**Electrical Load Angle (δ)** is the angle between the induced EMF and terminal voltage, or the angle between the stator and rotor magnetic fields. For a synchronous generator, the magnetic field rotates at synchronous speed and induces the rotating magnetic field in the stator. These two fields are not completely aligned. The stator field lags the rotating field and these two are not aligned. This lagging expressed is the **Load Angle**. The generated power is directly proportional to the sine of this angle.

Load Angle (δ) is also a direct representative of magnetic field torsional stiffness inside the air gap as well as the generator stability in operation (e.g. out of step). On-line measurement of load angle (static and dynamic) is of great importance to determine the actual working parameters of the generator when combining with on line capability diagram (P-Q diagram). Load angle, if measured with fine resolution, can be used to determine the losses of the generator. It is also a key parameter in understanding the torsional dynamics of the generator where magnetic field stiffness influences the dynamic response of the generator.

Scheme of Electromechanical representation of the load angle

On load	No load
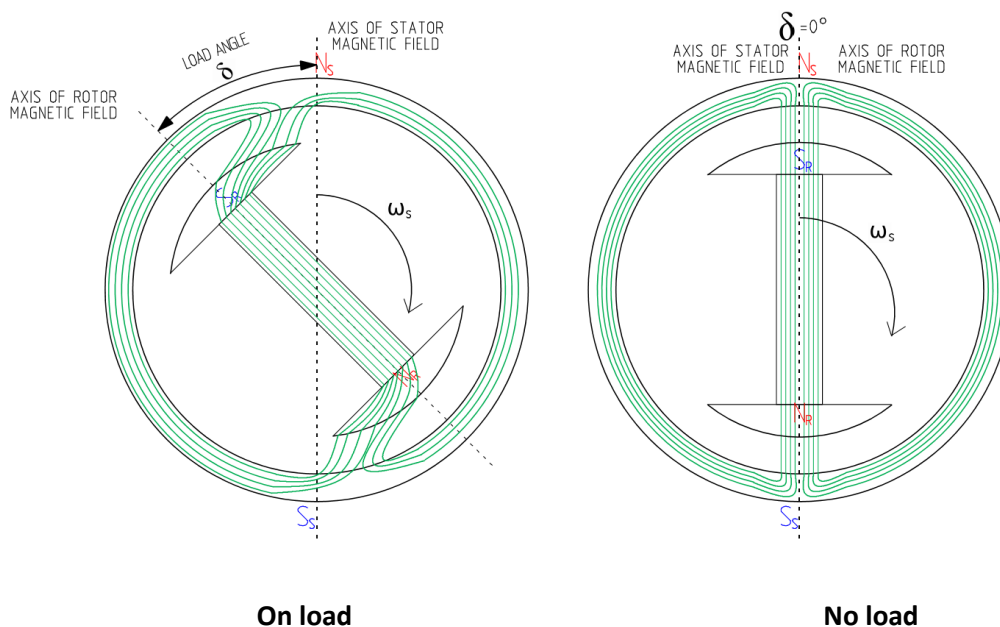
CoDiS (Computerized Diagnostic System) module for **electrical measurements and load angle** is equipped with automatic Real time analysis of the electrical Load Angle obtained from electrical signals and mechanical reference measured and analysed simultaneously.

REAL TIME ANALYSIS:

Correlating the electrical and mechanical signals Load Angle is analysed in real time and stored to the database alongside all other parameters monitored on the generator (e.g. vibration vectors, process quantities and electrical quantities).
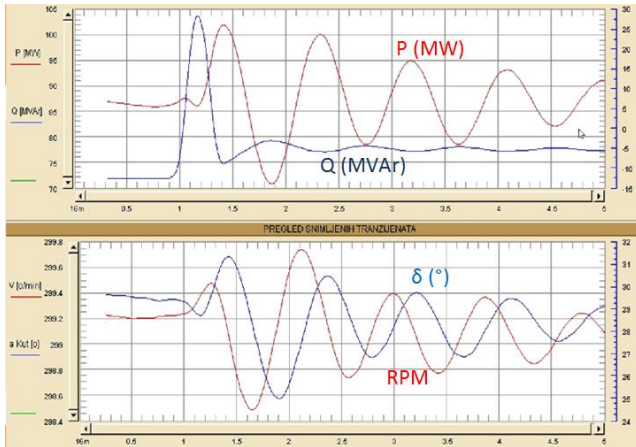
Load Angle monitoring application:
- Stability of operation (out of step) - *maximum capacitive load detection*
- Determination of *real time generator capability chart*
- Torsional dynamics of generator (analysis during power swing or electrical transient load)
- Electro-mechanical resonance detection
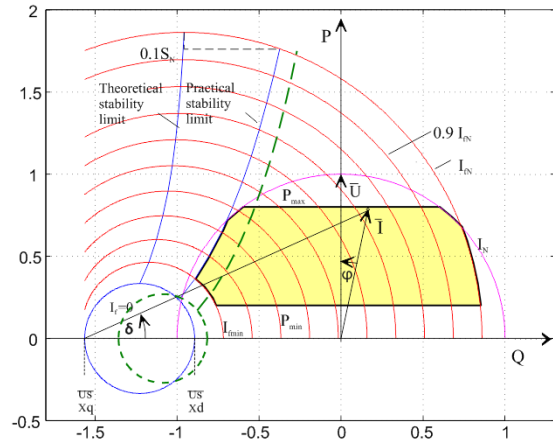- Measurement of losses (stator core and mechanical)

Dynamic Load Angle monitoring
Correlation of the Load Angle with Active and Reactive power during transient events used for operation stability prediction

Use to determine a Real Time Capability chart
Correlation of the Load Angle and grid parameters to obtain the true generator capability chart and predict its operating limits dynamically.

PRACTICAL APPLICATION – out of step operation limits
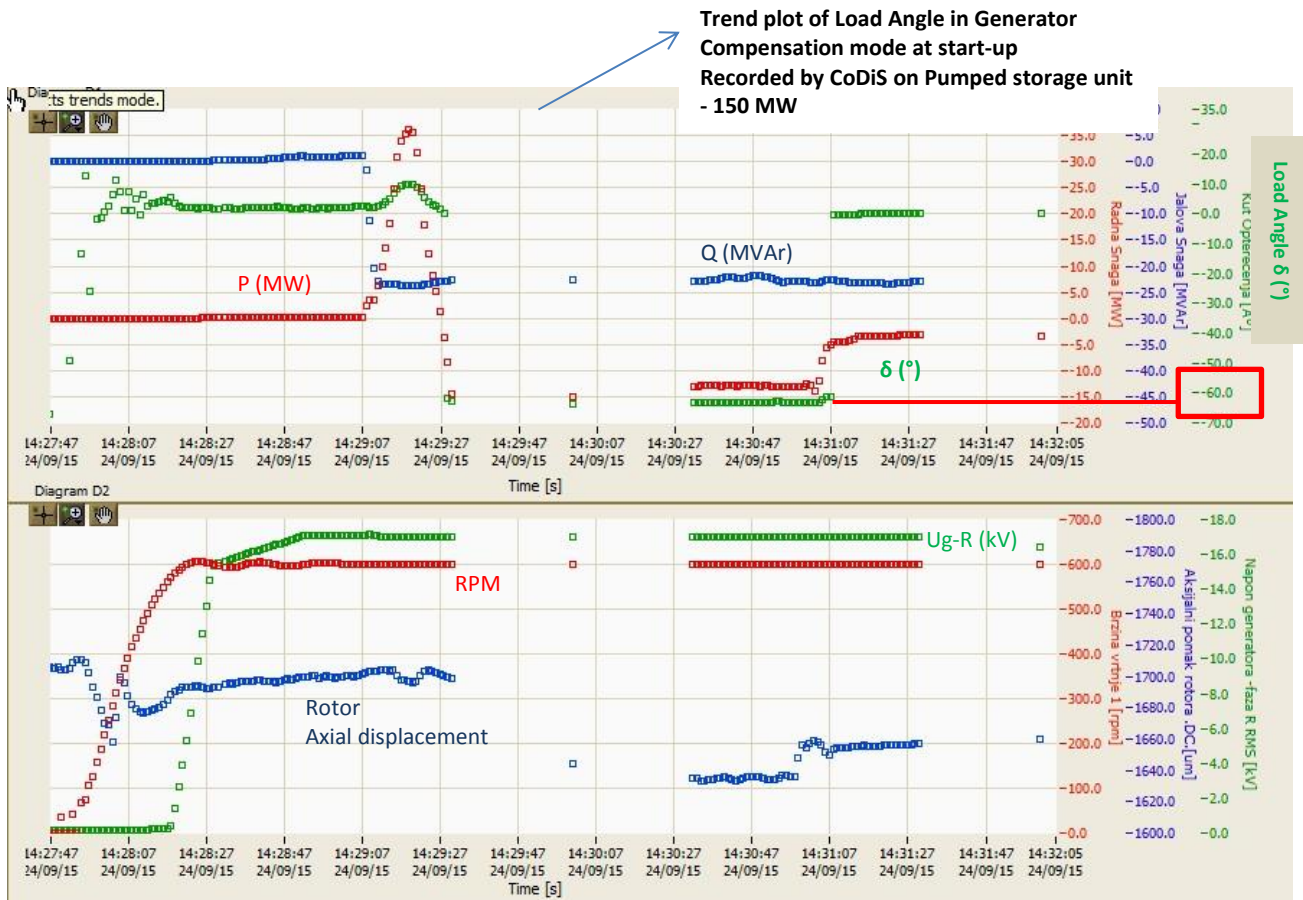
Trend plot of Load Angle in Generator Compensation mode at start-up Recorded by CoDiS on Pumped storage unit - 150 MW