Electronic Load (EL+ AC&DC)

Installation and operation manual

INDEX

1 WARNINGS

In case of DC models (B2C, EL+AC&DC, GE+AV&DC) the customer MUST install an isolation transformer in case of DC equipment if the EUT (Equipment Under Test) is NOT isolated from the GRID. If not, there is risk of damage to the CINERGIA unit or the EUT.

In case to install an isolation transformer, it is recommended to install an insulation monitor relay, to detect and recognize insulation faults in an IT system.

Please be sure that all parameters are appropriate for the EUT where the Cinergia converter is connected. For example, an over current or voltage can make irreversible damages to the EUT.

Before manipulating the cables in the cabinet terminals, please check the voltages with a voltmeter to assure no voltage is present. The grid cable and the EUT must be completely unpowered before connecting or disconnecting the cables. The user must be sure that the input and output switches are both in OFF position.

NEVER connect or disconnect the cables while the converter is in Standby Stop or Ready state.

When an accidental shutdown happens disconnect the mains and wait for at least 2 minutes for powering the cabinet again.

Inside the equipment there are dangerous voltages and metallic parts at high temperatures even when the equipment is stopped. The direct contact can cause electrocutions and burns. All the operations must be done by authorized technical staff.

This operation must be performed by personnel experienced with electrical systems. The direct contact can cause electrocutions and burns.

Due to high leakage currents of the CINERGIA equipment, the ground connection cables to be used must comply with Spanish regulations.

Before manipulating the equipment disconnect all the power supplies of the unit and wait until electrolytic capacitors are discharged (approx. discharge time: 5 minutes)

Please, take into account that the LIMITS in 3 CHANNELS are not working in 1 CHANNEL mode and vice versa.

Please, take into account that LIMITS don't be used as ALARMs. The unit will try to work between the limits configurated. If you want to be sure that the EUT is protected all the time, please configure the ALARMs correctly.

CINERGIA suggests installing an Inrush Current Limitation Circuit on the primary side of the external isolation transformer just to avoid the high leakage currents due to the magnetizing of the transformer.

In case of any DC models, it is MANDATORY installing an isolation transformer even if the EUT is galvanically isolated from the GRID.

Please, check that the recommendations provided fulfil with your country or local regulations. The recommendation we provide are based on Spanish regulations.

Please note that the isolation transformer presents a high inrush current due to the magnetizing of the transformer core. If this inrush current trips an upstream circuit breaker we recommend installing an inrush current limitation circuit.

It must never be forgotten that the EL is a power converter, so users must take all necessary precautions against direct or indirect contact.

In devices without isolation transformer, precautions must be taken as they are not isolated from the alternating input line, and there might be dangerous voltage between the output phases and the ground.

In case of discrepancies between labelling and this manual instruction, the label information will always prevail.

Do not store the unit where the ambient temperature exceeds 40ºC or falls below -20ºC.

It is very important to be sure that all connections are done properly.

It must never be forgotten that the EL is an Electronic Load, so users must take all necessary precautions against direct or indirect contact.

The ground cable (PE) of the main grid must be connected to ground transformer terminal (yellow-green) and ground Cinergia equipment terminals (X5 and X10) in all cases. If the protection earth wire is more than 10mm2 then only one cable (X5 or X10) needs to be connected.

The internal circuitry will be damaged if an external power supply is connected to X12 (J15) EPO terminals. Do not connect an external power supply or active signal. Only Normally Closed dry contact is allowed. The relay contact allows 230VAC/24VDC switching voltage and 2A switching current. Do not connect any other signal.

The maximum admitted input voltage is 24V (referenced to GNDMD). The digital outputs are 24V. The maximum admitted output current is 3A or 8mA (depending on the serial number of the equipment. Please see Digital Inputs and Outputs chapter. Applying an upper voltage or current can make irreversible damage to the equipment.

The analogue inputs accept a voltage range from -10 Vdc to +10 Vdc and the analogue output delivers a voltage range from -10 Vdc to +10 Vdc. Both input and output are referenced to GND_ADC; pin 1, 8 and 15. Applying an upper voltage or current can make irreversible damage to the equipment. Applying any voltage at the analogue output pins can make irreversible damage to the equipment.

Before operating the equipment, check that the Protective Earth is properly connected.

Check out the electrical installation in both sides (input and output) of the cabinet. All wires shall be connected and secured before proceeding to the converter start-up.

When the equipment is turned off, the user has to wait at least 15 seconds before turn it on again.

If the user needs the converter to work as a load, press the button LOAD. In this case the setpoint must be with a negative sign. On the other hand, the converter will work as a source with a positive sign.

The user can configure the positive limit of current and power at 0A and 0W on the LIMIT tab of the interface to be sure that the equipment never will work as a SOURCE.

Applications with capacitors will require a pre-charge circuit.

Before operating the equipment, check that all LIMITS from the equipment are correct. Please take care that CNG equipment are bidirectional, this means that the equipment can consume or inject current. Please check that EUT device. The equipment can operate as a source or as a load.

Configuring the unit in Source mode may inject power to the EUT. The EUT may be damaged if it is not regenerative.

When the equipment works in Virtual resistance mode, this resistance creates a voltage drop depending on the current flowing for each channel. In order to eliminate this voltage drop, there must be a value of 0 in all resistance.

If the user needs the converter to work as a load, press the button LOAD. In this case the setpoint must be with a negative sign. On the other hand, the converter will work as a SOURCE with a positive sign.

A setpoint with a ramp higher than 5 A/ms will produce over peaks bigger than 10%.

It should be noted that the Ipeak in every phase cannot exceed the maximum permitted value for the equipment (this maximum value varies according to the power range of EL used), i.e., when some harmonics are added to the fundamental frequency.

Important: using the Fault Generation take into account that the Electronic Load is a bidirectional equipment, this means that the equipment can consume or inject current. So, the user must be sure to define correctly the SIGNAL and PHASE of each SETPOINT to avoid any damage.

The equipment can operate as a source or as a load. Please take care about the signal of the setpoint to avoid any damage.

(AC mode) It is very important to be very aware of what is being connected in the output of the Cinergia equipment. It will be able to work in different modes for each channel (as a current source in current, power or impedance mode) injecting or consuming current/power. It is in the user responsibility to use this mode properly.

(DC mode) It is very important to be very aware of what is being connected in the output of the Cinergia equipment. It will be able to work in different modes for each channel (as a voltage or current source in current, power or impedance mode) injecting or consuming current/power. It is in the user responsibility to use this mode properly.

Please note that the converter can only place in the output the values within the accepted working range. However, a maximum CF of 3 is applied calculating the maximum pic current. Hence, an overcurrent alarm is possible in cases where the RMS value exceeds the converter limitations, for instance.

Please remember to turn OFF the equipment before modifying the connection mode at the output. Be sure that there is no voltage on any terminal.

Please be sure that no electrical connection between the phases exists. Keep in mind that, if two phases are actually interconnected, a shortcircuit may appear in voltage-based source.

Change the position of any switches disconnectors or selectors in RUN mode is NOT allowed. The equipment or EUT can be seriously damaged.

It is possible work with 3 different EUT at the same time, is important that the 3 EUT AC Power Supply are connected to the same neutral: the X9 terminal of the Electronic Load.

Please note that working with a single-phase grid requires a short circuit between the output terminals in the Cinergia converter. X6, X7 and X8 must be short circuited.

In case of working in 1 Channel mode the user must use 3 cables in the positive outputs (X6, X7 and X8) or use a bridge which put together all 3 phases. The negative outputs (X20, X21 and X22) must also be bridged in case of using only one cable.

Before running the equipment, please check all the limits and alarms.

Please keep in mind that not all EUTs are compatible with all operation modes. If the converter is operated as a voltage source, please do not connect any other voltage sources at the output.

In Current, Power or Impedance mode, the equipment controls current and it requires a voltage source connected at the output of the Cinergia equipment. The voltage source must be the first to be turned on. Once the Cinergia converter reads the voltage in the inverter, the Run state can be applied.

In case of doubts or problems with the converter, please make a screenshot or a photo of tabs mentioned in chapter 11 (Equipment ID) and send them to Cinergia.

The fuses can only be replaced by new ones of exactly the same model.

Make sure that the converter is in Local Mode before controlling the Steps, otherwise a message will pop-up denying the action.

Be aware that, when the information of the activated steps file changes, the same file must be re-activated to notify the converter of the changes.

Make sure that the converter is in Remote Mode before controlling the Steps, otherwise a message will pop-up denying the action.

Working with steps, without Multifaults? checked, the functionality of + button is to replace the information of the table with a new one.

Please get in mind that, in case of not changing the name of the transferred file, ACFaultsSteps.csv will be replaced with the new file (which has got the same name) once clicked “Transfer & Activate” button of AC Faults page.

Please remember to add the values to the table and transfer these by clicking “Transfer & Activate” button, if you want to activate each step.

Please get in mind that, in case of not changing the name of the transferred file, LVRT.csv will be replaced with the new file (which has got the same name) once clicked “Transfer & Activate” button from the current page.

Before powering the cabinet wait at least 50 seconds to be sure that the PC embedded inside the equipment starts correctly.

At improper handling of the optional battery test can cause irreversible damages, up to fire outbreaks can happen to the unit under test or battery. Read the operation, connections and test conditions of your battery carefully. Do not leave your energy storage unattended while a test is running!

Before powering the cabinet check step by step the items of chapter 7.5 Working with the equipment (vAC/DC)

LEAKAGE CURRENT: It is essential to connect the protection earth cable before connecting the input power supply cables.

This product can cause a DC current in the PE conductor. Where a residual current operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product.

This equipment is suitable for installation in networks with TT, TN or IT power distribution system, taking into account at the time of installation the particularities of the system used and the national electrical regulations of the country of destination

2 INTRODUCTION

Dear customer, on behalf of CINERGIA team, thank you for the confidence placed in our company and for the purchase of this product. Please, read carefully this manual before using the equipment to get familiarized with it and to obtain the maximum performance from it.

This document is intended for appropriately qualified personnel. Only personnel with the appropriate skills are allowed to perform the electrical connection and commissioning of the equipment.

The information in this documentation is not binding. CINERGIA reserves the right to make changes in part or in the whole at any time and without prior notice due to technical advance or product improvement.

This manual is valid for the following versions of PLUS family equipment:

- **EL+ vAC/DC**

Cinergia is in constant development to deliver always the best service to you, so it is possible to find some discrepancy between this manual and the real converter itself. Don't hesitate to contact us and ask for the latest version of the documentation.

2.1 Symbols used

DANGER: Indicates a hazardous situation which can result in death or serious injury and can cause important damage or destruction of the equipment or the property.

WARNING: Indicates important information that must be taken into account to operate the equipment. Take the appropriate prevention measures.

INFORMATION: Information that is important but is not safety-relevant.

2.2 Safety notes

Improper use of this equipment can cause both important personal injury and physical damage to the electrical power grid and the loads connected to it. Read this document carefully and follow all safety precautions at all times.

2.3 Quality and regulations

The equipment is based on a hardware designed, manufactured and commercialized in accordance with the standard EN ISO 9001 of Quality Management Systems. The marking shows conformity to the EEC Directive by means of application of the following standards:

• 2014/35/EU Low Voltage Directive (LVD)

• 2014/30/EU Electromagnetic Compatibility Directive (EMC)

• 2011/65/EU Restriction of Hazardous Substances in electrical and electronic equipments (RoHS)

In accordance with the specifications of the harmonized standards:

• EN-IEC 62040-1. Uninterruptible power supply (UPS). Part 1-1: General and safety requirements for UPS's used in accessible areas by end users.

• EN-IEC 60950-1. IT equipments. Safety. Part 1: General requirements.

• EN-IEC 62040-2. Uninterruptible power supply (UPS). Part 2: Prescriptions for Electromagnetic compatibility (EMC).

• EN-IEC 62040-3. Uninterruptible power supply (UPS). Part 3: Methods of operation specification and test requirements.

The manufacturer responsibility is excluded in the event of any modification or intervention in the product by the customer's side.

2.4 Legal Disclaimer

All product, product specifications, functionalities and datasheet are subject to change without notice in order to improve reliability, functionality, design, etc. Parameters provided in datasheets, manuals or in any other disclosure may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. CINERGIA, its employees and all persons acting on its behalf disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any disclosure relating to any product.

CINERGIA cannot warrant the suitability of the products for any particular application or the continuing operation of any product. Suitability of products for certain applications are based on CINERGIA's knowledge and tests but factory testing is limited and cannot reproduce all type of applications. It is the customer's responsibility to test and validate that a particular product is suitable for use in a particular application.

CINERGIA cannot be, and is not, aware of the particular application of our products. However, CINERGIA products might, from time to time, be used in Critical Applications such as medical, automotive, avionics, nuclear or military applications or in any other application where

inaccuracy or failure of CINERGIA products could directly or indirectly result in injury or death or damage to property. Please note that CINERGIA products have not been designed or qualified for any such Critical Application and that customers using CINERGIA products for use in such Critical Applications do so at their own risk. For legal reasons, CINERGIA products cannot be supplied and CINERGIA personnel cannot provide any training or support in nuclear, military or any potentially harmful and/or life-endangering application.

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Any information or documents involving industrial or intellectual property developed or provided by CINERGIA is exclusive property of CINERGIA. The customer or the seller cannot use such intellectual property, for purposes other than order fulfilment, operation and maintenance, without the prior written consent of CINERGIA.

3 GENERAL

The purpose of this manual is to provide information to use the Cinergia converter with all its different functionalities. It is important for the user to have this manual nearby and familiarize with it to operate efficiently with the converter.

The AC Electronic Load vAC/DC (EL+ vAC/DC) converter functionalities are the following:

- AC constant current
- AC constant power
- AC constant impedance (RLC)
- AC Current Faults: over/under current, flicker, current dip.
- Create sequences with all the functionalities above.
- Harmonic control: control odd and even harmonics up to the 15th. Configure the Nth harmonic up to the 50th.
- DC constant voltage
- DC constant current
- DC constant power
- DC constant resistance
- Create sequences with all the functionalities above in DC mode.
- Create data loggings and export the files into excel.
- Control the equipment with the delivered interface, the LCD touchscreen and the digitals/analogue inputs and outputs.

The equipment can also be upgraded with different optional, which have an additional cost:

- Use the EL in AC mode as a Power Amplifier: introduce the desired wave with an analogue signal and the equipment will amplify the power up to its nominal.
- Use the EL in DC mode as a Battery Test: charge and discharge batteries within, if desired, cycles that will be programed with the delivered interface.
- Use the EL in DC mode as a Battery Emulator introducing the datasheet parameters of any battery.
- Convert the EL in DC mode into a Photovoltaic Panel Emulator.

This document tries to be easy to understand, created with schematics and real pictures of the equipment with parts marked with letters and numbers which you can find the explanation just below the picture.

Cinergia is in constant development to deliver always the best service to you, so it is possible to find some discrepancy between this manual and the real converter itself. Don’t hesitate to contact us and ask for the latest version of the documentation.

4 ELECTRONIC LOAD: PRESENTATION

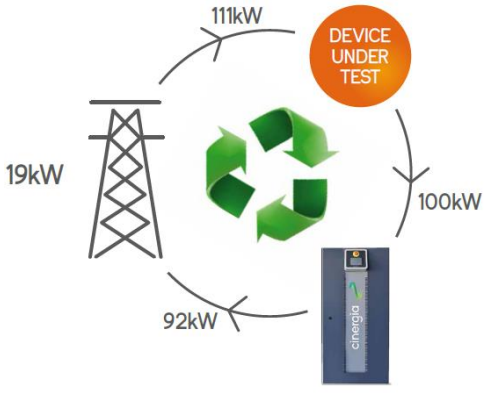
4.1 Introduction (vAC/DC)

As an electronic load, the EL is designed to test electric and electronic equipment in linear and non-linear AC and DC loading. It allows to verify the functionality of the Equipment Under Test (EUT) in normal and fault operation.

The main functionalities of the EL are the following:

- It converts the AC input, of the main grid, in a controlled AC (or DC) output by using an IGBT-based switching topology and DSP-based state-of-the-art digital control.
- It can be operated as:
    - CI: Constant Impedance output
    - CC: Constant Current output with harmonic definition
    - CP: Constant Power output (P,Q)
    - FG: Fault Generation
- It can generate different DC voltage source (DC mode):
    - Unipolar mode (phase to negative point):
        - from 20 to 750 VDC
        - from 20 to 800 VDC with HV option
    - Bipolar mode (phase U, W to Phase V)
        - from -350 to 350 VDC
        - from -380 to 380 VDC with HV option
- It can be operated as (DC mode):
    - CV: Constant Voltage output
    - CC: Constant Current output
    - CP: Constant Power output
    - CR: Constant Resistance output
    - BT: Battery Test *(optional)*
    - BE: Battery Emulator (*optional*)
    - PV: Photovoltaic panel emulator (*optional*)

- As a bidirectional converter, energy can flow from the grid to the EUT or vice versa. It allows energy saving during the tests by returning energy to the power grid. The following diagram explains this bidirectionality:



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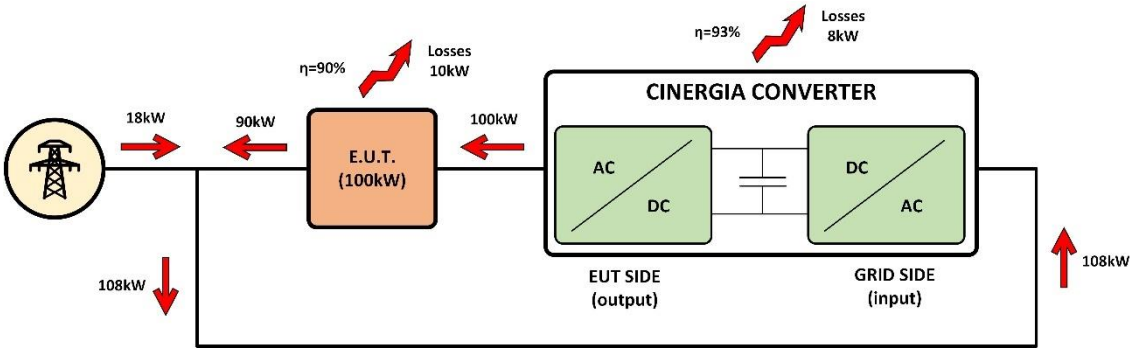

- The AC current consumed from the grid is sinusoidal (THD < 3%).
- The user can define the reactive power to be injected by the EL and choose between capacitive or inductive.

The power range covered by the EL electronic loads goes from 7.5 to 160 kW. The parallelization of ELs is also possible to increase power:

Reference	GE&EL+ 7.5 vAC/DC	GE&EL+ 10 vAC/DC	GE&EL+15 vAC/DC	GE&EL+20 vAC/DC	GE&EL+ 30 vAC/DC	GE&EL+40 vAC/DC	GE&EL+50 vAC/DC	GE&EL+60 vAC/DC	GE&EL+80 vAC/DC	GE&EL+100 vAC/DC	GE&EL+120 vAC/DC	GE&EL+160 vAC/DC	GE&EL+200 vAC/DC
Sout AC [kVA]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout AC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout DC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pin (Gen.) [kW]	8.3	11.1	16.7	22.2	30.0	44.4	55.6	60.0	88.9	111.1	120.0	161.1	177.8
Iin (Gen.) [A]	12	16	24	32	43	64	81	87	129	161	174	233	258
Iout AC 3ch [Arms]	11	15	22	29	40	58	73	80	116	145	157	211	232
Iout AC 1ch [Arms]	33	45	66	87	120	174	219	240	-				
Iout DC 3ch [A]	10	15	20	25	30	40	50	57	105	130	130	155	185
Iout DC 1ch [A]	30	45	60	75	90	120	150	171	315	390	390	465	555
Vout AC [Vrms ph-n]	0 - 277 (HV option: 295)												
Vout DC [V]	0 - 750 (HV option: 800)												
Fout AC [Hz]	10 - 400								10 - 100				
Weight (kg)	155					200			400			680	
Dimensions DxWxH [mm]	770x450x1100								880x875x1320			850x900x2000	

Note: All product, product specifications, functionalities and datasheet are subject to change without notice to improve reliability, functionality, design, etc. The information may not be current so please consult us for the latest update.

Note: All these values are for rated temperature of 20°C.

*For **more information**, see the "**Datasheet GE&EL+ vAC/DC**" document.*

Reference	GE&EL+ 7.5 vAC	GE&EL+ 10 vAC	GE&EL+15 vAC	GE&EL+20 vAC	GE&EL+ 30 vAC	GE&EL+40 vAC	GE&EL+50 vAC	GE&EL+60 vAC	GE&EL+80 vAC	GE&EL+100 vAC	GE&EL+120 vAC	GE&EL+160 vAC	GE&EL+200 vAC
Sout AC [kVA]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout AC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout DC [kW]	-												
Pin (Gen.) [kW]	8.3	11.1	16.7	22.2	30.0	44.4	55.6	60.0	88.9	111.1	120.0	161.1	177.8
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*For **more information**, see the "**Datasheet GE&EL+ vAC**" document.*

Reference	EL+7.5 vAC/DC	EL+10 vAC/DC	EL+15 vAC/DC	EL+20 vAC/DC	EL+30 vAC/DC	EL+40 vAC/DC	EL+50 vAC/DC	EL+60 vAC/DC	EL+80 vAC/DC	EL+100 vAC/DC	EL+120 vAC/DC	EL+160 vAC/DC	EL+200 vAC/DC
Sout AC [kVA]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout AC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
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Iout DC 1ch [A]	30	45	60	75	90	120	150	171	315	390	390	465	555
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Note: All these values are for rated temperature of 20°C.

*For **more information**, see the "**Datasheet EL+ vAC/DC**" document.*

Reference	EL+7.5 vAC	EL+10 vAC	EL+15 vAC	EL+20 vAC	EL+30 vAC	EL+40 vAC	EL+50 vAC	EL+60 vAC	EL+80 vAC	EL+100 vAC	EL+120 vAC	EL+160 vAC	EL+200 vAC
Sout AC [kVA]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout AC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout DC [kW]	-												
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Iout AC 1ch [Arms]	33	45	66	87	120	174	219	240	-				
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Note: All these values are for rated temperature of 20°C.

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Reference	EL+7.5 vHiL	EL+10 vHiL	EL+15 vHiL	EL+20 vHiL	EL+30 vHiL	EL+40 vHiL	EL+50 vHiL	EL+60 vHiL	EL+80 vHiL	EL+100 vHiL	EL+120 vHiL	EL+160 vHiL	EL+200 vHiL
Sout AC [kVA]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout AC [kW]	7.5	10	15	20	27	40	50	54	80	100	108	145	160
Pout DC [kW]	3.75	5	7.5	10	14	20	25	27	40	50	54	72.5	80
Pin (Gen.) [kW]	8.3	11.1	16.7	22.2	30.0	44.4	55.6	60.0	88.9	111.1	120.0	161.1	177.8
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Iout AC 1ch [Arms]	33	45	66	87	120	174	219	240	-				
Iout DC 3ch [A]	5	7.5	10	12.5	15	20	25	28.5	52.5	65	65	77.5	92.5
Iout DC 1ch [A]	15	22.5	30	37.5	45	60	75	85.5	157.5	195	195	232.5	277.5
Vout AC [Vrms ph-n]	0 - 277 (HV option: 295)												
Vout DC [V]	0 - 750 (HV option: 800)												
Fout AC [Hz]	10 - 400								10 - 100				
Weight (kg)	155					200			400			680	
Dimensions DxWxH [mm]	770x450x1100								880x875x1320			850x900x2000	

Note: All product, product specifications, functionalities and datasheet are subject to change without notice to improve reliability, functionality, design, etc. The information may not be current so please consult us for the latest update.

Note: All these values are for rated temperature of 20°C.

*For **more information**, see the "**Datasheet EL+ vHiL**" document.*

Reference	EL+15 vHF	EL+20 vHF	EL+30 vHF	EL+40 vHF	EL+50 vHF	EL+15 vHF/DC	EL+20 vHF/DC	EL+30 vHF/DC	EL+40 vHF/DC	EL+50 vHF/DC
Sout AC [kVA]	15	20	27	40	50	15	20	27	40	50
Pout AC [kW]	15	20	27	40	50	15	20	27	40	50
Pout DC [kW]	-					15	20	27	40	50
Pin (Gen.) [kW]	16.7	22.2	30.0	44.4	55.6	16.7	22.2	30.0	44.4	55.6
Iin (Gen.) [A]	24	32	43	64	81	24	32	43	64	81
Iout AC 3ch [Arms]	20	26	40	52	65	20	26	40	52	65
Iout AC 1ch [Arms]	60	78	120	156	195	60	78	120	156	195
Iout DC 3ch [A]	-					20	25	30	40	50
Iout DC 1ch [A]	-					60	75	90	120	150
Vout AC [Vrms ph-n]	0 - 277 (HV option: 295)									
Vout DC [V]	-					0 - 750 (HV option: 800)				
Fout AC [Hz]	360 - 900									
Weight (kg)	155			200		155			200	
Dimensions DxWxH [mm]	770x450x1100									

Note: All product, product specifications, functionalities and datasheet are subject to change without notice to improve reliability, functionality, design, etc. The information may not be current so please consult us for the latest update.

Note: All these values are for rated temperature of 20°C.

*For **more information**, see the "**Datasheet EL+ vHF**" or "**Datasheet EL+ vHF/DC**" document.*

4.2 Main power supply features

MAGNITUDE		VALUE
Power		7.5 kVA - 160 kVA
Input side (GRID side)		
AC Voltage	Rated	3x400 Vrms+Neutral+Earth 3F+N+PE
Voltage range		+15%/-10% (100% Power) -20% (Power limited by input current)
Rated AC Current	Depends on model (see on datasheet)	13-286 Arms per phase
Rated AC Power	Depends on model (see on datasheet)	8 - 178 kW
Frequency		48-62 Hz
Protective Class		Class I
Type electrical system		TN, TT, TI
Output side (EUT side)		
AC Voltage	Rated maximum, ch-neutral	25 - 277 Vrms (HV option: 295) (10 – 100 Hz)
		25 - 210 Vrms (101 - 200 Hz)
		25 - 115 Vrms (201 - 400 Hz)
Rated AC Current	3 Channels mode 1 Channel mode	10 - 232 Arms per channel 30 - 240 Arms global
Rated Power	Depends on model (see on datasheet)	7.5 – 160 kW
Frequency	Fundamental voltage	10 - 400 Hz(0.1 Hz resolution)(≤60 kVA) 10 - 100 Hz(0.1 Hz resolution)(>60 kVA) (HF option: 360 – 900 Hz)
DC Voltage	Channel-Com_neg Channel-Com_neg Bipolar	20 - 750 V (≤60 kVA)(HV option: 800 V) 40 - 750 V (>60 kVA)(HV option: 800 V) ±350 V (HV option: ±380 V)
DC Current	1 Channel mode 3 Channels mode Bipolar output	0 to ±555 A global 0 to ±185 A per channel 0 to ±185 A per channel
General		
Short circuit ratings input	Depends on model	
IP rating of enclosure	IP20	
Standards		
CE Marking		
Safety	EN 62477-1	
EMC	EN-IEC 62040-2	
Operating and storage environments		
OVC III Altitude: 2000 m.s.n.m Climatic: class 3K3 (Temperature: +5 °C to 40 °C, Humidity: 5 to 85% R.H. / non-condensing) Pollution degree: 3 Humidity condition of the skin: waterwet Chemically active substances: class 3C1 (No salt mist) Mechanically active substances: class 3S1 (No requirement) Mechanical: class 3M1 (1 m/s2) Biological: class 3B1 (No requirement) Rated conditional short circuit current I_{cc} 10 kA		

POWER UNIT	CNG7.5	CNG10	CNG20	CNG30	CNG40	CNG50
$I_{cp,mr}$ (A)	700	700	700	700	1400	1400

POWER UNIT	CNG60	CNG80	CNG100	CNG120	CNG160	CNG200
$I_{cp,mr}$ (A)	1400	2240	2800	2800	3500	4410

4.3 Hardware versions of EL

There are the following HARDWARE versions:

- vAC: this version has AC functionalities only, no DC or power amplifier functionalities at all.
    - All functionalities in AC (CC, CP, CZ)
    - Analogue inputs are rms setpoints
    - Analogue outputs are rms measurements
- vDC: it is a commercial name for the B2C+. This version has DC functionalities only, no AC functionalities at all. The model delivered will be a B2C+.
- vPA-C: new version Current Power amplifier for PHIL applications:
    - all functionalities in AC (CC, CP, CZ)
    - limited functionalities DC (only CC)
    - limitations in DC power to ½ of power in AC
    - analogue signals are configurable by user: rms setpoints or real-time waveforms (PHIL)

  This version is new from the PLUS family. It allows the user to send a real-time current waveform that will be amplified (reproduced) by the unit. Important: for the EL user must synchronize the current with the voltage waveform.

- vAC/DC: this version can work only in AC or DC (not AC+DC):
    - All functionalities in AC (CC, CP, CZ)
    - All functionalities in DC (CV, CC, CP, CR)
    - No limitation in DC power
    - analogue signals are configurable by user: rms setpoints or real-time waveforms (PHIL)
- vHF: this version can work only in AC in the frequency range of 360Hz to 900Hz:
    - All functionalities in AC (CC, CP, CZ)
    - Analogue inputs are rms setpoints
    - Analogue outputs are rms measurements

HARDWARE versions can be updated (for instance a vAC can be convertet into a vAC/DC or vPA) but it requires the unit to be send back to CINERGIA to make the hardware update, calibration and FAT.

Model	HW Version	AC modes				DC modes			
		CV	CC	CS/CP	CZ	CV	CC	CP	CR
EL+	vAC	-	✓	✓	✓	-	-	-	-
	vPA-V	-	✓	✓	✓	●	✓	●	●

	vAC/DC	-	✓	✓	✓	✓	✓	✓	✓

✓Available in theStandard version

•Available as an option

- Not available

In this manual, only EL vAC/DC is described. For more information about the other EL versions, please read the specific information of each version.

4.4 Hardware options of EL

HARDWARE (HW) options can be updated but it requires the unit to be send back to CINERGIA to make the hardware update, calibration and FAT.

SOFTWARE (SW) option can be updated without the need to sending the unit back to CINERGIA and are the same for the different models. The update is done by introducing a code into the CINERGIA HMI that unlocks the functionality in the unit. The code is unique for each unit and may require an additional cost. *Please, contact Cinergia for further information*.

Model	HW Version	Hardware options	Software Options				
			High Frequency Switching	Battery Test	Battery Emulation	PV Emulation	Datalogger
EL+	vAC	Low Ripple (current) Separated Channel Control High Voltage Single phase operation Dual Sensing Range	Only in 15,20&30kVA[1]	-	-	-	✓
	vPA-V			●	●	●	✓
	vAC/DC			●	●	●	✓

✓Available in the Standard version
●Available as an option
- Not available

4.4.1 Low ripple inductance (HW)

The low ripple inductance option will allow a reduction of the ripple current at switching frequency below 0.5% peak to peak.

All models up to and including 60kVA include the low ripple inductor, it is not an option. For other power range, please contact with CINERGIA to include this option.

4.4.2 Separated channel control (HW)

This option allows:

- To start/stop independently each channel. There is a 1-phase output contactor that will be open /closed independently.
- To operate each channel in a different mode (CC, CP, CA in AC; CV, CC, CP, CZ, CR and option modes battery emulator, PV emulator, Battery Test in DC). Note: the modes available depend on the type of the unit (EL+ in this case) and the version (AC, DC; PA, AC/DC, HF) and the optional acquired.
- The three channels will work either in AC or in DC. It's not possible to have one channel in AC and another in DC.
- An alarm will only stop the channel affected by the alarm, the other channels will continue operating normally. Each channel can be reset individually.

All models up to and including 60 kVA include the separated channel control option, it is not an option. For other power range, please contact with CINERGIA to include this option.

[1] *Power is derated when the High Frequency Switching is enabled to 7.5, 7.5 and 10kW respectively*

4.4.3 High Voltage (HW)

This option allows a maximum voltage up to 295 Vrms (phase to neutral) in AC versions and up to 800 V in DC versions.

4.4.4 Single phase operation (HW)

The units can work in 1 Channel mode by shortcircuiting physically the three output channels in AC mode and activating the 3 CHANNELS-1 CHANNEL manual switch in DC mode. It is important to consider that, in AC Applications (not in DC), working as a single-phase converter will increase the ripple in the internal DC-link and this will reduce the lifetime of the capacitors.

We strongly advise to communicate to CINERGIA those projects where the unit will be mostly used in single-phase. We will propose the single-phase option by which the internal DC-link capacitors will be reinforced.

4.4.5 2nd Sensing range (HW)

It is possible to add a second sensing range for the output current of the unit in all versions (AC, DC, AC/DC, PA) with the following features;

- The user will be able to choose between Low Range (new range added) and High Range (Standard range)
- When Low Range is activated, the unit will automatically activate also the High Frequency Switching (only in 15, 20 and 30 kVA)
- As a result the unit will have a higher resolution (and lower ripple if high frequency switching is activated) for the Low current Range

4.4.6 High frequency switching (SW)

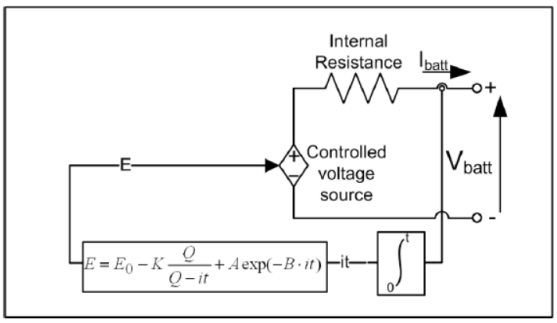
This option is available for all the CINERGIA models (GE+, EL+, B2C+, GE/EL+) and all hardware versions (vAC, vDC, vAC/DC, vPA, vHF) but only for the power up to 30 kVA. When this option is activated (using a code in the HMI):

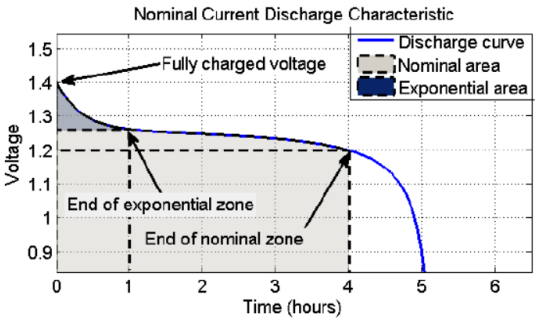
- The switching frequency is modified from 15 to 30 kHz
- The ripple (current and voltage) is reduced 50%, approx.
- The switching frequency is not audible
- The efficiency is reduced to 80% approximately
- The rated power is limited to:
    - 15 kVA and 20 kVA are limited to 7.5 kW
    - 30 kVA is limited to 10 kW

For further information, please read the document *High Frequency switching Optional*.

4.4.7 Battery Emulator (SW)

The Battery Emulator option can be only activated in DC units or AC/DC units in DC mode. The channel/s configured in battery emulator mode will work as a Constant Voltage source where the voltage is a function of a battery model as described by the function below:





Model and picture above are from: O. Tremblay, L.-A. Dessaint, A.-I. Dekkiche, "A Generic Battery Model for the Dynamic Simulation of Hybrid Electric Vehicles", 2007 IEEE® Vehicle Power and Propulsion Conference, September 9-13, 2007, Arlington/Texas, USA

The model allows the emulation of different technologies of battery: *Lead Acid, Nickel-Cadmium, Lithium-Ion, Nickel Metal-Hydrid, …*

For further information, please read the document *Battery Emulator Optional*.

4.4.8 Battery Test (SW)

Battery Test option can be only activated in DC units or AC/DC units in DC mode. It is included as a standard option in all B2C+ units. The Battery Test function are listed below:

- It allows charging and discharging any technology of battery by configuring the Constant Current/Constant Voltage IUoU charge algorithm
- It allosws the automation of cycling tests by configuring the number of cycles and transition conditions: min/max voltage, min/max current, Ah, time
- All parameters can be saved/loaded to/from a csv file

For further information, please read the document *Battery Test Optional*.

4.4.9 PV Emulator (SW)

The PV Emulator option can be only activated in DC units or AC/DC units in DC mode. The channel/s configured in PV emulator modes will work as a Constant Current source where the current setpoint is calculated by a Simplified PV Panel mode as described by the function below:

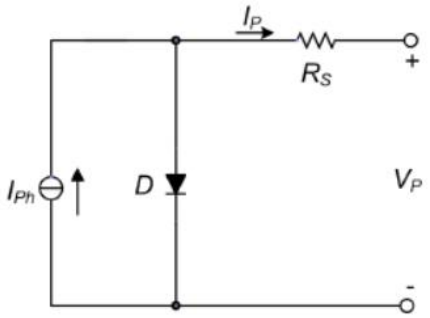


Fig. 1 – Single-diode equivalent circuit of a PV module.

$$I_P = I_{SC} \cdot \left[1 - C_1 \cdot \left(e^{\left(\frac{V_P}{C_2 \cdot V_{OC}}\right)} - 1\right)\right] \quad (1)$$

where

$$C_1 = \left(1 - \frac{I_{MPP}}{I_{SC}}\right) \cdot e^{\left(\frac{-V_{MPP}}{C_2 \cdot V_{OC}}\right)} \quad (2)$$

$$C_2 = \frac{\left(\frac{V_{MPP}}{V_{OC}} - 1\right)}{\ln\left(1 - \frac{I_{MPP}}{I_{SC}}\right)} \quad (3)$$

Model and above picture are from: Armando Bellini, Stefano Bifaretti, Vincenzo Iacovone, Cristina Cornaro, "Simplified Model of a Photovoltaic Module", Applied Electronics, 2009. AE 2009, 9-10 Sept. 2009, Pilsen, Czech Republic

This PV Panel Emulator allow the emulation of the connection serial/parallel of ideal PV panels. It's not possible to simulate shadows or more complex models.

For further information, please read the document *PV Emulator Optional*.

4.4.10 Datalogging (SW)

The units can log the variables of interest from the EUT side (voltages, currents, power, etc…). The datalogging interval can be configured by the user:

- Using the LCD locally on the unit
- Using the LCD remotely from a computer (using a VNC application)

When the datalogging is launched (manually) and the unit is in Run the system will start the logging of the variables without the need of any external computer. It is saved internally in the unit in a csv format.

For further information, please read the document *Datalogger Optional*.

4.5 Operation and connection modes (vAC/DC)

The output of the power converter is formed by three phases referenced to the neutral point of the system (N) in bipolar mode (AC and DC) or referenced to the DC common point (DC COMMON) in DC unipolar mode. Consequently, the user can choose between four possible connection modes for the electronic load:

- 3 Channels mode: Three phase power control. Each phase (U, V, W) is controlled independently. The current setpoint can be different in angle and magnitude for each of the three phases. Only voltage control mode in DC mode.
- 1 Channel mode: One phase power control (only DC case). In this case the user has one phase output. The total amount of current consumed will be the sum of all three phases. Only voltage control mode in DC mode. In AC mode the Electronic Load can work in 1 channel mode (called Single phase), but there is not hardware configuration.
- Unipolar mode: Electronic Load behaves as 3 independent and positive DC power supplies (only DC case).
- Bipolar mode: Electronic Load behaves as 2 independent DC power supplies. One is positive and the other negative. In AC case, the equipment must be in bipolar mode.

Four operation modes are allowed in AC mode and four in DC mode:

- Constant Impedance (CI): the output impedance is controlled to the set point value. The emulator will perform as a constant R, L, C (in case of choosing the DC Output option, only a constant R will be emulated).
- Constant Current (CC): the output current is controlled to the set point value (AC/DCmode). In AC Constant Current mode, the harmonic content of the current drawn by the equipment is configurable up to 15^{th}.
- Constant Power (CP): the output active and reactive power is regulated to the set point value (in case of choosing DC Output option, then active power is regulated).
- Constant Voltage (CV): the output voltage is controlled to the set point value. Only available in DC mode.
- Fault Generation (FG): create current disturbances such as over/under current and flickers in AC mode.
- Power amplifier or real-time waveforms (optional): the output of the converter will be the same waveform as the analogue input. Power Amplifier is an *optional* and has an additional cost.
- Battery Test (BT) (*optional*): B2C charge and discharge batteries within, if required, a cycling mode.
- Battery Emulator (BE) (*optional*): the converter behaves as a real battery by introducing the corresponding parameters. It is an *optional* and has an additional cost.
- Photovoltaic Panel Emulator (PV) (*optional*): the equipment behaves as a current source where the setpoint is calculated by a photovoltaic panel model. It is an *optional* and has an additional cost.

For further information, please go to chapter 7.3 (Connection modes) and 7.4 (Operation modes) of this document.

Please note that items marked as optional shall be requested specifically at additional cost.

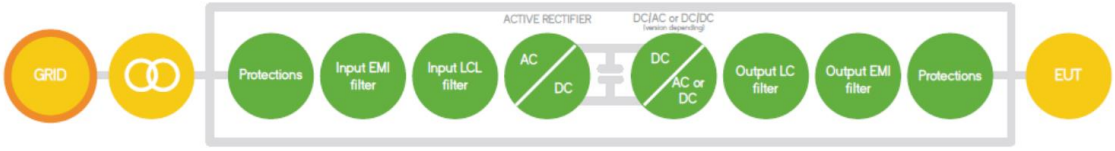
4.6 Configuration and control of the converter

The converter can be interfaced by three means:

- Local touchscreen: a 4.3" color local touchscreen panel can be used to configure, monitor and operate the electronic load. See section *Local Touchscreen Control Panel* for further information.
- Analog/Digital inputs/outputs: the converter owns 6 isolated analog inputs (+/-10 V) and 6 optocoupled digital inputs (max admitted current 3A in exception of equipment with serial number 2016XXXX, in which case the max admitted current will be 8 mA). The converter owns 6 analogue outputs and 6 digital outputs.
- Remote interface: An Ethernet communication interface with protocol MODBUS/TCP can be used to configure, monitor and operate the electronic load. By using HMI software application provided by CINERGIA, uploading of excel files is also possible.

4.7 Functional diagram

The diagram below is the conceptual function block diagram of the converter:



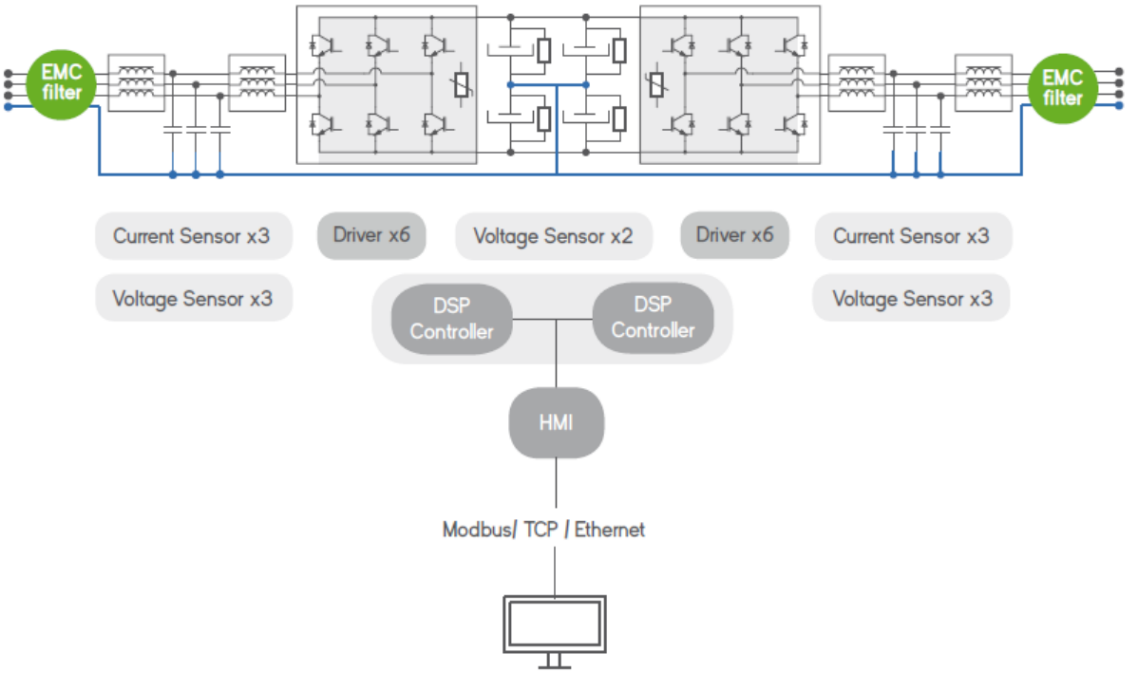
The main components of the diagram are the following (from grid side to EUT side):

- Isolation transformer: a 50/60 Hz isolation transformer can be provided optionally in order to isolate the output phases. In this case, an isolation monitor can be integrated in the converter also to detect isolation faults.
- Input protections: these protections include a thermal-magnetic circuit breaker and fuses. The connection of the converter input with the grid is done by screw terminals. Please follow the safety instructions in the *Installation* section to connect the electronic load.
- Input EMI filter: an electromagnetic filter is integrated to fulfil electromagnetic compatibility regulations. The structure of the filter is the same as the one of the output EMI filter.

- Input LCL filter: the purpose of this filter is to reduce the current distortion at frequencies equal to or higher than switching frequency and reduce THD.
- Active Rectifier: a three-branch IGBT active front end is integrated in the equipment to consume/inject a sinusoidal current from/into the grid.
  The DC link voltage is set to 800 V providing a regulation margin for fast transients at the output of the electronic load.
  The active rectifier has bidirectional power flow capability and the injected reactive power (grid side) can be defined by the customer.
- DC/AC output converter: it is a three-branch IGBT converter. Its topology is the three phases inverter and allows the conversion from the DC bus to each of the output AC phases.
  The user can choose between having each phase controlled independently or having the three of them controlled as a unique phase (sharing the same operation mode and setpoints).
- Output LCL filter: analogously to the input LCL filter, the filter reduces the current distortion (caused by switching) at the output of the electronic load.
- Output protections: a disconnector is provided to isolate the output from the EUT. Screw terminals are also integrated to connect the EUT. Please, follow safety instructions in *Installation* section to connect them.

4.8 Principle of operation

Below, a technical diagram of the converter is shown:



(Please note that earth protection cable is only connected to the cabinet chassis).

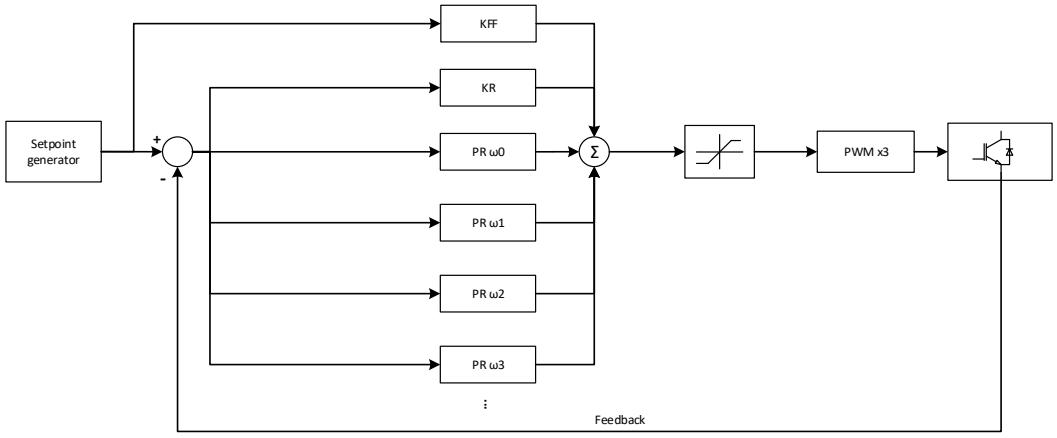
State-of-the-art digital control is used in all CINERGIA products. In the EL case, the control system algorithms are computed in two DSP based hardware, designed by CINERGIA, allowing a multitask execution of the regulation systems for the Active Rectifier and the Inverter output. This produces a fast transient response and a high performance against EUT changes. A 12 bits analog to digital conversion, with digital processing, allows a high resolution output up to 0.1%.

4.8.1 Resonant control (AC mode)

Control algorithms based on Resonant controllers are used in both AC sides; i.e. Resonant Control is always used in grid side but it is used in EUT side only when AC output option is chosen for the electronic load.

The algorithms regulation is structured in blocks resonating at a given frequency. Within the resonant frequency each block allows the suppression of gain and phase errors of the current. Thanks to this, each harmonic can be controlled independently and thus it can be generated or suppressed, as needed.

The following diagram illustrates how the mentioned algorithms operate:



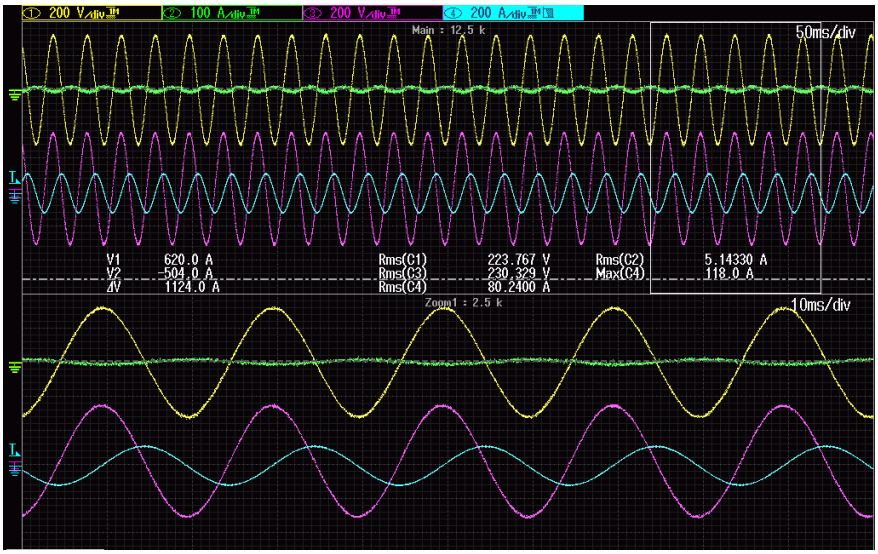
Therefore, the main characteristics of the Resonant Control applied are the ones listed below:

- Control loop rate of 30 kHz.
- Harmonics controlled up to 1000 Hz*
- 20 control loops executed per phase.
- 60 control loops executed in total (for the 3 phases).
- Each control loop controls independently magnitude and angle of one harmonic.
- Any kind of load can be implemented in the EUT side.
- All harmonics can be suppressed in the grid side.

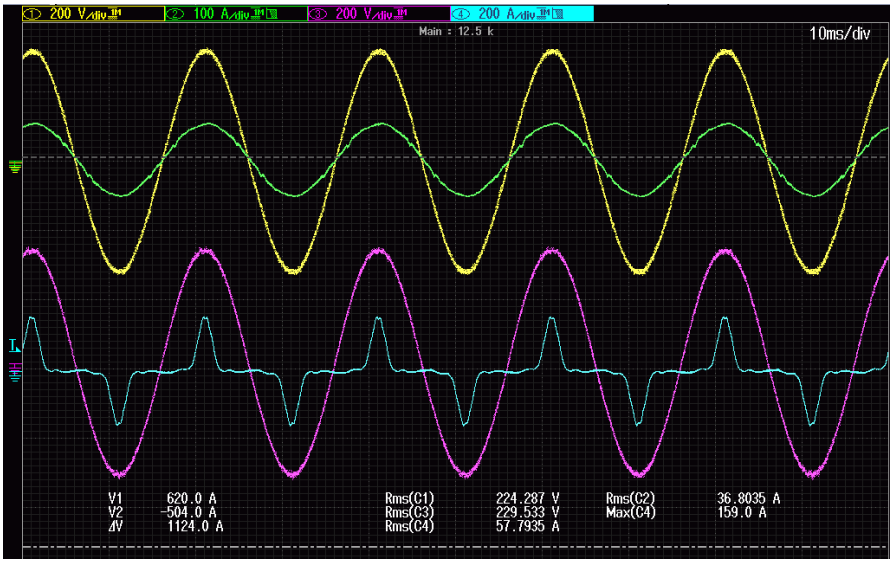
** It should be noted that the equipment bandwidth is 1000 Hz. Therefore, the harmonic content will be determined by the bandwidth as well as by the fundamental frequency specified by the user.*

Finally, the following pictures are some examples of how the EL Resonant Control can work. It is important to take into account that, in these three pictures:

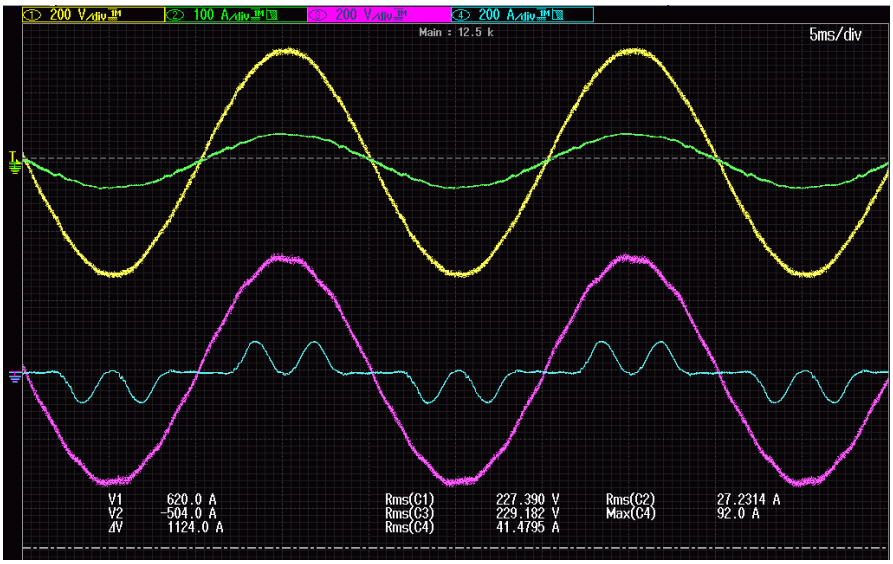
- Yellow waveform: input $U_{phase-N}$
- Green waveform: input $I_{phase-N}$
- Pink waveform: output $U_{phase-N}$
- Blue waveform: output $I_{phase-N}$



In this case, there is reactive power consumption from the EUT (PF = 0) and no power is injected into the grid.



In this second picture, the EL is behaving like a single-phase rectifier.

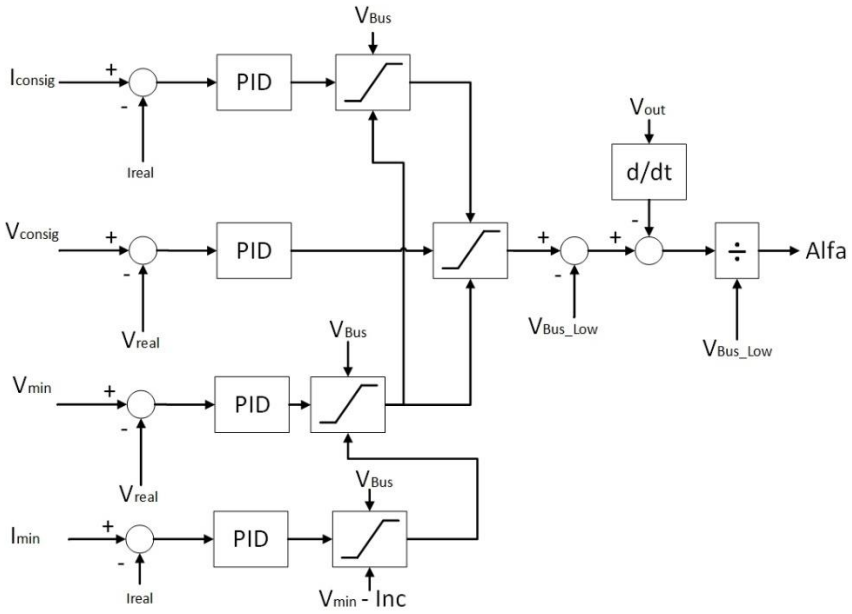


In this last case, the EL is behaving like a three-phase rectifier.

4.8.2 PID control (DC mode)

The EUT side control algorithm is based on a traditional current PID controller. In case controlling power, or even the impedance, both magnitudes are decoupled and translated to current set points on each control loop.

The following diagram illustrates how the algorithms operate:



Both in voltage mode and current mode, the equipment is regulated for the limits imposed by the interface: ***Max Current***, ***Min Current***, ***Max Voltage*** and ***Min Voltage***. In case that those limits are not configured, the equipment is protected by the natural limits (110% of the nominal current). The following table explains how those limits work.

Parameter	Description	Default
Max Current	Maximum limitation of positive output current: maximum current the equipment is able to inject	Maximum current limitation **110% Irated**
Min Current	Maximum limitation of negative output current: maximum current the equipment is able to drain	Maximum current limitation **110% Irated**
Voltage Max	Maximum limitation of voltage the equipment is able to put in the output	**750 V** Range: 0 V – 750 V
Voltage Min	Minimum limitation of voltage the equipment is able to put in the output	**20 V** Range: 0 V – 750 V

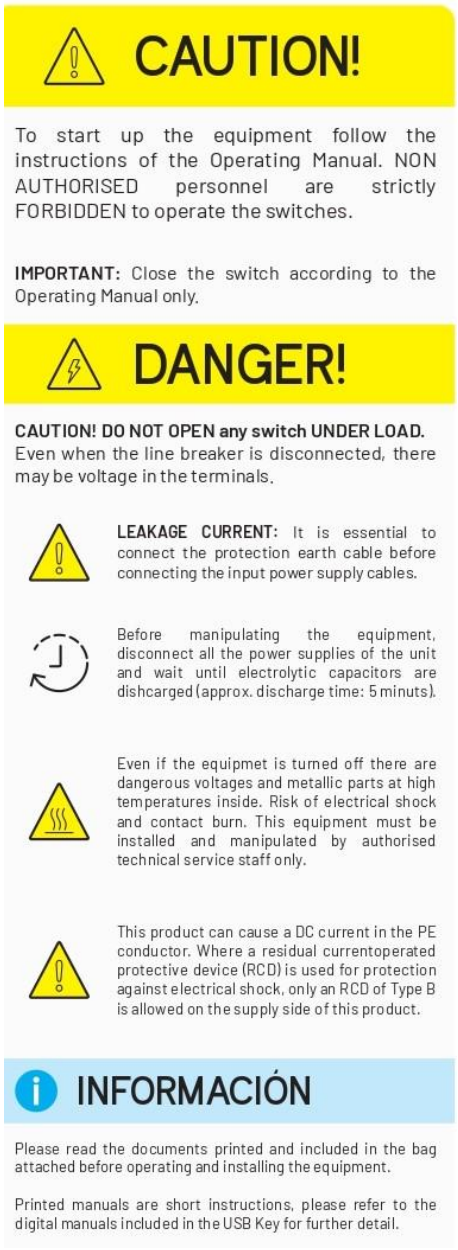
Please, take into account that the LIMITS in 3 CHANNELS are not working in 1 CHANNEL mode and vice versa.

Please, take into account that LIMITS don't be used as ALARMs. The unit will try to work between the limits configurated. If you want to be sure that the EUT is protected all the time, please configure the ALARMs correctly.

5 INSTALLATION AND WIRING RECOMMENDATIONS

CINERGIA is committed with the continuous improvement of the Service and Technical Support offered to you. For this reason, we are glad to provide you this guide of recommendations to install and start up the unit where you will find advice and recommendations for the installation of the equipment that you have just acquired.

We advise you to follow these instructions carefully and to contact us in case of any question or comment. If the commissioning of the unit has been agreed with CINERGIA or one of our distributors, please follow the recommendations in this document and once the installation is finished contact us to agree an appointment.



5.1 Requirements and process to locate and fit in the equipment

- The room where the equipment will be placed must be clean and aired, leaving a space around the equipment of 1 m.
- Unpack and place the equipment in its final location. Check that input and output connections are the same as the ones stated in the installation diagram. Terminal layout can differ from attached diagram, please pay attention to the equipment labelling when doing the connection.
- Proceed to make and connect the installation according to the diagram and table below. It is advisable to install all protection circuit breakers in a dedicated cabinet.
- Cables from electrical installation must have the suitable terminals to be connected on the terminals used in the equipment. Cable used in the installation has to be flexible and its length should be enough to allow moving the equipment without needing to disconnect it.

5.2 Installation features

- Cross cable section is recommended and based in the Spanish regulations. It is compulsory to respect the Local and/or National Low Voltage Regulations so please check the recommended values with respect to your local regulations.
- Recommended cross section with XLPW cable (cross linked polyethylene) is for a maximum total installed cable length of 30 meters.
- If the Equipment Under Test is a power electronics device we recommend to size the neutral wire to 200% of phase section.
- Cables trunks should be done over perforated shelves.
- The environmental conditions considered to calculate the recommended cross cable sections, in accordance with the Spanish regulations, are:
    - Ambient temperature: +40ºC.
    - Correction factor to install all input(s)/output cables of each single equipment in the same cable conduit.
    - Correction factor to install the input(s)/output cables of the system (equipments in parallel) in separate cable conduits.
- In case of installing fuses instead of moulded case circuit breakers, the fuses must be DIN gG/gL type.
- Recommended protection sizes do not provide selectivity with those in the equipment. If needed, choose a higher size than the recommended and size accordingly the cables.

5.3 Installation diagram

There are two different recommended installation diagrams to take into account.

- **Option A:** that NO external isolation transformer is provided or required. All units with internal isolation transformer must follow this recommendation installation diagram.
- **Option B**: that an external isolation transformer is provided or needed. All units with EXTERNAL isolation transformer required or installed must follow this recommendation diagram.

CINERGIA recommends installing safety protection elements at the input side of the unit. CINERGIA also recommends installing safety protection elements at the output side of the unit, between the CNG unit and EUT device. For an additional protection, in Option B where an external isolation transformer must be required, we recommend installing safety protection elements at the output of the transformer as well.

To know the recommended wiring and protective elements, please go to **CHAPTER 5.6**

Both recommended installation diagrams are shown below:

For more information about the terminal connection, please read the document provided with the unit *Quick Install*.

If the external transformer is not provided by CINERGIA, please ask the transformer's manufacturer for the correct safety protection elements to install.

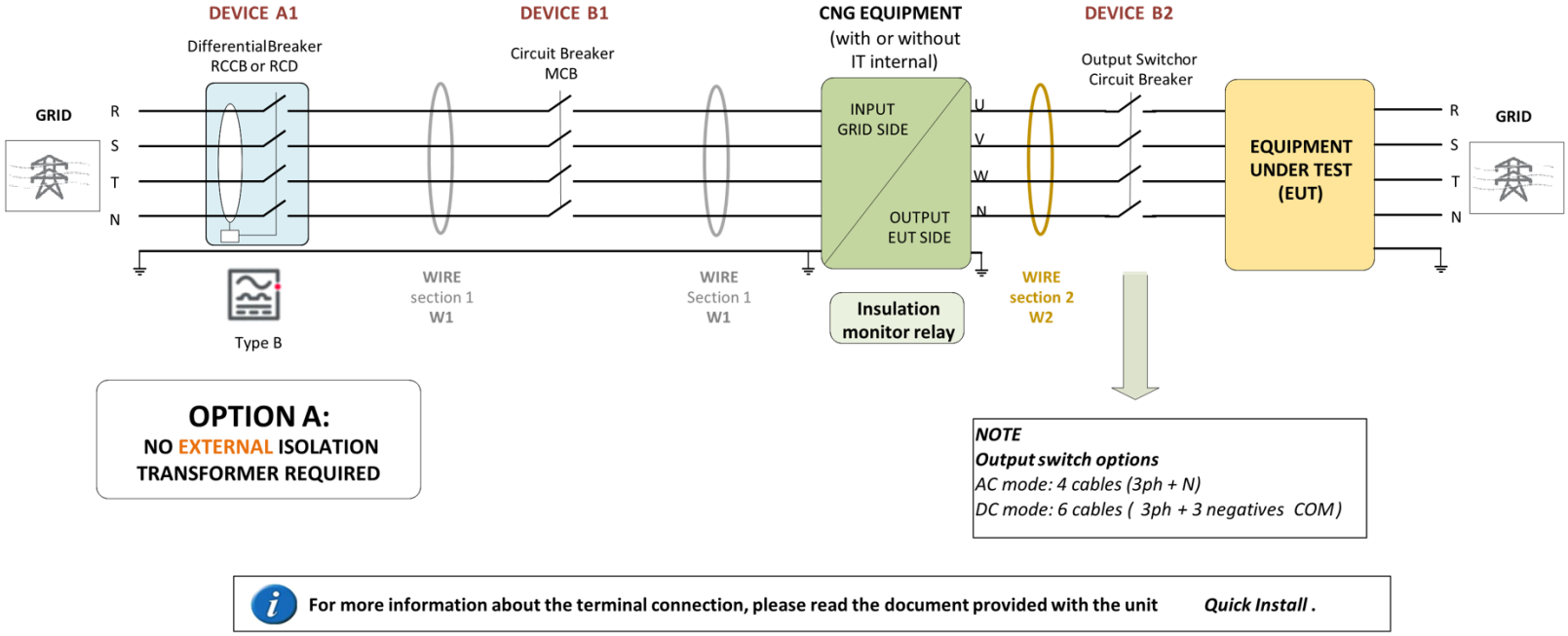
CINERGIA suggests installing an Inrush Current Limitation Circuit on the primary side of the external isolation transformer just to avoid the high leakage currents due to the magnetizing of the transformer.

Due to high leakage currents of the CINERGIA equipment, the ground connection cables to be used must comply with Spanish regulations.

5.3.1 OPTION A: WITHOUT EXTERNAL INSOLATION TRANSFORMER

This diagram must be used in all units provided WIHTOUT EXTERNAL transformer. To know about the DEVICES **A1**, **B1**, **B2** and **W1, W2**, go to **CHAPTER 5.4**.

If the installation requires an external transformer, even if the transformer is not provided by Cinergia, please look at **OPTION B** (CHAPTER 5.3.2) for the installation diagram.



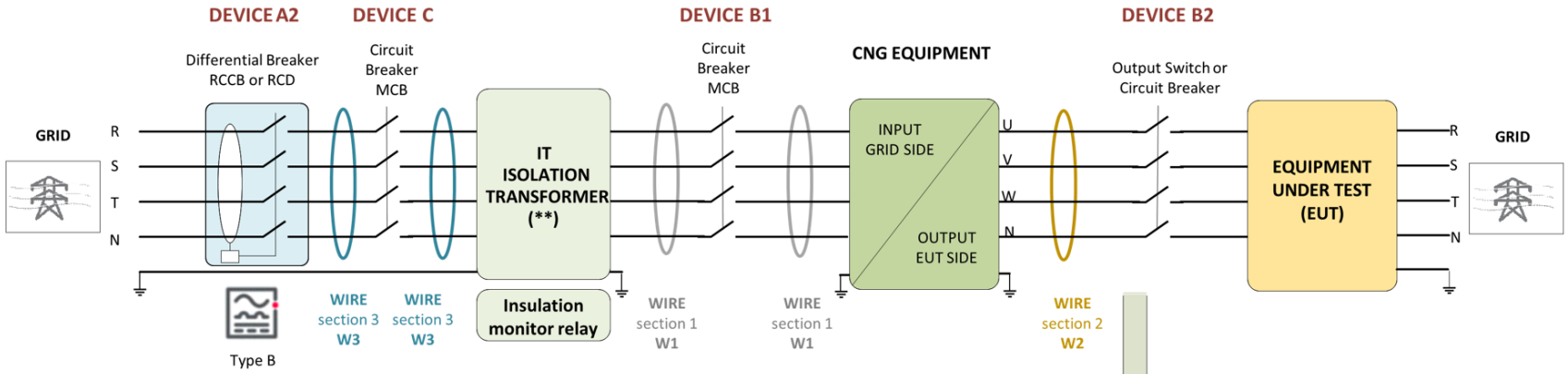
For more information about the terminal connection, please read the document provided with the unit *Quick Install* .

Take into account that the CINERGIA (CNG) unit can be provided with or without internal isolation transformer. In case of Internal Isolation Transformer, an Inrush current Limitation Circuit is always installed internally. In case of internal Isolation Transformer, the OPTION A must be followed.

5.3.2 OPTION B: WITH EXTERNAL INSOLATION TRANSFORMER

This diagram must be used in all units provided WITH EXTERNAL transformer. To know about the DEVICES **A2**, **B1**, **B2**, **C** and **W1**, **W2, W3**, go to **CHAPTER 5.5**

If the transformer is not provided by CINERGIA, please ask the transformer's manufacturer for the correct safety protection elements to install (**A**, **C** and **W3**).



OPTION B:
EXTERNAL ISOLATION TRANSFORMER REQUIRED

NOTE
Output switch options
AC mode: 4 cables (3ph + N)
DC mode: 6 cables (3ph + 3 negatives COM)

(**) If CINERGIA doesn't provide the transformer, please ask the transformers manufacturer for the correct safety protection elements required.

CINERGIA recommend installing an Inrush Current Limitation Circuit on the primary side of the external isolation transformer just to avoid the high inrush currents due to the magnetizing of the transformer.

5.4 Without isolation transformer (Option A)

CINERGIA standard units are not galvanically isolated from the grid. Therefore, the output terminals (including the negative rail and the neutral) are referenced electrically to the input grid neutral.

CINERGIA offers Isolation Transformer as an OPTIONAL for those test setups that require galvanic isolation. The necessity of an Isolation Transformer depends on the Equipment Under Test and the electrical installation of the laboratory (TT, TN or IT system).

It is mandatory to install an Isolation Transformer on units that will work in DC.

In CNG units up to 60 kVA, the Isolation Transformer can be installed internally. All units with internal transformer installed, an Inrush Current Limitation Circuit is also added internally.

Please, go to the **CHAPTER** 5.5 if your setup requires our unit with an Isolation transformer.

In case of DC models (B2C, EL+AC&DC, GE+AV&DC) the customer MUST install an isolation transformer in case of DC equipment if the EUT (Equipment Under Test) is NOT isolated from the GRID. If not, there is risk of damage to the CINERGIA unit or the EUT.

In case of any DC models, it is MANDATORY installing an isolation transformer even if the EUT is galvanically isolated from the GRID.

Please, ask to CINERGIA if your equipment has DC mode and does not integrate an isolation transformer.

Note that the internal or external transformer is an OPTIONAL. In units up to 60kVA the transformer can be internally installed.

When an Insulation Transformer is used the output terminals of the unit form an IT system. Please follow the local electrical safety regulations concerning IT systems and install an Insulation Monitor Relay when required.

The equipments with internal transformer provided by Cinergia (power range ≤ 60kVA) have the inrush current limitation box installed internally.

The values on all the tables in this document are valid for voltages of 230V

In case that CINERGIA deliver the unit without any Isolation transformer internally or externally installed, the recommended installation diagram to follow is the NO EXTERNAL TRANSFORMER connected (**OPTION A**).

Please, check that the recommendations provided fulfil with your country or local regulations. The recommendation we provide are based on Spanish regulations.

Following Spanish regulations and the diagram from chapter 5.3.1, the recommended element protections, and wires to install are:

ELEMENT	WHERE TO INSTALL	CHARACTERISTICS
DEVICE A1 - RCD	GRID SIDE	300 mA, type **B**, > Irated
DEVICE B1 – MCB	GRID SIDE	Rated current Type **C**
DEVICE B2 – MCB or SWITCH DISCONNECTOR	EUT SIDE	Rated current Type **C**
WIRE W1	GRID SIDE	3 phases + N + PE* on GRID SIDE
WIRE W2	EUT SIDE	3 phases + N + PE* on EUT SIDE in AC 3 phases + 3 DC- + PE* on EUT SIDE in DC

**The size of PE cable will depend on local regulations and electrical system (TN, TT, IT, etc…).*

This product can cause a DC current in the PE conductor. Where a residual current operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product

To know the sizing of the recommended wiring and protective elements, please go to CHAPTER 5.6

We recommend that the PE cable must be minimum section 10mm2 if only have one PE cable, in case that you have two PE cables, the size of the both PE cables will can be less.

5.5 Case external isolation transformer (Option B)

If the setup requires an External Isolation Transformer to be installed, the recommendation installation diagram to follow is the **OPTION B**, with EXTERNAL TRANSFORMER connected.

Following the recommendations from the transformer manufacturer of transformers provided by Cinergia, the recommended protection for the primary (grid) side of the transformer are two different alternatives to be installed[2]:

- ALTERNATIVE 1: a moulded circuit breaker type D[3] of Irated of the transformer (*),
- ALTERNATIVE 2: a moulded circuit breaker type C of 2xIrated of the transformer (*).

(*) To obtain the **rated current** (*Irated*) of the transformer take into account the ***performance of the transformer (90%)*** and a ***reduction of the 7% on the voltage range*** that the Spanish regulation permits.

Please note that the isolation transformer presents a high inrush current due to the magnetizing of the transformer core. If this inrush current trips an upstream circuit breaker we recommend installing an inrush current limitation circuit.

In case to install an isolation transformer, it is recommended to install an **insulation monitor relay,** to detect and recognize insulation faults in an IT system.

The equipments with internal transformer provided by Cinergia (power range ≤ 60kVA) have the inrush current limitation circuit box installed internally.

Please, check that the recommendations provided fulfil with your country or local regulations. The recommendation we provide are based on Spanish regulations.

Leave a minimum free space to cool the unit and according to power of:

Isolation transformer (kVA)	7.5 to 15	20 to 60	80 to 120	160 to 200
Sides (cm)	25	25	30	40
Rear (cm)	25	50	50	50
Top (cm)	50	50	70	100
Front (cm)	50	100	100	100

It is recommended to leave an additional **75 cm** at both sides, for possible interventions.

If the setup or the installation is not provided with any inrush current limitation circuit, this means that the installation diagram protective element and wirings must be increased or adapted to the high inrush current due to the magnetizing of the transformer.

[2] In case to add an Inrush current limitation circuit, please check the correct protection to install.
[3] *The type **D** circuit breaker permits a current peak of 15 x Irated.*

Following **Spanish regulations** and the diagram from chapter 5.3.2, the recommended element protections, and wires to install are:

ELEMENT	WHERE TO INSTALL	CHARACTERISTICS
DEVICE A2 - RCD	GRID SIDE - PRIMARY SIDE of the transformer	300 mA, type **B**, Alternative 1: > Irated of transformer Alternative 2: > 2xIrated of transformer
DEVICE C - MCB	GRID SIDE - PRIMARY SIDE of the transformer	Alternative 1: Type **D** Irated of transformer Alternative 2: Type **C** 2xIrated of transformer
DEVICE B1 – MCB	INPUT SIDE of the unit SECONDARY SIDE of the transformer	Rated current Type **C**
DEVICE B2 – MCB or SWITCH DISCONNECTOR	EUT SIDE	Rated current Type **C**
WIRE W3	GRID SIDE - PRIMARY SIDE of the transformer	3 phases + N + PE* on GRID SIDE
WIRE W1	INPUT SIDE of the unit or SECONDARY SIDE of the transformer	3 phases + N + PE* on INPUT SIDE
WIRE W2	EUT SIDE	3 phases + N + PE* on EUT SIDE in AC 3 phases + 3 DC- + PE* on EUT SIDE in DC

**The size of PE cable will depend on local regulations and electrical system (TN, TT, IT, etc…).*

This product can cause a DC current in the PE conductor. Where a residual current operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product

To know the sizing of the recommended wiring and protective elements, please go to CHAPTER 5.6.

The above **recommended protections** are useful in case that CINERGIA provides the transformer. In case that a third party supplies the transformer, please follow the recommendations from the transformer manufacturer.

Please, check that the recommendations provided fulfil with your country or local regulations. The recommendation we provide are based on Spanish regulations.

We recommend that the PE cables must be minimum section 10mm2.

5.6 Recommendation sizes of protection devices and wiring

Please, take into account that sizing of the wiring and protection elements must be calculated and depends on the country or local regulations:

All figures are calculated for a maximum total cable length of 30 m.

All figures are calculated for a **maximum total cable length of 10 m** between the equipment and the EUT.

Please, check that the recommendations provided fulfil with your country or local regulations. The recommendation we provide are based on Spanish regulations

The **sizing of the wires and protection elements** on grid side have been calculated considering rated grid voltage (230Vrms phase-neutral) and rated power. Please check the required sizing of wiring and protection elements in case that:

- The unit will be supplied permanently with an input voltage lower than 230 Vrms,phase-neutral (maximum drop of 20%)
- The unit will be overloaded within 125% (for 10 minutes), 150% (for 1 minute) or 200% for 2 seconds)
- The unit will be working in 3 independent channels or 1 channel mode in AC and DC mode (depend on the unit)

The values on all the tables in this document are valid for grid voltages of 230V.

The **sizing of wiring and protection elements** on the primary side of the transformer have been calculated considering a rated current of the transformer:

- Taking into account the performance of the transformer of 90%
- A reduction of the 7% in the grid voltage
- An inrush current due to the core magnetization

5.6.1 Option A: Without external isolation transformer (IT)

	WHERE TO INSTALL	CHARACTERISTICS
DEVICE A1 - RCD	GRID SIDE	300 mA, type **B**, > Irated
DEVICE B1 – MCB	GRID SIDE	Rated current Type **C**
DEVICE B2 – MCB or SWITCH DISCONNECTOR	EUT SIDE	Rated current Type **C**
WIRE W1 (*)	GRID SIDE	3 phases + N + PE* on GRID SIDE RZ1-K
WIRE W2 (*)	EUT SIDE	3 phases + N + PE* on EUT SIDE in AC 3 phases + 3 DC- + PE* on EUT SIDE in DC RZ1-K

(*) Cables and protection devices must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

All wiring sizes has been taken into account that in AC mode the current on output side are balanced between phases. If this is not your case, please review your setup and re size the wiring accordingly.

In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated.

This product can cause a DC current in the PE conductor. Where a residual current operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product

POWER UNIT (kVA)	CNG7.5	CNG10	CNG15	CNG20	CNG30	CNG40	CNG50
DEVICE A1 - RCD	16 A	20 A	32 A	40 A	50 A	80 A	100 A
DEVICE B1 – MCB	16 A	20 A	32 A	40 A	50 A	80 A	100 A
DEVICE B2 – MCB or SWITCH DISCONNECTOR	16 A	16 A	25 A	32 A	40 A	63 A	80 A
WIRE W1 (*)	4 mm^2	4 mm^2	6 mm^2	10 mm^2	10 mm^2	16 mm^2	25 mm^2
WIRE W2 (*)(**)	4 mm^2	4 mm^2	6 mm^2	10 mm^2	10 mm^2	16 mm^2	25 mm^2

(*) Cables must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

(**) In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated.

POWER UNIT (kVA)	CNG60	CNG80	CNG100	CNG120	CNG160	CNG200
DEVICE A1 - RCD	100 A	160 A	200 A	200 A	250 A	315 A
DEVICE B1 – MCB	100 A	160 A	200 A	200 A	250 A	315 A
DEVICE B2 – MCB or SWITCH DISCONNECTOR	100 A	125 A	160 A	200 A	250 A	250 A
WIRE W1 (*)	35 mm^2	50 mm^2	70 mm^2	95 mm^2	120 mm^2	185 mm^2
WIRE W2 (*)(**)	35 mm^2	50 mm^2	70 mm^2	95 mm^2	120 mm^2	150 mm^2

(*) Cables must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

(**) In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated

5.6.2 Option B: With external isolation transformer (IT)

	WHERE TO INSTALL	CHARACTERISTICS
DEVICE A2 - RCD	GRID SIDE - PRIMARY SIDE of the transformer	300 mA, type **B**, Alternative 1: > Irated of transformer Alternative 2: > 2xIrated of transformer
DEVICE C - MCB	GRID SIDE - PRIMARY SIDE of the transformer	Alternative 1: Type **D,** Irated of transformer Alternative 2: Type **C,** 2xIrated of transformer
WIRE W3 (*)	GRID SIDE - PRIMARY SIDE of the transformer	3 phases + N + PE* on GRID SIDE RZ1-K
DEVICE B1 – MCB	INPUT SIDE of the unit SECONDARY SIDE of the transformer	Rated current Type **C**
DEVICE B2 – MCB or SWITCH DISCONNECTOR	EUT SIDE	Rated current Type **C**
WIRE W1 (*)	INPUT SIDE of the unit or SECONDARY SIDE of the transformer	3 phases + N + PE* on INPUT SIDE RZ1-K
WIRE W2 (*)	EUT SIDE	3 phases + N + PE* on EUT SIDE in AC - RZ1-K 3 phases + 3 DC- + PE* on EUT SIDE in DC - RZ1-K

(*) Cables must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

The table below only the ALTERNATIVE 1 is shown.

All wiring sizes has been taken into account that in AC mode the current on output side are balanced between phases. If this is not your case, please review your setup and re size the wiring accordingly.

In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated.

This product can cause a DC current in the PE conductor. Where a residual current operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side of this product

POWER UNIT (kVA)	CNG7.5	CNG10	CNG15	CNG20	CNG30	CNG40	CNG50
DEVICE A2 – RCD (#)	16 A	25 A	32 A	40 A	50 A	80 A	100 A
DEVICE C – MCB (#)	16 A	25 A	32 A	40 A	50 A	80 A	100 A
WIRE W3 (*)	4 mm^2	6 mm^2	10 mm^2	10 mm^2	16 mm^2	25 mm^2	35 mm^2
DEVICE B1 – MCB	16 A	20 A	32 A	40 A	50 A	80 A	100 A
DEVICE B2 – MCB or SWITCH DISCONNECTOR	16 A	16 A	25 A	32 A	40 A	63 A	80 A
WIRE W1 (*)	4 mm^2	4 mm^2	6 mm^2	10 mm^2	10 mm^2	16 mm^2	25 mm^2
WIRE W2 (*)(**)	4 mm^2	4 mm^2	6 mm^2	10 mm^2	10 mm^2	16 mm^2	25 mm^2

(#) The table below only the ALTERNATIVE 1 is shown.

(*) Cables must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

(**) In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated.

POWER UNIT (kVA)	CNG60	CNG80	CNG100	CNG120	CNG160	CNG200
DEVICE A2 – RCD (#)	125 A	160 A	200 A	250 A	315 A	400 A
DEVICE C – MCB (#)	125 A	160 A	200 A	250 A	315 A	400 A
WIRE W3 (*)	50 mm^2	70 mm^2	95 mm^2	120 mm^2	185 mm^2	2x150 mm^2
DEVICE B1 – MCB	100 A	160 A	200 A	200 A	250 A	315 A
DEVICE B2 – MCB or SWITCH DISCONNECTOR	100 A	125 A	160 A	200 A	250 A	250 A
WIRE W1 (*)	35 mm^2	50 mm^2	70 mm^2	95 mm^2	120 mm^2	185 mm^2
WIRE W2 (*)	35 mm^2	50 mm^2	70 mm^2	95 mm^2	120 mm^2	150 mm^2

(#) The table below only the ALTERNATIVE 1 is shown.

(*) Cables must fulfill the local regulation. Cinergia recommends RZ1-K. Individual cable line section is indicated.

(**) In DC mode, for the DC COMMON cables the user must use three independent wires of the section indicated.

5.7 Configuration values of suitable terminal metric

Cables from electrical installation must have the suitable terminal metric value to connect at the input and output of the equipment.

Please consult the full document provided named *Installation and Wiring Recommendations* to understand the installation recommendations depend on the option of your final installation system (option A: with inrush current limitation box, option B: without inrush current limitation box).

Nomenclature	Characteristics	CNG7.5	CNG10	CNG15	CNG20	CNG 30	CNG40	CNG50	CNG 60	CNG80	CNG100	CNG120	CNG160	CNG 200
Input Electrical Connection	Terminal Metric Value	M6	M6	M6	M6	M6	M8	M8	M8	M10	M10	M10	M10	M10
Output AC Electrical Connection	Terminal Metric Value	M6	M6	M6	M6	M6	M8	M8	M8	M10	M10	M10	M10	M10
Common Electrical Connection	Terminal Metric Value	M6	M6	M6	M6	M6	M8	M8	M8	M10	M10	M10	M10	M10
Terminal details	Torque (Nm)	2.5	2.5	2.5	2.5	2.5	6.0	6.0	6.0	10.0	10.0	10.0	10.0	10.0

The values on all the tables in this document are valid for voltages of 230 V. In case to detect a lower grid voltage, please use a section cable of the following higher level of the table.

6 INSTALLATION

6.1 Important safety instructions

As a device with class I protection against electric shocks, it is essential to install a protective earth wire (connect earth ⏚). Connect the protection earth wire to the terminals (**X5 and X10**) before connecting the grid to the electronic load input.

All the electrical connections, including those for control (interface, remote control…etc.), shall be done with all the switches in OFF position and with the mains supply disconnected (thermal-magnetic circuit breaker in OFF position too).

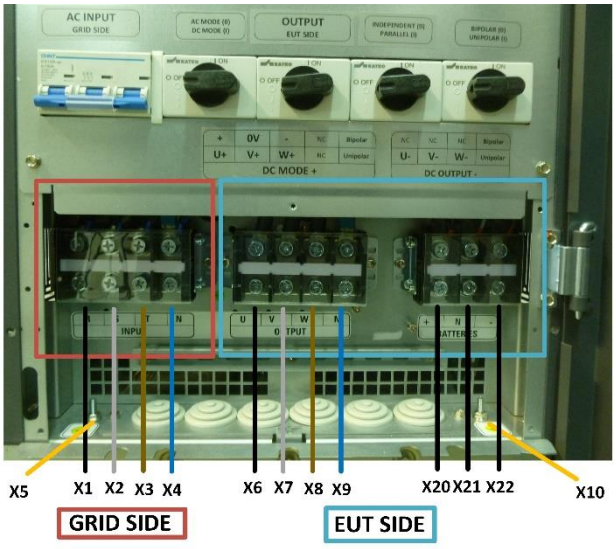
⚠ **It must never be forgotten that the EL is a power converter, so users must take all necessary precautions against direct or indirect contact.**

Warning labels should be placed on all primary power switches installed in places far from the device to alert the electrical maintenance personnel of the presence of a voltage in the circuit up to 10 minutes after stopping the device.

⚠ **In devices without isolation transformer, precautions must be taken as they are not isolated from the alternating input line, and there might be dangerous voltage between the output phases and the ground.**

6.2 Equipment views (vAC/DC)

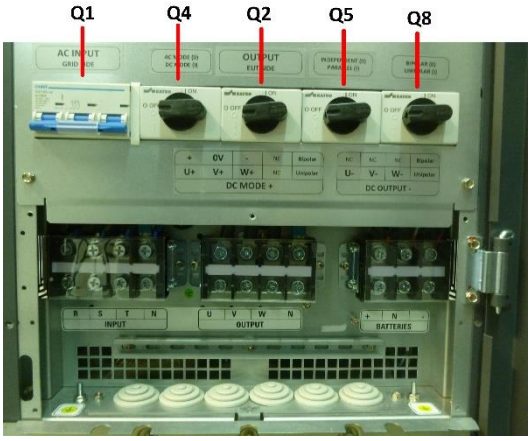
Electrical connections:



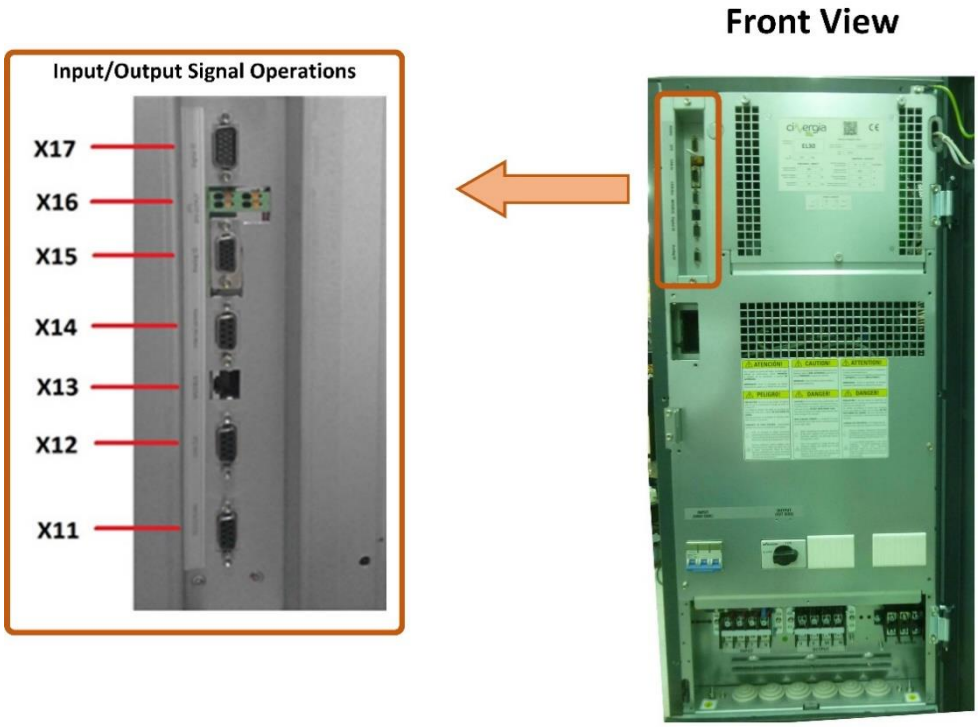
Local front panel:

Front view (with the door open):

Detailed view of the front protections and switches:



Detailed view of the signal front connectors:



General view (with the front door closed):

Protection elements (Q*):

- (Q1) Input thermal-magnetic circuit breaker or disconnector according to power of the equipment.
- (Q2) Output disconnector.
- (Q4) AC/DC switch.
- (Q5) 1 Channel connection switch.
- (Q8) Bipolar/unipolar switch.

Connection elements (X*):

- (X1) Phase input terminal R.
- (X2) Phase input terminal S.
- (X3) Phase input terminal T.
- (X4) Neutral input terminal N.
- (X5) Earth connection terminal for main supply ().

- (X6) Phase output terminal U.
- (X7) Phase output terminal V.
- (X8) Phase output terminal W.
- (X9) Neutral output terminal N.
- (X10) Earth connection terminal for main supply ().

- (X20) Negative output terminal U.
- (X21) Negative output terminal V.
- (X22) Negative output terminal W.
- (X11) DB9 femaleRS232 – RS485 connector for communications (optional).
- (X12) DB9 female CAN OUT.
- (X13) RJ45 connector for MODBUS interface.
- (X14) Internal comms (not used).
- (X15) *SUBD_15HD_FA_CI/SOP* connector for analogic inputs and outputs.
- (X16) Terminals for external Emergency Power Off (EPO) button.
- (X17) *SUBD_15HD_MA_CI/SOP* connector for digital inputs and outputs.

In case of discrepancies between labelling and this manual instruction, the label information will always prevail.

6.3 Equipment reception

6.3.1 Unpacking and checking the content

On receiving the device, make sure that the converter has not suffered any damage during the transportation. Otherwise, make all pertinent claims to the supplier or to CINERGIA.

The packing of the device consists of a wooden palette, a cardboard or wooden packaging (depending on the case), expanded polystyrene corner pieces, a polyethylene sleeve and bands; all recyclable materials. Therefore, they should be disposed of according to current regulations. We recommend to keep the packaging in case its use is necessary in the future.

In order to unpack, cut the bands and remove the cardboard packaging with a vertical movement. In case of wooden packaging, remove it with the appropriate tools. Afterwards, remove the corner pieces and the plastic sleeve. At this point the equipment will be unpacked on the pallet. Please, use suitable tools to lower the converter from the pallet.

For more information, see the specific "*Unpacking* ..." document.

After unpacking the equipment, check that the data in the nameplate (stuck on the inner part of the front door) correspond to those specified in the purchase order. Contact the supplier or CINERGIA in case of disconformity.

Keep the equipment in the original package if it will not be used in order to protect it from any possible mechanical damages, dust, dirt, etc…

Keep the original wooden package or original package safe for later use.

6.3.2 Storage

The equipment shall be stored in a dry, ventilated place and protected against rain, water jets or chemical agents. It is advisable to keep the converter into its original package, which has been designed to assure the maximum protection during the transport and storage.

Do not store the unit where the ambient temperature exceeds 40ºC or falls below -20ºC

6.3.3 Transport to location

The equipment includes castors to facilitate its transport to its final location.

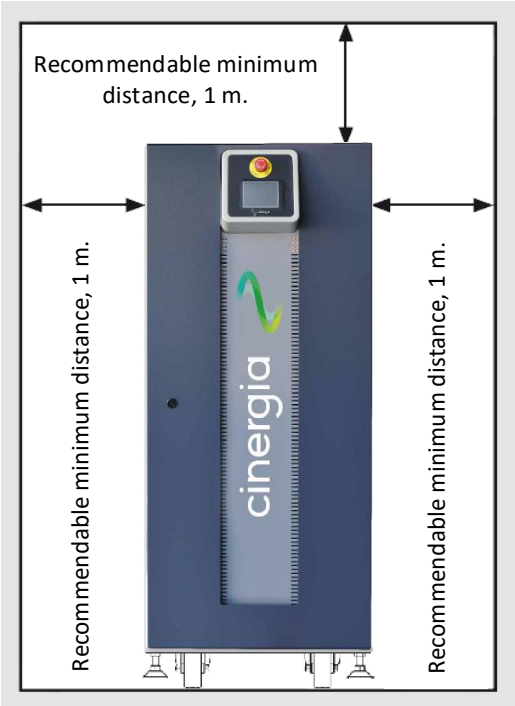
It is important to check previously if the weight of the converter is appropriate for the site where it will be located.

It is also important to consider the most suitable means to place the converter in its final location (floor, hoist, lift, stairs, etc…).

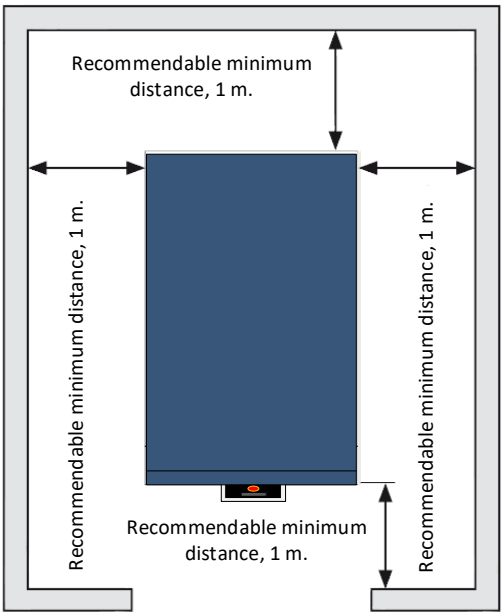
6.3.4 Location

It is necessary to leave a minimum of 25 cm in the contour of the equipment for its ventilation. If possible, as shown in following figures, it is recommended to leave additional 75 cm to facilitate the operations of maintenance of the equipment or the interventions of the technical service in case of breakdown.

Front view:



Top view:



The equipment may be installed in any place as long as the safety and ventilation requirements are fulfilled.

The converter includes 2 or 4 levelling elements (depend on the equipment) located near the front castors, which serve to immobilize the unit once it is in place.

To adjust the level, open the front door of the cabinet and proceed as follows:

- By hand, loosen the levelling elements by turning them anticlockwise until they touch the floor, and then, using a spanner, continue loosening until the castors are raised off the floor 0.5 cm maximum.
- Close the door once more.

6.3.5 Packing

If the equipment must be moved to a new location, please use the original package to avoid any damage during transportation.

For more information, see the specific "*Packing* ..." document.

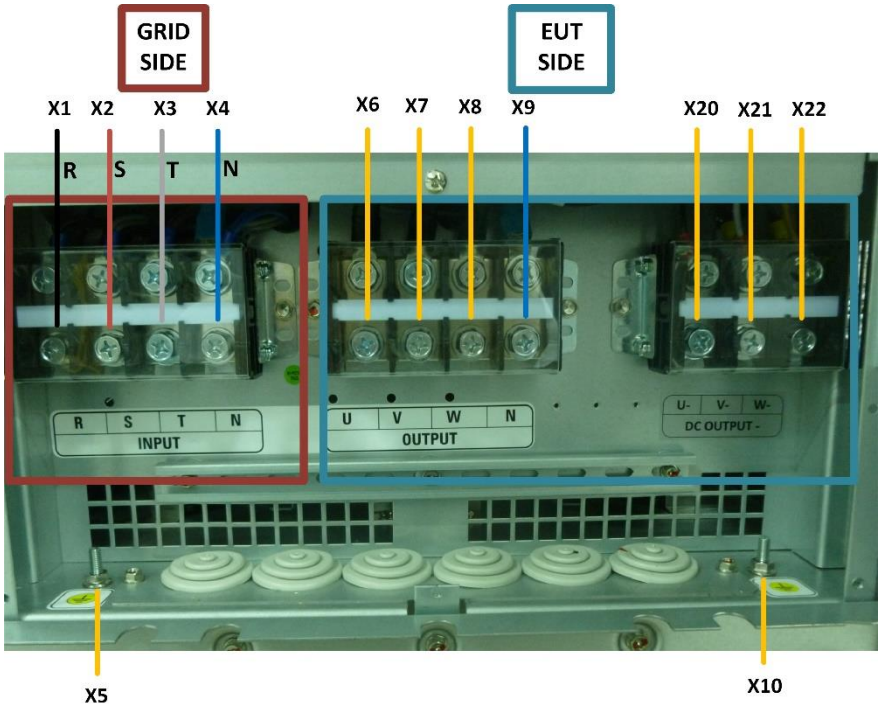
6.4 Wiring connection (vAC/DC)

Please, use a cable's section according to the rated power and current of the equipment. Check all the connection before turning on the equipment.

The recommended inspection interval to check terminal torque is once per year.

It is very important to be sure that all connections are done properly.

The following image details the equipment terminals:



6.4.1 Earth protection

As a device with class I protection against electric shocks, it is essential to install a protective earth wire (connect earth ⏚). Connect the protection earth wire to the terminals (**X5 and X10**) before connecting the grid to the electronic load input. If the protection earth wire is more than 10mm2 then only one cable (X5 or X10) needs to be connected.

All the electrical connections, including those for control (interface, remote control…etc.), shall be done with all the switches in OFF position and with the mains supply disconnected (thermal-magnetic circuit breaker in OFF position too).

It must never be forgotten that the EL is an Electronic Load, so users must take all necessary precautions against direct or indirect contact.

Warning labels should be placed on all primary power switches installed in places far from the device to alert the electrical maintenance personnel of the presence of a voltage in the circuit up to 10 minutes after stopping the device.

In devices without isolation transformer, precautions must be taken as they are not isolated from the alternating input line, and there might be dangerous voltage between the output phases and the ground.

We recommend that the PE cables must be minimum section 10mm2.

Due to high leakage currents of the CINERGIA equipment, the ground connection cables to be used must comply with Spanish regulations.

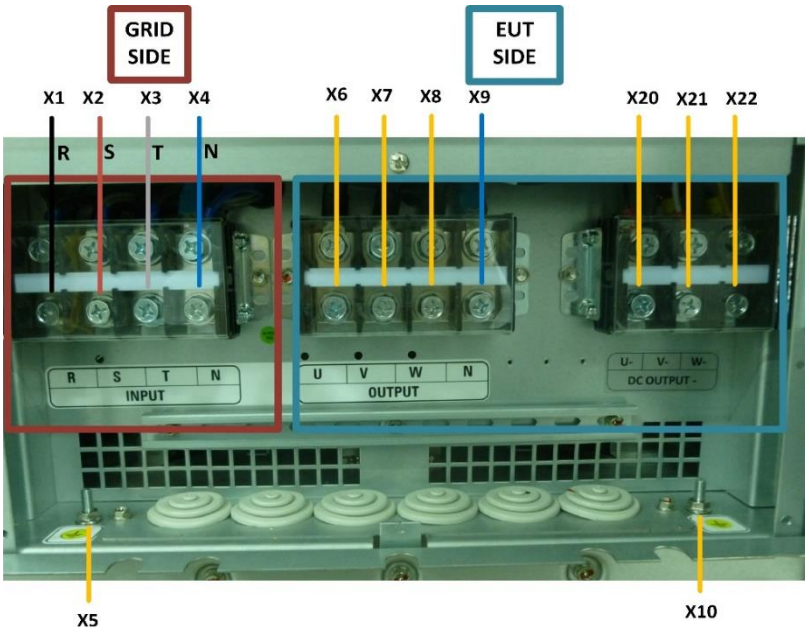
This equipment is suitable for installation in networks with TT, TN or IT power distribution system, taking into account at the time of installation the particularities of the system used and the national electrical regulations of the country of destination

6.4.2 Input connection, terminals (X1 to X5).

Connect the grid cables **R**, **S**, **T** and **N** to the terminals (**X1**), (**X2**), (**X3**) and (**X4**) respectively. This connection must always be done according to the label placed under the input screw terminals.

Confirm that the earth protection wire is connected on terminals **X5** and **X10**.

The connection of the neutral cable **N** to the terminal **X4** at the input side is always required.



In case of discrepancies between labelling and this manual instruction, **the label information will always prevail**.

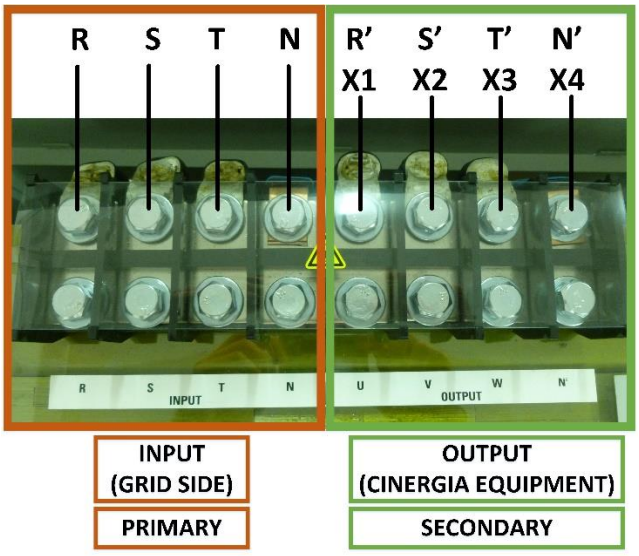
The maximum Voltage of the terminals X1, X2, X3 and X4:

X1, X2 and X3 to X4 → V_{ph-n} : 265 Vrms

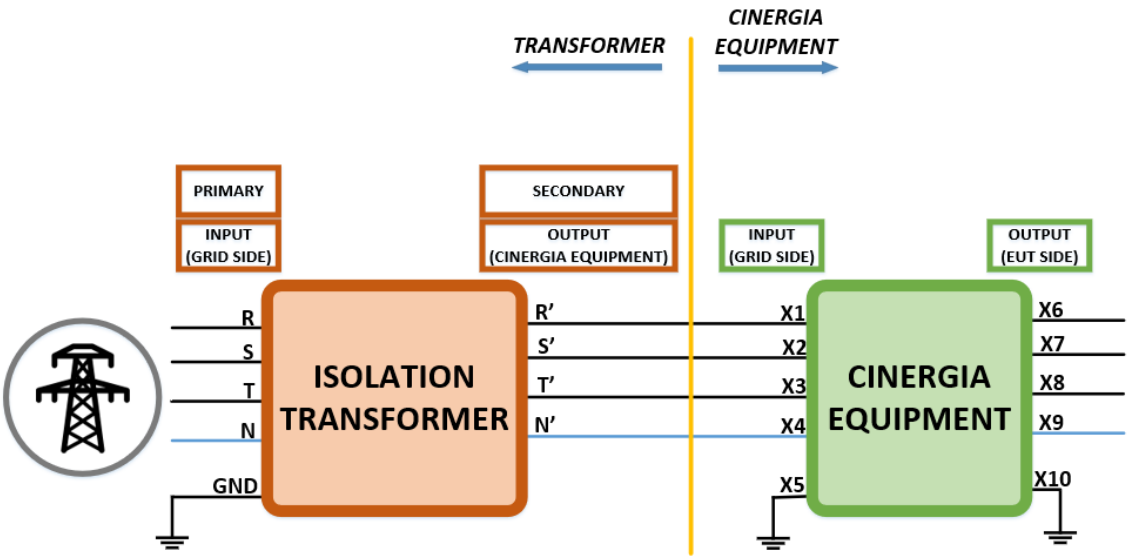
X1 to X2, X2 to X3, and X3 to X1 → V_{ph-ph}: 460 Vrms

6.4.3 Isolation transformer

In case of external isolation transformer, connect grid cables (R, S, T, N) to the primary of the transformer, and secondary of the transformer (R', S', T', N') to the input terminals (**X1**), (**X2**), (**X3**) and (**X4**) of Cinergia equipment. The connections in the transformer are the followings:



The following image is a simple schematic connection of the transformer between the grid and the Cinergia equipment:

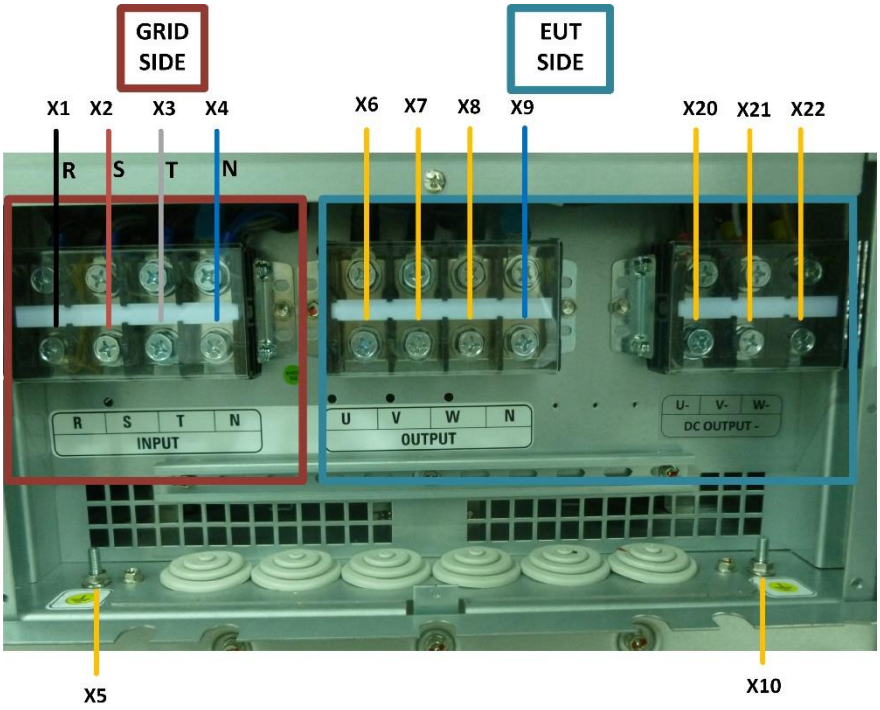


For further information, please go to chapter 5 (*Installation and wiring recommendations)* of this manual or read the document *Installation and wiring recommendations* located inside the USB stick delivered by Cinergia.

Please go to chapter 5 (*Installation and wiring recommendations*) of this manual to read about the electrical protections to be connected.

The ground cable (PE) of the main grid must be connected to ground transformer terminal (yellow-green) and ground Cinergia equipment terminals (X5 and X10) in all cases. If the protection earth wire is more than 10mm2 then only one cable (X5 or X10) needs to be connected.

6.4.4 Output connection, terminals (X6 to X10 and X20 to X22)



6.4.4.1 AC mode (X6 to X10)

The equipment has 3 output phases (U, V and W) which are referenced to the neutral point of the system (N). Therefore, the EUT must be connected to one phase/the three phases and the neutral point (phase-N):

- Output phase U (**X6**)
- Output phase V (**X7**)
- Output phase W (**X8**)
- Neutral point N (**X9**)
- GND (**X10**)

The maximum Voltage of the terminals X6, X7, X8 and X9:

X6, X7 and X8 to X9 → V_{ph-n} : 295 Vrms

X6 to X7, X7 to X8, and X8 to X6 → V_{ph-ph}: 510 Vrms

The connection of the neutral cable **N** to the terminal **X9** at the output side is always required.

6.4.4.2 DC unipolar mode (X6 to X8 and X20 to X22)

The equipment behaves as 3 independent (or parallel) positive power supplies. Each one is referenced to its common (negative) point (DC COMMON).

- First power supply: between **X6** and **X20**
- Second power supply: between **X7** and **X21**

- Third power supply: between **X8** and **X22**

It is important not to use **X9** terminal.

The maximum Voltage of the terminals X6, X7, X8, X20, X21 and X22:

X6, X7 and X8 to X20, X21 or X22 → $V_{ph-COMDC}$: +800 V DC

6.4.4.3 DC bipolar mode

The equipment behaves as 2 independent power supplies. One is always positive, the other always negative and both are referenced at the same point **X7**.

- Positive power supply: between **X6** and **X7**
- Negative power supply: between **X8** and **X7**
- It is important not to use **X9** terminal.

It is possible to use both independent power supplies as Positive or Negative power supplies.

The maximum Voltage of the terminals X6, X7 and X8:

X6 to X7, X8 to X7 → V_{ph-ph} : $\pm$ 400 V DC

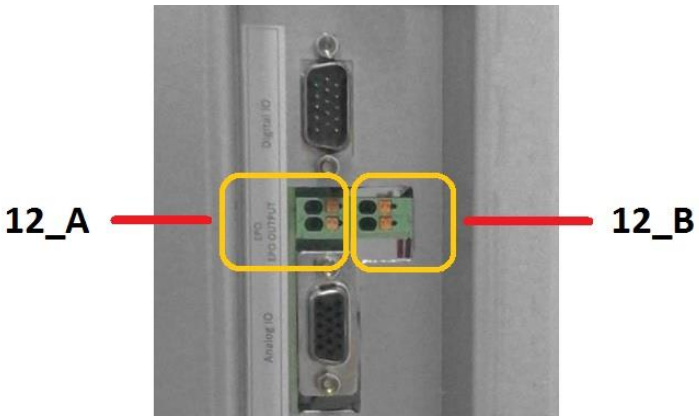
6.4.5 External Emergency Power Off connection (X12) (EPO)

CINERGIA units are equipped with a local Emergency Stop pushbutton at the front panel. When this local pushbutton is pressed, the unit will be completely switched off by disconnecting the main contactors at the input and at the output. For safety reasons, the operation is done by hardware.

In addition, CINERGIA units also integrate two terminals dedicated to an external Emergency Power Off (EPO). When these terminals are used, the unit will have two Emergency Pushbuttons active: the local pushbutton and the external-remote pushbutton. This document describes the connection of the external-remote pushbutton (hereafter EPO).

WARNING: the internal circuitry will be damaged if an external power supply is connected to X12 (J15) EPO terminals. Do not connect an external power supply or active signal. Only Normally Closed dry contact is allowed.

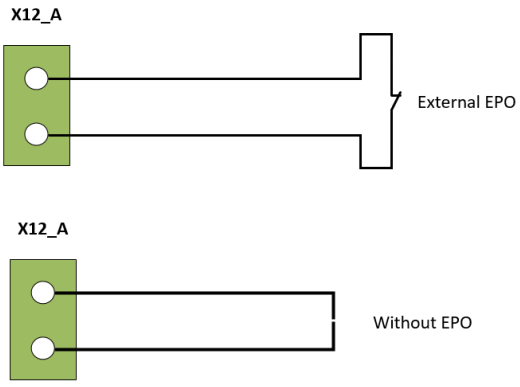
The following picture shows the 2 different connection points in **X12**, which are **X12_A** and **X12_B**.



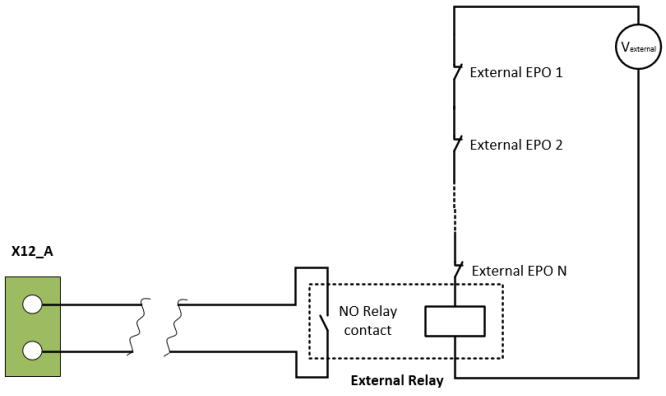
There are three alternatives for connection:

a) Connecting an external Emergency pushbutton to **X12_A** (NC contact, without potential)
b) Installing a cable bridge/shunt to close the circuit in terminal **X12_A** (in case an external EPO is not used)
c) Using the **X12_A** terminals to serialize an external Emergency Power Off sequence

The figures below describe the connection of the EPO.



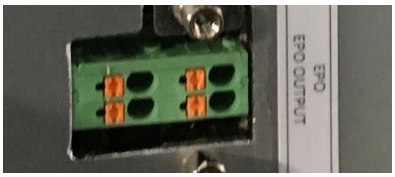
An External Emergency pushbutton (option a) or Cable bridge/shunt (option b) is required.



Connection to serialize the Emergency Power Off sequence (option c)

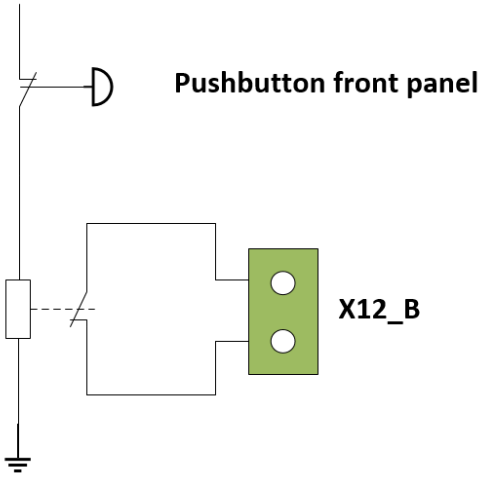
6.4.6 Output signal of local Emergency Stop pushbutton state (EPO OUTPUT)

WARNING: the internal circuitry will be damaged if any external power supply is connected to X12 (J15) EPO terminals. The relay contact allows 230 VAC/24 VDC switching voltage and 2 A switching current. Do not connect any other signal.



The Emergency Stop pushbutton installed on the front panel of equipment has a normally close contact which indicates the state of it. This output (EPO OTUPUT) will be ACTIVE (NC) when the local emergency stop button is NOT pressed.

This signal is wired to **X12_B**, as the following picture shows:



6.4.7 Communications (Optional)

There are several connectors dedicated to communications, which are listed below:

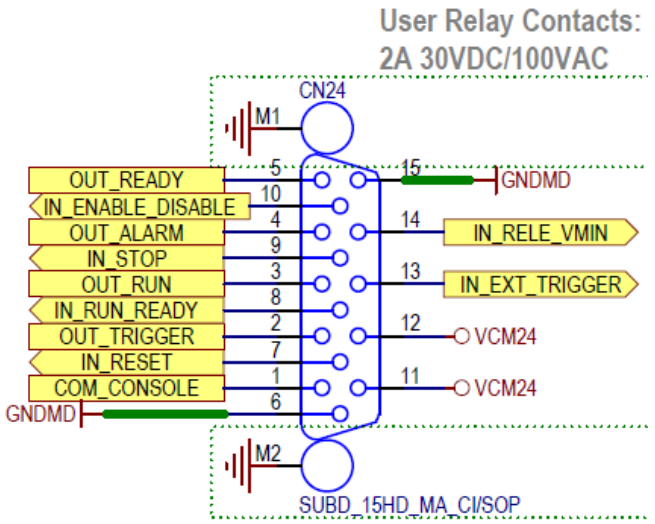
- (Optional) Connector for RS485/RS232 communications (X11): DB9 connector to be used when Modbus RS485 option is chosen. It is not possible to have both type of communication protocols running at the same time.
- (Optional) Connectors for CAN communications (X12): DB9 connectors to be used when several communications in parallel are required.
- Connector for MODBUS interface (X13): RJ45 connector A standard Ethernet cable must be connected between X13 and PC to communicate a remote PC with the grid emulator. Alternatively, a standard Ethernet cable can be connected between X13 and a Hub or a Router to communicate a remote PC with the Cinergia converter.

6.4.8 Digital inputs and outputs

This chapter is fully explained, extended and detailed in the delivered document *External Operation. Inputs and Outputs*.

The equipment can be controlled using digitals and analogue signals: the digitals are used for controlling the status of the equipment (Standby, Alarm, Ready and Run) whereas the analogue signals allows the user to set output values sending the corresponding setpoints. To sum, with these signals it is possible to control the basics of the equipment.

Specifically, there are 6 digital inputs which operate at **24 V** and 4 digital outputs (the maximum admitted current is 3 A. In case of equipment with serial number 2016XXXX, the maximum admitted current will be 8 mA). Both digital inputs and outputs are referenced of **GNDMD** (pins 6 and 15). The following scheme shows the connector with the pinout:



Please note that the connector for digital inputs and outputs of the equipment is a *SUBD_15HD_MA_CI/SOP, MALE CONNECTOR*. The necessary connector to use it is the *SUBD_15HD_FA_CI/SOP, FEMALE CONNECTOR*.

The maximum admitted input voltage is 24V (referenced to GNDMD). The digital outputs are 24 V. The maximum admitted output current is 3 A or 8 mA (depending on the serial number of the equipment. Please see table below). Applying an upper voltage or current can make irreversible damage to the equipment.

The list of each digital functionality is the following:

INPUT (referenced to the PIN 6 or 15):

- **PIN 7:** INPUT RESET. Makes a RESET to the equipment.
- **PIN 8:** INPUT RUN/READY. Changes from RUN to READY and vice versa.
- **PIN 9:** INPUT STOP. Makes the equipment go to READY if it is in RUN state during all the time that this digital input is enabled.
- **PIN 10:** INPUT ENABLE/DISABLE. Changes from ENABLE to DISABLE and vice versa.
- **PIN 13:** TRIGGER CONFIG. Applies the setpoint of the converter.
- **PIN 14:** TRIGGER FUNCTION. Applies the AC Steps parameters of the AC converter.

OUTPUT (referenced to the PIN 6 or 15):

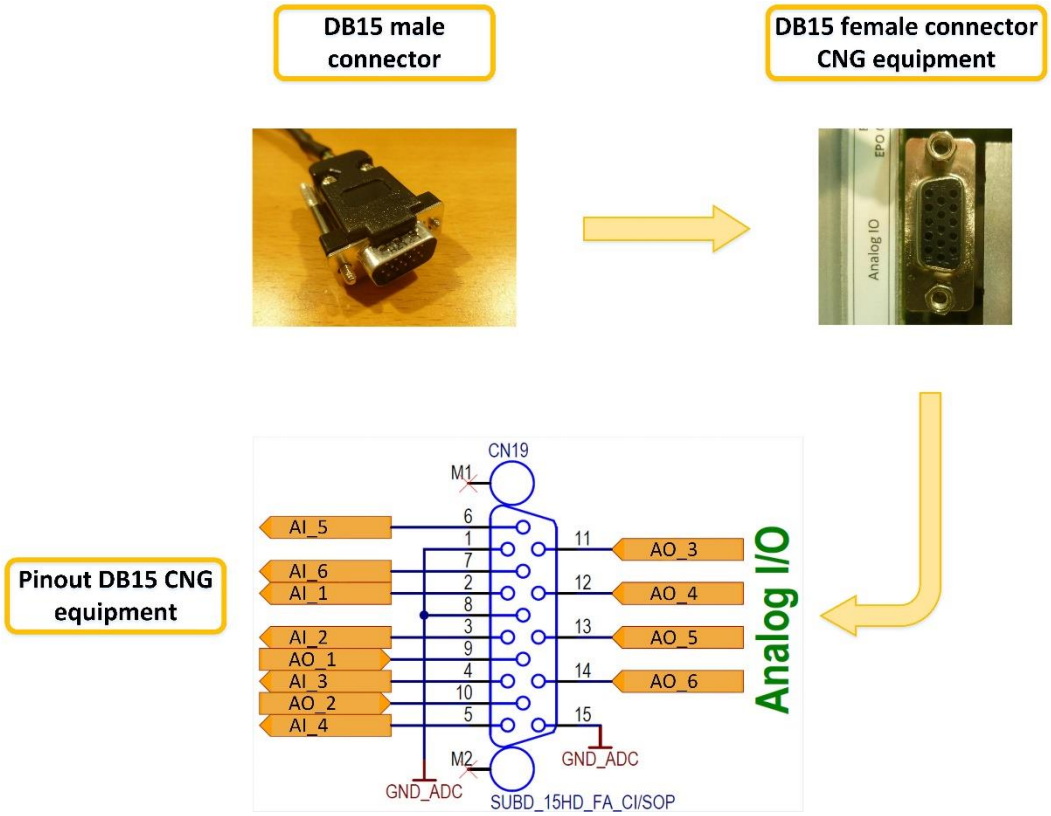
- **PIN 1:** COM CONSOLE. This led will be on when the unit is in digital mode.
- **PIN 2:** OUT TRIGGER. The output will turn on when the TRIGGER CONFIG or the TRIGGER FUNCTION are sent. When the equipment applies a setpoint, the *Trigger Out* is active (24 V) during 100 ms, whereas when the equipment applies an AC Fault, the *Trigger Out* is active (24 V) during all the Fault.
- **PIN 3:** RUN LED. The output will turn on when the equipment is in RUN state.
- **PIN 4:** ALARM LED. The output will turn on when the equipment is in ALARM state.
- **PIN 5:** READY LED. The output will turn on when the equipment is in READY state.

For further information, please read the document *External Operation. Inputs and Outputs*.

6.4.9 Analog inputs and outputs

This chapter is fully explained, extended and detailed in the delivered document *External Operation. Inputs and Outputs*.

The equipment contains 6 analogue inputs and 6 analogue outputs which are gathered in **X15** with a *SUBD_15HD_FA_CI/SOP* connector and the pinout is the following:



Please note that the connector for analog inputs and outputs of the equipment is *a SUBD_15HD_FA_CI/SOP, FEMALE CONNECTOR*. The necessary connector to use it is the *SUBD_15HD_MA_CI/SOP, MALE CONNECTOR*.

The analogue inputs accept a voltage range from -10 Vdc to +10 Vdc and the analogue output delivers a voltage range from -10 Vdc to +10 Vdc. Both input and output are referenced to GND_ADC; pin 1, 8 and 15. Applying an upper voltage or current can make irreversible damage to the equipment. Applying any voltage at the analogue output pins can make irreversible damage to the equipment.

The analogue inputs are isolated and accept a voltage range from -10 Vdc to +10 Vdc (referenced to GND_ADC) and the analogue output delivers a voltage range from -10 Vdc to +10 Vdc (referenced to GND_ADC).

These analogue signals are used to send the setpoint to the converter by introducing a small DC signal in the corresponding PIN of the X15. The output analogue signal will return the desired measurement of the converter configurable using the LCD touchscreen.

There is also the possibility to activate the optional Power Amplifier, where the output of the converter will be the instant value of the analogue input. So, for example, if the user needs a triangle waveform in the output of the Cinergia equipment, the input in the analogue PIN must be a triangle waveform as well.

Equipment in DC does not have *Power Amplifier* option.

For further information, please read the document *External Operation. Inputs and Outputs*.

7 OPERATION

7.1 Safety

Before operating the equipment, check that the Protective Earth is properly connected.

Check out the electrical installation in both sides (input and output) of the cabinet. All wires shall be connected and secured before proceeding to the converter start-up.

When the equipment is turned off, the user has to wait at least 15 seconds before turn it on again.

Before operating the equipment, check that all LIMITS from the equipment are correct. Please take care that CNG equipment are bidirectional, this means that the equipment can consume or inject current. The equipment can operate as a SOURCE or as a LOAD.

If the user needs the converter to work as a load, press the button LOAD. In this case the setpoint must be with a negative sign. On the other hand, the converter will work as a source with a positive sign.

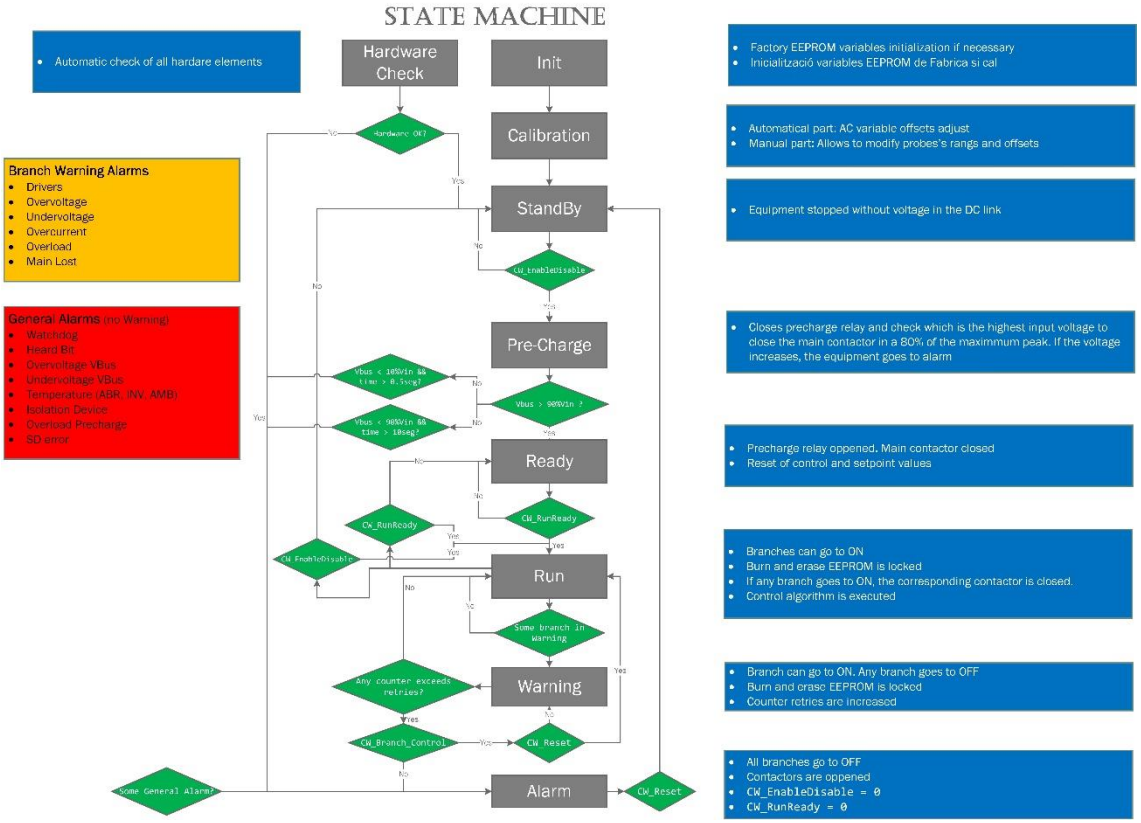
The user can configure the positive limit of current and power at 0A and 0W on the LIMIT tab of the interface to be sure that the equipment never will work as a SOURCE.

Please be sure that all parameters are appropriate for the EUT where the Cinergia converter is connected. For example, an over current or voltage can make irreversible damages to the EUT.

The limits of the equipment in the *Limits* tab can also be configured for more security.

7.2 State Machine

The operation of the converter is based on different states (rectangles) and transitions (rhombs). Each state defines the behavior and possible actions of the converter:



7.2.1 Initialization

During the initialization, the converter control system checks the presence of all internal components and the embedded PC loads the operating system.

No voltage is present at the DC link and the IGBTs PWMs are completely stopped.

The transition from Initialization state brings the converter to the Standby state as long as the emergency stop is deactivated (equipment armed).

7.2.2 Standby

The Standby state keeps the converter in low power mode until an Enable signal is received. While the converter is in standby only the internal power supplies are energized. In particular, this means that there is no voltage in the DC link and no voltage/current is applied to the output of the converter.

The transition from the Standby state is the Enable signal or, in case of errors, a Fault signal. The Enable signal will bring the State Machine to Precharge and eventually to the Ready state. If an error is detected the converter will go into Alarm state.

7.2.3 Precharge

The Precharge is an internal transition state between Standby and Ready. During this state the DC link is gradually charged through resistors until the rated DC link voltage is reached. The transition will finish successfully as long as, in less than 10 seconds of Precharge, the DC link has reached the specified voltage. Otherwise, the next state will be Alarm.

The Precharge state is only applicable to the grid side converter.

7.2.4 Ready

In the Ready state the converter is ready to operate but no PWM signal is sent to IGBTs. The DC link is charged to the rectified voltage and there is no voltage/current applied to the outputs.

The transition from Ready state can be the Run signal, the Not enable signal or, in case of errors, a Fault signal. When a Run signal is received the State Machine will evolve to the Run state. When a Not enable signal is received the State Machine puts the converter on standby, thus discharging the DC link capacitors. If a fault is detected the converter goes to Alarm state.

The user can change the operation mode between (CC, CI, CP or CV) in any state; even in RUN. So be careful when making this change in RUN state and check if the EUT is prepared for this.

Applications with capacitors will require a pre-charge circuit.

7.2.5 Run

In this state, the converter is completely operational. Due to the converter architecture, the grid side converter (Active Rectifier) will make the transition first while stabilizes the DC link voltage. After that, the three-phase inverter of the EL will measure the actual EUT voltage levels and will synchronize with them. Finally, the inverter will start the control algorithms and PWM.

This state can evolve to Standby state when a Not enable signal is received, to Ready state when a Not run signal is received or to Alarm state if an error condition is detected.

Even when the Cinergia equipment is in Run state, it is possible to change the working control. If the equipment has the Independent Branch Control enabled (it is an optional of the converter), each channel can be working in a different mode independently.

7.2.6 Alarm

In this state, the converter is stopped and kept in a safe condition: the DC link is discharged and the PWM signals are stopped.

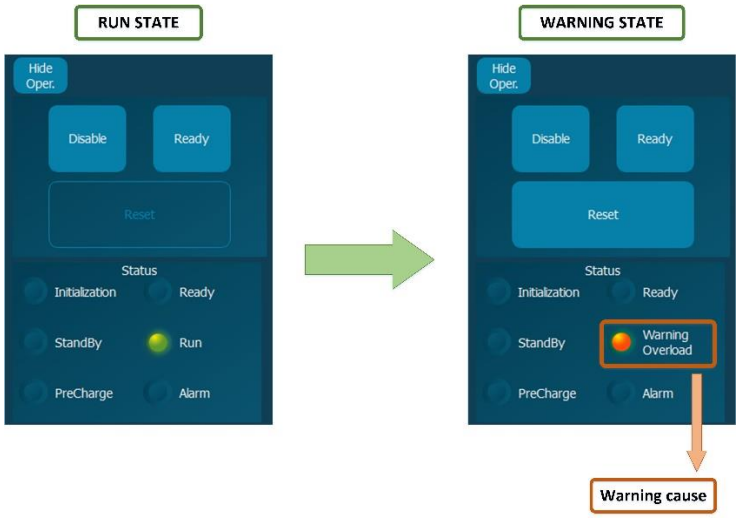
The Alarm state can be reached by any fault detected during the normal operation of the converter, for instance, an emergency stop activation (see *Alarms* chapter for further detail).

The only possible transition from Alarm state is to Initialization state. Once in Alarm state a Reset signal is required from the customer after clearing the fault condition. If the fault condition has not been cleared the converter state will be kept in Alarm (for example, when heatsink overheating has occurred, and the temperature is still high).

If the converter has the Multichannel or Separated Branch Control optional enabled, each channel work separately, which means that, for instance, one channel can be alarmed while the other two are running.

7.2.7 Warning

This state shows if the equipment working with some alarm. For example, if the maximum allowed current is 20A, the equipment can work up to 22A for 10 minutes. But while staying between 20A and 22A, the equipment will be working in Warning state instead of Run. The following picture shows an example of an equipment working with overload:



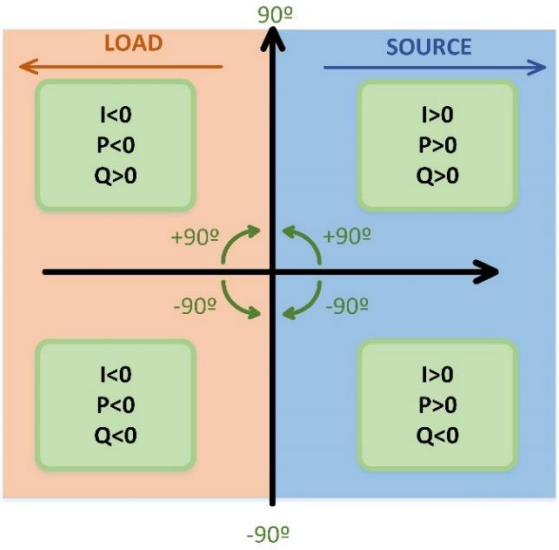
This state works as an indicator helping the user to be aware if the equipment will go to alarm state.

7.3 Operation modes (vAC/DC)

The CNG equipment has different operation modes depend on the hardware version of the unit. In this case, AC and DC operation mode are activated:

- Constant Voltage (CV): the output voltage is controlled to the set point value. Only available in DC mode.
- Constant Current (CC): the output current is controlled to the setpoint value. In this mode, the harmonic content of the current drawn by the equipment is configurable up to 15th (available in AC and DC mode). In DC mode it is not possible to configure any harmonics.
- Constant Power (CP): the output active and reactive power are regulated to the given setpoint value (in case of choosing DC Output option, only the active power is regulated) (available in AC and DC mode).
- Constant Impedance (CI): the output impedance is controlled to the setpoint value. The emulator will perform as a constant R, L, C (Only R in the DC operation).
- Power amplifier: the output is the same waveform as the analogue input. As an AC Electronic Load unit, the converter will control current at the output. In DC mode, it could control voltage or current depend on the control model selected.

The following figure illustrates how the CINERGIA converter works in all four quadrants. It explains where the equipment behaves as a source and where as a load:



Before operating the equipment, check that all LIMITS from the equipment are correct. Please take care that CNG equipment are bidirectional, this means that the equipment can consume or inject current. Please check that EUT device. The equipment can operate as a source or as a load.

The equipment can operate as a source or as a load. Please take care about the signal of the setpoint.

Configuring the unit in Source mode may inject power to the EUT. The EUT may be damaged if it is not regenerative.

7.3.1 Constant Voltage (CV)

Only in DC mode it is possible to works the unit in voltage control model. In CV mode, EL AC/DC works as a **DC** power supply.

Parameter	Allowed range of values
Unipolar voltage	[0 , +750] or [0 , +800] in HV option
Bipolar voltage	[-350 , +350] or [-380 , +380] in HV option

7.3.2 Constant Current (CC)

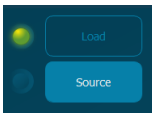
This mode allows the user to define the current shape for each output.

7.3.2.1 Parameters and limits (AC mode)

In CC mode, the user may modify the values of the following parameters as long as they are within the specified range:

Parameter	Allowed range of values
Fundamental harmonic magnitude	± Maximum permitted I AC mode
Fundamental harmonic angle	[0°, 360°]

If the user needs the converter to work as a load, press the button LOAD. In this case the setpoint must be with a negative sign. On the other hand, the converter will work as a SOURCE with a positive sign.



A setpoint with a ramp higher than 5 A/ms will produce over peaks bigger than 10%.

Harmonic control

The bandwidth of the harmonic control is fixed to 800 Hz for models 80 to 200, and 1000 Hz for models 7.5 to 60. Depending on the fundamental frequency the high harmonics must be disabled because exceed the 800 Hz (for models 80 to 200) or 1000 Hz (for models 7.5 to 60) (p.e. 15th harmonic of 60 Hz fundamental grid becomes 900 Hz).

The enabled harmonic controls follow the control of the cut off frequency, which is configurable and has a maximum of 770 Hz for models 80 to 200 and 1000 Hz for models 7.5 to 60, and a minimum of 70 Hz.

Harmonic set point

The maximum set point value can see below:

Setpoint	Range	
Fundamental	± Maximum permitted I	
Harmonics from 3 to 9	-1 to 1	*Percentage from the fundamental (1 means 100%)*
Harmonic 11	-0.5 to 0.5	
Harmonics 13 and 20	-0.2 to 0.2	

It should be noted that the I_{peak} in every phase cannot exceed the maximum permitted value for the equipment (this maximum value varies according to the power range of EL used), i.e., when some harmonics are added to the fundamental frequency.

Note that PC software interface calculates the maximum current and the RMS value as theorical values; and will not send any current command if it exceeds the maximum. The harmonic values can be set with an .csv file or by editing them directly from the PC interface.

7.3.2.2 Parameters and limits (DC mode)

In CC mode, the user may modify the values of the following parameters as long as they are within the specified range:

Parameter	Allowed range of values
3 Channels unipolar/bipolar	± Maximum permitted I DC mode
1 Channel	± Maximum permitted I DC mode multiplied by 3

7.3.3 Constant Power (CP)

This mode allows the user to define the active and reactive power consumption per output phase.

7.3.3.1 Parameters and limits (AC mode)

In CP mode, the user may modify the value of the following parameters, as long as they are within the specified range:

Parameter	Allowed range of values
Active power (P)	± Maximum permitted S
Reactive power (Q)	± Maximum permitted S

If the user needs the converter to work as a load, the setpoint must be with a negative sign. On the other hand, the converter will work as a source with a positive sign.

Considering that S is the apparent power, it is important to take into account that the following condition must always be fulfilled:

$$P^2 + Q^2 < S^2$$

If the resultant apparent power reaches the maximum value, the PC software will limit the set points given automatically.

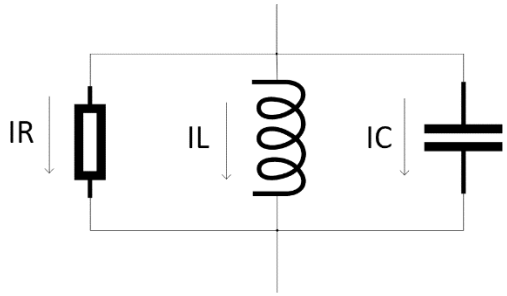
7.3.3.2 Parameters and limits (DC mode)

In CP mode, the user may modify the values of the following parameters as long as they are within the specified range:

Parameter	Allowed range of values
3 Channels unipolar/bipolar	± Maximum permitted S
1 Channel	± Maximum permitted S multiplied by 3

7.3.4 Constant Impedance (CI)

This mode allows the user to define the resistance, inductance and capacitance for each output phase. The passive components are connected in parallel:



Please note that in DC mode, the impedance is only resistive.

7.3.4.1 Parameters and limits (AC mode)

In CI mode, the user may modify the value of the following parameters as long as they are within the allowed range:

Parameter	Allowed range of values	Default values
Resistance	0.8 Ω - 1000 Ω	1000 Ω
Inductance	0.1 mH – 2000 mH	2000 mH
Capacitance	0 mF - 3.7 mF	0 mF

The allowed range for each of these parameters depends on the equipment's rated power. In order to calculate the global current, it is necessary to calculate the current for each branch (after calculating the reactance of the capacitor and the inductance):

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

$$I_R = \frac{V}{R};\quad I_L = \frac{V}{X_L};\quad I_C = \frac{V}{X_C}$$

Afterwards, global current is calculated using the following formula:

$$\boldsymbol{I = \sqrt{(I_L - I_C)^2 + I_R^2}}$$

7.3.4.2 Parameters and limits (DC mode)

In CI mode, the user may modify the value of the following parameters as long as they are within the allowed range:

Parameter	Allowed range of values	Default values
Resistance	0.8Ω - 1000 Ω	1000 Ω

7.3.5 Faults Generation (FG)

This mode allows the user to define and apply faults in the flowing current.

Important: using the Fault Generation take into account that the Electronic Load is a bidirectional equipment, this means that the equipment can consume or inject current. So, the user must be sure to define correctly the SIGNAL and PHASE of each SETPOINT to avoid any damage.

Before operating the equipment, check that all LIMITS from the equipment are correct. Please take care that CNG equipment are bidirectional, this means that the equipment can consume or inject current.

The equipment can operate as a source or as a load. Please take care about the signal of the setpoint to avoid any damage.

Configuring the unit in Source mode may inject power to the EUT. The EUT may be damaged if it is not regenerative.

I. Parameters and limits

In FG mode, the user can modify the value of the following fault general parameters as long as it is within the specified range:

Parameter	Allowed range of values
Fault duration	Minimum: 100ms
Fault delay (β) – from phase U	0 - 360 °

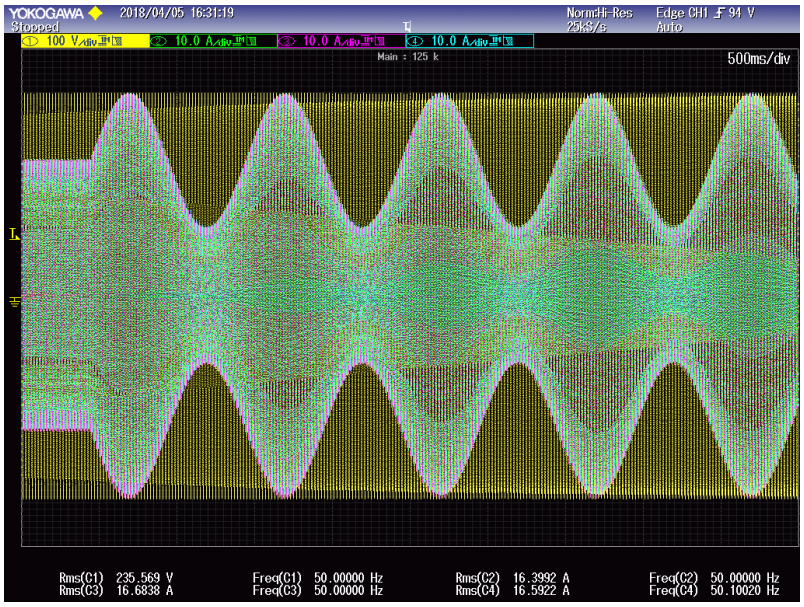
The specified fault will start when the button “Execute Single Fault” is activated. The two following images show an example of a current dip with different fault delay (β). The first one has a β=0º whereas the second one β=90º.

Additionally, in the FG mode, each kind of fault has its own parameters to be modified by the user. These parameters are listed below:

Parameters of *Current Dip, Over/Under Current*	Allowed range of values
Current of fundamental harmonics of phases U, V, W	0-200% 0% means 0A
Angle of fundamental harmonics of phases U, V, W	0-360°
Ramp [A/ms]	Fade in: 0.1 ≤ Ramp ≤ 1000 Fade out: 0.1 ≤ Ramp ≤ 1000
Ramp Angle [deg/ms]	Fade in: 0.01 ≤ Ramp ≤ 1000 Fade out: 0.01 ≤ Ramp ≤ 1000

**The converter will be limited at a maximum current depending on the power of the equipment in case the percentage makes the current exceed this value.*

Parameters of *Flicker*	Allowed range of values
Current of fundamental harmonics of phases U,V,W	A_{RMS} ± 50%
Frequency of flicker	0.01-20 Hz
FadeIn Ramp [%/ms]	0.01-1000
FadeOut Ramp [%/ms]	0.01-1000



Example Flicker 50% 1Hz

II. Creation of Fault Sequence

It is possible to create a *.csv* file to be introduced in the interface to create a Fault Sequence. It can be made using an editor such as Excel, a notepad or directly through the interface. This chapter explains how to create this file via Excel. The creation of this file via interface is explained in the document *Human Machine Interface*.

Each row of the Excel has the parameters, separated by comas, of the fault to send. It is also possible to modify or configure the current setpoints during the execution of the faults. This setpoint configuration is also a row of the sequence.

The different rows are the following:

- Current configuration (Current SP). Configure the flowing current by introducing the setpoints, the ramps and angles for each channel.
- Current Over/Under current (Dip).
- Flicker.

The following table details which the parameters of each column of the *csv* file are. Please note that the columns are different depending on the fault to configure.

DESCRIPTION WORD	PARAMETERS														
Current SP	**2000**	**20**	**20**	**20**	**0**	**0**	**0**	**10**	**10**	**10**	**1**	**1**	**1**		
Current SP	Step Time [ms]	Setpoint U	Setpoint V	Setpoint W	Angle U	Angle V	Angle W	Ramp U	Ramp V	Ramp W	Angle Ramp U	Angle Ramp V	Angle Ramp W		
Dip	**1000**	**100**	**0**	**-120**	**-240**	**20**	**20**	**20**	**0**	**0**	**0**	**10**	**10**	**0.1**	**0.1**
Dip	Step Time [ms]	Defect Duration [ms]	Fault Start Angle U	Fault Start Angle V	Fault Start Angle W	Current Depth U	Current Depth V	Current Depth W	Delta Angle U	Delta Angle V	Delta Angle W	Ramp FadeIn	Ramp FadeOut	Ramp Angle FadeIn	Ramp Angle FadeOut
Flicker	**1000**	**10000**	**0**	**-120**	**-240**	**10**	**1**	**10**	**10**						
Flicker	Step Time [ms]	Defect Duration [ms]	Fault Start Angle U	Fault Start Angle V	Fault Start Angle W	Current	Freq	FadeIn Ramp	FadeOut Ramp						

The numbers above the description are examples.

The first column is always reserved for the name of the fault (*Dip* or *Flicker*) or the new current setpoint (*Current SP*).

The sequence above (the numbers without the description) is the following:

Current SP,2000,20,20,20,0,0,0,10,10,10,1,1,1,
Dip,1000,500,0,-120,-240,50,50,50,0,0,0,1,1,0.1,0.1
Flicker,1000,5000,0,-120,-240,50,1,10,10

The file must have all data separated by comas and saved as .CSV file.

7.3.6 Separated Channel Control (optional)

This chapter is fully explained, extended and detailed in the delivered document *Human Machine Interface EL+*.
It should be noted that Separated Channel Control is an optional and has an additional cost.

(AC mode) It is very important to be very aware of what is being connected in the output of the Cinergia equipment. It will be able to work in different modes for each channel (as a current source in current, power or impedance mode) injecting or consuming current/power. It is in the user responsibility to use this mode properly.

(DC mode) It is very important to be very aware of what is being connected in the output of the Cinergia equipment. It will be able to work in different modes for each channel (as a voltage or current source in current, power or impedance mode) injecting or consuming current/power. It is in the user responsibility to use this mode properly.

This optional allows the user to control each branch (U, V and W) separately, which means that the phases can be in a different status (*Initialization*, *Running*, *Warning* or *Alarmed*) and a different control mode (Voltage, *Current*, *Power* or *Impedance*).

Separated Channel Control is possible in AC or in DC Cinergia converters in exception of the AC Grid Emulator.

7.3.7 Power amplifier

This chapter is fully explained, extended and detailed in the delivered document *External operation. Inputs and Outputs.*

The EL converter can work as a current amplifier from the analogue inputs. It means that the waveform in the analogue input will appear in the output of the converter. For instance, if the analogue input is a square waveform, the output of the EL will be a square current waveform.

The equivalences of the ranges are shown in the following table:

	MIN	MAX	
Analogue input	0 Vpp	20 Vpp	
EL output	min Current	Max Current	Depending on the datasheet

As an extra option, the user can adjust the desired range modifying the Limits AC Min and Max current settings of each phase by the user Interface. The value of *Limit_max_peak* is calculated based on a CF of 3 with a maximum of 3*Nominal value.

Please note that the converter can only place in the output the values within the accepted working range. However, a maximum CF of 3 is applied calculating the maximum pic current. Hence, an overcurrent alarm is possible in cases where the RMS value exceeds the converter limitations, for instance.

7.3.8 Virtual Resistance

There is the possibility to introduce a virtual resistance, which has a range of 0 Ω to 1 Ω. This resistance creates a voltage drop depending on the current flowing for each channel. For example, if there are 20 A in the channel U and the resistance (Virtual Resistance) is configured at 1 Ω, there will be 20 V of voltage drop. But if the resulting voltage is less than the minimum accepted one, there will be this minimum voltage in the output. In the same example with a voltage drop of 20 V, if there are 30 V in the output, the output resulting voltage will be 20 V instead of 10 V because the minimum voltage is 20 V.

In order to eliminate this voltage drop, there must be a value of 0 in all resistance.

7.3.9 Battery Test (DC Optional)

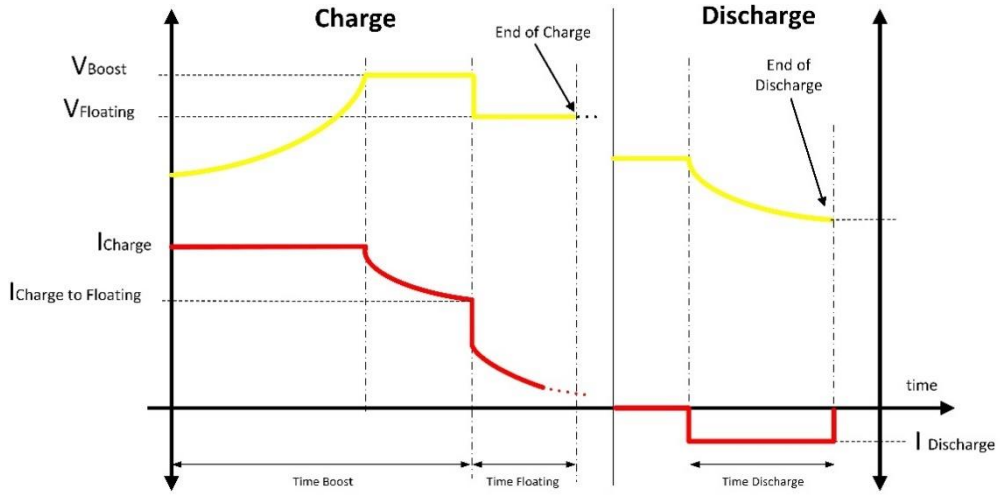
This chapter is fully explained, extended and detailed in the delivered document *Battery Test Optional*.
It is important to stress that the Battery Test is an optional and has an additional cost.

At improper handling irreversible damages, up to fire outbreaks can happen to the unit under test or battery. Read the operation, connections and test conditions of your battery carefully. Do not leave your energy storage unattended while a test is running!

The equipment is prepared to charge and discharge batteries and create cycles to test them. The user must introduce the basic parameters (maximum and minimum voltage and current of the battery…) and the converter will start charging, discharging or both. Remember that it is possible to work with 3 independent power supplies (3 Channels unipolar connection) or 1 power supply (1 Channel unipolar connection).

Apart from the basic settings, the user can also introduce advanced settings, which will provide more accuracy in the battery test. These parameters are times between states of charge and discharge and amperes per hour of charge and discharge.

Those parameters are the ones represented in the following graphic:



BASIC PARAMETERS		
Parameter	**Description**	**Allowed range of values**
V_{Boost}	Boost Voltage or Battery charge voltage	V_{max} battery (from battery datasheet) or 750 V (DC limit)
$V_{Floating}$	Floating voltage	$V_{Charge} < V_{Floating} < V_{Discharge}$
I_{Charge}	Charging current	$I_{ChargeMax}$ battery (from battery datasheet) or I_{rated} DC
$I_{ChargeToFloating}$	Charging to floating current	$0 < I_{ChargeToFloating} < I_{Charge}$
$I_{Discharge}$	Discharging current	$-I_{DischargeMax}$ battery (from battery datasheet) or $-I_{rated}$ DC
$V_{Discharge}$	Discharging voltage	V_{min} battery (from battery datasheet)

ADVANCED PARAMETERS		
Parameter	**Description**	**Allowed range of values (in seconds)**
Boost Time	Absolute time that the equipment is charging the battery	86400 seconds (1 day)
Floating Time	Absolute time that the equipment is in floating state	86400 seconds (1 day)
Time transition	Absolute time that the equipment is waiting between charging and discharging states.	86400 seconds (1 day)
Time discharging	Absolute time that the equipment is discharging the battery	86400 seconds (1 day)

Ah Stop Charge	Ah measured calculated by the equipment during charge state. Consider that it is possible to erase or change the value.	< 1MWh
Ah Stop Discharge	Ah measured calculated by the equipment during discharge state. Consider that it is possible to erase or change the value.	< 1MWh

For further information, please read the document *Battery Test Optional*.

7.3.10 Battery Emulator (DC *Optional*)

This chapter is fully explained, extended and detailed in the delivered document *Battery Emulator Optional*.
It is important to stress that the Battery Emulator is an optional and has an additional cost.

The Battery Emulator option can be only activated in DC units or AC/DC units in DC mode. The channel/s configured in battery emulator mode will work as a Constant Voltage source where the voltage is a function of a battery model.

The mathematical model is saved and executed in the firmware of the DSP so it warrants precise and deterministic behaviour, but the model cannot be changed. The user is able to simulate different batteries by adjusting the parameters of the model and the parameters of the battery (cells in series/parallel, capacity of the cell, etc…). The model allows the emulation of different technologies of battery.

7.3.11 Photovoltaic Emulator (DC *Optional*)

This chapter is fully explained, extended and detailed in the delivered document *PV Emulator Optional*.
It is important to stress that the Photovoltaic Emulator is an optional and has an additional cost.

The PV Emulator option can be only activated in DC units or AC/DC units in DC mode. The channel/s configured in PV emulator mode will work as a Constant Current source where the current setpoint is calculated by a Simplified PV Panel model as described by the function below:

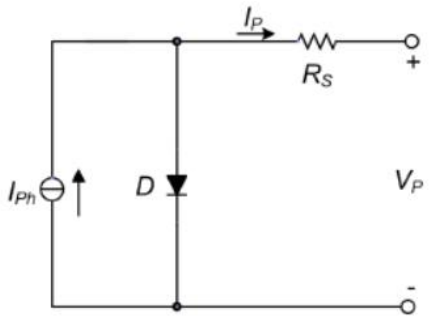


Fig. 1 – Single-diode equivalent circuit of a PV module.

$$I_P = I_{SC} \cdot \left[1 - C_1 \cdot \left(e^{\left(\frac{V_P}{C_2 \cdot V_{OC}}\right)} - 1\right)\right] \quad (1)$$

where

$$C_1 = \left(1 - \frac{I_{MPP}}{I_{SC}}\right) \cdot e^{\left(\frac{-V_{MPP}}{C_2 \cdot V_{OC}}\right)} \quad (2)$$

$$C_2 = \frac{\left(\frac{V_{MPP}}{V_{OC}} - 1\right)}{\ln\left(1 - \frac{I_{MPP}}{I_{SC}}\right)} \quad (3)$$

Model and expressions above are from: A. Bellini, S. Bifaretty, V. Iacovone, C. Cornaro, "Simplified Model of a Photovoltaic Module"

7.4 Connection modes (vAC/DC)

As it has been previously mentioned, for the EL vAC/DC there are four possible connection modes:

- 3 Channels phases: Three phase power control. Each phase (U,V,W) is controlled independently. The current setpoint can be different in angle and magnitude for each of the three phases in AC mode. The setpoint can be different in magnitude for each phase in DC mode.
- 1 Channel phases: (only DC mode) One phase power control. In this case the user has one phase output. The total amount of current consumed will be the sum of all three phases. Only in DC mode works. (In AC mode, *it is called Single phase: One phase power control).*
- Unipolar mode: Electronic Load behaves as 3 independent and positive DC power supplies (only in DC mode).
- Bipolar mode: Electronic Load behaves as 2 independent DC power supplies. One is positive and the other negative. In AC mode, the unit must be bipolar configured. Otherwise the unit will go to Alarm state, Wrong connection.

It must be remembered that the equipment has 3 output phases (U, V and W) which are referenced to the neutral point of the system (N) in AC configuration and to the Negative point or DC COMMON point in DC configuration. Therefore, the EUT must be connected between one of the phases and the neutral point (phase-N). In this way, the Electronic Load could, for instance, be connected at three independent single-phase sources at the same time with different voltages, frequencies, etc.

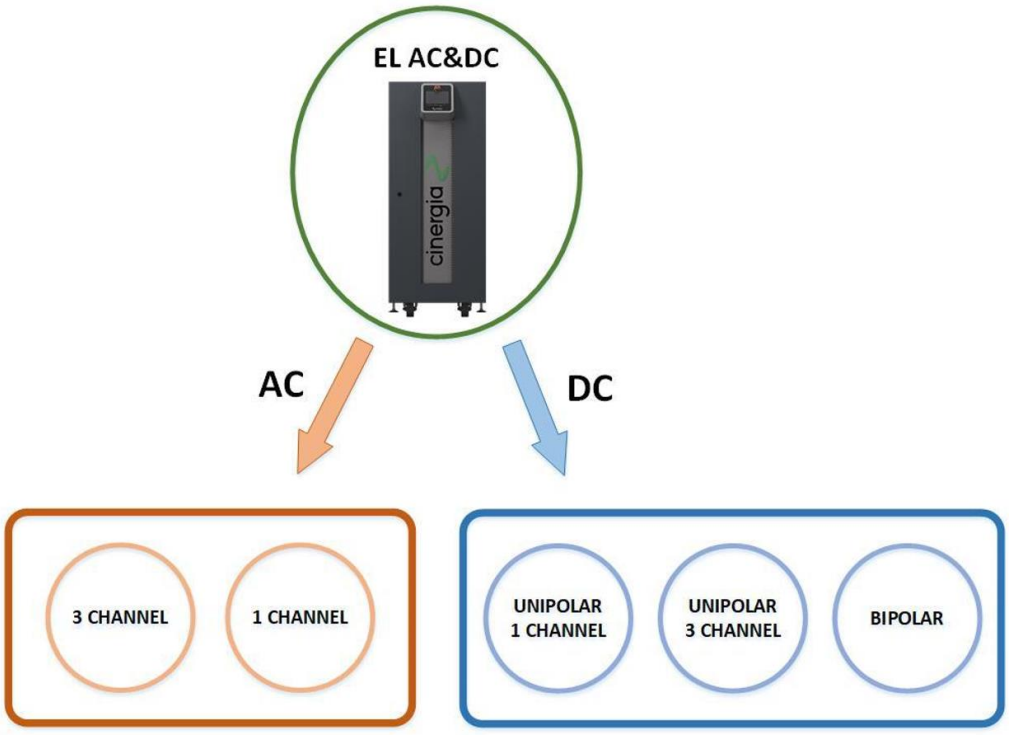
Please remember to turn OFF the equipment before modifying the connection mode at the output. Be sure that there is no voltage on any terminal.

Please be sure that no electrical connection between the phases exists. Keep in mind that, if two phases are actually interconnected, a shortcircuit may appear in voltage-based source.

It is possible to change the position of the switches in any state different than *Run*. If the new position is not allowed, there will appear the *Wrong Connection* alarm.

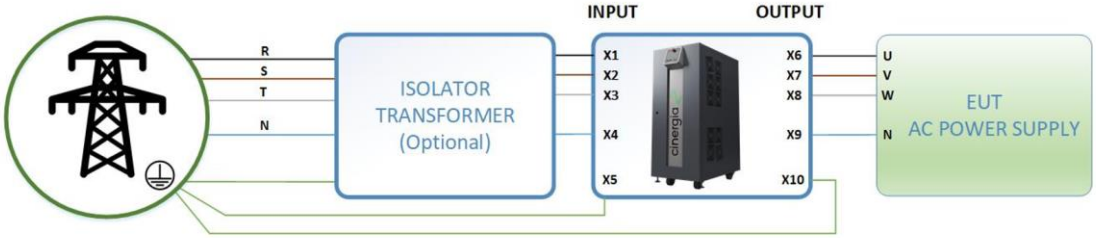
Change the position of any switches disconnectors or selectors in *RUN* mode is NOT allowed. The equipment or EUT can be seriously damaged.

The following diagram illustrates the different connection modes:



7.4.1 AC

7.4.1.1 3 Channels mode

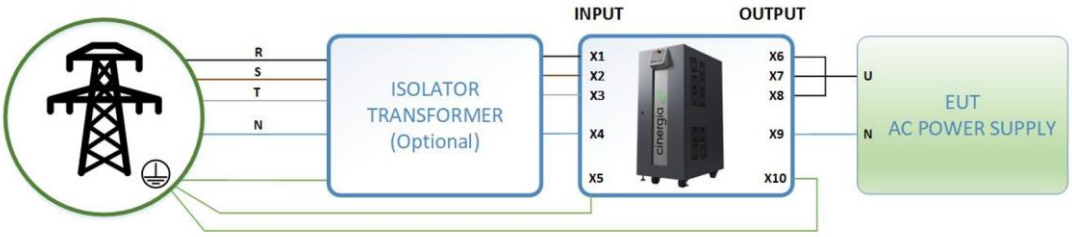


It is possible work with 3 different EUT at the same time, is important that the 3 EUT AC Power Supply are connected to the same neutral: the X9 terminal of the Electronic Load.

7.4.1.2 1 Channel mode

To operate an EL in 1 Channel mode, a single-phase mains voltage must be present at the output terminals.

If the 3 Channels/1 Channel selector is in 1 Channel mode the equipment will go into alarm state.



Please note that working with a single-phase grid requires a short circuit between the output terminals in the Cinergia converter. X6, X7 and X8 must be short circuited.

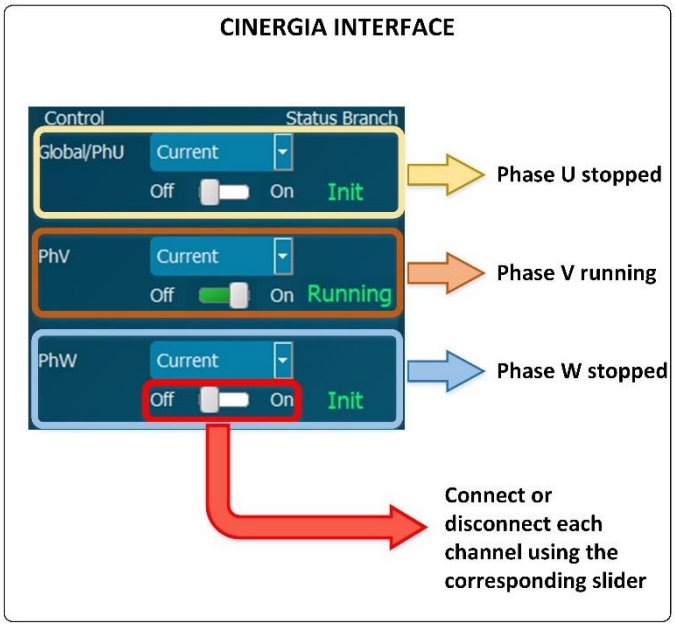
7.4.1.3 1 Channel mode with the Separated Branch Control optional

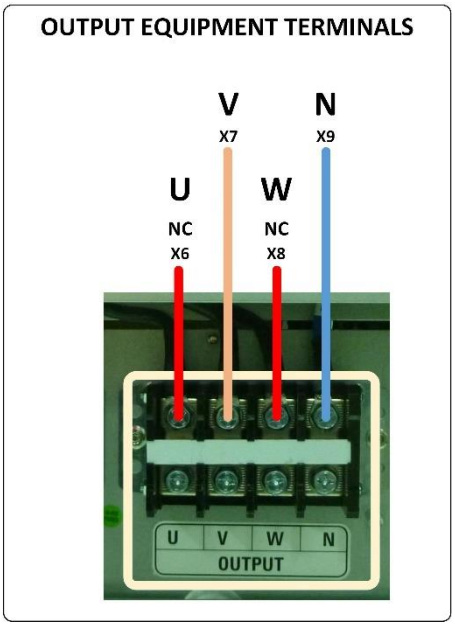
The Electronic Load with the optional *Separated Branch Control* enabled can work without the short circuit between the output terminals (X6, X7 and X8) because the user can run the desired channel independently.

***Separated Branch Control* is an optional and has an additional cost. Please read the equipment's manual to know more about this optional**

Please connect the output cable to the phase that is going to work. The other 2 phases can be disconnected. For example, if the user requires only phase V (terminal **X7**) to be working, the other two terminals (**X6** and **X8**) can be disconnected (with no cable)

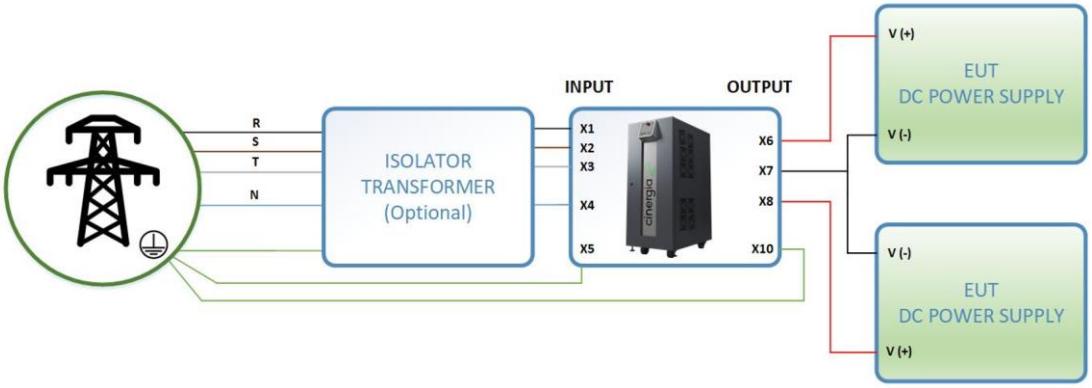
To activate or disactivate each phase, use the slider of the interface delivered by Cinergia. The left image below shows how the phase **V** is running whereas the other two are not (*Cinergia Interface*). The image of the right shows the required cables to be connected in the output terminals (**V** is connected whereas **U** and **W** are Not Connected, NC):



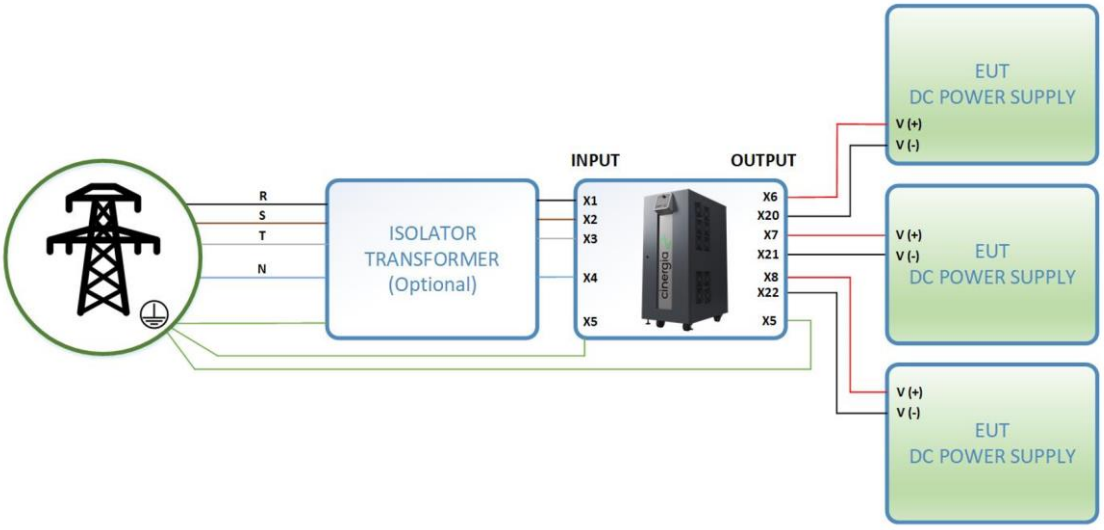


7.4.2 DC

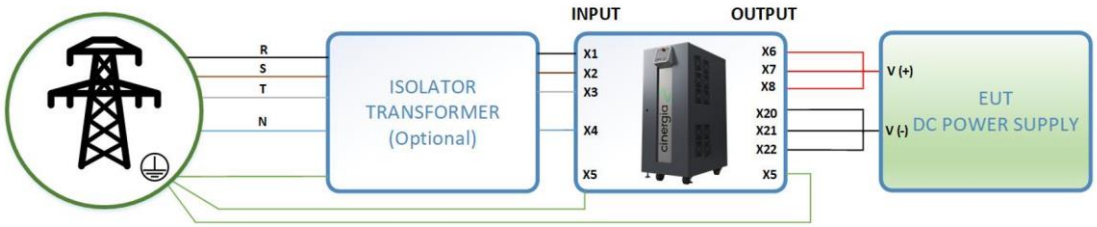
7.4.2.1 Bipolar mode



7.4.2.2 Unipolar 3 Channels mode



7.4.2.3 Unipolar 1 Channel mode



In case of working in 1 Channel mode the user must use 3 cables in the positive outputs (X6, X7 and X8) or use a bridge which put together all 3 phases. The negative outputs (X20, X21 and X22) must also be bridged in case of using only one cable.

It is possible to change the position of the switches in any state different than Run. If the new position is not allowed, there will appear the Wrong Connection alarm.

These mode operations apply to equipment from 7.5kVA to 27kVA. If your equipment has a higher power, read the corresponding manual:

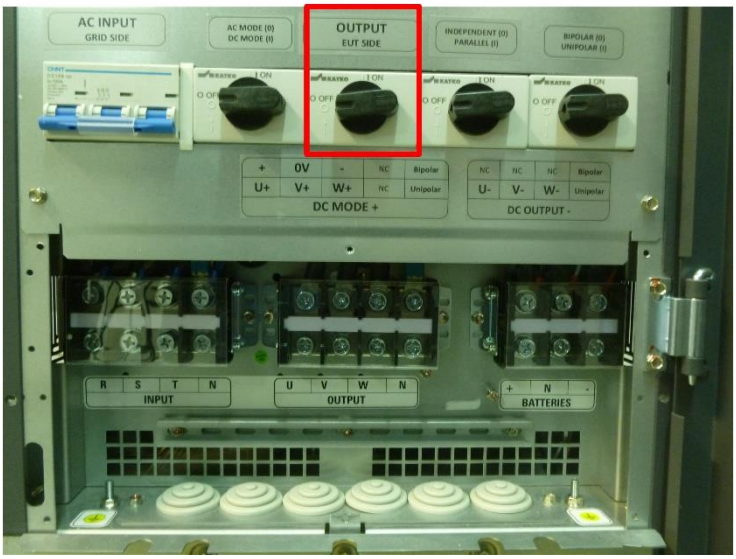
- **PR397A04_Operation Modes EL 40-60 AC&DC ePLUS:** Units from 40kVA to 54kVA
- **PR401A02_Operation Modes EL 80-120 AC&DC ePLUS:** Units from 80kVA to 108kVA
- **PR399A01_Operation Modes EL 160-200 AC&DC ePLUS:** Units from 145kVA to 160kVA

7.5 Working with the equipment (vAC/DC)

Before powering the cabinet check step by step the following items:

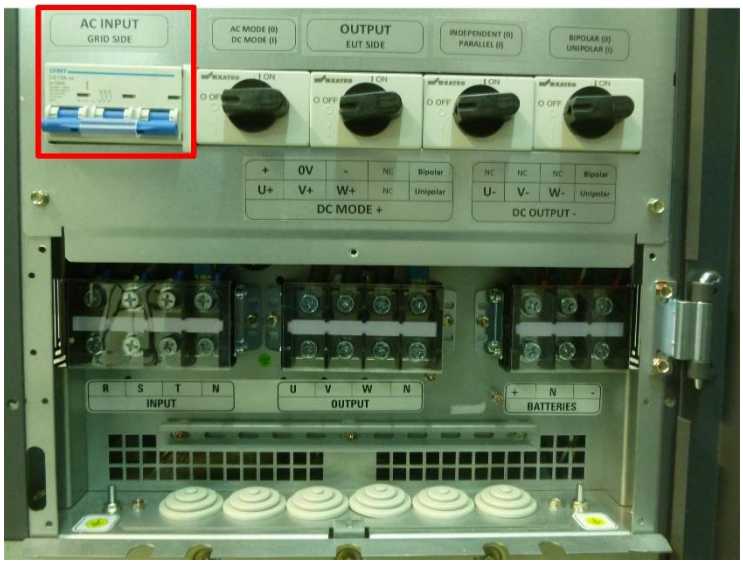
- The converter output (Q2) must be disconnected (or in OFF position):

Q2



- The grid side of the converter is protected by a thermal-magnetic circuit breaker.
- Be sure that this breaker (Q1) is switched off:

Q1



- Check that all wires are connected and secured before proceeding to the converter start-up.

If these steps are validated the converter is ready to be started.

7.5.1 Start-up

Before powering the cabinet wait at least 50 seconds to be sure that the PC embedded inside the equipment starts correctly.

Before operating the equipment, check that all LIMITS from the equipment are correct. Please take care that CNG equipment are bidirectional, this means that the equipment can consume or inject current. The equipment can operate as a SOURCE or as a LOAD.

Before running the equipment, please check all the limits and alarms.

Switch on the thermal-magnetic circuit breaker of the grid side of the converter. After switching it on, the converter will initiate the start-up sequence. This sequence will activate the high-speed cabinet fans for one second.

At this point the converter will start the initialization process, as described previously. During this time the embedded PC will load the operating system and the communications program. The converter will ignore any command during this process.

The Initialization state can last up to 50 seconds. If every step is completed successfully the converter will move automatically to Standby state.

Summarizing, to put the equipment in Run state the user should follow step by step the next checklist:

1. Connect the mains.
2. Turn on the thermal-magnetic circuit breaker.
3. Activate the cabinet output by switching the disconnector.
4. Deactivate the emergency stop (pull out the button). (*Initialization → Standby*).
5. Send the Enable signal. (*Standby → Precharge → Ready*).
6. Select the connection mode between 3 Channels or 1 Channel phases. This option cannot be done while the converter is running.
7. Select the operation mode. Please keep in mind that not all EUTs are compatible with all operation modes. For example, if the converter is acting like a voltage source, do not connect any other voltage sources at the output. In AC and DC mode, the connection mode CANNOT be changed during Run operation.
8. Send the Run signal. (*Ready → Run*).

Please keep in mind that not all EUTs are compatible with all operation modes. If the converter is operated as a voltage source, please do not connect any other voltage sources at the output.

When the equipment is turned off, the user must wait at least 15 seconds before turning it on again.

7.5.2 Stop

Once the equipment is running (Run state) it may be stopped in three ways:

7.5.2.1 Full stop

This type of stop is recommended if the electrical connections are to be modified or the converter will be stopped for a long time.

When the converter is running, special care must be taken. It is strongly recommended to follow the next steps:

1. Send, in case of current control source mode, a 0A/0W setpoint. In case of voltage source control mode, please stop the EUT current source connected at the output.
2. Send the READY signal to the converter (Run→ Ready).
3. Send the DISABLE signal to the converter (Ready → Standby).
4. Press the emergency stop button (EPO) (Standby → Alarm).
5. Disconnect the output switch disconnector (Q2).
6. (DC mode) Disconnect the Unipolar/Bipolar switch disconnector or selector (Q8).
7. **Wait at least 60 seconds** so that the most part of the internal DC link capacitors get discharged.
8. Disconnect the input thermal-magnetic circuit breaker (Q1).

Before manipulating the cables in the cabinet terminals, please check the voltages with a voltmeter to assure no voltage is present. The grid cable and the EUT must be completely unpowered before connecting or disconnecting the cables. The user must be sure that the input and output switches are both in OFF position.

Before powering the cabinet wait at least 50 seconds to be sure that the PC embedded inside the equipment starts correctly.

Before manipulating the equipment disconnect all the power supplies of the unit and wait until electrolytic capacitors are discharged (approx. discharge time: 5 minutes)

7.5.2.2 Standby stop

This type of stop is recommended if the converter will be stopped during some hours. The DC link is discharged and therefore aging of the DC bus capacitors is prevented.

Send the Not enable signal to the converter. If the user wants to lock the converter in order to avoid an accidental start-up, press the emergency stop button, and keep it pressed.

When the converter is running, special care must be taken. It is strongly recommended to follow the next steps:

1. Send, in case of current control source mode, a 0A/0W setpoint. In case of voltage source control mode, please stop the EUT current source connected at the output.
2. Send the READY signal to the converter (*Run → Ready*).
3. Send the DISABLE signal to the converter (*Ready → Standby*).
4. Press the emergency stop button (EPO) (*Standby → Alarm*).

For restarting operation, release the emergency stop button and send the Reset signal. After doing this, proceed as a standard start-up sending the Enable signal.

NEVER connect or disconnect the cables while the converter is in this state.

7.5.2.3 Ready

This type of stop is recommended if the converter will be stopped for a short time. The DC link is kept charged and the converter is ready to run.

When the converter is running, the user may send the Not run signal at any time. This will stop the IGBT PWM signals but all internal parts will be kept powered. To restart operation, send the Run signal.

When the converter is running, special care must be taken. It is strongly recommended to follow the next steps:

1. Send, in case of current control source mode, a 0A/0W setpoint. In case of voltage source control mode, please stop the EUT current source connected at the output.
2. Send the READY signal to the converter (*Run → Ready*).

NEVER connect or disconnect the cables while the converter is in this state.

7.5.3 Emergency Stop

The emergency stop button may be pressed at any time bringing the converter to the Alarm state. The emergency stop shall be only used when an emergency is detected. Please, avoid to stop the equipment with the emergency button as a “normal practice” since it will contribute to

premature component aging. To lock the converter and bring it to the Alarm state, follow the Full stop or Standby stop procedure.

The emergency Stop unpowers all the electromechanical devices in the cabinet, so the converter is stopped by hardware assuring a full stop. The internal contactors will be open, so no power will be present at the DC link or at the output of the converter. Only the control boards, fans, the embedded PC and the local touchscreen remain powered.

7.5.4 Accidental shut down

When the converter is suddenly disconnected from the mains special care must be taken for restarting it. When the converter is shut down with a charged DC link, some thermal protections of the internal power supplies will prevent its start-up.

When an accidental shutdown happens disconnect the mains and wait for at least 2 minutes for powering the cabinet again.

When an accidental shutdown happens disconnect the mains and wait for at least 2 minutes for powering the cabinet again.

7.5.5 Alarms and troubleshooting

There are different sources of alarm in the converter. The following table describes them and offers possible causes and solutions to the user.

#	Name	Cause	Solution
0	Watchdog	Internal microcontroller error.	If this alarm persists and is the only alarm triggered, contact Cinergia's technical support.
1	Emergency sequence	The emergency stop button is activated or the EPO wire is no longer connected.	Unpress the emergency stop button or reconnect the EPO wire.
2	Drivers PhR, PhS or/and PhT (input side)	IGBTs saturation protection has been activated. This alarm is triggered when there is a sudden overcurrent in the power supply input.	Contact Cinergia for technical support if this alarm persists. Check the equipment under test before restarting the power supply.
3	Overload precharge	Internal alarm caused by a shortcircuit. It may also be triggered if there is not enough time between the EPO release and the enable signal.	Repeat the Enable action 5 seconds after the EPO release. Contact Cinergia for technical support if this alarm persists.
4	Overvoltage in the DC link	The DC link voltage has exceeded its maximum value.	Reduce the output step transition time. Contact Cinergia for technical support if this alarm persists.
5	Undervoltage in the DC link	Undervoltage in the DC link caused by a fast output transient.	Reduce the output step transition time. Contact Cinergia for technical support if this alarm persists.
6	AC overvoltage in main grid	The voltage in the emulated grid is too high. Also in DC indicates overvoltage.	Check the emulated grid voltage. It can be triggered due to connection/disconnection load transition.
7	AC undervoltage in main grid	The voltage in the emulated grid is too low. Also in DC indicates undervoltage.	Check the emulated grid voltage. It can be triggered due to connection/disconnection load transition.
8	AC overcurrent in main grid	The input current has exceeded the configured limitation.	Check the output load.
9	AC overcurrent Peak in main grid	The input current has exceeded the configured limitation (peak value).	Check the output load.
10	AC overload in main grid	The input power exceeds 200% during 2s, 150% during 150% or 125% during 10 minutes.	Check the output load.
11	Heatsink temperature ABR or INV	Overtemperature in the heatsink of ABR or INV.	Check if there is enough space between the power supply and the wall. There is insufficient air flow inside the power supply. Check if the fans are working correctly.
12	Room temperature	Overtemperature in the room	Check that room temperature does not exceed 50ºC.
13	ABR/INV Alarmed	One of the two control boards has an alarm.	Reset alarms

14	SD Error	SD in Control Board is damaged.	Reset the equipment. Contact Cinergia for technical support if this alarm persists.
15	Heart Beat	Communications cable is broken or there is a control board without response.	Contact Cinergia in order to isolate the problem.
16	Mains lost	There has been an interruption in the mains.	Check the mains and the grid impedance
17	Device Not Initialized	One of the control card has not initialized properly.	Reset the equipment. Contact Cinergia for technical support if this alarm persists.
18	Isolation Device	The isolation detector detects less than 10kOhm between any phases and ground	Check the output and input electrical connections. Check the EUT to isolator faults.
19	Drivers PhU, PhV or/and PhW (input side)	IGBTs saturation protection has been activated. This alarm is triggered when there is a sudden overcurrent in the power supply output.	Contact Cinergia for technical support if this alarm persists. Check the equipment under test before restarting the power supply.
20	Output Overload	The output power exceeds 200% during 2s, 150% during 60s or 125% during 10 minutes.	Reduce de EUT power. Note that the equipment has an internal protection against consecutive overload test.
21	Wrong Connection	The output connection is not correct configured. Some switch has been switched during the converter operation or in a forbidden connection.	Do not operate the 3 Channels/1 Channel switch while the converter is running.
22	Output Overvoltage	The Output voltage has exceeded its maximum value at the output side.	Check limits configured on the CNG unit and the equipment under test voltage.
23	Output Overvoltage Peak	The Output voltage has exceeded its maximum value (peak value).	Check the equipment under test voltage.
24	Output Undervoltage	The Output voltage has exceeded its minimum value.	Check limits configured on the CNG unit and the equipment under test voltage.
25	Output Overcurrent	The output current has exceeded the configured limitation.	Check the output load. Note that the equipment has an internal protection against consecutive overload test.
26	Output Overcurrent Peak	The output current has exceeded the configured limitation (peak value).	Check the output load. Note that the equipment has an internal protection against consecutive overload test.
27	Neutral overcurrent	The current of the neutral wire has exceeded its maximum value permitted.	Check the output configuration and load.
28	Output capacitor overcurrent	The current of the output capacitors has exceeded its maximum value permitted.	Check the output configuration and load.
29	Output contactor failure	The equipment has a synchronization failure. It means that there is an issue at the output side of the	Check the output source.

		equipment (for example, there is NO grid in case EL_AC).	
30	Phase U	Indicates that the phase U is in alarm. Check the alarm.	Check the alarm and how to proceed.
31	Phase V	Indicates that the phase U is in alarm. Check the alarm.	Check the alarm and how to proceed.
32	Phase W	Indicates that the phase U is in alarm. Check the alarm.	Check the alarm and how to proceed.

7.5.6 Alarms reset

The user shall follow the next steps for resetting the alarms:

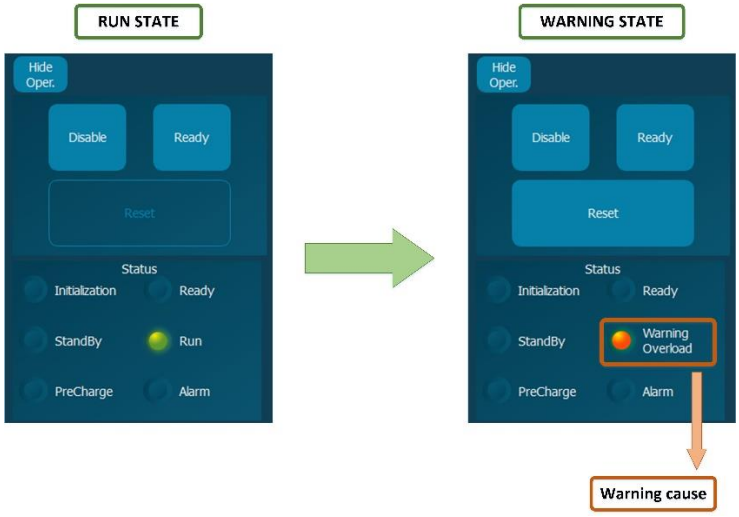
1. Send a DISABLE (0) and READY (0) signals to the converter (note: this step is done automatically when the user is interfacing the converter by the LCD or by the software provided by Cinergia).
2. Send a Reset signal sequence (0 – 1 – 0) to the converter.
3. Proceed as a standard start-up process by disabling the emergency stop (pull out the button).

A Reset will be performed only in the case that the alarm source has been cleared. If the problem persists after resetting the converter, a new alarm will be triggered.

The HISTORIC of ALARMS can be checked in any time (interface and LCD).

7.5.7 Warning

The equipment has a state to indicate whereas the converter is working over the alarms limits, but below the maximum limits. For example, if the maximum allowed current is 20A, the equipment can work up to 22A for 10 minutes. But while staying between 20A and 22A, the equipment will be working in Warning state instead of Run. The following picture shows an example of an equipment working with overload:



This state works as an indicator helping the user to be aware if the equipment will go to alarm state sooner.

8 LOCAL TOUCHSCREEN CONTROL PANEL

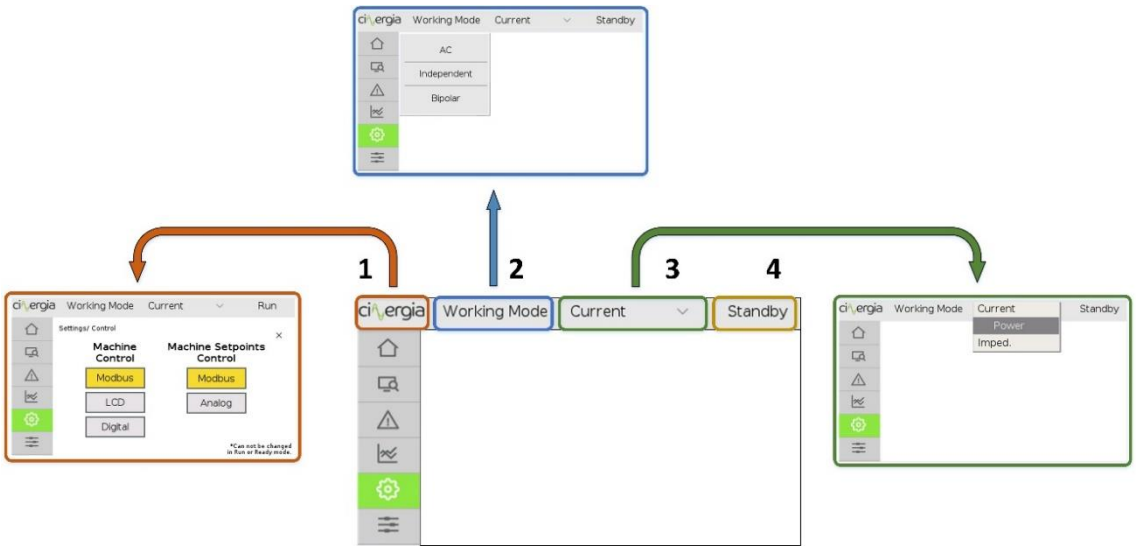
This chapter is fully explained, extended and detailed in the delivered document *Local Touchscreen+ Manual*.

The equipment of Cinergia has the possibility to be controlled with the local touchscreen situated in the front panel of the equipment, which also delivers the necessary information of the status of the converter. The following list illustrates the basic functionalities of the touchscreen:

Information about the status of the converter (initialization, ready, standby, run, Precharge, warning or alarm).
Information about the connection and configuration (3 Channels /1 Channel, unipolar/bipolar and AC/DC).
Information of the input and output voltage, current and power.
Operate with the equipment by changing the status.
Send setpoints and configure limits and ramps.
Create plots.
Change the IP of the equipment.
Configure the analogue output.

To create a friendly navigation of the LCD, Cinergia has designed a tab distribution ubicated in the right of the screen. There is also an upper bar, which has the purpose to inform and modify the control operation and mode as well as the status of the equipment.

These schematics below illustrate the upper and the left sided bar and the information that they deliver:



9 DIGITAL CONTROL

This chapter is fully explained, extended and detailed in the delivered document *External Operation. Inputs and Outputs*.

The equipment can be controlled using digitals and analogue signals: the digitals are used for controlling the status of the equipment (Standby, Alarm, Ready and Run) whereas the analogue signals allows the user to set output values sending the corresponding setpoints. To sum, with these signals it is possible to control the basics of the equipment.

Specifically, there are 6 digital inputs which operate at **24V** and 4 digital outputs (the maximum admitted current is 3A. In case of equipment with serial number 2016XXXX, the maximum admitted current will be 8mA). Both digital inputs and outputs are referenced of **GNDMD** (pins 6 and 15).

The list of each digital functionality is the following:

INPUT (referenced to the PIN 6 or 15):

- **PIN 7:** INPUT RESET. Makes a RESET to the equipment.
- **PIN 8:** INPUT RUN/READY. Changes from RUN to READY and vice versa.
- **PIN 9:** INPUT STOP. Makes the equipment go to READY if it is in RUN state during all the time that this digital input is enabled.
- **PIN 10:** INPUT ENABLE/DISABLE. Changes from ENABLE to DISABLE and vice versa.
- **PIN 13:** TRIGGER CONFIG. Applies the setpoint of the converter.
- **PIN 14:** TRIGGER FUNCTION. Applies the AC Faults parameters of the AC converter.

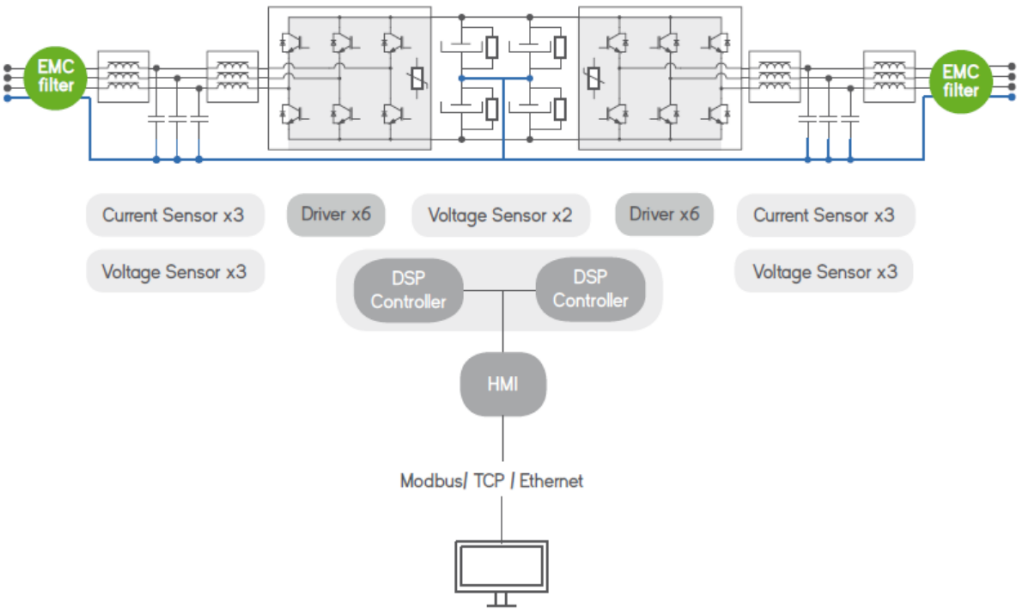
OUTPUT (referenced to the PIN 6 or 15):

- **PIN 2:** OUT TRIGGER. The output will turn on when the TRIGGER CONFIG or the TRIGGER FUNCTION are sent. When the equipment applies a setpoint, the *Trigger Out* is active (24V) during 100ms, whereas when the equipment applies an AC Fault, the *Trigger Out* is active (24V) during all the Fault.
- **PIN 3:** RUN LED. The output will turn on when the equipment is in RUN state.
- **PIN 5:** READY LED. The output will turn on when the equipment is in READY state.
- **PIN 4:** ALARM LED. The output will turn on when the equipment is in ALARM state.

For further information, please read the document *External Operation. Inputs and Outputs*.

10 REMOTE COMMUNICATIONS

CINERGIA's power supplies can be operated and supervised remotely through an Ethernet communications bus. An internal embedded PC, with CINERGIA's proprietary software, allows the exchange of information between the internal CAN bus and the external Modbus TCP/IP (Ethernet). In this way, the customer can build specific HMI client software application while CINERGIA's power supply acts as a Modbus TCP/IP server.



This Modbus TCP slave has the following properties:

PROPERTY	SERIAL	TCP
Function Codes:	0x03: READ_HOLDING_REGISTER 0x10: WRITE_MULTIPLE_REGISTER	
Server port:	Not used	502 (decimal)
Modbus node ID (Slave ID):	Only used in serial and configurable via LCD touchscreen	IGNORED Ignored
CRC	2 Bytes	Not used IN TCP. Relayed on the TCP stack.
Multiple connections	Available. Unresolved conflict management.	As many connections as required.
Idle connections	Serial Bus never closes.	Idle connections might be closed by the slave. Anyway, the listen socket will force the master to keep the connection active, even when there is no active connection at all.
Other	All variables are 32-bit length. This is 2 Modbus base register addresses. And so all Read operations must begin at the beginning of one variable and be Even.	

Please read the document *EL+ MODBUS DATA TABLE UNIC and DC+ MODBUS DATA TABLE UNIC*.

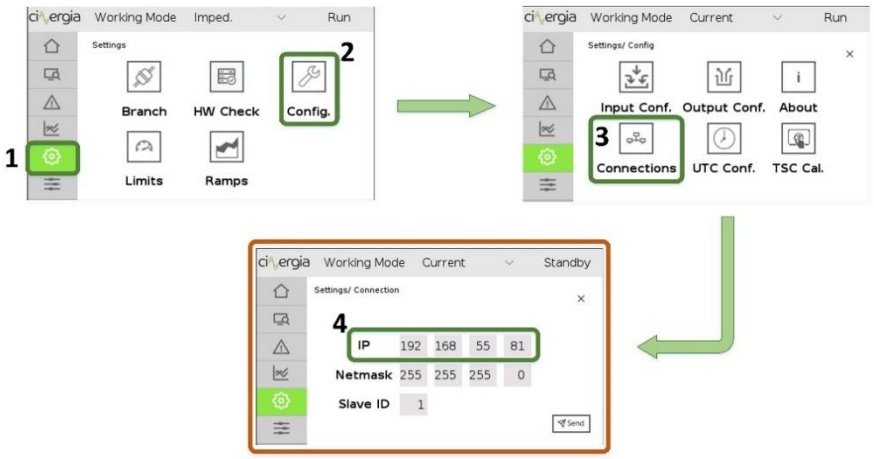
11 HUMAN MACHINE INTERFACE

This chapter is fully explained, extended and detailed in the delivered document *Human Machine Interface EL+*.

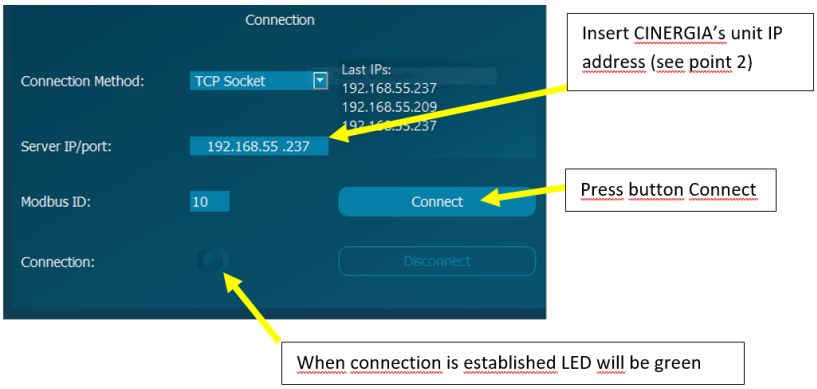
CINERGIA delivers, within the scope of the supply, a Human Machine Interface software that communicates with the equipment using MODBUS protocol. This application is compatible on Windows 10/Windows 7/Windows XP. The software can be installed by executing Setup.exe file in Administrator Mode and following the instructions of the application.

To connect Cinergia units to a PC, follow these steps:

- Connect a standard RJ45 Ethernet cable to terminal X13. The unit can be connected directly either to a computer or to a router (wired or wireless). If the CINERGIA unit is connected through a router, several computers could be connected to the unit at the same time.
- Check the IP address of CINERGIA unit in the LCD Touchscreen following these steps:



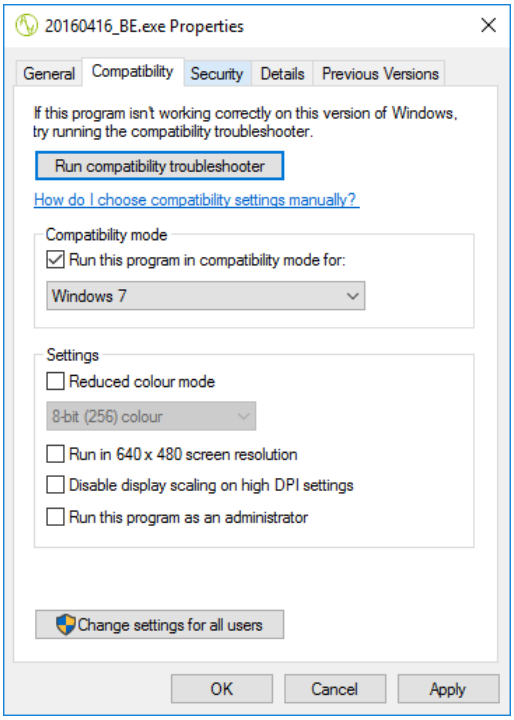
- Check the computer's Ethernet configuration panel and make sure that both the computer and the CINERGIA unit are in the same subnetwork. For instance, if the CINERGIA unit IP address is 192.168.55.81 the computer Ethernet configuration shall be:
  a) Computer IP address: 192.168.55.XXX (XXX can be any address different from 81 and different from any other device in the same network)
  b) Subnet mask: 255.255.255.0
  c) Gateway and DNS configuration are not needed for a connection with a CINERGIA unit
- Run the graphical user interface delivered by CINERGIA, write the IP address of the unit to be connected and press the Connect button.



If there is an error when trying to run Cinergia application, please check the compatibility mode of your computer. For instance, in a Windows 7 computer, right click CINERGIA application → Properties; go to Compatibility panel and check the box Run this program in compatibility mode; and select the operating system of your computer.

Read the document *Connecting CINERGIA+ units to a PC* for more information.

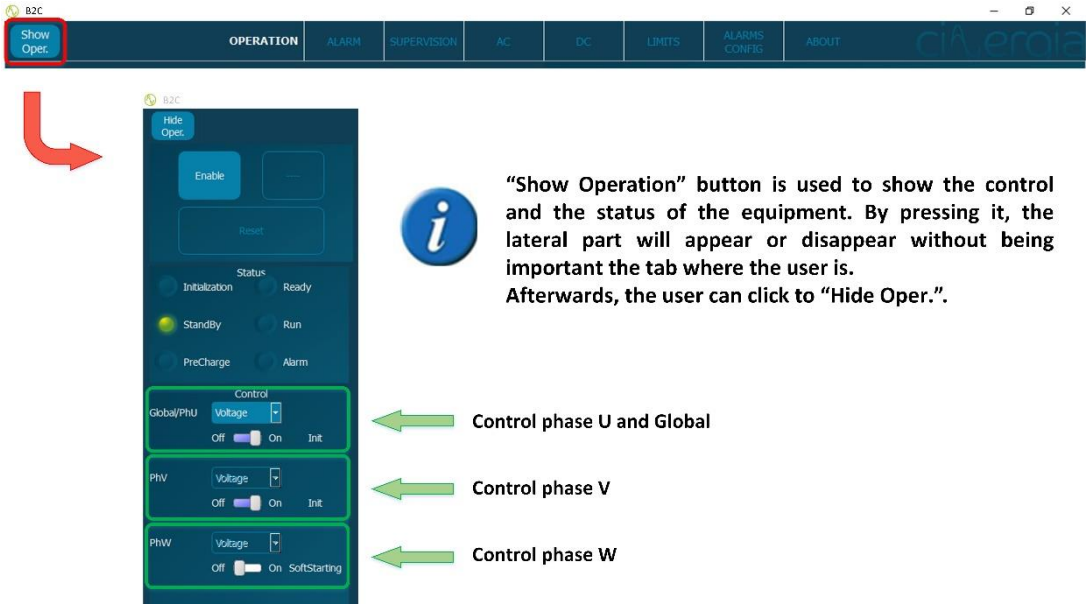
If there is an error when trying to run CINERGIA application, please check the compatibility mode of your computer. For instance, in a Windows 7 computer, right click CINERGIA application → *Properties*; go to *Compatibility* panel and check the box *Run this program in compatibility mode*; and select the operating system of your computer. For instance, for a Windows 7 computer:



The interface delivered by Cinergia has a correct visualization with screens configured with a minimal resolution of 1366x768 (16:9)

11.1 Show operational button

This chapter is fully explained, extended and detailed in the delivered document *Human Machine Interface EL+*.



The functionality of the buttons that control the status of the equipment is the following:

Button	State transitions
Enable	Standby → Ready
Disable	Ready/Run → Standby
Run	Ready → Run
Ready	Run → Ready
Reset	Alarm → Initialization → Standby

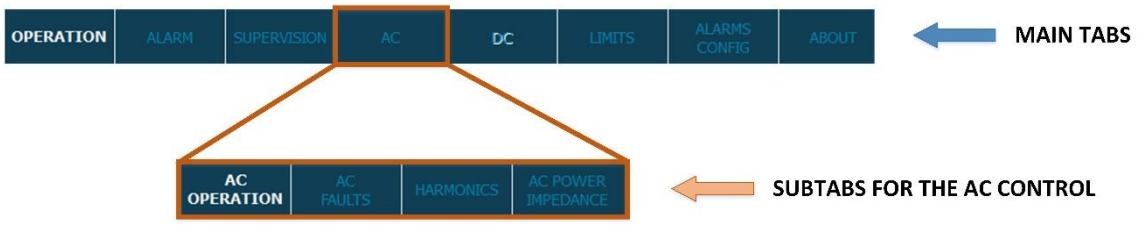
Independent control mode is optional, and it has an additional cost.

In Current, Power or Impedance mode, the equipment controls current and it requires a voltage source connected at the output of the Cinergia equipment. The voltage source must be the first to be turned on. Once the Cinergia converter reads the voltage in the inverter, the Run state can be applied.

If no voltage is applied at the output of the Electronic Load, the Electronic Load will remain in *Softstarting* state, this means waiting for a voltage at the output.

11.2 Distribution of the interface

To create a friendly navigation of the interface, Cinergia has designed a Tab Dialog distribution, in which each tab has one of the following purposes:



The description of all the tabs is explained in the delivered document *Human Machine Interface EL+*.

There is the possibility to configure the unit with specified limits and alarms values, but a password is required. Cinergia will deliver the password to this advanced user, which functionalities are the followings:

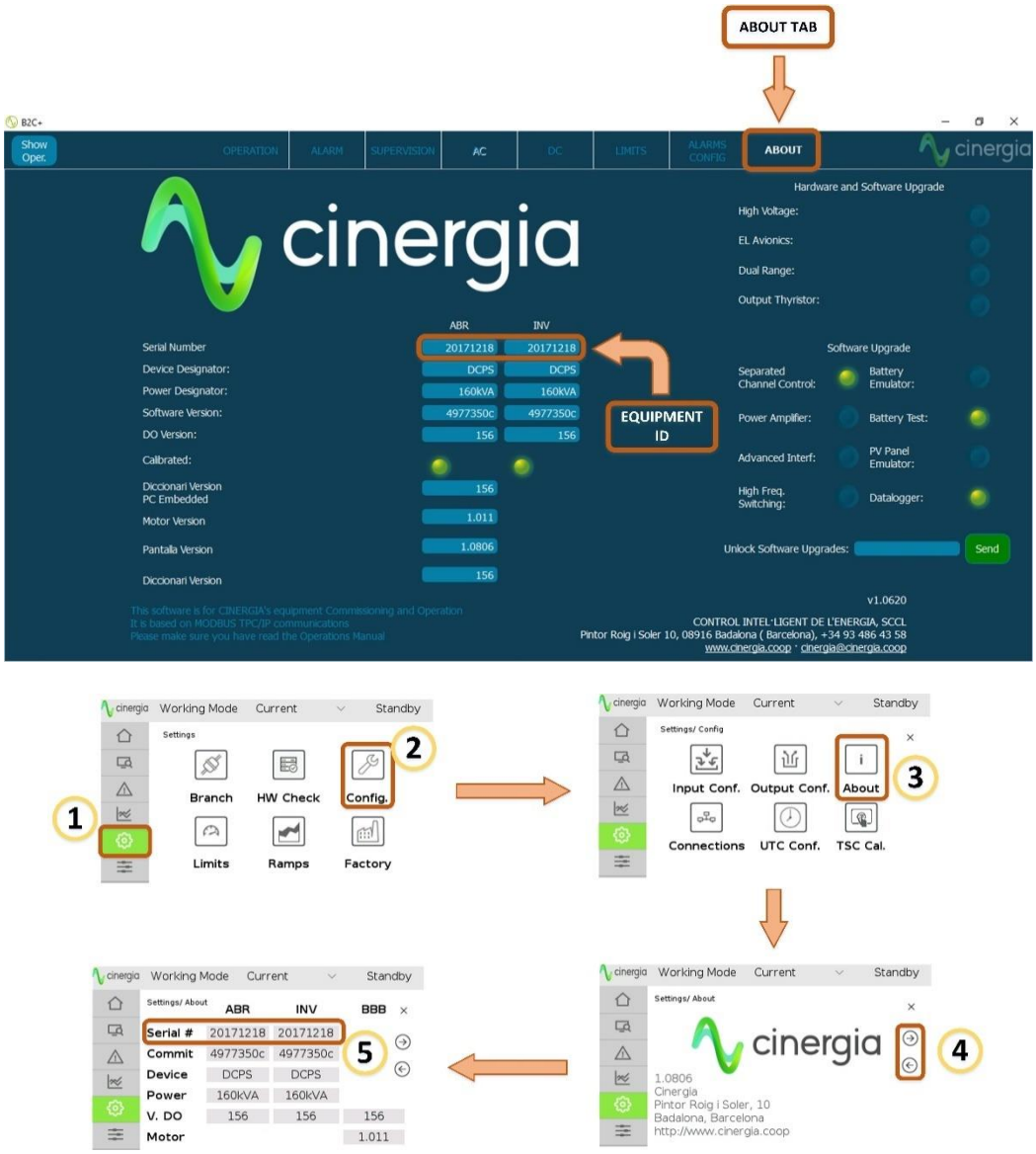
- Save new operating *Default Limits Values* (on Limits Tab)
- Configure, send and save new *Alarm Values* (on Alarm Config Tab)
- Recover *Factory Values* (on Limits and Alarm Config Tab)

Please read the document *Human Machine Interface Advanced User* to know everything about these functionalities and the execution of them.

12 EQUIPMENT ID

Each Cinergia converter has an identification number visible for the user. This ID is necessary to give the best service to you.

In case of doubts or problems with the equipment, please find this ID number and deliver it to Cinergia. It can be found in the interface or in the LCD touchscreen:



In case of doubts or problems with the converter, please make a screenshot or a photo of these tabs and send them to Cinergia.

13 WARRANTY AND MAINTENANCE

Fans and capacitors must be replaced at the end of their useful lifetime.

Inside the equipment there are dangerous voltages and metallic parts at high temperatures even when the equipment is stopped. The direct contact can cause electrocutions and burns. All the operations must be done by authorized technical staff.

13.1 Replacing the input fuses

This operation must be performed by personnel experienced with electrical systems. The direct contact can cause electrocutions and burns.

In order to replace the input fuses follow procedure below:

A. Stop the converter following the instructions of FULL STOP chapter section

When the converter is running, special care must be taken. It is strongly recommended to follow the next steps:

1. Send, in case of current control source mode, a 0A/0W setpoint. In case of voltage source control mode, please stop the EUT current source connected at the output.
2. Send the READY signal to the converter (Run→ Ready).
3. Send the DISABLE signal to the converter (Ready → Standby).
4. Press the emergency stop button (EPO) (Standby → Alarm).
5. Disconnect the output switch disconnector (Q2).
6. (DC mode) Disconnect the Unipolar/Bipolar switch disconnector or selector (Q8).
7. Wait at least 60 seconds (time to get discharged the internal DC link capacitors).
8. Disconnect the input thermal-magnetic circuit breaker (Q1).

Before manipulating the cables in the cabinet terminals, please check the voltages with a voltmeter to assure no voltage is present. The grid cable and the EUT must be completely unpowered before connecting or disconnecting the cables. The user must be sure that the input and output switches are both in OFF position.

Before powering the cabinet wait at least 50 seconds to be sure that the PC embedded inside the equipment starts correctly.

B. Open the fuse holder and replace the fuses

These fuses can only be replaced by new ones of exactly the same model.

13.2 Fans

The useful lifetime of the fans used to cool the power circuits depends on the use and environment conditions. It is recommended their preventive replacement by authorized technical staff.

13.3 DC bus capacitors

The useful lifetime of the DC bus capacitors and those ones used in the input and output filtering depends on the use and the environment conditions. It is recommended their preventive replacement by authorized technical staff.

13.4 Warranty

CINERGIA warrants that the delivered equipment is free from any defect affecting the functioning thereof for a time period not exceeding one (1) year from the Ex Works delivery date. If a purchased CINERGIA product becomes defective because of a faulty component or manufacturing, at any time during its standard warranty period, CINERGIA shall provide one of the following solutions:

• On-site technical assistance

• Product or component repair at CINERGIA's premises

• Replacement of the defective product or component

The decision whether to perform the assistance on-site, to repair or replace the faulty product and/or component shall be taken in any case exclusively by CINERGIA.

13.5 Claim procedure

The warranty rights can be exercised during the validity of the warranty period and immediately upon detecting any abnormalities, except in the case of visible defects, in which case the claim shall be submitted within a maximum time of 7 days from the date of receipt of the equipment and always prior to its installation.

If defect of malfunction is detected, please proceed as follows:

• Immediately notify in writing CINERGIA by submitting a brief report describing the type of fault detected and all the data contained in the product data plate (serial number of the unit), attaching a copy of the purchase invoice/receipt. Such documentation shall be sent to the email address of the Sales Team (comercial@cinergia.coop).

• Upon receiving the documentation, CINERGIA will analyze it to decide whether the intervention required is covered by the warranty terms described herein.

• If the claim is covered by the warranty terms, CINERGIA shall provide on-site technical assistance or, alternatively, can request the shipping of the defective product and/or component to have it repaired at CINERGIA premises. At last, CINERGIA shall decide to send a replacement product and/or component. The faulty product and/or component shall be returned to CINERGIA. Any shipping damages attributable to improper packaging shall not be covered by warranty. The faulty product should be shipped back in upright position over a pallet and properly covered and protected.

• Failure to return the replaced equipment within 10 (ten) standard days shall authorize CINERGIA to invoice the equipment supplied as replacement.

• In case the defect of the returned equipment is deemed not to be covered by the warranty, CINERGIA shall issue an invoice to the purchaser for the repair activity.

• If on arrival at CINERGIA's premises the returned equipment is deemed to be in perfect operating conditions, CINERGIA shall be authorized to issue an invoice for all the costs resulting from its replacement (analysis and testing of the equipment and shipping costs).

• CINERGIA reserves the right to provide a different model of product and/or component to process the claims covered by the warranty terms, in case the original model and/or component is out of production.

14 ANNEXES

This document will describe on the ANNEXES the functionality of some advanced features provided by particular versions of CINEINA V2. Those are Steps Functionality and IEC61000 normative.

14.1 STEPS FUNCTIONALITY

14.1.1 INTRODUCTION

Some advanced-versions of CINEINA V2 provide the user with the STEPS feature, a new functionality that differs from the normal operation in that it guarantees a deterministic behavior.

Before analyzing in detail this functionality, let's define what a "step" is:

Step is an input which invokes three desirable parameters in a specific time (as long as it has been previously ACTIVATED). As said, it is a must to activate the desired step previous its execution; thanks to that, the step guarantees a deterministic behavior.

CINERGIA's converters can execute a group of Steps whose information is stored in a specific CSV format file, with a limited number of 40 steps.

CINERGIA's converters can also save multiple files, therefore, their information is not lost after the converter shut down.

It is important to notice that, a group of files can be saved in the converter, but only one can be activated.

The user can access to this functionality via STEPS tab on CINEINA V2, as indicated below:

Take notice of that the STEPS functionality is only available on CINEINA versions V2.0038 and above. Remember that the current version of the software interface can be checked via ABOUT tab.

Figure 1: The STEPS functionality can be found on one of the general tabs in CINEINA V2.

In the HMI, the user can access to STEPS functionality, but with some limitations. In order to access to the functionality in question, in the HMI it must be selected: CONFIG> Steps, as it can be seen in the following image.

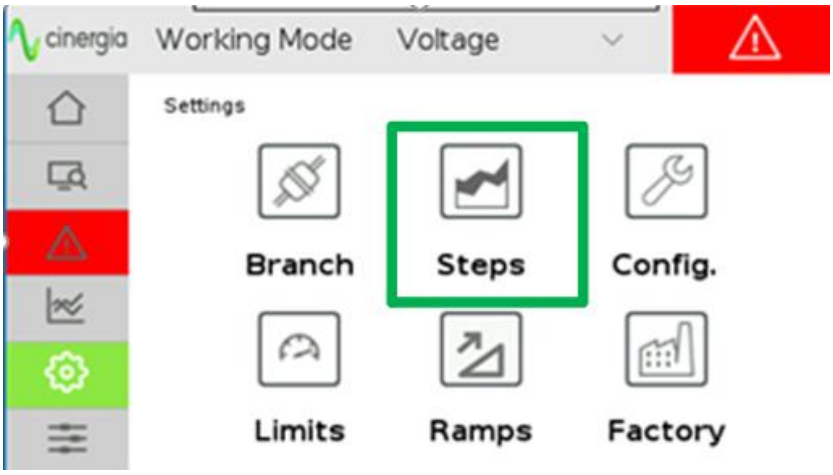


Figure 2: The STEPS functionality can be found by going on Settings menu.

The only difference between using STEPS through HMI or CINEINA, is that CINEINA can create the desirable steps and manipulate the resulting files (i.e. deleting, renaming…etc.) while HMI cannot, as HMI can only activate STEPS and control their execution.

14.1.2 ACTIVATING AND CONTROLLING STEPS THROUGH HMI

Once the user enters the Steps option through the HMI, it can be seen a page similar to the following picture:

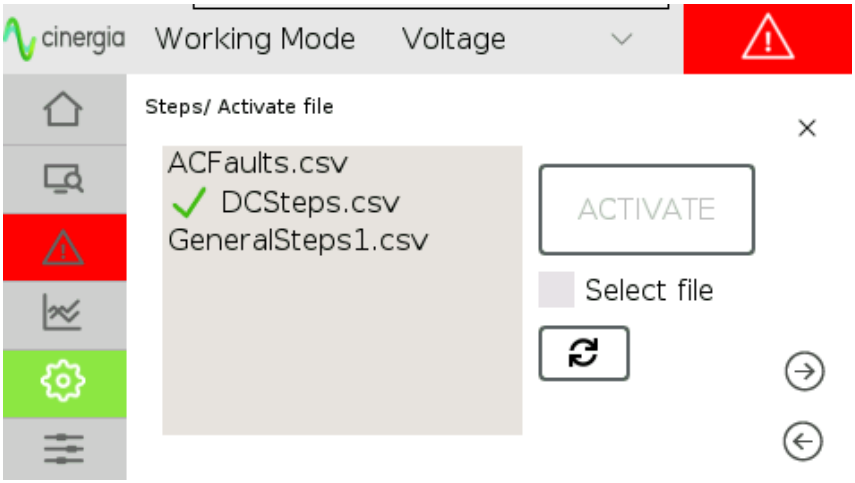


Figure 3: List of three steps files stored inside the Converted. The activated one is indicated with the green-tick

In the picture above, for example, it is indicated that the converter has three steps files and that the **DCSteps.csv is activated.**

If the user wants to activate another file, it must be pressed the “Select file” option, and then, it must be chosen one of the files from the List. Once the desirable file is selected, the user must click on “Activate” and wait approximately 10 seconds. After that time has elapsed, it must be checked if the *green tick* has been changed, which it will indicate that a new step has been activated.

Once a group of steps is activated, now the user can execute them via the “Run sequence“ page. The user can access to it by clicking <- and -> arrows, as indicated in the following image:

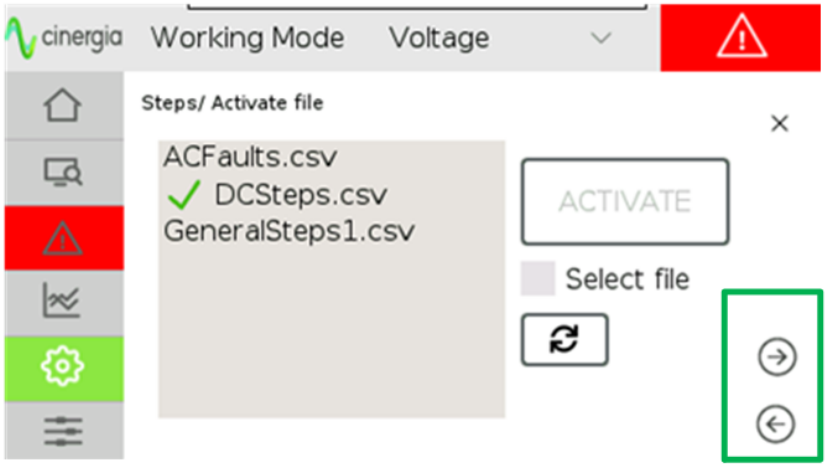


Figure 4: The user can navigate through the different pages of Steps by the left and right arrows.

As it can be seen, the user can Run, Pause or Stop the activated steps. There are also two indicators: *Time Left*, which is the remaining time for the steps to be finished, and *Current Step*, which indicates which step is being executed. In addition, there are two modifiable options: a check-box labeled *Repeat Sequence?*, which indicates what to do once the execution has finished, and the *Start N step*, which indicates which Step from the list should the converter execute first.

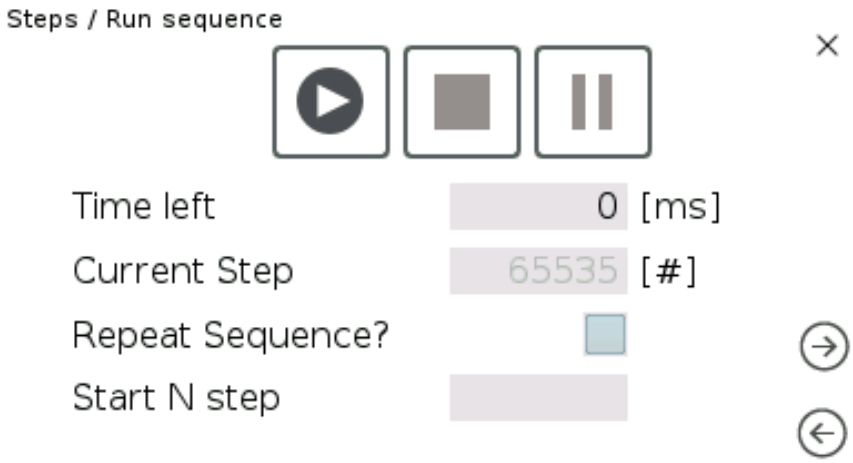


Figure 5: Step Control page, which can execute the activated steps, and get desirable information of the execution.

Make sure that the converter is in Local Mode before controlling the Steps, otherwise a message will pop-up denying the action.

14.1.3 ACTIVATING AND CONTROLLING STEPS THROUGH CINEINA

In the previous section, it has been described how to activate and control Steps through HMI. In this section, we are going to focus on how to do the same, but with CINEINA V2. In this case, the user should go to the STEPS tab and remain in the GENERAL tab. There, a similar page to the following one can be found:

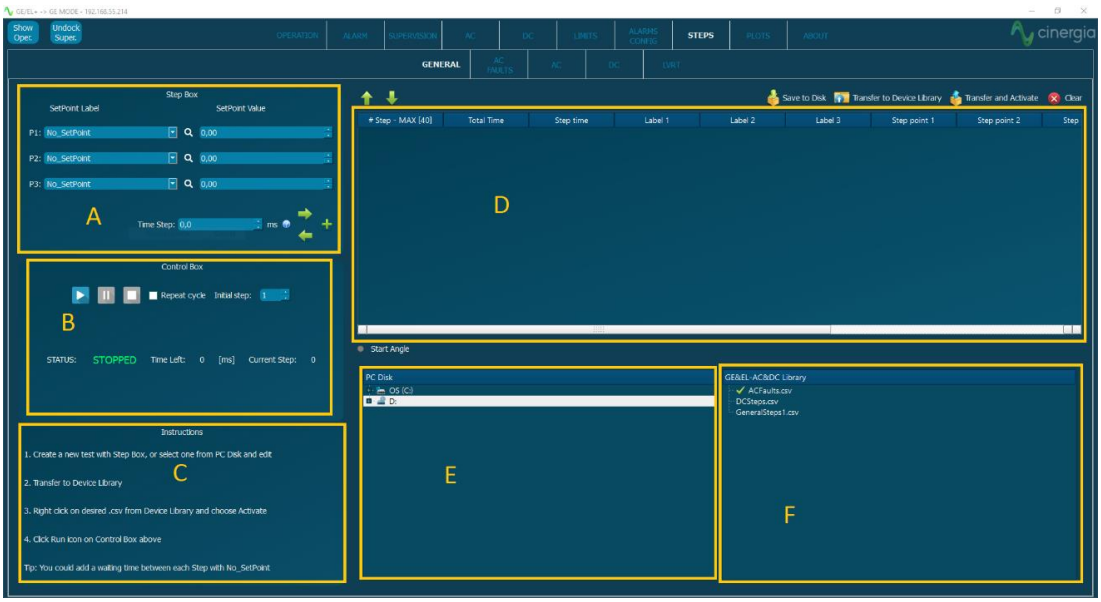


Figure 6: View of the General page from the Steps tab.

To Activate a group of steps, the user must go to F section, as indicated on the previous image, the converter Library, which contains all the steps files that are saved in the unit. One of these must be selected by right-clicking on it and choosing “Activate” option.

Right-Click on one of the listed files from the unit Library and choose “Activate” to activate the steps. The file can be Removed, Refreshed and Renamed by using this similar methodology.

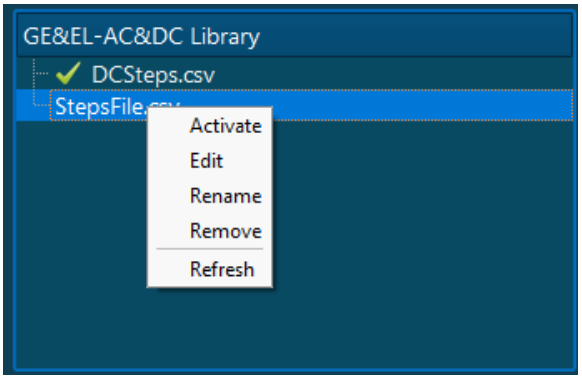


Figure 7: Pop-up menu will appear once the user right-click a file from the Library.

Be aware that, when the information of the activated steps file changes, the same file must be re-activated to notify the converter of the changes.

Once a steps group is activated, the user can control this via the Control Box of CINEINA V2 (located in the B box of the previous image), which contains the same information as the HMI together with the current STATUS of the execution of the STEPS:

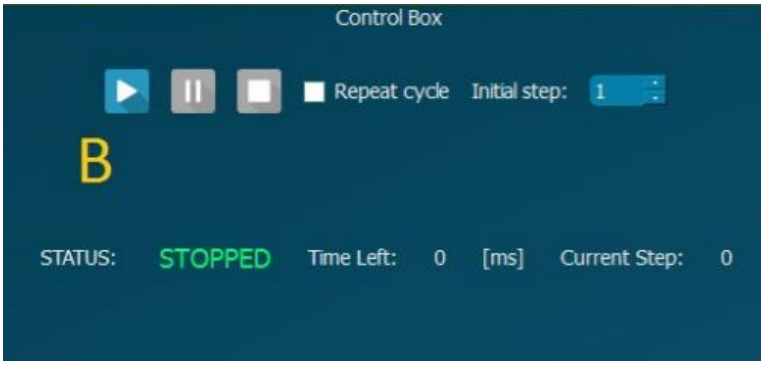


Figure 8: Control Box of General page.

Make sure that the converter is in Remote Mode before controlling the Steps, otherwise a message will pop-up denying the action

14.1.4 CREATING NEW STEPS

Once learnt how to control and activate steps, it is time to create new ones. To do that, and to avoid any possible confusion with the terms of activation, it is recommended to remove all the Steps files that are saved in the unit (i.e. to Remove each of these from the General TAB via Right-Clicking them). It is also recommended to start playing with the *AC Faults* sub tab.

14.1.5 AC FAULTS STEPS

Once the user enters the AC Faults page (in the STEPS tab), a similar page to the following one is shown:

Figure 9: View of AC Faults page from Steps tab.

The AC Faults page is divided into 5 groups: Input values, the AC Faults options, the Transferring options, the Table, and the Control box. As it can be appreciated, the page in question invites us to configure a Voltage Dip, asking for parameters like the Fall Time, or the Dip voltage, for each branch.

For further information about any parameter please click on button, or Right-Click the Plot.

Once the user has configured correctly the values corresponding to the desired behavior, it is time to add the values in question to the table by clicking the button.

If the user accidentally changes the values of the input section and wants to recover the information given by the table, he can press the button to replace the current values with the table ones.

In order to configure two AC Faults at the same time, the *Multifaults?* check-box must be checked (which is located in the C section) and then the + button must be pressed again.

Without *Multifaults?* checked, the functionality of + button is to replace the information of the table with a new one.

Once filled the table, the user can use it to control the converter by clicking *Transfer & Activate* button and waiting until a pop-up appears with a satisfactory image. At this point, the user can execute the activated steps through Control Box (located in the E section).

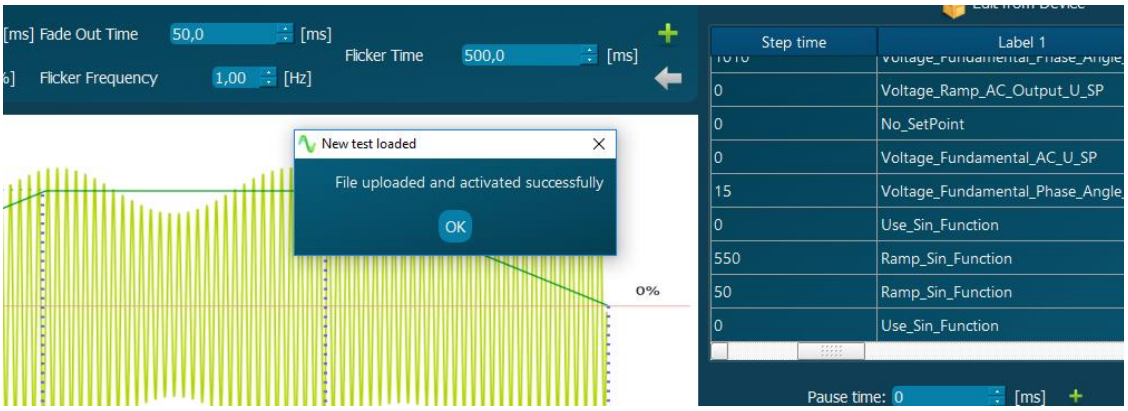


Figure 10: Pop-up with a satisfactory message, indicating that the table has been activated correctly.

Also at this point, it can be checked in the GENERAL tab that the activated step file has changed to ACFaultsSteps.csv, and its execution can be controlled by its Control Box.

Now that the converter has got the information, the information from the table can be removed, and the user can create a new Voltage Dip with a different configuration.

Please get in mind that, in case of not changing the name of the transferred file, ACFaultsSteps.csv will be replaced with the new file (which has got the same name) once clicked "Transfer & Activate" button of AC Faults page.

It is possible to add a Frequency Variation or Flicker effect after the Voltage Dip, just by configuring it in each option, and Adding it to the table when *Multifaults?* is checked.

Please remember to add the values to the table and transfer these by clicking "Transfer & Activate" button, if you want to activate each step.

14.1.6 AC/DC STEPS

The functionality of AC STEPS is basically the same as DC STEPS; the only difference is in the setpoints values.

Let´s have a look at the parts of the AC steps page and see how we can create a table, transfer it to the unit and activate it.

Figure 11: Pop-up with a satisfactory message, indicating that the table has been activated correctly.

As it can be seen, only A section has changed comparing AC steps page with the AC Faults page. B and C sections have got the same behavior as described previously.

The user can add to the table the desired setpoint and values just by clicking the corresponding + button. This way, the user can construct the table with certain flexibility, always according to the options that the converter permits. For example, in the previous image, the GE option is disabled because CINEINA is connected to an EL device. In addition, only Current setpoints are enabled because the unit is working in Current mode.

It is important to know the capabilities of the converter in order to understand why some input setpoints are enabled or disabled.

On the other hand, the user can replace one specific step from the table with another one, just by selecting the row which wants to replace, and clicking the button from the corresponding D section.

Finally, to know which is the setpoint corresponding to a specific row from the table, it is necessary just to Double-Click on the row in question. At this point, the corresponding Setpoint from the A section will be highlighted with the loaded value.

Once a table is filled, as explained before, it can be transferred to the device by clicking *Transfer and Activate* button. In the AC case, the new file is going to be called ACSteps.csv, whereas in DC case it is going to be called DCSteps.csv. Then CINEINA will show a pop-up message, indicating the status of the transfer. After that, the Steps can be controlled by the Control Box.

Please get in mind that, in case of not changing the name of the transferred file (ACSteps.csv for the AC page, DCSteps.csv for DC page), it will be replaced with the new file (which has got the same name) once clicked "Transfer & Activate" button of the corresponding page.

Please remember to add the values to the table and transfer these by clicking "Transfer & Activate" button, if you want to activate each step

14.1.7 LVRT

The STEPS functionality gives to the user the possibility of executing and simulating the behavior of Low Voltage Ride Through effects, in LVRT subtab from STEPS.

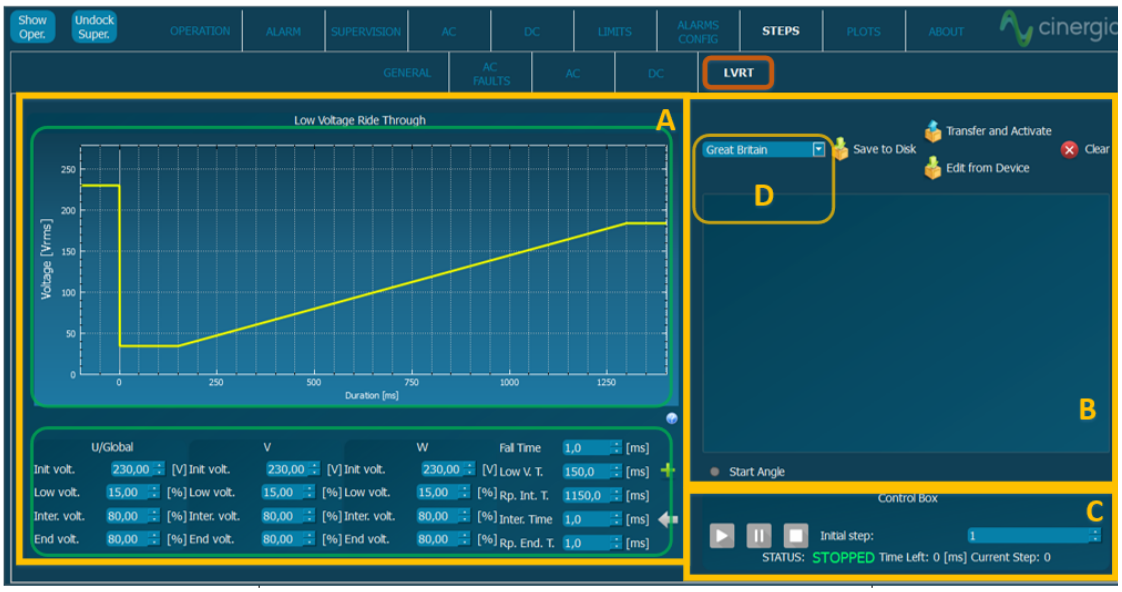


Figure 12: View of LVRT page from Steps tab.

As the previous image indicates, LVRT can be divided into four sections: the input values, the table, the Control Box, and a list of LVRT presets for various countries.

The user can choose any country from the list given in D section. Once a country is selected, the input values will be modified accordingly. However, the user will be able to remodify them as he wants.

For further information about any parameter please click on button, or Right-Click the Plot.

Once the user configures the values as he wants, he should add them to the table by pressing + button. It must be noticed that + button will replace the contains of the table with the new ones.

The user can click button to replace the input values with the values from the table. Finally, the user can activate the table values and transfer them to the unit by clicking the “Transfer & Activate” button. Then, the activated steps can be executed by the Control Box of LVRT or GENERAL pages.

Please get in mind that, in case of not changing the name of the transferred file, LVRT.csv will be replaced with the new file (which has got the same name) once clicked “Transfer & Activate” button from the current page.

Please remember to add the values to the table and transfer these by clicking “Transfer & Activate” button, if you want to activate each step

14.1.8 GENERAL TAB

So far this manual has described how a user can create, activate and control new Steps with each of the previously mentioned subtabs. However, each of the subtabs in question has been limited to specific options of Setpoints, to make it more user friendly.

Unlike with the previously mentioned subtabs, with the General tab it can be created any kind of behavior that the converter permits. It is the most flexible but also the most complicated to use subtab from STEPS. Its overall structure is the following:

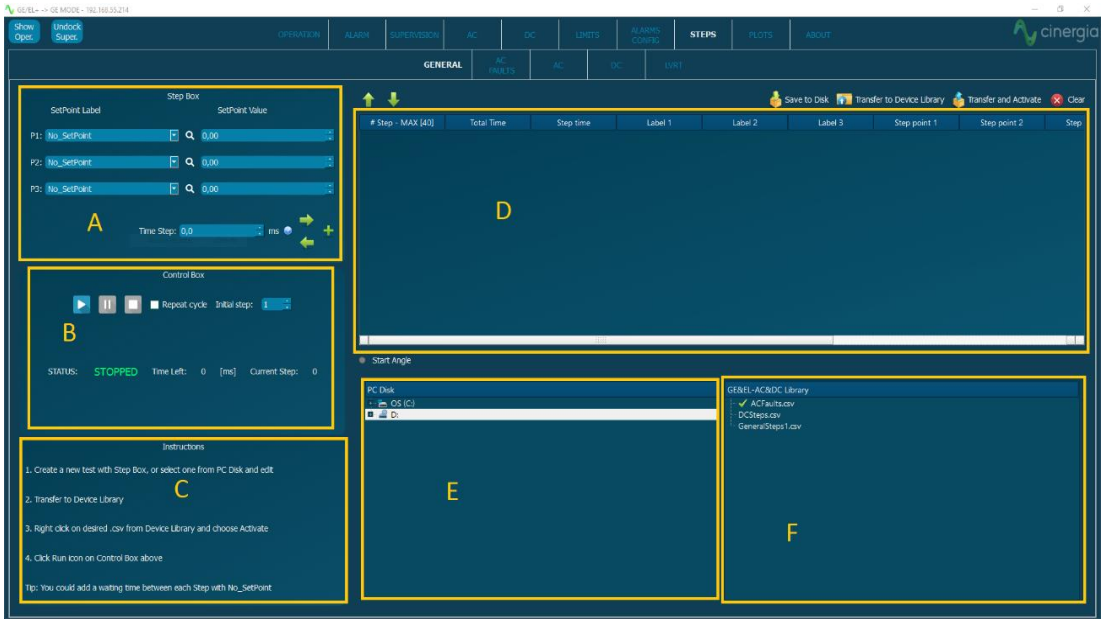


Figure 13: View of General page from Steps tab.

The General view has got six different sections, which are described below:

A - Step Box: it invites the user to select three setpoints and a time in order to create a specific step. Once the values have been chosen, they can be added to the table by clicking + button.

B - Control Box: it controls the execution of the activated steps.

C - Instructions: Reminder of the functionality of the steps.

D - Table: Group of steps that are going to be transferred to the device or saved locally.

E - PC Disk: Browser Window to search for locally saved steps files.

F - Device Library: List of steps files that are saved in the converter. It also indicates which group of Steps is activated.

As it can be seen, the Control Box, the Table and its transferring options are globally the same as the ones in the previously analyzed sub tabs. The only difference is that, in General Tab, for storing purposes, Steps can be transferred without the need to Activate them. This functionality can be executed by pressing "Transfer to Device Library" button once the table is created.

Let's now examine in detail A, E and F sections:

A section: Step Box

In this section the user can choose different setpoints by three ways:

1. – Choosing the desired SetPoint from the list. To access to it, click on the down arrow of the object.

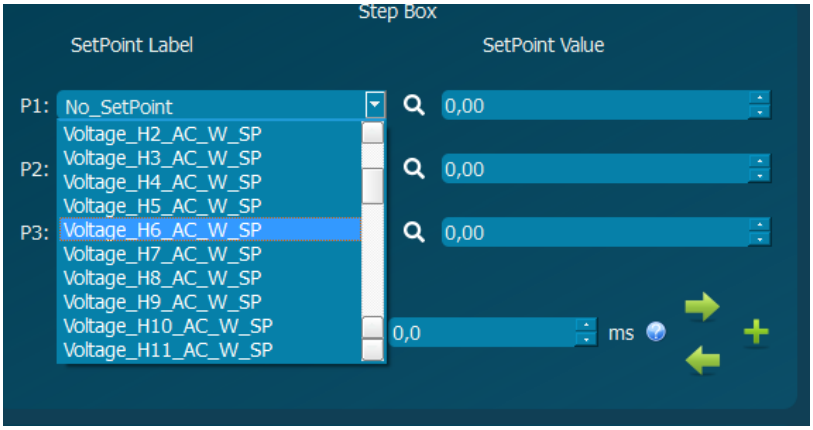


Figure 14: List method to access to the setpoints.

2. – Searching for a specific Setpoint with the Magnifier icon. It will pop-up a Search dialog.

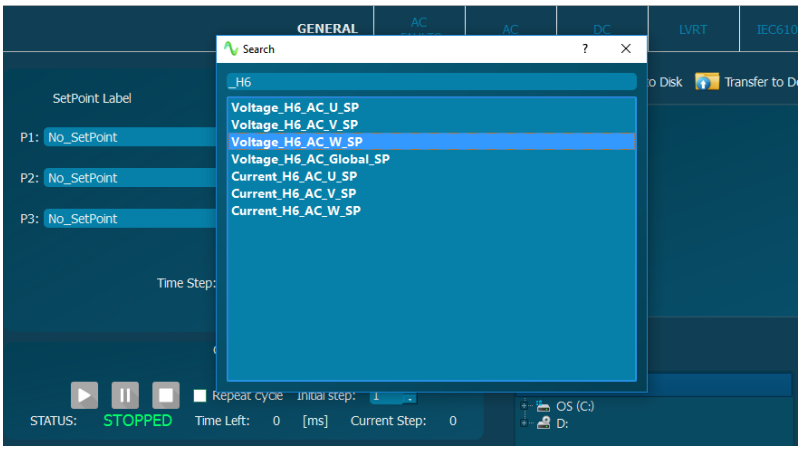


Figure 15: Magnifier method to search specific setpoint.

3. - Searching for a specific Setpoint by its group. To access to it, Right-click on the object. It will pop-up a menu with some clarified classification:

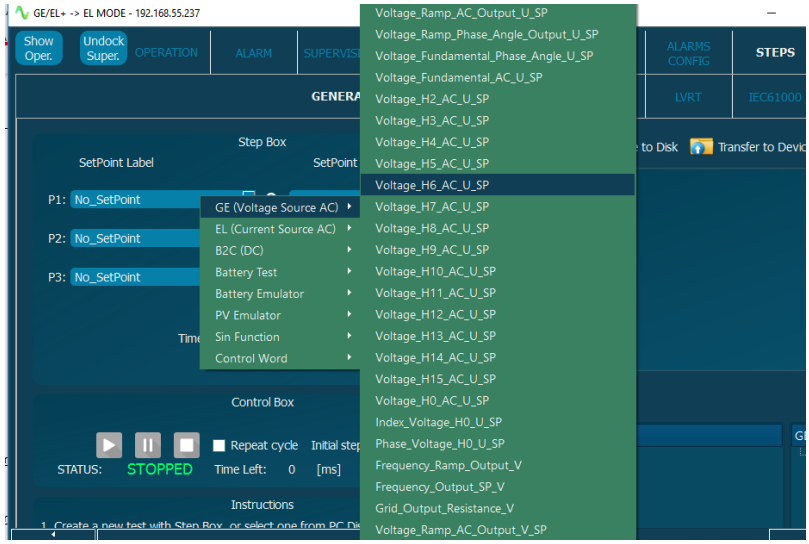


Figure 16: Right-click access to search a specific step by group.

Once the step is configured, the user should add it to the table by pressing the + button, creating the desirable functionality. The table can be saved locally by clicking “Save to Disk” (which will pop-up a File Explorer asking for a path and a name) or saved in the Device by clicking “Transfer to Device Library”. However, in order to execute the step directly, it must be clicked the “Transfer and Activate” button, which transfers the file to the device, and then, activates it in order to control its execution.

In order to modify the table, it is useful to know the functionality of the buttons and the right-click menu, as shown in the image below:

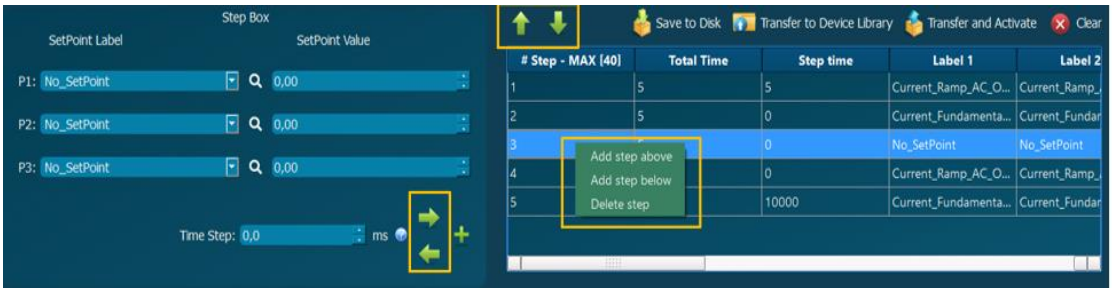


Figure 17: Different operations to a specific selected step from the table.

There are several operations that can be done on a selected step from the table (see yellow squares in the previous image):

-it can be replaced with a new one, with button.

-its values can be cloned into the step box, with button.

-its position in the table can be modified, with and buttons.

It must be noticed that, when a step is selected, the button will insert the new step below the selected one.

For further information about any parameter or a simple reminder please click on button.

E section: PC Disk

In this section, when executing Cineina V2, the user can search for steps files that are saved locally in the PC. The desired file can be searched by either navigating along the proposed tree or Right-Clicking a folder (then a File Explorer will pop-up). Once selected a CSV file, it will be automatically loaded into the table.

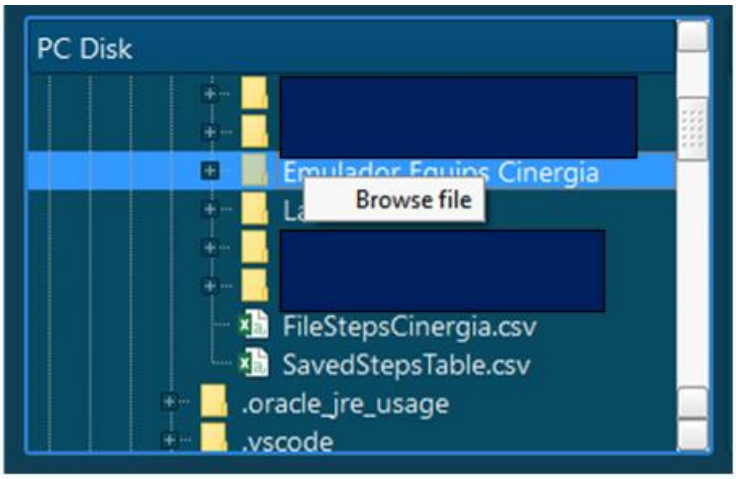


Figure 18: Right click a folder, it invites the user to Browse a file step using a native File Explorer.

In case of finding the desired file in the tree view, it can be directly transferred to the converter,

(with the same name).

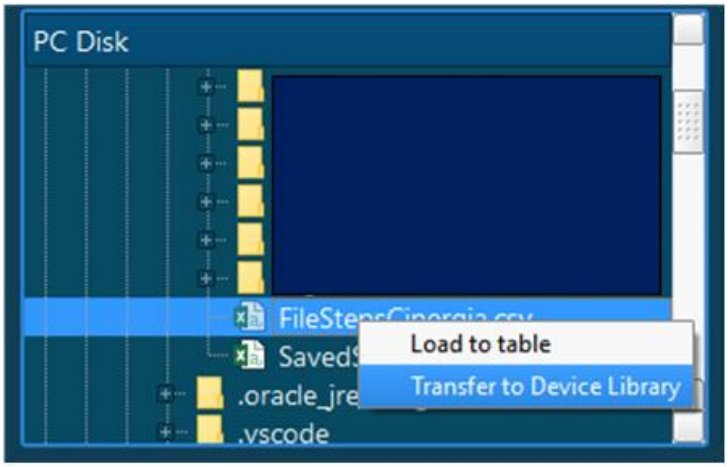


Figure 19: Right click a folder, it invites the user to Browse a file step using a native File Explorer.

F section: Device Library

All step files saved in the converter are listed in this section. When Right-Cliking a file from the list, the user can choose to carry out one of the following actions:

- Active: The selected group of steps will be activated.

- Edit: The information from the CSV file will be loaded into the table.

- Rename: The filename is modified. Please, note that an activated file cannot be renamed.

- Remove: The selected steps file is deleted.

- Refresh: The directory is refreshed.

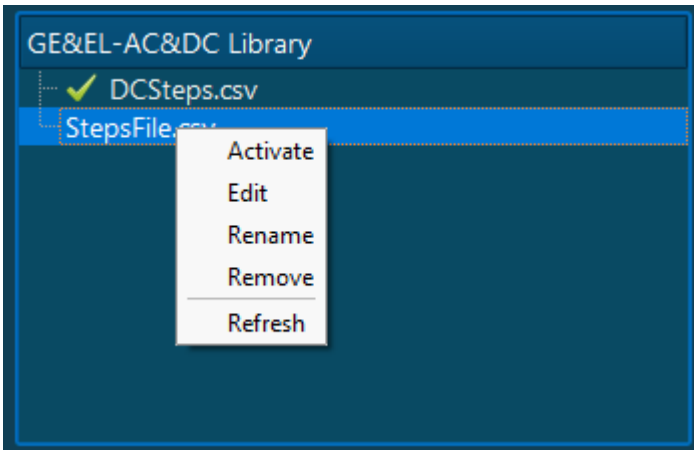


Figure 20: Right click a file from the Library, it will pop-up a group of different operations.