WAMSTER:
Field experiences 2010-2014

WAMSTER Ad-hoc synchrophasor measurement network

Presentation Contents

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1. About out company

STER (Studio Elektronike Rijeka)

Our company → STER

Studio Elektronike Rijeka d.o.o. (STER)

- Located in the Technology-Innovation Centre of Rijeka (TIC), J. P. Kamova 19
- Development of technological solutions in automation, measurement and electronics
- Founded in 2006 based on previous achievements in the field of power quality

Our competence

- Complete service in the field of measurement:
  - Hardware development
  - Firmware/software development
    - firmware: development of real-time measurement and control algorithms
    - software: distributed systems for data acquisition, storage, analysis, event detection, alarming
  - Management of complex measuring campaigns
  - Locating faults in naval and terrestrial power systems
- Design and commissioning of automation systems
  - Steel plants, tobacco industry, shipyards and ships

2. WAMSTER system: wide area monitoring system based on the synchrophasor (PMU) technology, using mobile telephony for data transmission

WAM – wide area monitoring
PMU – phasor measurement unit

Synchrophasors

- GPS satellite signal provides an accurate time base (1μs) across the globe
- **Precise time base allows system monitoring to be based on <u>absolute</u> phasor angles**
- 50/60 samples per second

WAMSTER system

- Integrates measurement devices, data storage as a service and online analysis of distributed synchrophasor measurements
- Key properties:
  1. STER PMU: a handheld, portable device for synchrophasor measurements
  2. Uses the mobile network (GPRS/UMTS) for communication
  3. Server application (service) for data acquisition, storage, online (web) analysis, event detection and integration with third-party systems

WAMSTER
AD HOC PHASOR MEASUREMENT NETWORK

STER PMU

- Handheld phasor measurement unit
- 4 voltage + 4 current inputs
- 3 voltage ranges: 150/300/1000V
- External toroids / current clamps
- 32GB flash memory (5mo.)
- Battery backup (5h)
- GPS synchronization (1μs/3μs)
- GPRS communication
- RS232 / USB / Ethernet

Technological advance:

Mainstream PMU

- Switchboard weighing 80 kg
- Wired communication

STER PMU

- Handheld device (4 kg incl. bag)
- Wireless communications (mobile networks)

STER PMU

- Small dimensions
- No ventilation
- No rotating parts
- Installed in any position

STER PMU

- Magnetic baseplate allows direct mounting to switchboard doors or backplanes

WAMSTER.NET

- Server application
- Data concentration over GPRS/Ethernet
- Data storage provided
- Online access from any web enabled device (laptop, smartphone)
- Online data analysis and event detection with configurable event triggering
- Extensions: integration with existing systems (continuous forwarding, offline/daily/weekly archiving, FTP uploading)

WAMSTER System

WAMSTER.NET

- Online device status monitoring
- Full remote access to all devices over web

WAMSTER.NET

- Offline measurement analysis (trends)
- Online measurement comparison

WAMSTER.NET

- Configurable event detection
- Export to other formats (CSV) and download

WAMSTER extensions

- Custom system state visualization on request
- Integration with other systems:
  - Synchroshield (2010) – continuous data forwarding over the Internet towards CARWAMS
  - Energynautics (2012-2013) – daily archives are automatically sent to the client's FTP server
- Custom communication protocols
- E-mail/SMS notifications

3. WAMSTER installations and use cases

Installations 2010-2014

- CARWAMS, Croatia
  2010-2011, 9 PMUs for University of Rijeka
- ZAGREB Ring, Croatia
  2011-2012, 6 PMUs for HEP (Croatian TPO)
- HEP PP Sjever, Croatia
  2012, 4 PMUs for HEP (Croatian TPO)
- UMEME 24/7, Kenya
  2012-2013, 6 PMUs for Energynautics Germany
- NIAF Abuja demonstration project, Nigeria
  2013, Bridging SCADA demonstration for KU Leuven (Belgium), Nigeria Infrastructure Agency Facility (NIAF) and Bauchi State University, Nigeria
- Renewable Energy Systems assessment, Seychelles
  2014 (ongoing), 3 PMUs for Energynautics Germany
- Dynamic React. Compensation Strategy project, UAE
  2014 (ongoing), 20 PMUs for TRANSCO/ADWEA United Arab Emirates

CARWAMS

- Implemented for University of Rijeka
- Active since **09/2010** until **09/2011**
- Hor.: 0.4kV, Vert.: 0.4kV - 110kV
- Data stream towards the TSO PDC

CARWAMS LV analysis

Event triggering:

- **50 fps** on demand

Monitoring and baselining:

- Continuous 1 fps reporting
- Daily angle fluctuations
- Seasonal fluctuations

CARMAWS: HV-MV-LV voltage levels

Zagreb ring 110kV

- SIPS Project / HEP, conducted by Faculty of Engineering Rijeka
- 09/2011 until 03/2012

Zagreb ring: Topology loop reconfiguration

Zagreb ring: islanding caused by operator's mistake

HEP PP Sjever

- TSO HEP Production, HE Sjever, Jul-Aug 2012.
- Problem: HP Dubrava power generator stopped due to power oscillations – cause unknown

HEP PP Sjever

- Customer requested a custom page for system overview and online monitoring

HEP PP Sjever

- Retrieved data provided new insights

Switching events

Atmospheric discharges

HEP PP Sjever

- 18-Jul-201: Detected power fluctuations

NIAF Abuja, Nigeria

- „Bridging SCADA“ demonstration, Apo Substation, in cooperation with:
  - KU Leuven, Belgium
  - Nigeria Infrastructure Agency Facility (NIAF), Nigeria
  - Bauchi State University, Nigeria

NIAF Abuja, Nigeria

- Typical frequency fluctuations (49-51 Hz), blackout and switch to the DG supply

NIAF Abuja, Nigeria

- Frequency fluctuation details (2h interval)

Kenya, Africa (2012/2013)

- Energynautics Germany, UMEME 24/7 Germany
- 6 PMU devices, event detection, FTP upload

Kenya UMEME24/7

Kenya UMEME 24/7

a) National blackout 28-May-2013

ref. angle: PMU#43 Kismu (-> Uganda). df/dt = 0.5 Hz/s

Kenya UMEME 24/7

b) Synchronism lost (1/2)

ref. angle: PMU#45 Diani Beach. Angle at marker for PMU#43 = -161°

Kenya UMEME 24/7

b) Synchronism lost (2/2)

ref. angle: PMU#45 Diani Beach.

Kenya UMEME 24/7

c) Resynchronization example

Seychelles, Africa (2014)

- Energynautics Germany
- Ongoing World Bank project for Assessment of Grid Absorption Capacity, Grid Code, Feed-In Tariffs and Model Power Purchase Agreements for Renewable Energy Systems
- 3 PMU devices, event detection, added active/reactive power and energy trends and triggers

DRCS Project, UAE (2014)

- **D**ynamic **R**eactive **C**ompensation **S**trategy project TRANSCO/ADWEA, United Arab Emirates
- 20 PMUs, event triggering, SMS/mail alarming

DRCS Project, UAE (2014)

- Development of a strategy for **dynamic reactive compensation**
- Reactive power study
- Distribution load modeling
- 20 PMUs:
  - Abu Dhabi area: island and mainland (**11 kV**)
  - Al-Ain area (**33 kV**)
  - Central Area (**220 kV**)
  - Critical National Infrastructure Area (**220 kV**)

Example: Analyzing disturbances in the distributive network

- Synchrophasor approach to analysis
- Allows angle comparison between key PMU measurement points in the system

Rijeka interruption on 23-Sep-2011

Rijeka interruption on 23-Sep-2011

Detail “A”

Detail “B”

Thank you.

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