
vizimax
Phasor Measurement Technology and the requirements for new Algorithms for Control
Authors:
Innocent Kamwa, PhD., FIEEE
Manager of Power Systems & Mathematics
Chief Scientist for Smart Grids, HQ - Research Institute
Robert O'Reilly,
Past Director- Technological Innovations & Architectures
ENERGY 3.0

PRESENTATION OVERVIEW

PMU Challenges and Drivers

Requirements for the data

General control aspects

Wide area control

Special Protection Systems

Situational Awareness and applications within the Distribution System

PMUs and their use in Microgrids

Conclusion

CHALLENGES

Before looking at control applications, consider some of the parameters required from a PMU.

From a measurement point of view:

- Accuracy
- Repeatability
- Timely availability
- Stability of the readings
- Capability of detecting key harmonics,

DRIVERS

- Increasing complexity of the grid. Need of network monitoring and control in real time.
- Increasing demand. Need of increasing the power flow with existing infrastructure.
- System operators need synchronized information to make decisions in line with network requirements.
- Need to improve the operational security of the power system.
- After harmful blackouts, the need to prevent a power system`s collapses emerges. The need for accurate and real time information is critical.

REQUIREMENTS FOR ALGORITHMS

Reliable and highly effective at rejecting harmonic components, including sub-harmonics caused by series compensation

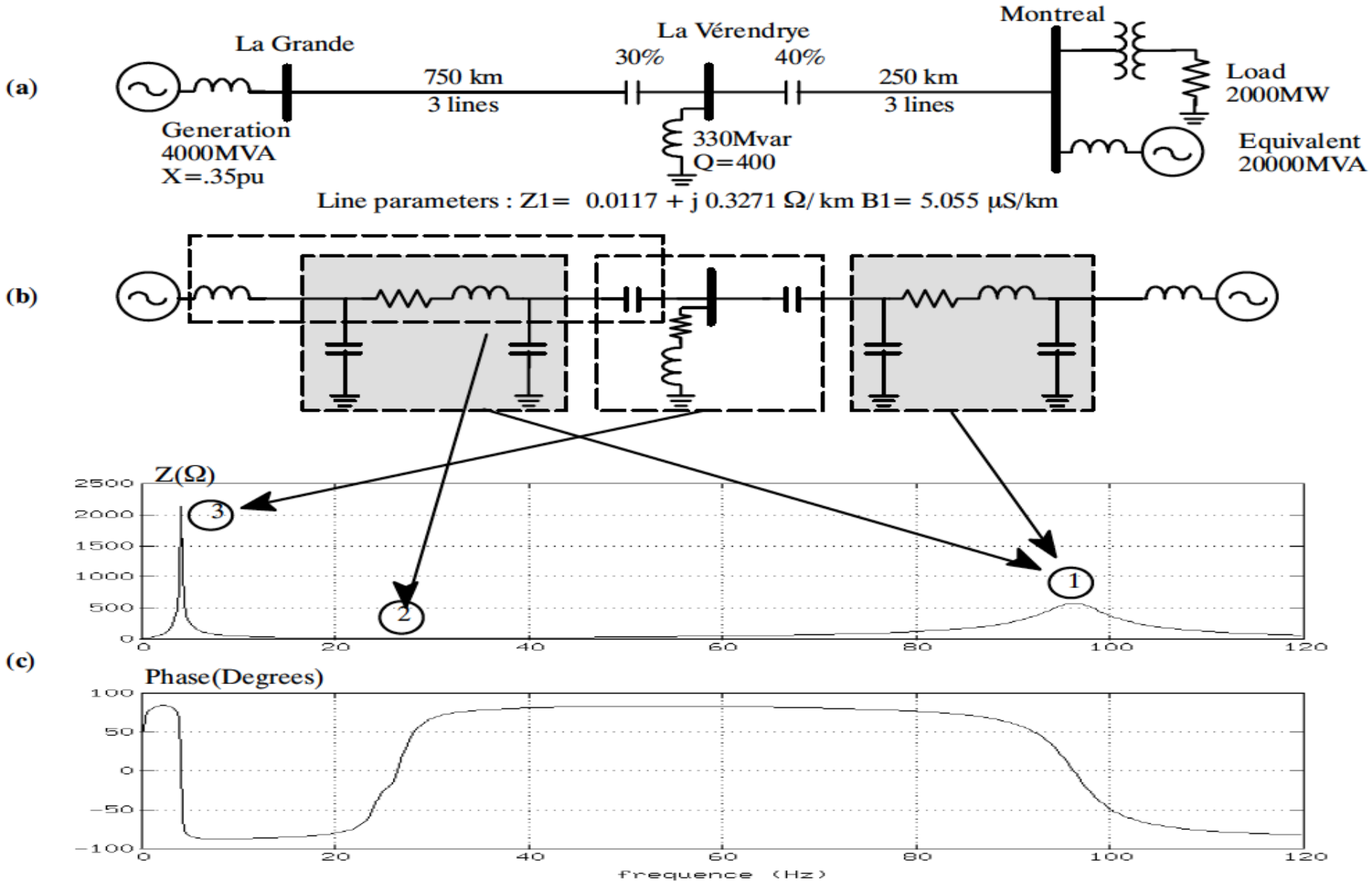
Performs very well in stressed and disturbed power systems, providing good and reliable measurements and faster operation of control and protection systems.

Exceptional reporting rate that allows implementation of fast intelligent protection and control schemes, special protection schemes, etc.

REQUIREMENTS FOR ALGORITHMS, (CONT)

Resilience to harmonics provides an ideal approach for single-phase applications, microgrids and power islands.

A PMU with adaptive algorithms operating under a wide frequency range for phasor & frequency (especially in dynamic conditions) must work within a ± 15 to 20Hz range from the selected base frequency and should not to be affected by harmonics, inter-modulation, sub and hyper-synchronous resonances.


(a)
La Grande
750 km
3 lines
La Vérendrye
30%
40%
250 km
3 lines
Montreal
Load
2000MW
Generation
4000MVA
X=.35pu
330Mvar
Q=400
Equivalent
20000MVA
Line parameters : Z1= 0.0117 + j 0.3271 Ω/ km B1= 5.055 µS/km
(b)
(c)
Z(Ω)
Phase(Degrees)
frequence (Hz)

TYPICAL REQUIREMENTS BY HQ FOR PMUs

1. Fundamental frequency range fc=54-66Hz - however, the device must work in the range 40-70Hz (bind to hydro-generators requirements)

2. Rate of Change of Frequency (ROCOF) range ±3Hz/s - however, the device must work up to ±6Hz/s. The algorithms should remain stable up to 25Hz/s.

3. Out-of-band filtering of series damped resonance in the range 25-32Hz, (2.5% on voltage more than 10% on current)

4. Out-of-band filtering of parallel damped resonance in the range 70-100Hz (up to 10% on voltage)

TYPICAL REQUIREMENTS BY HQ FOR PMUS, (CONT)

5. Out-of-band filtering of sub-synchronous parallel resonances

   {in the range fss = 5-20Hz (5 to 25%) }

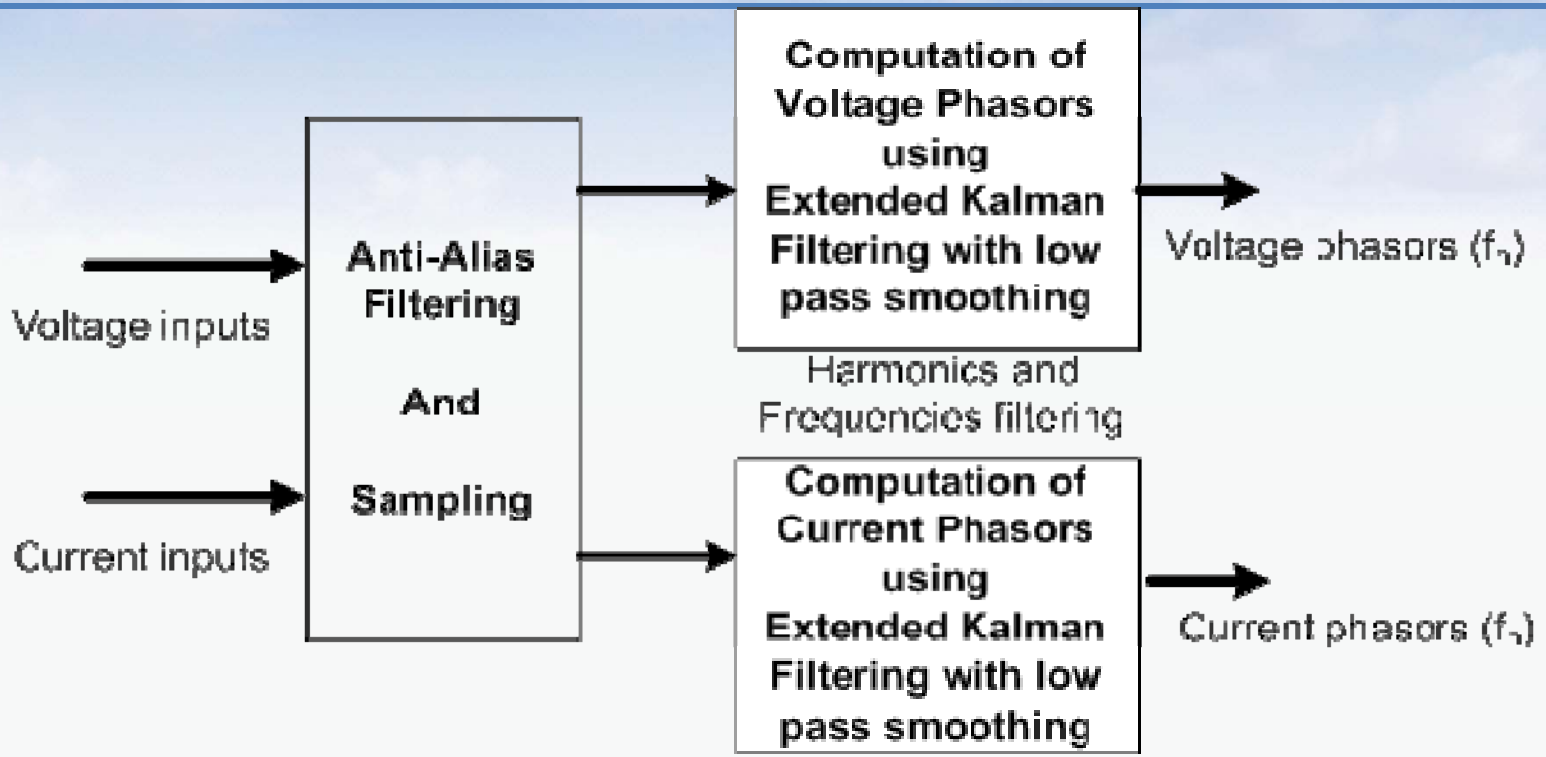
6. Intermodulation rejection (due to coupling of transformer saturation and sub-synchronous parallel resonance) in the range:

   fi = fc ± fss and fi = fc ± 2fss (5% on the voltage)

7. Harmonics rejection (5% for 2nd to 5th and 2% from 6th to 10th) at the fundamental and at offset frequencies (54-66Hz).

6. Should exceed the requirements of C37.118.1 for both M and P class accuracy (thus providing a wider linearity range than what is specified in the standard)

SIMPLIFIED ARCHITECTURE OF SAMPLING ENVIRONMENT



Unique capability to identify the user's selected harmonics within the measurement sampling stream, (certain harmonics are normally used as key detection points in a number of applications. Example: solar storms).

PRE-PROCESSING AND CONTROL

Prepares the information within the context of the requirements of the overall control objectives

Control aspect must be planned for having the capability of performing control locally or via communications

Must be able to select the communication medium and protocols

- C37.118 (with any desired frame rate up to 240)
- 61850-90-5 (for PMU data transmission)
- GOOSE messaging (in/out)

WIDE AREA CONTROL & SITUATIONAL AWARENESS

Since 2004, Hydro-Québec has been operating a PMU network

- Connected to the EMS for the purposes of GIC early warning in real-time
- Frequency measurement for AGC backup input signal
- Used daily for SPS performance reporting to NERC
- Plays a major role in blackout forensics

Now being deployed - a new WAMS for all major 735kV subs (with dynamic shunt compensators)

- Using the latest C38.118.1 grade of PMUs
- Together with improved SPDC (Substation Phasor Data Concentrator)
- Deployed more specifically for wide-area and local voltage control to boost reactive power

WIDE AREA CONTROL AND SITUATIONAL AWARENESS (CONT'D)

Vision developed at the Hydro-Quebec Research (IREQ)

- Equip all 735kV with the advanced PMUs
- Equip all wind farms with PMUs
- This will allow robust synchrophasor analytics for:
  - Grid performance monitoring
  - Forensics

The goal of this approach

- Evolve towards wide-area Special Protection Systems (SPS)
- Implement damping controllers when it makes good business sense

PMU USED AS AN ADVANCED SENSOR AT HYDRO QUEBEC

Geo-Magnetic Induced Current (GIC) early warning

Analytics for decision making require certain key harmonics

Wide area SPS

- Remote under-frequency load shedding
- Remote under-voltage load shedding

Wide range of new automation applications

SPECIAL PROTECTION SYSTEMS, (SPS)

PMUs provide information to allow improvement of transient & voltage stability

The systems would operate at ≥240 frames per second

Allowing for local dampening of a wide variety of oscillation modes

Capability for local and wide area control contribution of shunt compensation to voltage control

APPLICATIONS WITHIN THE DISTRIBUTION SYSTEM

Situational awareness within the distribution environment

Power islanding control applications

Unique possibilities down to single phase applications

Control within Microgrids

APPLICATIONS WITHIN MICROGRIDS

Microgrids incorporate multiple types of power generation

Wind turbines (various outputs)
Diesel Generator(s)
Battery storage system(s)
Solar, (PV, Thermal)

CONCLUSION

Increased applications using PMU information

Monitoring
Analysis
Alarming and situational awareness
Control aspect possibilities in many areas

THANK YOU

North America
2284, de la Province Street
Longueuil (Qc) Canada J4G 1G1

T : +1 450 679-0003
F : +1 450 679-9051
sales@vizimax.com
www.vizimax.com

Europe, Middle East
475 Louise Avenue
1050 Brussels

T: +32 2 669 0735
F : +32 2 669 0739
sales@vizimax.com
www.vizimax.com

India
HIG-408, Street no.12
Madhavanagar,
Ramachandrapuram
Hyderabad-502032, India

T : +91 9848822724
sales@vizimax.com
www.vizimax.com

Latin America
Alameda Itù # 1267, Conj. 122
Jardins, CEP 01421-001
São Paulo • SP • Brazil

T : +55-11-96307-6174
F: +55-11-3081-9077
sales@vizimax.com

РОССИЯ
МОСКВА 115088
Ул. Южнопортовая, д.5, офис 344
Бизнес-Центр «Золотое Кольцо»

тел. +7 495 665 62 79
russia@vizimax.com
www.vizimax.com

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