Symbols

- Circuit breaker
- Isolator
- Grid
- Inverter
- Battery
- Current Transformer
- PV arrays
- 3 Phase Smart Energy Meter
- RJ45 port

- Solar panels, DC cables and Grid side
- BESS, Inerters and Power cables
- CAT 6 cable (Modbus TCP)
- Digital signal from PLC to trip MCCBs
- Current senser/transformer 0-5A signal to smart meter

Supply
TN-C-S 400/230V 50Hz
Ipf: 12.03kA
Ief: 6.94kA, Ze: 0.0333Ω

L/N 2x4x1Cx240mm²
PVC70/SI/Cu
CPC 1x240mm²

0-5A (Current Senser scaled reading to Smart Energy meter)
CT ratio 200/5A

CT
200/5A

MCCB 3P 630A
Ir=504A/50kA
Adjustable

SCHNEIDER MAIN BOARD
1600A

3_L1 | 3_L2 | 3_L3 | 4_L1 | 4_L2 | 4_L3

24V UVR
MCCB 3P 400A
Ir=280A/50kA
Adjustable

MCB B 3P
100A/20kA

AC2
L/N 2x5Cx95mm²
SWA/XLPE90/Cu
CPC cable core

Isolator
400A

L/N 4x1Cx50mm²
PVC70/SI/Cu
CPC 1x2.5mm²
c-d-3

SITE LOADS

Site Loads
The site loads are variable. We need the ability to import a load profile into the HIL software, defined as load (kW) versus time. This load profile will be provided in a CSV file.

PVDB

1_L1 | 1_L2 | 1_L3 | 2_L1 | 2_L2 | 2_L3 | 3_L1 | 3_L2 | 3_L3 | 4_L1 | 4_L2 | 4_L3

24V UVR
MCCB 3P 80A
Ir=63A/18kA
Adjustable (Bi-Dir)

24V UVR
MCCB 3P 125A
Ir=125A/18kA (Bi-Dir)

24V UVR
MCCB 3P 125A
Ir=125A/18kA (Bi-Dir)

24V UVR
MCCB 3P 100A
Ir=100A/36kA
Adjustable

AC4
L/N 5Cx35mm²
SWA/XLPE90/Cu
CPC cable core

AC5
L/N 5Cx70mm²
SWA/XLPE90/Cu
CPC cable core

AC6
L/N 5Cx70mm²
SWA/XLPE90/Cu
CPC cable core

AC3
L/N 5Cx70mm²
PVC70/SI/Cu
CPC cable core

Isolator
125A

Isolator
125A

Isolator
125A

Inv 1 (57.7A)
Solis S5-GC40K

Inv 2 (86.6A)
Solis S5-GC60K

Inv 3 (86.6A)
Solis S5-GC60K

Villion EnerArk
215kWh
50 kVA

6mm² Solar/SI/Cu

6mm² Solar/SI/Cu

6mm² Solar/SI/Cu

Modbus TCP (Cat6 cable)

Modbus TCP (Cat6 cable)

Modbus TCP (Cat6 cable)

Earth Terminal

Earth Terminal

Earth Terminal

8 x Strings
86 x Modules
35.69kWp

10 x Strings
179 x Modules
74.26kWp

10 x Strings
179 x Modules
74.29kWp

3 phase Smart Energy Meter
Details: Eastron Smart X95
Modbus TCP (registers are in table)
IP: 168.254.10.200

Wh

Address	Description
30001	phase 1 L-N volts
30003	phase 2 L-N volts
30005	phase 3 L-N volts
30007	phase 1 current
30009	phase 2 current
30011	phase 3 current
30053	Total system power (W)
30071	System frequency (Hz)
30073	Total Import kWh
30075	Total Export kWh

3 phase Inverter (INV1 to INV3)
Details: Solis inverters
Modbus TCP (registers are in table)
INV1: IP: 168.254.10.201
INV2: IP: 168.254.10.202
INV3: IP: 168.254.10.203

Address	Description
40001	Inverter Status
40003	Inverter Active Power Output
40005	Max AC Output Power
40007	Export Limit Value
40009	Active Power Setpoint
40011	phase 3 current
40013	Reactive Power Setpoint
40015	Grid Frequency Reading
40017	DC Input Power
40020	Inverter Temperature

AC battery (inveter intergrated inside)
Details: Villion battery
Modbus TCP (registers are in table)
IP: 168.254.10.205

Address	Description
41001	Battery State of Charge (SOC)
41003	Battery Voltage
41005	Battery Current
41007	Charge Command Enable
41009	Battery Temperature
41011	Battery Status
41013	Charge Power Setpoint
41015	Discharge Command Enable
41017	Discharge Power Setpoint
41019	Max Charge/Discharge Rate Limit

Solar Panels:
We need to import a CSV file containing irradiance and temperature versus time in order to simulate the resulting variable PV generation. We already have this CSV file prepared. Does the HIL101 support loading time-series irradiance and temperature data for PV generation simulation?

Unmanaged
Ethernet Switch

Digital signal from PLC to MCCBs

PLC CPU AXF2152 | PLC Digital Output Card | PLC Digital Input Card | PLC Digital Output Card

Phoenix Contact PLC
Details: ACX F2152 COU
IP: 168.254.10.1

Note:
The PLC is the Energy management system
Requirements:
1. Ensure the power export is limmetd to 11kW
- If the generation is

AWS cloud

MQTT

MQTT

Remote
Monitoring platform

1. Plots of inveter current, voltage, power
2. Plots of meter import and exports
3. Plots of battery SOC, charging status

1. Power System Model (SLD Level, Not Component Level)
I need the ability to draw and simulate the power network exactly as it appears in the Single Line Diagram (SLD). The model should stay at system level—not detailed switching models like MATLAB Simulink component-level circuits.

Key required elements in the SLD:
a). PV inverters
b) Battery system
c) Point of connection (PCC) meter
d) Site loads
e) Grid connection
f) Circuit breakers (optional)

2. PV Inverters (with Modbus TCP Interface)
Real-time Generation Simulation
- Each inverter is connected to PV strings.
- I need to import CSV files containing irradiance and temperature vs. time.
- The HIL should simulate inverter AC output power based on these inputs.
- Modbus TCP Communication With Real PLC

Each digital created inverter model in HIL softwate must:
- Have a configurable IP address, just like a real device.
- Provide the Modbus TCP registers needed for:
a) Reading power generation
b) Reading voltages and currents
c) Writing control commands from the physical PLC (e.g., ramp down or ramp up power)

Important:
Ramp-down/ramp-up commands should not modify irradiance; they should limit inverter output power regardless of available solar input.

Questions for Typhoon
a) Can HIL101 support multiple simultaneous Modbus TCP slave devices (one per inverter)?
b) Can custom Modbus register maps be defined?

3. Battery Energy Storage System (BESS)
The digital twin should include a battery connected as shown on the SLD.
Modbus TCP Control and Monitoring
a) The digital battery model must have a configurable IP address and expose registers for:
- State of Charge (SOC)
- Charge command
- Discharge command
- Charge rate
- Discharge rate
- Battery status (Running / Idle / Fault)

A real external PLC should be able to:
- Command charging
- Command discharging
- Read SOC and status in real time

Question
a) Can the HIL101 battery model support external charge/discharge commands with defined power limits?

4. PCC Meter (Grid Connection Meter)
The platform should include a smart meter at the point of connection.

Required Capabilities
a) Combine and measure total power from PV inverters and the battery
b) Provide import/export direction (active power flow sign)
c) Provide Modbus TCP access for the PLC
d) Allow configurable IP address
e) Provide required Modbus registers for power measurement

Question
a) Is a configurable digital meter with Modbus TCP available in HIL101?

5. Site Load Simulation
a) The system must allow importing a load profile CSV (kW vs time).
b) The load should vary dynamically during the simulation according to the CSV file.

6. Circuit Breakers (Optional)
This is not a major requirement, but would be useful:
a) Ability to connect PLC digital outputs to HIL101 digital inputs
b) Use the signals to trip breakers on inverters or battery
c) Any workaround is acceptable if internal breaker trip units are not available

7. Integration With External Systems

My PLC already connects to a cloud monitoring platform via AWS.
The HIL101 simulation will serve as the digital twin to:
a) Test the already-developed Energy Management System (EMS)
b) Validate the PLC control logic
c) Read digital power system data via modubus TCP to the PLC and PLC will send it to the could for remote monitoring
d) Respond to forecast-based commands coming from the PLC connected (e.g., battery charge/discharge)

What I Expect From the HIL101 Platform
a) A system-level drawing environment to model the SLD. Not a componet level model like like power electronics Mosfets to ramp up and down. I expect a modbus registers like real power systems devices
b) Ability to load CSV profiles for PV generation (irradiance, temperature).
c) Ability to load CSV load profiles.
d) Multiple digital devices (inverters, battery, meter) each with:
-Configurable IP addresses
-Modbus TCP server functionality
-Read/write registers to communicate with a real PLC
-Ability to simulate inverter power output and battery charge/discharge in real time.
-Ability to ramp inverter power up/down using PLC commands.
-Ability to measure power flow at the PCC and report import/export direction.
-Optional digital I/O interaction for breaker tripping.

Final Clarifying Questions for Typhoon
a) Can HIL101 host multiple Modbus TCP slave devices simultaneously (inverters, battery, meter)?
b) Can we define custom Modbus register maps for each digital device?
c) Can HIL101 simulate inverter power limiting independently of irradiance?
d) Does the standard library include system-level inverter, battery, and meter components, or must these be custom-built?
e) Are CSV-driven time-series inputs directly supported?
f) Can the HIL101 handle full-day or multi-day simulation time profiles?

Project Notes:

Major Components:

Modules-
474 x JA Solar Holdings JAM54S30-415/MR
Inverters-
2 x Solis S5-GC60K
1 x Solis S5-GC40K
1 x Vilion battery
1 x Phoenix Contact PLC (AXC F 2152)

generic logo company

Revision	Design
By: Brighton Chikomo	By: Brighton Chikomo
Date: 10/12/2025	Date: 24/01/2025
Checked By:	Approved By:

Revision notes:
Rev A- Initial design HIL101 Typhoon

Project client:	Project title:
Project 1	HIL-Typhoon
Drawing title: SLD	

Scale:	Size:	Drawing No:	Job No:	Revision:
NTS	A3	001	Z0001	B