Expandable And Modular Monitoring and Actuation System for Engineering Cabinets at Sirius Light Source

CNPEM
ORGANIZAÇÃO SOCIAL DO MCTI

P. H. Nallin*, J. G. R. S. Franco, G. F. Freitas, R. W. Polli

Brazilian Center for Research in Energy and Materials – CNPEM
**patricia.nallin@cnpem.br*

WEPV027

ICALEPCS 2021

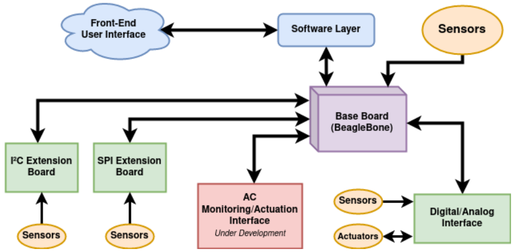
Introduction

- Sirius: 4th generation light source
- Construction began in 2014
- SIMAR: Integrated System for Monitoring and Performance in Racks

Sirius (2020)

Hardware Design

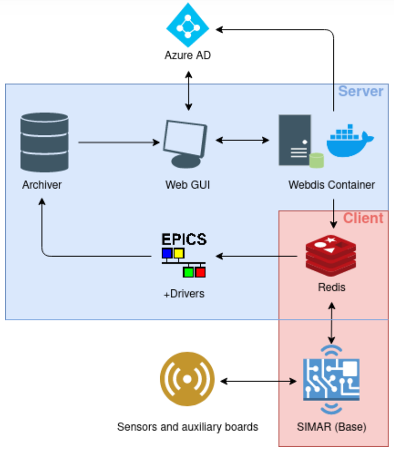
- Base board
- I²C and SPI communication board
- Digital and analog interface board
- BeagleBone as embedded hardware
- Supports I²C, SPI, UART, 1-wire



Hardware conceptual design

Software

- Remote actuation & command processing
- Obtaining and transmitting data
- Graphical User Interface
- Security (authentication, logging)
- EPICS integration



Software Stack

Future Developments and Conclusion

- Voltage and current monitoring improvements
- Prediction through sound signatures
- Remote actuation
- Support for more sensors
- Enables higher efficiency
- Eases maintenance

Sensor installed on a cabinet

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES
PÁTRIA AMADA BRASIL
GOVERNO FEDERAL

Introduction

Sirius, Brazilian 4th Generation Light Source

- Supersedes UVX, which closed its operations in 2019
- Construction began in 2014
- Engineering assemblies and installation started in 2018
- First x-ray microtomography images in late 2019

Figure 01: Sirius (2020)

Motivation

- Need for a compact, versatile rack monitoring solution
- Simple components, easy maintenance
- Good precision and sampling rates
- Quick installation, integration with existing systems

SIMAR – Integrated System for Monitoring and Performance in Racks

- Modular system for data acquisitions
- Using BeagleBone Black as Embedded Hardware
- Hardware and software developments
- (software) Graphical interface, EPICS integration

Figure 02: Assembled SIMAR unit (minus frontal panel) with interface and base boards

Figure 03: SIMAR with front panel

Hardware Designs

Base Board

- Main board, working as master on the communication buses
- Four serial protocols available (SPI, I²C, 1-wire, UART)
- Six-channels 12-bits AD Converters, from 0V to +1.8V
- Two Programming Real-Time Unit (PRU)
- BeagleBone Black as Embedded Hardware
- Responsible for communications flow control

SPI and I²C Communication Extension Board

SPI

- SPI communication channel extension, from one to six
- SPI communication protocol to change the chosen channel

I²C

- I²C communication channel extension, from one to four
- Channels chosen manually (by a dip switch) or serially, via SPI communication

Digital and Analog Interface Board

- General in/out 8-bit digital data
- Six channels for positive analog voltage input: 5 channels up to +10V and 1 channel up to +15V
- SPI communication protocol to digital interface

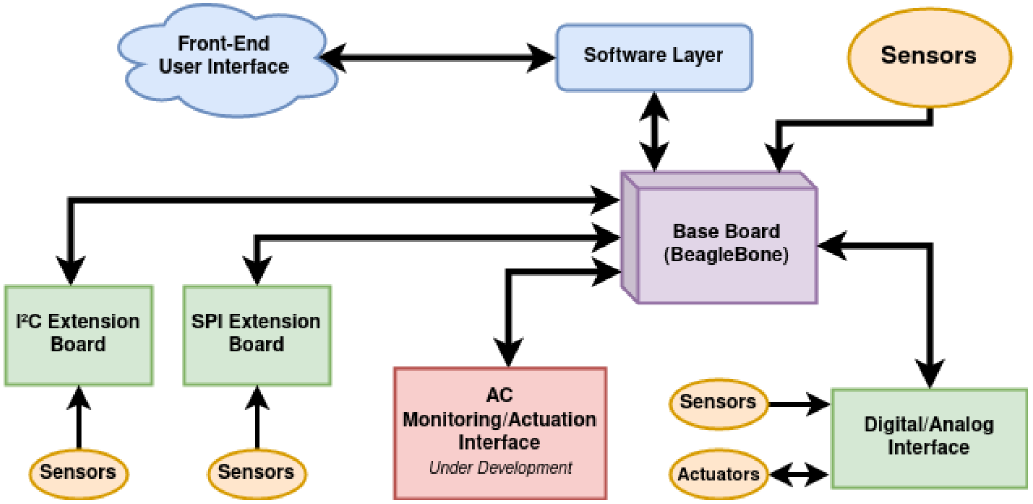


Figure 04: Simar project, conceptual design.

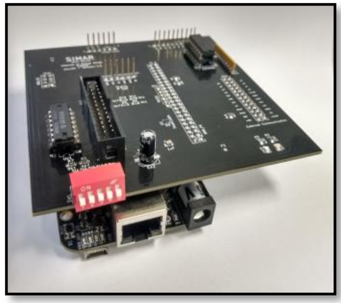


Figure 05: Base board

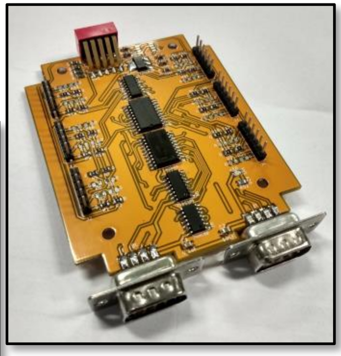


Figure 06: SPI/Serial expansion board

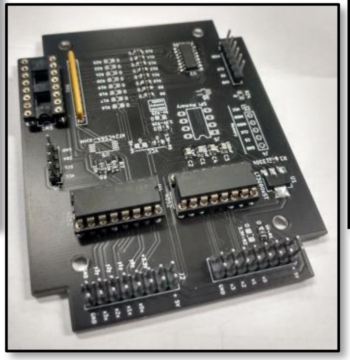


Figure 07: I²C Expansion Board

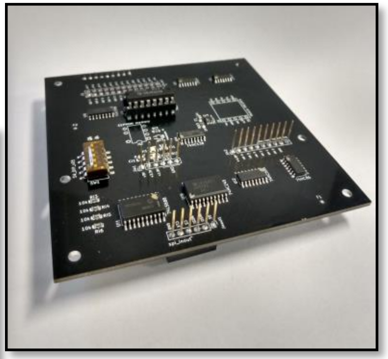


Figure 08: Digital and Analog Interface Board

(Github)

Software

Base Software (Github)

- Automatic sensor detection, naming
- Module based (initialize what you use)
- Written in C, Assembly, Python
- Minimal memory (1MB) and CPU usage (0.7%) for base sensor module
- Quick communication (can poll 8 sensors at over 800 Hz)
- Wired or Wireless (WiFi), logs data to plugged USB devices
- Each unit is monitored constantly; user can be warned of outages

Web GUI (Github)

- Actions limited to logged users, authentication with Microsoft AD
- Responsive, mobile friendly
- User-defined limits
- Dynamic links to archived data
- Redis communication through a version of Webdis with authentication
- Real time updates (Epics2Web websockets)

Software Stack

- Data is fetched/written using a Redis IOC
- Custom redundancy enabled Asyn Driver, created in collaboration with Dirk Zimoch (PSI) (asyn-failover)
- Logs actions to server, target SIMAR unit (user, timestamp)
- Interprets commands through Redis, GUI or caput
- All portions of the stack on the server are containered

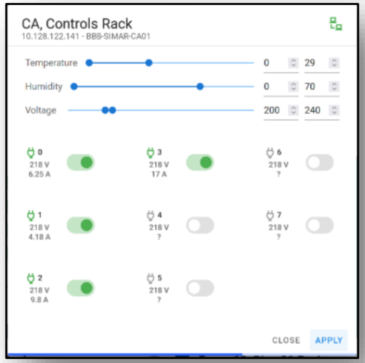


Figure 09: Configuration and actuation screen

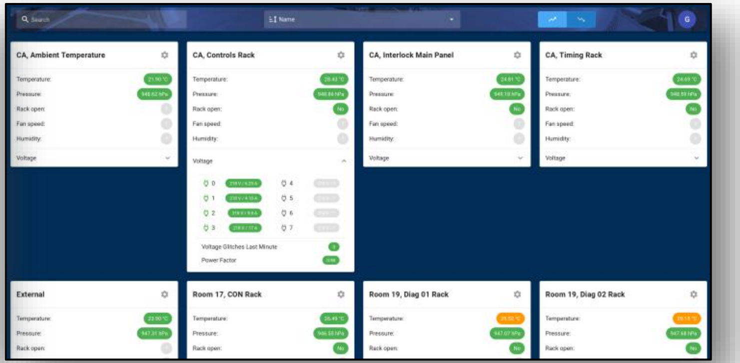


Figure 10: SIMAR's Web GUI

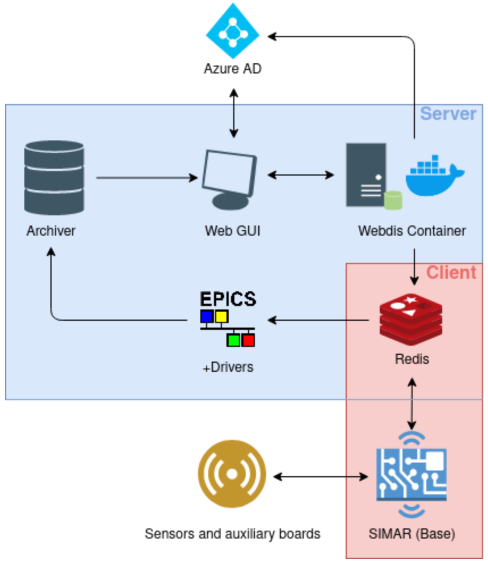


Figure 11: Software Stack

WEPV027

Future Developments and Conclusion

Features under development

- Voltage glitch detection at 2.3 kHz, supporting pulse widths greater than 7us
- Sound signature monitoring
- Power over Ethernet
- Local alarms and interaction
- Power factor readouts
- Remote outlet actuation
- Wireless "plug-and-play" version
- Support for more families of sensors

Conclusion

- Part of Sirius' effort to monitor instrastructure efficiently
- Aids in troubleshooting, reducing downtime
- Enables more informed purchase/design decisions
- Provides information necessary to predict faults
- Monitors impacts of new installations and updates
- Can substitute systems deemed too unwieldy for certain situations

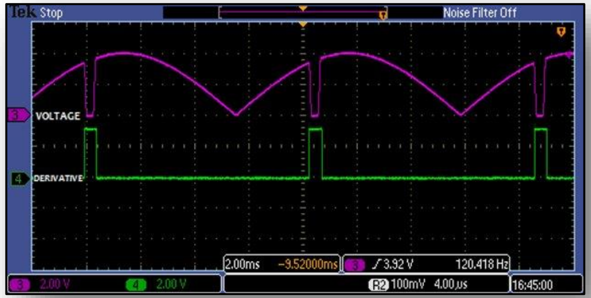


Figure 12: Voltage glitch detector using a derivative circuit.

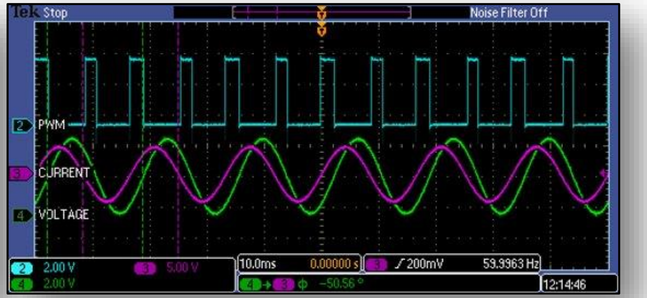


Figure 13: Power factor measurement based on a PWM circuit.

Figure 14: Temperature (green), pressure (blue) and humidity (red) readings for a pulsed magnets cabinet.

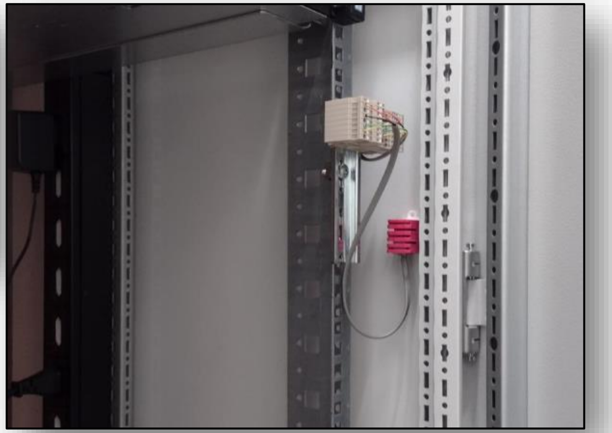


Figure 15: Sensor installed on a cabinet.