

Defining and conveying transmission line current and temperature limits.



Helping operators implement dynamic line rating

The more electric current a line carries, the hotter it gets. After a certain point, a line operator cannot add additional current without overheating and damaging the line.

However, by paying close attention to the weather, wind power researchers at Idaho National Laboratory believe there is potential to take advantage of wind cooling on transmission and distribution lines concurrent with wind power generation. An increase in wind speed blowing at a right angle to a high-voltage line can cool the line enough to safely increase the amount of current it can carry by 10 to 40 percent.

To perform such dynamic line ratings, engineers need accurate real-time information about wind conditions and factors such as the line's temperature and amount of current it's

carrying. That information then needs to be conveyed to utility operators in a way that enables them to quickly and safely adjust generation to meet load demands while operating within transmission limits.

Time-Scale Analysis

Real-time information about transmission line temperature and current is difficult to obtain. The simultaneous presence of "slow" and "fast" dynamics in a transmission line makes the whole system computationally "stiff" — meaning its mathematical models are extremely challenging and time-consuming to solve. Furthermore, the current national standard (IEEE Std. 738) addresses neither the interactions between the inherent dynamics, nor how transmission and distribution lines respond to perturbations.

INL researchers are developing a time-scale analysis approach

to capture the dynamic interactions and compute instantaneous values of line current and line temperature. The approach will offer an efficient software control design for mitigating perturbations.

At its core, this method decouples the system dynamics into slow and fast subsystems, followed by design of separate slow and fast subcontrollers. These decoupled controllers are of lower order, and facilitate on-line, real-time control implementations. Also, it is possible to embed subcontrollers in the utility's Energy Management System (EMS).

Based on instantaneous line temperature, the analysis approach can determine a safe level of ampere capacity, or "ampacity," which defines the maximum amount of electric current a conductor or device

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can carry before sustaining immediate or progressive deterioration.

That ability makes real-time decision-making possible for the transmission line operator or controller.

Human Factors

Utility operators already monitor a massive amount of information in the control room. Numerous readings and data streams help them instantly match supply to demand. Although information about wind conditions and line capacities could allow operators to increase output, it adds to the number of factors they must consider in order to maintain reliability.

INL researchers want to integrate advanced modelling information into a simplified recommendation for operators. The system would assess wind and transmission line conditions to compute the maximum safe capacity of a transmission line in real-time. Rather than conveying all that information to operators, the system would simply provide a recommendation for action.

The goal, developers say, is to integrate advanced modeling into control rooms as seamlessly as possible. Rather than compounding control room complexity, the new information would be consistent with existing displays and presented in a way that's easy to process.

By considering the actual needs of control room operators, INL aims to help make dynamic line rating a tool that can be easily integrated into today's utility control rooms.



The Human Systems Simulation Laboratory at INL is a reconfigurable virtual control room used for operator training and research.

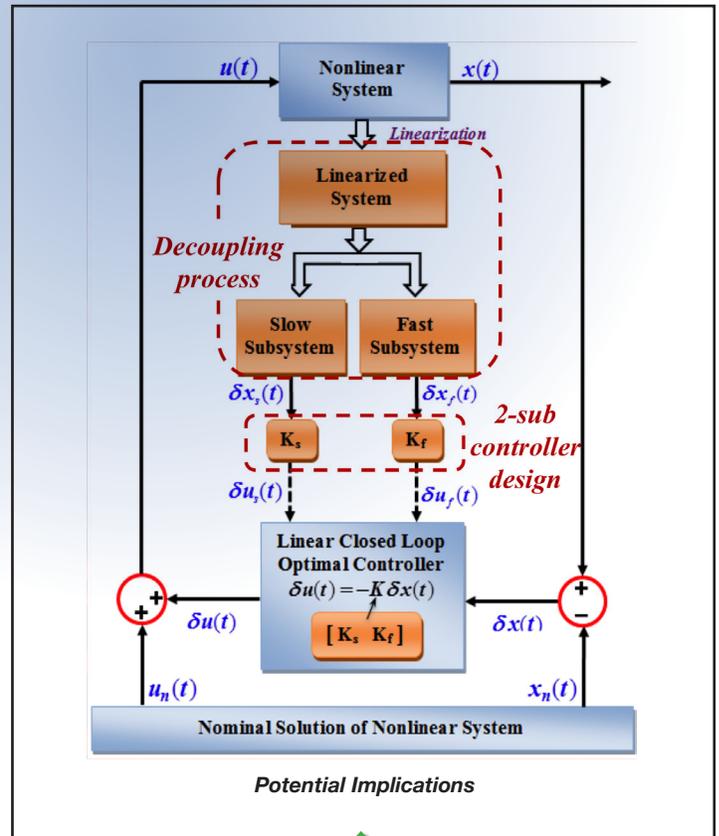
For more information

Christopher T. Wright
 Wind Program Manager
 (208) 526-3075
 christopher.wright@inl.gov

Jake P. Gentle
 Project Manager
 (208) 526-1753
 jake.gentle@inl.gov

Nicole Stricker
 Research Communications
 (208) 526-5955
 nicole.stricker@inl.gov

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Approach defines limits for transmission line current and temperature.