NGPS

High-Stability and High-Precision New Generation Power Supply Series

CAENels
Gear For Science

OCEM
POWER ELECTRONICS

User's Manual

MAGNET POWER SUPPLY SYSTEMS

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This product is CE & UKCA compliant.

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User Manual – Models – Options – Custom Models

This manual covers the following standard NGPS Power Supplies models:

• **NGPS 100-100E(H)** • **NGPS 105-100E(H)** • **NGPS 120-50E(H)** • **NGPS 150-70E(H)** • **NGPS 170-60E(H)** • **NGPS 200-50E(H)** • **NGPS 200-60E(H)** • **NGPS 300-30E(H)** • **NGPS 400-25E(H)** • **NGPS-CAX 100-100E(H)** • **NGPS-CAX 150-70E(H)** • **NGPS-CAX 200-50E(H)**	• **NGPS-CAX 300-30E(H)**

And it is also applicable to the basic functions of the following custom NGPS Power Supplies models:

• **NGPS 600-15EH **** • **NGPS 1100-5EH **** • **NGPS 400-30EH **** • **NGPS 160-60EH **** • **NGPS 200-25EH **** • **NGPS 160-30EH **** • **NGPS-CQD 1100-5EH **** • **NGPS-CQD 600-10EH **** • **NGPS-CQD 600-15EH **** • **NGPS-CQD 600-5EH **** • **NGPS-CMD 150-70E **** • **NGPS-CMD 200-50E **** • **NGPS-CMD 300-30E ****	• **NGPS-CAI 300-18EH**** • **NGPS-CAI 400-25EH**** • **NGPS-CAI 300-36EH**** • **NGPS-CVF 30-300E****

****: These models are not fully compatible with "Remote Control Manual" from CAEN ELS S.r.l., are not compatible with other Firmware other than the factory one, and support for these models must be required at: support.pe@ocem.eu**

This manual also covers the basic functions of Custom Models named as following:

NGPS Cxx-xxx-yyyZK

Where:

- CAX has an Auxiliary 230 VAC input
- Cxx is an optional code only present in custom bespoke models
- xxx is a number between 30 and 1100
- yy is a number between 5 e 300
- Z can be "E" or "A" or "U"
- K can be "H" or blank

Table Of Contents

Document Revisions

Document Revision	Date	Comment
0.1	February 7th 2016	Draft Release
0.2	February 22nd 2016	Pre Release Version
0.3	March 15th 2016	Visual PS information added and corrected
0.4	May 27th 2016	Added Safety Information and Installation Chapter 2. Removed parts from Introduction and Chapter 1
1.0	September 1st 2016	Official Release
1.01	February 1st 2017	Layout change
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1.1	November 15th 2017	Added Auto shut down feature on Display
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1.3	February 25th 2019	Added 250-30, 150-60 and 300-30 models. Added parallel operation
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1.5	June 18th 2019	Waveform execution minimum period updated information
1.6	October 23rd 2019	Added new standard and custom models and related information
1.7	March 9th 2022	Removed 140-50 model
1.8	April 2022	Removed Remote Control sections
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1.10	November 22nd 2022	Added CE-UKCA compliance logos
1.20	November 28nd 2023	Added new NGPS-CAX
2	August 8th 2024	Updated address and revision numbering
3	January 15th 2025	Updated Parallel Operation and Local Control sections

Safety information

The following table shows the general environmental requirements for a correct operation of instruments referred in this User's Manual:

Environmental Conditions	Requirements
Environment	Indoor use
Operating Temperature	0°C to 40°C
Operating Humidity	20% to 80% RH (non-condensing)
Altitude	Up to 2000 m
Pollution degree	2
Overvoltage Category	II
Storage Temperature	-10°C to 60°C
Storage Humidity	5% to 90% RH (non-condensing)
Water Cooled Model	
Max Water Input Pressure (continuous)	8 bar
Water Pressure drop	1.5 bar
Water Flow	1.5 l/min

The following symbols are used within this manual or are reported on the NGPS box and along this manual:

CAUTION Risk of Electrical Shock

Caution: Documentation must be consulted in all cases where this symbol is marked

Indicates ground terminal

Protective Ground Conductor Terminal

Off (Power)

On (Power)

WARNING

The WARNING sign denotes a hazard. An attention to a procedure is called. Not following the procedure correctly could result in personal injury. A WARNING sign should not be skipped and all indicated conditions must be fully understood and met

CAUTION

The CAUTION sign denotes a hazard. An attention to a procedure is called. Not following procedure correctly could result in damage to the equipment. Do not proceed beyond a CAUTION sign until all indicated conditions are fully understood and met

CAEN ELS s.r.l. and Energy Technology s.r.l. will either repair or replace any product within the guarantee period if the Guarantor declares that the product is defective due to workmanship or materials and has not been caused by mishandling, negligence on behalf of the User, accident or any abnormal conditions or operations.

Please read carefully the manual before operating any part of the instrument

WARNING

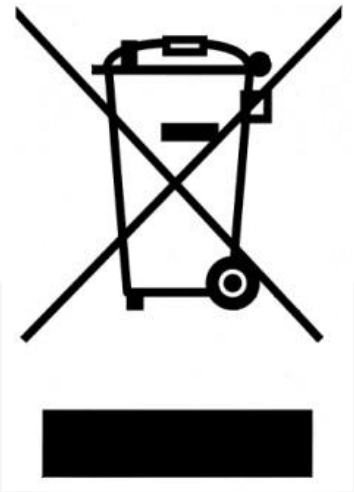
Do NOT open the BOX TOP COVER

CAEN ELS s.r.l. and Energy Technology s.r.l. decline all responsibility for damages or injuries caused by an improper use of the Modules due to negligence on behalf of the User. It is strongly recommended to read thoroughly this User's Manual before any kind of operation.

CAEN ELS s.r.l. and Energy Technology s.r.l. reserve the right to change partially or entirely the contents of this Manual at any time and without giving any notice.

Disposal of the Product

The product must never be dumped in the Municipal Waste. Please check your local regulations for disposal of electronics products.



WARNING

- Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in this manual.
- Do not use the device if it is damaged. Before you use the device, inspect the instrument for possible cracks or breaks before each use.
- Do not operate the device around explosives gas, vapor or dust.
- Always use the device with the provided cables.
- Turn-off the device before establishing any connection.
- Do not operate the device with the cover removed or loosened.
- Do not install substitute parts or perform any unauthorized modification to the product.
- Return the product to the manufacturer for service and repair to ensure that safety features are maintained.
- Installation shall be made by Qualified Personnel according to the Electrical Codes and Standards.
- Operation of the NGPS units shall be carried out by professional skilled personnel.

1. Introduction

This chapter describes the general characteristics and main features of the NGPS – New Generation Power Supply series.

1.1 NGPS Overview

High performances, high efficiency, high stability, easiness of configuration and maintenance are the key features of the NGPS power supply series, generated by the joint effort of CAEN ELS and OCEM – Power Electronics.

The NGPS is an independent current (or voltage) digitally controlled monopolar power supply module. There are available different models with different current and voltage ranges. Standard models are air-cooled units, enclosed in 19-inch 3U crates.

Alternatively, custom models are enclosed in 19-inch crates with different unit height size, depending upon space requirements of internal electronics.
Among custom models, several options are available such as:

- Auxiliary 230 Vac power supply separated from the main power supply: **NGPS-CAX** models;
- Coordination with Quench Detector and Heater optional crates for superconductive magnet applications: **NGPS-CQD** models;
- Voltage generator: **NGPS-CVF** models;
- Custom data communication protocol: **NGPS-CMD** models.

Moreover, water cooled model are available, whose names ends with "**H**" letter.

Table 1a: Standard NGPS models reports standard air-cooled units in 3U size, while **Table 1b** reports the list of available custom models.

Although this manual refers to standard models, it can also be applied to custom models for what regards the basic functionalities.
Anyway, dedicated manual addendum for custom models are available.

Model Name	Current (A)	Voltage (V)	Max. Power (kW)
NGPS 100-100E(H)	100	100	10
NGPS 105-100E(H)	105	100	10,5
NGPS 120-50E(H)	120	50	6
NGPS 150-70E(H)	150	70	10,5
NGPS 170-60E(H)	170	60	10,2
NGPS 200-50E(H)	200	50	10
NGPS 200-60E(H)	200	60	12
NGPS 300-30E(H)	300	30	9
NGPS 400-25E(H)	400	25	12
NGPS-CAX 100-100E(H)	100	100	10
NGPS-CAX 150-70E(H)	100	100	10,5
NGPS-CAX 200-50E(H)	200	50	10
NGPS-CAX 300-30E(H)	300	30	9

Table 1a: Standard NGPS models

Model Name	Current (A)	Voltage (V)	Max. Power (kW)
NGPS 160-30EH	160	30	4,8
NGPS 160-60EH	160	60	9,6
NGPS 200-25EH	200	25	5
NGPS 400-30EH	400	30	12
NGPS 600-15EH	600	15	9
NGPS-CQD 600-5EH	600	5	3
NGPS-CQD 600-10EH	600	10	6
NGPS-CQD 600-15EH	600	15	9
NGPS-CQD 1100-5EH	1100	5	5,5
NGPS-CMD 150-70E	150	70	10,5
NGPS-CMD 200-50E	200	50	10
NGPS-CMD 300-30E	300	30	9
NGPS-CMD 300-18EH	300	18	5.4

NGPS-CMD 400-25E	400	25	10
NGPS-CMD 300-36E	300	36	10.8
NGPS-CVF 30-300E	30	300	9

Table 1b: Customized NGPS models

The NGPS units are available in three different values of nominal three-phase input voltage:

Version	Three-Phase Input
"A"	208 V (AC)
"E"	400 V (AC)
"U"	480 V (AC)

Table 2: NGPS versions

The NGPS module is composed of a single 19-inch standard crate. The power unit implements a completely digital control loop, with a Pulse Width Modulation (PWM) generation technique that allows adapting the system to any load condition.

The control board houses a dedicated FPGA with an integrated dual-core ARM CPU. The loop regulation task is performed directly by the FPGA logic, in order to have high performance and deterministic loop control. On the ARM CPU it is installed an embedded Linux OS, that supervises all processes as communication, diagnostics and local interface handling.

Remote communication is guaranteed by means of an Ethernet 10/100/1000 autosensing socket, mounted on the front panel of the power unit. The power supply can be also monitored and controlled via a graphic high-resolution color display featuring user-friendly menus and a navigation switch for moving within them.

In addition to the standard Ethernet interface, it is possible to communicate with the unit using the SFP-ports on the front panel. This interface allows to communicate with the unit using a proprietary packet structure with a very high updating rate (more than 10 kHz). These ports are connected directly to the FPGA logic, allowing the given packet to be elaborated directly by the hardware logic.

This approach eliminates the software stratification that manages the packet and the computational time is smaller and deterministic, allowing a very high updating rate of the setpoint, giving the user more flexibility and excellent rates for the digital control of the power supply.

1.2 NGPS at a Glance

The standard NGPS system is composed by a single 19-inch 3U crate. The NGPS unit and its I/O connections can be easily seen in **Figure 1** (front view), **Figure 2** (rear view for air cooled models) and .

Figure 1: NGPS front view

On the front side (**Figure 1**, no differences between air- and water-cooled units) of the NGPS power supply are placed: a circuit breaker, a colour graphic display with navigation switch for the local control and monitor of the module, three communication sockets (2 SFPs and one Ethernet ports), four status LEDs and one USB device connector.

Figure 2: Air-cooled NGPS rear view

On the rear side of the unit (**Figure 2**) are placed: three-phase input connector, earth connection terminal, output terminals, the D-Sub 15 Female Pin I/O connector

and a connector for the voltage remote sensing. Exclusively for water cooled models, on the rear panel are present two plugs to the hydraulic system also (input plug the left one – output plug the right one), highlighted in **Figure 3**: **Water cooled NGPS rear view**.

Figure 3: Water cooled NGPS rear view. Plugs for the connection to the hydraulic system are highlighted

The connectors used for water cooling are quick connecting types as follows:

The connectors are of model **PLC42006** and have the following main specifications (**PLC42006** - 3/8 Hose Barb Non-Valved Panel Mount CPC Coupling Insert):

- Material: Acetal;
- Pressure Range: Vacuum to 120 psi, 8.3 bar;
- Color: White;
- Temp. Range: -40°F to 180°F (-40°C to 82°C);
- Mounting Option: Panel Mount;
- Seal Options: BUNA-N;
- Valve Spring: 316 Stainless Steel.

The corresponding mating hydraulic plug (to be plugged into the power units) is the **PLCD17006**, which is as follows:

- Material: Acetal;
- Pressure Range: Vacuum to 120 psi, 8.3 bar;
- Color: White;
- Temp. Range: -40°F to 180°F (-40°C to 82°C);
- Mounting Option: Free Floating;
- Seal Options: BUNA-N;
- Valve Spring: 316 Stainless Steel.

Custom models may mount additional I/O connectors; these cases are covered in **Section 1.9**.

1.3 Modes of Operation

The NGPS system has multiple features and multiple configurations that allow using the unit for a very widespread topology of applications.

A brief summary of the basic configurations that the unit is able to handle are hereafter presented.

1.3.1 Regulation Mode

The NGPS can be used as either current-controlled or voltage-controlled bipolar unit, namely:

- **C.C.** mode: it is the Constant Current regulation mode. The power supply regulates the output current set by the user;

- **C.V.** mode: it is the Constant Voltage regulation mode. The power supply regulates the output voltage set by the user.

In C.V. mode it is possible to use the *remote sensing* terminals (on the rear side) that allow regulating the output voltage directly on the load, thus compensating the voltage drops due to the output cables. The maximum voltage drop that the power supply is able to compensate is of 1V.

1.3.2 Control Mode

The NGPS unit can be controlled in three main different ways, hereafter listed:

- **LOCAL** control: the unit can be controlled directly via the front panel color display and the navigation switch. When the unit is set in LOCAL mode, it is possible to perform readings and monitor the unit from the remote interface also but any setting command is denied;

- **REMOTE** control: the unit is controlled via the TCP-IP Ethernet interface. The setting and control of the unit can be performed exclusively via this interface, while monitoring is still possible from the local display;

1.3.3 Update Mode

The current or voltage setting of the unit can be performed in four different modes:

- **NORMAL**: the update of the set-point (current or voltage, depending on the regulation mode, see **Section 1.3.1**) is performed as soon as a new set-point is received via the remote, local or fast interfaces;

- **WAVEFORM**: the update of the set-point is performed on a specific timing (defined as a "waveform" attribute, more information in the *Remote Control Manual*) and it is done internally;

- **TRIGGER**: the set-point is updated by an external event – i.e. a hardware trigger coming from the rear BNC connector. Please note that this mode of operation is obtainable only on the units that have the external trigger input connector installed (ordering option – factory configurable);

- **ANALOG INPUT**: the unit is controlled by an external signal that is fed to the rear BNC connector. The unit acts as a C.C. or C.V. generator depending on the pre-set regulation mode (see **Section 1.3.1**). This option is available in units that have been factory configured only (ordering option).

Please note that the last two Update Modes (Trigger Input and/or the Analog Control Input) are available only in models that have been factory configured at the time of purchase.

1.4 Interlock and Status Signals

The NGPS module has four configurable dry-contact input interlocks and two output status signals that are directly available on the D-Sub 15 Pin Female connector on the rear panel (**Figure 4**).

A mating connector, a standard D-Sub 15 Pin Male type, can be installed in order to use/access these available signals.

Figure 4: I/O Connector

The pin index of the D-Sub 15 rear connector is summarized in the following table:

Pin Number	Signal name
#1	Interlock #1 return
#2	Interlock #2 return
#3	Interlock #3 return
#4	Interlock #4 return
#5	**DO NOT CONNECT**
#6	**DO NOT CONNECT**
#7	Solid State Relay- Terminal #2
#8	Solid State Relay- Terminal #1
#9	Interlock #1 input
#10	Interlock #2 input
#11	Interlock #3 input
#12	Interlock #4 input
#13	Magnetic Relay Common Contact (C-TAP)
#14	Magnetic Relay Normally Closed Contact (NC-TAP)
#15	Magnetic Relay Normally Open Contact (NO-TAP)

Table 3: D-sub 15 Pin pin-out

WARNING

Magnetic Relay Contact (C-TAP, NO-TAP & NC-TAP) and Solid State Relay Terminals (Terminal #1 & #2) shall not float more than ±60 VDC above/below chassis ground.
Interlocks input and return pins shall not float more than ±60 VDC above/below chassis ground.

CAUTION

Voltage between relay C-TAP and NC-TAP or NO-TAP pins shall never exceed ± 48 V.
Maximum current rating for the Magnetic Relay is 1 A; current trough pins #13 and #14 or pins #13 and #15 shall never exceed 1 A.
Maximum current rating for the Solid State Relay is 400 mA; current trough pins #7 and #8 shall never exceed 0.4 A.
Do not apply voltage between any input interlock and its corresponding return.

The interlock pins are galvanically isolated from ground and outputs terminal; nevertheless, the absolute maximum voltage (w.r.t. to ground) that pins can sustain is 48 V. The two interlocks inputs have their own return connection. The interlock is hardware-activated when the input pin and its corresponding return pin are shorted.

The system is provided with four external interlock inputs that can be easily configured using the VISUAL PS graphic software (provided with the power unit, see the *Remote Control Manual*) or directly using the standard power supply commands. A detailed description of the configuration of the external interlock using the power supply commands is hereafter given.

Two output status signals provide the output status of the power module: when the module is ON, the Normally Closed contact (NC-TAP) switch opens and vice-versa. The Solid-state relay close the terminals when the module is ON. The behaviour of the solid state relays (i.e. the status of #7 and #8 in **Table 3)** can be modified changing the value of an internal cell memory (cell #74). Please refer to the *Remote Control Manual* for more information.

1.4.1 Interlock Enable/Disable Mask

The NGPS series external interlock can be enabled or disabled by writing to the corresponding Interlock Enable/Disable Mask field of the advanced configuration parameters (field #90), using the MWG command. Please refer to the *Remote Control Manual* for more information.

1.4.2 Interlock Activation Level Mask

Each external interlock can be chosen to trip at high or low logic level. The high-level means that the interlock trips when the interlock input signal is shorted, otherwise with low-level the interlock trips when the input is open. To configure the interlock state mask, it is necessary to write on the advanced configuration parameters (field #91), please refer to the *Remote Control Manual* for more information.

1.4.3 Interlock Intervention Time

The module allows to set also the interlock intervention time (how long an interlock signal needs to be at its activation level before tripping and thus generating a fault condition). The intervention time parameters are stored from field #92 to #96 for Interlock #1 to #4, respectively. Please refer to the *Remote Control Manual* for more information.

1.4.4 Interlock Identification Name

The NGPS also allows associating a name to the interlocks in order to read form the remote interface or to display on the local display the interlock condition name. The intervention names are stored in the field #93 for Interlock #1, in field #95 for Interlock #2, in field #97 for Interlock #3 and in field #99 for Interlock #4. Please refer to the *Remote Control Manual* for more information.

1.4.5 Output Status

The magnetic relay provides the output status of the power module: when the module is ON, the Normally Closed contact (NC-TAP) switch opens and vice-versa. Instead, the solid state relay is closed when the module is ON. The absolute maximum current that can be sunk by the relays are shown in the following table:

Relay	Pins	Max Current	Max Voltage
Magnetic	# 13-14-15	1 A	48 V
Solid state	# 7-8	400 mA	48 V

Table 4: Ratings of relays

1.5 Remote Sensing

WARNING

There is a potential shock hazard at the sense point when using power supply with rated output voltage greater than 60 V. Anyway, even at lower output voltages, the energy hazard is still present due to the high current capability of the unit. Ensure that the connections at the load ends are protected to prevent accidental contact with hazardous voltages or accidental short circuit (e.g. with tools, screwdriver, etc.) of the output lines.

CAUTION

A short from **V**SENS**+** or **V**OUT**+** to **V**SENS**–** or **V**OUT**–** pins will cause damage to the power supply. Reverse the sense wire might cause damage to the power supply in local and remote sensing. Do not connect **+S** to **–** or **–S** to **+.**

The NGPS mounts a voltage-sensing connector on the rear panel that allows using the voltage sensing feature, especially when using the power supply in C.V. mode. Anyway, even in C.I. mode it is possible to use this feature, with the advantage of having a more accurate output voltage read. The voltage-sensing connector is shown in **Figure 5**.

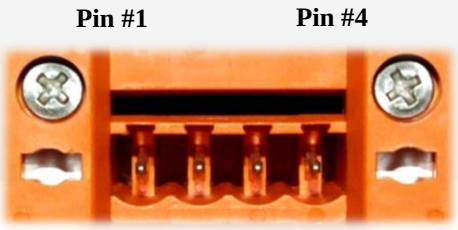


Figure 5: Remote sensing connector

The NGPS is provided with a **factory-default** configuration, with a mating connector (on the rear panel) already shorting the pins 1-2 and 3-4 in order to have direct sensing at the output terminals (see **Figure 6**: Factory mating connector and **Table 5**: Remote sensing pinout for the pinout connector).

Figure 6: Factory mating connector

Description	Pin	Name
V_{SENSE} +	#1	+S
V_{OUT} +	#2	+
V_{OUT} –	#3	–
V_{SENSE} –	#4	–S

Table 5: Remote sensing pinout

By using the two "sensing" pins, it is possible to sense the output voltage directly on the load, thus recovering possible voltage drops on the output cables up to 1V.

It is strongly suggested to use twisted cables when using the remote sensing feature in order to minimize possible noise pick-up.

The NGPS is shipped with the mating connector for the remote sensing in the factory-default configuration: +S and + pins are shorted as well as –S with –. This configuration performs the remote sensing directly at the output connector of the power unit. Leaving +S and –S pins disconnected, the remote sensing is still made but in a less accurate way. When using the remote sensing feature, leave pins #2 (+) and #3 (–) disconnected.

Follow the instructions below to configure the power supply for remote sensing:

1. ensure that Mains switch is on Off position "O";
2. remove factory jumpers between **+S** to **+** and **–S** to **–**;
3. by using a twisted pair or shielded cable (suggested wire size is 0.3 or 0.5 mm^2), connect the **+S** terminal to the positive output terminal and the **–S** to the negative output terminal, as illustrated in **Figure 7**;
4. **For NGPS with output voltage rating > 60 V**, fix the safety cover to the rear panel using the four M3x8 mm screw.

In order to perform remote sensing at different points – e.g. the load terminals – it would be necessary to connect Pin #1 and Pin #4 as in **Figure 7**:

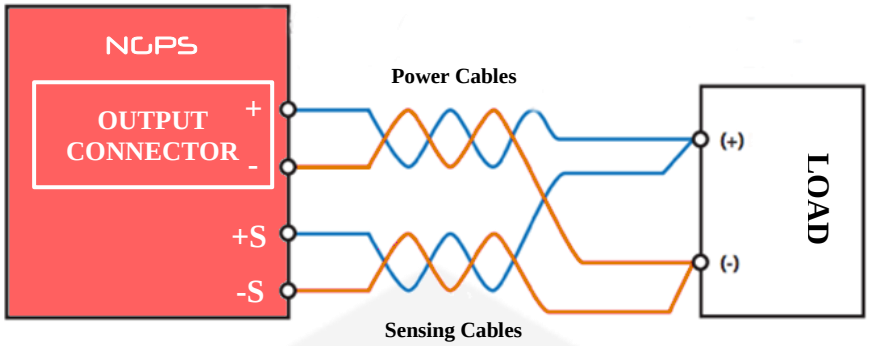


Figure 7: Example of remote sensing

1.6 Trigger and Analog Control inputs

On the rear side of the NGPS there are two BNC input connectors, as shown in **Figure 8**, which can be used as trigger and analog control inputs.

Figure 8: Trigger and analog input connectors

1.6.1 Trigger Input

The trigger input accepts TTL (5V) and LVTTL (3.3V) compatible signals and should be driven by a low-impedance source or generator.

The logic levels are subject to a hysteresis to guarantee the correct trigger operation, as listed in **Table 6**.

Logic Level	Value
Low-to-HIGH	> 2.2 V
High-to-LOW	< 0.7 V

Table 6: Trigger logic levels

CAUTION

The absolute maximum rating for the trigger input signal is of **5.5 V** (a higher voltage level applied to this input can seriously damage the device).

A visual representation of the voltage levels for the trigger operation is presented in **Figure 9**.

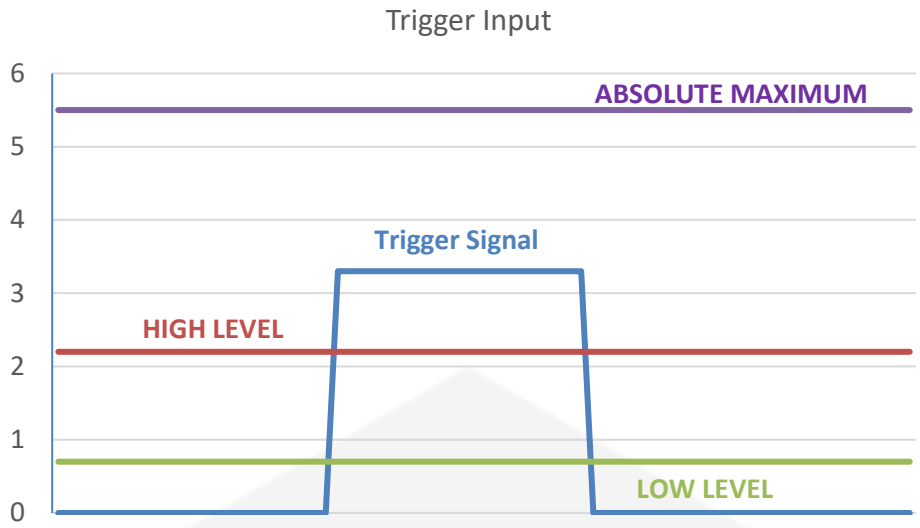


Figure 9: Trigger thresholds

1.6.2 Analog Control Input

The analog control input allows controlling the NGPS unit almost as an "amplifier". This input is labelled as "AN CTRL".

This input accepts signals ranging from 0V to +10V and generates an output which is proportional to the input signal: zero output for a 0V input and Full-Scale output for a +10V input. An example of the relation between the analog input signal and the output (can be either current or voltage, depending on the Regulation mode, see **Section 1.3.1**) is shown in **Figure 10**.

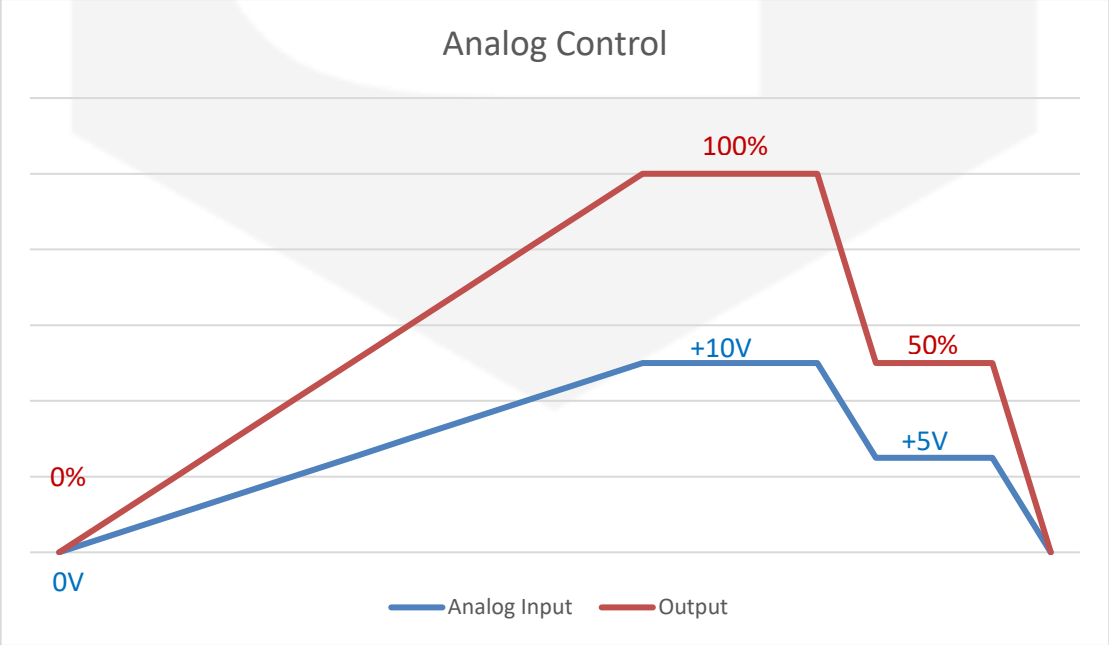


Figure 10: AN CTRL vs OUTPUT dependence

1.7 Front Panel Indicators

The NGPS has four (4) front panel LED indicators as shown in **Figure 11**.

Figure 11: Front panel LED indicators

The front panel indicators and their behaviour are hereafter listed (clockwise starting from top-left, see **Figure 11**):

- **STAT** (**green**): it signals the correct operation of the module diagnostics. The blinking signaling the correct operation has a 1-second period;
- **OUT ON** (**blue**): it signals if the output is enabled or not. The blue LED is on when the output is enabled and it is regulating either the output current or the output voltage;
- **ALARM** (**red**): if turned on, it signals a fault condition experienced by the power unit. It is necessary to perform a "reset fault" command in order to turn-off this LED and to turn-on the module output again (only if the fault condition/cause has been removed);
- **C.C.** (**blue**): if turned on, the NGPS is working in constant-current mode. When off, it is regulating the output voltage (see **Section1.3.1**).
-

1.8 Internal Protections

The NGPS is equipped with several internal protections that allow configuring the unit for optimal operation. These protections have the dual role of protecting the unit and the connected load/device from undesired operation conditions.

A brief description of the NGPS internal protections is hereafter presented with some more basic considerations on their operation and use.

1.8.1 Earth Leakage Current

This protection continuously monitors the current flowing to earth and it has a settable threshold [A] that can be modified by experienced users. The tripping of this protection generates a fault condition that shuts off the power supply output.

1.8.2 Earth Fuse

An earth fuse is present on the rear side of each NGPS and it is rated at 5 A, 500 V (F5AH500VAC). The blowing of this fuse generates a fault condition of the power unit and the fuse needs to be replaced in order to get rid of the fault condition before resetting the NGPS internal status register. The fuse holder is shown in **Figure 12**.

Figure 12: Earth fuse holder

CAUTION

In case of replacement, always use a fuse with the same characteristics:
Fast Acting Fuse (33.2 A^2s)
Size 6.3 x 32 mm 5 A, 500 V
Breaking capacity 1500 A @ 400 VDC
(Example Schurter F5AH500VAC, code 8020.5075.G or equivalent)

1.8.3 Regulation Fault

This fault is generated when the power supply is not able to correctly regulate the output current or output voltage (in C.C. or C.V. mode, respectively).

A threshold for the differential current, differential voltage and the intervention time can be set by experienced users.

A typical example of a regulation fault is represented by a 1Ω load connected to a NGPS 200-50 (i.e. the maximum power supply output voltage is 50V, see **Table 1a**: Standard NGPS models). By setting a current of 100A to the load, the output voltage would reach a value of 100V, which obviously is not feasible with this model. Indeed, once the power unit supplies 50A to the load, it has already reached the maximum output voltage condition. The power unit recognizes the difference between the set-point (100A) and the actual output current (50 A), thus generating a "regulation fault" condition.

The tripping of this fault implies an automatic turning off of the NGPS unit. A status reset – i.e. reset faults – needs to be performed in order to turn the unit back on.

1.8.4 OVerPower - OVP

The NGPS can work continuously at 1% over its power rating (see **Table 1a**: Standard NGPS models).

The module is able to work at a power comprised between 1% and 5% over its rating – i.e. between 101% and 105% – for a 20-seconds interval before turning off and tripping an over-power fault.

If the requested output power is more than 5% above the nominal ratings, the power unit will suddenly shut down after 1 second.

This behaviour is summarized in **Table 7** (a realistic example of a NGPS 200-50 unit is also listed), where P_N is the rated nominal output power of the power supply unit, as indicated in **Table 1a**: Standard NGPS models.

Output Power	Time of Operation
< 101% of P_N *e.g. NGPS 200-50: < 10.1 kW*	**Continuous**
> 101% and < 105% of P_N *e.g. NGPS 200-50: > 10.1 kW and < 10.5 kW*	**20 s**
≥ 105% of P_N *e.g. NGPS 200-50: ≥ 10.5 kW*	**1 s**

Table 7: Time of operation of an NGPS under over power condition

1.8.5 OVerTemperature - OVT

Internal monitoring of temperature is performed in different places inside the NGPS power supply. If a pre-defined threshold is exceeded by any of these internal sensors, an OVT condition is generated, thus shutting off the power unit.

The threshold value [°C] can be modified by experienced users. A reset fault operation needs to be executed on the status register of the NGPS before turning the output on again.

1.8.6 DC-Link Undervoltage

The NGPS is internally composed by a power AC-DC section cascaded with a DC-DC stage. The DC voltage generated by the AC-DC section is also called DC-Link and it is proportional to the maximum rated voltage of the specific model.

A continuous monitoring of the DC-Link voltage is performed in order to always guarantee the capability of obtaining the maximum voltage from the power supply. If the DC-Link drops below a certain threshold, the power supply unit could not be able to correctly regulate its output anymore, so that a fault condition is generated.

It is necessary both to reset the status register and to get rid of the fault cause before turning on the power supply again.

1.9 Custom Models

This section covers peculiar features provided in specific models only.

1.9.1 NGPS-AUX yyy-zzzK

NGPS-AUX models are common custom models provided with an additional single-phase input connector on the rear side (see **Figure 13**: NGPS-AUX additional single-phase input)

Figure 13: NGPS-AUX additional single-phase input

The auxiliary 230 VAC, 1-phase input connector is a plug filter which includes both a switch and fuse-box and it is provided with two interchangeable fuses 5x20 [mm] rated at 2 A.

For the NGPS-AUX models, the single-phase input feeds the circuitry of the power supply dedicated to the control, while the power part is fed via the 3-phase input.

1.9.2 NGPS-CAI yyy-zzzEH

NGPS-CAI models use Push-In water connectors. The ones placed on the rear panel of power converters, that allows the water pipes to cross the panel, are the 3816 (EQUAL BULKHEAD CONNECTOR) from Legris, which is reported in Figure 14.

Figure 14: NGPS-AUX additional single-phase input

This connector presents the specifications as hereafter presented.

TECHNICAL SPECIFICATIONS

maximum working pressure	30 bar 3 MPa 435 psi
working temperature	-25 to 150 °C -13 to 302 °F 248 to 423 °K
vacuum capability	755 mm Hg
body	STAINLESS STEEL 316L
retaining nut	STAINLESS STEEL 316L
'O'-rings	FKM
collar	STAINLESS STEEL 316L
sealing washer	STAINLESS STEEL 316L

The PUSH-IN connectors mates with standard Semi-Rigid Polyamide (PA) tubing.

2. Installation

This chapter contains the detailed instructions for the module installation, from the initial inspection phase to the first switch-on of the power unit.

2.1 Preparation for Use

Do not apply power before reading this chapter. **Table 8** summarizes the basic sequence of instructions to prepare the power supply for its use.

Step	Checklist	Description
1	**Initial inspection**	Physical inspection of the power supply
2	**Mounting**	Install the power supply, ensure proper ventilation
3	**AC Input Power Connection**	Connect the power supply to the AC source
4	**Load connection**	Wire size selection, remote sensing
[5]	**Hydraulic Plugs Connection**	Exclusively for water cooled models
6	**Output Grounding**	Grounding or floating output
7	**First switch-on**	Switch-on checkout procedure

Table 8: Installation checklist

2.2 Initial Inspection

Prior to shipment, the power supply has been inspected and found free of mechanical or electrical defects. Upon unpacking of the power supply, inspect for any damage which may have occurred in transit.

The inspection should confirm that there is no exterior damage to the power supply (e.g. broken switch or connectors) and that all the panels and the display are not scratched or cracked. Keep all packing material until the inspection has been completed. If a damage is detected, compile the RMA form (available to the CAEN ELS web site).

2.3 Mounting

The NGPS is a rack-mount device since the unit form factor is designed to be installed in a standard 19-inch cabinet.

CAUTION

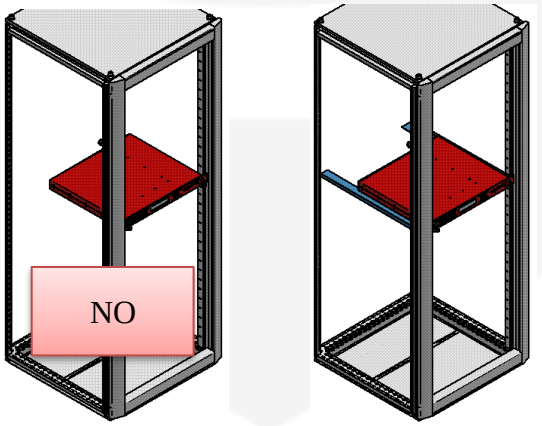
The unit(s) shall be installed assuring that the main circuit breaker on the front panel can be always easily operated by user personnel.

CAUTION

This power supply is fan cooled, the air intake occurs at the front panel and the exhaust exits from the rear panel. Upon installation, allow cooling air to reach the front panel ventilation inlets. Allow minimum 10 cm of unrestricted air space at the front and the rear of the unit.

CAUTION

Use a support bar to provide adequate support for the power supply.



WARNING

The front panel of the NGPS is rated IK08 (5J) against external mechanical impacts. The place of installation must be chosen so that impacts with heavy equipment or tools are unlikely

2.4 AC Input Power Connection

CAUTION

Connection of this power supply to an AC power source should be made by electrician or other qualified personnel. Do not exceed the torque specified on input stud terminals (0.8 Nm).

WARNING

There is a potential shock hazard if the power supply chassis (with cover in place) is not connected to an electrical safety ground via the safety ground in the AC input stud terminals.

The three-phase input connector on the rear panel is a Phoenix Contact 1777749 (PC 5/4-ST1) connector. The three-phase ground has to be connected on the bottom terminal, as shown in **Figure 15**. The phases can be connected to any of the three upper phase terminals (the connection order of the phases is not defined).

Tightening torque shall be between 0.5 to 0.8 Nm.

WARNING

Perform all these operation with the cables and the power supply disconnected from the AC mains.

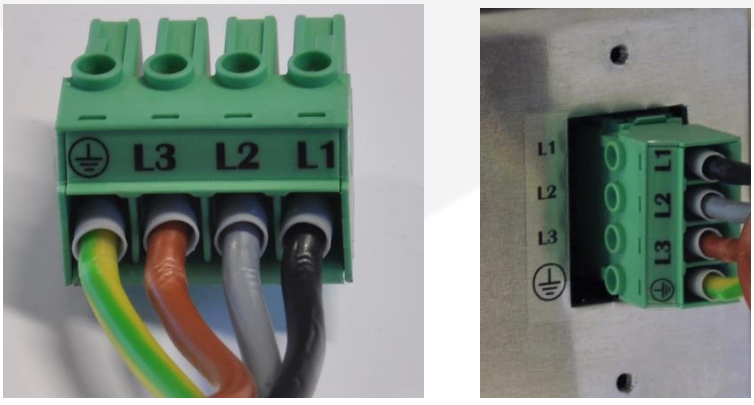


Figure 15: Three-phase input connector

Recommended Cable Size for Input Connection are listed in **Table 9**: AC cable size.

Input voltage	Current RMS per phase	Recommended copper wire size
208 V	34 A	6 mm^2
400 V	18 A	4 mm^2
480 V	16 A	4 mm^2

Table 9: AC cable size

The AC input current and voltage rating are marked on the rear terminal of the power supply.

WARNING

The Protective Earth Ground ⏚ must be connected before applying AC Line Power to the power supply. There is a potential shock hazard if the power supply chassis is not connected to an electrical safety ground via the safety ground in the AC input connector!

WARNING

Sizing of the Protective Earth Ground cable and check of the Protective Earth impedance coordination with electrical distribution system protections shall be carried out by the Qualified Installer according to the standards (e.g. IEC 60364-1, IEC 60364-5-54 CEI 64-8 in Italy, etc.)

After connecting the input connector to the crate mating connection, it is necessary to mount the metal protective cover by first screwing the four M4 threaded screw (top and bottom of the cover in **Figure 16**) and then by rotating the cable fastener (**Figure 17**: AC mains cable fastener).

For safety reasons, the mains supply voltage ratings should not exceed the indicated voltage range.

Figure 16: Protective cover mounting

Figure 17: AC mains cable fastener

2.4.1 AC Source Requirements

The NGPS power supplies are designed for 208 V AC, 400 V AC or 480 V AC input range depending on the model (see **Table 2**: NGPS versions); accepted input frequency is in the range from 47 Hz to 63 Hz. Installation category shall be **CAT II**, so the maximum voltage impulse on the network mains must be below 2500 V.

WARNING

The NGPS power supply is designed to be connected to TN-C or TN-S electrical distribution systems, but without Neutral connection (pure three-phase system). NGPS is not suitable to be used on IT electrical systems.
AC power supply lines shall be referred to Neutral and Earth and must not float.

2.5 Load Connection

WARNING

Turn off the AC input power before making or changing any rear panel connection. Ensure that all connections are securely tightened before applying power. There is a potential shock hazard when using a power supply with a rated output greater than 60 V

2.5.1 Wire Selection

The following factors must be considered when selecting the wires:

- Current carrying capacity strictly linked to the cross-section area;
- Maximum wire length;
- Insulation voltage.

Wire size for the load connection should be selected to ensure the voltage drop per lead to be less than 1 V at the maximum power supply current, in order to prevent excessive output power consumption. Wire cross-section area and the corresponding resistivity are listed in the following **Table 10**: Wire selection.

Wire Cross Section Area [mm²]	Resistivity [Ω/km] @ 20°C	Maximum Cable length in meters to limit voltage drop to be less than 2 V (1 V per lead)		
		120 A	200 A	300 A
35	0.524	16	-	-
50	0.387	21	-	-
70	0.268	31	18,5	-
95	0.193	43	25,5	17
120	0.153	54	32,5	21,6
150	0.124	66	40,1	26,7

Table 10: Wire selection

For higher lengths and/or higher currents it is advisable to use more than one cable in parallel for each polarity. In those cases, a detailed design of the lines shall be prepared by a Qualified Installer according to standards (e.g. IEC 60364-5-52).

Voltage ratings of the cable shall be rated for the maximum output voltage of the NGPS power supply.

By using the values reported in **Table 10**: Wire selection, the maximum voltage applied to the load will be:

$$V_{DC}^{N} + V_{S}^{max} - V_{cable} \quad ,$$

Where:

- V_{DC}^{N}: NGPS nominal output voltage;
- V_{S}^{max}: Maximum compensation Voltage if Remote sensing is used (N.B. Maximum compensation Voltage is 1 V for all models);
- V_{cable}: Cable Drop Voltage.

2.5.2 Lug terminal connection

CAUTION

Screws provided with the NGPS should be used for screw the cable lug. Maximum length of the screws is 20 mm. Longer screws may damage the power supply.
Tightening torque shall be between 4 to 5 Nm.
Always use spring washer and plane washer for a reliable connection.

The load needs to be connected to the output terminals placed on the rear panel of the unit as shown in **Figure 18**. This type of terminals offers a convenient and reliable form of connection. These screw connections accept standard **M8** connections and the terminals are already threaded. Cable lug terminal shall be for M8 screws.

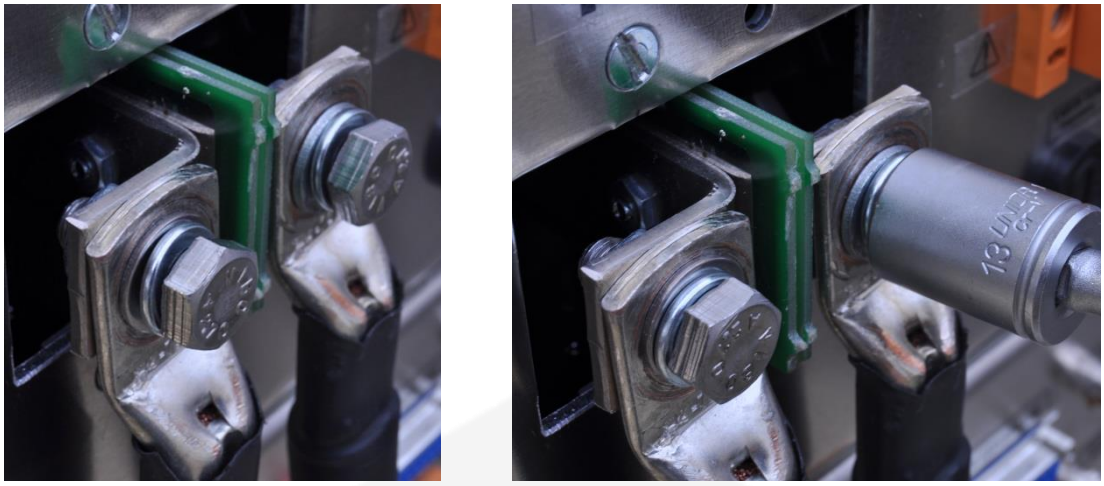


Figure 18: Output terminal connections (insert screw and secure it)

The symbols "+" and "-" on the rear panel indicate the positive and negative polarity of the terminal, respectively.

After securing both output connections, it is necessary to mount the metallic protective cover, since the power supply delivers high current and/or hazardous voltage (i.e. in case of NGPS with output voltage ratings > 60 V) on these output terminals.

Figure 19: Metallic protective cover on the output terminal connections

2.6 Hydraulic Plug Connection

In order to properly cool the model, each NGPS needs to be connected to the hydraulic system by mean of the plugs on the rear panel of the module (**Figure 3**: **Water cooled NGPS rear view. Plugs for the**). As mentioned in **Section 161.2**, the corresponding mating hydraulic plug (to be plugged into the power units) is the **PLCD17006** and is described in detail.

2.7 Grounding Outputs

By factory-default configuration, the NGPS minus output terminal is grounded to the Protective Ground (i.e. chassis, Mains-Earth terminal and all metallic parts composing the box) through a fuse. This fuse, namely Earth Fuse (E.F.), is accessible from the rear panel. By means of E.F., the output terminals are not floating and cannot be connected to Protective Ground.

If accidentally one of the output terminals is conducting to the Protective Ground, a fault will be triggered and the power supply is switched off. Refer to Earth Leakage Fault (**Section 1.8.1**) and Earth Fuse Fault (**Section 1.8.2**).

To allow floating operation of the output, it is sufficient to remove the Earth Fuse from the fuse-holder and set the power supply for floating operation (for more information please refer to the *Remote Control Manual*).
When the FAST-PS is configured to operate in floating mode, either the positive or the negative output terminals can be grounded. Always use two wires to connect the load to the power supply regardless of how the system is grounded.

WARNING

Models up to 60 VDC rated output shall not float outputs more than ±60 VDC above/below chassis ground. Models > 60 VDC rated output shall not float outputs more than ±500VDC above/below chassis ground.

2.8 Parallel Operation

NGPS modules can be run in parallel operation, thus increasing the output current of the paralleled solution while maintaining the same voltage of each building block.

The user can build a 400A 50V system by parallelizing two NGPS 200A 50V units, a 600A 50V system by parallelizing three NGPS 200A 50V units, or an 800A 50V system by parallelizing four NGPS 200A 50V units.

CAUTION

- Up to 4 PS can be connected in parallel configuration.
- Only PS of the same model and same firmware version can be connected in parallel configuration.
- Interlocks have to be connected only to the MASTER PS.

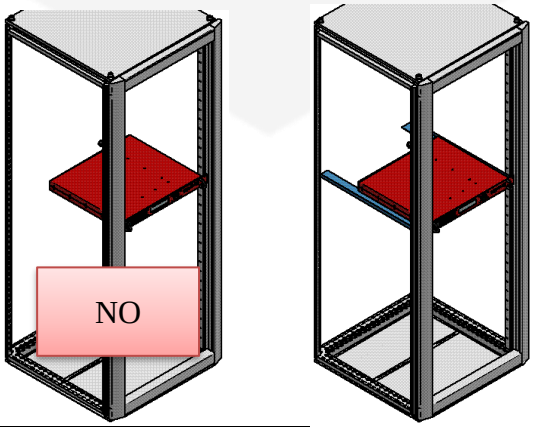
To run a paralleled system, the hardware must first be properly connected (see below). Then, one module must be configured as the Master, and all others as Slaves. Each step is detailed below.

HARDWARE CONNECTION

- Each NGPS has to be properly mounted on a 19'' rack (**N.B. do not connect AC main at this point**);

CAUTION

Use a support bar to provide adequate support for the power supply.



- Connect the output terminals in parallel, i.e., positive to positive terminals and negative to negative terminals. To parallel the output terminals, bar connections are preferred over cable connections. Below is an example of a 2-NGPS and a 4-NGPS system.

- Remove the caps from the optical cable **(Figure 20**);

Figure 20: SFP/SFP+ optical transceiver

- To release the plugs from the slot to prepare the daisy-chain connection, pull back the white sheath from the cable (blue arrow) and push the connector forward (green arrow);

- Connect the SFP/SFP+ optical transceiver module into the **SFP1** slot on the front panel of the PS (**Figure 21**):

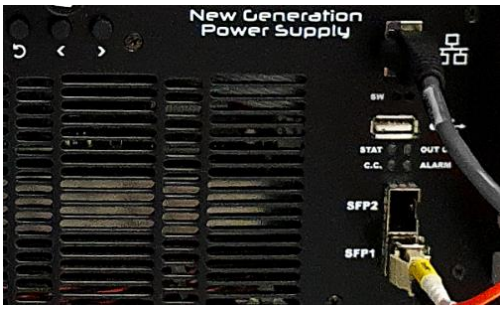


Figure 21: SFP1 connection slot

- Insert the SFP/SFP+ optical cables into the optical transceivers following the connections reported in **Figure 22**:

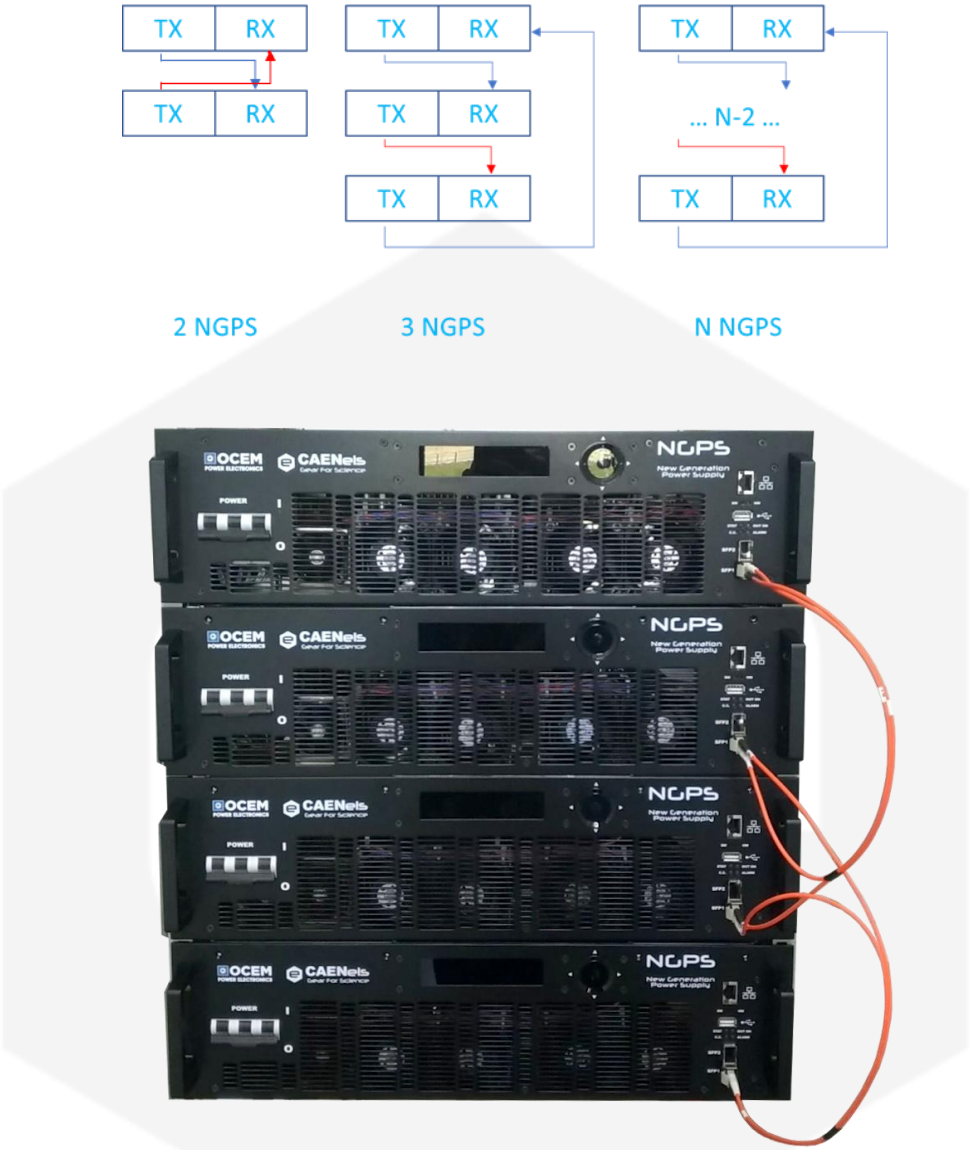


Figure 22: SFP/SFP+ connections

SFP plug-ins and optical cables, pre-configured to respect the daisy-chain configuration, will be shipped together with the modules to be paralleled. Since it is a daisy-chain, the user can connect the optical cable plugs to the SFP plug-ins in any order.

- **Remove the earth fuse** from each NGPS, except one (selected as Master).
- Connect each module to the AC main.
- Turn on the switch of each module (main switch on "I"). **Do not set the output ON at this stage.**

MASTER SLAVE(S) CONFIGURATION

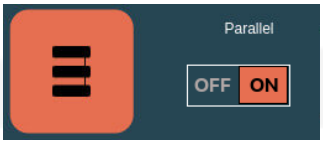
- From the Local Control, enable parallel mode on all the PSs, assigning the Master role to the chosen one and the Slave role to all the others. To do this press Enter to the Navigation Switch and select:

Advanced →

Next Page →

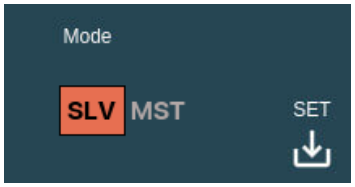
Parallel →

ON →



if the PS is designated as MASTER, select "MST" and press SET;

if the PS is designated as SLAVE, select "SLV" and press SET.



3. Local Control

This chapter describes the local control functionalities that are provided by the NGPS power supply and some useful information for its use.

The power supply can work either in LOCAL mode or in REMOTE mode. Please note that only readbacks are allowed from the remote communication interfaces when the unit is in LOCAL mode (i.e. settings are inhibited).

The control mode (LOCAL / REMOTE) can be set on the configuration page of the local menu.

3.1 Navigation Switch

Each NGPS power supply module is equipped with a Navigation Switch on the front panel of the unit, as shown in **Figure 23**.

Figure 23: Navigation switch

Multiple actions can be performed via this front navigation switch:

- Encoder rotation (CW and CCW) and central pushbutton (it will also be referred to as "Enter");
- Left/Right arrow pushbuttons;
- Back pushbutton.

3.2 Display

The colour display on the NGPS power supply unit allows users to visualize information about the power supply status and to control the unit in order to use it locally. User friendly menus and sub-menus can be navigated by means of the navigation switch.

By default, the display will be automatically turned off after 30 minutes from the last local command or from the turning on of the power supply.

The user can disable this feature or change the turning off time (more information in the *Remote Control Manual*).

3.2.1 *Power-up*

The NGPS, upon power-up or power-cycling, will display an empty screen until the unit embedded OS is initialized.

Please note that this procedure will take approximately 25-seconds before the *Home Screen* is displayed.

3.2.2 Home Screen

The NGPS home screen is the first loaded page upon power-up or power-cycling of the module (**Figure 24**) and contains information on:

- the PS model;
- the module IP address;
- output current readback value [A] with the light blue status bar;
- PS module ID;
- output voltage readback value [V] with the green status bar;
- four (4) indicators on the bottom side (described in the next paragraph).

Figure 24: *Home Screen*

The *Home screen* presents four indications on the bottom side of the Local Display (**Figure 25**) with the following information:

- **MON – OFF**: shows if the PS output is enabled or not;
- **REM – LOC**: shows the active control mode;
- **C.C. – C.V.**: shows the active regulation mode;
- **NOR – WAV – AIN – SFP**: shows the active setpoint mode.

Figure 25: Home Screen indicators

If the PS has experienced one or more faults – e.g. interlock intervention, over-temperature, DC-Link, etc. – the *Home Screen* would display a list the faults (as reported in **Figure 26)**.

Figure 26: LCD Fault

3.2.3 Menu Page

The *Menu page* is reachable by performing any action on the navigation switch when in the *Home Screen*.

The *Menu Page* gives access to all the local features of the NGPS power supply unit. There are four different options that can be selected as shown in **Figure 27**:

Figure 27: Menu Page

The accessible sub-pages and/or actions from this page are hereafter listed (note that the selected sub-page is lightened in a lighter shade):

- **CONTROL** – *sub-page*;
- **CONFIG** – *sub-page*;
- **ADVANCED** – *sub-page*;
- **RESET FAULTS** - *action*;

The access to each sub-page (or action) is necessary to highlight the selected rectangle by using the encoder or the arrows of the navigation switch and press the "Enter" button.

The **Reset faults** rectangle, once pressed, resets the status register of the power supply and sends back to the visualization of the *Home Screen*.

3.2.3.1 *Control Page*

The *Control Page* is reachable by selecting the corresponding rectangle from the *Menu Page*.

The *Control Page* gives access to the main settings of the NGPS power supply unit. An example of a *Control Page* visualization is shown in **Figure 28**:

Figure 28: Control Page

From this page it is possible to turn the PS output ON and OFF and to set the output current or voltage (depending on the regulation mode, C.C. or C.V.).

Actual values of output current and output voltage (readbacks) can are reported on the right side.

3.2.3.2 *Config Page*

The *Config Page* is reachable by selecting the corresponding rectangle from the *Menu Page*.

This page allows the user to set the control mode of the power supply – e.g. LOCAL or REMOTE – to select the regulation mode – Constant Current (C.C.) or Constant Voltage (C.V.) – and to set the slew rate either in [A/s] or [V/s], depending on the selected regulation mode.

An example of a *Config Page* visualization is shown in **Figure 29**:

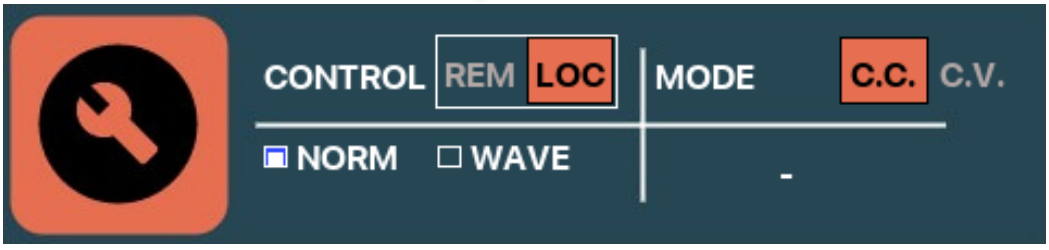


Figure 29: Config Page

3.2.3.3 *Advanced Page*

The *Advanced Page* is reachable by selecting the corresponding icon from the *Menu Page*. An example of an *Advanced Page* visualization is shown in **Figure 30**:

Figure 30: Advanced Pages. Top: page 1, bottom: page 2

The accessible sub-pages and/or actions from this page are hereafter listed (note that the selected sub-page is lightened in a lighter shade):

- **NETWORK** – *sub-page*;
- **RAMP SR** – *sub-page*;
- **INFO** – *sub-page*;
- **NEXT PAGE** - *action*;
- **PREV. PAGE** - *action*;
- **PARALLEL** – *sub-page*;
- **INFO SFP** – *sub-page*;

The access to each sub-page (or action) is necessary to highlight the selected rectangle by using the encoder or the arrows of the navigation switch and press the "Enter" button.

The Network sub-page is reported in **Figure 31**.

Figure 31: Network sub-page

This page allows to locally set the power PS IP address, the Network Mask and the Gateway. Alternatively, the user may select "DHCP ON" and the Network configuration will be automatically assigned by DHCP server (if present).

To change the Network configuration, use the Navigation Switch and complete the operation by placing the cursor on the "*SET*" icon and by pressing *Enter*. **Wait some seconds for the configuration to be applied.**

4. NGPS Utilities

The NGPS Utilities allow a user-friendly and fast access to the functionalities and configuration of the NGPS unit.

Two different software are available for operation with the NGPS power supply: *Device Manager* and *Visual PS*.

Concerning the former, it is a software useful for the detection of the NGPS units connected to the local network, as well as to check and eventually modify their network configuration (as an alternative to the use of the local interface, see **Section3.2.3.3**).

The *Visual PS* makes it easy to remote control the main features of the NGPS series using a Graphic User Interface (GUI).

Both utilities can be downloaded from this link: http://support.caenels.com/caenels/repos/apps/ .

For details and their operation please refer to the *Remote Control Manual*.

5. Mechanical Dimensions

The mechanical dimensions of the air cooled NGPS unit are shown in **Figure 32**.

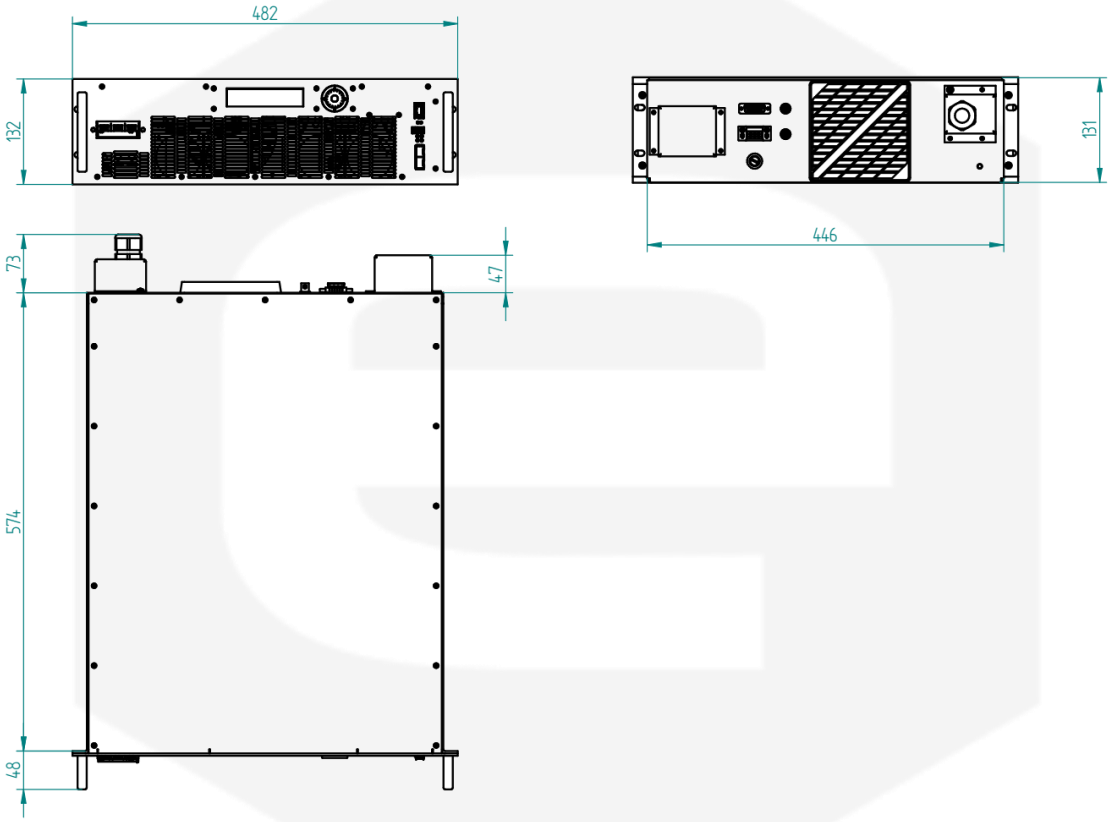


Figure 32: Air cooled NGPS mechanical drawings

The mechanical dimensions of the water cooled NGPS unit are shown in **Figure 33**: .

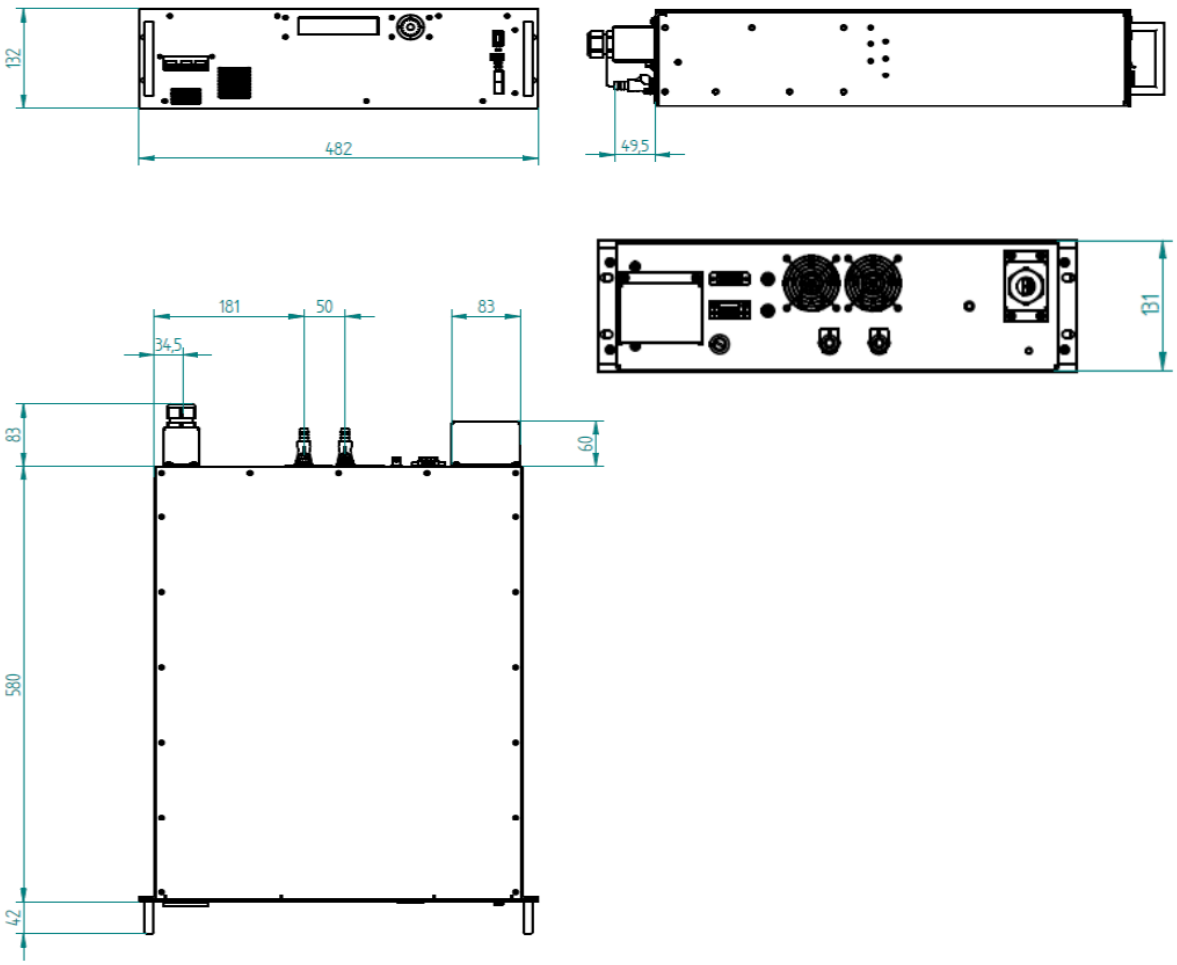


Figure 33: Water cooled NGPS mechanical drawings

6. Technical Specifications

The main technical specifications for the NGPS models are hereafter presented:

Technical Specifications	NGPS
Output current range	See **Table 1a**: Standard NGPS models and **1b**
Output voltage range	See **Table 1a**: Standard NGPS models and **1b**
Maximum output power	See **Table 1a**: Standard NGPS models and **1b**
Regulation Type	Current- or Voltage- Control
Current and Voltage Setting	18 bit
Current and Voltage Readback	20 bit
Output insolation	500 V
Power Factor	> 0.93
Efficiency	> 90%
Max Current/Voltage update rate	10 kHz (over SFP)
Closed-loop Bandwidth	> 100 Hz (C.C. mode) > 200 Hz (C.V. mode)
Accuracy	< 0.01% (0.005% upon request) (C.C. mode) < 0.05% (C.V. mode)
Line Regulation	±5 ppm / FS
Load Regulation	±5 ppm / FS
Remote Sensing Compensation	up to 2V
Cooling **(Air cooling models)**	Forced Air Convection (front-to-rear)
Cooling **(Water cooling models)**	Water Flow: 1.5 l/m Water Pressure Drop: 1.5 bar Max Water Input Pressure (continuous): 8 Bar Service Forced Air Convection (front-to-rear)
Temperature Stability	5 ppm/K (C.C. mode) (1ppm/K upon request) 50 ppm/K (C.V. mode)
Communication interfaces	1x Ethernet 10/100/1000 TCP-IP 2x SFP ports
Itnernal Interlocks	Over-Temperature MOV Input Over-Voltage Main circuit-breaker for Over-Current Output Free-wheeling diodes Output Over-current and Over-Voltage Earth current leakage Input Phase-Loss (DC-link undervoltage)

Technical Specifications	NGPS
External Interlocks/States	User-configurable "dry" contacts Magnetic relay Solid-state relay
Modularity	Parallel connection (up to 4)
Drivers	EPICS
Extra-features	Point-by-point current waveform User-definable interlock thresholds, active levels and timings Firmware remote update (with password)
Dimensions	19" x 3U x 600 mm
Input Ratings	208 VAC ± 10% ("A") Three-phase 50/60 Hz 400 VAC ± 10% ("E") Three-phase 50/60 Hz
Weight	28 kg
Enclosure impact withstand rating (damages possible but no safety impaired)	IK 08 (5 J)
Operating Temperature	0…40 °C
Operating current range (rated stability and accuracy)	2 - 100 %
EU directive conformity and Standard compliance	LVD: 2014/35/UE EMC - EMC: 2014/30/UE EN 61010-1:2010 - EN 61326-1:2013

Table 11: Technical specifications