1. Product Description

The automation of electric power systems is characterized by the use of robust, reliable, and high-tech equipment and devices with the ability to operate in hostile environments, where there are significant levels of electromagnetic interference and exposure to higher operating temperatures. This is the reality of applications in hydroelectric power plants (HPPs), electricity substations, and wind farms, among others.

In this context, the Hadron Xtorm Series is an innovative Remote Terminal Unit (RTU), perfect for applications in electricity generation, transmission, and distribution. The Series has an ideal set of features with high performance and facilities for the various stages in the life cycle of an application, to reduce engineering, installation, and commissioning costs and minimize downtime and system maintenance when in operation. With intuitive and user-friendly interfaces, precise and intelligent diagnostics, a modern and robust design, and several innovative features, Hadron Xtorm exceeds the requirements of applications in this market.

The Series has an intelligent and versatile architecture, offering modularity in input and output (I/O) points, redundancy options, hot-swapping of modules, high-speed communication protocols such as IEC 61850 and DNP3, implementation of logic in compliance with the IEC 61131-3 standard and time synchronization.

The Hadron Xtorm Series HX6065 module offers three AC voltage measurement inputs, an additional AC voltage input for synchronization, four AC current measurement inputs, and four analog outputs for control that can be individually configured by software as voltage or current outputs in different scales.

Its main features are:

- 3 AC voltage inputs (300 V)
- 1 AC voltage input (300 V) for synchronization
- 4 AC current inputs (5 A)
- 4 configurable analog outputs for voltage or current scales
- Short circuit protection for voltage outputs
- Galvanic isolation between inputs, outputs and internal logic
- Protection against surge voltage
- Display for indicating the status of inputs, outputs and diagnostics
- Hot-swap support
- Highly robust mechanical design and extended operating temperature
- High electromagnetic noise immunity (EMC/EMI)
- Intelligent diagnostics, such as One Touch Diag and Electronic Tag on Display
- Phase, line and synchronism voltage measurement
- Phase and neutral current measurement
- Control voltage measurement
- Measurement of frequency, power angle and angle between phases
- Voltage and current unbalance measurement
- Measurement of voltage and current sequence components
- Measurement of active, reactive and apparent power and power factor
- Configurable AC value calculation window

2. Ordering Information

2.1. Included Itens

The product package contains the following items:

- HX6065 Module
- Four connectors 00.303.121-6

2.2. Product Code

The following codes should be used to purchase the product:

Code	Description
HX6065	AC Measurement / 4O Voltage/Current Mixed Module

Table 1: Product Code

3. Innovative Features

Hadron Xtorm Series brings to the user several innovations in utilization, supervision and system maintenance. These features were developed focusing a new concept in automation of hydropower plants, substations and other applications of the segment.The list below shows some new features that the user will find in Hadron Xtorm Series:

One Touch Diag: One Touch Diag is an exclusive feature that Hadron Xtorm Series brings to PLCs. With this new concept, the user can check diagnostic information of any module present in the system directly on CPU's graphic display with one single press in the diagnostic switch of the respective module. OTD is a powerful diagnostic tool that can be used offline (without supervisor or programmer), reducing maintenance and commissioning times.

ETD – Electronic Tag on Display: Another exclusive feature that Hadron Xtorm Series brings to PLCs is the Electronic Tag on Display. This new functionality brings the process of checking the tag names of any I/O pin or module used in the system directly to the CPU's graphic display. Along with this information, the user can check the description, as well. This feature is extremely useful during maintenance and troubleshooting procedures.

4. Product Features

4.1. General Features

	HX6065
Module type	Mixed AC measurement module with analog outputs
Input types	3 inputs for AC voltage measurement (300 V) 1 input for synchronous AC voltage measurement (300 V) 4 isolated inputs for AC current measurement (5 A)
Input configuration	4- Wye Wire (star) 3- Delta Wire (triangle) 2- Single Wire (single-phase)
Frequency measurement range **0.25% accuracy** **No precision**	 45 to 65 Hz 10 to 45 Hz; 65 to 180 Hz
A/D converter resolution	24 bits with simultaneous sampling between channels
Sample rate	7.2 kSPS
Input data format	32-bit Floating Point, IEEE 754 compliant
Input status indication	Yes
Output type	4 voltage or current outputs, individually configurable by software
Output Data Format	12 bits in two's complement, left-justified
D/A converter resolution	12 bits with guaranteed monotonicity, no missing codes
Output status indication	Yes
One Touch Diag (OTD)	Yes
Electronic Tag on Display (ETD)	Yes
Status and diagnostic indication	Display, web page, and internal memory of the CPU
Hot Swap Support	Yes
Module Protections	Yes, protection against voltage surges at the inputs and against short circuits at the outputs
Isolation **Input and Output to logic** **Input and Output to protective earth⏚** **Logic for protective earth ⏚**	 2500 Vac / 1 minute 2500 Vac / 1 minute 2500 Vac / 1 minute
Current consumption from backplane	350mA
External power supply	19.2 to 30 Vdc
Maximum current consumption of the external power supply	175 mA
Maximum power dissipation	7 W
Wire gauge	0.5 to 1.5 mm²
IP level	IP 20
Operating temperature	-5 to 70 °C
Storage temperature	-25 to 75 °C
Operation and storage relative humidity	5% to 96%, non-condensing
Conformal coating	Yes
Module dimensions (W x H x D)	38.0 x 235.3 x 187.2 mm
Package dimensions (W x H x D)	55.0 x 308.0 x 266.0 mm

	HX6065
Weight	800 g
Weight with package	1100 g

Table 2: General Features

Notes:

The frequency range for precise measurements: The accuracy of the module's input variables is guaranteed between 45 and 65 Hz.

Frequency measurement range: Input-derived frequencies and variables are indicated between 10 Hz and 180 Hz. Outside this range, they are null/zero.

One Touch Diag (OTD): This option is available only when the module is in operating mode

Maximum power dissipation: Considering the nominal voltage and current levels at the module's inputs/outputs.

Conformal coating: Conformal coating protects the electronic components inside the product from moisture, dust and other harsh elements to electronic circuits.

4.2. Standards and Certifications

Standards and Certifications	
IEC	61131-2: Industrial-process measurement and control - Programmable controllers - Part 2: Equipment requirements and tests
CE	2014/30/EU (EMC) 2014/35/EU (LVD)

Table 3: Standards and Certifications

4.3. AC Input Features

	AC Voltage Input
Nominal - Phase - Neutral (L-N)	300 V
Voltage measurement range **Phase - Neutral (L-N)** **Phase - Phase (L-L)**	 50 – 300 V 87 – 520 V
Maximum - Phase - Neutral (L-N)	330 V / 20 s
Input Impedance	>1 MΩ

Table 4: AC Voltage Input Features

	AC Current Input
Nominal	5 A
Current measurement range	0.1 – 5 A
Maximum	10 A / 10 s
Input Impedance	< 30 mΩ

Table 5: AC Current Input Features

4.4. Analog Output Features

	Voltage Mode Outputs		
Output range	Range	Scale	Resolution
	0 to 10 Vdc -10 to 10 Vdc	0 to 30.000 -30.000 to 30.000	5,03 mV 5,03 mV
Precision	±0.6 % of full scale rating @ 25 °C ± 0.005 % of full scale rating / °C		
Update time	3 ms for all outputs		
Stabilization time	4 ms		
Maximum output value	± 10.3 V		
Load impedance	> 1 kΩ		

Table 6: Voltage Mode Outputs Features

	Current Mode Outputs		
Output range	Range	Scale	Resolution
	0 to 20 mA 4 to 20 mA	0 to 30.000 0 to 30.000	10.25 uA 10.25 uA
Precision	±0,6 % of full scale rating @ 25 °C ± 0.005 % of full scale rating / °C		
Update time	3 ms for all outputs		
Stabilization time	4 ms		
Maximum output value	20.5 mA		
Load impedance	< 600 Ω		

Table 7: Current Mode Outputs Features

Note:
Output Range: The resolutions shown are the best provided by the hardware.

4.5. Accuracy of AC Measurements

The precisions mentioned in the next topics are valid under the following conditions:

- Temperature of 25 °C;
- Frequency in the range of 45 Hz to 65 Hz
- Voltage in the range of 30 V to 300 V RMS
- Current in the range of 0.5 A to 5 A RMS

4.5.1. Effective Voltages

± 0.30% of the read value ±0.3 V
± 0.005% of the read value °C

4.5.2. Effective Currents

± 0.35% of the read value ±0.20 mA
± 0.005% of the read value °C

4.5.3. Control Voltage

± 0.5% of the read value
± 0.005% of the read value °C

4.5.4. Surge Voltage

±0.5% of the read value

4.5.5. Surge Current

±0.5% of the read value

4.5.6. Frequencies

± 0.03 Hz

4.5.7. Angle between Phases

± 0.5 degrees

4.5.8. Active Power

± 0.5% of the read value, for power factor > 0.1.

4.5.9. Reactive Power

± 0.5% of the read value, for power factor < 0.9.

4.5.10. Other AC Measurements

The other AC measurements are called derived measurements because they are calculated through relatively simple mathematical equations from the previously mentioned measurements, called primary measurements. The dependency relationship between derived measurements and primary measurements is defined by the following table.

Derived AC measurement	Primary measurements on which it depends
Power Factor	Active power Reactive power
Power Angle	Active power Reactive power
Voltage unbalance	Effective voltages L1, L2, L3
Current unbalance	Effective current L1, L2, L3
Sequence components PNZ voltage	Effective voltages L1, L2, L3 Angles between phases L1L2, L2L3
Sequence components PNZ current	Effective currents L1, L2, L3 Angles between current phases L1L2, L2L3
Apparent power	Active power Reactive power

Table 8: Derived AC measurement

Note:

Angle between current phases L1L2, Angle between current phases L2L3: The angles between current phases are calculated internally to calculate the PNZ current sequence components but are not made available in variables for use by the user application. The accuracy of these angles is ±0.5 degrees.

Therefore, the accuracy of a derived measurement depends on the accuracy of the primary measurements on which it depends and on the particular mathematical equation used. Some examples of mathematical equations are given below:

Apparent_Power = Square_Root(Active_Power^2 + Reactive_Power^2)
Power_Angle = Arc_cosine(Active_Power / Apparent_Power)
Power_Factor = Cosine(Power_Angle)

4.6. Compatibility with Other Products

Support for this product was introduced in version 2.12 of MasterTool Xtorm. Additional information regarding compatibility can be found in the Hadron Xtorm User Manual – MU223600.

5. Physical Dimensions

Dimensions in mm.

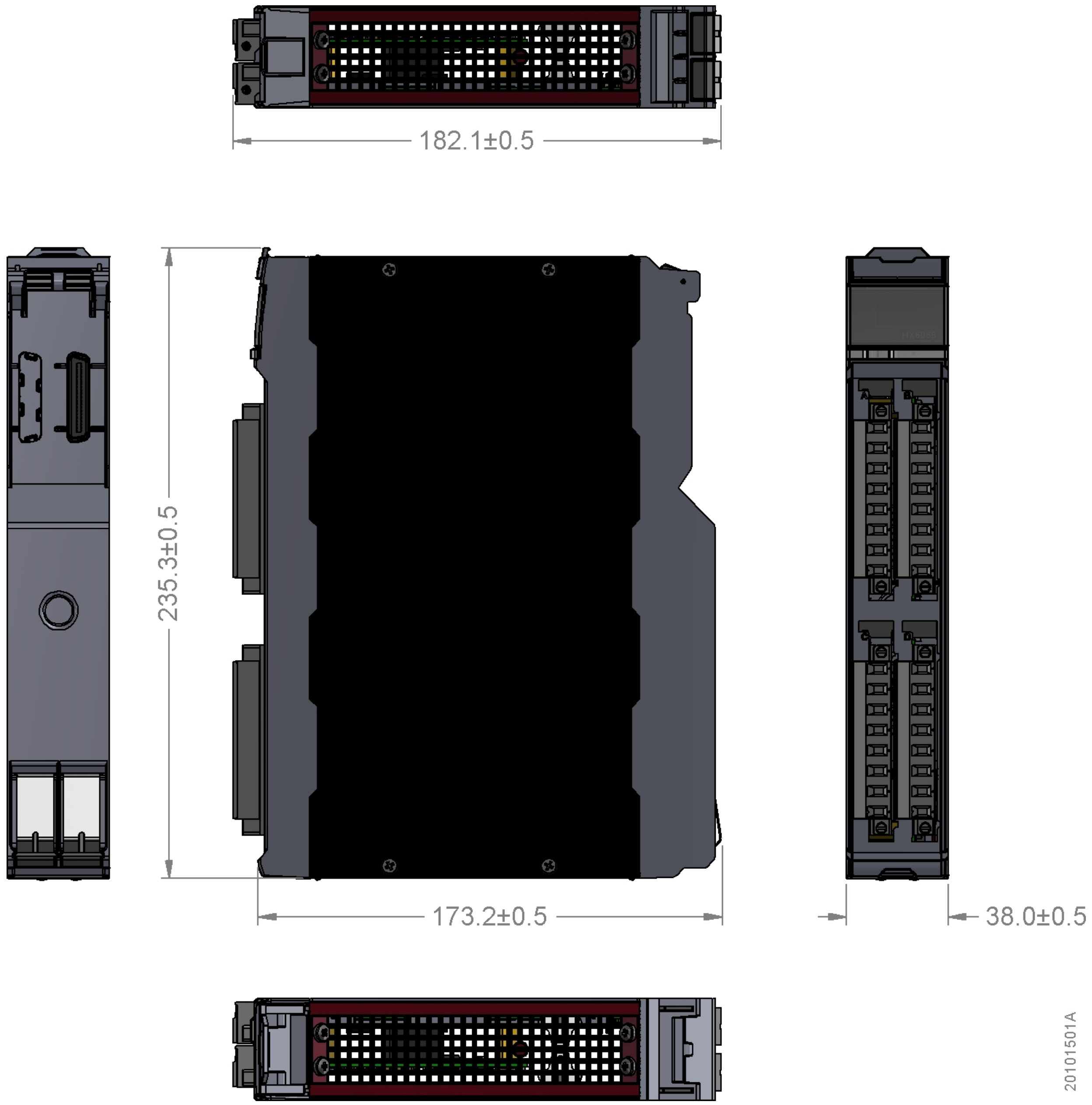

Figure 1: Physical Dimensions

6. Installation

For the correct installation of this product, it is necessary to use a rack (backplane rack) and it must be carried out according to the mechanical and electrical installation instructions that follow.

DANGER

ELECTRIC SHOCK HAZARD
This module can work with voltages above 520 Vac. Special care must be taken during installation, which should only be done by qualified technicians. Do not touch the field wiring connection to the base when in operation.

DANGER

ARC AND HIGH VOLTAGES IN SECONDARY OF CURRENT TRANSFORMERS
Take care for not opening the secondary of current transformers connected to current inputs of HX6065. This may lead to dangerous arc formation that can cause severe injuries to personnel and equipment.

6.1. Product Identification

This product has some parts that must be observed before installation and use. The following figure identifies each of these parts.

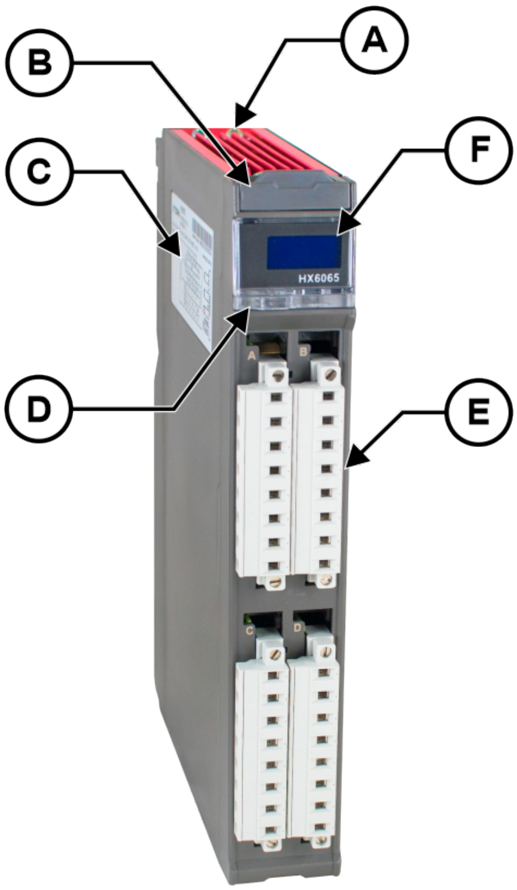

Figure 2: HX6065

- Ⓐ Fixing lock.
- Ⓑ Module Slot locking slider.
- Ⓒ Label for module identification.
- Ⓓ Diagnostic LED and switch.
- Ⓔ I/O connector.
- Ⓕ Status and diagnostic display.

The product has in its mechanics a label that identifies it and in it are presented some symbols whose meaning is described below:

⚠ Attention! Before using the equipment and installing, read the documentation.

⎓ Direct Current.

6.2. Electrical Installation

The following diagrams show the connection of inputs of the HX6065 module using several configurations (star, triangle, single-phase, and synchronism voltage).

Other diagrams show the connection of analog outputs (voltage or current) of the HX6065 module to the actuators

6.2.1. Diagram for three-phase 4-wire measurement (star) with potential transformers

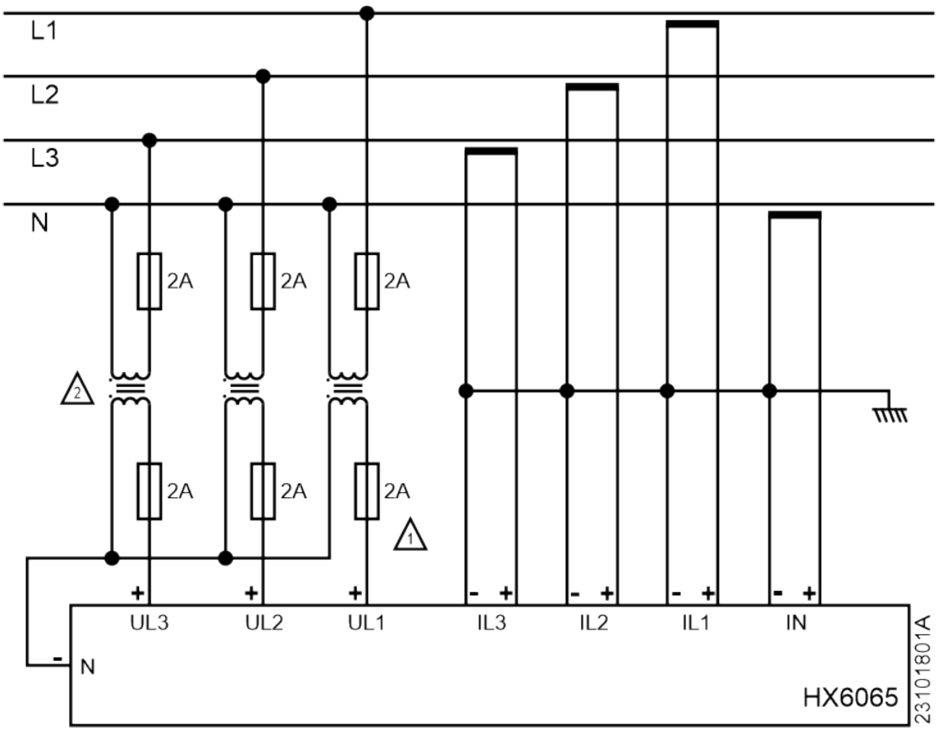

Figure 3: Three-phase 4-wire measurement (star) with potential transformers

Notes:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs to prevent damage to the module.

⚠2 Potential transformers are necessary for measuring phase-to-neutral voltages higher than 300 V RMS.

6.2.2. Diagram for three-phase 4-wire measurement (star) without potential transformer

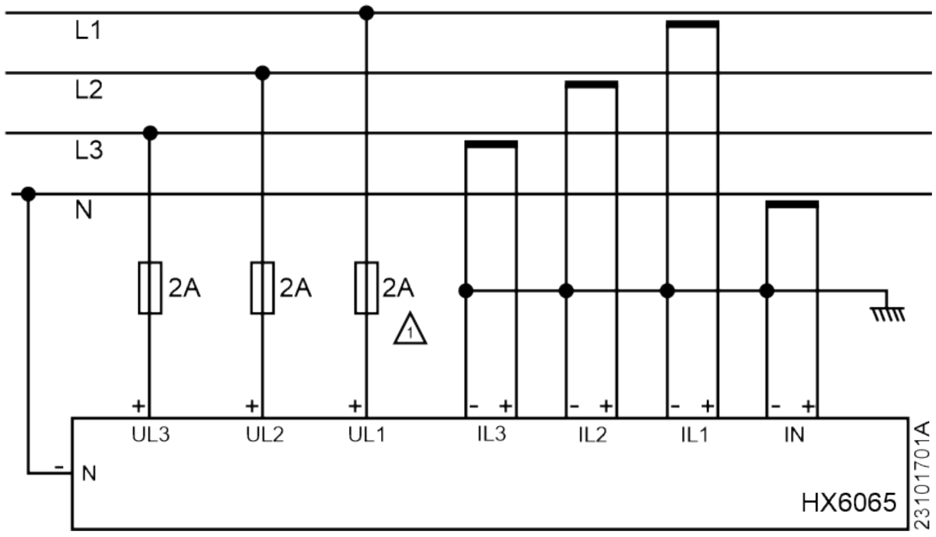

Figure 4: Three-phase 4-wire measurement (star) without potential transformer

Note:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

6.2.3. Diagram for three-phase 3-wire measurement (triangle) with potential transformer

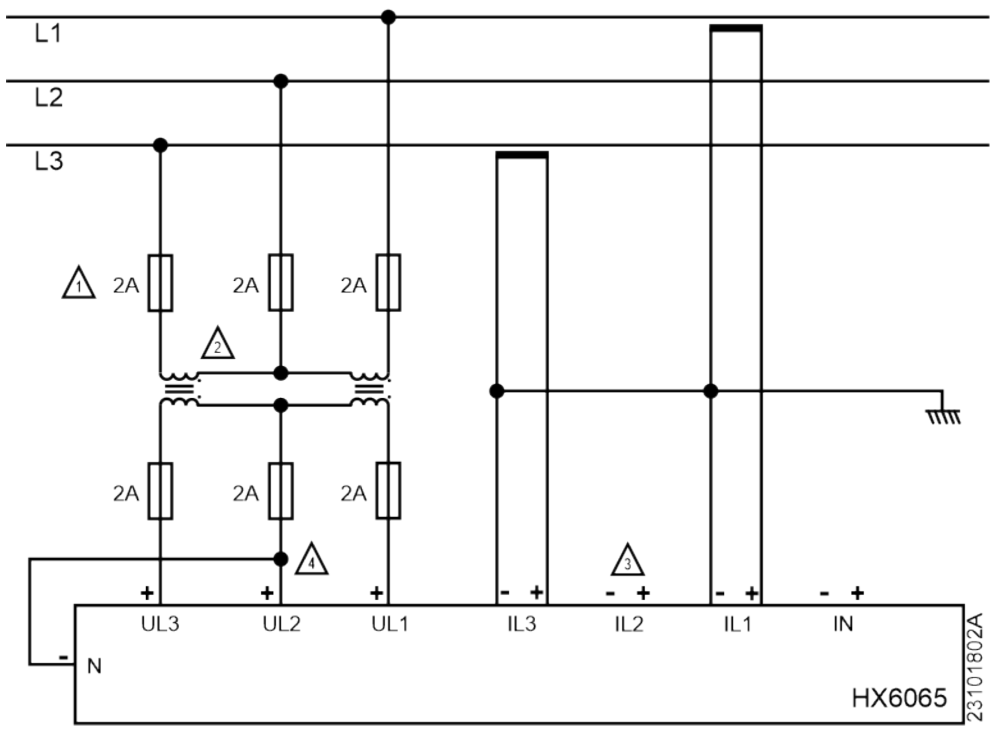

Figure 5: Three-phase 3-wire measurement (triangle) with potential transformer

Notes:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

⚠2 Potential transformers are necessary for measuring phase-to-phase voltages higher than 520 V RMS.

⚠3 In a 3-phase measurement mode with a triangle-type connection, the current inputs IL1 and IL3 must be used. The resulting current value IL2 will be calculated by the module instead of being measured.

⚠4 In a 3-phase measurement mode with a triangle-type connection, the UL2 input must be connected to the N input (neutral) in the HX6065 module.

6.2.4. Diagram for three-phase 3-wire measurement (triangle) without potential transformer

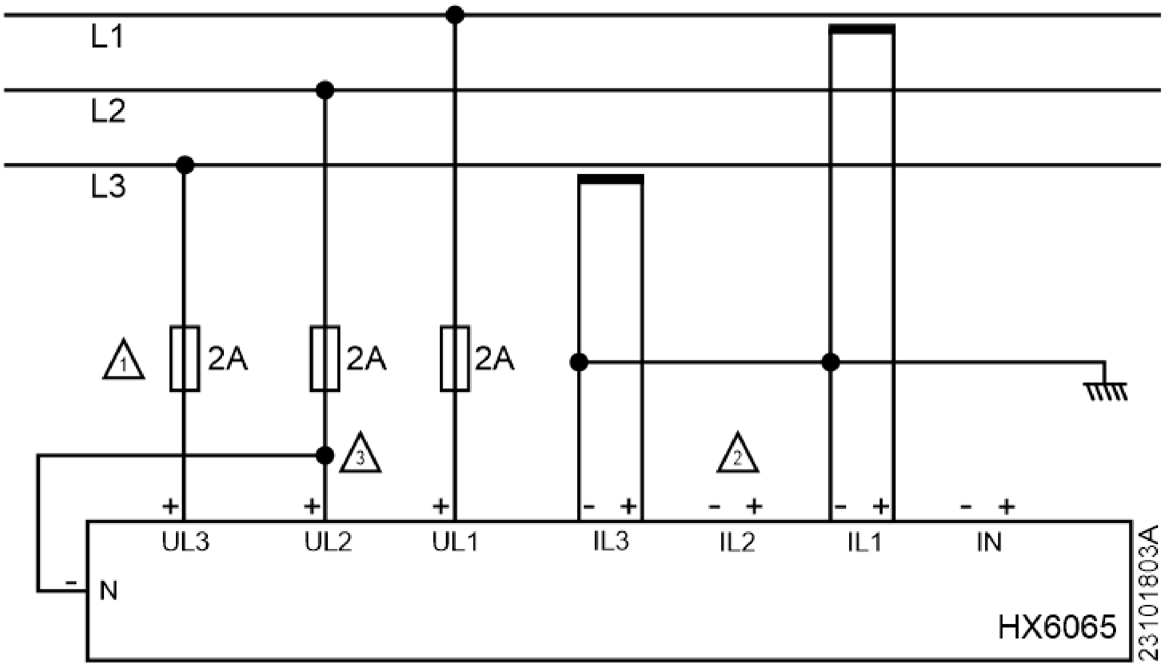

Figure 6: Three-phase 3-wire measurement (triangle) without potential transformer

Notes:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

⚠2 In a 3-phase measurement mode with a triangle-type connection, the current inputs IL1 and IL3 must be used. The resulting current value IL2 will be calculated by the module instead of being measured.

⚠3 In a 3-phase measurement mode with a triangle-type connection, the UL2 input must be connected to the N input (neutral) in the HX6065 module. The resulting voltage value UL2 will be calculated by the module instead of being measured.

6.2.5. Diagram for single-phase 2-wire measurement with potential transformer

In single-phase measurement mode, it is possible to measure the voltages and currents of up to three independent single-phase lines simultaneously, using the available voltage and current inputs (UL1 and IL1, UL2 and IL2, or UL3 and IL3). For not measuring some of the single-phase lines, simply leave the unused inputs disconnected.

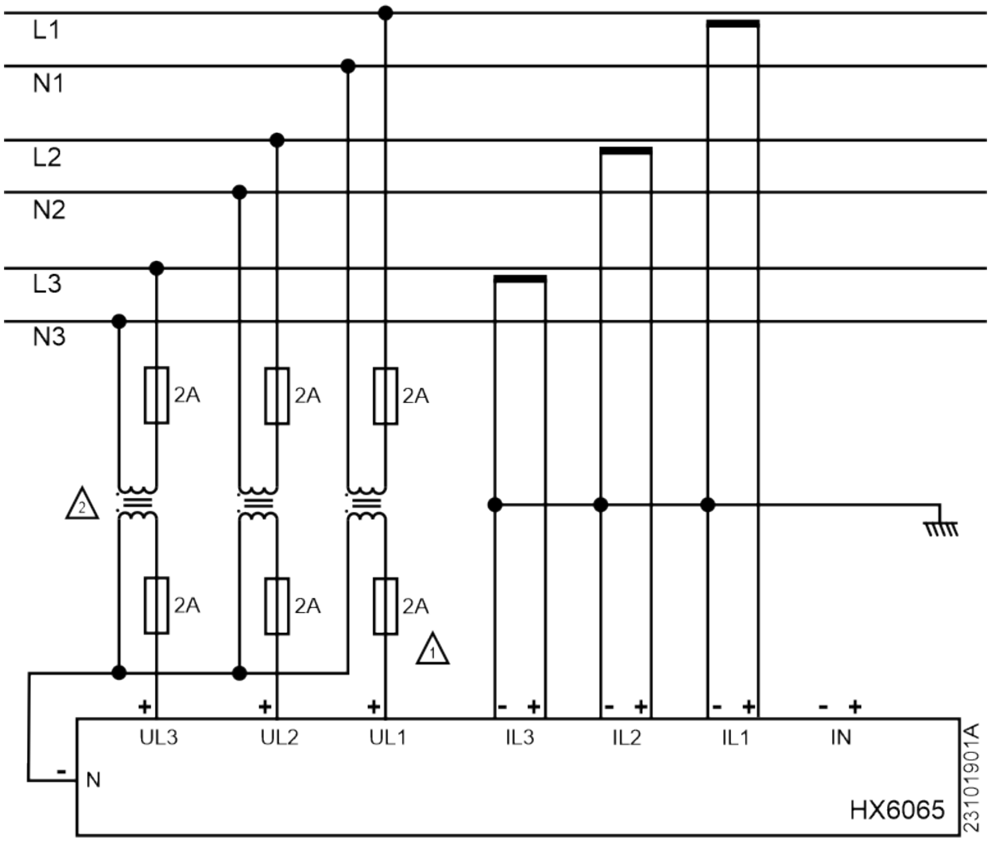

Figure 7: Single-phase 2-wire measurement with potential transformer

Notes:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

⚠2 Potential transformers are necessary for measuring phase-to-neutral voltages higher than 300 V RMS.

6.2.6. Diagram for single-phase 2-wire measurement without potential transformer

In single-phase measurement mode, it is possible to measure the voltages and currents of up to three independent single-phase lines simultaneously, using the available voltage and current inputs (UL1 and IL1, UL2 and IL2, or UL3 and IL3). For not measuring some of the single-phase lines, simply leave the unused inputs disconnected.

ATTENTION

For connecting more than one single-phase line to the HX6065 module, we suggest using the Diagram for single-phase 2-wire measurement with potential transformer since the neutral input (N) is common to the 3-phase voltage inputs of the module (UL1, UL2, and UL3). If there are significant risks or potential differences between the neutrals of the different single-phase lines, this diagram without a potential transformer is not recommended.

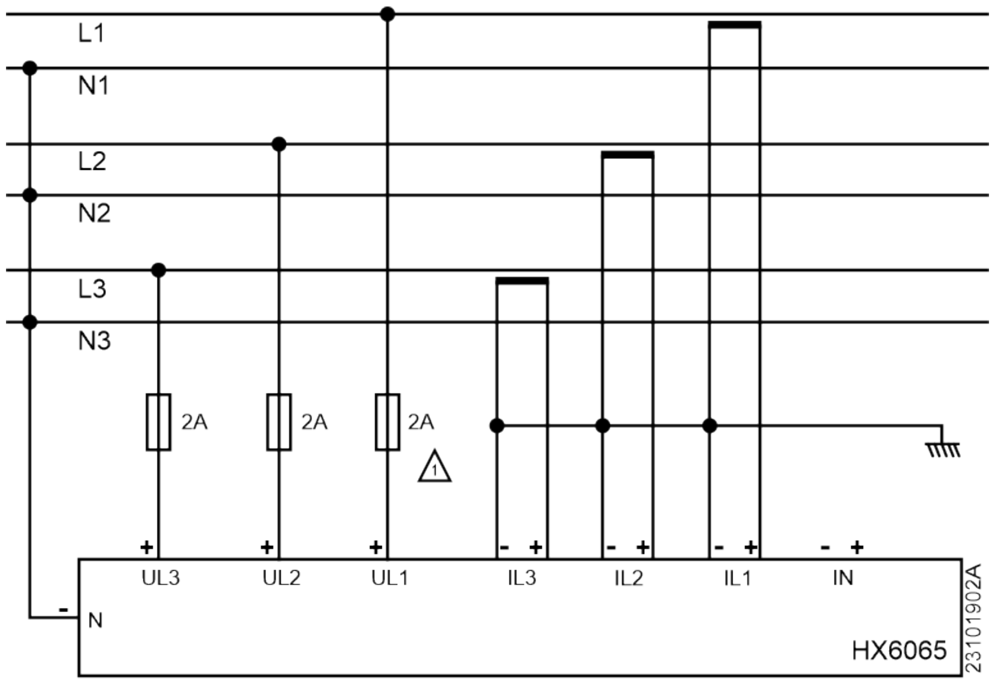

Figure 8: Single-phase 2-wire measurement without potential transformer

Note:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

6.2.7. Diagram for synchronism voltage measurement with potential transformer

This synchronism voltage measurement diagram can be used in combination with any of the previous measurement diagrams, be it a star, triangle, or single phase.

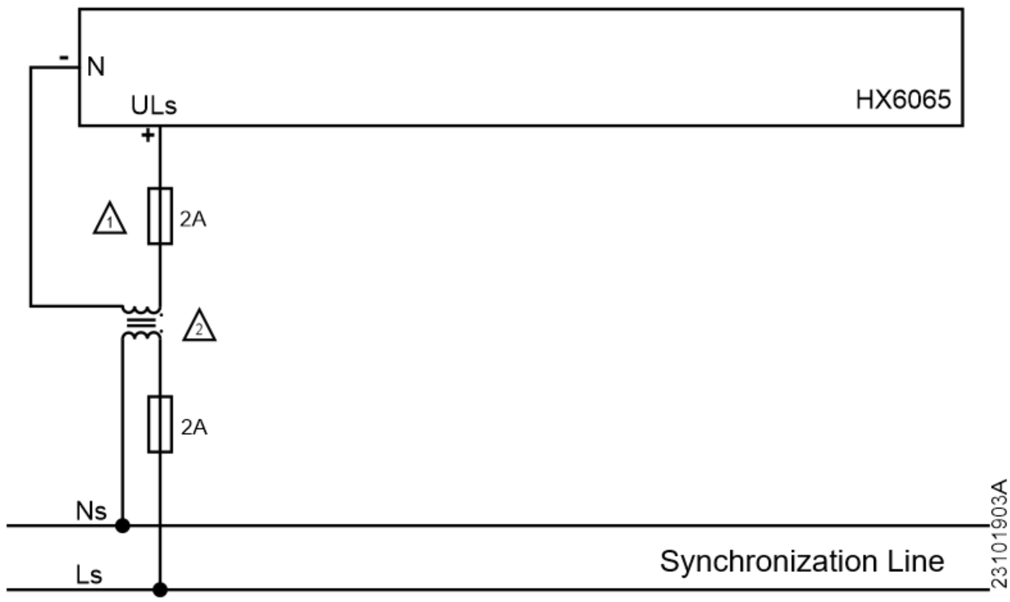

Figure 9: Synchronism voltage measurement with potential transformer

Notes:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

⚠2 Potential transformers are necessary for measuring phase-to-neutral voltages higher than 300 V RMS.

6.2.8. Diagram for synchronism voltage measurement without potential transformer

This synchronism voltage measurement diagram can be used in combination with any of the previous measurement diagrams, be it a star, triangle, or single phase.

> **ATTENTION**
>
> It is normally suggested to use the Diagram for synchronism voltage measurement without potential transformer because the neutral input (N) is common to all three phase voltage inputs of the module (UL1, UL2, and UL3) and the synchronism input (ULs). If there are risks or significant potential differences between the neutrals of the various lines (UL1, UL2, UL3, and ULs), this diagram without a potential transformer is not recommended.

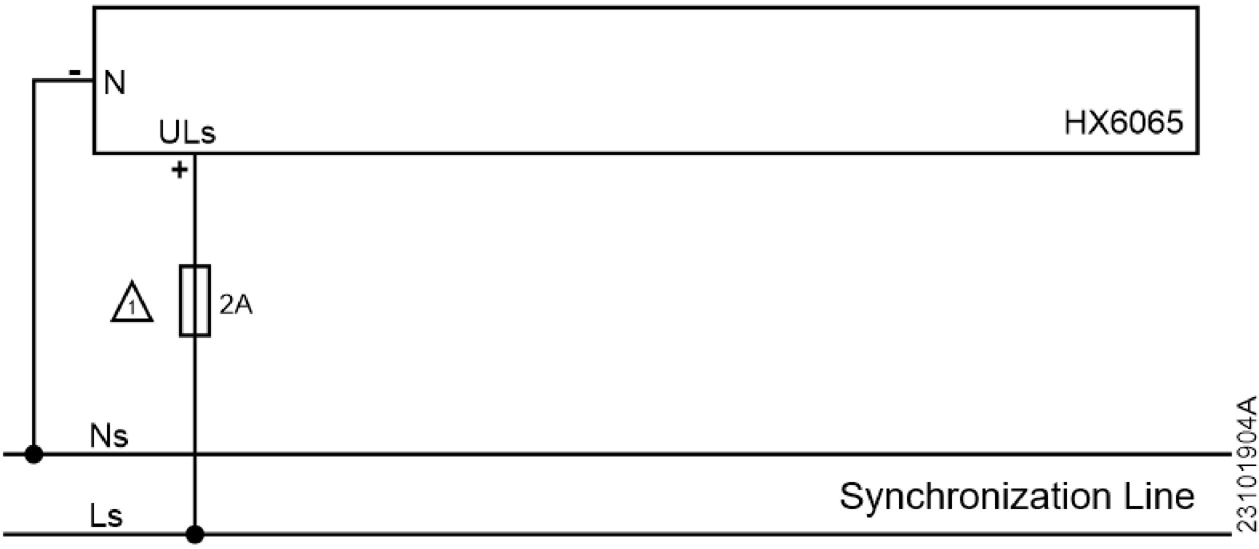

Figure 10: Synchronism voltage measurement without potential transformer

Note:

⚠1 It is recommended to use 2 A protection fuses at the voltage inputs, to prevent damage to the module.

6.2.9. Diagram for connecting the analog outputs

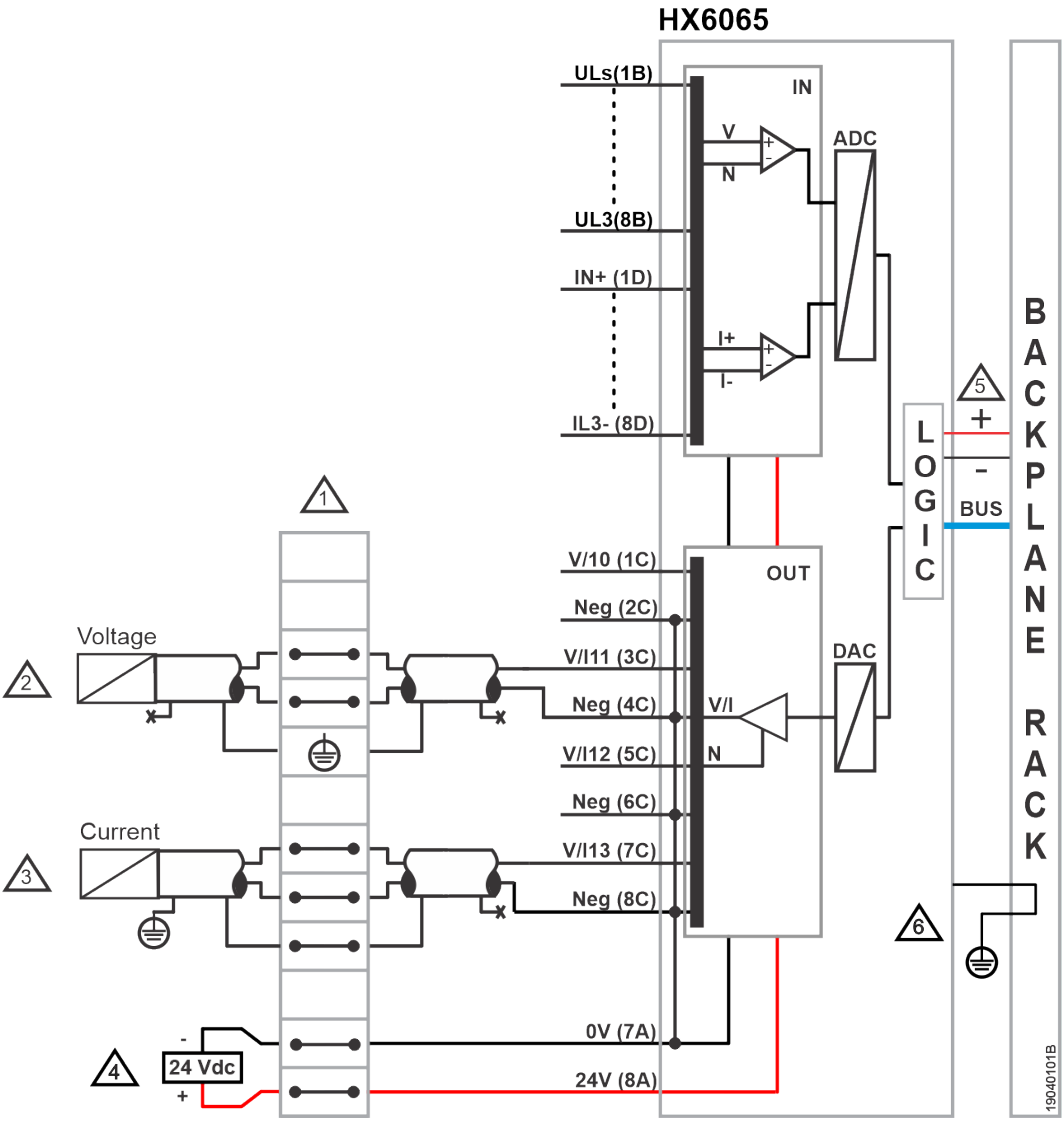

Figure 11: Diagram for connecting the analog outputs

Notes:

1. The diagram above shows a set of terminal blocks where each symbol represents a different type: represents a standard connection terminal block and it represents a grounding terminal block.
2. Output 11 is connected in voltage mode.
3. Output 13 is connected in current mode.
4. The external power supply is connected to pins 7A (negative) and 8A (positive).
5. Power for the module's internal logic is derived from the connection to the rack.
6. The HX6065 is connected to the protective earth through the rack.

6.2.10. Connector Pinout

The following table describes each terminal of each connector, and the corresponding AC inputs (voltage and currents), analog outptus, and power inputs.

A		**Terminal Number**	**B**	
Power Signal	**Ref.**		**Ref.**	**Input Signal**
N.C.	-	1	ULs	Synchronism voltage - phase
N.C.	-	2	-	N.C.
N.C.	-	3	N	Neutral - lines & synchronism
N.C.	-	4	UL1	Line voltage 1 - phase
N.C.	-	5	-	N.C.
N.C.	-	6	UL2	Line voltage 2 - phase
Power - negative	0V	7	-	N.C.
Power - positive	24V	8	UL3	Line voltage 3 - phase
C		**Terminal Number**	**D**	
Output Signal	**Ref.**		**Ref.**	**Input Signal**
Analog output 0	V/I10	1	IN+	Neutral Current - phase
Negative	Neg	2	IN-	Neutral Current - return
Analog output 1	V/I11	3	IL1+	Current line 1 - phase
Negative	Neg	4	IL1-	Current line 1 - return
Analog output 2	V/I12	5	IL2+	Current line 2 - phase
Negative	Neg	6	IL2-	Current line 2 - return
Analog output 3	V/I13	7	IL3+	Current line 3 - phase
Negative	Neg	8	IL3-	Current line 3 - return

Table 9: Connector Pinout

6.3. Mechanical and Electrical Assembly

Information and guidance on proper mechanical installation can be found in the Hadron Xtorm Utilization Manual - MU223600.

ATTENTION

Products with broken warranty seal are not covered in warranty.

CAUTION

The device is sensitive to static electricity (ESD). Always touch in a metallic grounded object before handling it.

DANGER

Hadron Xtorm Series can operate with voltage up to 250 Vac. Special care must be taken during the installation, which should only be performed by qualified technical personnel. Do not touch the field wiring when in operation.

7. Configuration

The HX6065 module is designed for use with Hadron Xtorm Series products. The configuration data for a particular module can be accessed by double-clicking on the desired module in the graphical editor.

7.1. Process Data

Process Data are the variables used to access and control the module. The following tables describe all variables made available by the HX6065.

In addition to this data, the HX6065 module also provides a set of variables containing diagnostic-related information, which is also described in this document.

7.1.1. Process Input Data

The following table shows the organization structure of the HX6065's input variables in the memory at the CPU.

Variable	Size	Process Data	Description	Unit	Type	Operation
%ID(n)	DWORD	Effective Voltage	Effective Voltage L1-N L1-L2	V	REAL	Read
%ID(n+4)	DWORD		Effective Voltage L2-N L2-L3	V	REAL	Read
%ID(n+8)	DWORD		Effective Voltage L3-N L3-L1	V	REAL	Read
%ID(n+12)	DWORD		Effective Voltage SYNC	V	REAL	Read
%ID(n+16)	DWORD	Effective Current	Effective Current L1	A	REAL	Read
%ID(n+20)	DWORD		Effective Current L2	A	REAL	Read
%ID(n+24)	DWORD		Effective Current L3	A	REAL	Read
%ID(n+28)	DWORD		Effective Current N	A	REAL	Read
%ID(n+32)	DWORD	Control Voltage	Control Voltage	V	REAL	Read
%ID(n+36)	DWORD	Peak Voltage	Peak Voltage L1-N L1-L2	V	REAL	Read
%ID(n+40)	DWORD		Peak Voltage L2-N L2-L3	V	REAL	Read
%ID(n+44)	DWORD		Peak Voltage L3-N L3-L1	V	REAL	Read

Variable	Size	Process Data	Description	Unit	Type	Operation
%ID(n+48)	DWORD		Peak Voltage SYNC	V	REAL	Read
%ID(n+52)	DWORD	Peak Current	Peak Current L1	A	REAL	Read
%ID(n+56)	DWORD		Peak Current L2	A	REAL	Read
%ID(n+60)	DWORD		Peak Current L3	A	REAL	Read
%ID(n+64)	DWORD		Peak Current N	A	REAL	Read
%ID(n+68)	DWORD	Power Factor	Power Factor L1	-	REAL	Read
%ID(n+72)	DWORD		Power Factor L2	-	REAL	Read
%ID(n+76)	DWORD		Power Factor L3	-	REAL	Read
%ID(n+80)	DWORD	Power Angle	Power Angle L1	degrees	REAL	Read
%ID(n+84)	DWORD		Power Angle L2	degrees	REAL	Read
%ID(n+88)	DWORD		Power Angle L3	degrees	REAL	Read
%ID(n+92)	DWORD	Angle Between Phases	Angle Between Phases L1-L2	degrees	REAL	Read
%ID(n+96)	DWORD		Angle Between Phases L2-L3	degrees	REAL	Read
%ID(n+100)	DWORD		Angle Between Phases L3-SYNC	degrees	REAL	Read
%ID(n+104)	DWORD	Frequency	Frequency L1	Hz	REAL	Read
%ID(n+108)	DWORD		Frequency L2	Hz	REAL	Read
%ID(n+112)	DWORD		Frequency L3	Hz	REAL	Read
%ID(n+116)	DWORD		Frequency SYNC	Hz	REAL	Read
%ID(n+120)	DWORD	Voltage Unbalance	Voltage Unbalance	%	REAL	Read
%ID(n+124)	DWORD	Current Unbalance	Current Unbalance	%	REAL	Read
%ID(n+128)	DWORD	Sequence Components	Positive voltage sequence component - magnitude	V	REAL	Read
%ID(n+132)	DWORD		Positive voltage sequence component - phase	degrees	REAL	Read
%ID(n+136)	DWORD		Negative voltage sequence component - magnitude	V	REAL	Read
%ID(n+140)	DWORD		Negative voltage sequence component - phase	degrees	REAL	Read
%ID(n+144)	DWORD		Zero voltage sequence component - magnitude	V	REAL	Read
%ID(n+148)	DWORD		Zero voltage sequence component - phase	degrees	REAL	Read
%ID(n+152)	DWORD		Positive current sequence component - magnitude	A	REAL	Read
%ID(n+156)	DWORD		Positive current sequence component – phase	degrees	REAL	Read
%ID(n+160)	DWORD		Negative current sequence component – magnitude	A	REAL	Read
%ID(n+164)	DWORD		Negative current sequence component – phase	degrees	REAL	Read
%ID(n+168)	DWORD		Zero current sequence component - magnitude	A	REAL	Read
%ID(n+172)	DWORD		Zero current sequence component – phase	degrees	REAL	Read
%ID(n+176)	DWORD	Active Power	Active Power L1	W	REAL	Read
%ID(n+180)	DWORD		Active Power L2	W	REAL	Read
%ID(n+184)	DWORD		Active Power L3	W	REAL	Read
%ID(n+188)	DWORD		TOTAL Active Power	W	REAL	Read

Variable	Size	Process Data	Description	Unit	Type	Operation
%ID(n+192)	DWORD	Reactive Power	Reactive Power L1	VAR	REAL	Read
%ID(n+196)	DWORD		Reactive Power L2	VAR	REAL	Read
%ID(n+200)	DWORD		Reactive Power L3	VAR	REAL	Read
%ID(n+204)	DWORD		TOTAL Reactive Power	VAR	REAL	Read
%ID(n+208)	DWORD	Apparent Power	Apparent Power L1	VA	REAL	Read
%ID(n+212)	DWORD		Apparent Power L2	VA	REAL	Read
%ID(n+216)	DWORD		Apparent Power L3	VA	REAL	Read
%ID(n+220)	DWORD		TOTAL Apparent Power	VA	REAL	Read

Table 10: Process Input Data

7.1.2. Process Output Data

The following table shows the organization structure of the HX6065's output variables in the memory at the CPU.

Variable	Size	Process Data	Description	Type	Operation
%QW(n)	DWORD	AO 10	Analog Output 10	INT	Read/Write
%QW(n+2)	DWORD	AO 11	Analog Output 11	INT	Read/Write
%QW(n+4)	DWORD	AO 12	Analog Output 12	INT	Read/Write
%QW(n+6)	DWORD	AO 13	Analog Output 13	INT	Read/Write

Table 11: Process Output Data

7.2. Module Parameters

Name	Description	Default Value	Options	Configuration
Connection Type	Wiring diagram of the AC voltage and current inputs	Star	Star Triangle Single-phase	Module
Phase Sequence	Phase Sequences	L1L2L3	L1L2L3 L1L3L2	Module
Number of Cycles of the Calculation Window	Number of grid cycles used for accomplishing AC measurements	12	1/6 1/2 1 2 4 6 8 10 12	Module
Input Type	Analog AC voltage input type	Voltage 0 – 300 V RMS	Not configured Voltage 0 – 300 V RMS	Input 00 Voltage Line 1 (UL1)
PT Relation	Relation between the primary and secondary voltage of the potential transformer	1,0	0,0 to 100000,0	

Name	Description	Default Value	Options	Configuration
Input Type	Analog AC voltage input type	Voltage 0 – 300 V RMS	Not configured Voltage 0 – 300 V RMS	Input 01 Voltage Line 2 (UL2)
PT Relation	Relation between the primary and secondary voltage of the potential transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC voltage input type	Voltage 0 – 300 V RMS	Not configured Voltage 0 – 300 V RMS	Input 02 Voltage Line 3 (UL3)
PT Relation	Relation between the primary and secondary voltage of the potential transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC voltage input type	Voltage 0 – 300 V RMS	Not configured Voltage 0 – 300 V RMS	Input 03 Synchronism Voltage (ULs)
PT Relation	Relation between the primary and secondary voltage of the potential transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC current input type	Current 0 – 5 A	Not configured Current 0 – 5	Input 04 Current Line 1 (IL1)
CT Relation	Relation between the primary and secondary current of the current transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC current input type	Current 0 – 5 A	Not configured Current 0 – 5	Input 05 Current Line 2 (IL2)
CT Relation	Relation between the primary and secondary current of the current transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC current input type	Current 0 – 5 A	Not configured Current 0 – 5	Input 06 Current Line 3 (IL3)
CT Relation	Relation between the primary and secondary current of the current transformer	1,0	0,0 to 100000,0	
Input Type	Analog AC current input type	Current 0 – 5 A	Not configured Current 0 – 5	Input 07 Neutral Current (IN)
CT Relation	Relation between the primary and secondary current of the current transformer	1,0	0,0 to 100000,0	
Output Type	Analog output type	Not configured	Not configured Voltage 0 – 10 Vdc Voltage ± 10 Vdc Current 0 – 20 mA Current 4 – 20 mA	Output 10 Analog Output (V/I10)

Name	Description	Default Value	Options	Configuration
Output Type	Analog output type	Not configured	Not configured Voltage 0 – 10 Vdc Voltage ± 10 Vdc Current 0 – 20 mA Current 4 – 20 mA	Output 11 Analog Output (V/I11)
Output Type	Analog output type	Not configured	Not configured Voltage 0 – 10 Vdc Voltage ± 10 Vdc Current 0 – 20 mA Current 4 – 20 mA	Output 12 Analog Output (V/I12)
Output Type	Analog output type	Not configured	Not configured Voltage 0 – 10 Vdc Voltage ± 10 Vdc Current 0 – 20 mA Current 4 – 20 mA	Output 13 Analog Output (V/I13)

Table 12: Module Parameters

Notes:

Configuration: This column indicates whether the parameter is related to the module as a whole or to a specific channel (AC input voltage, AC input current, or analog output channel).

PT Relation: This factor multiplies the voltage measured by the HX6065 (secondary of the PT) to get the actual system voltage (primary side of the PT). For example, if a 138 V measurement at the HX6065 corresponds to 13,800 V in the system, this relation must be 100.

CT Relation: This factor multiplies the current measured by the HX6065 (secondary of the CT) to get the actual system current (primary of the CT). For example, if a 1 A measurement at the HX6065 corresponds to 100 A in the system, this relation must be 100.

Phase Sequences: If the HX6065 module realizes that the phase sequence configuration is different from the measured phase sequence it takes the following actions:

- Activates a diagnostic that indicates incorrect phase sequence;
- Zeroes the voltage and current sequence components;
- If the selected connection type is triangle, it also resets the active, reactive, and apparent powers to zero, resets the power angles to zero, and sets the value 1 in the power factors.

7.2.1. Number of Cycles in the Calculation Window

The vast majority of AC variables are measured or calculated based on the last N grid cycles, set by the user through the *"Number of Cycles of the Calculation Window"* parameter of the HX6065 module.

This parameter works as a kind of filter. The greater the number of cycles in the calculation window, the more stable the value of the AC variables and the less susceptible to electromagnetic noise.

The time interval with which the AC measurements are updated, that is, the time between successive changes of values of the AC measurements, will also depend on the parameter *"Number of Cycles of the Calculation Window"*, but not in a direct way and does not extend to all AC measurements.

The following table shows the relationship between the *"Number of Cycles of the Calculation Window"* parameter, the interval considered in the calculation, and the time between updates for the primary AC measurements.

Primary AC Measurement	Parameter "Number of Calculation Window Cycles"	Interval considered in the calculation [grid cycles]	Time between updates [grid cycles]	Commentary
Effective Voltage Effective Current Active Power Reactive Power	1/6	1	1/6	With a calculation window < 1, the aim is to get a better response time by anticipating the changes a bit. With a calculation window > 1, a more stable value is obtained by filtering noise through a moving average.
	1/2		1/2	
	1	1	1	
	2	2		
	4	4		
	6	6		
	8	8		
	10	10		
	12	12		
Control Voltage	-	1/2	1/2	The parameter "Number of Cycles of the Calculation Window" does not influence this measurement.
Peak Voltage Peak Current Angle between Phases Frequency	1/6	1	1	With a calculation window > 1, a more stable value is obtained by filtering noise through a moving average.
	1/2			
	1	1		
	2	2		
	4	4		
	6	6		
	8	8		
	10	10		
	12	12		

Table 13: Number of Cycles in the Calculation Window

The following table shows the derived AC measurements, in other words, those that depend on primary AC measurements (see previous table) to have their values calculated. These derived AC measurements are quickly recalculated every time one of the primary measurements on which they depend changes.

Derived AC measurement	Primary measurements on which it depends
Power Factor	Active power Reactive power
Power Angle	Active power Reactive power
Voltage unbalance	Effective voltages L1, L2, L3
Current unbalance	Effective current L1, L2, L3
Sequence components PNZ voltage	Effective voltages L1, L2, L3 Angles between phases L1L2, L2L3
Sequence components PNZ current	Effective currents L1, L2, L3 Angles between current phases L1L2, L2L3
Apparent power	Active power Reactive power

Table 14: Derived AC measurement

Note:

Angle between current phases L1L2, Angle between current phases L2L3: The angles between current phases are calculated internally to calculate the PNZ current sequence components but are not made available in variables for use by the user application. The accuracy of these angles is ±0.5 degrees.

7.3. I/O Mapping

Even if the user does not configure/enable one or more voltage or current input channels, or even analog output channels, the mapping variables of the inputs (AC measurements) and analog outputs will always be reserved for the HX6065 module, that is, the amount reserved for the module is fixed (4 output variables and 56 input variables), and these variables will constantly be updated by the main task of the application (the task MainTask).

7.3.1. Output Channels

The following table shows all the channels mapped in the HX6065 module into output variables, all of type INT.

Channel	Type
Analog Output V/I10	INT
Analog Output V/I11	INT
Analog Output V/I12	INT
Analog Output V/I13	INT

Table 15: Output Channels

7.3.2. Input Channels

As discussed earlier in the Number of Cycles in the Calculation Window section, there are primary AC measurements that are measured directly by the module, and there are also derived AC measurements that are calculated from primary AC measurements. In addition, some measurements are meaningless in a specific configuration, such as neutral current in triangle or single-phase configurations, and will therefore be set to zero.

The following table indicates, for each channel, how the AC measurement is determined depending on the *Connection Type* parameter. According to the previous considerations, there are three possibilities:

- Primary
- Derivative
- Zeroed

Channel(1)	Connection Type			Unit	Type
	Star	Triangle	Single-Phase		
Effective voltage L1-N / L1-L2(2)	Primary	Primary	Primary	V	REAL
Effective voltage L2-N / L2-L3(2)	Primary	Primary(5)	Primary	V	REAL
Effective voltage L3-N / L3-L1(2)	Primary	Primary(5)	Primary	V	REAL
Effective voltage SYNC(2)	Primary	Primary	Primary	V	REAL
Effective current L1(3)	Primary	Primary	Primary	A	REAL
Effective current L2(3)	Primary	Primary(6)	Primary	A	REAL
Effective current L3(3)	Primary	Primary	Primary	A	REAL
Effective current N(3)	Primary	Zeroed	Zeroed	A	REAL
Control voltage	Primary	Primary	Zeroed	V	REAL
Peak voltage L1-N / L1-L2	Primary	Primary	Primary	V	REAL
Peak voltage L2-N / L2-L3	Primary	Primary(5)	Primary	V	REAL
Peak voltage L3-N / L3-L1	Primary	Primary(5)	Primary	V	REAL
Peak voltage SYNC	Primary	Primary	Primary	V	REAL
Peak current L1	Primary	Primary	Primary	A	REAL
Peak current L2	Primary	Primary(6)	Primary	A	REAL
Peak current L3	Primary	Primary	Primary	A	REAL
Peak current N	Primary	Zeroed	Zeroed	A	REAL

Channel[1]	Connection Type			Unit	Type
	Star	Triangle	Single-Phase		
Power Factor L1	Derivative	Derivative[7]	Derivative	-	REAL
Power Factor L2	Derivative	Derivative[7]	Derivative	-	REAL
Power Factor L3	Derivative	Derivative[7]	Derivative	-	REAL
Power Angle L1	Derivative	Derivative[7]	Derivative	degrees	REAL
Power Angle L2	Derivative	Derivative[7]	Derivative	degrees	REAL
Power Angle L3	Derivative	Derivative[7]	Derivative	degrees	REAL
Angle between phases L1-L2	Primary	Primary	Primary	degrees	REAL
Angle between phases L3-L3	Primary	Primary	Primary	degrees	REAL
Angle between phases L3-SYNC	Primary	Primary	Primary	degrees	REAL
Frequency L1[4][8]	Primary	Primary	Primary	Hz	REAL
Frequency L1[4][8]	Primary	Primary	Primary	Hz	REAL
Frequency L1[4][8]	Primary	Primary	Primary	Hz	REAL
Frequency SYNC[4]	Primary	Primary	Primary	Hz	REAL
Voltage unbalance	Derivative	Derivative	Zeroed	%	REAL
Current unbalance	Derivative	Derivative	Zeroed	%	REAL
Positive voltage sequence component - magnitude	Derivative	Derivative	Zeroed	V	REAL
Positive voltage sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Negative voltage sequence component – magnitude	Derivative	Derivative	Zeroed	V	REAL
Negative voltage sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Zero voltage sequence component - magnitude	Derivative	Derivative	Zeroed	V	REAL
Zero voltage sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Positive current sequence component - magnitude	Derivative	Derivative	Zeroed	A	REAL
Positive current sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Negative current sequence component – magnitude	Derivative	Derivative	Zeroed	A	REAL
Negative current sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Zero current sequence component - magnitude	Derivative	Derivative	Zeroed	A	REAL
Zero current sequence component – phase	Derivative	Derivative	Zeroed	degrees	REAL
Active Power L1	Primary	Derivative[7]	Primary	W	REAL
Active Power L2	Primary	Derivative[7]	Primary	W	REAL
Active Power L3	Primary	Derivative[7]	Primary	W	REAL
TOTAL Active Power	Derivative	Primary	Zeroed	W	REAL
Reactive Power L1	Primary	Derivative[7]	Primary	VAR	REAL
Reactive Power L2	Primary	Derivative[7]	Primary	VAR	REAL
Reactive Power L3	Primary	Derivative[7]	Primary	VAR	REAL
TOTAL Reactive Power	Derivative	Primary	Zeroed	VAR	REAL
Apparent Power L1	Primary	Derivative	Primary	VA	REAL
Apparent Power L2	Primary	Derivative	Primary	VA	REAL
Apparent Power L3	Primary	Derivative	Primary	VA	REAL
TOTAL Apparent Power	Derivative	Derivative	Zeroed	VA	REAL

Table 16: Input Channels

Notes:

1. **Channel:** The accuracy of the module's input variables is guaranteed for grid frequencies between 45 and 65 Hz.
2. **Effective voltage** (example for phase L1): When Peak voltage L1-N / L1-L2 does not reach 0.707 V in one measurement cycle, which corresponds to Effective voltage L1-N / L1-L2 less than approximately 0.5 V, the following actions occur:

- A diagnostic indicates that voltage channel L1 is disconnected;
- The following variables are reset to zero: Effective voltage L1-N / L1-L2, Peak voltage L1-N / L1-L2, Control voltage, Frequency L1, Angle between phases L1-L2, Active Power L1, Reactive Power L1, Apparent Power L1, Power Angle L1;
- The Power Factor L1 is set to 1.

3. **Effective current**(example for phase L1): When Peak current L1 does not reach 0.0141 A in one measurement cycle, which corresponds to Effective current L1 of less than approximately 0.01 A, the following actions occur:
   - A diagnostic indicates that current channel L1 is disconnected;
   - The following variables are reset to zero: Effective current L1, Peak current L1, Active Power L1, Reactive Power L1, Apparent Power L1, Power Angle L1;
   - The Power Factor L1 is set to 1.
4. **Frequency L1, Frequency L2, Frequency L3, Frequency SYNC:** These frequencies are measured from the corresponding voltage channels. Frequencies of current channels are also measured internally by the module but are not indicated for the user application. Frequencies are indicated only if they are in the range between 10 Hz and 180 Hz, otherwise, they are reset to zero. Considering an example for voltage phase L1, if the frequency is out of the range between 10 Hz and 180 Hz, the following actions occur:
   - A diagnostic indicates that current channel L1 is disconnected;
   - Effective Voltage L1-N / L1-L2, Peak Voltage L1-N / L1-L2, Control Voltage, L1 Frequency, Phase Angle between L1-L2, Active Power L1, Reactive Power L1, Apparent Power L1, Power Angle L1;
   - The Power Factor L1 is set to 1.
5. **Voltages, triangle connection type:** In the triangle configuration, the module measures the line voltage L1L2 and the line voltage L3L2. But it is necessary to indicate the voltages L1L2, L2L3, and L3L1. The voltage L2L3 is calculated as the negative of the voltage L3L2. Next, voltage L3L1 is calculated as the negative of the sum between voltages L1L2 and L2L3 because it is known that the sum of voltages L1L2, L2L3, and L3L1 is zero in a triangle configuration.
6. **Currents, triangle connection type:** In the triangle configuration, the module measures the line current L1 and the line current L3. But it is also necessary to indicate the line current L2. The line current L2 is calculated as the negative of the sum between the currents L1 and L3 since it is known that the sum of the currents L1, L2, and L3 is zero in a triangle configuration.
7. **Active power, reactive power, power angle, and power factor, triangle connection type:** In the triangle configuration, the module cannot measure the individual active and reactive powers of each line (L1, L2, L3). However, the module can measure the total active and reactive powers. The individual active power indicated on each line will be 1/3 of the total active power. Similarly, the individual reactive power indicated on each line will be 1/3 of the total reactive power. The individual power angles and power factors on each line will be calculated from the total active and total reactive powers.
8. **Frequency L1, Frequency L2, Frequency L3, triangle connection type:** In the triangle configuration, the frequencies L1, L2, and L3 correspond to the voltages L1L2 (L1), L2L3 (L2), and L3L1 (L3) respectively.

7.3.3. Control voltage

Considering the measurements listed in the section Process Input Data, all are well-known in electrical power applications, except the control voltage.

The control voltage is indicated only in three-phase configurations (star or triangle) and is reset to zero in single-phase configurations. This is an effective voltage averaged between the three individual effective voltages of lines L1, L2, and L3. In addition, a special calculation algorithm allows the control voltage to have a shorter response time compared to the average voltage calculated from the individual effective voltages of lines L1, L2, and L3.

According the section Number of Cycles in the Calculation Window, the calculation interval for the individual effective voltages is at least one grid cycle. For the control voltage, the calculation interval is always 1/2 grid cycle.

In this way, the control voltage allows to optimize applications that require a shorter response time, such as a voltage regulator.

The following figure graph shows the control voltage (blue line) and an average control voltage calculated from the three individual effective voltages (green line) after a step from 100 V to 110 V on the three individual voltages. In this case, the parameter *"Number of Calculation Window Cycles"* was set to 1. These voltages were sampled by the MainTask cyclic task, with a cycle of 10 ms. The interval between the two vertical black cursors is 20 ms in the figure (2 cycles of the MainTask task).

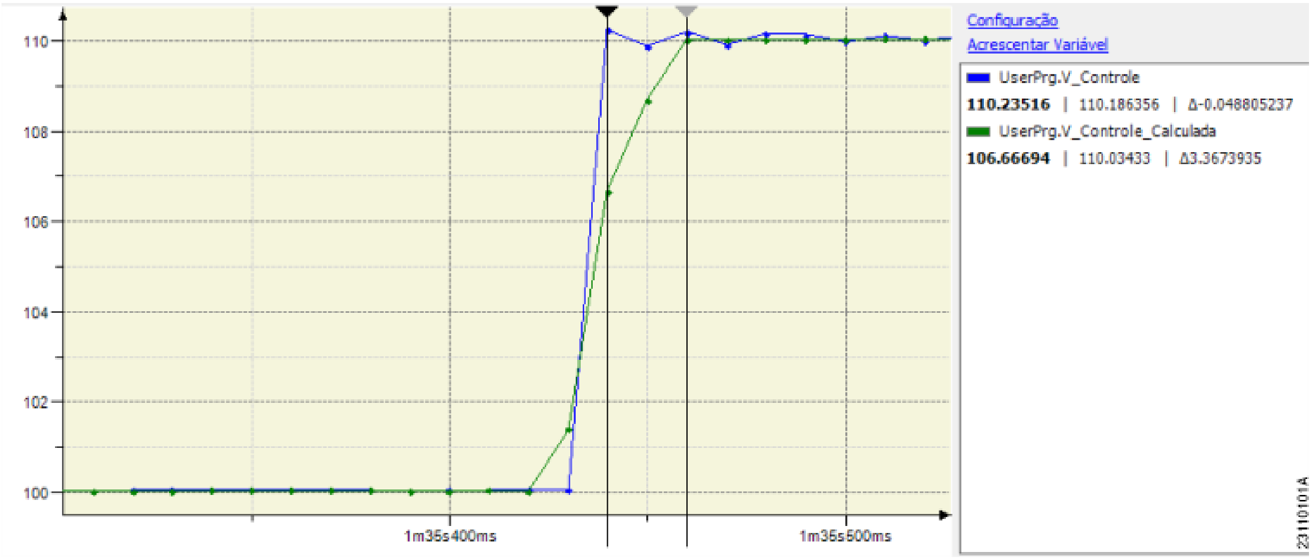

Figure 12: Number of Cycles in the Calculation Window configured with value 1

The graph in the following figure illustrates the same situation as the previous graph. However, this time the *"Number of Calculation Window Cycles"* parameter was set to a value of 1/6, reducing a little bit the response time of the calculated control voltage from the three effective voltages. In this case, the calculation interval of the individual effective voltages remains one grid cycle, but value updates occur every 1/6 grid cycle. The interval between the two vertical black cursors is 10 ms in the figure (1 cycle of the MainTask). It can be seen that the calculated control voltage has a response time almost as fast as the control voltage, with the advantage that it is more stable because it is being calculated over one cycle.

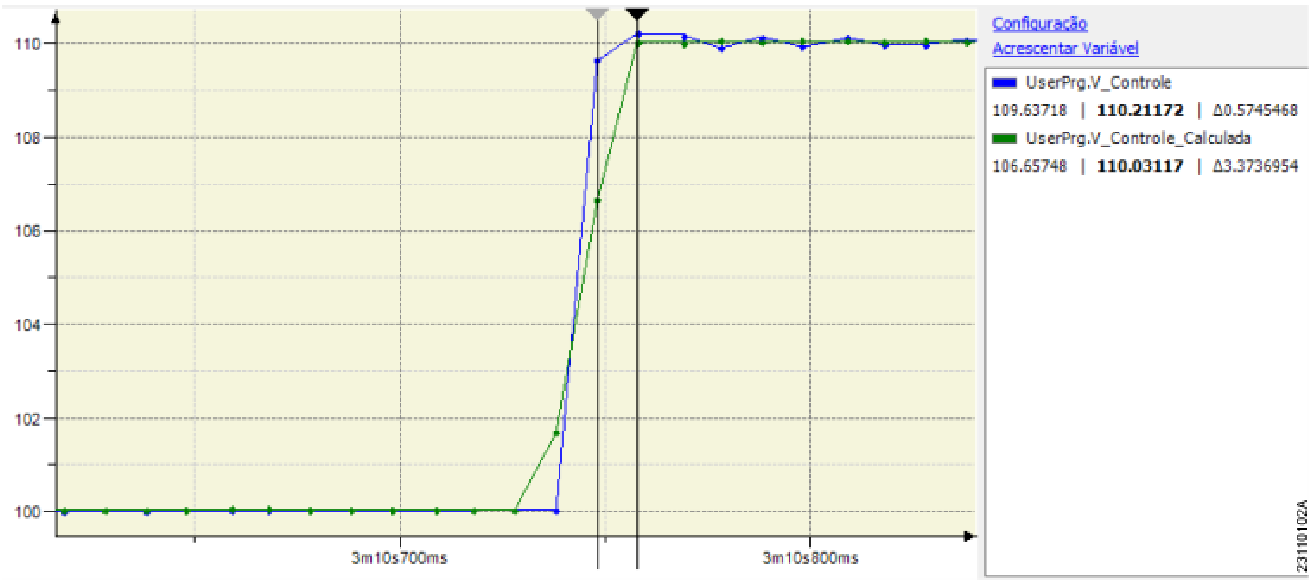

Figure 13: Number of Cycles in the Calculation Window configured with value 1/6

The graph in the following figure again illustrates the same situation as the previous graphs. However, this time the *"Number of Calculation Window Cycles"* parameter was set to value 6, to produce even more stable values for the individual effective voltages. In this case, the calculation interval of the individual effective voltages increases to 6 grid cycles, and value updates occur every one grid cycle. The interval between the two vertical black cursors is 100 ms in the figure (10 cycles of the MainTask).

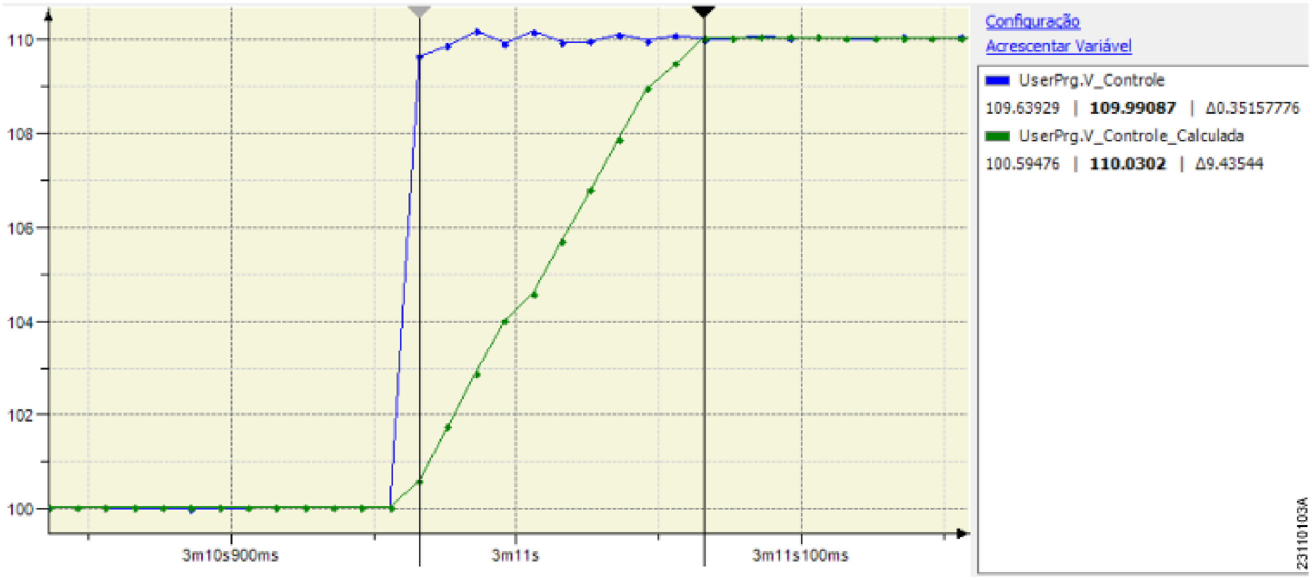

Figure 14: Number of Cycles in the Calculation Window configured with value 6

ATTENTION

For achieving a low response time in control applications (for example, voltage regulators), it is also important that the variables of the HX6065 (measurement inputs and analog outputs) are updated quickly through the backplane bus. To reduce these update times for the control variables, it is recommended to call the REFRESH_INPUT function just before running the control algorithm and to call the REFRESH_OUTPUT function just after running the control algorithm. For further information about these instructions, see the Hadron Xtorm Utilization Manual .

7.3.4. Special Values for Input Channels

Considering the channels listed in the section Input Channels, some of them may assume special values under certain circumstances, such as 0 (zero), 1 (one), and -1 (minus 1), among others.

The following table points out the special values that each channel can assume, and the circumstances under which this occurs. In many cases, the circumstance is related to an active diagnostic. In this case, the diagnostic is referred to with the variable name mentioned in the section Diagnostics through Variables. In other cases, the circumstance is a parameter setting, described in the Module Parameters section.

The table also explains the conventions for displaying the angles between phases, power angles, power factors, and signs of the active and reactive powers (because active and reactive powers can be supplied or consumed).

Channel	Special Value and Circumstance
Effective voltage L1-N L1-L2 Effective voltage L2-N L2-L3 Effective voltage L3-N L3-L1 Effective voltage SYNC Effective current L1 Effective current L2 Effective current L3 Effective current N	▪ The value -1 is assumed if the bHwFailure diagnostic is active (hardware failure on the channel). This is a faster way to detect hardware failure diagnosis to take a control action. ▪ The value 0 is assumed if bDisconnected diagnosis is active. The channel disconnected diagnosis occurs when the peak voltage is below 0.707 V or the peak current is below 0.0141 A, or when the frequency is outside the range 10 Hz to 180 Hz. ▪ The value 0 is assumed if the parameter Input Type is set as "not configured". ▪ In the specific case of the effective current N, the value 0 is assumed if the parameter Connection Type is Triangle or Single Phase.
Control voltage	▪ The value -1 is assumed if one of the three effective voltages (L1-N/L1-L2, L2-N/L2-L3, L3-N/L3-L1) has value -1 (hardware failure diagnosis). This is a faster way to detect hardware failure diagnosis to take a control action. ▪ The value 0 is assumed if one of the three effective voltages (L1-N/L1-L2, L2-N/L2-L3, L3-N/L3-L1) has the value 0 (diagnosis of disconnected channel or not configured channel). ▪ The value 0 is assumed if the parameter Connection Type is Single Phase.
Peak voltage L1-N / L1-L2 Peak voltage L2-N / L2-L3 Peak voltage L3-N / L3-L1 Peak voltage SYNC Peak current L1 Peak current L2 Peak current L3 Peak current N	▪ The value 0 is assumed if the corresponding effective voltage/current has the value 0 (diagnosis of disconnected channel or unconfigured channel). ▪ The value 0 is assumed if the corresponding effective voltage/current has the value -1 (hardware failure diagnosis). ▪ In the specific case of the peak current N, the value 0 is assumed if the parameter Connection Type is Triangle or Single Phase.
Power factor L1 Power factor L2 Power factor L3	▪ The value 1 is assumed when the apparent power is 0. ▪ In other cases, it corresponds to the cosine of the power angle and can vary between -1 and 1.

<table>
<tr><th>Channel</th><th>Special Value and Circumstance</th></tr>
<tr><td>Power Angle L1
Power Angle L2
Power Angle L3</td><td>The value 0 is assumed when the apparent power is 0.
The value 0 is assumed when the active power is positive (active power being supplied) and the reactive power is 0.
The value +180 is assumed when the active power is negative (active power being consumed) and the reactive power is 0.
Values between 0 and -90 degrees occur when active power is being supplied and capacitive reactive power is being supplied.
Values between 0 and +90 degrees occur when active power is being supplied and inductive reactive power is being supplied.
Values between -90 and -180 degrees occur when active power is being consumed and inductive reactive power is being consumed.
Values between +90 and +180 degrees occur when active power is being consumed and capacitive reactive power is being consumed.</td></tr>
<tr><td>Angle between phases L1-L2
Angle between phases L2-L3
Angle between phases L3-SYNC</td><td>The value 0 is assumed if one of the two corresponding effective voltages is 0 (diagnosis of disconnected or not configured) or -1 (diagnosis of hardware failure).
In other cases, the angle is measured.
The angles L1-L2 and L2-L3 are positive when the phase sequence is L1L2L3. If the phases are well balanced, these angles will be close to +120 degrees.
The angles L1-L2 and L2-L3 are negative when the phase sequence is L1L3L2. If the phases are well balanced, these angles will be close to -120 degrees.
When the L3-SYNC angle is positive, it means that the L3 voltage is ahead of the SYNC voltage.</td></tr>
<tr><td>Frequency L1
Frequency L2
Frequency L3
Frequency SYNC</td><td>The value 0 is assumed if the corresponding effective voltage is 0 (diagnosis of disconnected or not configured) or -1 (diagnosis of hardware failure).</td></tr>
<tr><td>Voltage unbalance</td><td>The value 0 is assumed if the corresponding effective voltage is 0 (disconnected or not configured diagnosis) or -1 (hardware failure diagnosis).
The value 100% is assumed if the parameter Input Type is "not configured" for any of the three effective voltages (L1-N/L1-L2, L2-N/L2-L3, L3-N/L3-L1).
The value 0% is assumed if the parameter Connection Type is Single Phase.</td></tr>
</table>

Channel	Special Value and Circumstance
Current unbalance	▪ The value 100% is assumed if any of the three effective currents (L1, L2, L3) has value -1 (hardware failure diagnosis). ▪ The value 100% is assumed if the parameter Input Type is "not configured" for any of the three effective currents (L1, L2, L3). ▪ The value 0% is assumed if the parameter Connection Type is Single Phase.
Positive voltage sequence component - magnitude Positive voltage sequence component – phase Negative voltage sequence component – magnitude Negative voltage sequence component – phase Zero voltage sequence component - magnitude Zero voltage sequence component – phase	▪ The value 0 is assumed if the *bWrongSequence* (phase sequence error) diagnostic is active. ▪ The value 0 is assumed if any of the three effective voltages (L1-N/L1-L2, L2-N/L2-L3, L3-N/L3-L1) has a value -1 (hardware failure diagnosis). ▪ The value 0 is assumed if any of the three effective voltages (L1-N/L1-L2, L2-N/L2-L3, L3-N/L3-L1) has a value 0 (channel disconnected or channel not configured). ▪ If the calculated magnitude for a voltage component is less than 0.707 V, this magnitude and the phase corresponding to this voltage component will be reset to zero.
Positive current sequence component - magnitude Positive current sequence component – phase Negative current sequence component – magnitude Negative current sequence component – phase Zero current sequence component - magnitude Zero current sequence component – phase	▪ The value 0 is assumed if the *bWrongSequence* (phase sequence error) diagnostic is active. ▪ The value 0 is assumed if any of the three effective currents (L1, L2, L3) has a value of -1 (hardware failure diagnosis). ▪ The value 0 is assumed if any of the three effective currents (L1, L2, L3) has a value of 0 (diagnosis of disconnected channel or channel not configured). ▪ If the calculated magnitude for a current component is less than 0.0141 A, this magnitude and the phase corresponding to this current component will be reset to zero.

Channel	Special Value and Circumstance
Active power L1 Active power L2 Active power L3	▪ When the Connection Type parameter is Star or Single Phase, the value 0 is assumed when the corresponding effective voltage or current value is 0 (diagnosis disconnected or not configured) or -1 (hardware failure diagnosis). ▪ When the Triangle Connection Type parameter is set, all three individual active powers are equal to 1/3 of the total active power. ▪ When the Connection Type parameter is Triangle, the value 0 is assumed for the three individual powers when the value of any of the three effective voltages or three effective currents is -1 (hardware failure diagnosis). ▪ The value 0 is assumed when the *bWrongSequence* (phase sequence error) diagnostic is active, and the parameter Connection Type is Triangle. ▪ The value 0 can also occur when the corresponding power angle is +90 or -90 degrees. ▪ Positive values indicate active power supplied. ▪ Negative values indicate active power consumed.
TOTAL active power	▪ The value 0 is assumed if the parameter Connection Type is Single Phase. ▪ In the other cases, it corresponds to the sum of the three individual active powers (L1, L2, L3).

Channel	Special Value and Circumstance
Reactive power L1 Reactive power L2 Reactive power L3	▪ When the Connection Type Parameter is Star or Single Phase, the value 0 is assumed when the corresponding effective voltage or current value is 0 (diagnosis disconnected or not configured) or -1 (hardware failure diagnosis). ▪ When the Connection Type parameter is Triangle, all three individual reactive powers are equal to 1/3 of the total reactive power. ▪ When the Connection Type Parameter is Triangle, the value 0 is assumed for the three individual powers when the value of any of the three effective voltages or three effective currents is -1 (hardware failure diagnosis). ▪ The value 0 is assumed when the *bWrongSequence* (phase sequence error) diagnostic is active, and the parameter Connection Type is set to Triangle. ▪ The value 0 can also occur when the corresponding power angle is 0 or +180 degrees. ▪ A positive reactive power value, in combination with a positive active power value, corresponds to the supply of inductive reactive power. In this case, the corresponding power angle is in the range of 0 to +90 degrees. ▪ A negative reactive power value, combined with a positive active power value, corresponds to the supply of capacitive reactive power. In this case, the corresponding power angle is in the range of 0 to -90 degrees. ▪ A positive reactive power value, combined with a negative active power value, corresponds to capacitive reactive power consumption. In this case, the corresponding power angle is in the range of +90 to +180 degrees. ▪ A negative reactive power value, in combination with a negative active power value, corresponds to inductive reactive power consumption. In this case, the corresponding power angle is in the range of -90 to -180 degrees.
TOTAL reactive power	▪ The value 0 is assumed if the parameter Connection Type is Single Phase. ▪ In the other cases, it corresponds to the sum of the three individual reactive powers (L1, L2, L3).
Apparent power L1 Apparent power L2 Apparent power L3	▪ Values are always calculated from the corresponding active and reactive powers using the power triangle.

Channel	Special Value and Circumstance
TOTAL apparent power	▪ The value 0 is assumed if the parameter Connection Type is Single Phase. ▪ In the other cases, it corresponds to the sum of the three individual apparent powers (L1, L2, L3).

Table 17: Special Values for Input Channels

8. Maintenance

Altus recommends that all modules' connections should be checked and any dust or any kind of dirt in the module's enclosure should be removed at least every 6 months.

This module offers five important features to assist users during maintenance: Electronic Tag on Display, One Touch Diag, status and diagnostics indicators, web page with complete status and diagnostics list, and diagnostics mapped to internal memory.

DANGER

The current connector must be firmly screwed onto the HX6065 module so that there is no risk of opening the secondary of the current transformer, as this could cause a serious accident.
Do not touch the field wiring when in operation.

8.1. Electronic Tag on Display e One Touch Diag

Electronic Tag on Display and One Touch Diag are important features that provides to the user the chance to check the tag, description and diagnostics related to a given module directly on the CPU display.

To view the tag and diagnostics of a particular module, a short press on the diagnostics button is all that is needed. After one press, the CPU will show the tag and diagnostics of the module. To access the respective description, a long press on the diagnostic button of the corresponding module is all that is needed.

More information about Electronic Tag on Display can be found at Hadron Xtorm Utilization Manual – MU223600.

8.2. Status and Diagnostic Indicators

The Hadron Xtorm Series HX6065 module has a display and a bicolor LED to represent the diagnostics. The display has the following symbols: D, E, 0, 1, and numeric characters. The states of the D and E symbols are common to all Hadron Xtorm Series slave modules. These states can be seen in the following table. The same states as the D and E symbols are indicated by the color of the LED on the front of the module.

The meaning of the numeric characters can be different for specific modules.

8.2.1. Status of Symbols D, E, and Diagnostic LED (DL)

Symbol D	Symbol E	DL (Color)	Description	Cause	Solution	Priority
Off	Off	Off	Display fail, module off or OTD fail	Disconnected module, no external supply, hardware fail or OTD button fail	Check if the module is completely connected to the backplane rack and if the backplane rack is supplied by an external power supply	-
On	Off	On (Blue)	Normal use	-	-	7 (Lower)
Blinking 1x	Off	Blinking 1x (Blue)	Active Diagnostics	There is at least one active diagnostic related to this module	Check what the active diagnosis is. More information can be found in the Maintenance section of this document	6
Blinking 2x	Off	Blinking 2x (Blue)	CPU in STOP mode	CPU in STOP mode	Check if CPU is in RUN mode. More information can be found on CPU's documentation	5
Blinking 4x	Off	Blinking 4x (Blue)	Hardware non-fatal error	Hardware fault	The module remains with its main functionality, but in order to correct the fault, Altus support team must be contacted	4
Off	Blinking 1x	Blinking 1x (Red)	Parameterization Error	The module isn't parameterized or received an invalid parameter	Check if the module parameterization is correct	2
Off	Blinking 2x	Blinking 2x (Red)	Loss of master	Loss of communication between module and CPU	Check if the module is completely connected to the backplane rack. Check if CPU is in RUN mode	3
Off	Blinking 4x	Blinking 4x (Red)	Hardware fatal error	Hardware fault	Contact Altus support team in case of hardware fatal error	1 (Higher)

Table 18: D, E and Diagnostics LED (DL) States

Note:
Any signaling pattern different from those listed above indicates that the module should be forwarded to Altus Support.

8.2.2. 0, 1, and Numeric Characters

Segments 0 and 1 are used to group the numeric characters used for the 8 AC inputs and 4 analog control outputs. The characters placed on the right side of the character 0 represent the AC voltage (UL1, UL2, UL3, and ULs) and current (Il1, IL2, IL3, and IN) inputs, respectively. The characters to the right of character 1 represent the analog voltage/current outputs (V/I10, V/I11, V/I12, and V/I13), respectively. The numeric characters 14 through 17 do not represent anything, since the HX6065 module has only four analog outputs. The figure below shows the relationship between the numeric characters and their respective inputs and outputs

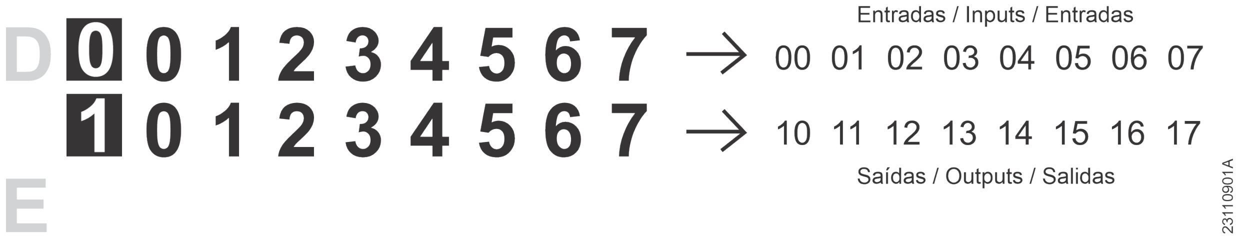

Figure 15: Display

8.3. Web Page with Complete Status and Diagnostics List

Another way to access diagnostic information on Hadron Xtorm Series is via web page. Hadron Xtorm Series CPU's has an embedded web pages server that provides all status and diagnostic information, which can be accessed using a simple browser.

More information about web page with complete status and diagnostic list can be found at Hadron Xtorm Utilization Manual – MU223600.

8.4. Diagnostics through Variables

All HX6065's diagnostics can be accessed through variables that can be handled by the user application or even forwarded to a SCADA supervision system using a communication channel. The following table shows all available diagnostics for HX6065 and their respective symbolic variables, description and string that will be shown on the CPU Graphical Display and Web.

8.4.1. General Diagnostics

Diagnostic Message	Symbolic Variable DG_modulename.tGeneral.	Description
WRONG PHASE SEQUENCE	bWrongSequence	**TRUE –** Invalid phase sequence detected **FALSE –** Invalid phase sequence not detected
UNKNOWN DIAGNOSIS	bReserved_09..15	Reserved
MODULE W/ DIAGNOSTICS	bActiveDiagnostics	**TRUE –** Module has active diagnostics
NO DIAG		**FALSE –** Module doesn't have active diagnostics
MODULE W/ FATAL ERROR	bFatalError	**TRUE –** Fatal error **FALSE –** No fatal error
CONFIG. MISMATCH	bConfigMismatch	**TRUE –** Parametrization Error **FALSE –** Parametrization OK
WATCHDOG ERROR	bWatchdogError	**TRUE –** Watchdog has been detected **FALSE –** No watchdog detected

Diagnostic Message	Symbolic Variable DG_modulename.tGeneral.	Description
OTD SWITCH ERROR	bOTDSwitchError	**TRUE –** Failure on the diagnostic switch **FALSE –** No failure on the diagnostic switch
OUTPUTS FAILURE	bAnalogOutputsFailure	**TRUE –** Analog outputs with failure or without external power supply **FALSE –** Analog outputs without failures
UNKNOWN DIAGNOSTIC	bReserved	Reserved
BUS COM. ERROR	bCommunicationError	**TRUE –** Failure in module communication with the backplane bus **FALSE –** Module communication with the backplane bus is OK

Table 19: General Diagnostics

8.4.2. Specific Diagnostics

Diagnostic Message	Symbolic Variable DG_modulename.tSpecific.	Description
OUTPUT 10 W/ DIAG	bActiveDiagnosticsOutput10	**TRUE –** Output 10 has active diagnostics **FALSE –** Output 10 doesn't have active diagnostics
OUTPUT 11 W/ DIAG	bActiveDiagnosticsOutput11	**TRUE –** Output 11 has active diagnostics **FALSE –** Output 11 doesn't have active diagnostics
OUTPUT 12 W/ DIAG	bActiveDiagnosticsOutput12	**TRUE –** Output 12 has active diagnostics **FALSE –** Output 12 doesn't have active diagnostics
OUTPUT 13 W/ DIAG	bActiveDiagnosticsOutput13	**TRUE –** Output 13 has active diagnostics **FALSE –** Output 13 doesn't have active diagnostics
UNKNOWN DIAGNOSTIC	bReserved_12..15	Reserved
INPUT 00 W/ DIAG	bActiveDiagnosticsInput00	**TRUE –** Input 00 has active diagnostics **FALSE –** Input 00 doesn't have active diagnostics
INPUT 01 W/ DIAG	bActiveDiagnosticsInput01	**TRUE –** Input 01 has active diagnostics **FALSE –** Input 01 doesn't have active diagnostics
INPUT 02 W/ DIAG	bActiveDiagnosticsInput02	**TRUE –** Input 02 has active diagnostics **FALSE –** Input 02 doesn't have active diagnostics
INPUT 03 W/ DIAG	bActiveDiagnosticsInput03	**TRUE –** Input 03 has active diagnostics **FALSE –** Input 03 doesn't have active diagnostics
INPUT 04 W/ DIAG	bActiveDiagnosticsInput04	**TRUE –** Input 04 has active diagnostics **FALSE –** Input 04 doesn't have active diagnostics

Diagnostic Message	Symbolic Variable DG_modulename.tSpecific.	Description
INPUT 05 W/ DIAG	bActiveDiagnosticsInput05	**TRUE –** Input 05 has active diagnostics **FALSE –** Input 05 doesn't have active diagnostics
INPUT 06 W/ DIAG	bActiveDiagnosticsInput06	**TRUE –** Input 06 has active diagnostics **FALSE –** Input 06 doesn't have active diagnostics
INPUT 07 W/ DIAG	bActiveDiagnosticsInput07	**TRUE –** Input 07 has active diagnostics **FALSE –** Input 07 doesn't have active diagnostics

Table 20: Specific Diagnostics

ATTENTION

In star configurations, inputs 00, 01, and 02 correspond to the voltages L1, L2, and L3, respectively. On the other hand, in the triangle configurations, inputs 00, 01, and 02 correspond to the voltages L1L2, L2L3, and L3L1, respectively.

8.4.3. Detailed Diagnostics

Diagnostic Message	Symbolic Variable DG_modulename.tDetailed.tAnalogInput_XX.	Description
UNKNOWN DIAGNOSTIC	bReserved_08..15	Reserved
NO DIAG	bInputNotEnabled	**TRUE –** Input not enabled **FALSE –** Input enabled
INPUT DISCONNECTED	bDisconnected	**TRUE –** Input disconnected **FALSE –** Input connected
HW INPUT FAILURE	bHwFailure	**TRUE –** Input with HW failure **FALSE –** Input without HW failure
UNKNOWN DIAGNOSTIC	bReserved_03..07	Reserved

Table 21: Detailed Diagnostics - Analogical Inputs

Diagnostic Message	Symbolic Variable DG_modulename.tDetailed.tAnalogOutput_XX.	Description
UNKNOWN DIAGNOSTIC	bReserved_08..15	Reserved
NO DIAG	bOutputNotEnabled	**TRUE –** Output not enabled **FALSE –** Output enabled
OPEN LOOP	bOpenLoop	**TRUE –** Output with open loop **FALSE –** Output without open loop
OUTPUT SHORT-CIRC.	bShortCircuit	**TRUE –** Output with short-circuit **FALSE –** Output without short-circuit
UNKNOWN DIAGNOSTIC	bReserved_03..07	Reserved

Table 22: Detailed Diagnostics - Analogical Outputs

ATTENTION

If an analog input or output is not configured, the diagnostic message NO DIAG will be displayed on the HX3040 CPU LCD. However, the message HW INPUT FAILURE may be indicated even if the input is not configured.

ATTENTION

In star configurations, inputs 00, 01, and 02 correspond to the voltages L1, L2, and L3, respectively. On the other hand, in the triangle configurations, inputs 00, 01, and 02 correspond to the voltages L1L2, L2L3, and L3L1, respectively.

ATTENTION

In the triangle and single-phase configurations, the neutral current is not measured and the value shown for it is zero. In these configurations, the DISCONNECTED INPUT diagnostics will not be activated, even if the input is configured.

ATTENTION

In the triangle configuration, the L2 current is not connected and is calculated based on the L1 and L3 currents. If there is a hardware failure diagnosis for either L1 or L3 current, a hardware failure diagnosis for the L2 current will also be triggered, even though it is not connected

8.5. Hot Swap

The HX6065 module supports hot swapping. For more information on how to perform correctly a hot swap, see the Hadron Xtorm Utilization Manual – MU223600.

9. Manuals

For further technical details, configuration, installation and programming, the table below should be consulted.

The table below is only a guide of some relevant documents that can be useful during the use, maintenance, and programming of this product.

Code	Description	Language
CE123000	Hadron Xtorm Series Technical Characteristics	English
CT123000	Características Técnicas Série Hadron Xtorm	Portuguese
MU223600	Hadron Xtorm Utilization Manual	English
MU223000	Manual de Utilização Hadron Xtorm	Portuguese

Table 23: Related Documents