

# South Texas SSR

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ERCOT ROS Meeting  
May 3<sup>rd</sup>, 2018

# Background

- **October 2017:** AEP notified ERCOT after observing two events involving a brief period of oscillations between wind farms and adjacent series capacitors ending in protective relay action.
- **November 2017:** ERCOT worked with AEP to inform the impacted WGR REs about the events and to request additional information:
  - Confirmed that SSR mitigation was in-service
  - Verified there was no damage to the WGRs or series capacitors
  - Turbine vendors were engaged to investigate the root cause
- **March, 2018:** One vendor responded to the ERCOT questionnaire, updated the controllers, and deployed changes in the field.
- **April, 2018:** Second vendor is currently studying controller updates and expects to deploy changes in mid-June

# Were these WGRs previously identified with SSR risk?

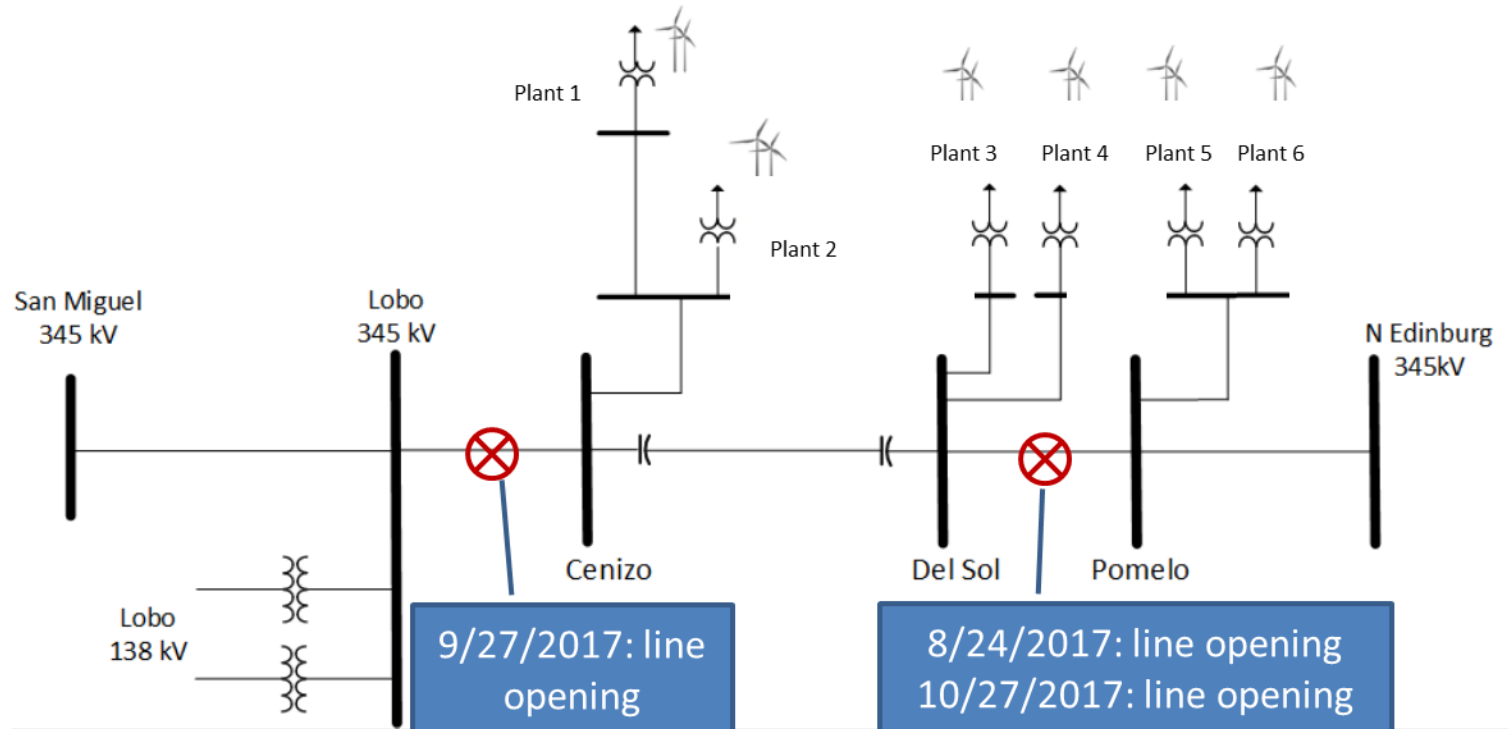
- Yes, these units were previously identified with SSR concern
- These units completed SSR studies as part of the FIS process
- SSR vulnerability was identified and SSR mitigation was studied
- Units were equipped with SSR mitigation
- All affected units also have protection as a back up

# WGRs Tripped or Rode Through with Detected Oscillation when Radially Connected to Series Capacitors

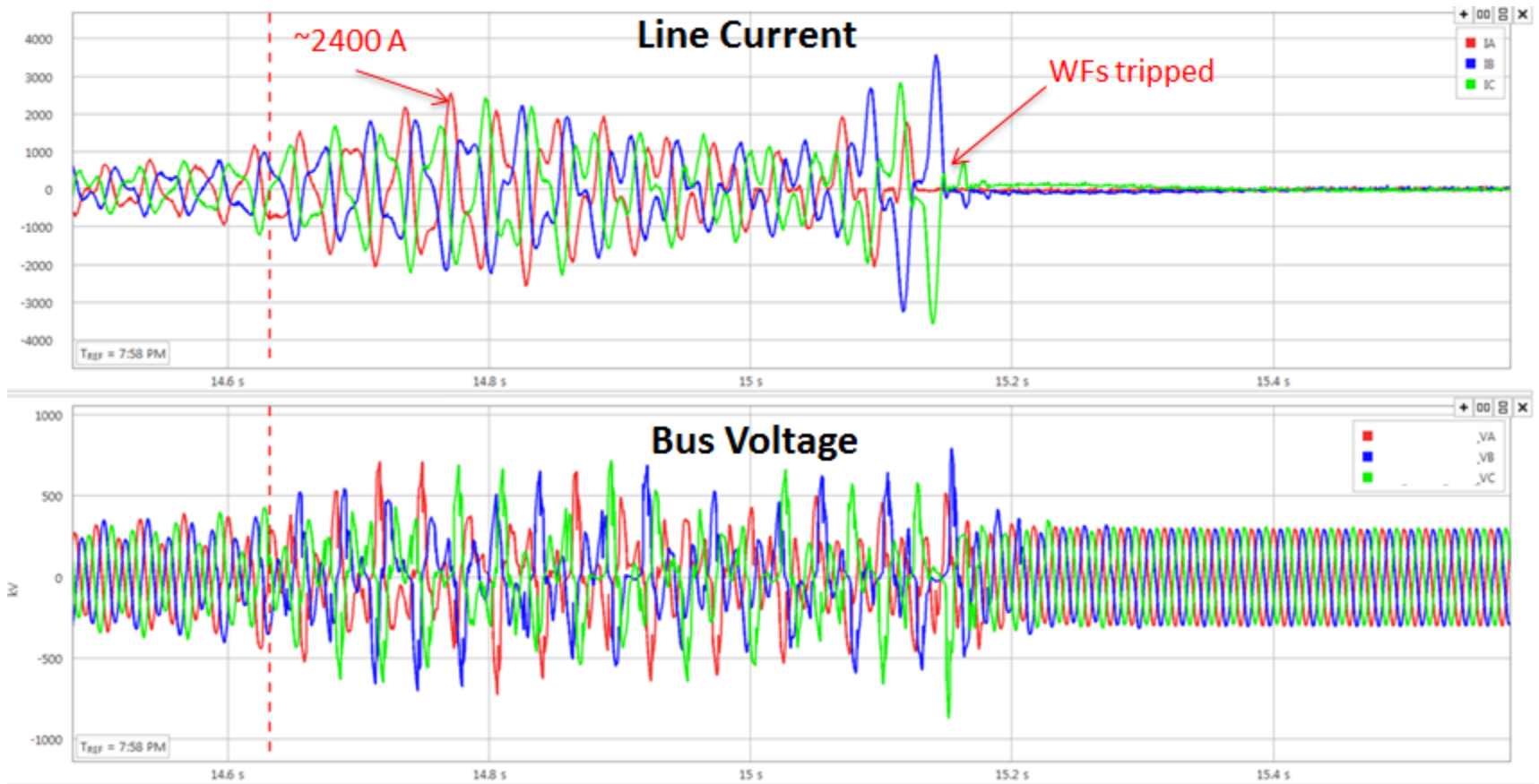
**Case 1: August 24<sup>th</sup>, 2017, Del Sol – Pomelo line outage and Plant 3 and 4 tripped**

**Case 2: September 27<sup>th</sup>, 2017, Lobo – Cenizo line outage and Plant 1 and 2 tripped**

**Case 3: October 27<sup>th</sup>, 2017, Del Sol – Pomelo line outage and no WGR trip**

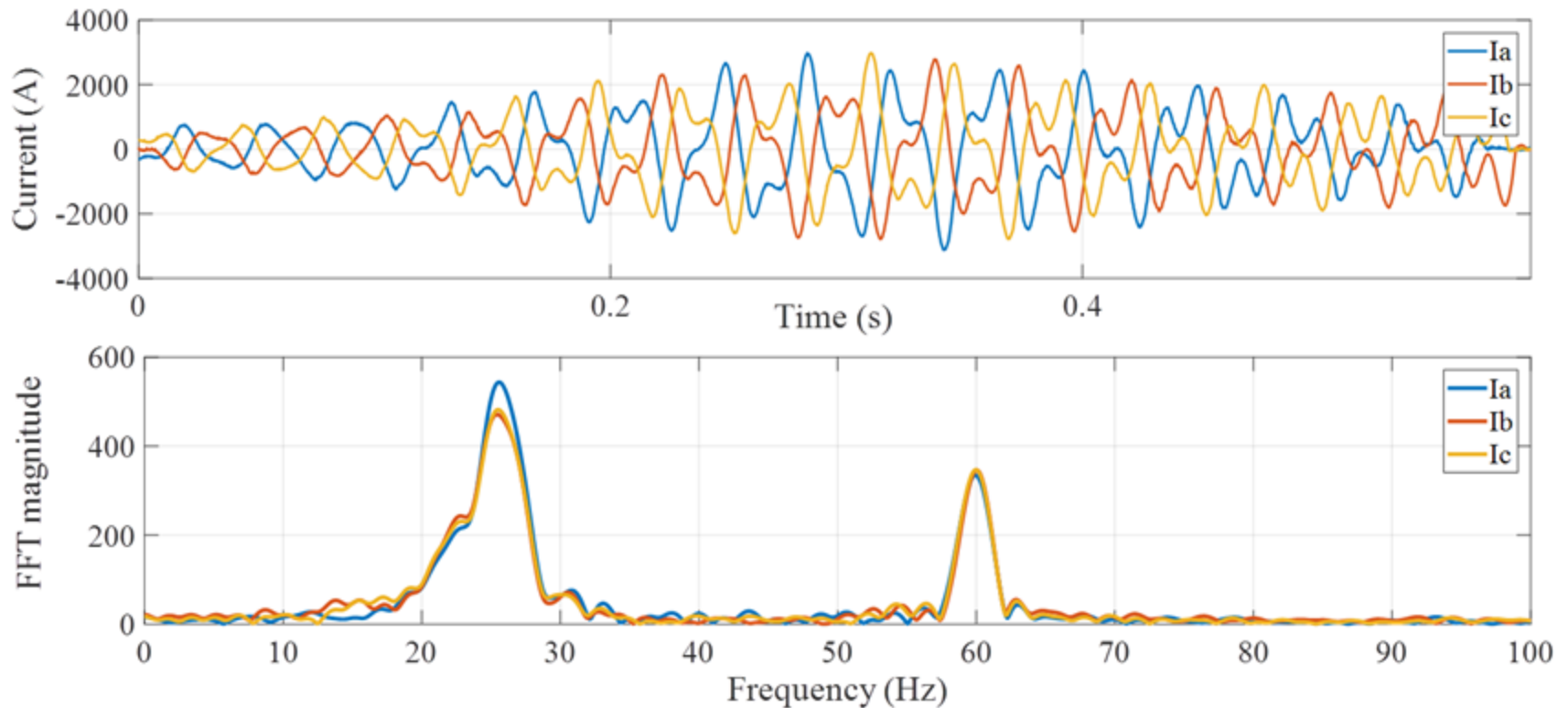


# Aug. 24th, WGRs Tripped Due to SSR



**SSCI started after WGRs became radially connected to series capacitors**

# 345 kV Line Current Frequency Spectrum Analysis before WGRs Tripped



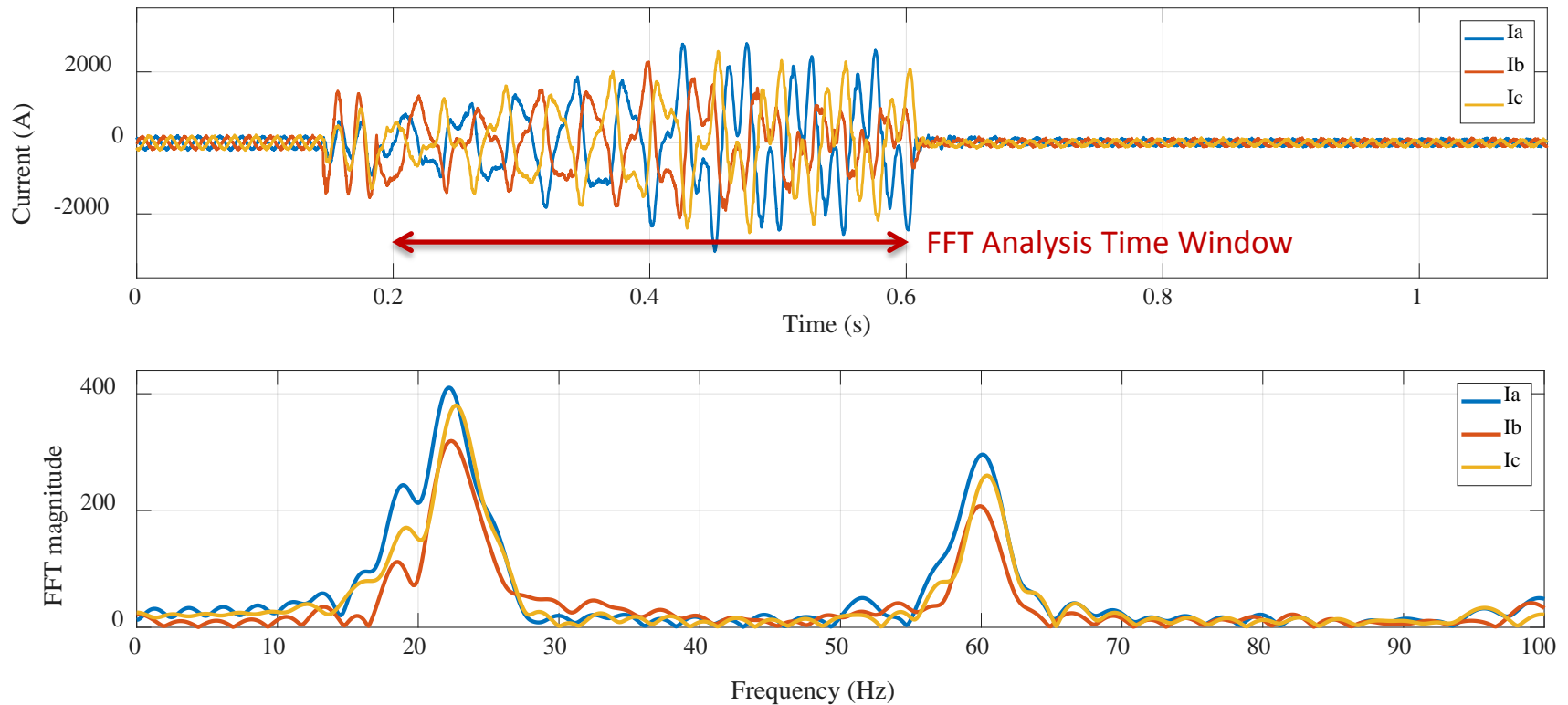
**Oscillation frequency around 25.6 Hz**

# Sept 27, WGRs Tripped Due to SSR



**SSCI started after WGRs became radially connected to series capacitors**

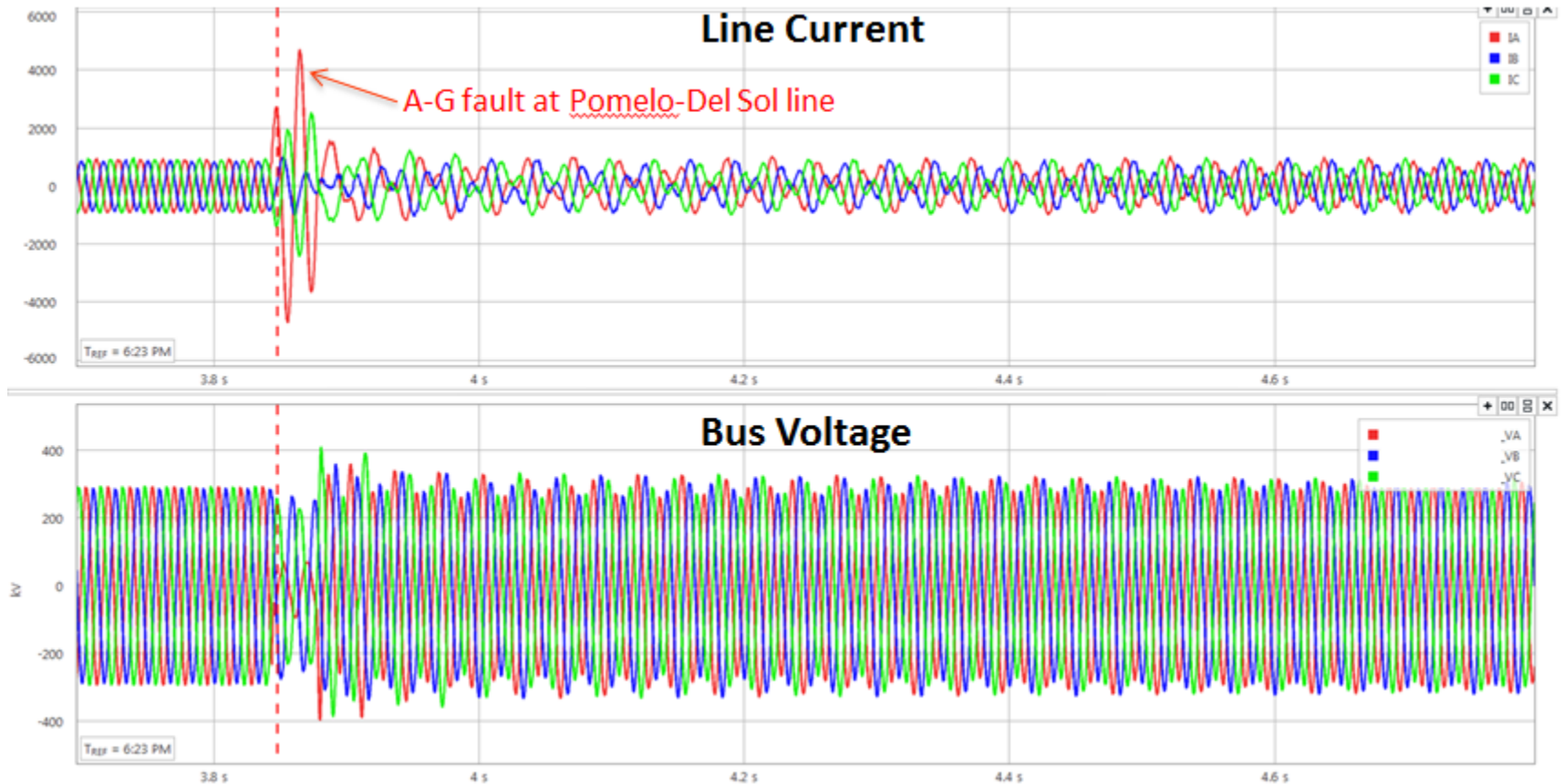
# 345 kV Line Current Frequency Spectrum Analysis before WGRs Tripped



**Oscillation frequency at 22.5 Hz**

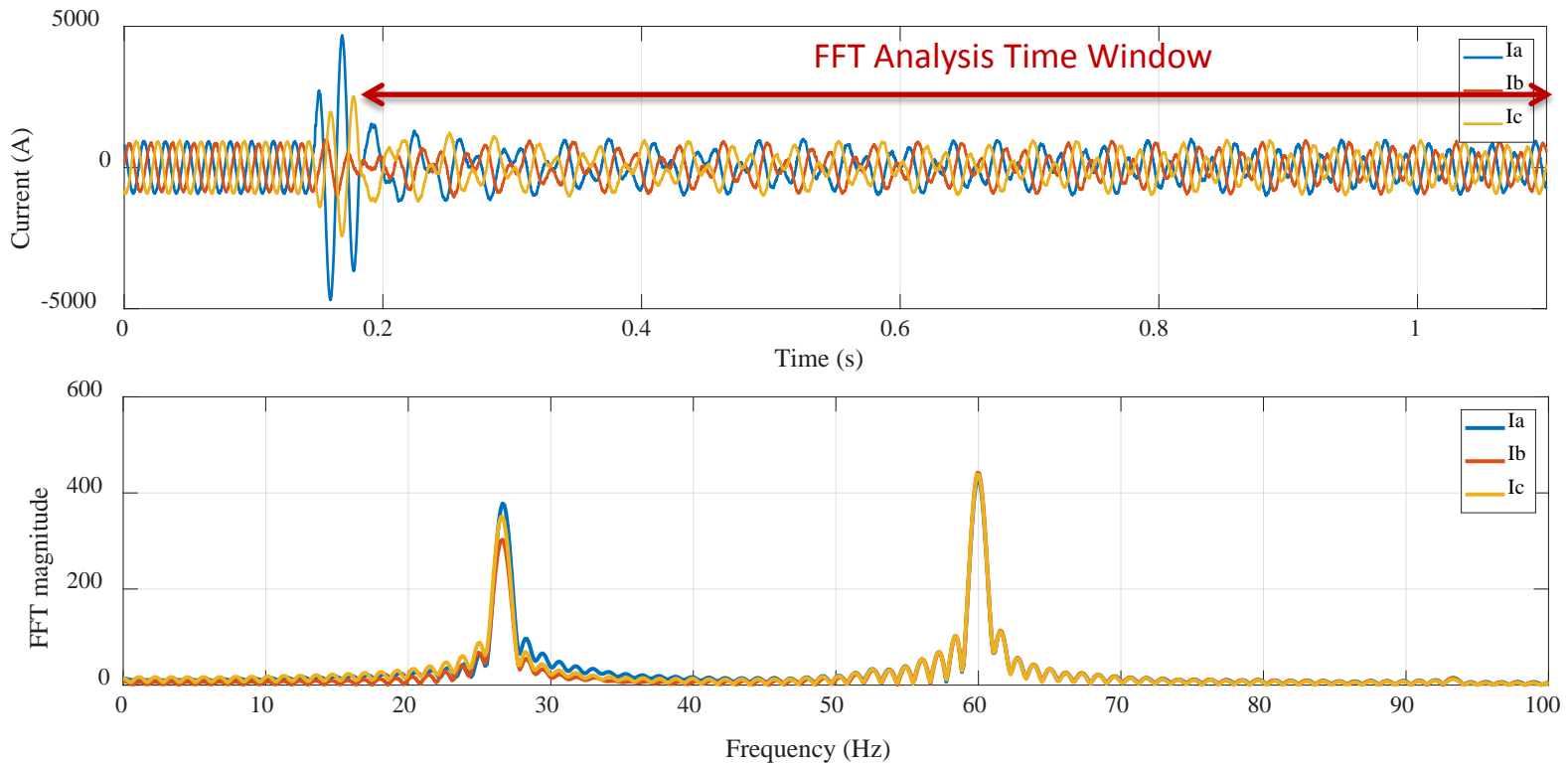


# Oct 27, Damped Oscillations and WGRs Remained Online



**After radial connection to series capacitors, damped SSR was observed**

# 345 kV Line Current Frequency Spectrum Analysis after Line Fault



**Oscillation frequency at 26.5 Hz**

# Event Observations

- SSRs were detected when WGRs were radially and directly connected to series capacitors.
- WGRs did not always trip (October Event Rode Thru)
- No reported damage for WGRs and series capacitors
- Different WGRs with different turbine manufactures were impacted
  - Updated WGR models with improved SSR mitigation controls are available for the turbines affected in the September incident
  - Work continues with the other Resource Entity and manufacturer affected by August incident

# Challenges with Interconnecting at or near to Series Capacitors

- SSR/SSCI events were not easily observable
  - In many ways, the disturbance appeared to be a simple relay trip
  - Detection of oscillations required high resolution measurements
  - PMUs are not suitable for detecting SSCI events
- Reproducing the disturbance requires detailed analysis
  - Model adequacy and assumptions are critical
- Controller tuning is inherently difficult
  - Wide variety of grid conditions and dispatch conditions
  - May require controller re-design (not just a parameter change)
  - (Possible contributor) Type III (DFIG) wind turbines tend to be more vulnerable and thus rely more heavily on damping controllers

# Lessons Learned

- Require detailed modeling of nearby units (even those equipped with SSR mitigation) when close to series capacitors
- PSCAD model adequacy
  - PSCAD models must provide certain flexibility / usability to enable modeling of nearby plants in same study case
  - DMTF PSCAD Model Guidelines
- Direct connecting to series capacitors can pose reliability issues
  - SSR mitigation is vendor specific and highly sensitive to the system conditions (nearby generators, topology), especially when connecting near series capacitors

# Next Steps

- ERCOT and TSPs will work to better understand the vendor's SSCI mitigation feature before they are implemented.
  - Model assumptions and methodology for SSR studies will continue to evolve as turbines, inverters, and mitigation scheme changes
- WGRs that plan to interconnect that are close to series capacitors will require additional time and analysis that will be reflected in the interconnection process.
- Additional coordination with TSPs, REs, and vendors may be required when assessing proposed SSCI mitigation.