

Optimal Operation of Transmission Networks with Dynamic Line Ratings under High Penetration of RESs



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Abstract

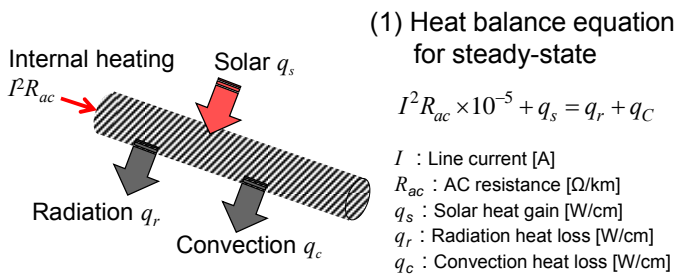
For a high penetration of Intermittent Renewable Energy Sources, transmission line current also fluctuates and has much uncertainty. Therefore, it is possible that the line current may exceed the transmission line capacity. In this study, the fundamental characteristics of the temperature-based dynamic power flow calculation are analyzed with the line-temperature upper limits as the transmission capacity constraints.

Research Target in the Project

In a research project (PI: Prof. Jun-ichi Imura), Transmission and Distribution (T&D) research unit focuses on the following three issues in power system operations and controls under high penetration of photovoltaic generations.

- [Transmission line overload](#)
- Synchronization stability (Transient and steady state)
- Voltage stability and static lower/upper limits

Model of Line Conductor Temperature



(2) Heat balance equation for transient-state
(θ : Difference between line temp. and ambient temp.)

$$\frac{d\theta}{dt} = \frac{(I^2 R_{ac} \times 10^{-5} + q_s) - (q_r + q_c)}{C}$$

Dynamic Line Ratings

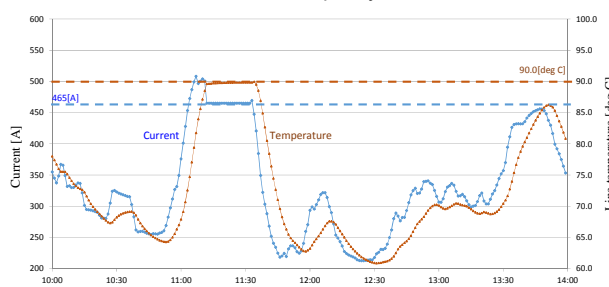
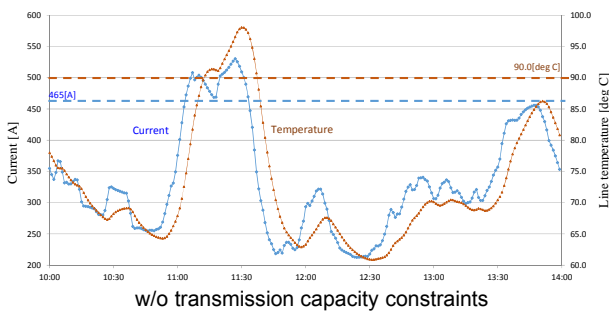
(a) Dynamic line rating methods

	Current Change	Meteorological conditions	Notes
1. Constant current	×	×	Continuous allowable current
2. Step change current	△	×	e.g. Line fault clearing
3. Variable current	○	×	← Research Target
4. Partial variable met. conditions	×	△	e.g. Seasonal difference
5. Variable met. conditions	×	○	← Research Target
6. Line temp. estimation	○	○	← Research Target

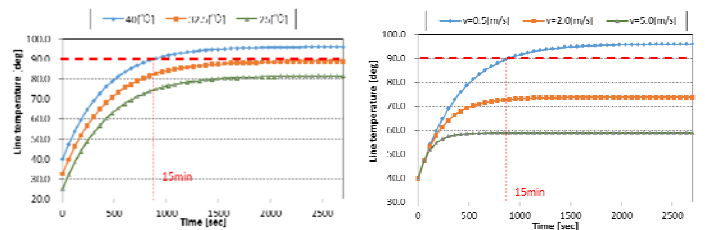
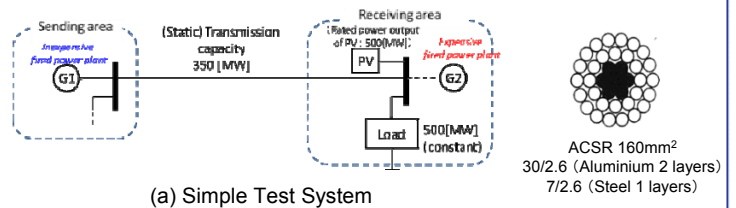
(b) A typical meteorological condition

Atmospheric temp.	Solar irradiation	Wind speed	Wind direction
40 [deg C]	0.1 [W/cm ²]	0.5 [m/sec]	45 [deg]

Simulation Results



(b) Line current and conductor temperature fluctuations due to PV output



- Development of dynamic optimal power flow
- Extension to underground cable-based grids

This research is performed in a Research Project "Towards Harmonized Power System Control under Photovoltaic Power Prediction Uncertainty (PI : Prof. Jun-ichi Imura)".