determined from the operation guarantee time of the LRT, SVR and to prevent the hunting phenomenon of LRT tap and SVR tap. If the deviation resolved during the accumulation, the integrated value is reset.

The results of ADVCS and CVCS were compared. Also, the voltage regulation in Japan is a 30-minute average value of low voltage within 101±6 [V] and 202±20 [V].
Results could be confirmed that the ADVCS deviates from the operation target voltage, while the CVCS managed to control the voltage within the operation management target voltage. In addition, the number of tap operations in CVCS is less than that of ADVCS . In this demonstration system, the effectiveness of coordinated control of LRT and SVR could also be confirmed.

om this result, CVCS is effective for distribution lines with a large amount of renewable energy because voltage deviation occurs due to reverse power flow in fine weather. However, as the number of adjusting devices increases, the amount of processing also becomes large. So it is better to use CVCS and ADVCS properly in consideration of the number of renewable energy connections.