cinergia

ePLUS Family units

DELTA OPERATION MODE in ELECTRONIC LOAD

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Revision number	Document changes	Date
A00	Creation	November 20

CONTENT

1. GENERAL

Standard Cinergia units are based on the neutral point to reference their measurements. Therefore, it can be confusing in systems where there is no neutral point (3 wire systems) or the neutral point is floating. For this reason, in Delta mode configuration, the measurements will be referenced between phases, i.e. U-V, V-W, W-U, solving this issue and expanding the possibilities and applications of the Electronic loads.

This manual is designed to be an extension of the common EL Installation and Operation manual. Please refer to it before using the unit. Connections and security issues are not included in the current document.

This extra mode is free included on ePLUS platform Electronic Load units. So, all the Electronic Load ePLUS units has the capabilities to work on this mode.

As the unit is working in delta mode (this means without neutral), be sure that no wire is connected to this point (X9 neutral terminal) at the output side of the unit. Just to clarify, only three wires (3 phases U, V and W) at the output side must be connected. It is mandatory to connect the three phases at the output side of the Electronic load.

As the unit is working in delta mode (without neutral), be sure that the phase sequence of the EUT connected at the output side of the EL is U, V and W; minus 120 degrees between phases.

The online changing mode is not allowed in DELTA mode. So, the user cannot change current mode to power or impedance mode if the unit is in RUN state.

IT IS MANDATORY to NOT CONNECT THE NEUTRAL WIRE at the output terminal side if the test is working on DELTA mode (only the three phases must be connected). Otherwise, the unit could be damaged.

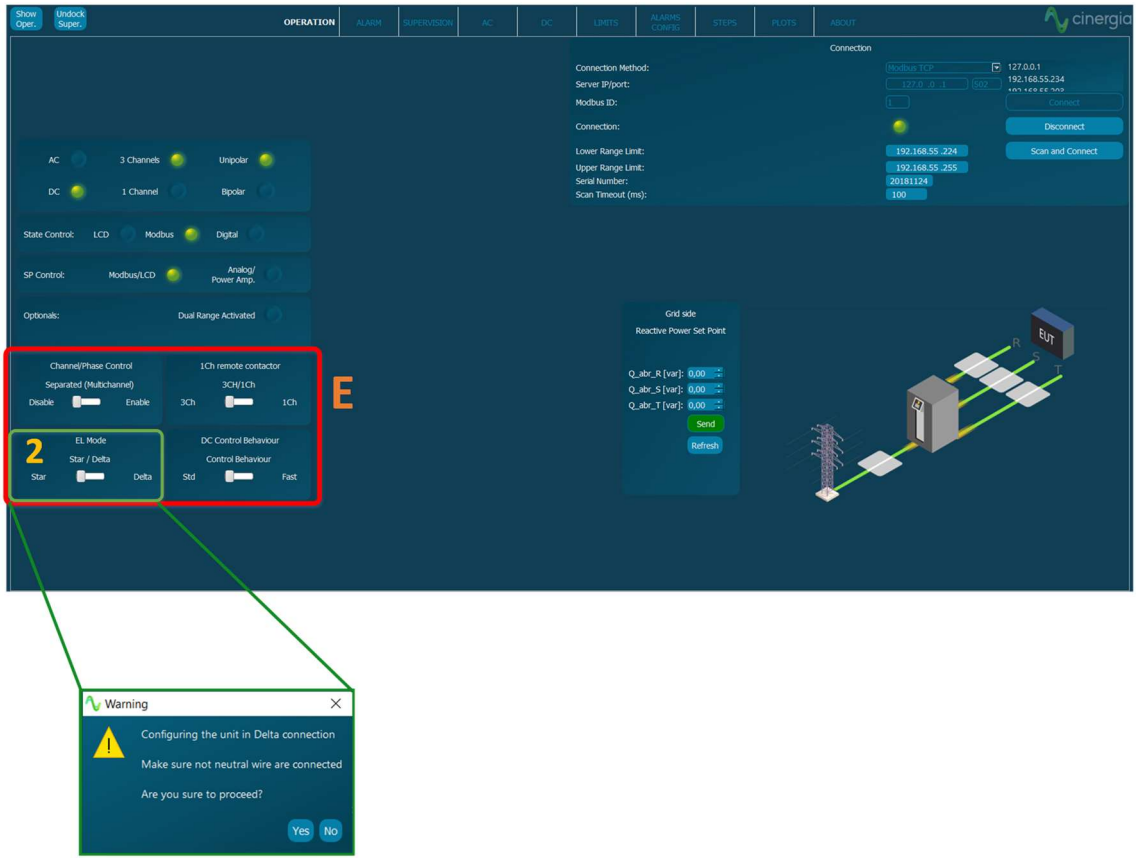
2. DELTA MODE CONFIGURATION

First of all, **any change on wiring must be done** with no power in the system and **following the premises of the EL+ AC Installation and Operation manual**.

Regarding switching between STAR and DELTA mode, it must be done by the Cineina interface. It must be done while the Unit is **STANDBY or in ALARM status**. The configuration must be consistent to the wiring.

The user must configure the Electronic Load in DELTA mode using the switch located on the Operation Tab, marked on picture below with an E.2 – EL mode, choosing DELTA configuration mode. A pop-up will appear, to confirm it.

Once the mode is configured, it is stored on the unit so as to remind the mode each time it is turned on.



The Electronic Load must be in AC BIPOLAR mode configured. In addition, separated operating (multichannel mode) is NOT ALLOWED in DELTA operation mode.

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3. DELTA MODE CONNECTION

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 terminal (**X5**) before connecting the grid to the electronic load input.

On the other hand, connect the protection earth wire to the terminal (X10) before connecting the EUT (Equipment under test) to the Electronic Load output.

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.

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.

Connect the output cables **U**, **V**, **W** to the terminals (**X6**), (**X7**), (**X8**) respectively. Disconnect or not connect any cable on the N terminal (**X9**). This connection must always be done according to the label placed under the output screw terminals.

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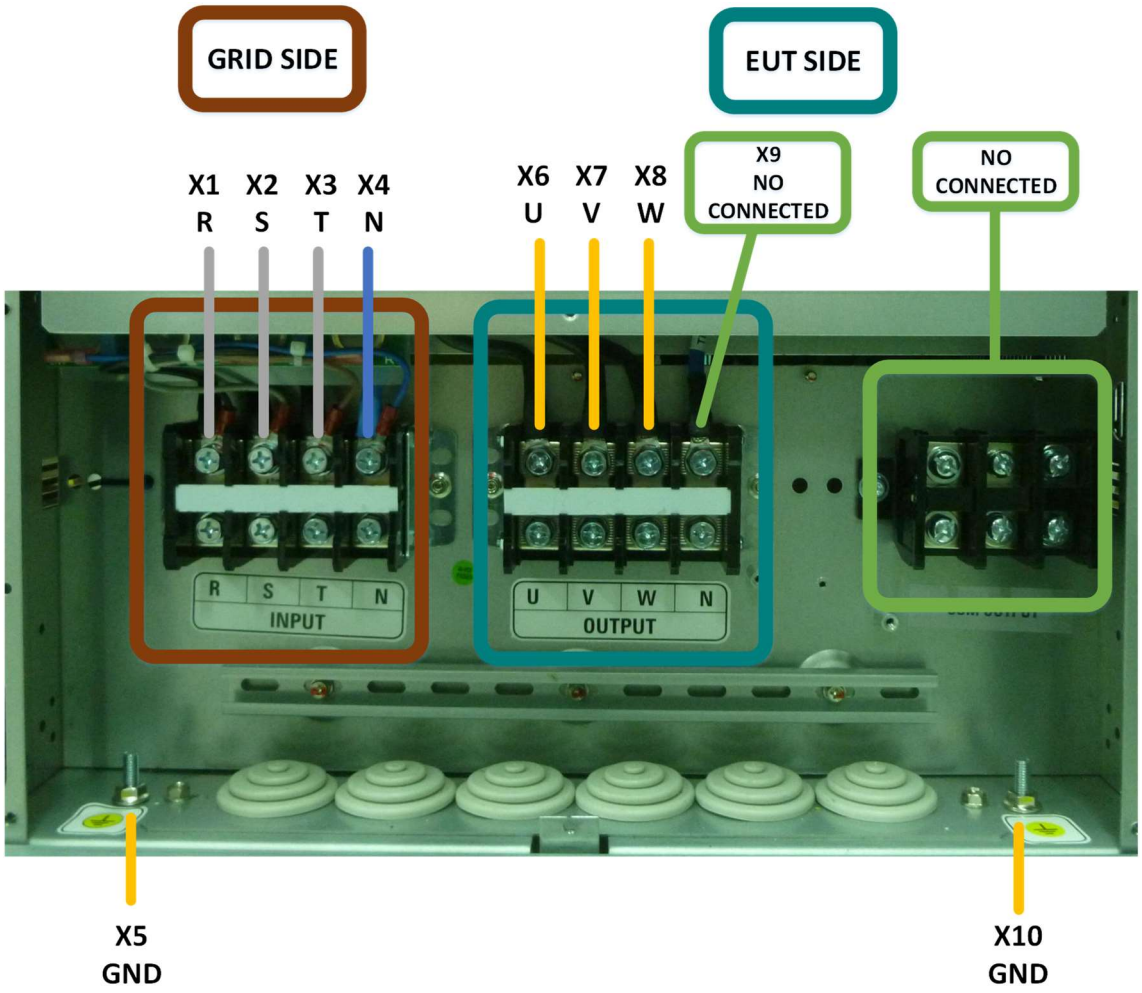


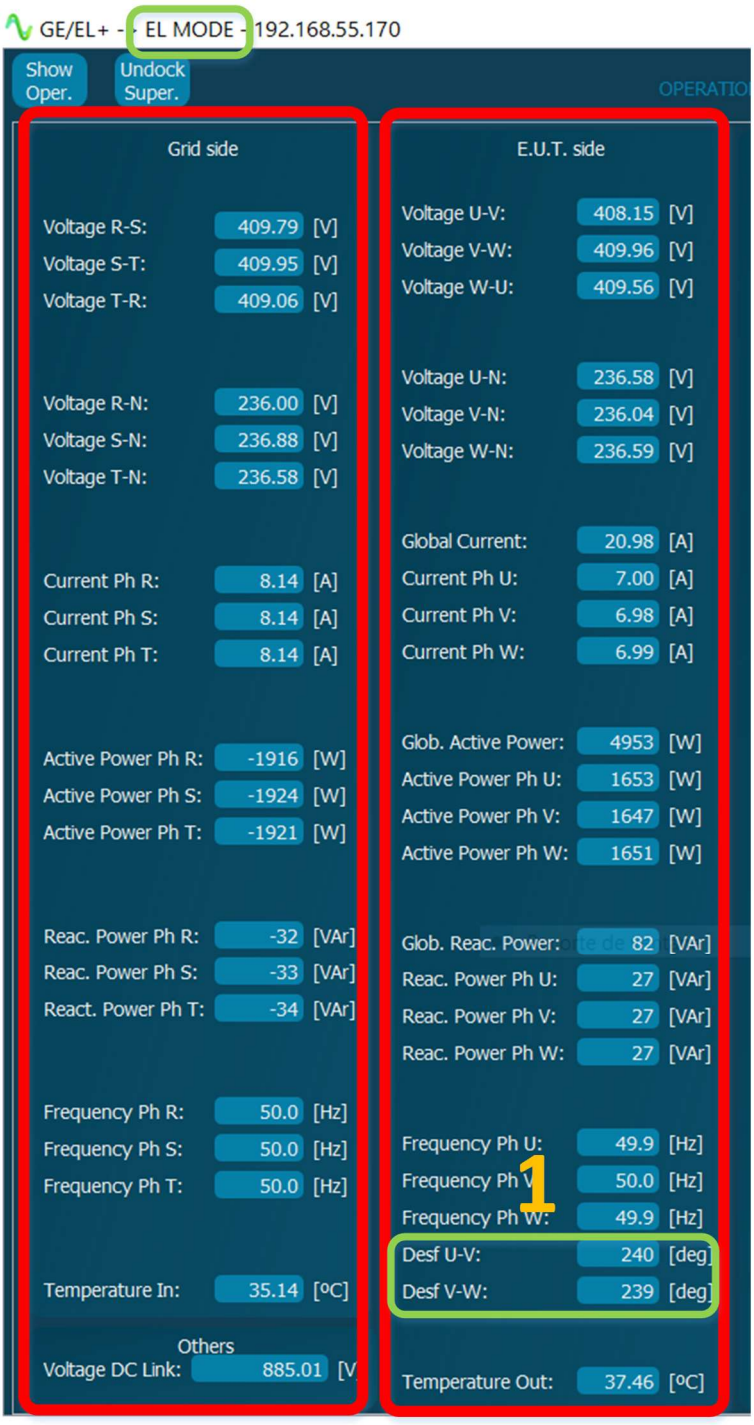
IT IS MANDATORY TO NOT CONNECT THE NEUTRAL WIRE at the output side if the test is working on DELTA mode (only the three phases must be connected). Otherwise, the unit could be damaged.

4. POWER ANALYZER

Two main points need to be considered while using Delta mode.

Line voltages are the displayed on the SUPERVISION TAB and plotted on the Cineina interface graph. Phase voltages can be still checked but they may not be consistent because of the lack of an active neutral point. This means that in some scenario phase voltages can be equal to 0.

The user can confirm that the phase sequence on DELTA setup is correctly using the ***Desf U-V***, and ***Desf V-W*** values displayed on SUPERVISION TAB, EUT side, see green marked on picture below.

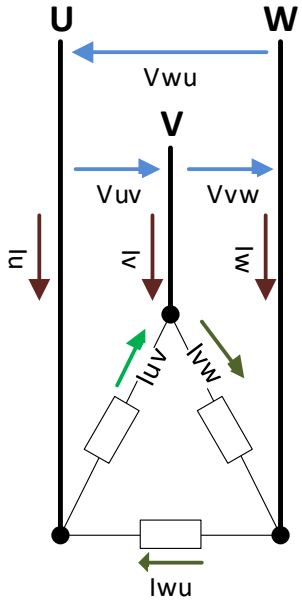


There are several methods to calculate the power of the phases. One method could be to multiply the voltage phase-neutral and the phase current. This would give a proper value for the overall power but will not be useful to prevent phase overload (because of the wide variation of phase-neutral voltage).

Therefore, a usual method to calculate power in a 3-wire system is using the 2-watímeter method. It is based on the Blondel's theorem, that states that you need one less element in your wattmeter than the number of wires in the service to accurate meter the service.

In this case, phase W is used as a reference to calculate power U-W and power V-W. The total power is calculated adding both power measurements providing an accurate value for balanced and unbalanced systems.

Please find below an illustration clarifying the sign conventions of the system.



For more information, please read the following link from YOKOGAWA webpage:

https://www.yokogawa.com/library/resources/media-publications/how-to-measure-electrical-power/

5. OPERATION-USER SETPOINT

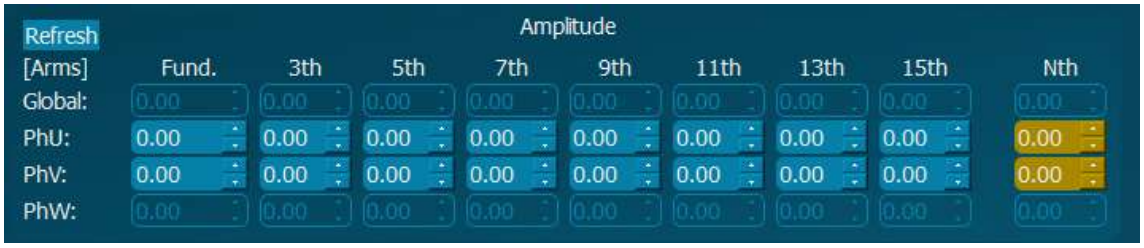
In DELTA mode, the three-phases of the EL shall be understood as a unique system. Therefore, the control algorithm calculated two currents (phase U and V) and the instant current of the phase W is derived from them. This is a hard condition (I_U + I_V + I_W=0) because of the lack of neutral wire. Based on this principle, the user setpoint is modified to always match this constraint.

Each setpoint method (current, power and impedance) uses a different approach willing to fulfill different needs and user requirements. Therefore, changing between modes (current-power, power-impedance,…) cannot be done while the unit is in Run state.

Despite this, the EL in DELTA can be operated likewise other units or STAR mode (common EL).

5.1. CURRENT CONTROL MODE

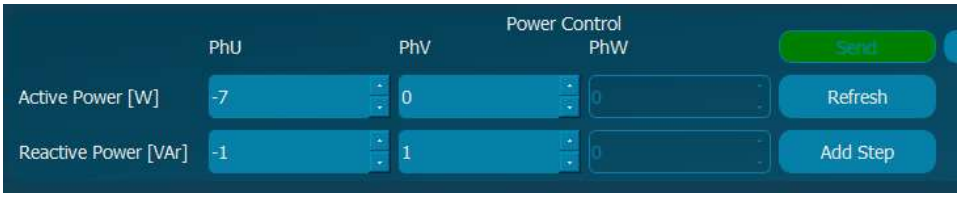
The user can set two currents (I_U and I_V) magnitude and angle, and the third current is calculated by the system. **Only two setpoints are available to set**. Regarding the angle of the current, the reference angle of I_U is the angle of voltage UV minus 30º, and the reference angle of I_V is the angle of voltage VW minus 30º. Hence, in a balanced system where a current of 5A 0º (I_U) and 5A 0º (I_V) is set, the currents (UV, VW and WU) will be in phase with their corresponding voltages (UV, VW and WU) generating power totally active. On the other hand, setting currents of 5A 90º will generate power totally reactive. In cases where balanced current is not desired, the user can calculate the required angle knowing that the reference is the line voltage minus 30º.



5.2. POWER CONTROL MODE

Following the same convention explained on chapter 4, the power of the system can be set by defining two power setpoints Only two setpoints are available to set. Phase W is set as a reference to calculate voltages UW and VW and their corresponding power.

P delta system = P_UW + P_VW
Q delta system = Q_UW + Q_VW



5.3. IMPEDANCE CONTROL MODE

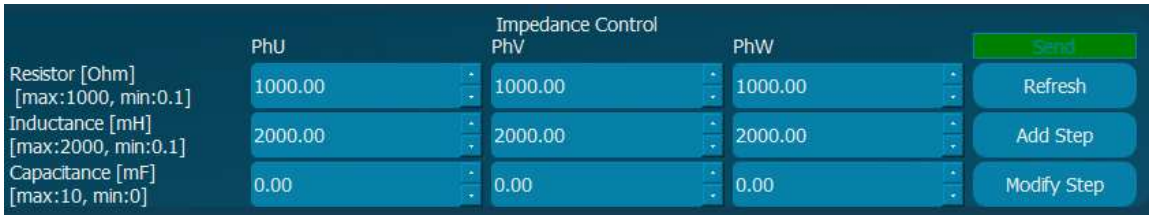
In this case, the principle is slightly different to make it more comprehensible. The user sets impedances Zuv, Zvw and Zwu, then the control algorithm calculated currents I_UV, I_VW and I_WU.

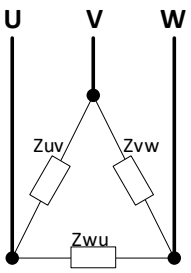
From these values, the system calculated and applies the final current setpoints:

I_U = I_UV – I_WU
I_V = I_VW – I_UV
I_W = I_WU – I_VW

In the same manner than the Star mode, the current applied on the impedance mode is derived from calculating the currents of **R, C and L in parallel**, i.e. each one connected phase to phase.

Ireact_C = voltage*(freq *capacitance);
Ireact_L = voltage /(freq *inductance);
Ireact = Ireact_C - Ireact_L;
Ires = voltage /resistor;





6. LIMITS AND ALARMS

Voltage and power limitations and alarms are internally changed to be consistent to the delta mode configuration. This change is transparent, i.e. no change is seen on the interface and no value is reduced. However, the user must be aware of it in case of willing to modify them. On the other hand, no modification is done regarding the current limits or alarms. The nominal power of the system remains the same.

STAR/INTERFACE		**DELTA**	
VARIABLE	**MAGNITUDE**	**ADAPTED VARIABLE**	**MAGNITUDE**
Alarm_OverVoltage	Voltage ph-N	Alarm_OverVoltage*$\sqrt{3}$	Voltage ph-ph
Limit_Max_Voltage	Voltage ph-N	Alarm_OverVoltage*$\sqrt{3}$	Voltage ph-ph
Alarm_Overload	Power Apparent ph-N	Alarm_Overload*1.5	Power Active UW Power Active VW
Limit_Overload	Power Apparent ph-N	Limit_Overload*1.5	Power Aparent UW Power Aparent VW

Reactive power and apparent power alarms are DISABLED in DELTA mode. Active power and current alarms are still sufficient for protecting unit and EUT.

IT IS MANDATORY TO NOT CONNECT THE NEUTRAL WIRE at the output side if the test is working on DELTA mode (only the three phases must be connected). Otherwise, the unit could be damaged.