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Voltage drop phenomenon due to large-scale DERs integration and countermeasures

SC C6

PS2 Question 2.1

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Group Discussion Meeting

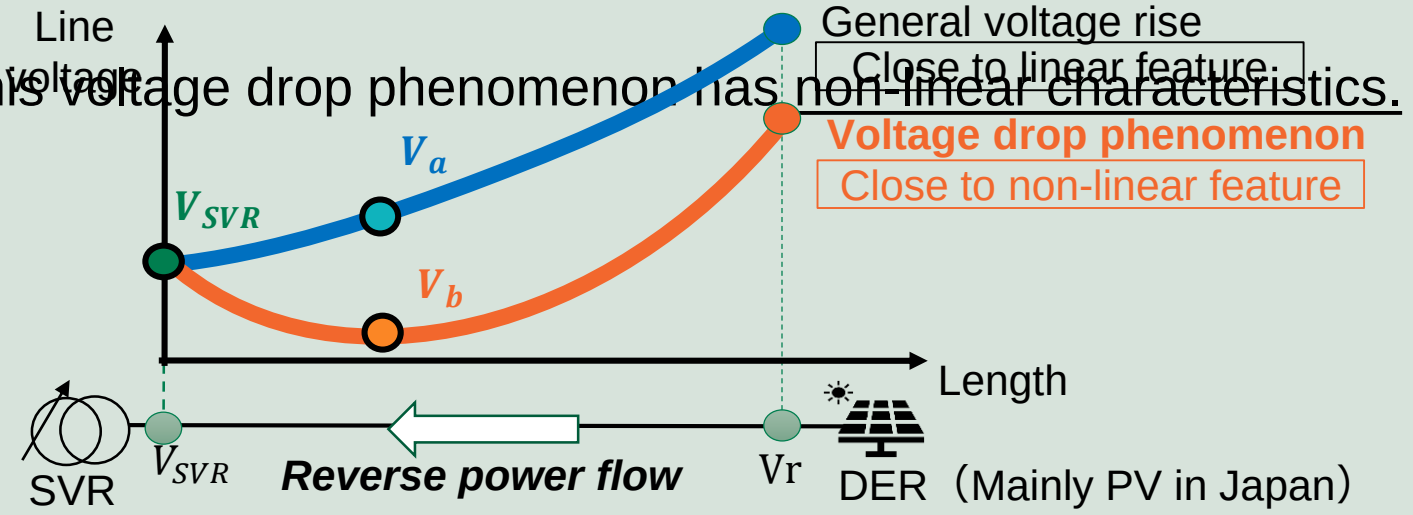
- Reverse power flow from DER often causes voltage rise in the distribution system.

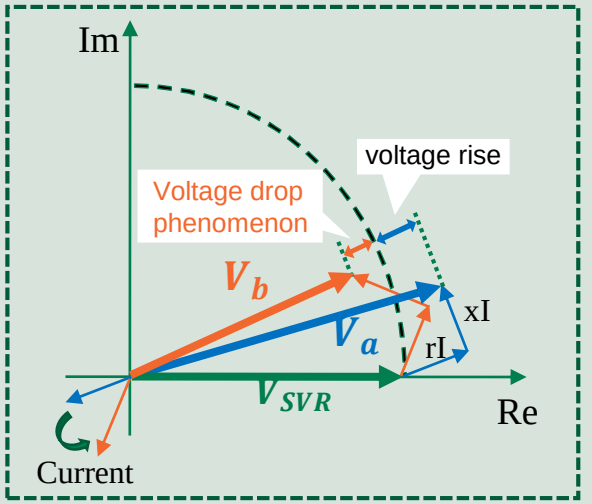
Background

- On the other hand, when large-scale DERs are integrated into a long distribution line, the voltage drops due to a large phase change in the current.

- In Japan, this voltage drop phenomenon has occurred on some long distribution lines with large-scale PV integrated at the end of the distribution line.

- This voltage drop phenomenon has non-linear characteristics.





Issue

- SVR with line drop compensator (LDC) method estimates the distribution voltage assuming linear voltage changes.

  ➡ It is difficult to estimate the non-linear voltage drop by the LDC method.

Development of the new voltage-estimation method for SVR

- The new voltage-estimation method is suitable for large-scale DERs installation.

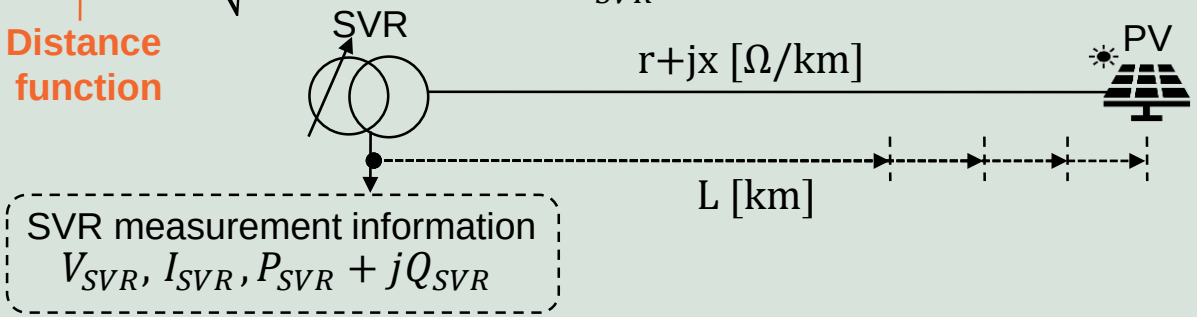
[Conventional estimation method（LDC method）] $\mathrm{V_{ref}} = V_{SVR} - \sqrt{3} I_{SVR}(R\cos\theta + X\sin\theta)$

➢ The LDC method estimates one point of the distribution voltage assuming linear voltage changes.

[New Voltage-estimation method （New method）]

$$V_{ref}(L) = \sqrt{V_{SVR}^2 + \frac{L^2(P_{SVR}^2 + Q_{SVR}^2)(r^2 + x^2)}{V_{SVR}^2} - 2L(P_{SVR}r + Q_{SVR}x)}$$

Distance function



$P_{SVR} = \sqrt{3} V_{SVR} I_{SVR} \cos\theta$
$Q_{SVR} = \sqrt{3} V_{SVR} I_{SVR} \sin\theta$
V_{ref}: reference voltage
V_{SVR}: secondary voltage of SVR
I_{SVR}: passing current through SVR
R : simulated line impedance
X: simulated line reactance
r : R of unit length
x: X of unit length
cosθ: power factor
L: distance from SVR

➢ The new method estimates the distribution voltage at any distance.

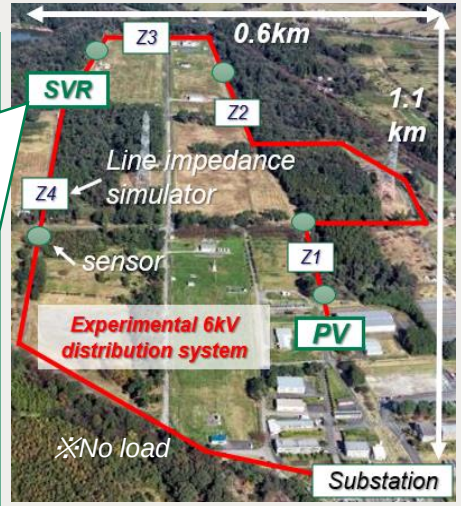
➡ It is possible to estimate non-linear voltage fluctuations.

Field test with prototype of new SVR

Demonstration using experimental 6kV distribution system

- Evaluation results of each method based on amount of voltage deviation and the number of tap switching.

Prototype of new SVR equipped with each method



		LDC method	New method
Amount of the voltage deviation [kV·s]	Sunny	118.1	**8.8**
	Cloudy	172.4	**10.6**
Total number of tap switching	Sunny	6	**2**
	Cloudy	53	**2**

➡ The performance of the voltage control and the life-span of SVR have been improved by the new method.

Demonstration using the commercial 6kV distribution system

- The new SVR will be demonstrated in the commercial distribution system in 2022.
  - ➢ Rural area.
  - ➢ Distribution line length is 16km.
  - ➢ 2MW PV is integrated at the end of the distribution line.