MiCOM ALSTOM P341

Dynamic line rating

Customer profile

Transmission or distribution system operators.

Business challenges

For more than 100 years, electric power plants have mainly been large, utility-owned facilities, feeding distributed loads based on unidirectional power flow. Recently over the past 20 years, smaller, independent power generation plants have been developed and set up at various places in electrical networks. The increasing number of Distributed Generation (DG) sites, and their increasing power ratings from KW to hundreds of MW, creates new challenges for network planning and operation.

Currently where large DG sites (such as onshore or offshore windfarms) are connected to the grid, the ratings of grid components such as overhead lines can be exceeded. Alstom Grid's modern Dynamic Line Rating (DLR) helps to manage and optimise power generation according to the actual dynamic or real time thermal rating of the overhead lines by taking into account the weather conditions.

Customer Benefits

- Maximise the usable capacity of overhead line assets by 50% or more
- Avoid upgrading or replacing existing transmission lines (saving significant capital investment)
- Increase energy yields, thus improving the cost effectiveness of renewable energy projects and reducing greenhouse gas emissions
- Provide easy and flexible integration with the control system with a large choice of industry standard communication protocols
- Allow easy scheme customisation with Programmable Scheme Logic (PSL)

Dynamic line rating

The line thermal rating is based on the highest current that a power line can carry without compromising the strength of the conductor material or without the conductor sagging too low. The conventional way to evaluate a line rating is to use fixed, generally conservative, meteorological values in standard, internationally used formulae to calculate the summer and winter ratings. But in reality, the real capacity is not static; it varies with the weather conditions - the wind speed and direction, ambient temperature and solar radiation, which all contribute to cooling or heating of the transmission line, which in turn affects how much power it can carry. DLR uses real-time measurements from weather sensors to calculate the real time rating automatically, which is then compared to the line current. When the line current is close to the line rating, control commands can be sent to hold or lower the power output of distributed generation (DG) such as windfarms. This allows optimisation of the transmission line capacity and power output of the DG. Gains of 50% or more can be achieved depending on the environmental conditions.

Protection relay design

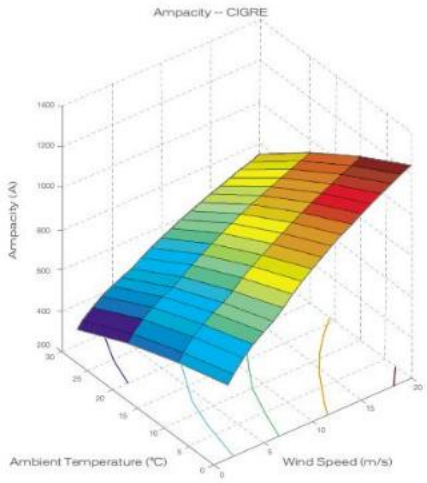
The P341 relay includes a number of protection functions for the interface protection of distributed generation connected to the grid such as overcurrent, earth fault, power, voltage, frequency and loss of mains protection as well as the new DLR protection.

DLR calculates the real time rating (ampacity) of the line from the local weather measurements - wind speed, wind direction, ambient temperature and solar radiation via the relay transducer (current loop) inputs and compares this rating to the maximum line current. The relay allows the user to select the type (0-1mA, 0-10mA, 0-20mA or 4-20mA) and the current loop input channels to be used by the weather sensors. In the relay the user can select from the two most commonly used international standards, the CIGRE 207 standard and the IEEE 738 standard for the current temperature relationship of the line.

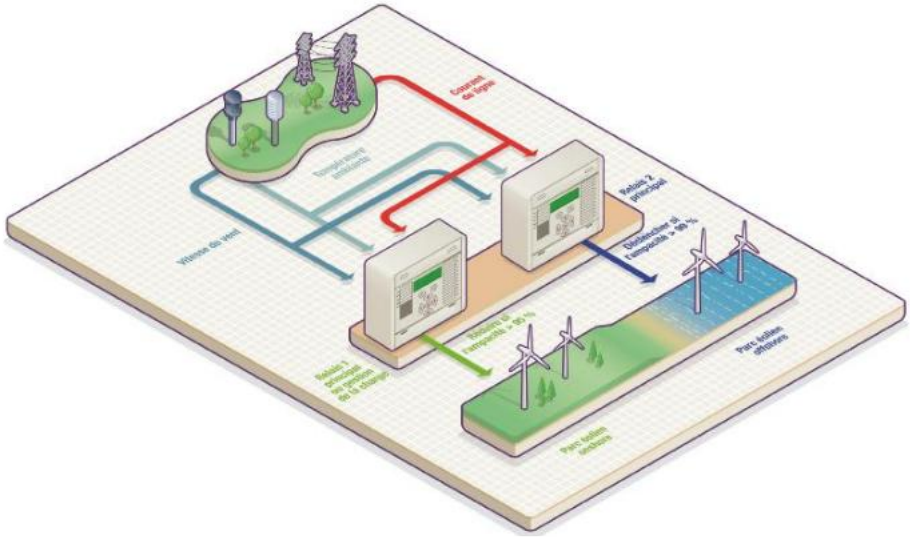
The relay has six definite time DLR stages which can be set as a percentage of the line ampacity. In configuring the relay, apart from setting the DLR thresholds and time delays, it is also necessary to enter a range of conductor data parameters, which are required for the heating and cooling calculations.

To assist the user, the relay stores the relevant parameters of 36 standard types of conductors. For other conductor types, settings are available for the user to enter the relevant parameters directly.

The current magnitudes, the sensor measurements together with the calculated ampacity and conductor temperature are available from the relay as measurement quantities. The diagram below shows a typical application of DLR.



Ampacity Vs Wind Speed and Temperature



DLR eliminates the need to upgrade or replace existing transmission lines at a fraction of the cost

Applications

Main application

The six DLR stages can be used to provide load management directly, giving commands to the windfarm to hold or lower its output as the line current approaches the line ampacity rating. It can also trip the windfarm locally if the measured line current exceeds the rating.

Scalable and flexible

The application can be scaled by using as many weather sensors as required with fixed values used for the weather parameters where sensors are not used.

The weather station used by the relay may not be sited near the most critical span for the worst case weather conditions. For example some sections of the line may be shielded from the wind, such as in forest areas and some sections of the line may be at different altitudes and so have varying ambient temperatures.

To allow for shielding, shading and different line elevation effects and to provide some safety margins for the measured weather parameters, correction factors can be applied to the ambient temperature, wind velocity, wind direction and solar radiation values.

Reliable and secure

For the 4-20 mA transducer inputs, an alarm is available when the current level is below 4mA to indicate that there is a fault with the transducer or the wiring. If a 4-20mA input indicates a weather sensor failure, the relay falls back to using a default conservative value for the input quantity. In addition, the user can set minimum and maximum values for the measured weather inputs, which can be averaged over a set time. These setting limits can be used to limit the weather sensor measurements to sensible values in case the sensors give an unrealistic value.

The user can also set minimum and maximum values for the measured ampacity to prevent under or over-calculating the line ampacity. In practice, ratings of other components (e.g. cables, joints and switchgear) may limit the maximum ampacity.

DLR reduces the cost of renewable energy projects and helps increase the amount of green energy

Application examples

In 2006, a leading U.K. distribution network operator was concerned about capacity problems on its network where offshore and onshore windfarms were connected. Due to the proposed additional new wind generation and the relatively small local load, there would be an increase of reverse power flow along a 132 kV double-circuit line that could cause the static rating to be exceeded.

Alstom Grid proposed a solution where the thermal rating, or ampacity, was calculated in real time based on the actual measured wind speed, wind direction, ambient temperature and solar radiation, which takes into account the cooling effect of the wind. In June 2008, 2 relays were set up on a trial section of a dual-circuit 132 kV line in northeast England, with the load management system also doing real time calculations using local weather measurements. Power DonutTM sensors at three locations directly monitored conductor temperature, providing an independent measurement to compare with the relay calculated measurements.

The trial showed that 50 percent or more wind generation could be connected to the grid compared to using the fixed summer/winter thermal ratings. Furthermore, analysis of the data showed a close correlation between actual and theoretical calculations of conductor temperature. Over a year, the algorithm was verified providing more understanding and confidence in the scheme.

A DLR special protection system was installed in April 2009 in Northern Ireland to determine the overload capability of two 110 kV circuits. The output of the special protection scheme targeted one 30 MW windfarm connected to the 33 kV network which was identified as impacting on the overload of the 110 kV circuits.

The philosophy of a main and back-up scheme was adopted with each line protected by two relays to provide redundancy and each relay used a different communications channel to the windfarm - broadband and radio communication channels - to provide additional redundancy.

A DLR scheme using ambient temperature measurement, with other weather parameters set at fixed values, based on UK standards (Engineering Recommendation P27), was used to determine the maximum allowable current flows on the circuits. The DLR scheme calculates the dynamic rating of the 110 kV feeders, determines whether an overload is occurring on the 110 kV feeders and determines if a run back of the windfarm will alleviate the overload. If the overload is not alleviated the scheme will initiate time delayed tripping of the 33 kV circuit breakers.

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Environment
Enabling more renewable energy and reducing CO2 emissions.

Energy efficiency
Optimising the capacity of power lines and maximising the energy yield of renewable energy.

Reliability
Improving security of supply by maximising the output of distributed generation.

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