RED ELÉCTRICA DE ESPAÑA

Grupo Red Eléctrica

Inelfe HVDC

InnoDC

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October 2020

Indice

Main Characteristics

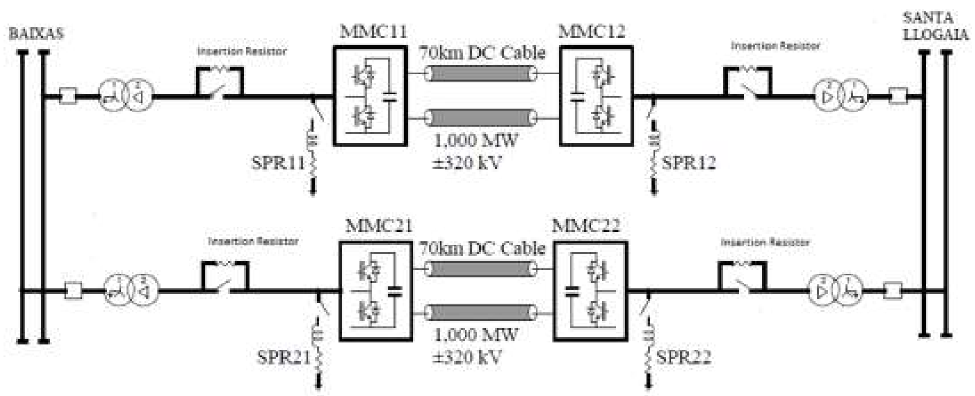
Overview of the Interconection

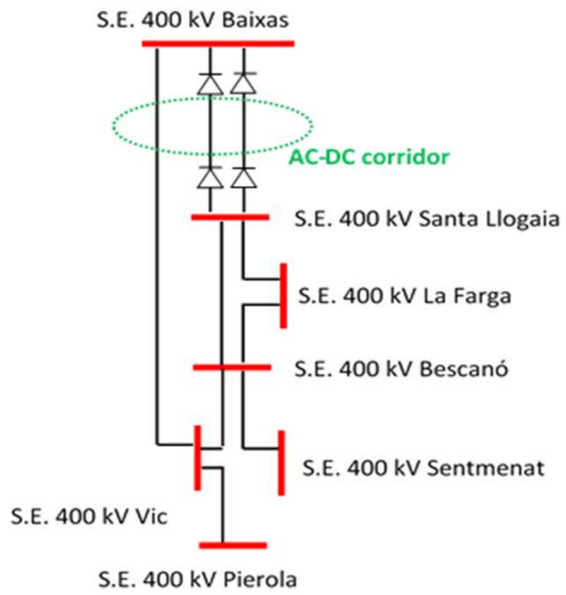
AC
interconnections

HVDC

Tunnel to cross
Albères mountains
l = 8,5 km

Technical Background





HVDC Rated Power: 2 x 1.000 MW

Configuration scheme: Symmetric monopole

AC Voltage: 400 kV

DC Voltage: ±320 kV

Reactive Power Capacity: +400/-600 Mvar per converter station

Converter Stations Technology: Modular Multilevel Converter (MMC)

- In parallel to the 400 kV Vic-Baixas
- With a constant power flow between France and Spain, if the DC power changes in 100 MW, the 70% is assumed by the 400 kV Vic-Baixas line and the remaining 30% by the rest of interconnection lines

Angle Difference Control

$$P_{VSC} = P_0 + K * \Delta\delta = P_0 + K * (\delta_{Baixas} - \delta_{Santa\ Llogaia})$$

P_0 parameter

- $P_0 \in [-1.000, 1.000]$ MW per link
- Modifications of P0 have a low impact on the total power transmitted by the VSC link:

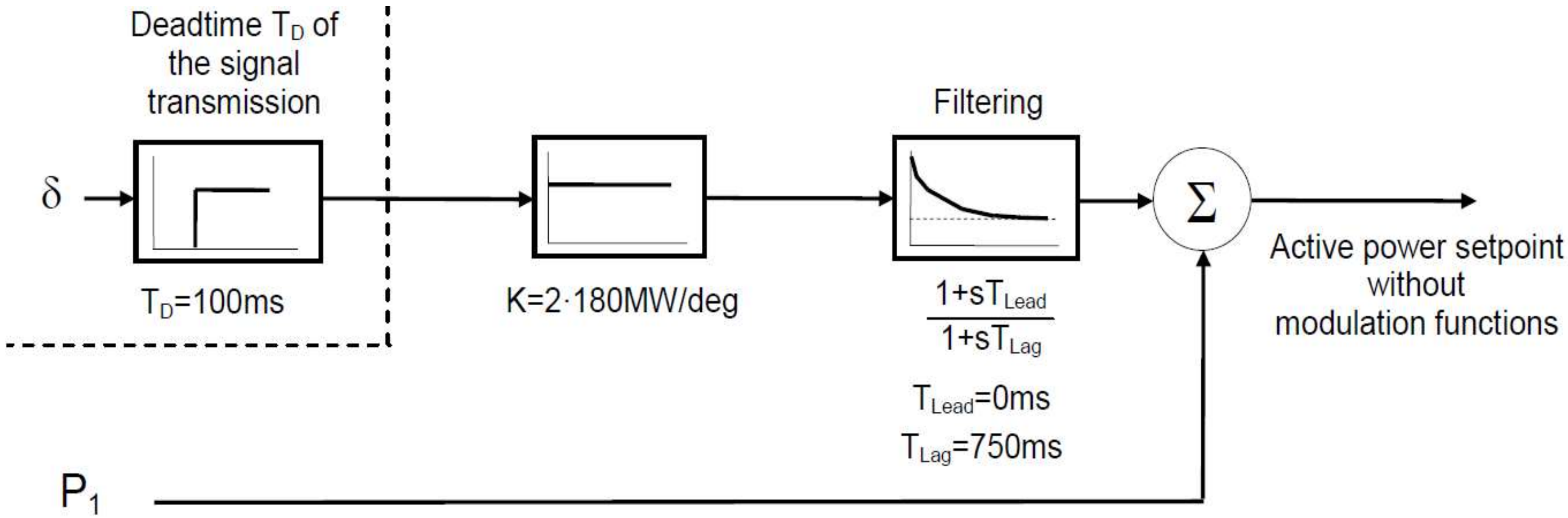
  $\Delta P_0 = 1.000$ MW → ΔP_{DC}=160 MW.
- Modifications of P_0 have a low impact on the active power flows of the AC interconnection lines:

  $\Delta P_0 = 1.000$ MW → $\Delta P_{Vic\text{-}Baixas}$=-245 MW.
- Moderate impact on the system transient stability
- Moderate impact on the system small signal stability

K parameter

- $K \in [0\text{-}180]$ MW/s per link
- Increasing K would imply considering a shorter line and therefore greater active power by the VSC link
- There is a saturation of the control for high values of K and the control can produce oscillations.
- A small value of K will require large changes $\Delta\delta$ to cause significant modification in the DC active power set-point.
- Changes in $\Delta\delta$ will modify the DC active power and vice versa, changes in the DC active power will also modify $\Delta\delta$, although in smaller amount due to the AC line in parallel

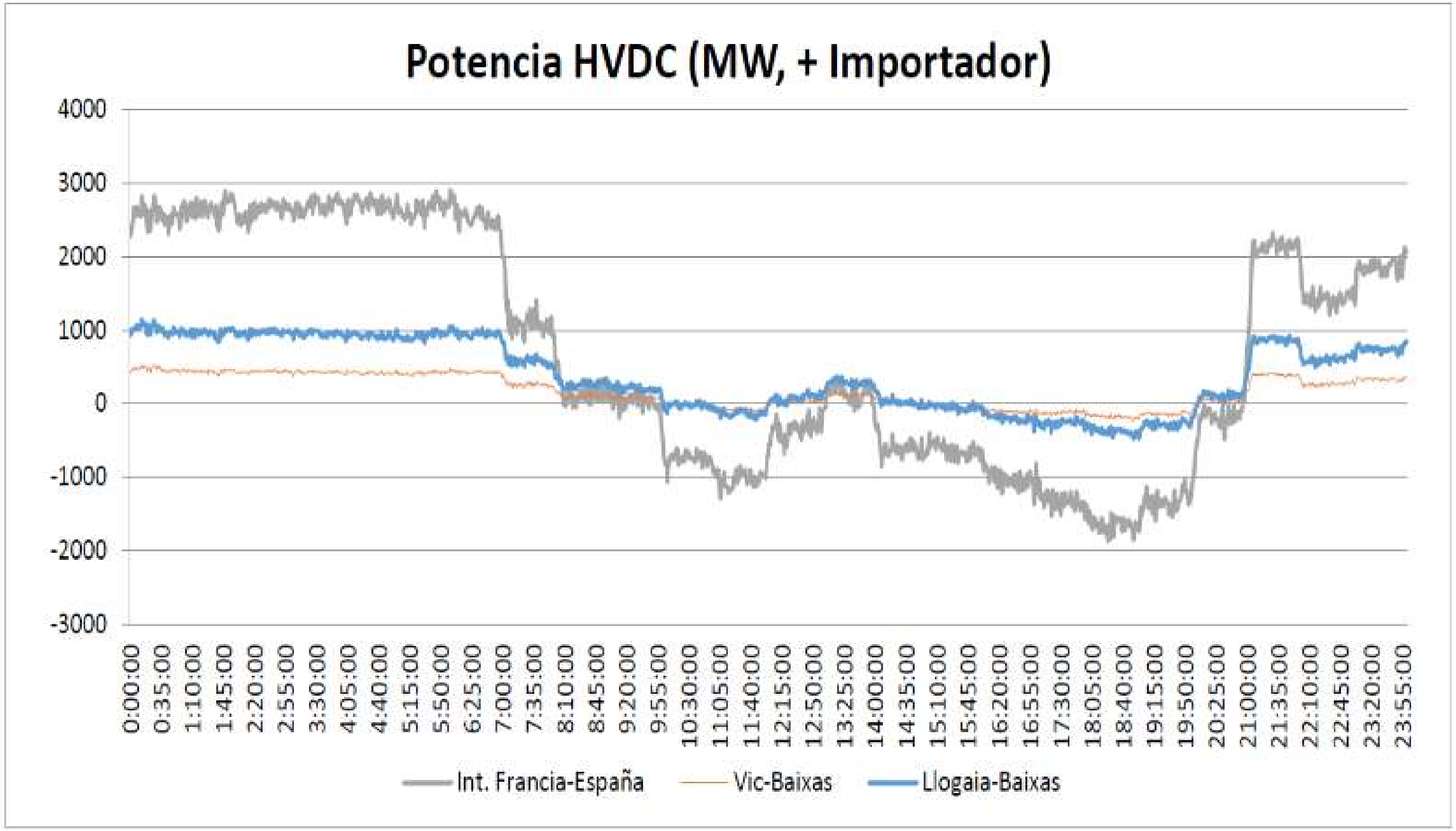
Angle Difference Control. Implementation



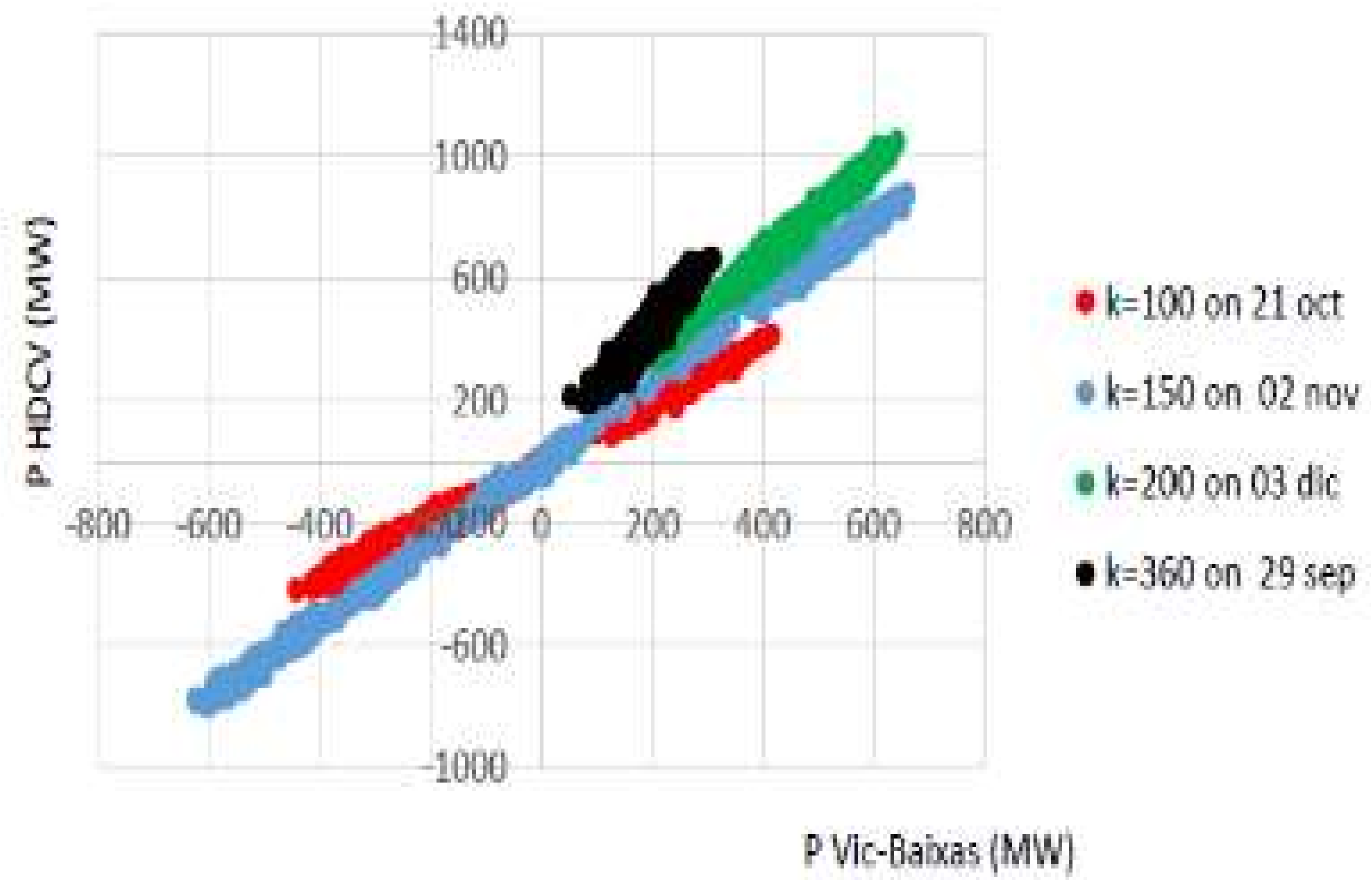
Filter: Damping of Oscillations due to the ADC

Steady State and Other Contingencies

HVDC Active Power Related to Interconnection Power



HVDC Active Power Related to K Value



HVDC Active Power Related to τ Value

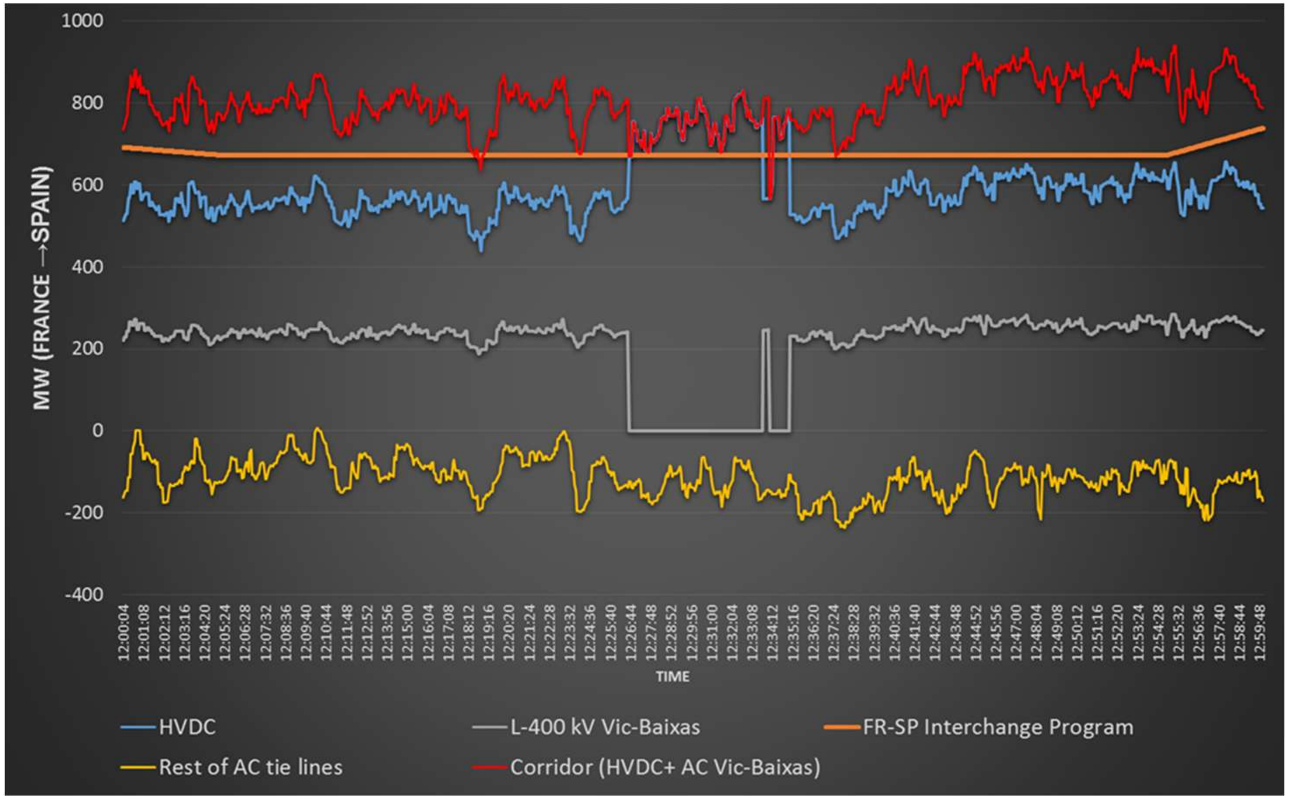
Constant T for the first order delay filter:

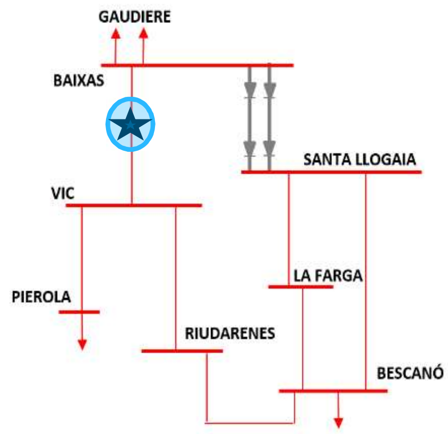
Until January 2019: **750 ms** (value stablished based on the studies developed during the design of the HVDC)

From January 2019: **50 s** (value stablished based on the studies performed after the CE interarea oscillations of 1st December 2016)

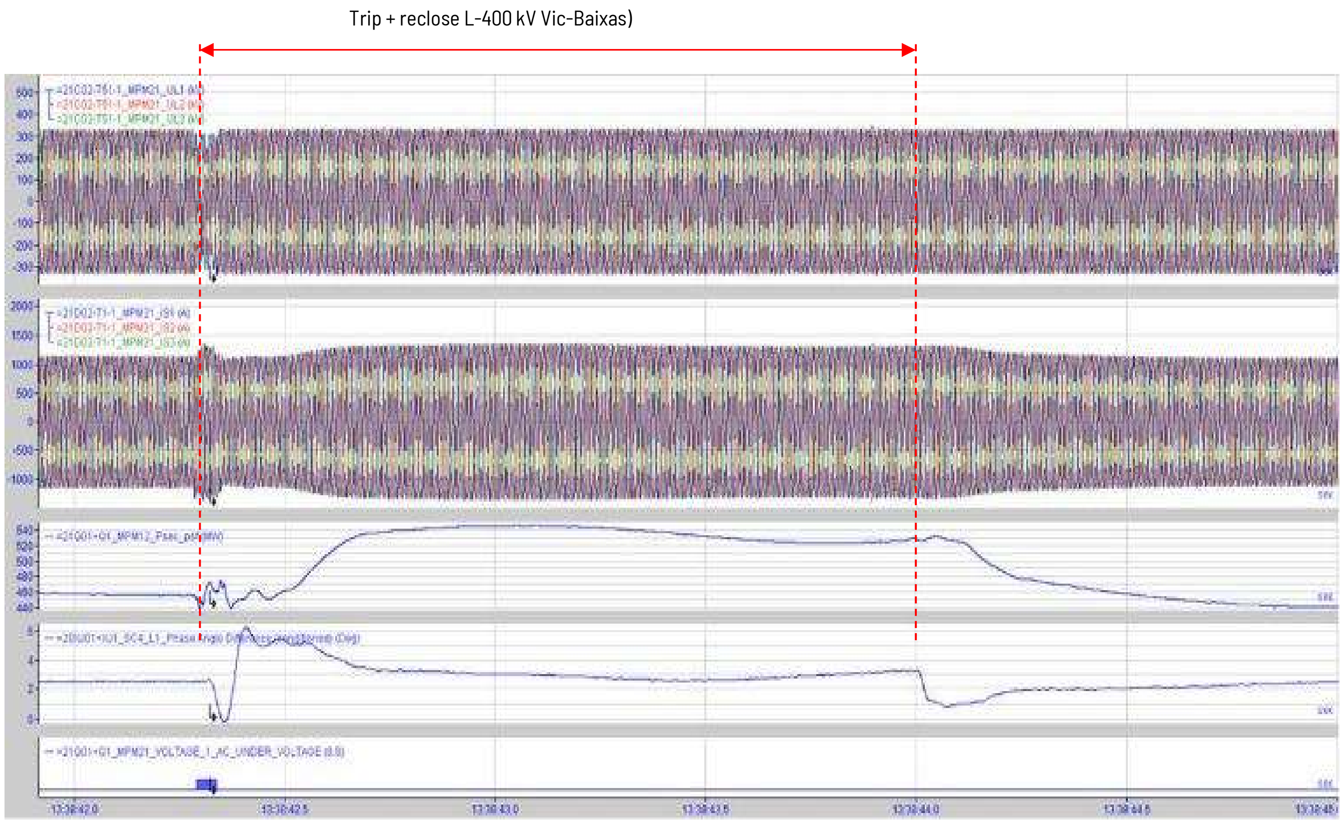
Opening of L 400 kV Vic-Baixas Line

29/06/2016 → Topological action in L-400 kV Vic-Baixas line.





Single phase in 400 kV Vic-Baixas Line with Reclosing

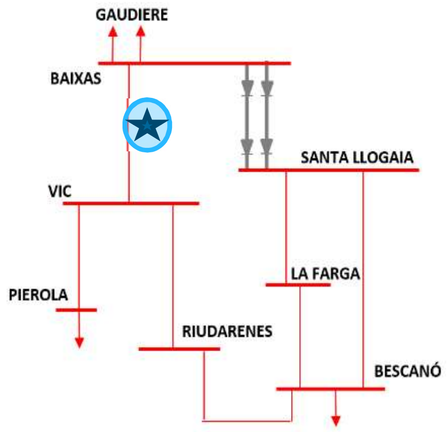


Voltage

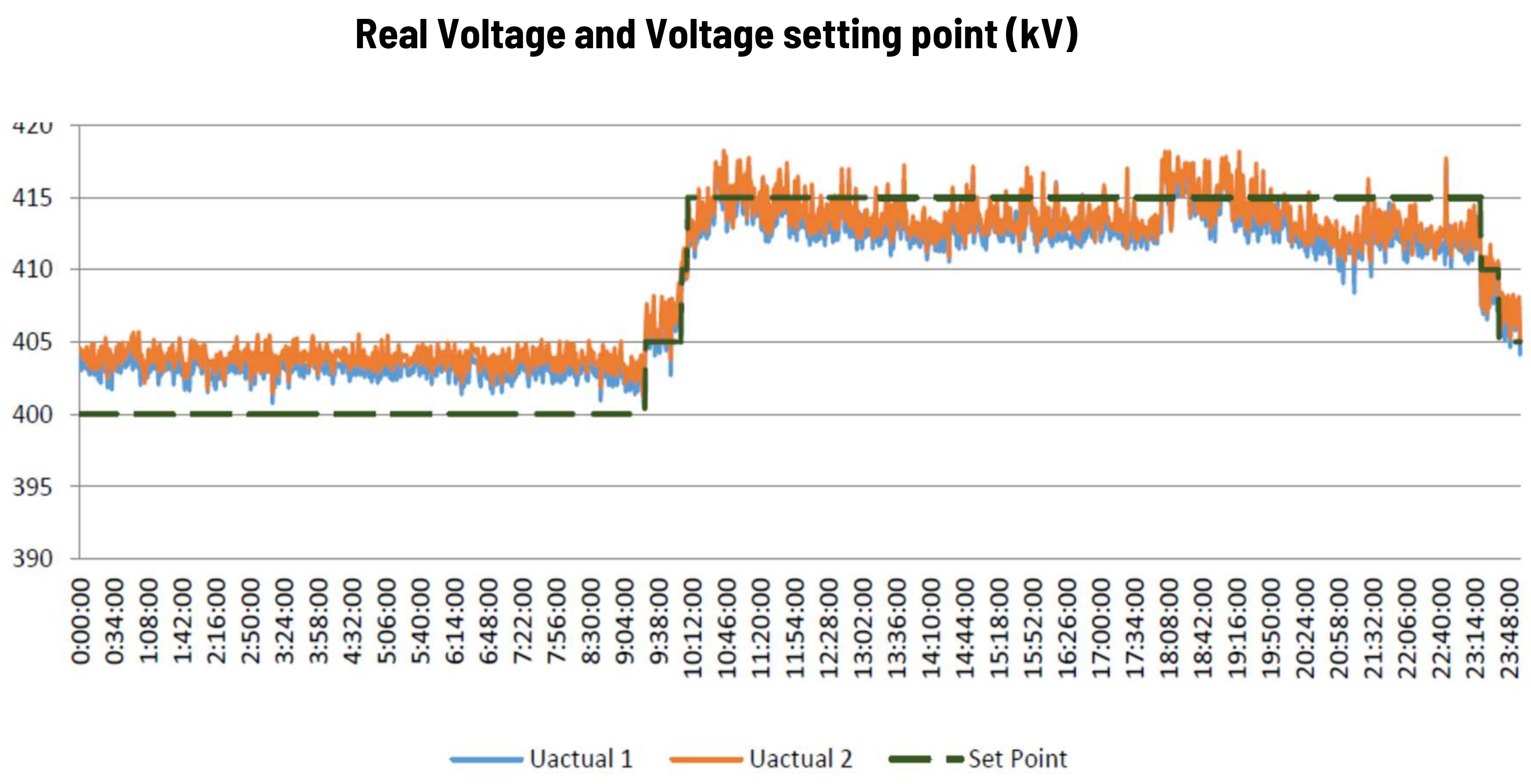
Current

Active Power

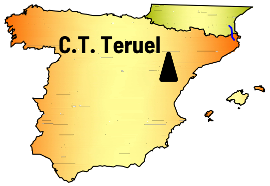
Angle



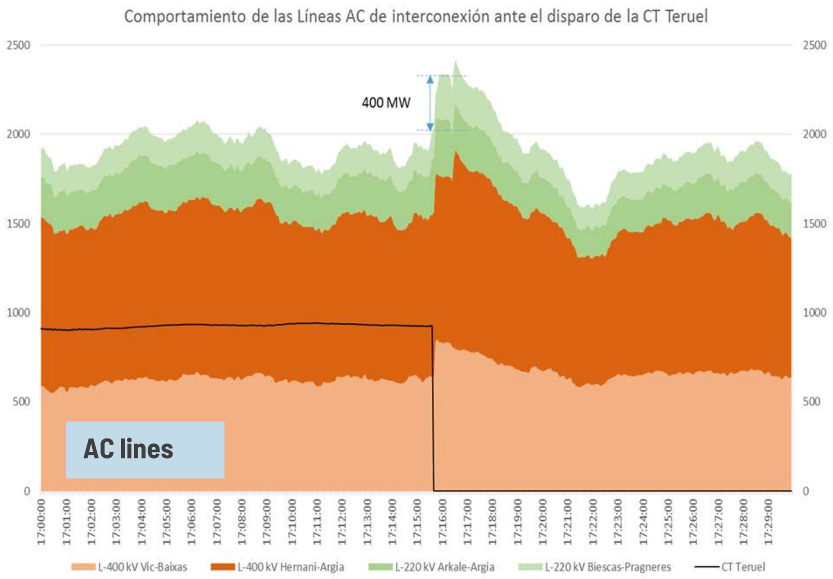
Voltage Control in S. Llogaia

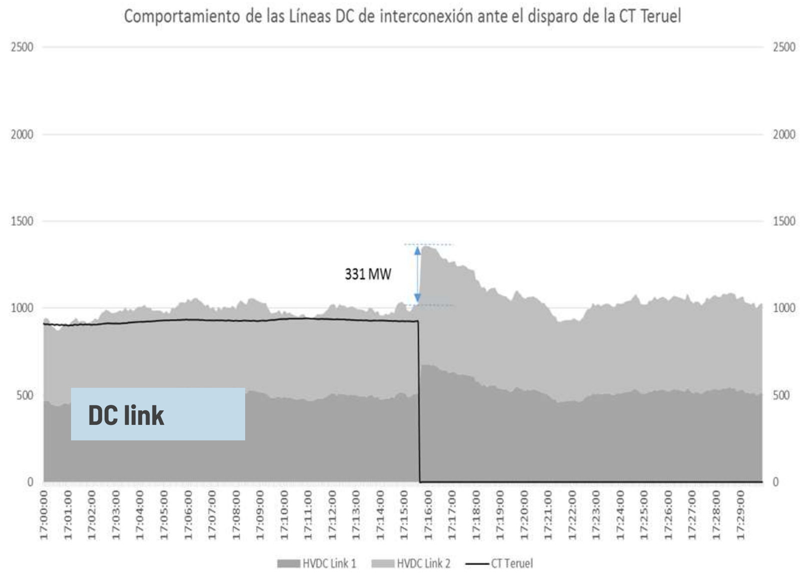


Trip of C.T. Teruel



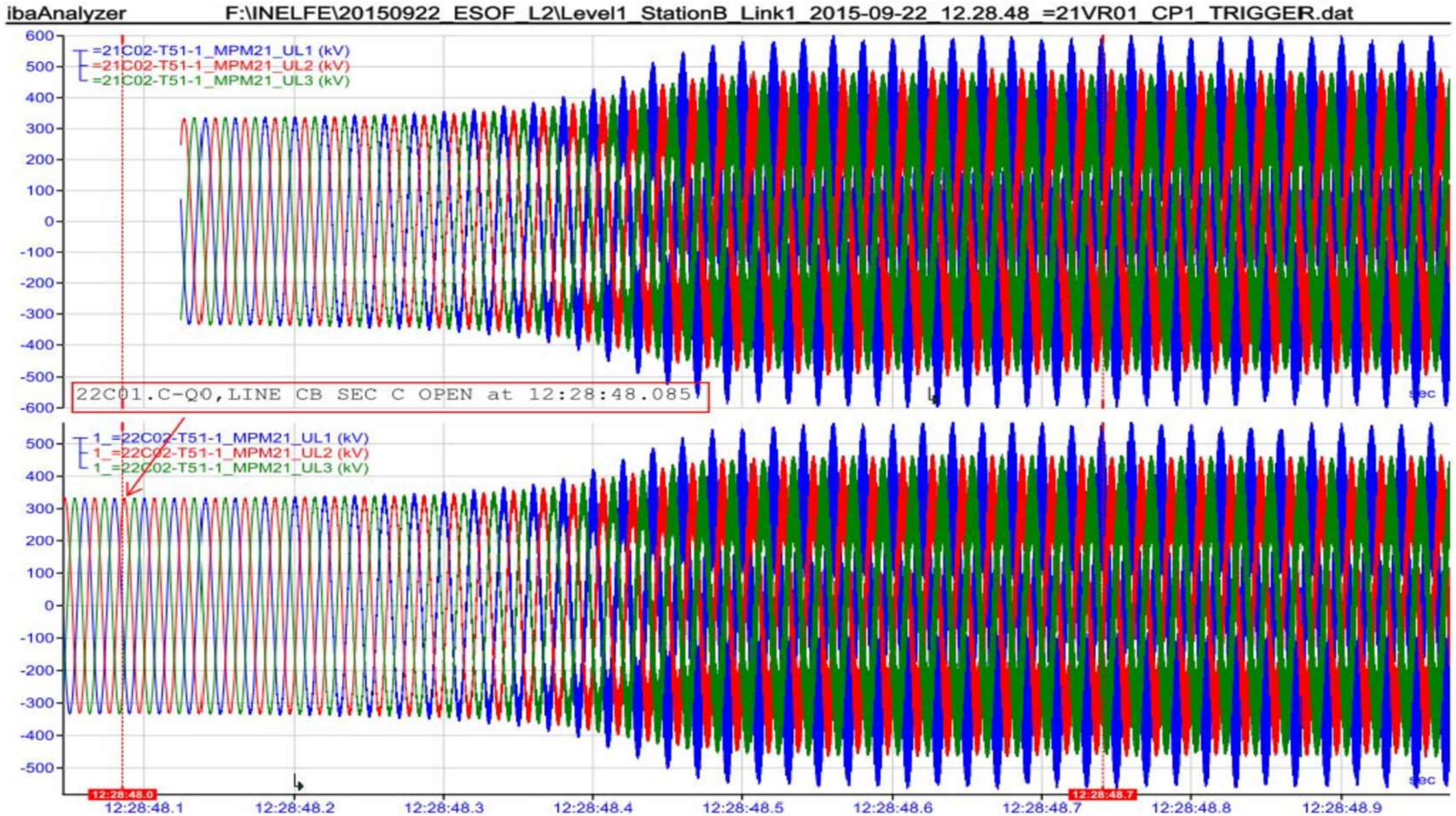
08/12/2015 → Trip of the C.T. Teruel (900 MW):

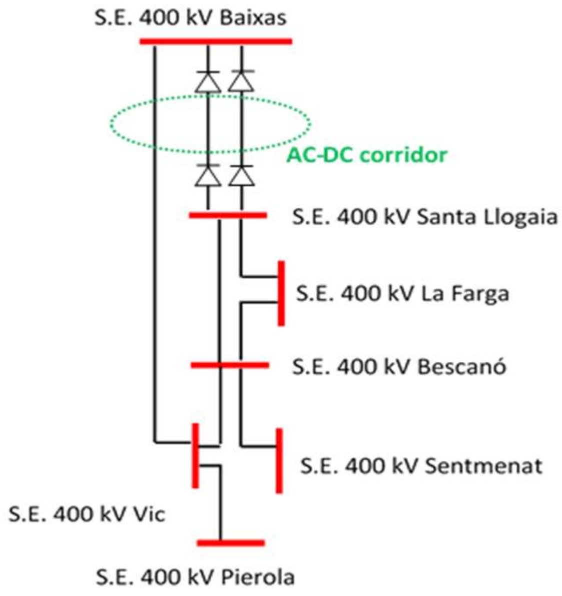




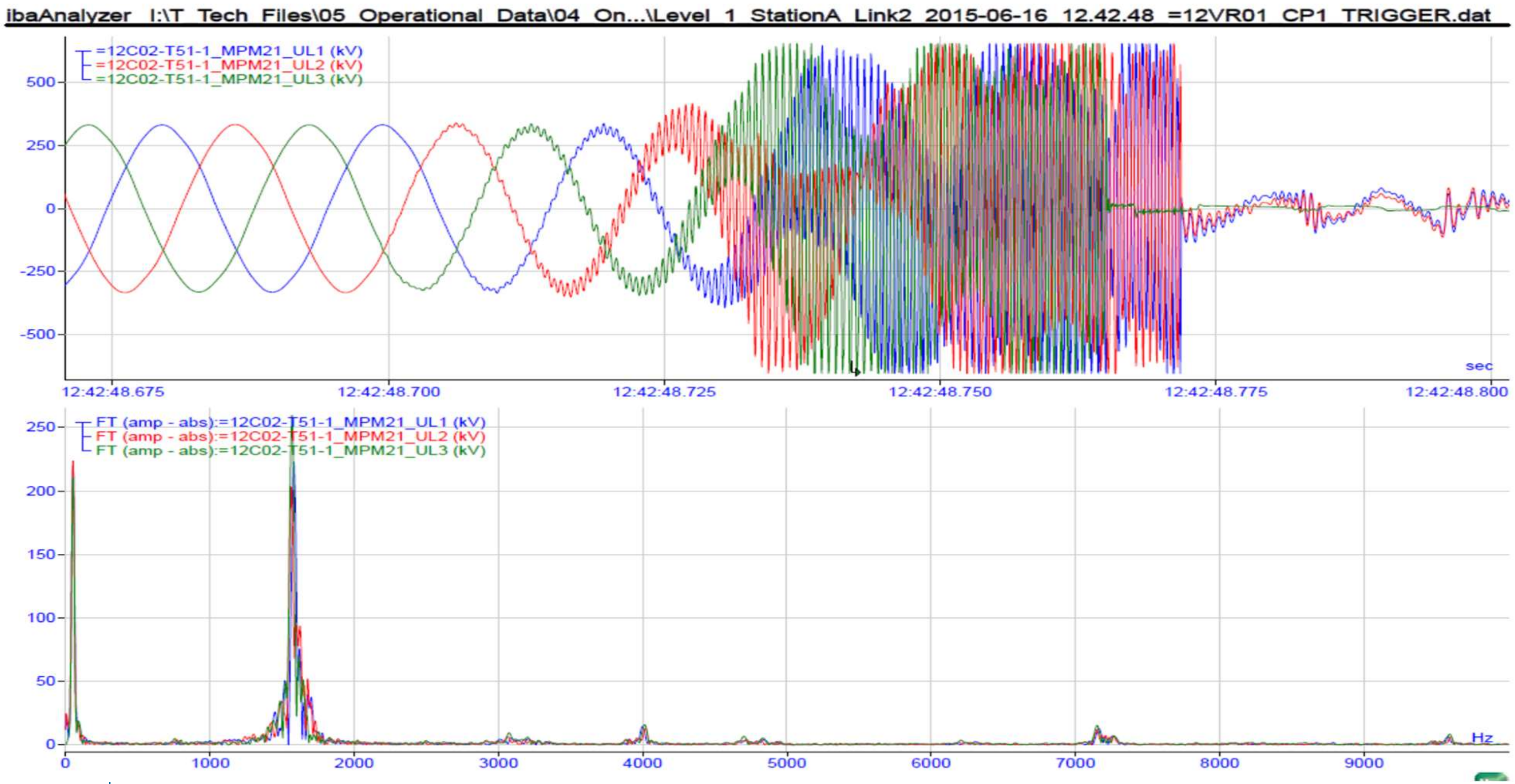
Interaction between both Converters

Oscillation in Both Converters

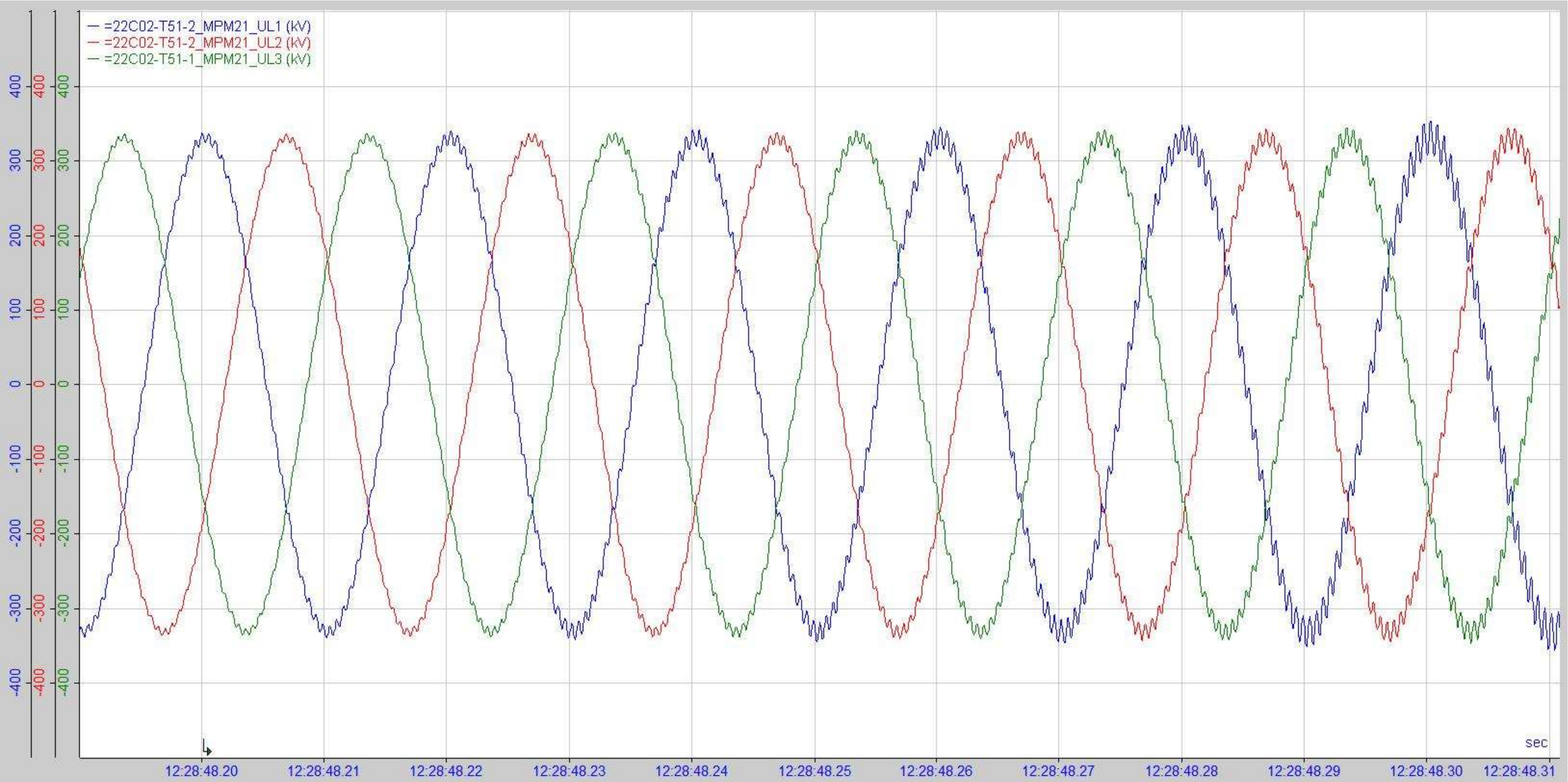




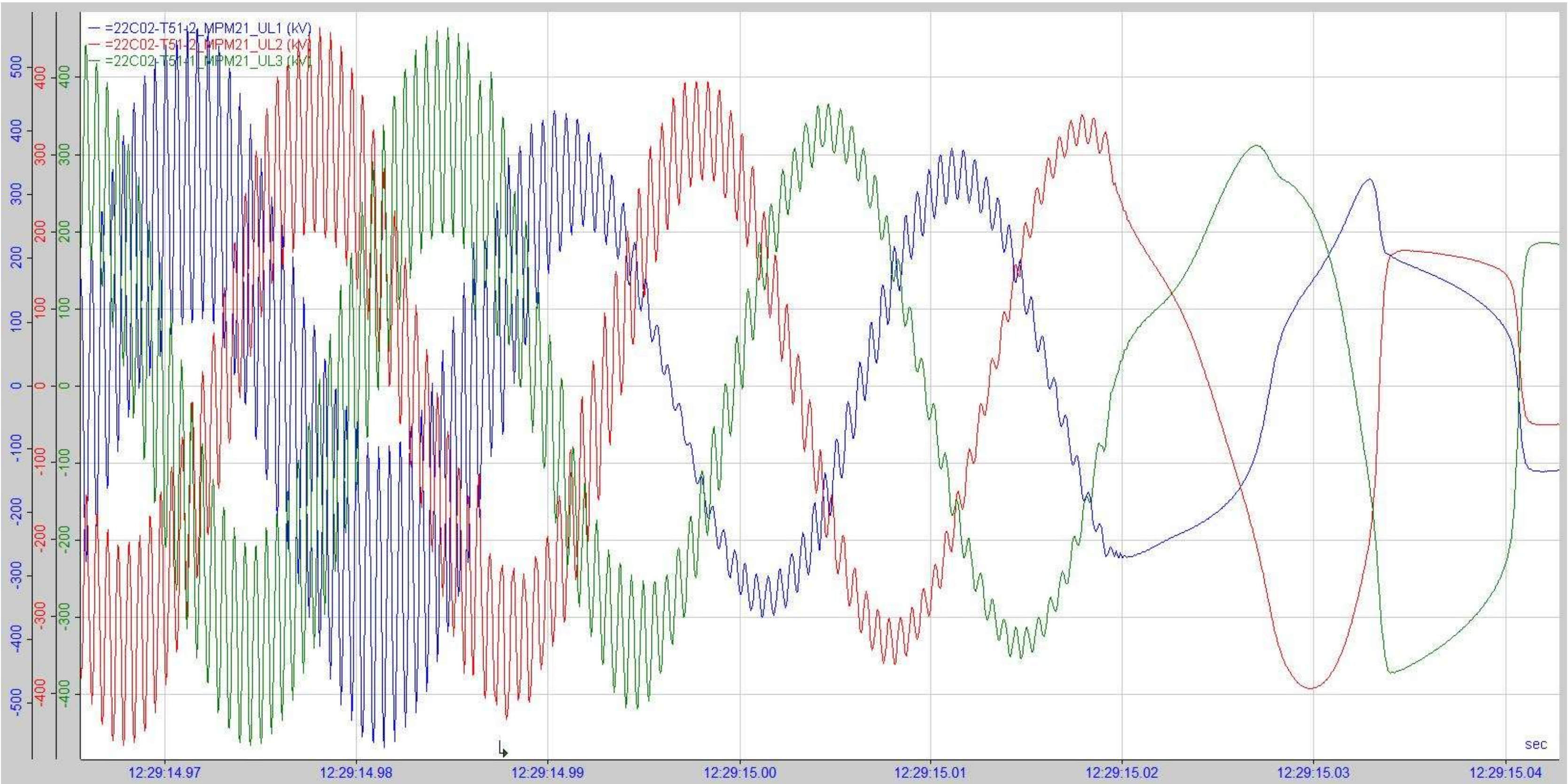
Oscillation Frequency ~ 1.700 Hz



Beginning of the Osciñllation

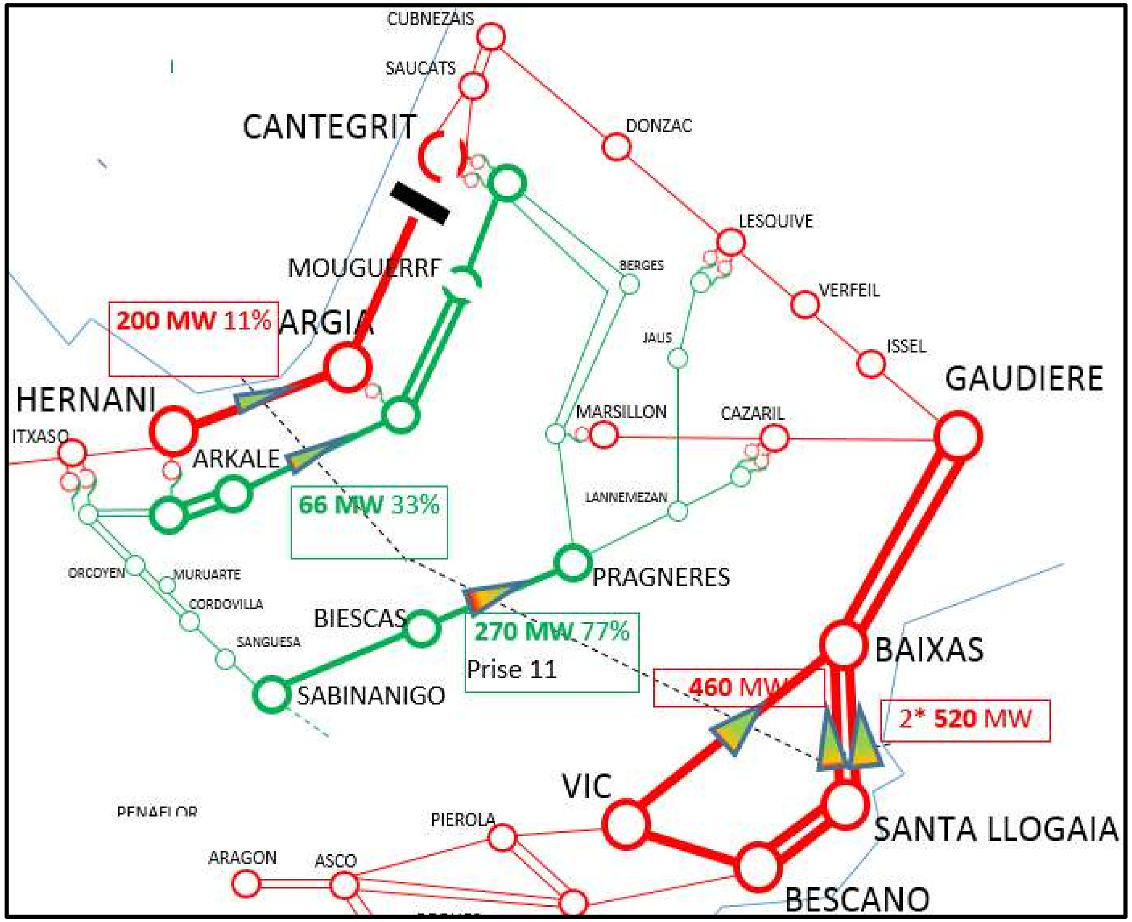


End of Oscillation. One converter trip

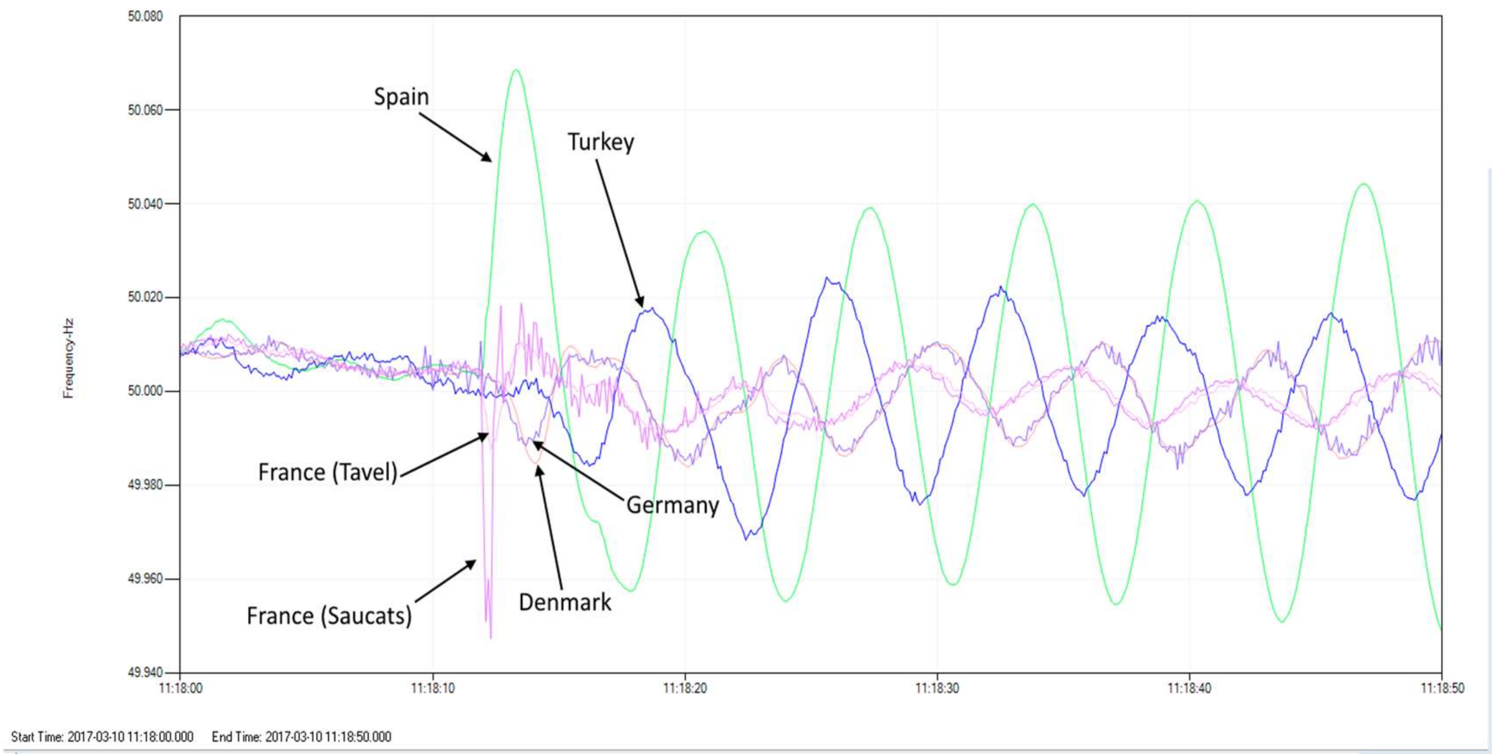


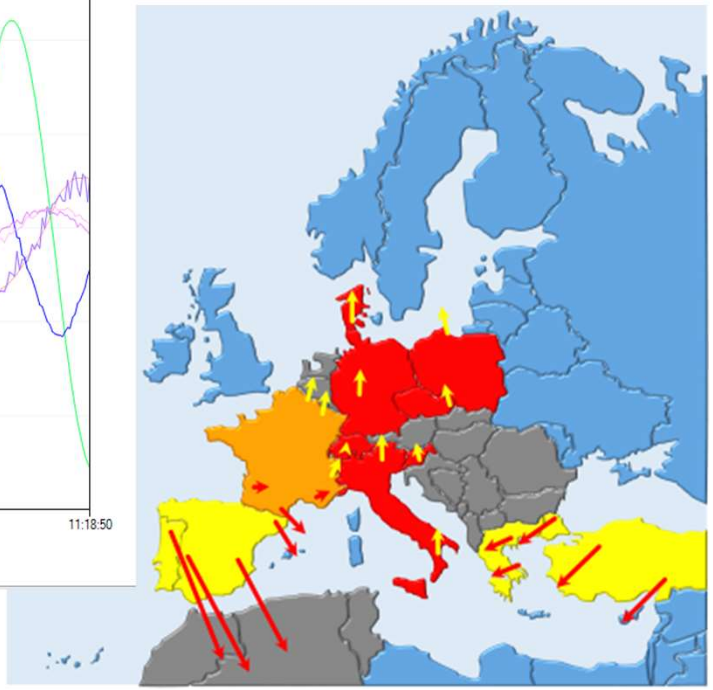
Interarea Oscillation

Incident 1 December 2016 (11:18 h)

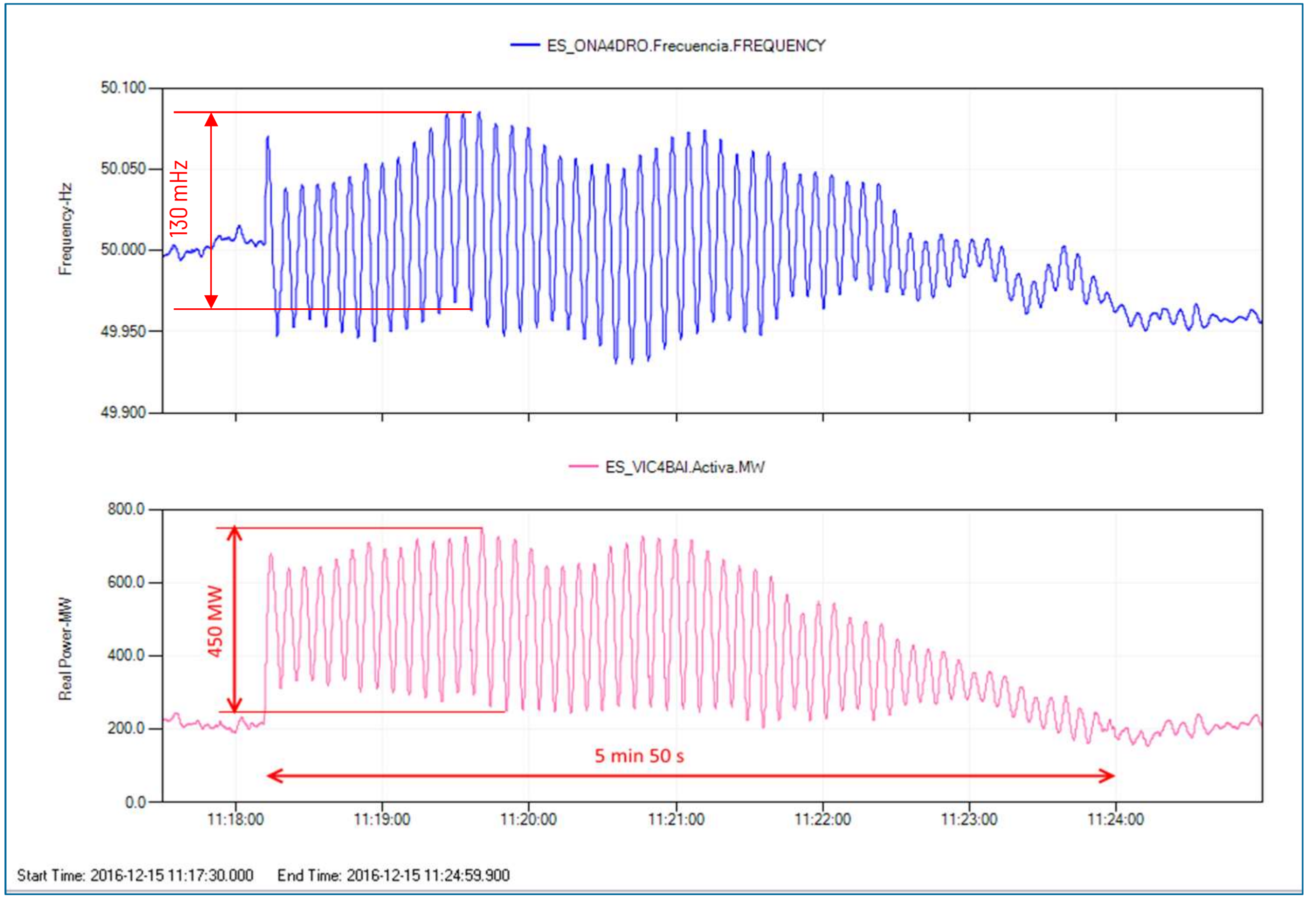


Oscillations in The System





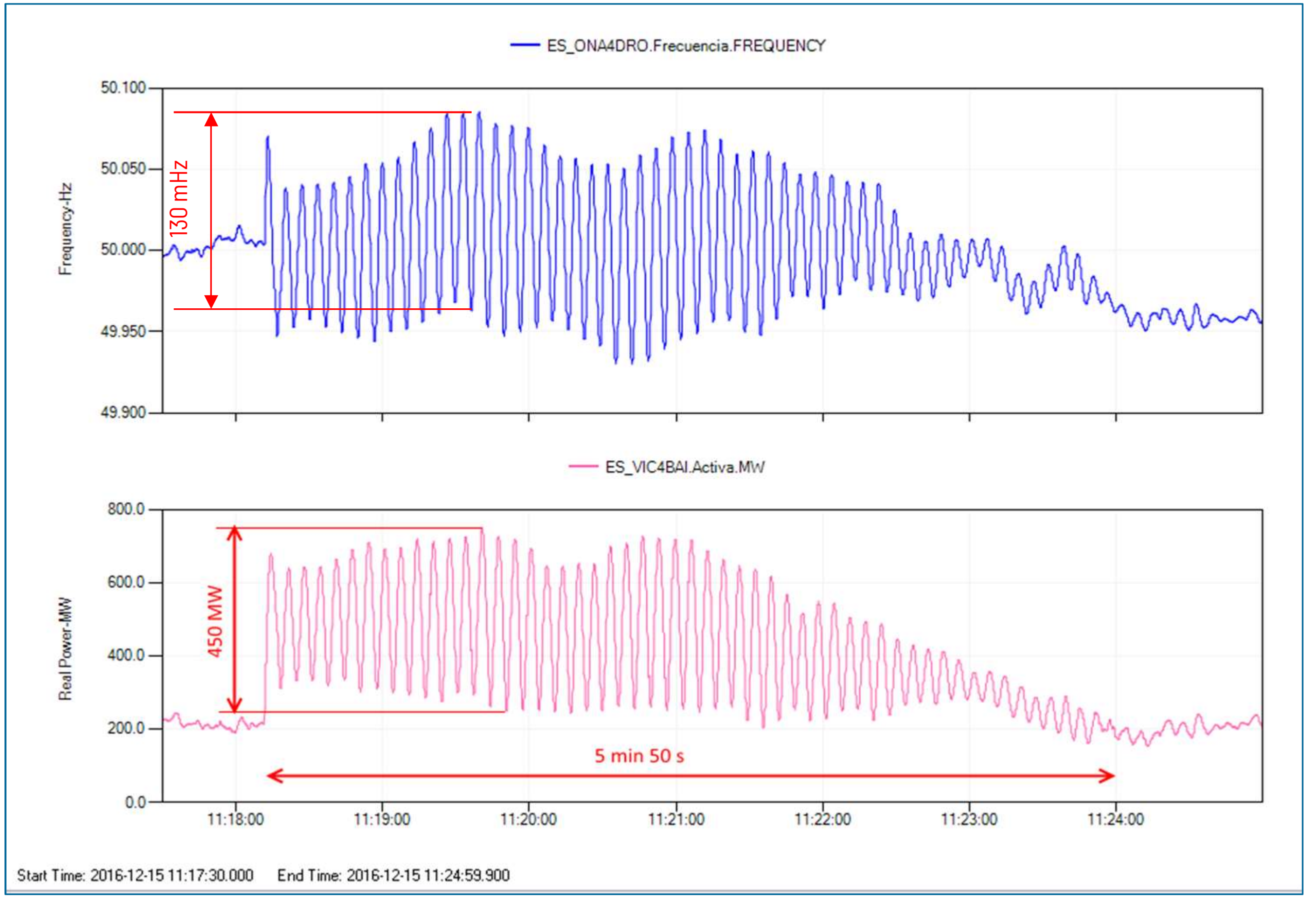
Frequency South of Spàin and Power Vic-Baixas



Frequency Carmona

Power Vic-Baixas

Frequency South of Spain and Power Vic-Baixas



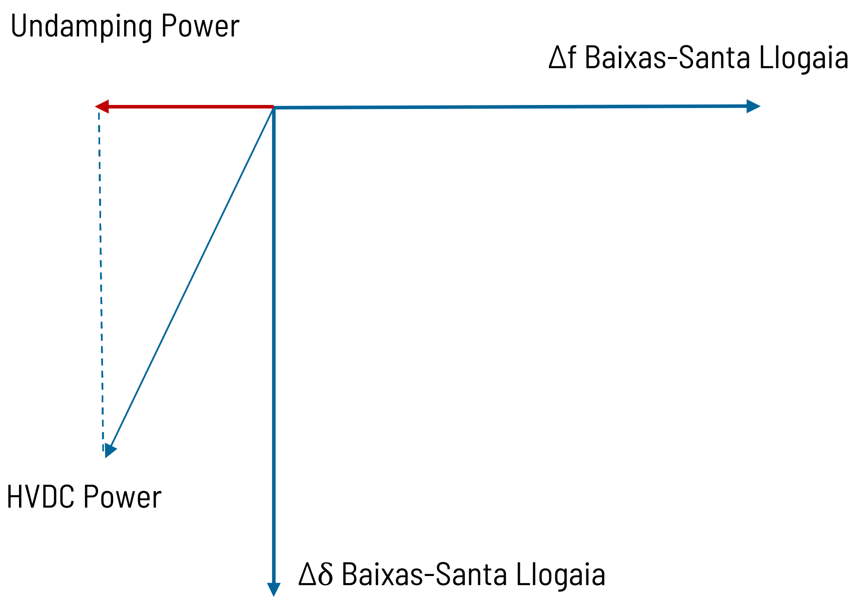
Frequency Carmona

Power Vic-Baixas

Less damping ADC tan Constant Power

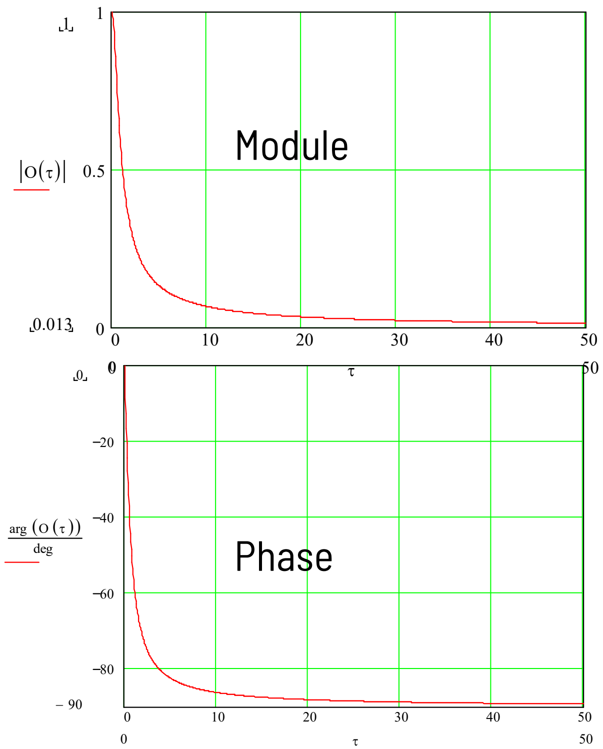
The angle difference between Baixas and Santa Llogaia is the integral of the frequency difference $\Delta\delta = \int \Delta f$ => in sinusoid oscillation $\Delta\delta$ will be at 90º lag of Δf.

First order delay will lag HVDC power and reduce its module.



Possible Explanation

First Order Response(f=0,24 Hz)



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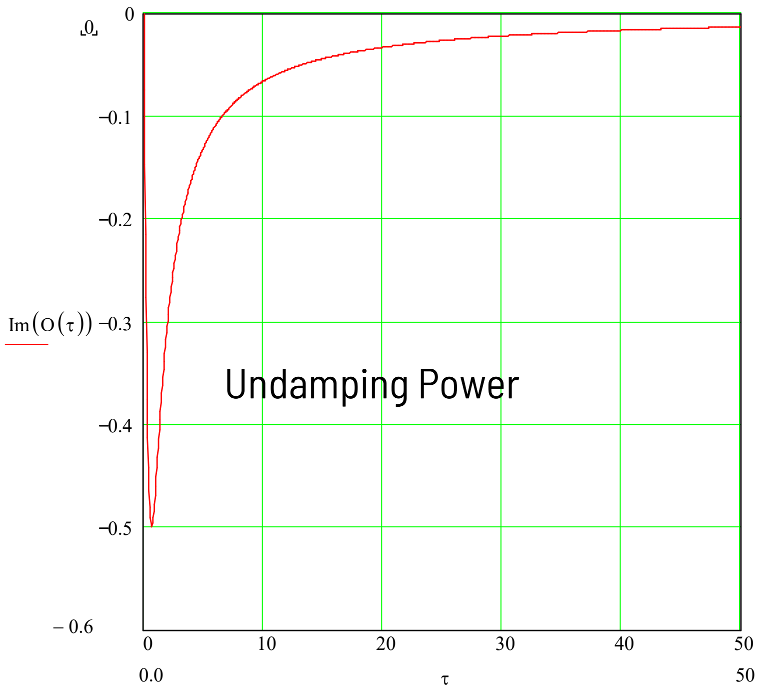
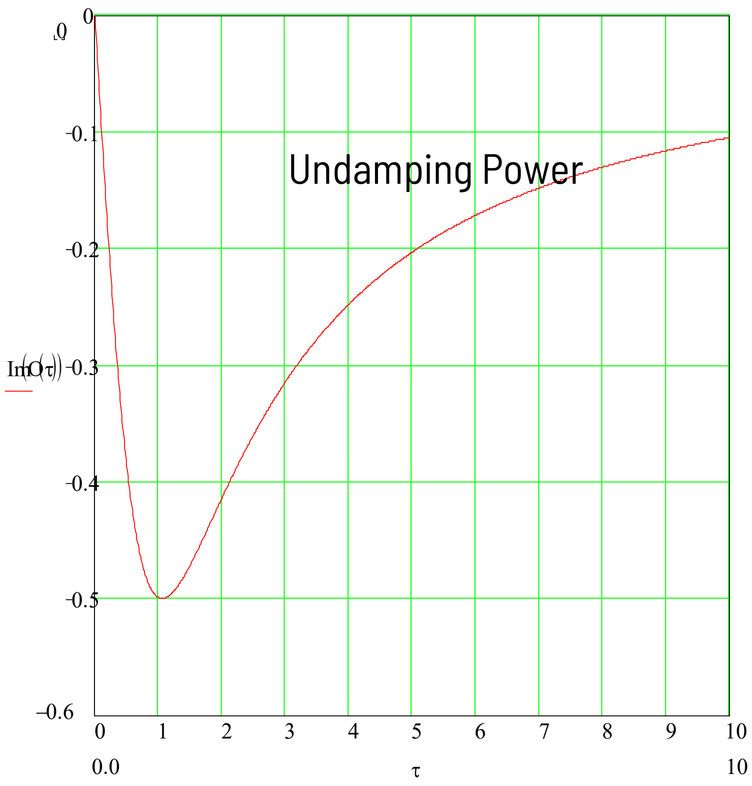
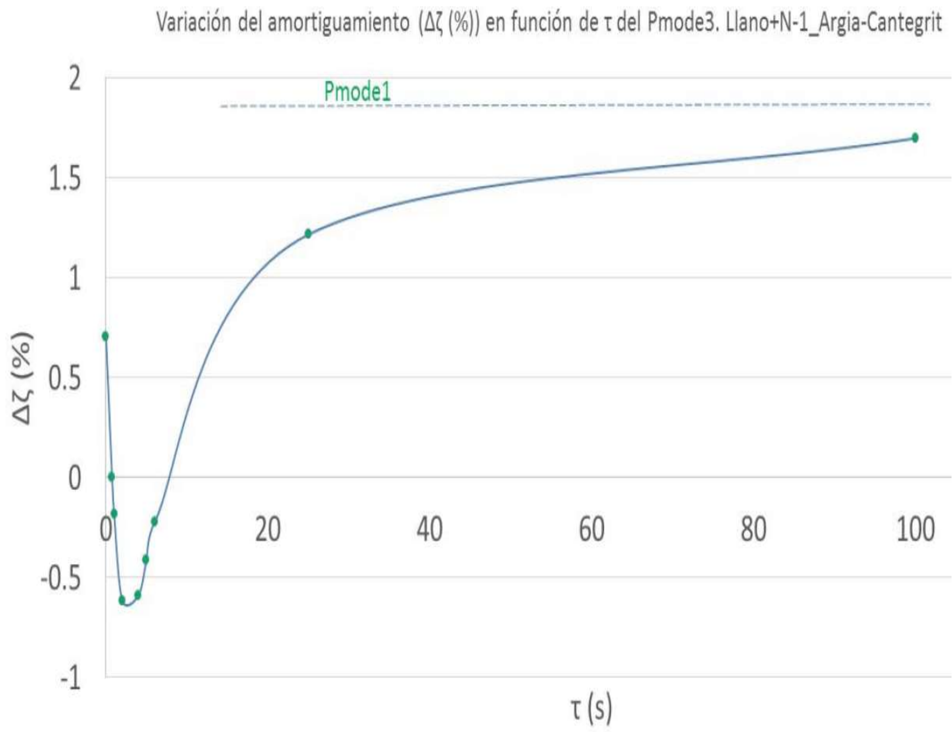


Possible Explanation

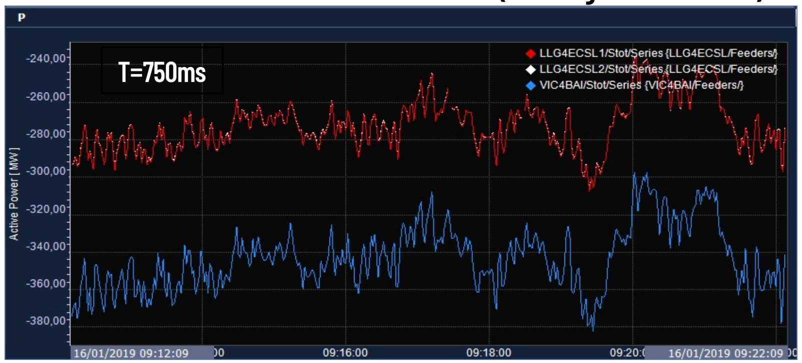


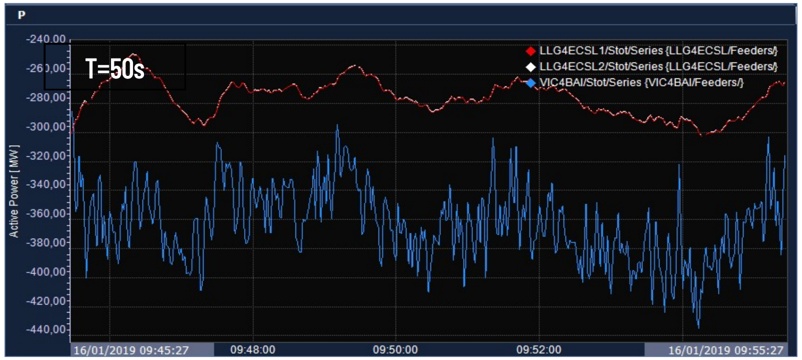


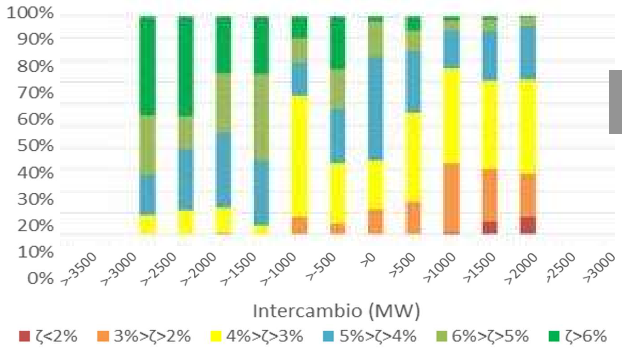
Small Signal stability Study

Change of First Order Constant Time

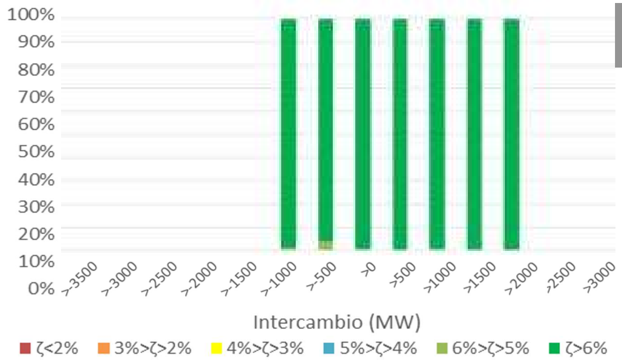
Modification of τ (Filtering Time Constant)







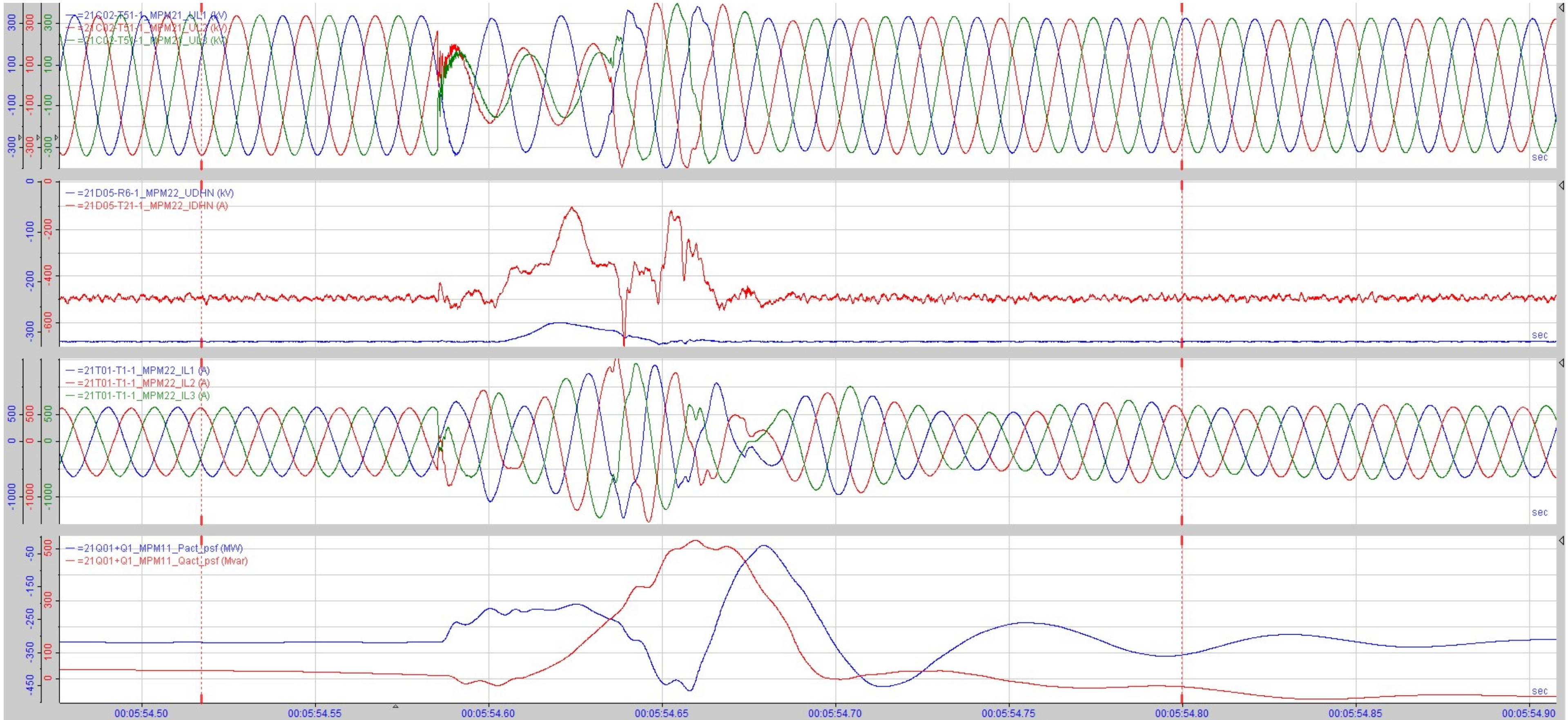
OLD parameters
August 2018



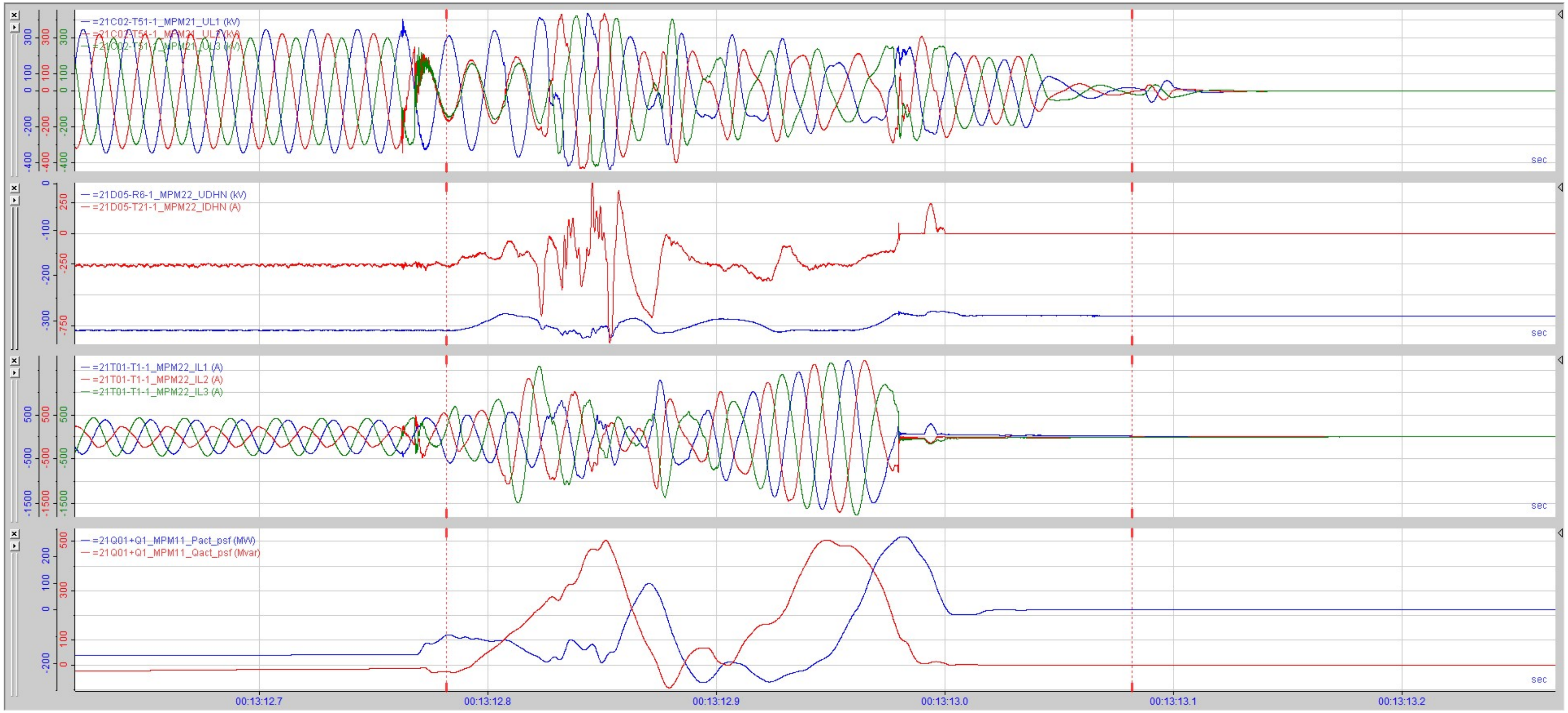
NEW parameters
January2019

2-phase faults with different short circuit power

2-Phase Fault with High Short-Circuit Power



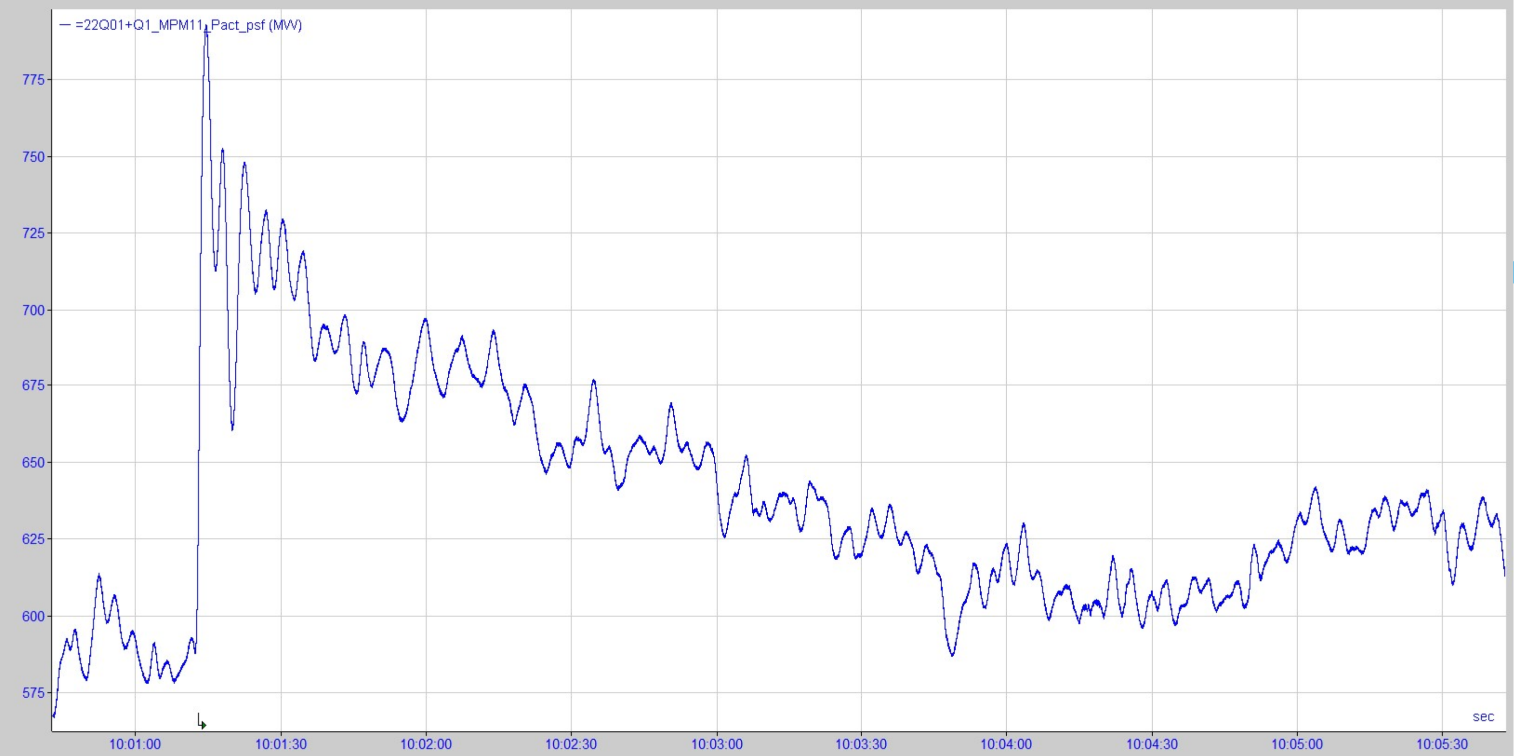
2-Phase Fault with Low Short-Circuit Power



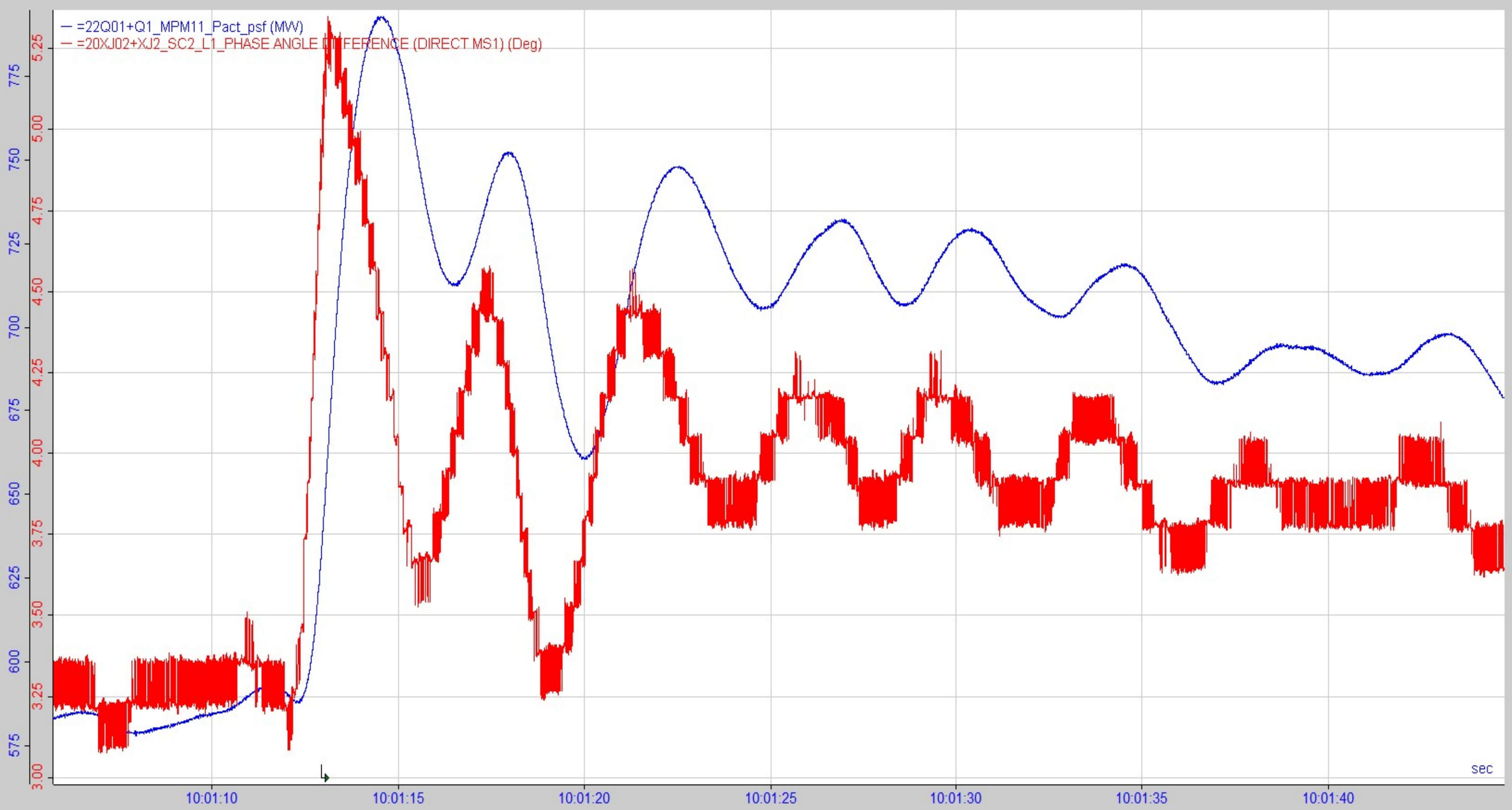
Trip C.N. Almaraz

HVDC Power

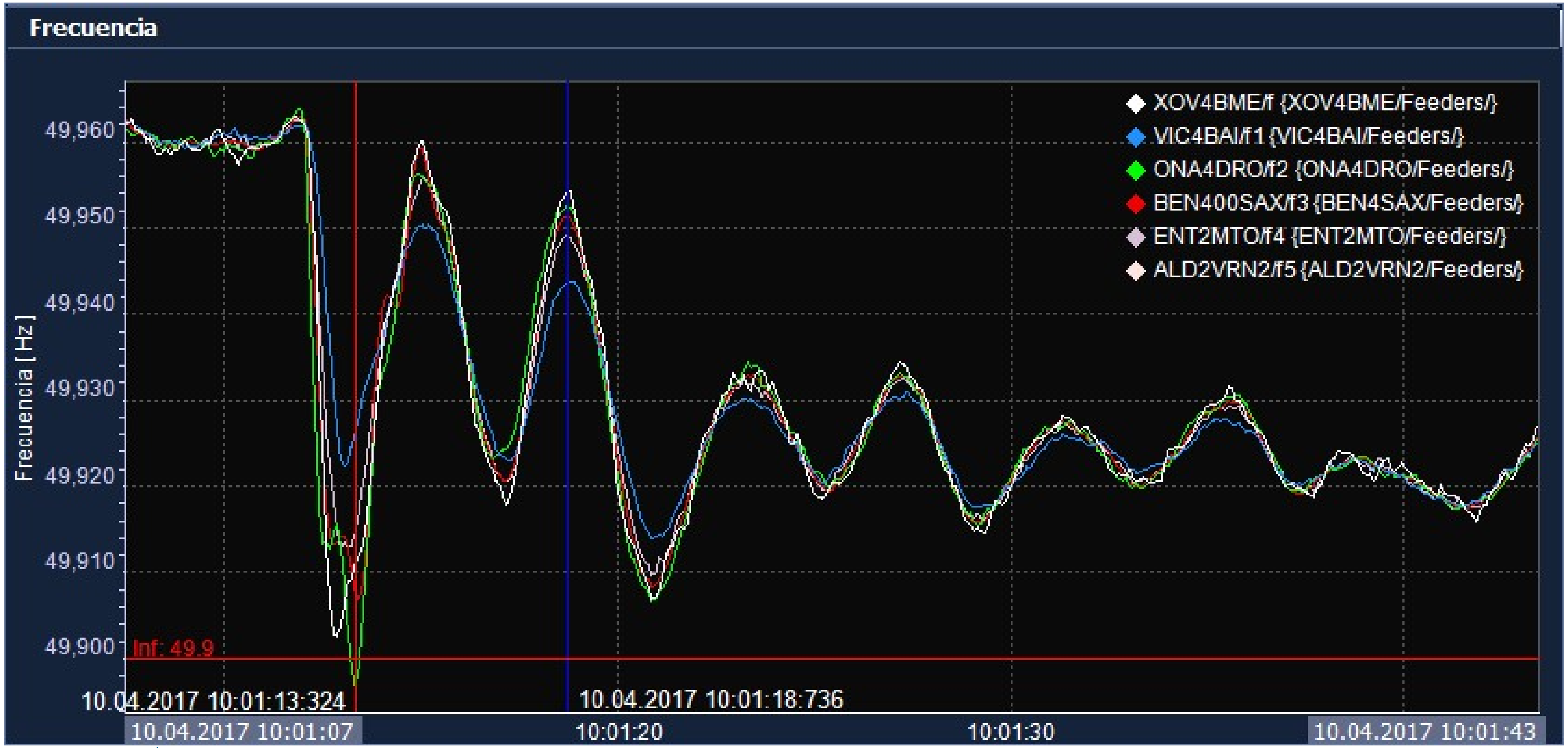
10/04/2017→ Trip of C.N. Almaraz (1.000 MW):



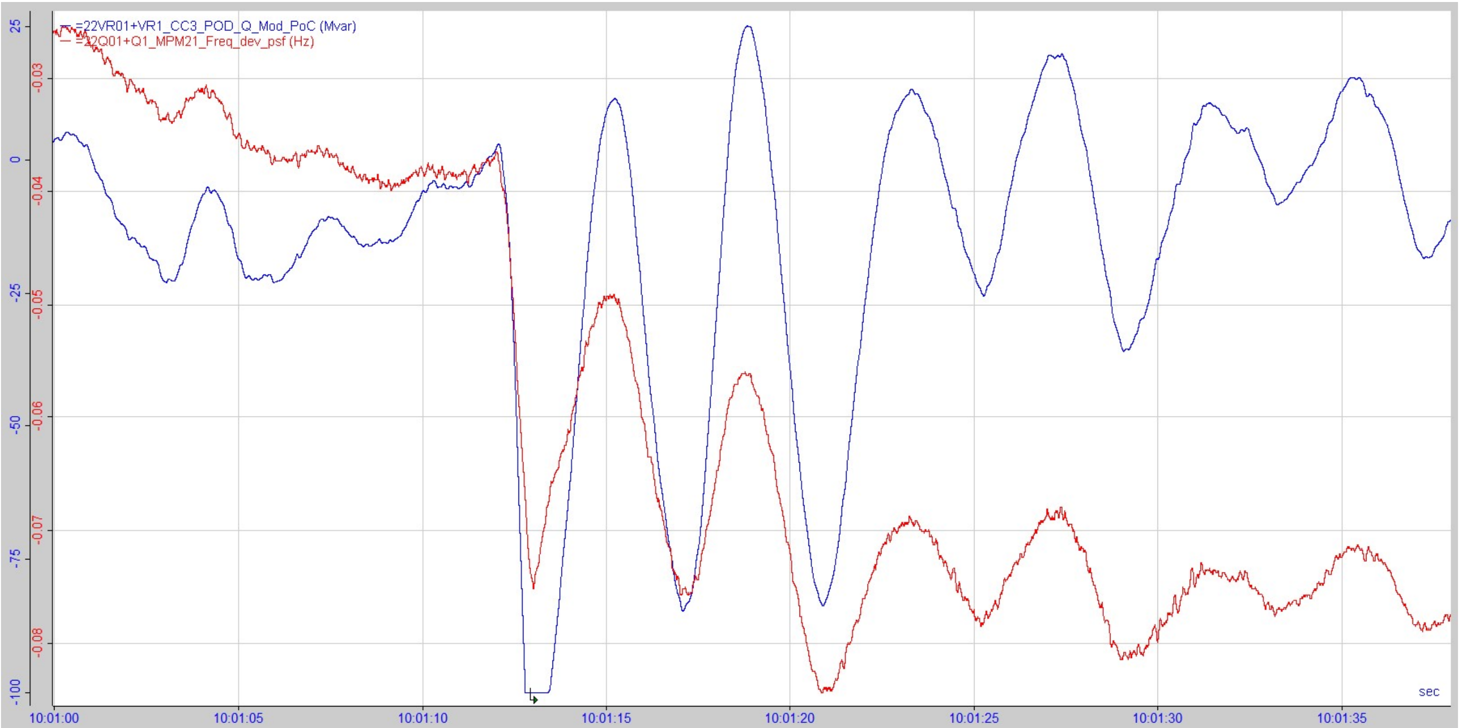
HVDC Power: Detail



Frequency in Spanish Network



HVDC Power Oscillation Damping Reactive Power (POD-Q)



Thank you very Much

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