

# EPCC 13 in Bled, Slovenia

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## Methods of defining generator synchronizing power during low frequency oscillations

Pavel Kovalenko

AlteroPower, Yekaterinburg, Russia



# Presentation structure

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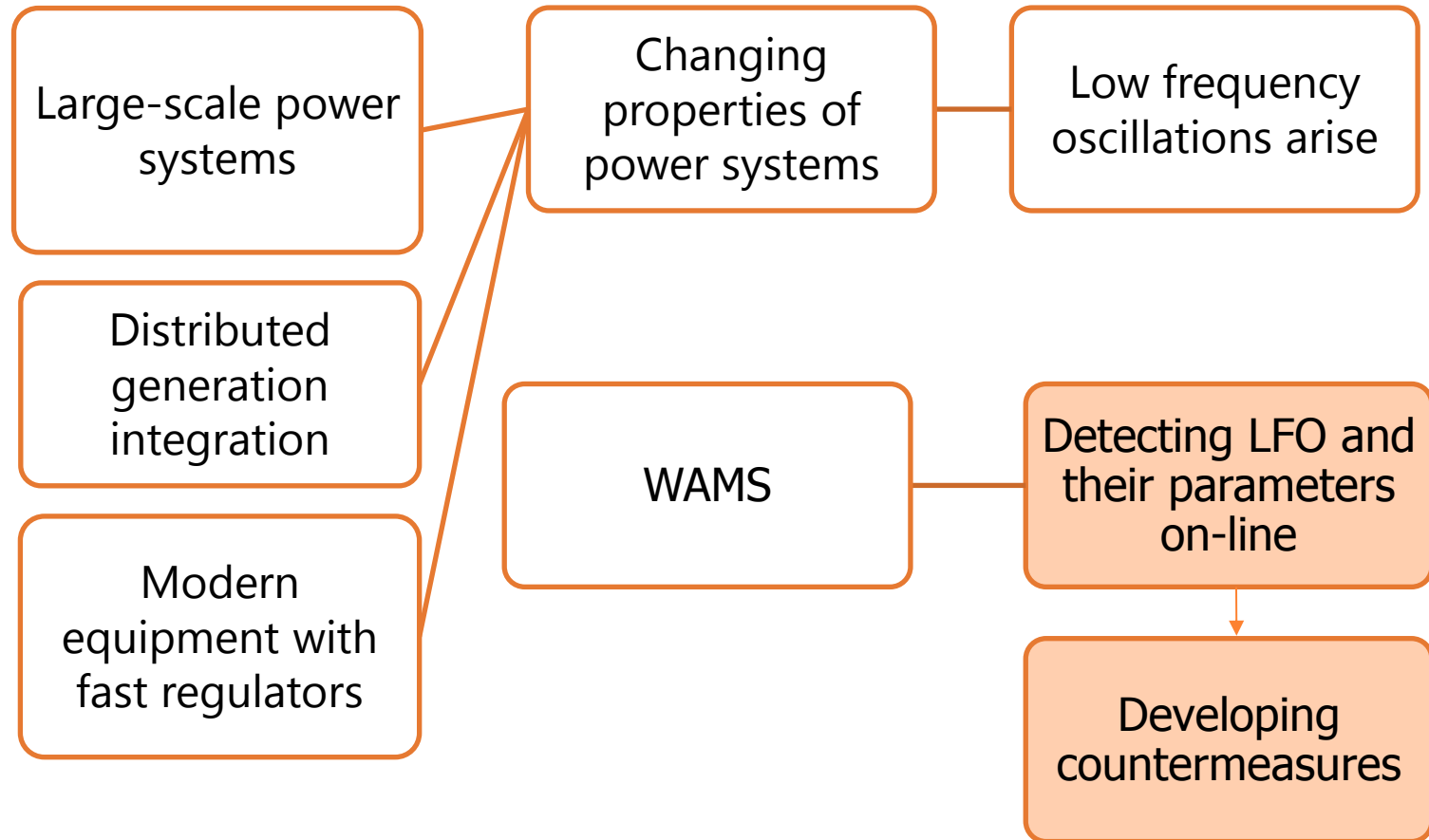
- Research background
- Assessing generator participation in LFO
- Results
- Future perspectives
- Conclusion

# Presentation structure

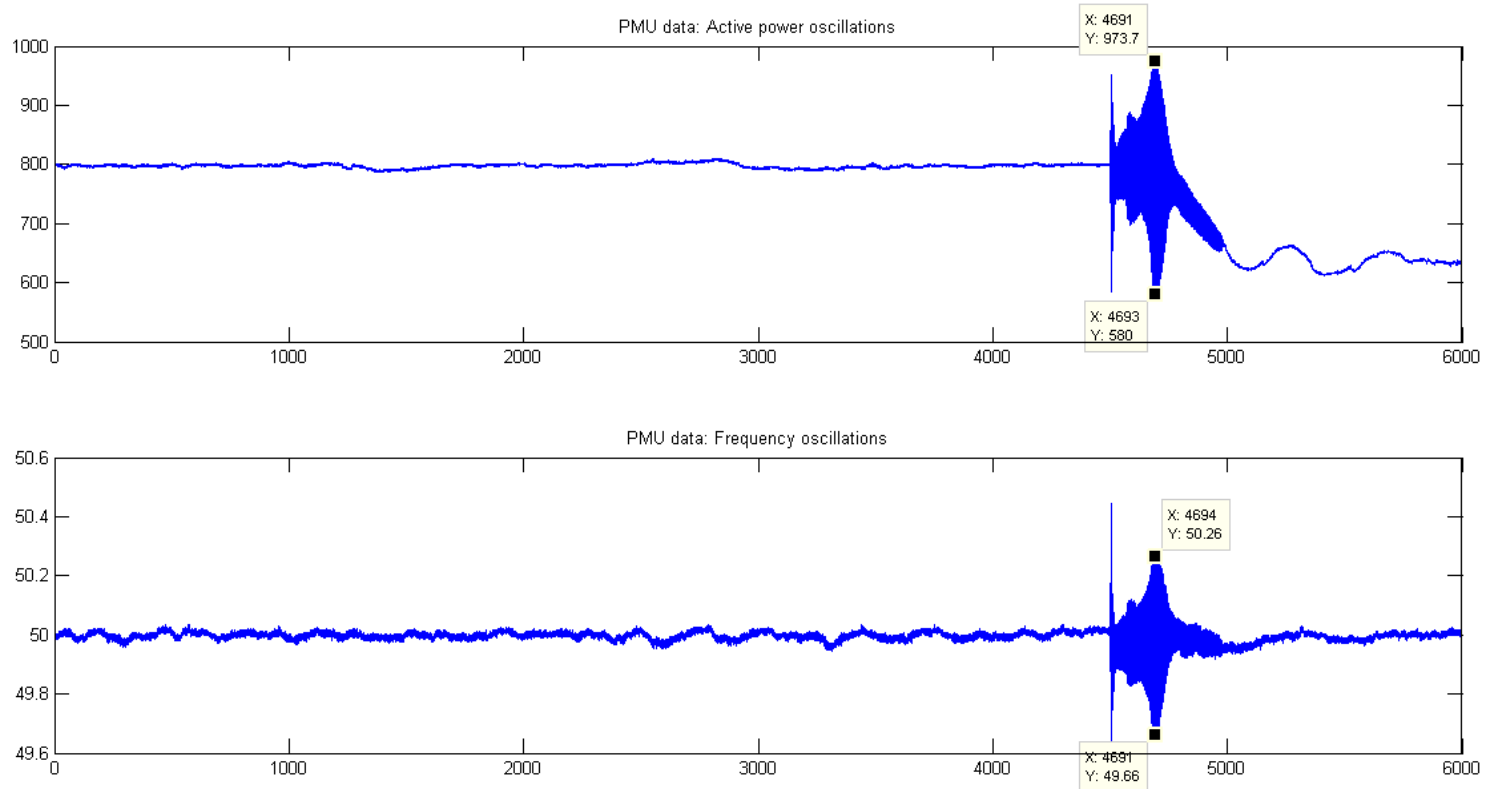
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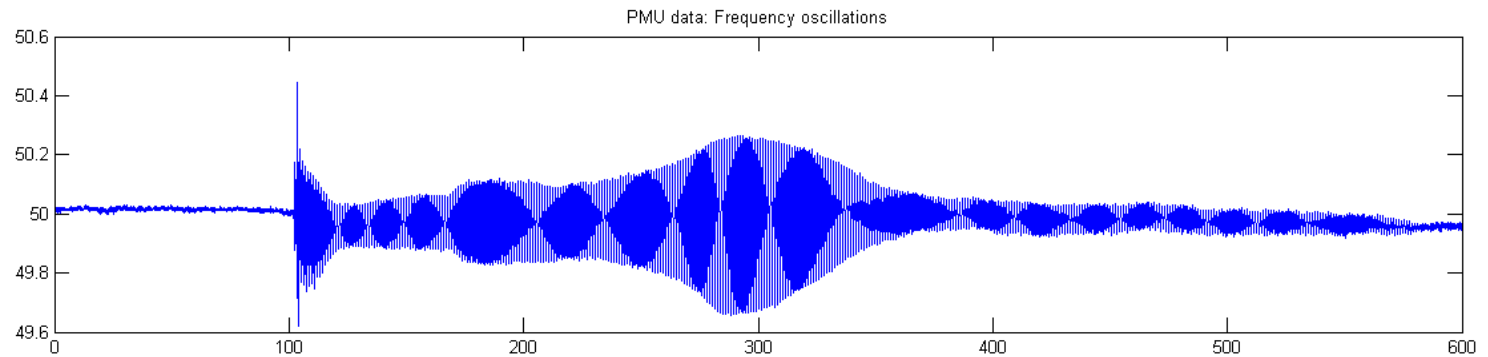
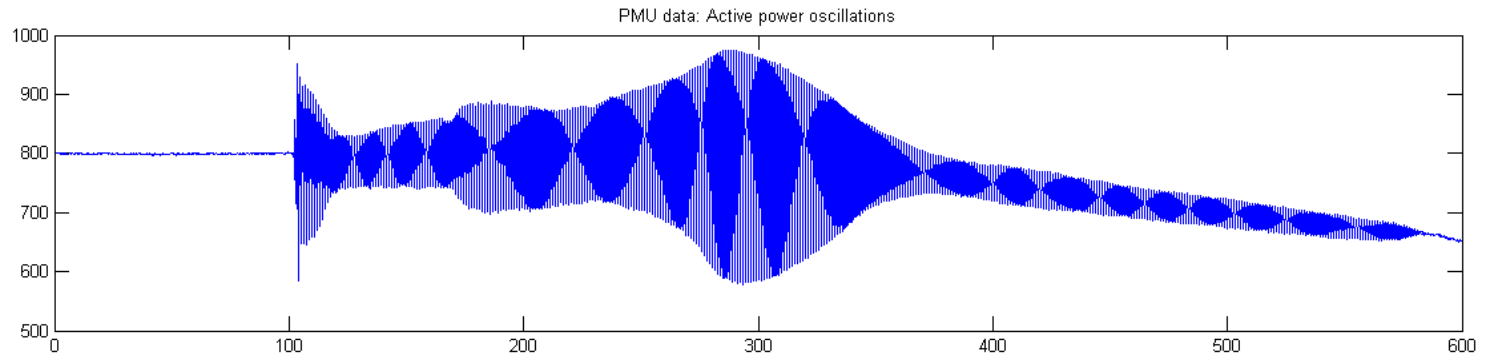
# Research background



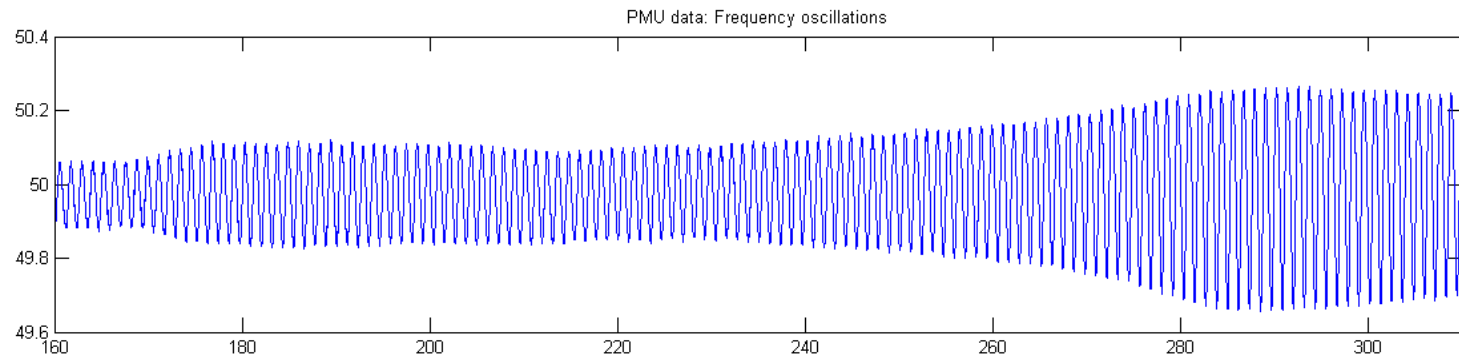
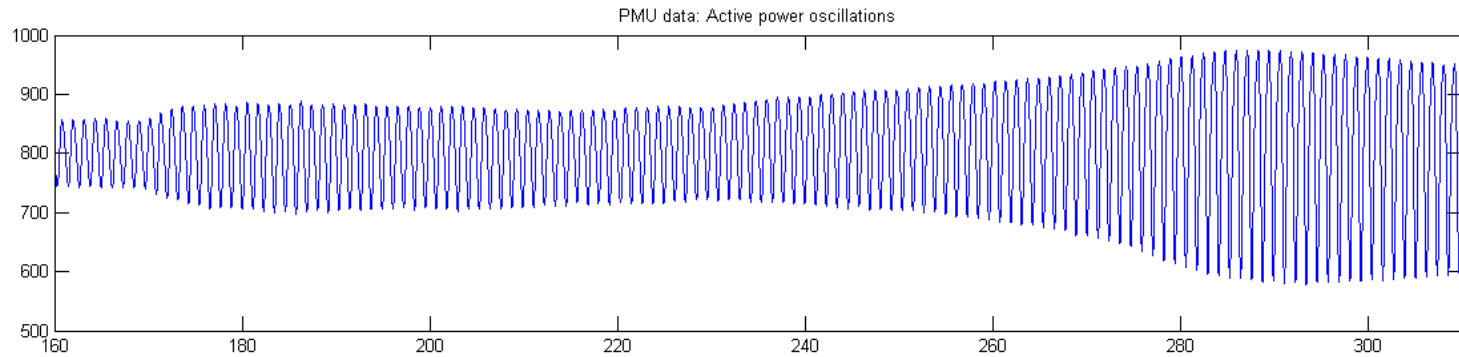
# Case of LFO in Russian power system



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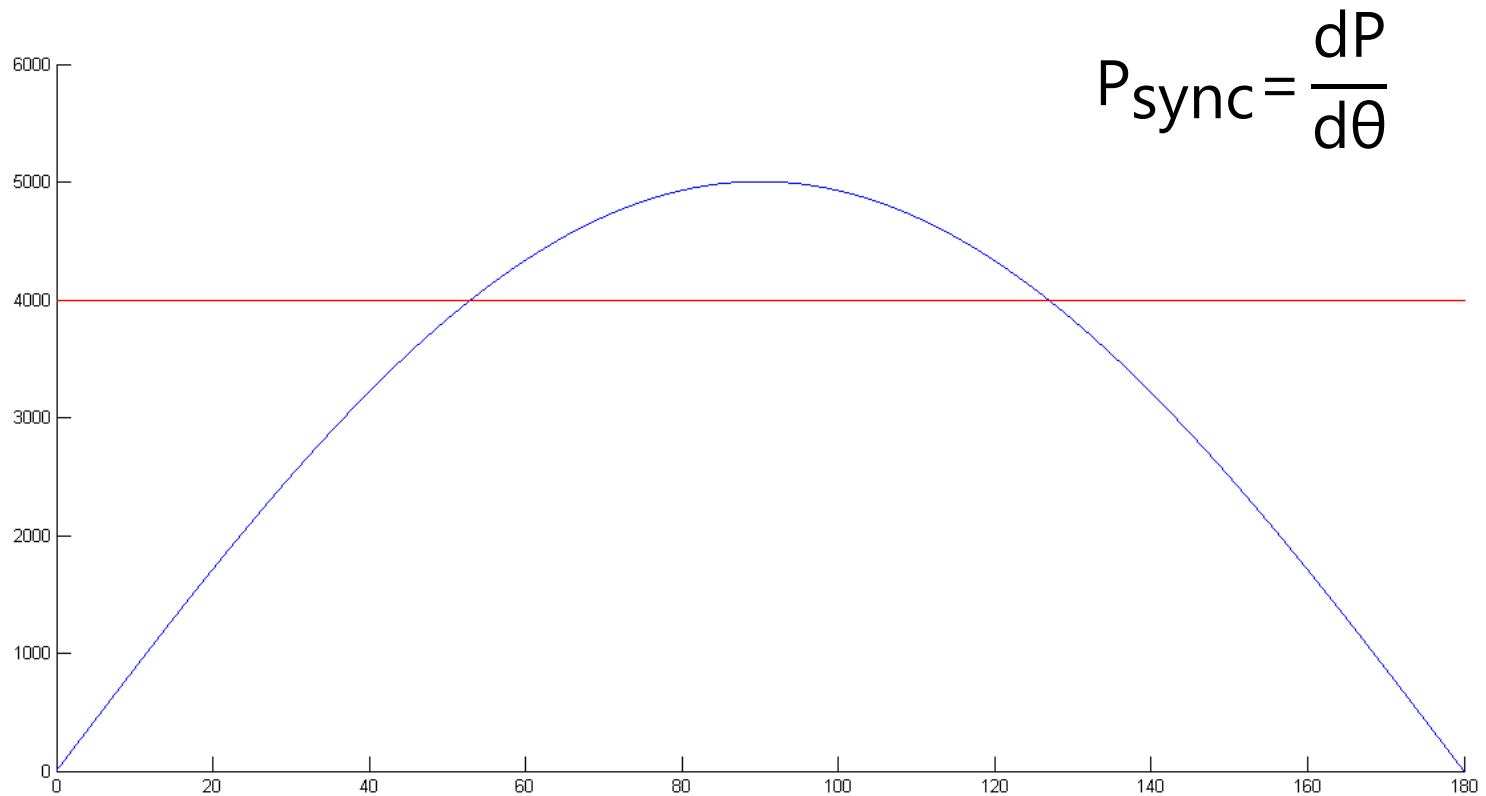
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# Power-angle diagram



# Defining generator load angle

- Direct measurements

$$\boxed{U_{a,b,c}} \quad \boxed{i_{a,b,c}} \quad \boxed{\varphi_{a,b,c}} \quad \boxed{f_c} \quad \boxed{\theta}$$

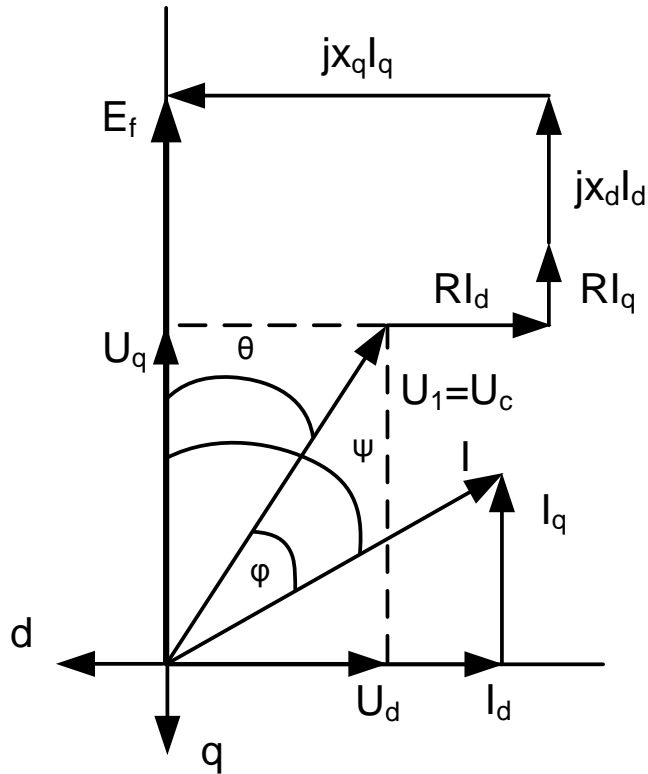
- Deriving from measurements involving excitation parameters values

$$\boxed{U_{a,b,c}} \quad \boxed{i_{a,b,c}} \quad \boxed{\varphi_{a,b,c}} \quad \boxed{f_c} \quad \boxed{u_f} \quad \boxed{i_f}$$

- Deriving from measurements of stator parameters only

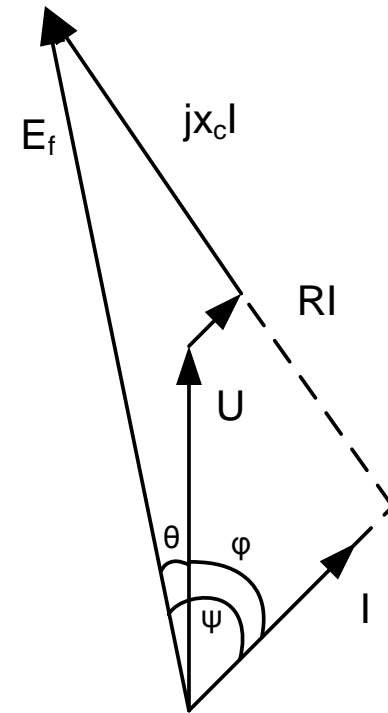
$$\boxed{U_{a,b,c}} \quad \boxed{i_{a,b,c}} \quad \boxed{\varphi_{a,b,c}} \quad \boxed{f_c}$$

# Load angle of the generator



$$\theta = \arctg\left(\frac{X_q I_q - R I_d}{E_f - X_d I_d - R I_q}\right)$$

salient-pole machine



$$\theta = \arctg\left(\frac{U \sin\phi + I X_c}{U \cos\phi + I R}\right) - \phi$$

round-rotor machine

# Measuring the load angle - model



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# Measuring the load angle - model

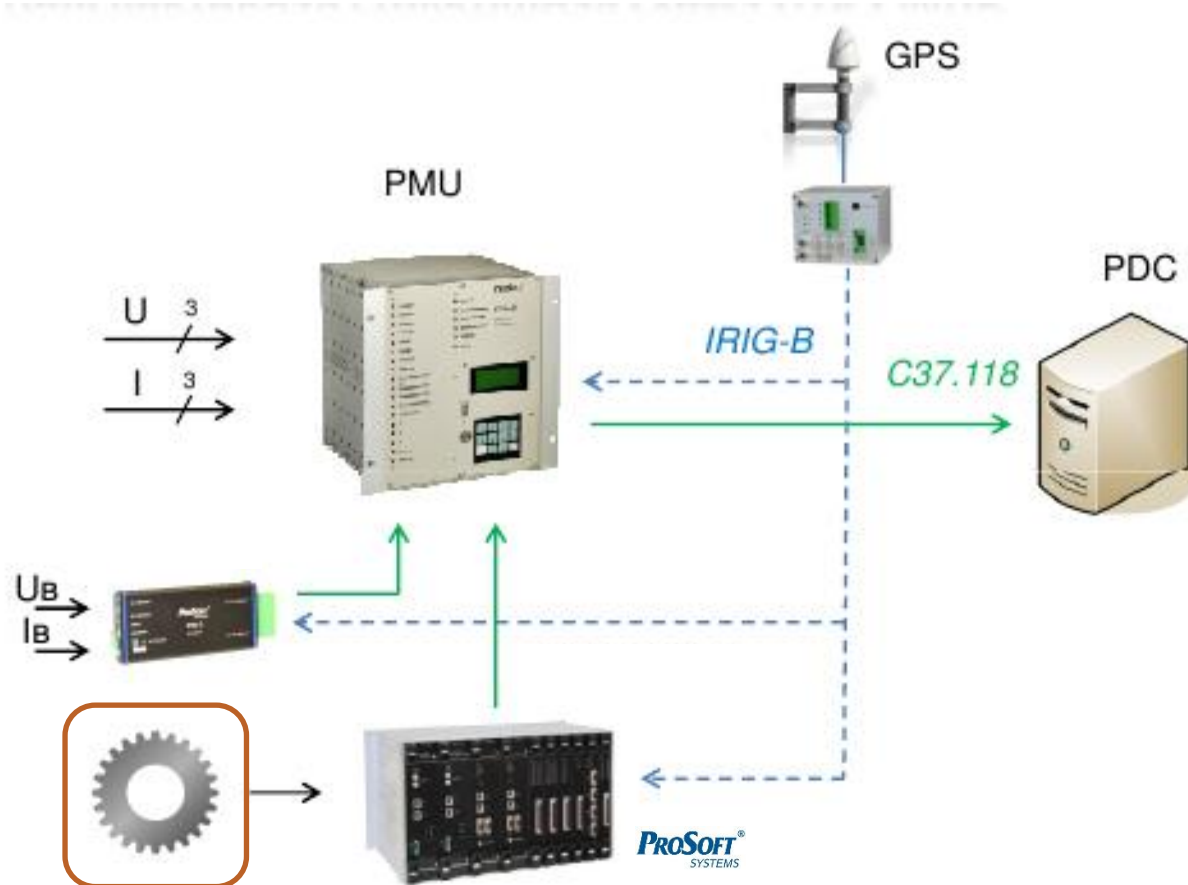


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# Load angle measurement

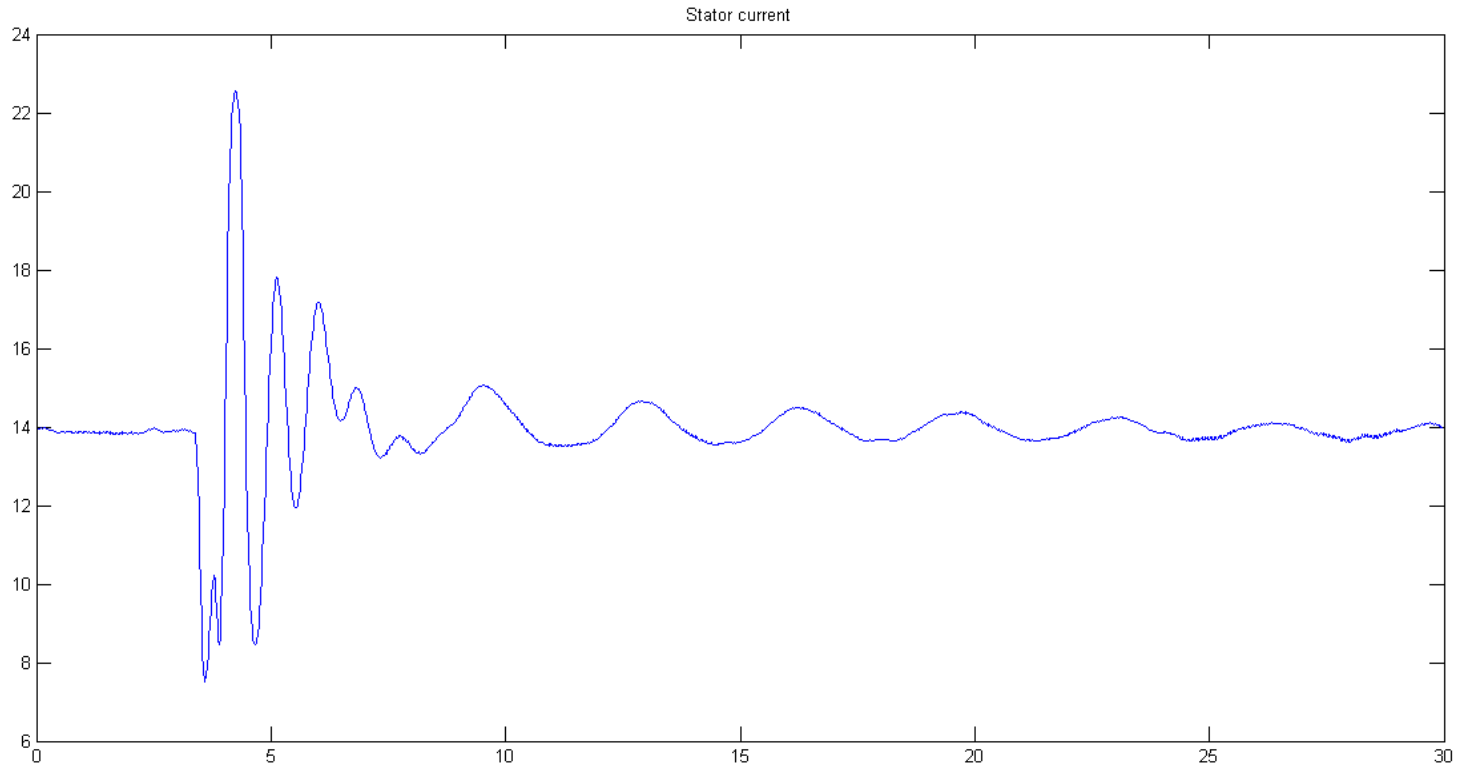


# Presentation structure

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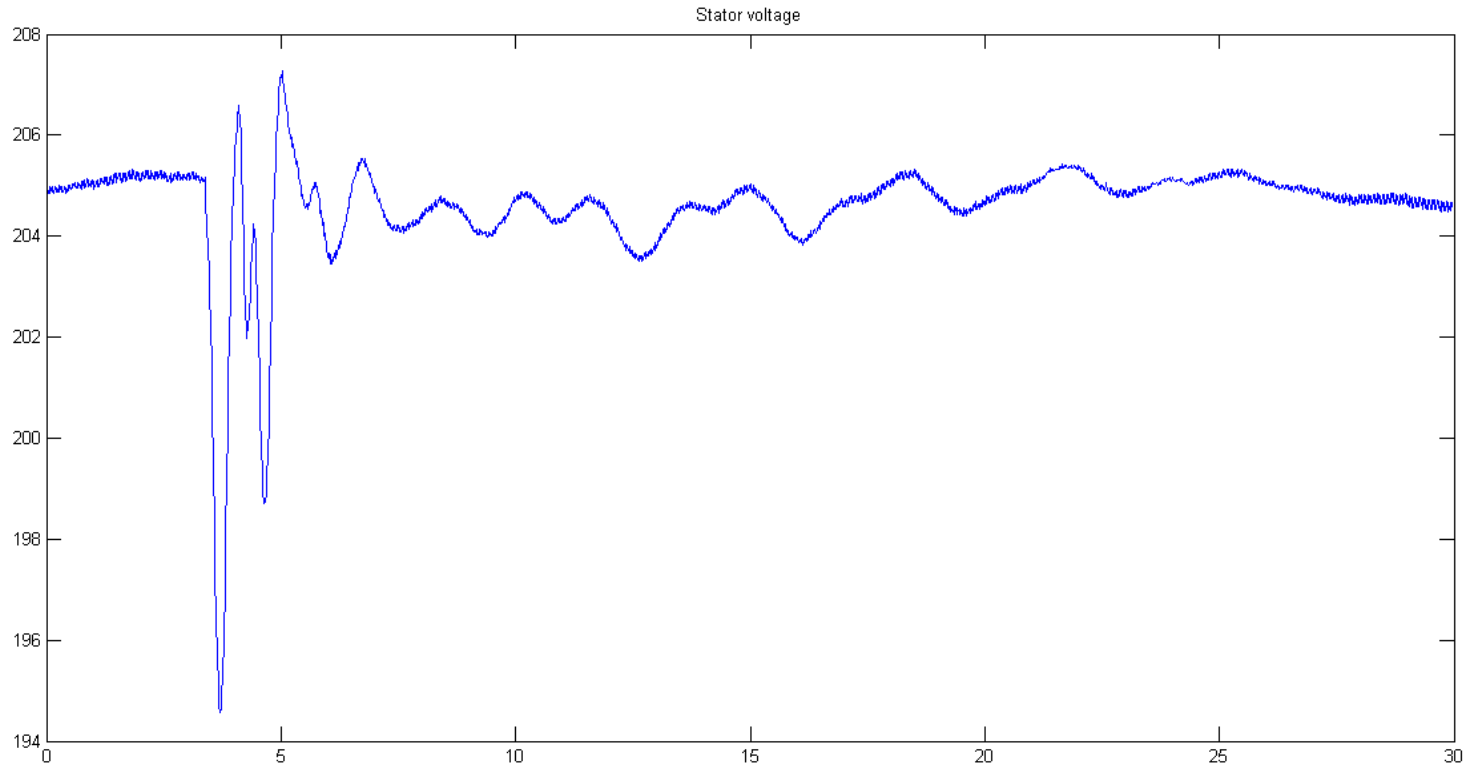
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# Initial data – Stator current

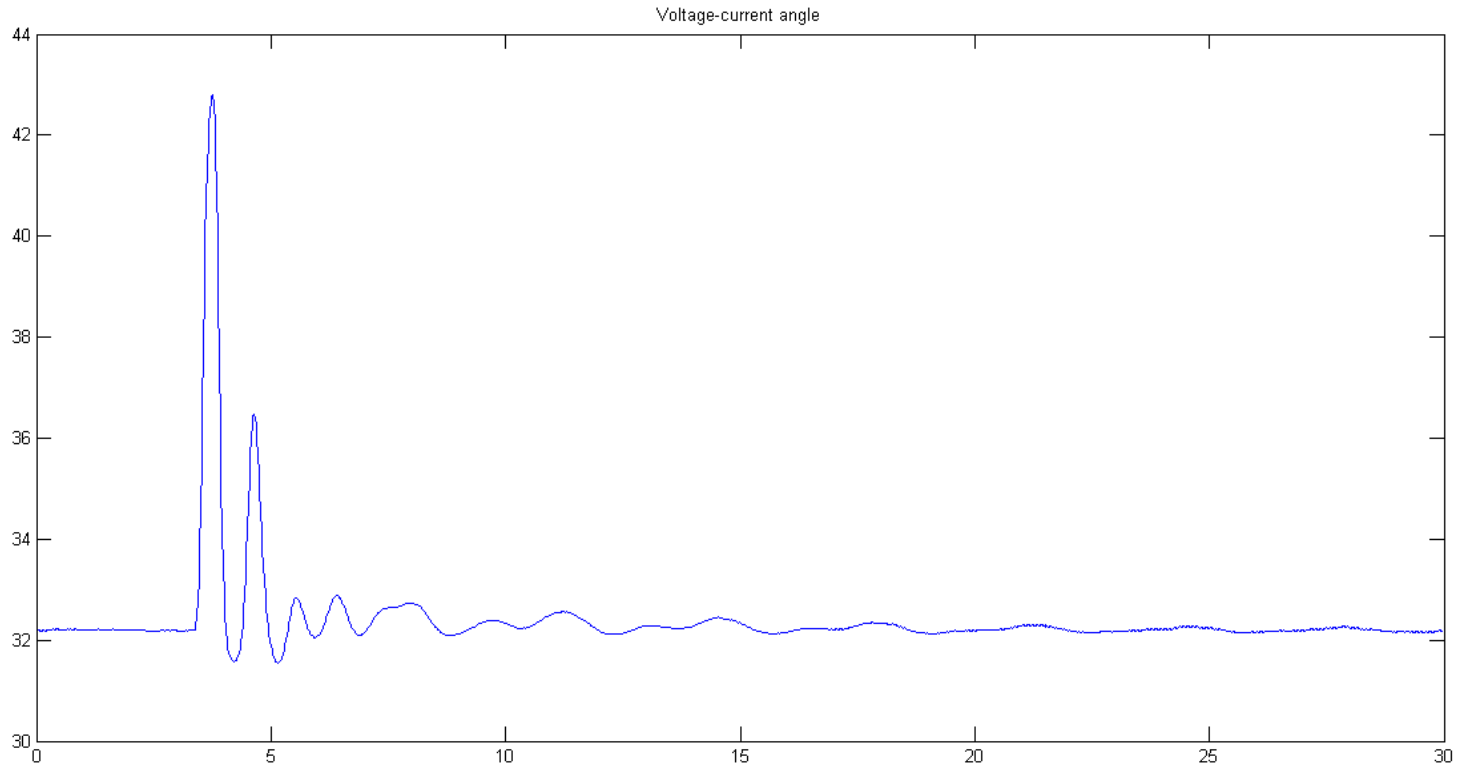




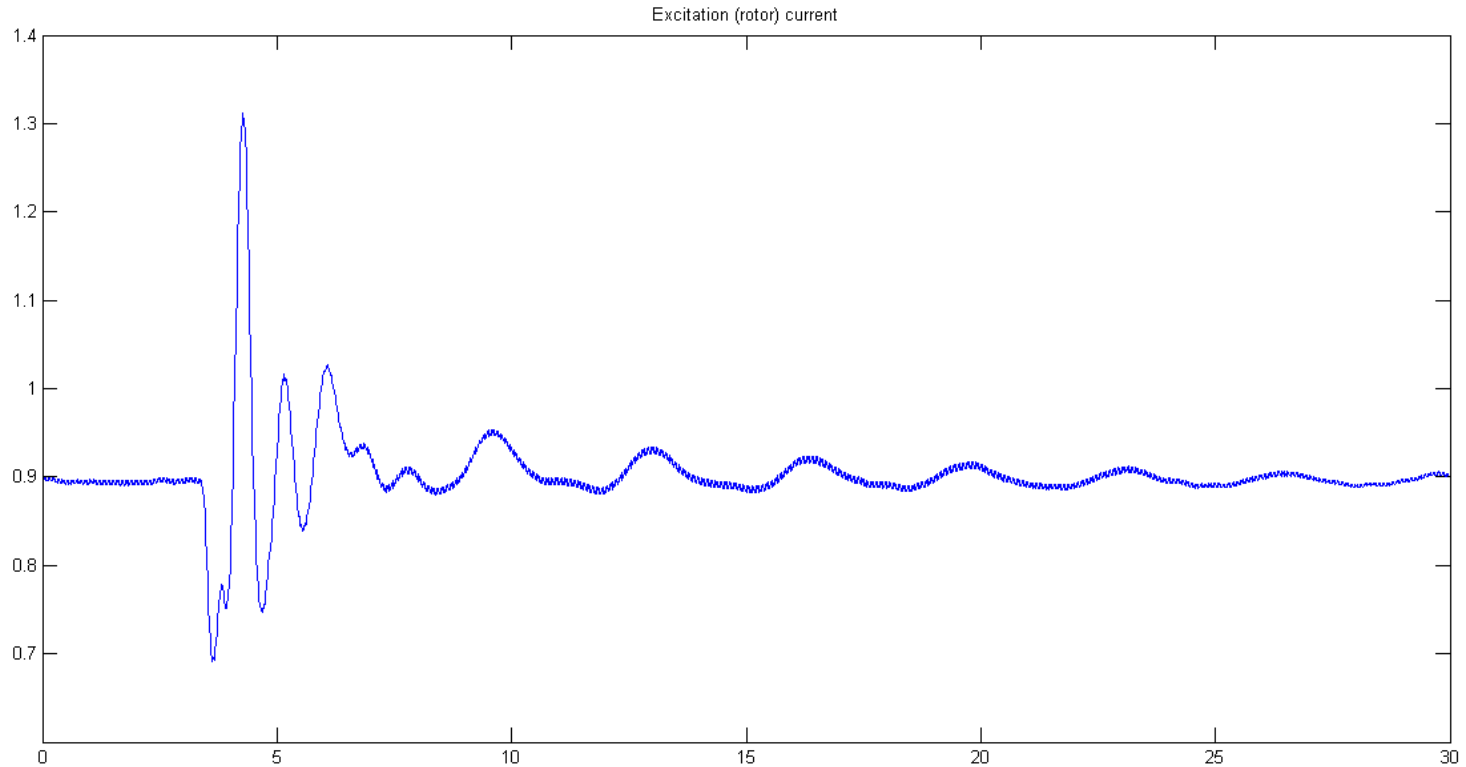
# Initial data – Stator voltage



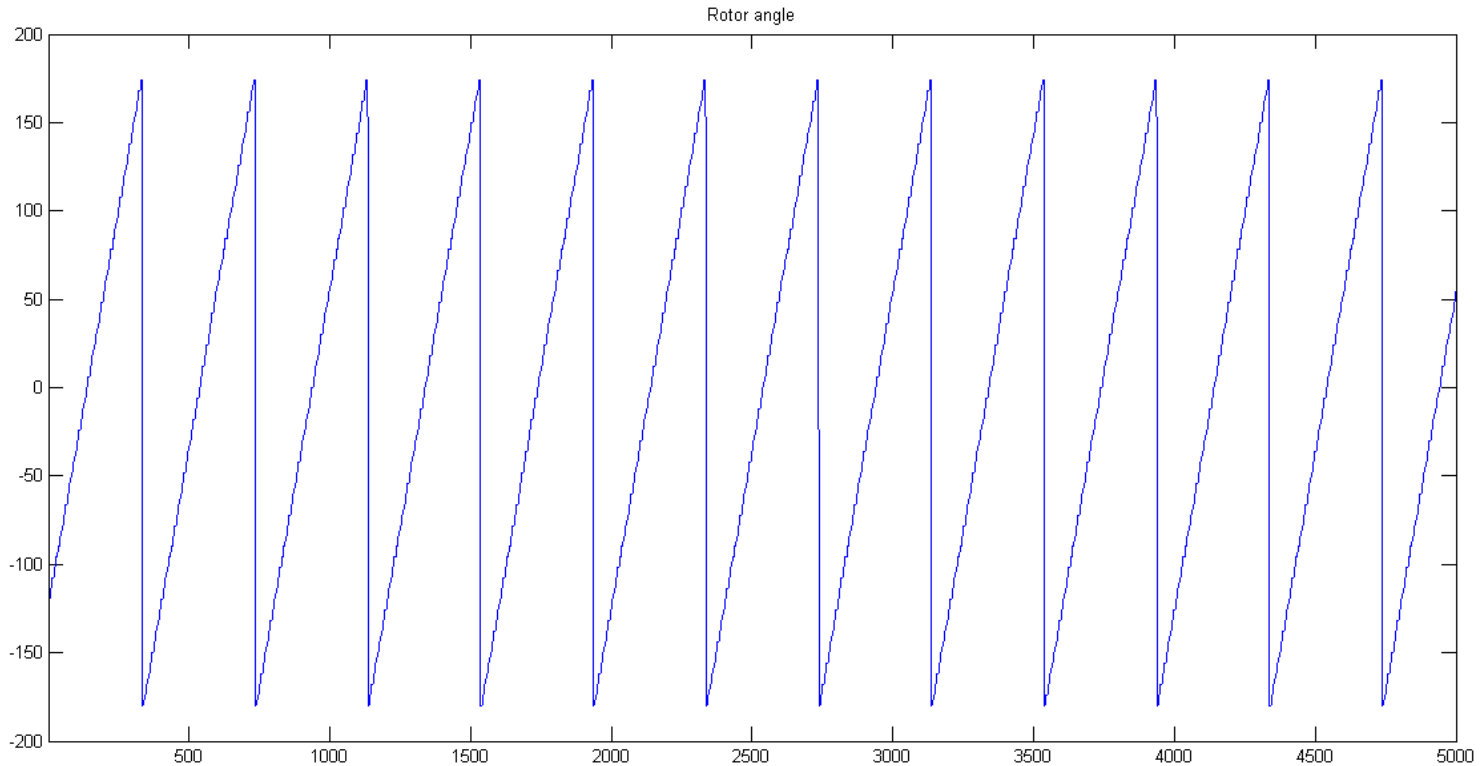
# Initial data – Voltage-current angle



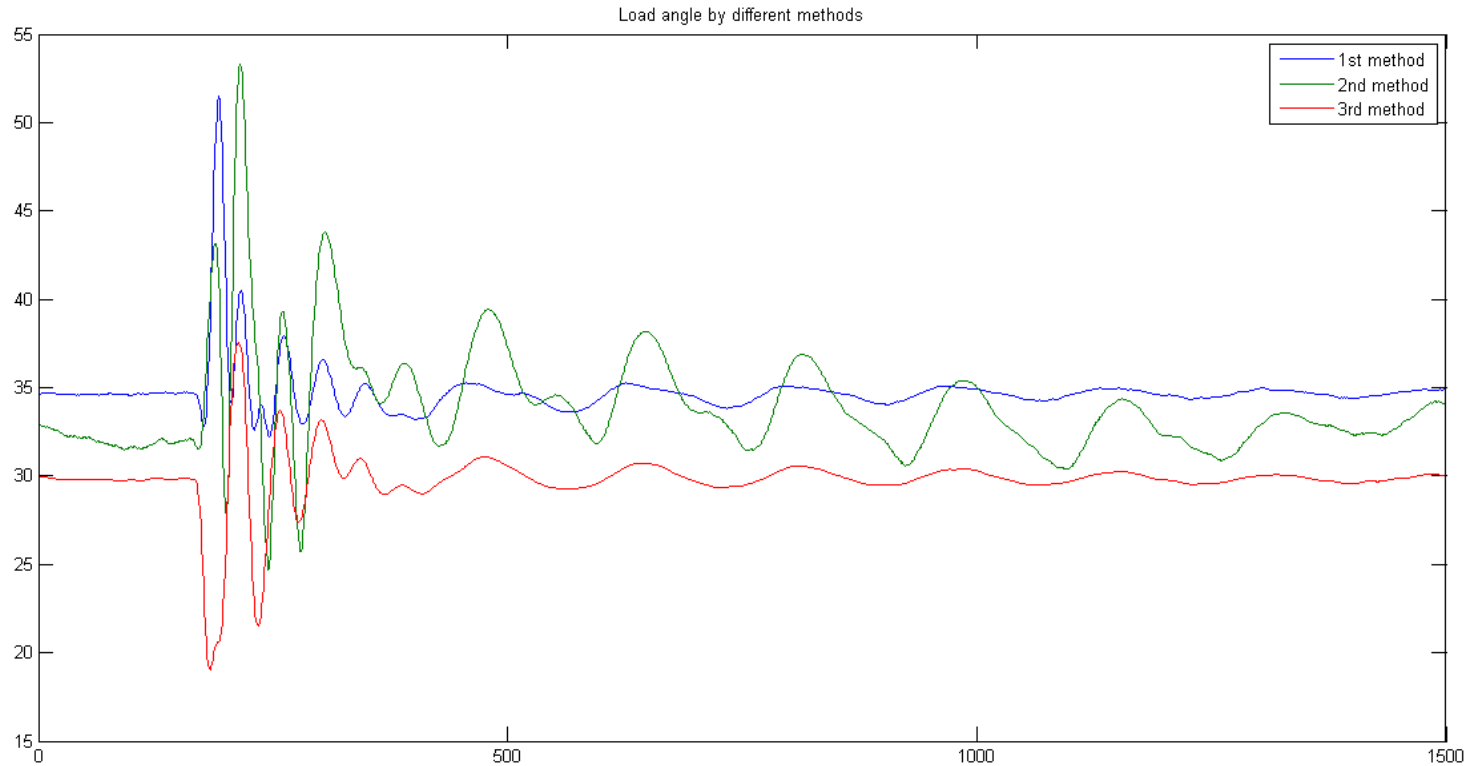
# Initial data – Excitation current



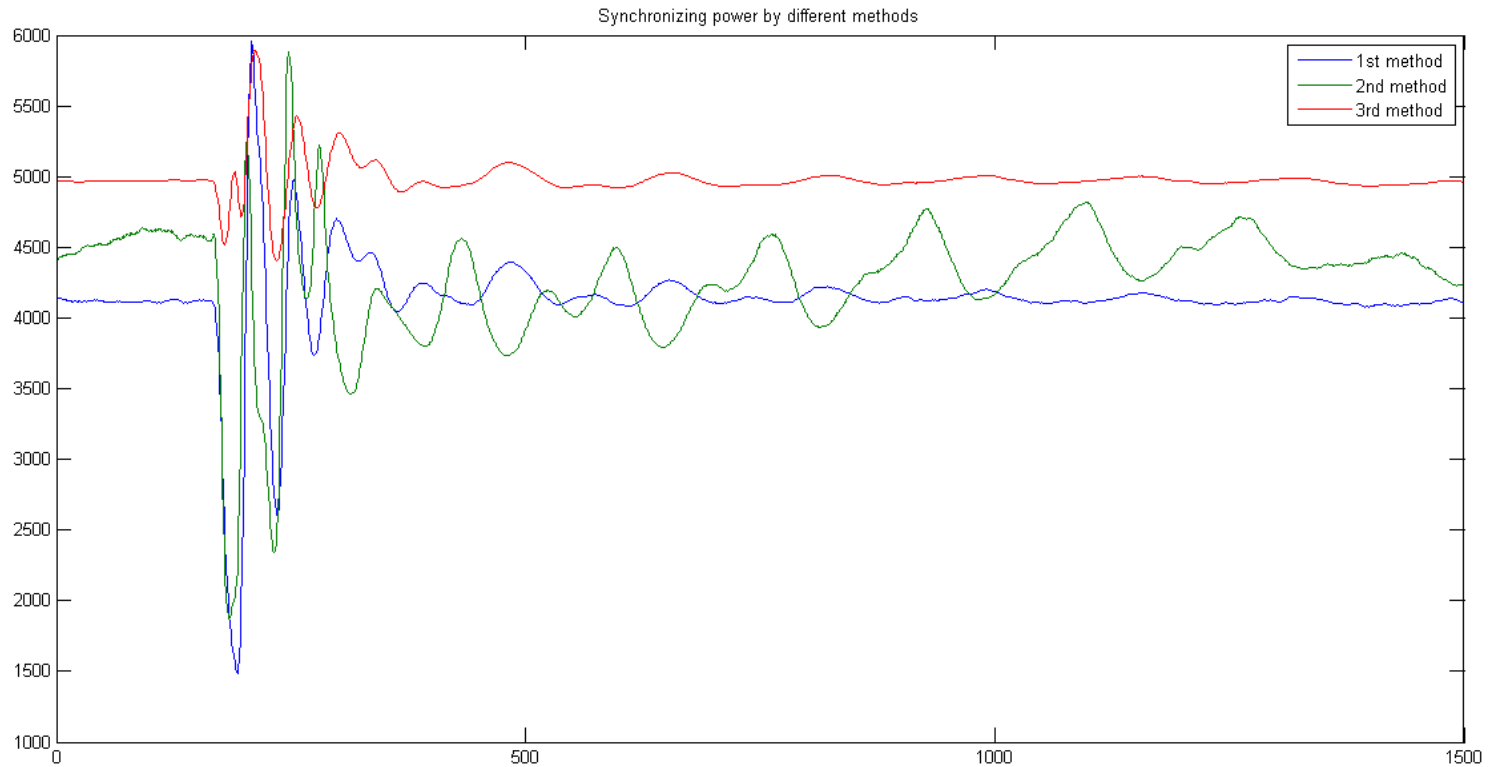
# Initial data – Rotor angle (10 kHz)



# Results – Load angle



# Results – Synchronizing power



# Results statistical assessment

	Synchronizing power (W)		
	1 (measured)	2 (with excitation)	3 (without excitation)
Average	4124	4276	4979
Maximum	5953	5879	5895
Minimum	1486	1872	4401
Standard deviation	358	433	123
Average difference		151	854
Difference standard deviation		425	284

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# Generators controllers monitoring

Controllers monitoring system involves detecting the following distinctive failures:

- detecting improper controllers operation;
- failure to keep within parameters limits.

Controllers monitoring is a distributed and hierarchical system with the unified control center based on measurements of generators operation parameters.

# Generators controllers monitoring

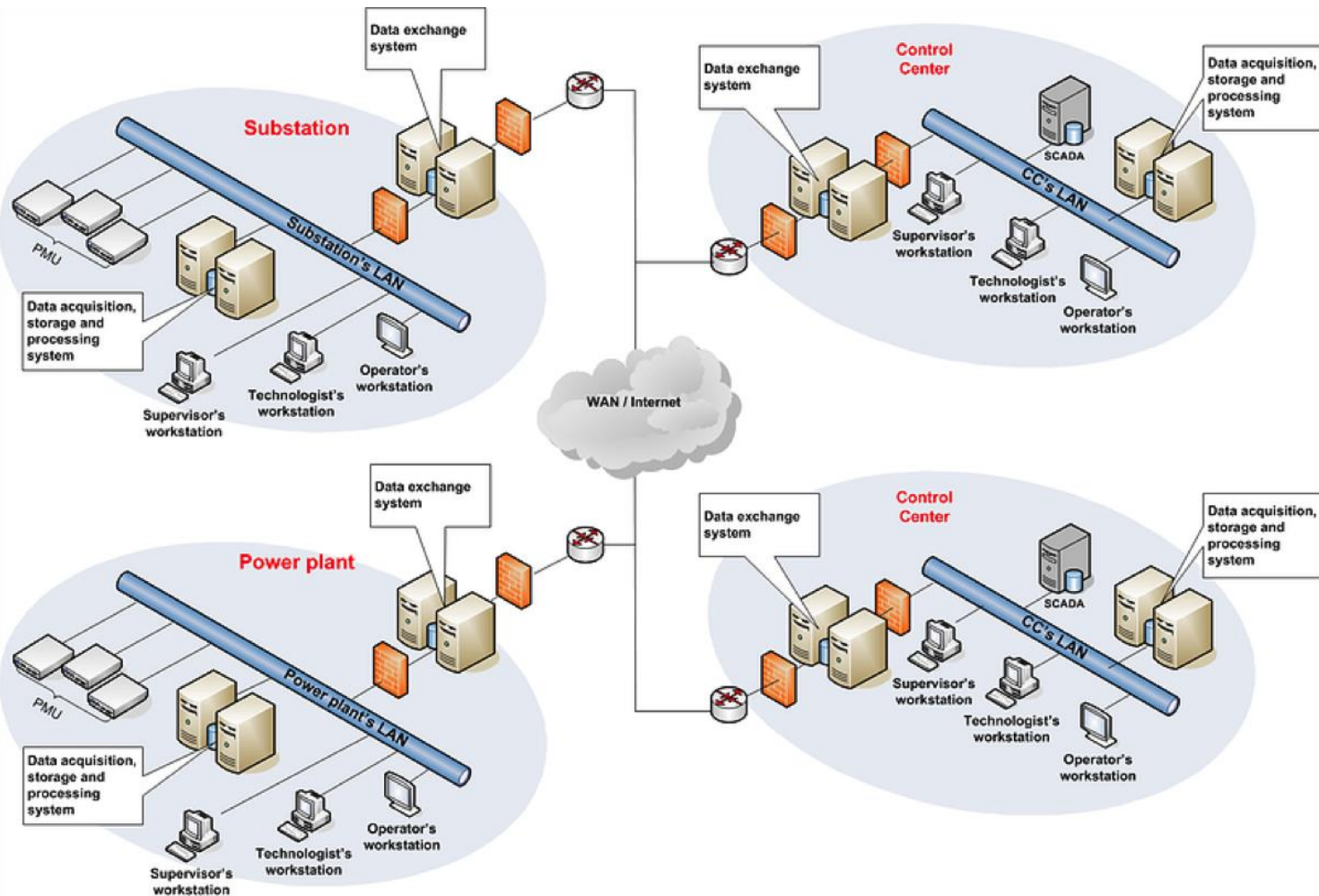
Local means of generators controllers monitoring on-site



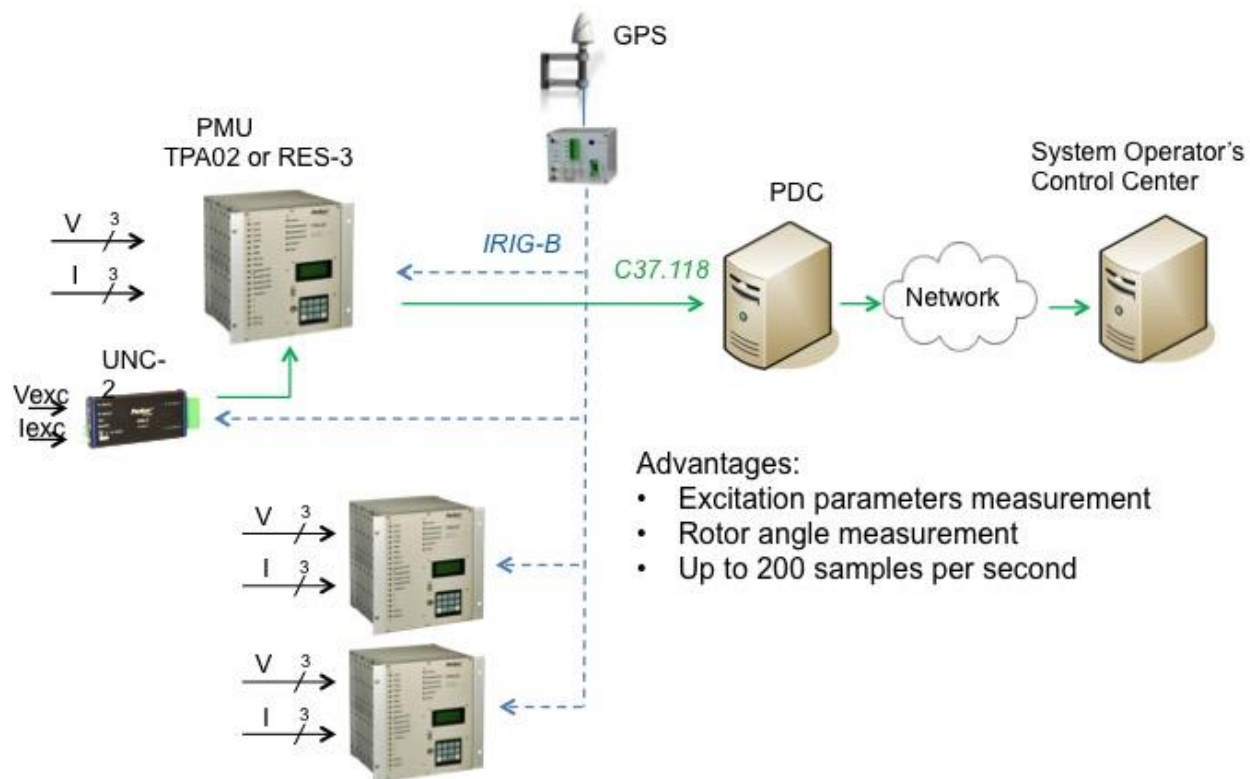
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# Automatic WAMS Data Acquisition and Processing System



# On-site equipment scheme



## Advantages:

- Excitation parameters measurement
- Rotor angle measurement
- Up to 200 samples per second

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# Conclusion

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- For the test case disturbance at the considered generator the derivation methods show reasonable results
- Taking excitation measurements into account allows to get more accurate values close to the measured ones
- Involving this method may lead to an impressive effect regarding controllability of the system along with economics as well

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Thank you for attention.  
Any questions?

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