# Webinar and Demo: The GTSOC – Black Box Control Integration with the RTDS Simulator

RTDS Technologies

Presented with SMA

RTDS.COM

# Agenda

1. RTDS GTSOC overview
    - Motivation for development
    - How it works

2. SMA presentation
    - Inverter overview
    - Testing approaches
    - Vendor side of GTSOC process

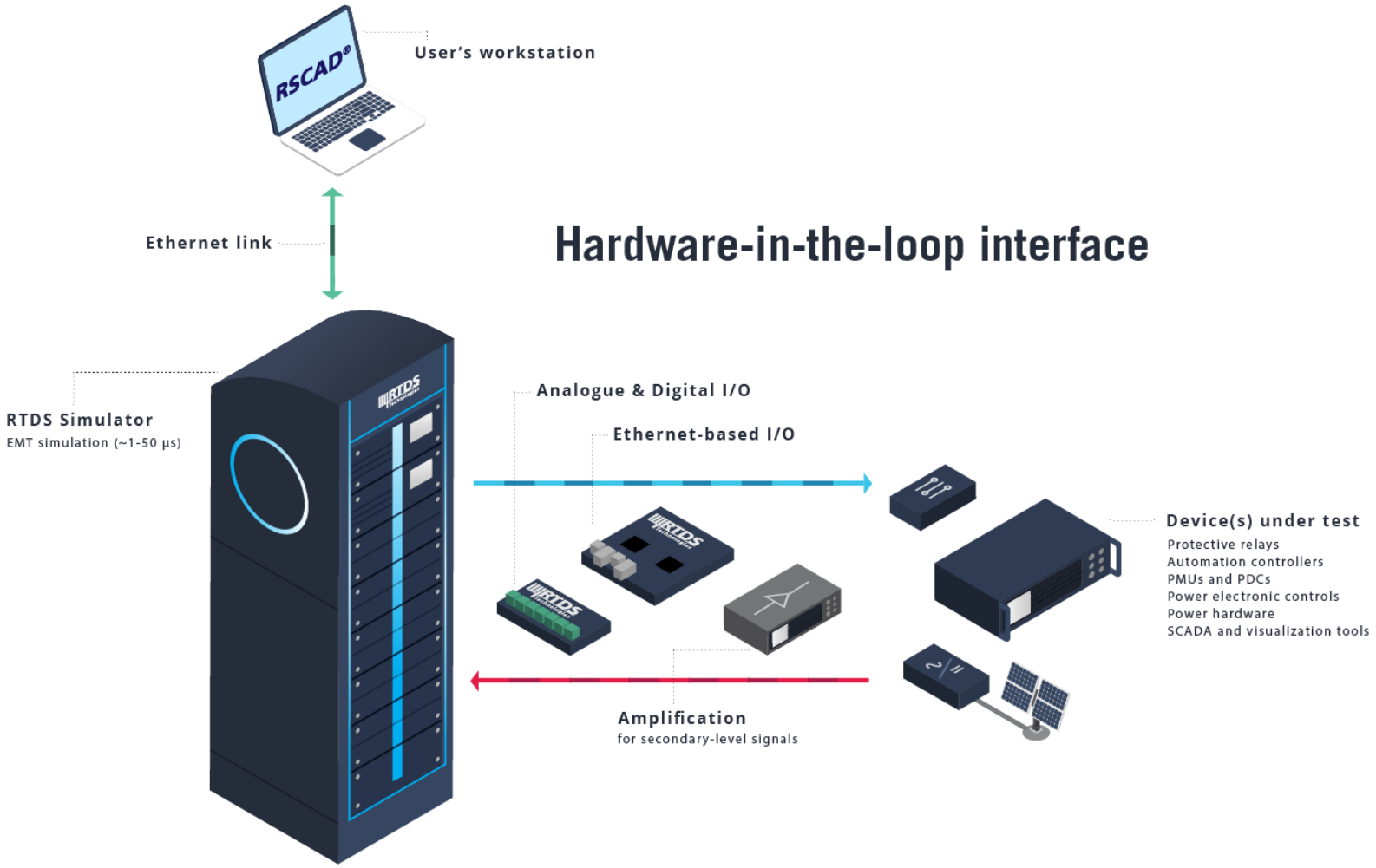
3. RTDS demo
    - GTSOC workflow explanation
    - RSCAD screenshare of simulation case with GTSOC-integrated SMA inverter controls

# About RTDS Technologies


- Headquarters in Winnipeg, Canada
- Pioneered real-time power system simulation in the 1980s
- The RTDS Simulator is the industry standard for real-time simulation and closed-loop testing, used by utilities, manufacturers, research and educational institutions, and consultants worldwide
- Learn more at www.rtds.com or the large library of videos on the RTDS Technologies YouTube channel

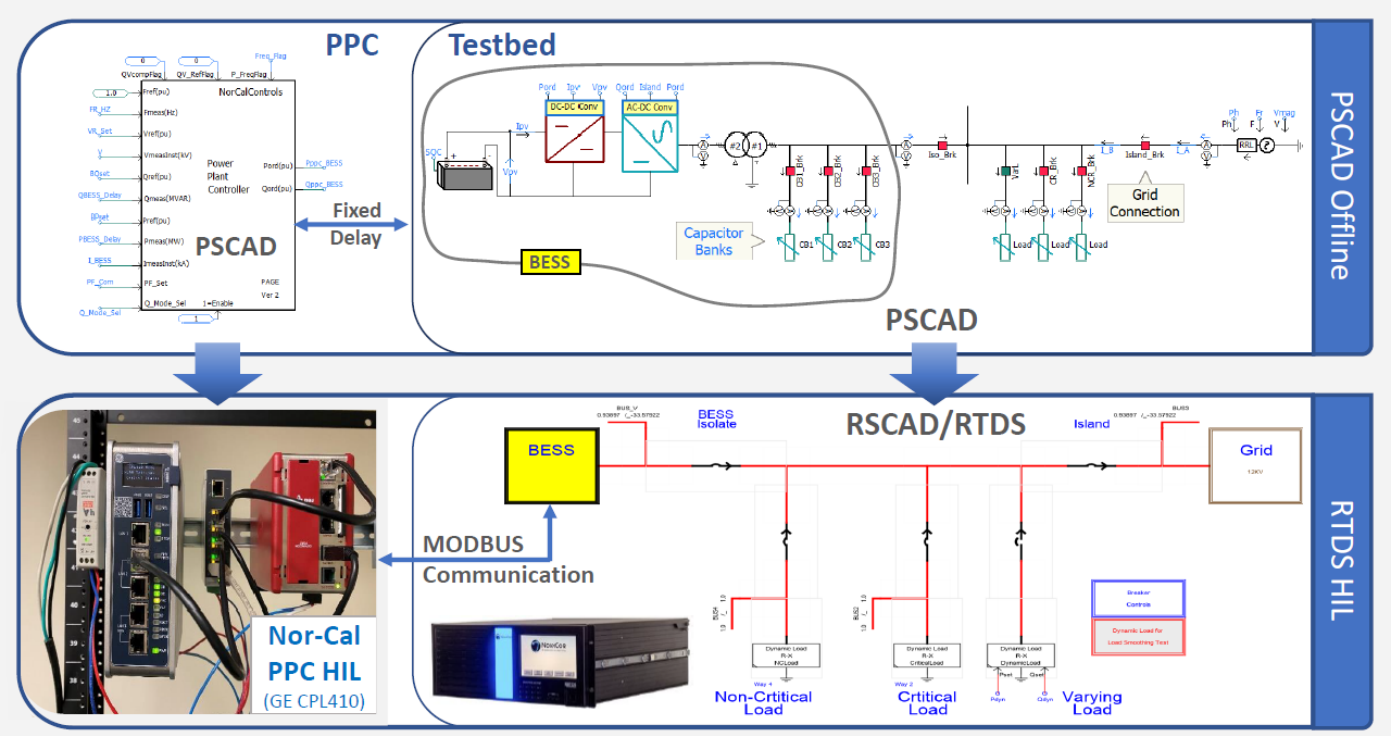
# HIL testing with a real-time simulator

- **True closed-loop testing** is only possible with a real time simulator
  - Test multiple devices (and entire schemes) at once
  - Much more detailed system representation than open-loop test systems provide (e.g. modelling power electronics)
  - Provides unique insights on interactions & dependencies that traditional modelling/ testing may be blind to



# Renewable energy applications

- DER integration studies
- Impacts/interactions of DERs with existing automation
- Grid-forming control testing
- Inverter testing
- PPC testing
- Replica testing

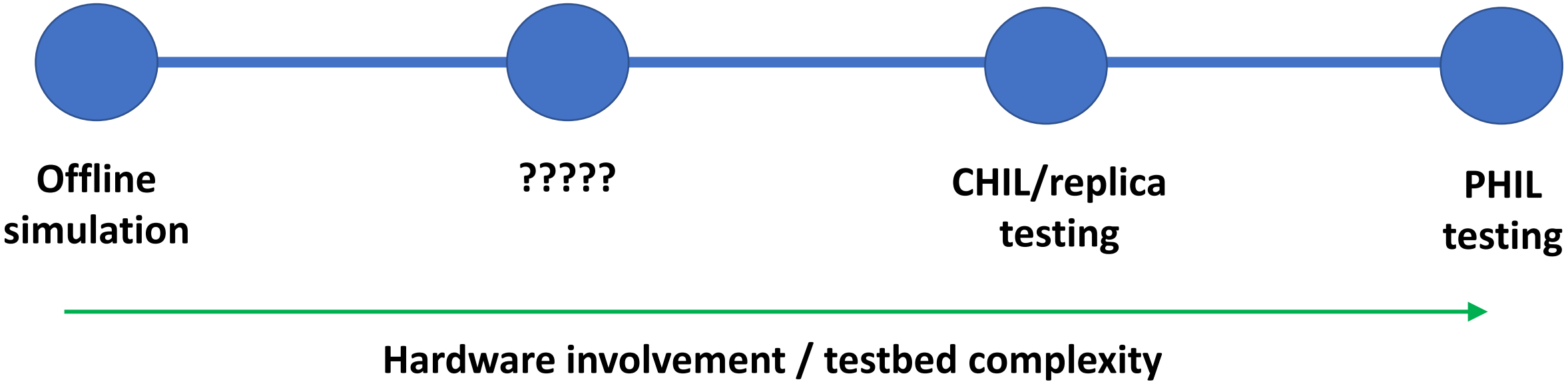


# Black box control simulation

- Generic models do not always suit the purpose
- Vendors need a way to provide models that accurately reflect their control/protection to customers while protecting IP
- Most vendors have black-boxed offline (PSCAD) models of their controls which they can provide to utility customers
- Implementation challenges for real-time environment

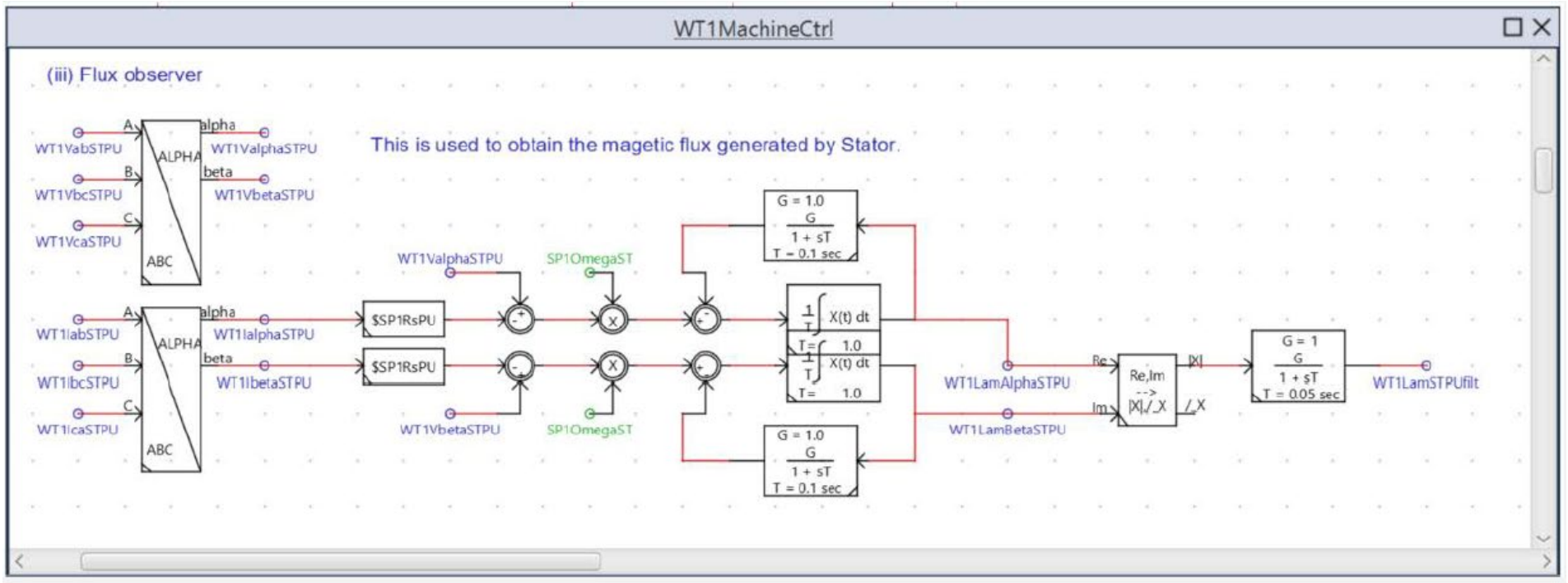
# Filling the gap

- Black box control simulation for accurately studying interoperability in the HIL environment without requiring all physical control hardware to be present
    - i.e. studying impact of renewables on protection



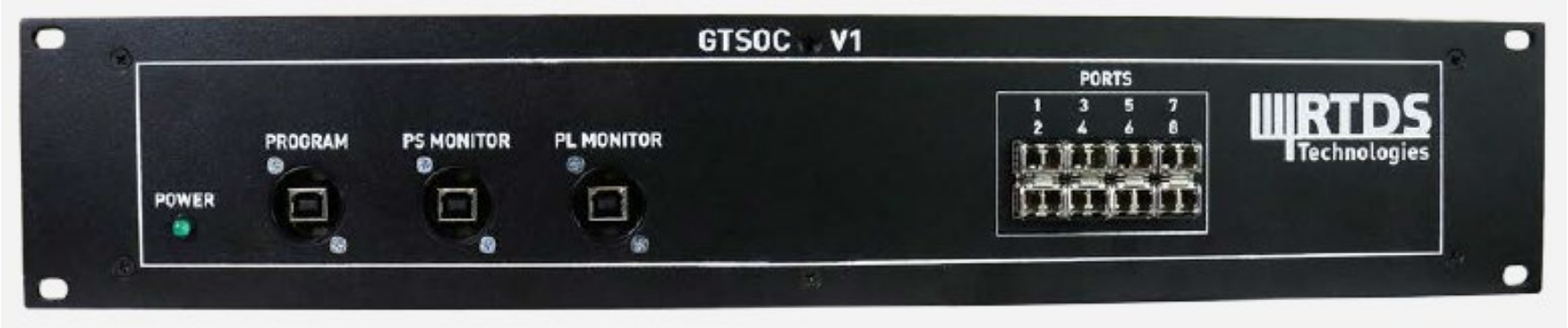
# Existing options in RSCAD

- ComponentBuilder
- Secure compiled hierarchy box



# The new GTSOC

- Features an FPGA board with multi-processor system-on-a-chip technology specifically targeted for vendor black box models
- Supports execution of static library (.a) model compiled from original source code
- Compatible with NovaCor systems (connected via fiber cable)



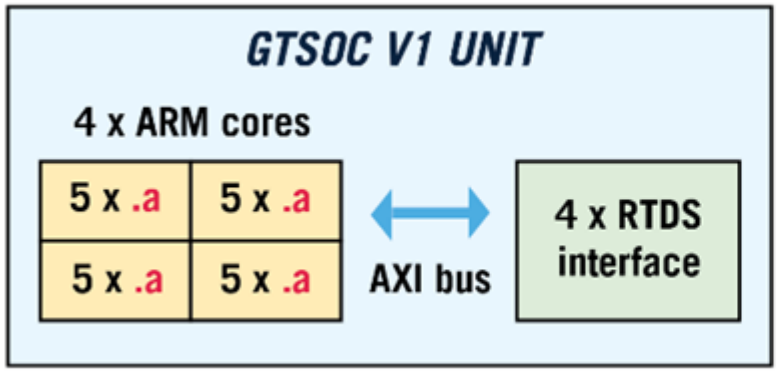
# What is a .a file?

- Deterministic real-time operation required
- .a static library file runs bare metal on ARM core of the GTSOC

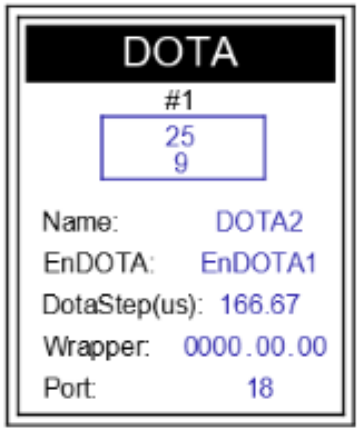
| Operating System / Hardware | Windows | Linux | Bare metal |
|---|---|---|---|
| PC | Dynamic: .dll<br>Static: .lib | Dynamic: .so<br>Static: .a |  |
| ARM |  | Dynamic: .so<br>Static: .a | **Static: .a** |

# GTSOC capabilities

- Each GTSOC core needs one DOTA component (up to 4 DOTA components per GTSOC board)
- Each DOTA component supports Maximum 5 DOTA instances (up to 20 DOTA instances per GTSOC board)
- Each DOTA instance has maximum 64 inputs and 64 outputs







# GTSOC interface tool

- RTDS GTSOC Interface Tool is used for cross-compilation of vendor C code to .a and to generate GTSOC firmware

- Wrapper code maps controller inputs/outputs to signals in RSCAD

# Future direction

- Currently working with vendors on a case by case basis for implementation – in the future, vendors will be able to create GTSOC models independently
- Not necessary for the vendor to have an RTDS (or GTSOC) to create the model using the cross-compiler, but very helpful for debugging

# Thank you!

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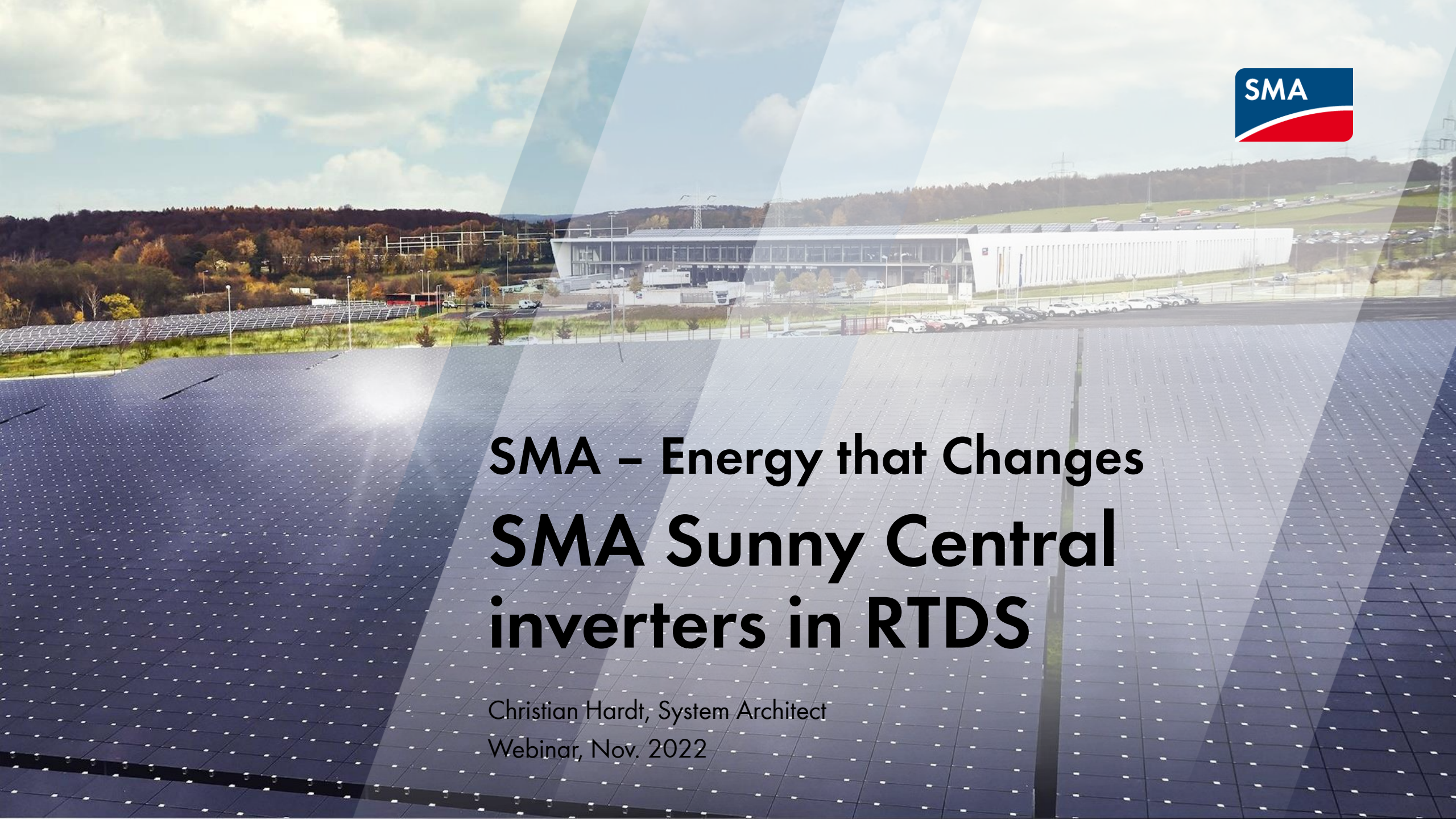

SMA – Energy that Changes

# SMA Sunny Central inverters in RTDS

Christian Hardt, System Architect

Webinar, Nov. 2022

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# SMA Solar Technology AG, Kassel/Germany

- **FOUNDED IN 1981**
- **35 YEARS** EXPERIENCE IN PV INVERTERS
- **3500+ SMA EMPLOYEES**
- **13.6 GW** SOLD IN 2021 (DESPITE COVID-19)
- **113 GW** INSTALLED GLOBALLY
- **40+ GW** SUNNY CENTRAL INVERTERS
- **4 GW** BATTERY INVERTERS
- **U.S. HEADQUARTERS,** ROCKLIN, CALIFORNIA

| **Key financials 2021** | | **Guidance 2022** | |
|---|---|---|---|
| Sales: | MEUR984 | Sales: | MEUR900 to MEUR1,050 |
| EBITDA: | MEUR9 | EBITDA: | MEUR10 to MEUR60 |
| Inverter power sold: | 13.6 GW | | |

# A pioneer in PV and storage system technology for 35 years

**1987**
SMA develops the first transistor inverter for photovoltaics.

**2001**
Sunny Island delivers an autonomous electricity supply to off-grid areas.

**2010**
Sunny Central CP redefines the technology for large PV plants

**2013**
The SMA Fuel Save Solution integrates large PV shares into diesel grids.

**2017**
Sunny Tripower CORE1 is the first free-standing string inverter.

**2018** ennexOS CROSS-SECTOR ENERGY MANAGEMENT
With ennexOS, SMA establishes the first IoT platform for cross-sector energy management.

**2020**
SMA 360° is the most comprehensive installer App on the market.

**2020**
The SMA EV Charger enables fast, intelligent and cost-efficient EV-charging.

**1995**
With the development of string technology, SMA paves the way for the mass distribution of photovoltaics.

**2002**
SMA develops multi-string technology making highly efficient control of differently developed module threads possible with only one inverter.

**2011**
Sunny Tripower is the first inverter to achieve 99% efficiency.

**2016**
Sunny Boy Storage is the first AC-coupled system to integrate high-voltage batteries.

**2019**
Sunny Central UP delivers 50% more power than its predecessor and integrates large storage systems.

**2020**
The SMA Power Plant Manager optimally integrates decentral energy sources into the grid.

# **Sunny Central UP –** One family, many applications

- Generate solar power and use it effectively
- Store energy and use it broadly
- Achieve 100% grid independence
- Safe and stable grids
- Power conversion for hydrogen applications

# Sunny Central UP

# Large Scale Solutions

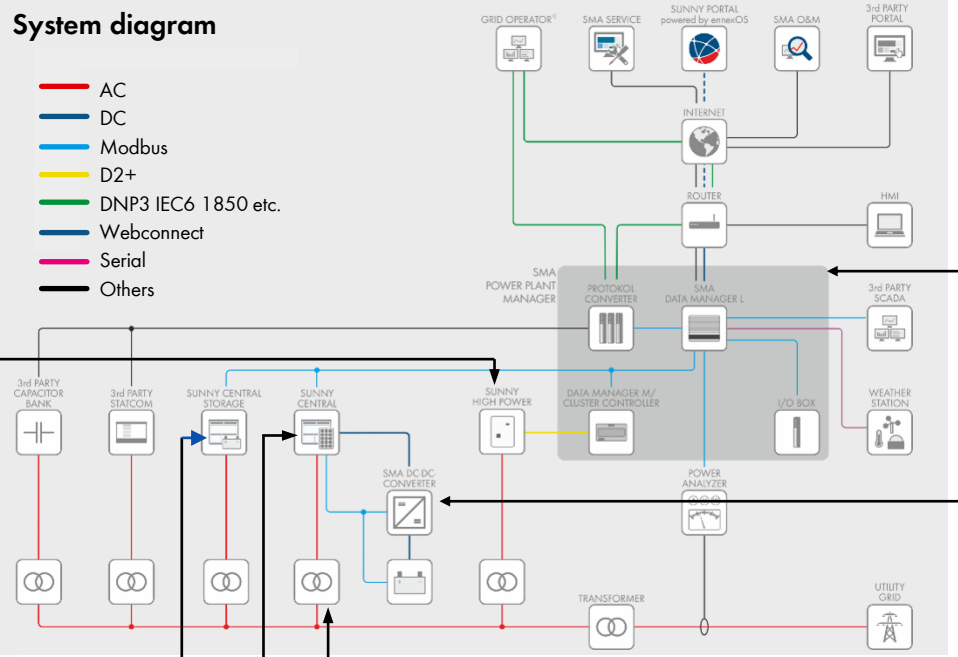
## Engineering Services

## SUNNY HIGHPOWER PEAK3

- SHP 150
- SHP 125
- SHP 100

## System diagram

- AC
- DC
- Modbus
- D2+
- DNP3 IEC6 1850 etc.
- Webconnect
- Serial
- Others




## POWER PLANT MANAGER

## SMA DC/DC Converter

- DPS-500

## SUNNY CENTRAL STORAGE UP (-US)

- SCS 2300-UP-XT
- SCS 2400-UP-XT
- SCS 2530-UP-XT
- SCS 2630-UP-XT
- SCS 3450-UP (-XT)
- SCS 3600-UP (-XT)
- SCS 3800-UP (-XT)
- SCS 3950-UP (-XT)

## SUNNY CENTRAL UP (-US)

- SC 2660-UP
- SC 2800-UP
- SC 2930-UP
- SC 3060-UP
- SC 4000-UP
- SC 4200-UP
- SC 4400-UP
- SC 4600-UP

## MVPS S2 (-US)

- MVPS 4000 S2
- MVPS 4200 S2
- MVPS 4400 S2
- MVPS 4600 S2
- MVPS 2660 S2
- MVPS 2800 S2
- MVPS 2930 S2
- MVPS 3060 S2



… more on: SMA Energy System » Large Scale | SMA Solar

# Testing done seriously

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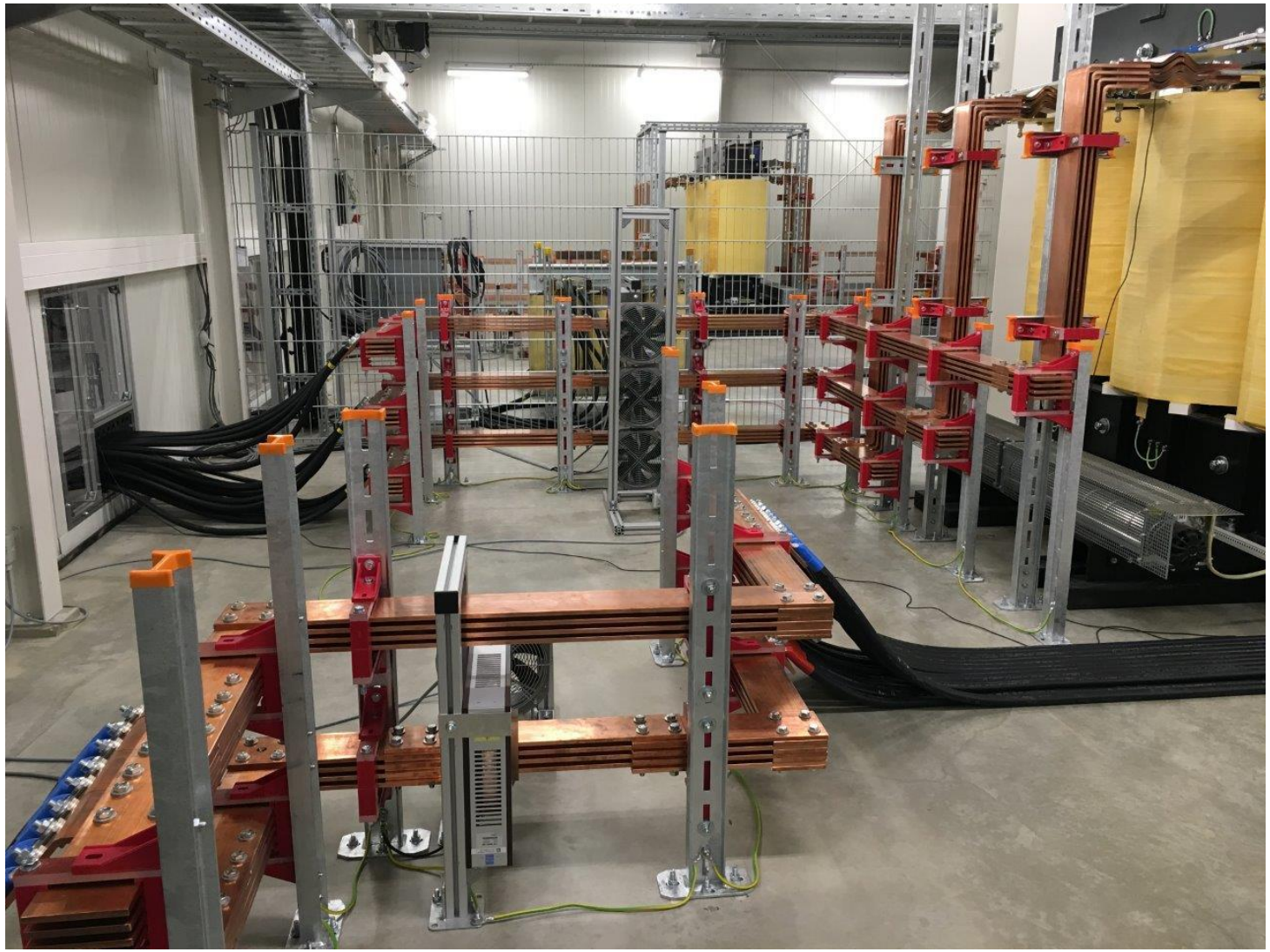

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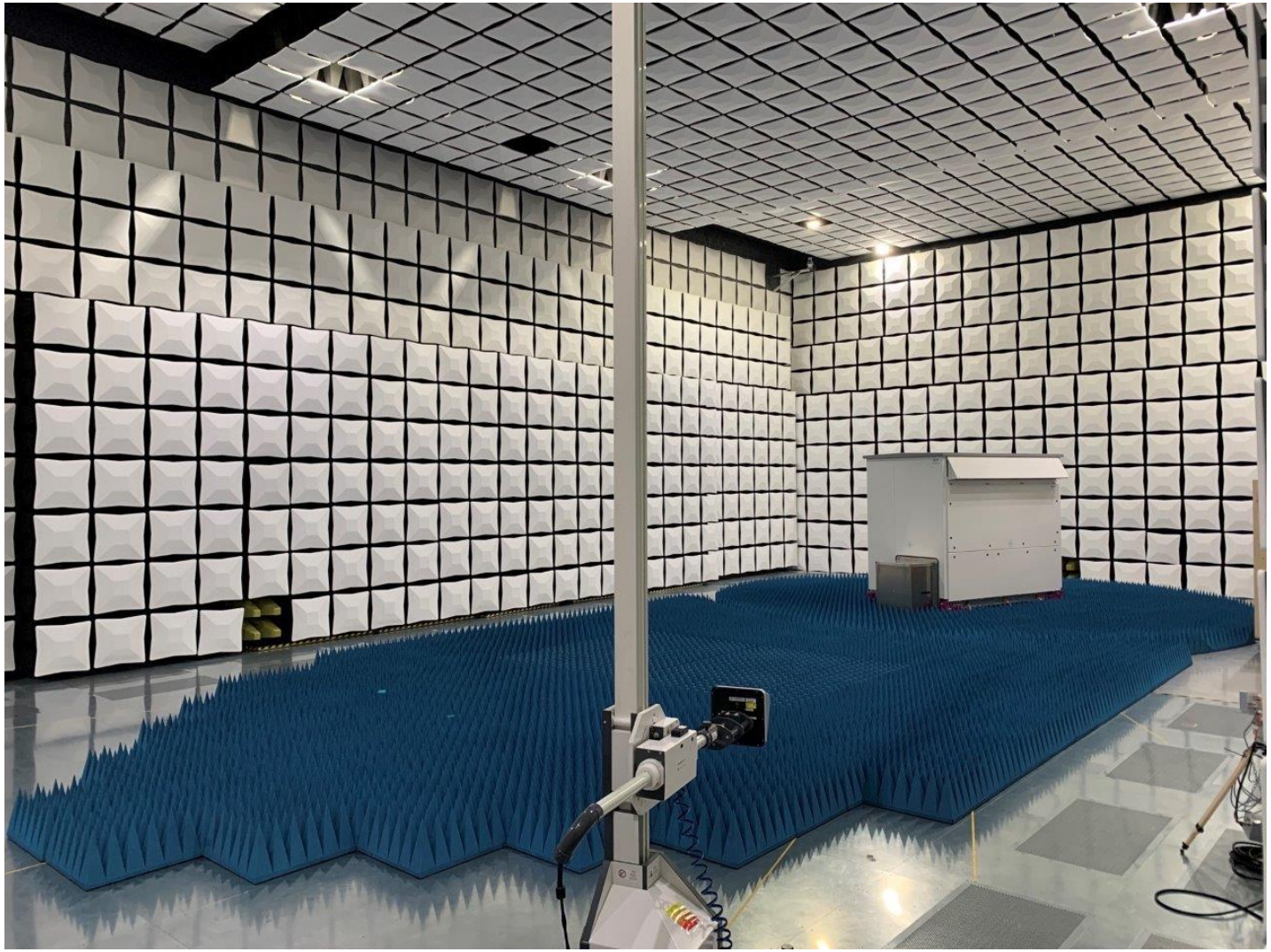

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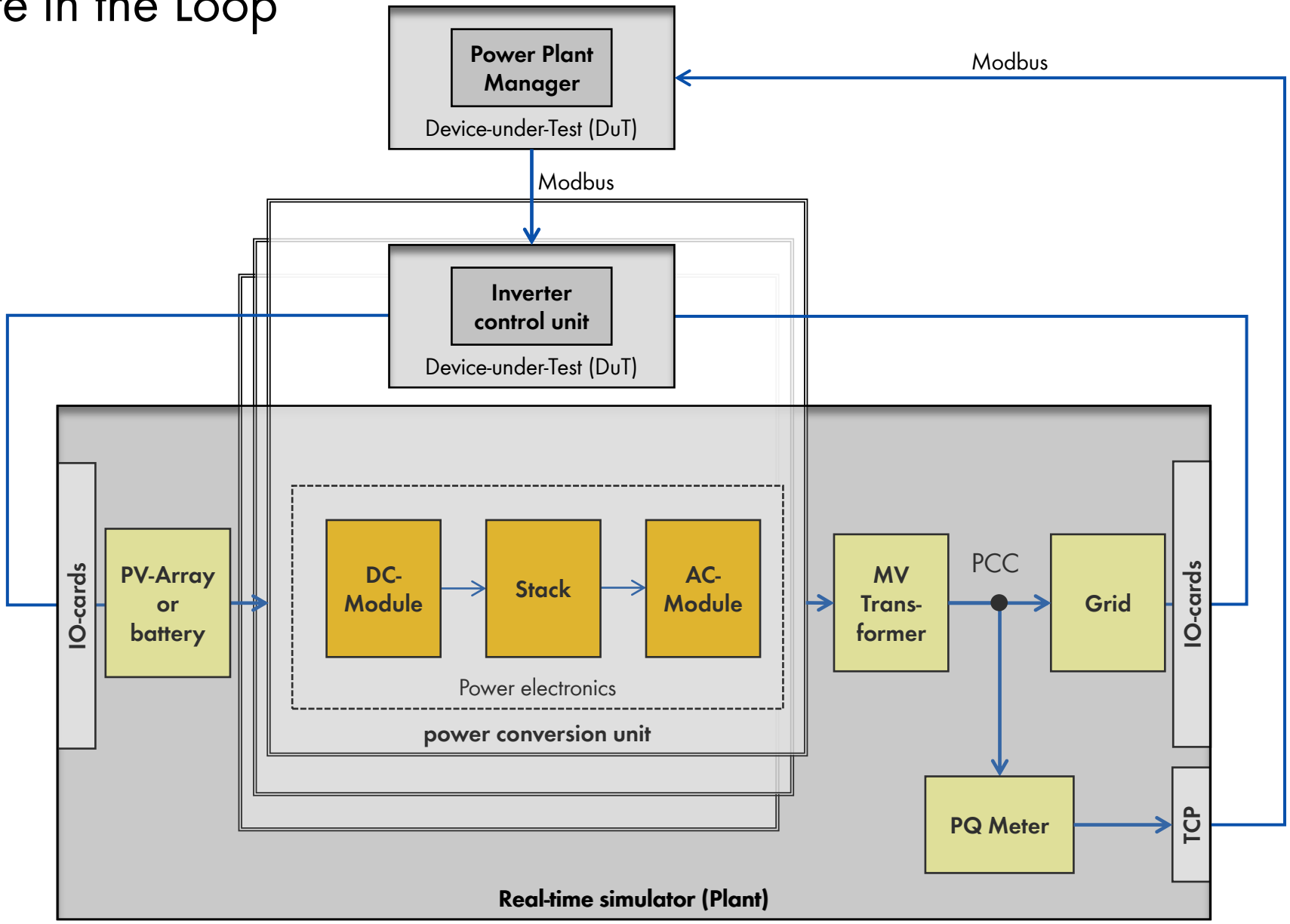
# Hardware in the Loop

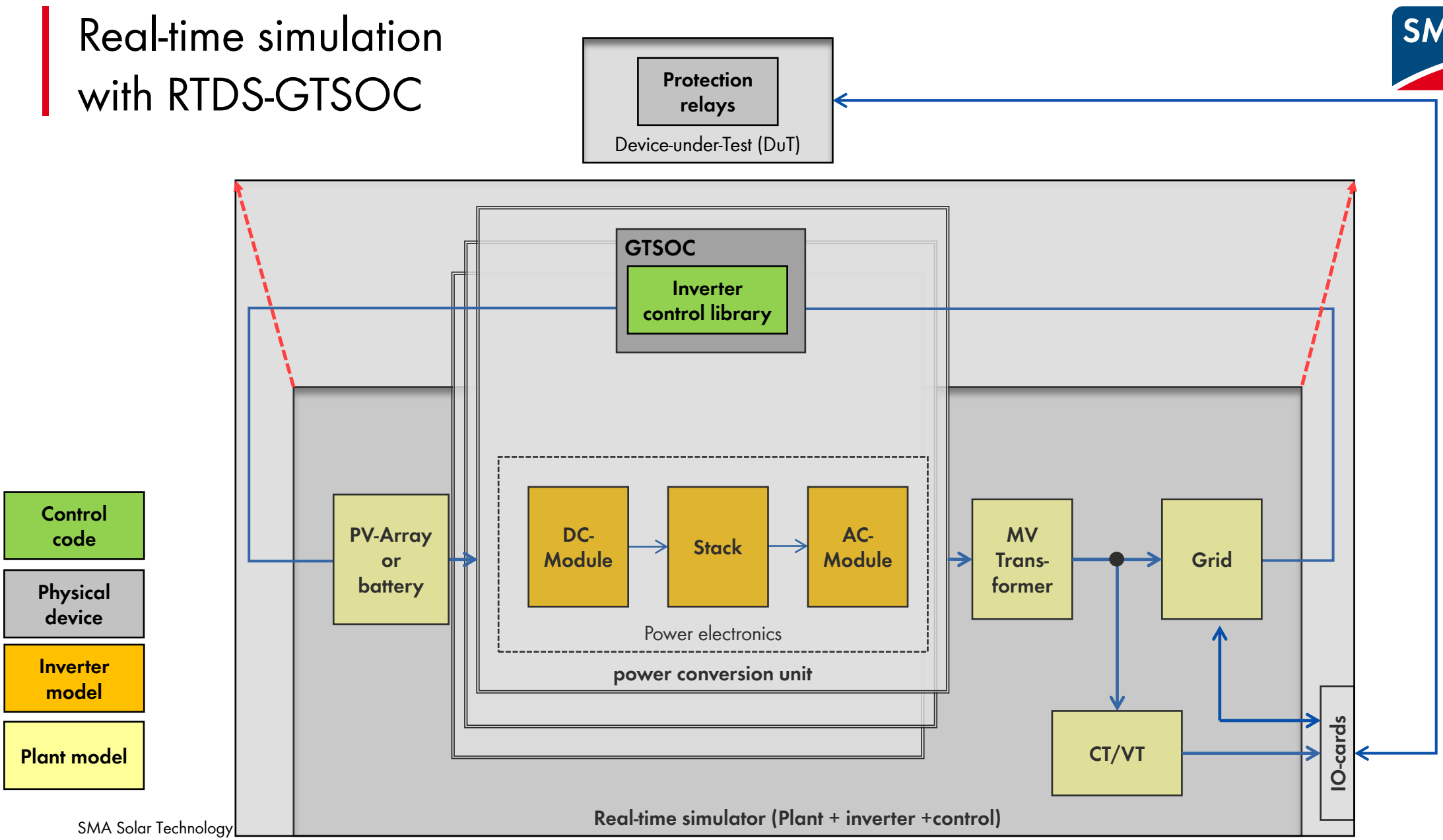



Physical device

Inverter model

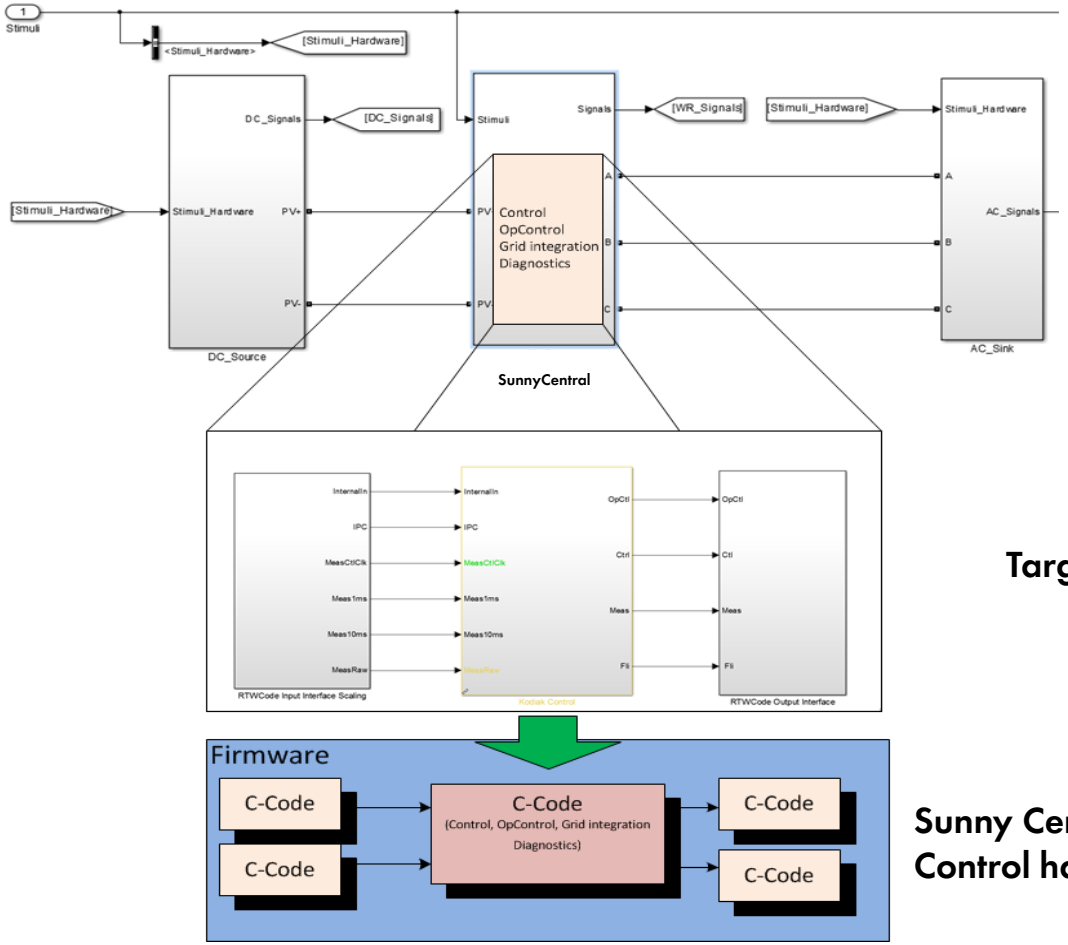
Plant model

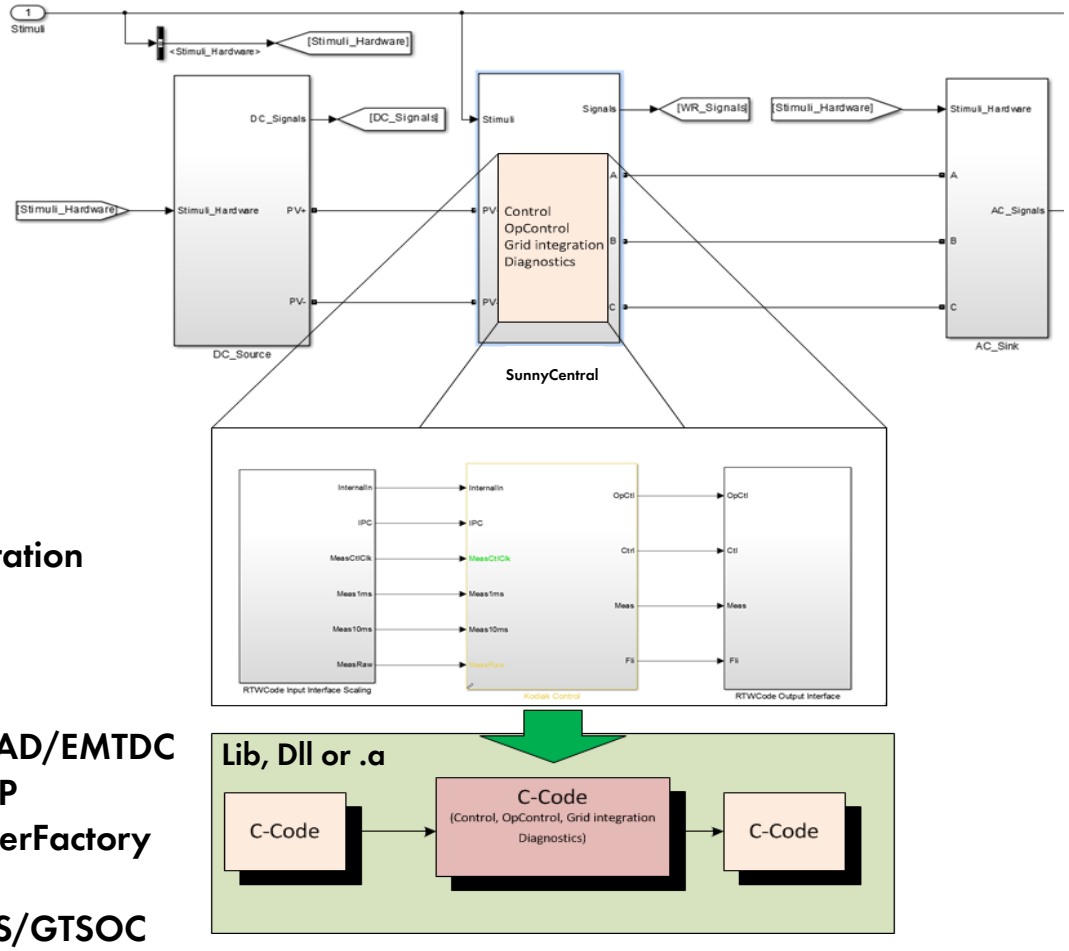
# Real-time simulation with RTDS-GTSOC



# Model based development of control code

**Common model for firmware and EMT simulation**



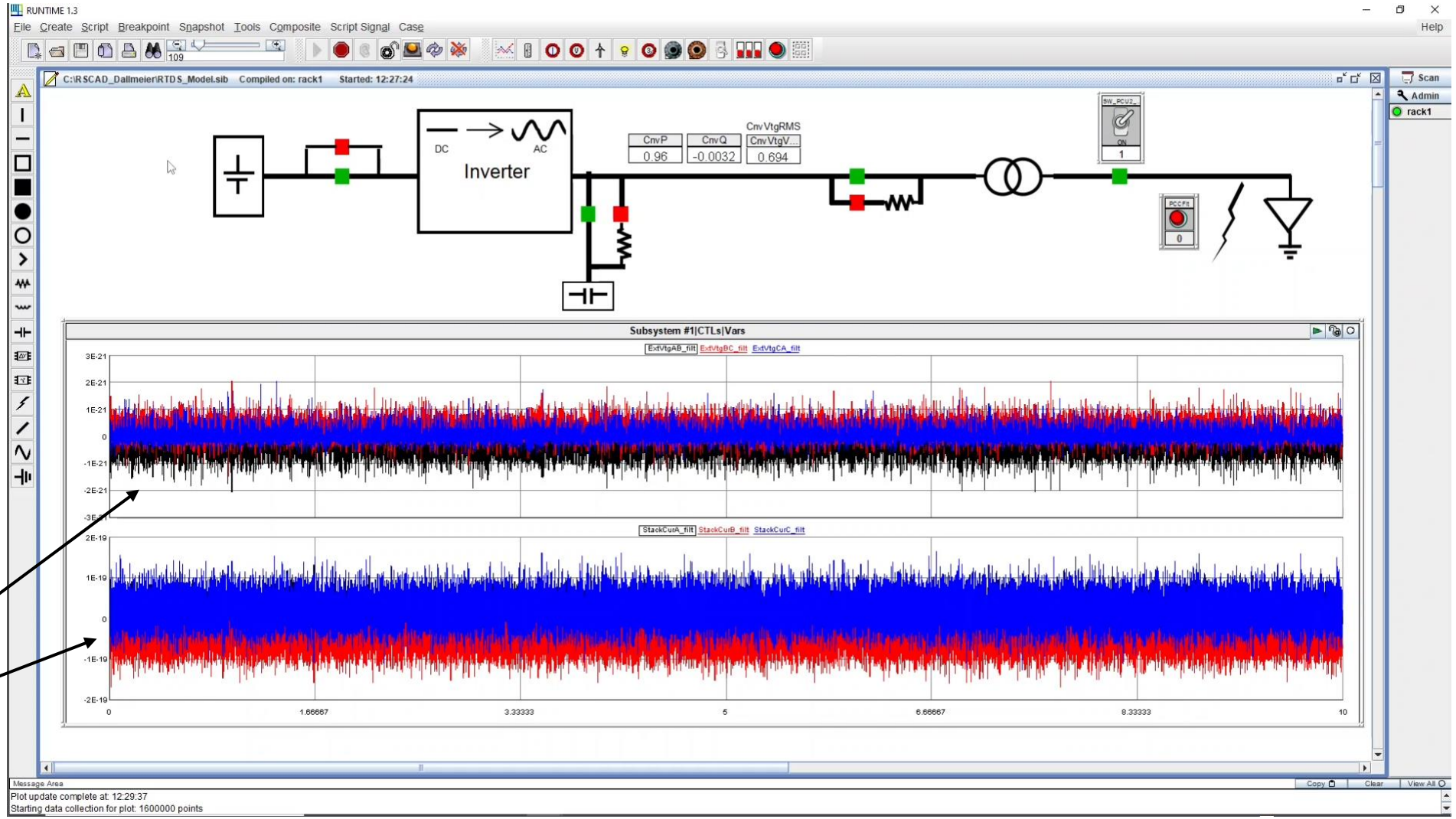

**Target specific code generation**

**Sunny Central Control hardware**

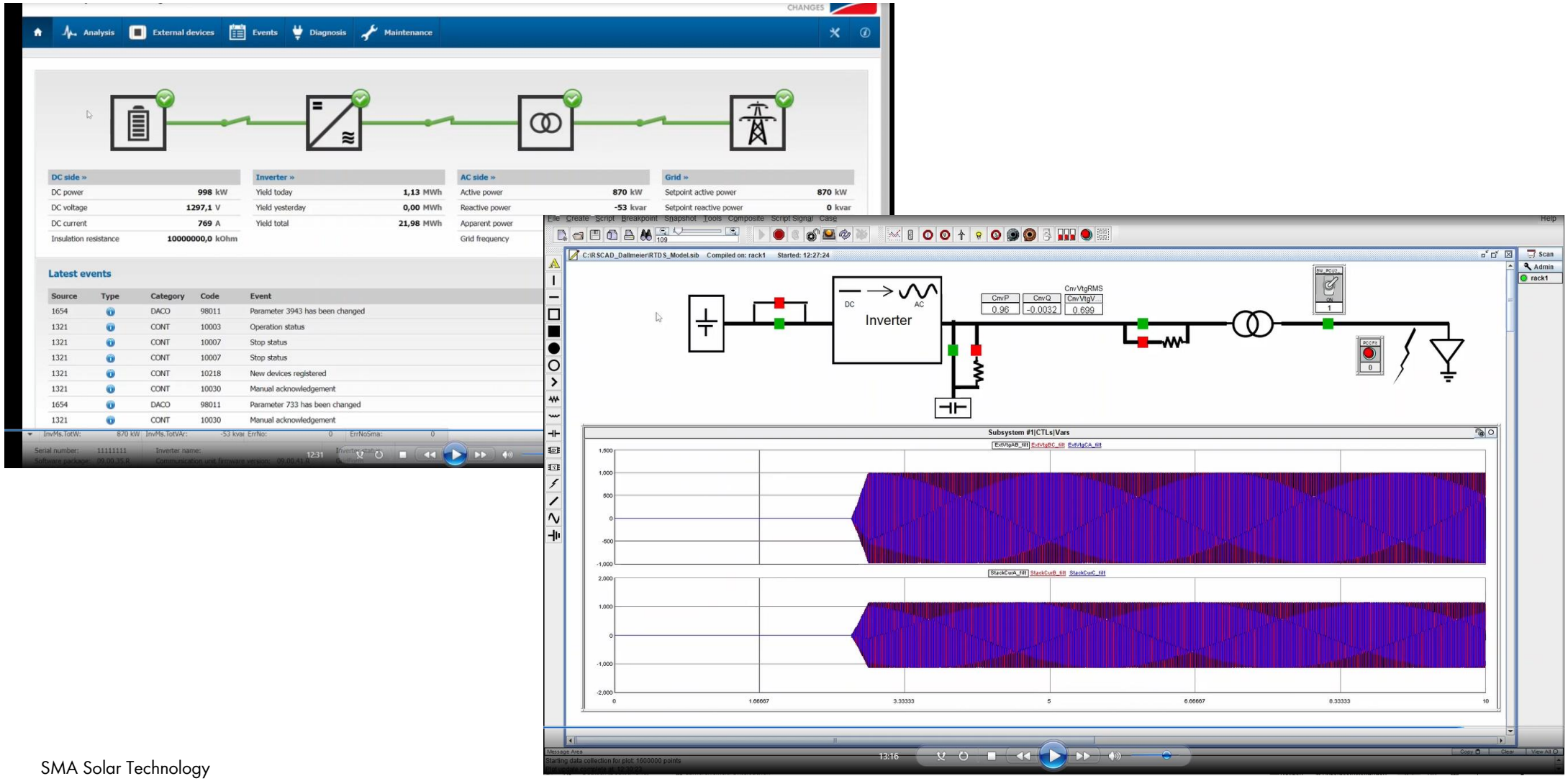
- **PSCAD/EMTDC**
- **EMTP**
- **PowerFactory**
- **ATP**
- **RTDS/GTSOC**

# HIL demonstration: Blackstart of Sunny Central Storage

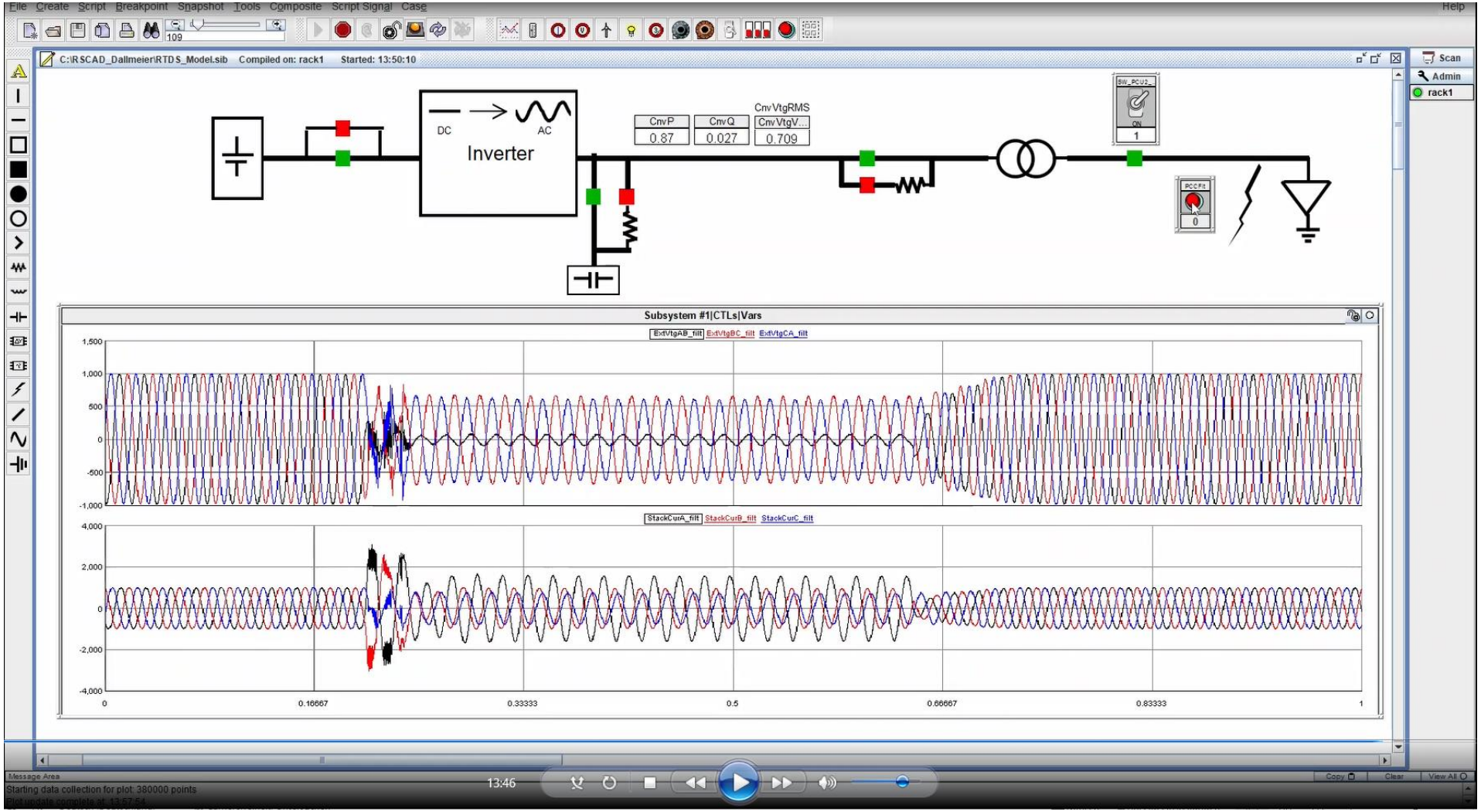
- **Sunny Central Storage hardware**
- **Battery represented by a voltage source with resistance**
- **Ygd transformer grounding starpoint of the MV side**
- **Resistive load**
- **Single phase to ground fault**
- **Terminal voltage**
- **Inverter current**



# HIL demonstration: Blackstart of Sunny Central Storage



# HIL demonstration: Fault ride through in Grid Forming operation



# Conclusion

- **HIL SYSTEMS SIGNIFICANTLY SIMPLIFY TESTING OF COMPLEX SYSTEMS**
- **GTSOC HARDWARE PROVIDES AN EASIER WAY FOR OEMS TO INCLUDE REAL CONTROLS IN RTDS**

# Thank you for watching!

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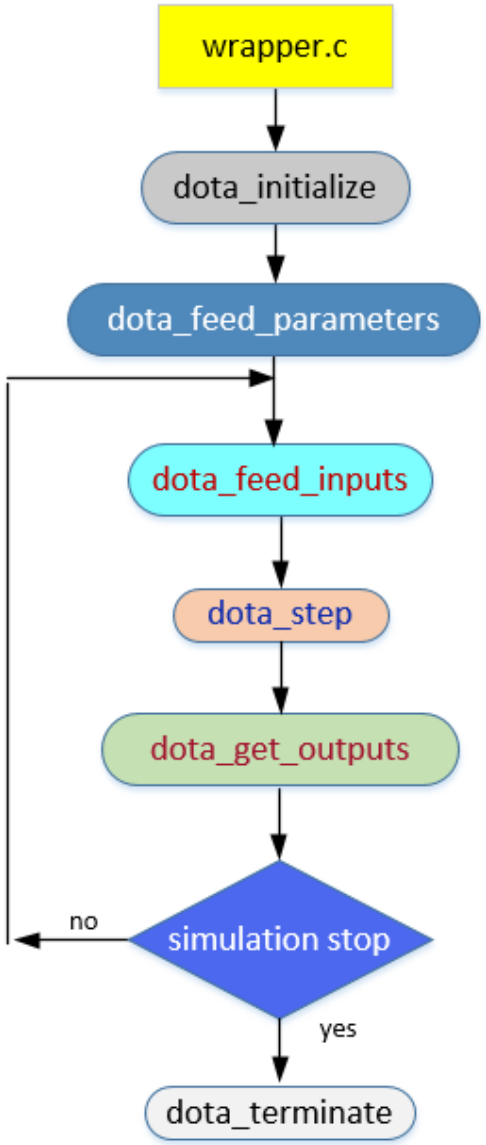
# Procedure

1. Compile library file
2. Create Application/Firmware



# GTSOC Interface Tool

# Hardware Setup


# Thank you!

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