UNIVERSITÀ DEGLI STUDI FIRENZE

PhD Dinfo Seminars - Second Series

Sub-Synchronous Torsional Interaction (SSTI) in Oil and Gas Plant

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Outlines.

- Research activity introduction.
- Sub Synchronous Torsional Interaction (SSTI) phenomena
- Moto compressor start-up:
  - Sub Synchronous Torsional Interaction dettail model rapresentation.
  - Results and performance evaluation.
- Small signal model of Liquefied Natural Gas (LNG)
- Conclusion.

Research Activity Introduction.

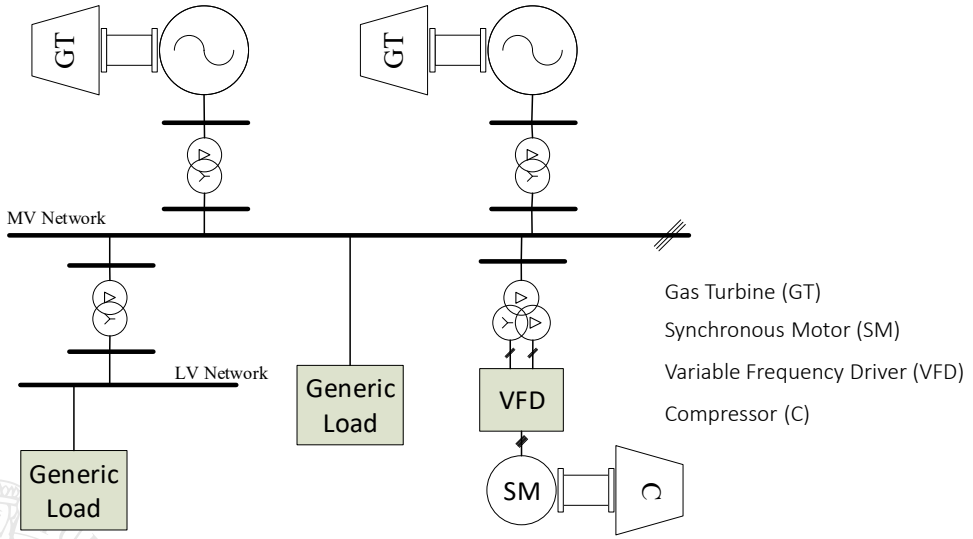
Medium Voltage electrical machines are commonly used in Oil&Gas applications.

- Turbine Generator
- Moto Compressor

Research principle Aim

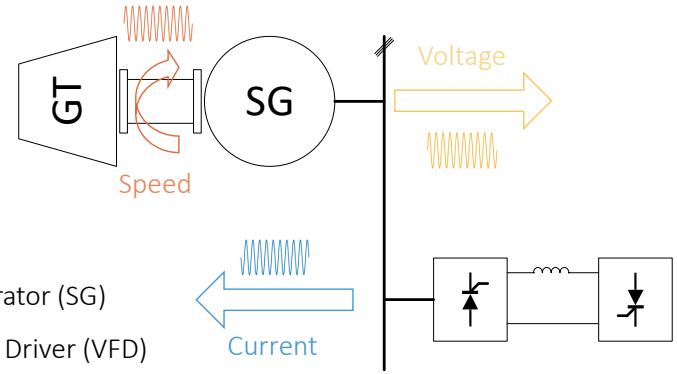
Develop and validate detailed models, at either machine and plant levels. To obtain an adequate prediction of the electrical torsional excitations

Research Activity Introduction.



SSTI Phenomena

Sub-Synchronous Torsional Interactions (SSTIs):
interaction of Variable Frequency Drive (VFD) with power generator units, such as turbine generators.



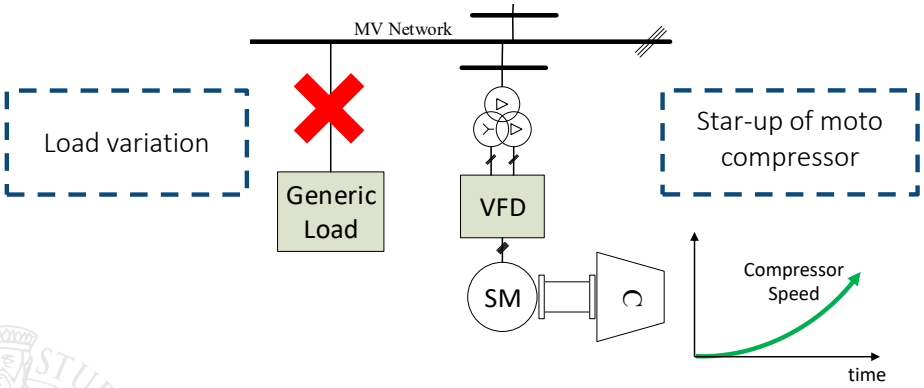
Gas Turbine (GT)

Synchronous Generator (SG)

Variable Frequency Driver (VFD)

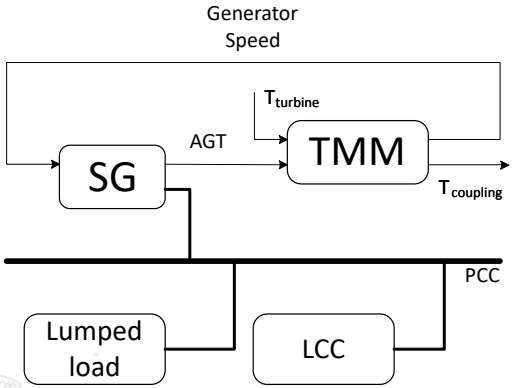
SSTI Phenomena

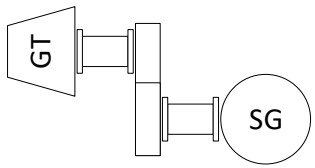
Possible causes of SSTI phenomena:
any contingency in the electrical network, which can cause a transient on the turbo generator.



Moto Compressor Start-Up: Model Description

The SSTI have been emulated through a model developed in Matlab/Simulink and PLECS environment:



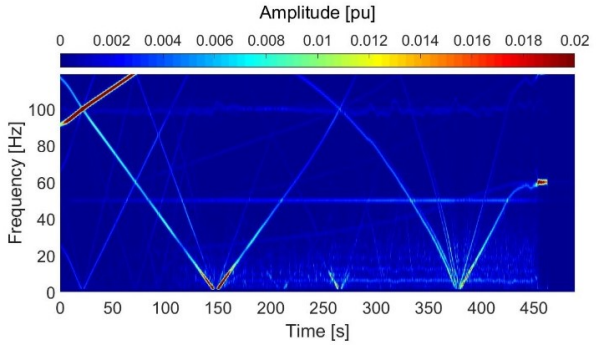


Synchronous Generator (SG)
Torsional Mechanical Model (TMM)
Load Commutated Converter (LCC)
Point of Common Coupling (PCC)
Gas Turbine (TG)

Moto compressor Start-Up: Performance Evaluation

First Case (Satisfactory)	Second Case (Unsatisfactory)
▪ Lumped Load absorbs about 24% of generator rated power. ▪ The starting-motor drives the moto-compressor train in [0 – 24%] speed range. ▪ The plant is supplied by **three identical turbo-generator**.	▪ Lumped Load absorbs about 24% of generator rated power. ▪ The starting-motor drives the moto-compressor train is [0 – 24%] speed range. ▪ The plant is supplied by **one turbo-generator**.

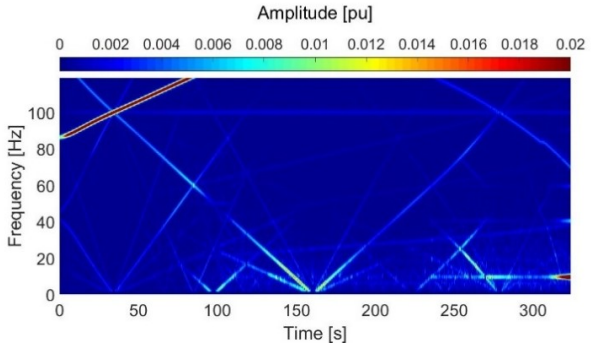
Moto compressor Start-Up: Performance Evaluation



Waterfall of i'_{DC} during satisfactory start-up operation

Interharmonics	1° TNF intersection	2° TNF intersection
$f_{6,6}$	370 and 387 s	354 and 407 s
$f_{6,12}$	135 and 159 s	109 and 184 s
$f_{12,18}$	259 and 271 s	//

Moto compressor Start-Up: Performance Evaluation

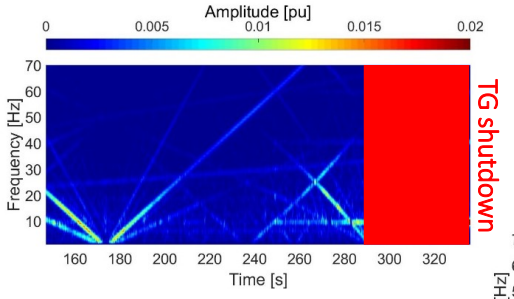


Waterfall of i'_{DC} during unsatisfactory start-up operation

Interharmonics	1° TNF intersection	2° TNF intersection
$f_{6,6}$	//	//
$f_{6,12}$	150 and 174 s	124 and 200 s
$f_{12,18}$	274 and 286 s	261 and 297 s

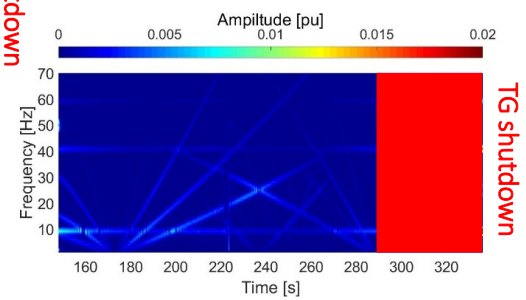
Moto compressor Start-Up: Performance Evaluation

Second case (unsuccessful start-up) measurements and simulation comparison.



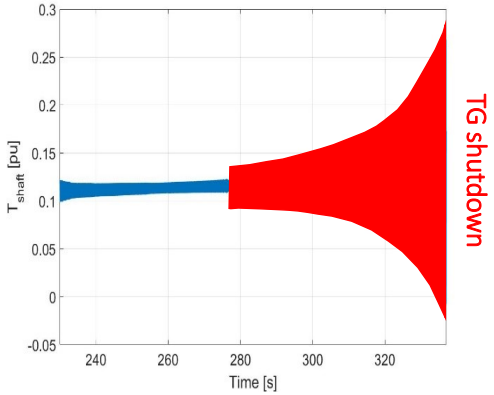
Waterfall of i'_{DC} during start-up operation, measured data

Waterfall of i'_{DC} during start-up operation, simulated data



Moto compressor Start-Up: Performance Evaluation

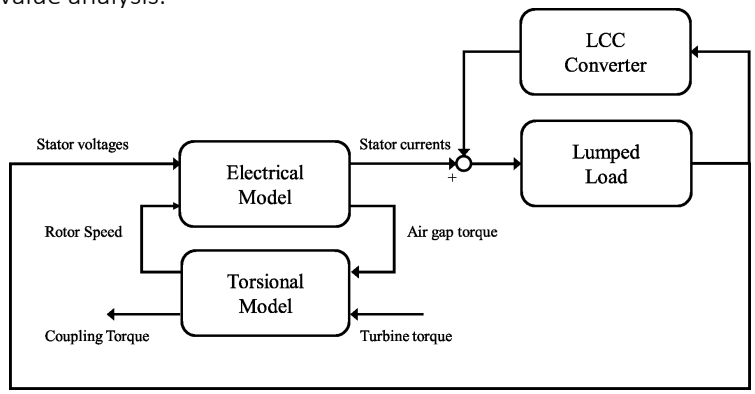
Second case (unsuccessful start-up) measurements and simulation comparison.



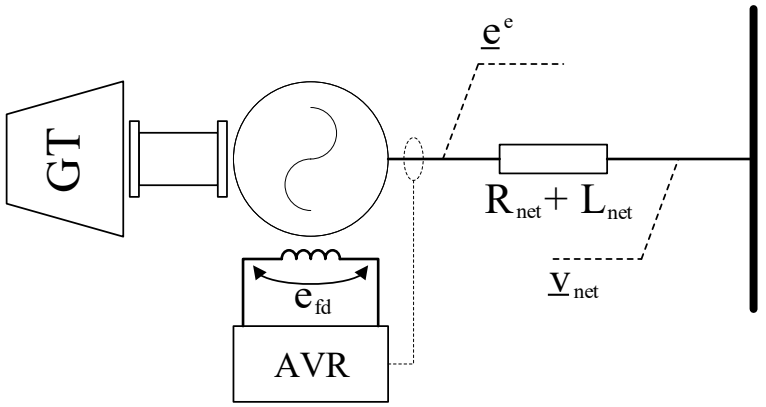
TG Torsional Torque at the turbine coupling, during moto-compressor start-up, simulated data

Small signal model.

The torsional stability of the Oil&Gas plant is evaluated through the eigenvalue analysis.



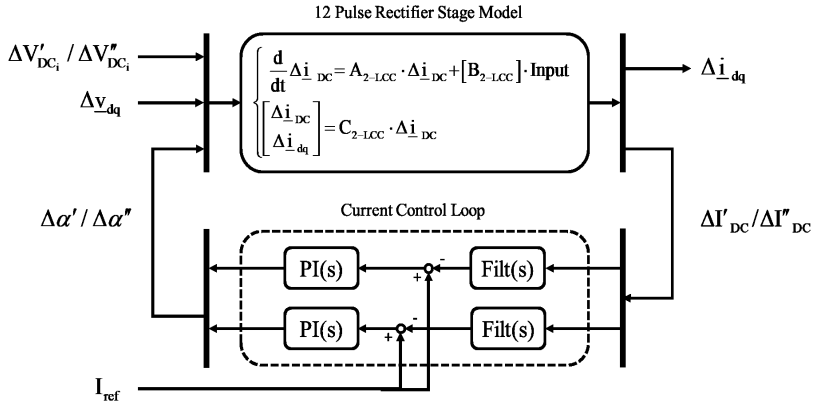
Small signal model: turbine generator.



Gas Turbine (GT)

Automatic voltage Regulator (AVR)

Small signal model: power conversion stage.



Conclusion

It is provided an evaluation of the main issues related to the moto-compressor train.

- SSTI phenomena are assessed through a complete electrical and mechanical model of Oil & Gas plant.

It is provided the preliminary results of the torsional stability assessments, respect an Oil&Gas plant.

- A small signal model of the main items of the plant are presented and the eigenvalue study is introduced, as method to determine the stability.

Thank you for your attention

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