WAMSTER
A decade dedicated to synchrophasor technology

STER - Studio Elektronike Rijeka Ltd.

NASPI Work Group Virtual Meeting and Vendor Show
October 05-07, 2021

STER Ltd. Croatia · www.ster.hr · www.wamster.net
WAMSTER-RT in HOPS

- **WAMSTER-RT** PDCs in HOPS
  - 1 in NDC, 2 in area control centers
- PDC in NDC - WAMS to WAMPAC transition testbed
  - Communication delays and issues
  - Line protection monitoring (basic, differential, impedance)
  - Line monitoring: voltage angle difference, charging currents, high resistance faults, corona losses, synchro-check
- Fault locator - superior for high resistance SLG faults
- Oscillation monitoring: detection, Prony tool analysis
- Performance monitoring: primary frequency control
- Integration with EMS – Emergency load shedding
- Equipment deterioration, protection coordination flaws
1) Installation in 19” rack – 1U size
2) Current ranges: 2A precision, 32A high current overload 100A: > 2 min
3) 4 x binary inputs, 4 x relay outputs
4) Binary outputs controlled by IEEE C37.118 protocol achieved: PMU-PDC-PMU loop reaction time: 40 ms
STERPMU-R1

...5) secondary service channel (GPRS)
STERPMU-Rx

- R1 in reduced footprint
- external *clamp-on* current sensor
- RES monitoring
- Distribution, generation and older transmission feeders

- 4th U&I channels with DC measurement capability
- excitation, PSS, synchro-check
- extensions for R&D
Differential current

- Event 107: 220 kV Konjsko Brinje (P8/1450)
  - Event started with value 6.5 kA at 2019-05-05 18:07:37.400 UTC,
  - Event ended at 2019-05-05 18:07:37.940 UTC,
  - 6499.15479 2009-05-05 20:07:37.400 540ms
  - Additional information: Use this field to add custom description text to this event (temporarily disabled)

- Event 67: 110 kV Obrovac Velebit (#319-320)
  - Event started with value 152.7 A at 2018-10-14 21:06:31.460 UTC,
  - Peak value was 204.3 A at 2018-10-14 21:06:31.980 UTC,
  - Event ended at 2018-10-14 21:06:31.980 UTC,
  - 204.30998 2018-10-14 23:06:31.460 520ms

- Graphs showing current and voltage changes over time with 30 s time scale.
Fault locator tooltip window

PowerLine: 400 kV Melina Velebit; Length = 178.8 km

<table>
<thead>
<tr>
<th>Event</th>
<th>Distance</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.12.2020, 13:44:45:780</td>
<td>136.28 km</td>
<td>0.10%</td>
</tr>
<tr>
<td>08.12.2020, 13:21:14:720</td>
<td>136.45 km</td>
<td>0.20%</td>
</tr>
<tr>
<td>05.12.2020, 18:20:50:920</td>
<td>136.24 km</td>
<td>0.08%</td>
</tr>
<tr>
<td>04.12.2020, 22:23:52:560</td>
<td>136.43 km</td>
<td>0.18%</td>
</tr>
<tr>
<td>OHL Team</td>
<td>136.1 km</td>
<td></td>
</tr>
</tbody>
</table>
Emergency load shedding
Istrian peninsula
Trip 2.5 min after reclosure

Observed: 2019-09-07
Historical: 2018-09-03
Similar event confirmed: 2021-09-17
HOPS was informed about the problem in Feb. 2020.
A tripping on 15/09/2020 caused by PT deterioration was not declared as false by EMS.
400 kVPT was replaced on 18/09/2020
WAMSTER
AD HOC PHASOR MEASUREMENT NETWORK

Sterpmu
synchrophasors

GPRS
node

WAMSTER
PDC Service

WAMSTER
Cloud Storage

Web clients
(PC, laptop, smartphone)

NASPI WG Fort Worth 2011
www.wamster.net

WAMSTER web PDC service

Synchrophasor Wide Area Monitoring over a mobile network.

- Portable phasor measurement units.
- No dedicated networking infrastructure needed.
- No dedicated server equipment needed.
- Negligible deployment costs.
- Online since 2010.

View online demo now

Wamster Features at a Glance

- Portable PMU devices
- Lightweight, handheld PMUs with rechargeable
- GPRS/Ethernet IEEE C37.118 link
- STER PMU devices can use a custom, optimized
- Deployment in 15 minutes
- All the equipment necessary to deploy a STER PMU
STERPMU

2010 Portable phasor measurement unit

- 4 voltage + 4 current inputs
- 3 voltage ranges: 150/300/1000V phase
- External clamp-on current sensors (1..3000A)
- Battery backup (>4h)
- GPS, GPRS modules in set

2012

- 32GB flash memory, Harmonics, Continuous Waveform Recorder (CPOW)

2019

- GNSS, LTE, 200+ GB flash memory
- Ethernet connectivity for IEEE C37.118
STERPMU

- Baseplate with magnetic fixture
- No ventilation, any orientation
- **20 minutes to PMU data on web**
- **60 minutes for installation**
STERPMU-Rp

- Integrated design
- Reduced footprint
- LTE, GNSS

- 100BASE-TX RJ45
- IEEE C37.118
Projects 2010-2021

- **CARWAMS, Croatia** 2010-11, 9 PMUs for University of Rijeka
- **Zagreb 110kV, Croatia** 2011-12, 6 PMUs, HEP (Croatian TSO, now HOPS)
- **Hydro North, Croatia** 2012, 4 PMUs for HEP (Croatian TSO)
- **UMEME 24/7, Kenya** 2012-13, 6 PMUs, Energynautics Germany
- **NIAF Abuja, Nigeria** 2013, Bridging SCADA demo, KU Leuven
- **RES assessment, Seychelles** 2014, 3 PMUs, Energynautics
- **Dynamic React. Compensation, UAE** 2014, 20 PMUs, TRANSCO
- **INA RNR Rijeka, Croatia** 2015-19, 6 PMUs, troubleshooting, oil refinery
- **Barbados, Caribbean** Assessment of frequency and voltage, Energynautics
- **Wind turbine R&D project, India** 2015-16, 3 PMUs, PDC, POSOCO
- **200 MVA Phase shifter validation, Croatia** 2016, 6 PMUs, HOPS
- **Dynamic modelling, Oman** 2016-17, 20 PMUs, TRACTABEL & OETC
- **PFC monitoring pilot, Croatia** 2019, 2 PMUs, HOPS
- **Modular Offshore Grid, Belgium** 2019-20, 3 PMUs, Elia grid
- **ALEGRO islanding test, Belgium** 20, 3 PMUs, Elia grid
- **Crete-Peloponnese interconnector, Greece** 2020-21, 4 PMUs, IPTO
- **Polar cruiser sea trial, Croatia** 2021, 3 PMUs, PDC, Quark Expeditions
WAMSTER POSOCO Installation

KALADUNGER
JAIISMER, RAJASTHAN

0.69 / 33 kV  33 / 132 kV

PMU#75  PMU#76

GPRS

NIWE test station
KAYATHAR, TAMIL NADU

PMU#74

Web access

IEEE C37.118

Synchrophasors
Waveforms
Harmonics

POSOCO
NEW DELHI

WAMSTER

PMU data

POSOCO PDC

IEEE C37.118

Synchrophasors
Waveforms
Harmonics

WAMSTER-2

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Dynamic modelling of Oman power system (2016-17)

- Capturing dynamics of Oman Transmission system
- Distribution load & reactive power flow study
- 20 PMUs
  - Main interconnection system & Dhofar governorate (distance to Muscat: 1000 km)
  - Installation completed in 7 working days (4000 km)
Crete – Peloponnese interconnection

- Phase 1: 150kV AC, 2×200MVA (~2x140MW)
- Lines energized on 22/12/2020 (A) and 18/05/2021 (B)
On a polar class cruiser
On a polar class cruiser
On a polar class cruiser

ROCOF: ±15 Hz/s

2 s
PDC-less pilot projects

DI Slavonija / 2017
Cogeneration (HR)

MHE Zavidovići / 2019
Small hydro plant (BIH)
Islanding detection

Hybrid WAMPAC

PMU A  PMU B

Primary channel (IEEE C37.118)
Secondary channel (Mobile Internet)
User interface (Internet browser)

Access for authorized users

DSO

PMU E
PMU F

PMU – RES
PMU – Distribution level
PMU – Transmission level
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Thank you!

Questions?