FAST-PS-1K5

1.5-kW Current- and Voltage-Controlled Digital Bipolar Power Supply Series

CAENels
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MAGNET POWER SUPPLY SYSTEMS

User's Manual

Rev. 4 – January 2025

This product is CE & UKCA compliant.

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User Manual – Models – Options – Custom Models

This manual covers the following standard Power Supplies models:

- **FAST-PS-1K5 100-15**
- **FAST-PS-1K5 50-30**
- **FAST-PS-1K5 30-50**
- **FAST-PS-1K5 15-100**
- **FAST4R100015 - FAST-PS-1K5 100-15 - 4-Q Ready**
- **FAST4R050030 - FAST-PS-1K5 50-30 - 4-Q Ready**

This manual covers the following optional units:

- **F1K5D4100015 - F1K5-DISS-100-15 - 4-Quadrant Operation Crate for FAST-PS-1K5 ±100 A @ ±15 V**
- **F1K5D4050030 - F1K5-DISS-50-30 - 4-Quadrant Operation Crate for FAST-PS-1K5 ±50 A @ ±30 V**

This manual also covers the Custom Models identified as follows:

FAST-PS-1K5 xxx-yyy

Where:
- xxx is the maximum output current expressed in Amps
- yyy is the maximum output voltage expressed in Volts

Identified by the ordering codes:

- **FAST1K5C01XA :** *FAST-PS-1K5 10-100 – Fast Digital Bipolar Power Supply ±10A@±95V – Curr. Acc. < 0.01% (10…40°C)*
- **FAST1K5C02XA :** *FAST-PS-1K5 1-15 – Fast Digital Bipolar Power Supply ±1A@±15V – Curr. Acc. < 0.01% (10…40°C)*

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Document Revisions

Revision	Date	Comment
0.1	March 10th 2016	Preliminary Release
1.0.0	June 19th, 2016	Revision of all parts for first issue
1.0.1	August 8th, 2016	Updated product disposal LOGO and pictures for models from 60 V to 100 V
1.0.2	October 25th, 2016	Updated company name
1.1	October 25th, 2016	Added information on the analog input control
1.2	September 13th, 2017	Changed information on the solid-state relay behavior (user-defined applications)
1.3	November 15th, 2017	Added Auto shut down feature on Display
1.4	April 18th, 2018	Crowbar triggering voltages listed
1.5	June 15th, 2018	Toroid instructions added
1.6	November 15th, 2018	FAST1K5C01XA and FAST1K5C02XA ordering codes and related specifications added
1.7	April 18th, 2019	Updated information on maximum energy adsorption allowed (sections 1.10.5 and chapter 5)
1.8	November 11th, 2019	Typo errors fixed (pages 12 and 52)
1.9	June 16th, 2020	OVP fault limits redefined
2.0	July 8th, 2020	4-Quadrant options added
2.1	October 12th, 2020	Images of the 4-Quadrant options changed and toroid instructions removed for new mechanics. Added information on the memory cell #54 for operation.
2.2	March 2nd, 2021	Figure 17 removed (toroid instructions)
2.3	November 22nd, 2022	Updated: (i) UKCA compliance logo (ii) rear panel figures (iii) related connectors and navigation switch section. Added persistent switch section
3	August 8th 2024	Updated address and revision numbering
4	January 17th 2025	Updated Parallel Operation and Local Control sections. Minor correction in the Persistent Switch section.

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	Indore use
Operating Temperature	0°C to 45°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)

The following symbols are used within this manual or are reported in the 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
- **O** Off (Power)
- **I** 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. will 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

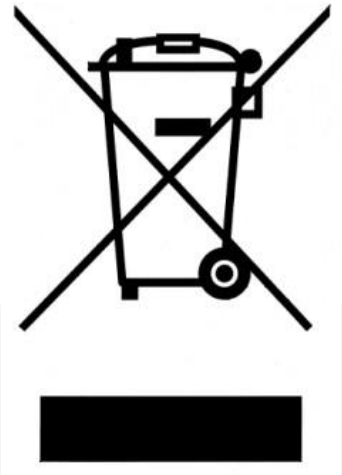
Do NOT open the BOX TOP COVER

CAEN ELS S.r.l. declines 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. reserves 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 cables provided.
- 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

1. Introduction

This chapter describes the general characteristics and main features of the FAST-PS-1K5 bipolar power supply series.

1.1 FAST-PS-1K5 Overview

High performances, high efficiency, extreme stability, easiness of configuration and maintenance are the key features of the FAST-PS-1K5 power supply series.

The FAST-PS-1K5 is an independent current- or voltage-controlled digital bipolar power supply module. Different models with several output current and voltage ranges are commercially available:

Model Name	Current	Voltage
FAST-PS-1K5 100-15	±100 A	±15 V
FAST-PS-1K5 50-30	±50 A	±30 V
FAST-PS-1K5 30-50	±30 A	±50 V
FAST-PS-1K5 15-100	±15 A	±95 V
FAST4R100015	±100 A	±15 V
FAST4R050030	±50 A	±30 V

Table 1: FAST-PS-1K5 standard models

The FAST-PS-1K5 module is compact and fits in a single 19-inch 2U 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 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 process as communication, diagnostics and local interface handling.

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

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 communicating with the unit using a proprietary packet structure with a very high update rate (more than 10 kHz). These ports are connected directly to the FPGA logic and so the given packet is 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 update rate of the setpoint, giving the user more flexibility and excellent rates for the digital control of the power supply.

1.2 FAST-PS-1K5 at a glance

The FAST-PS system is composed by a single 19-inch 2U crate. The FAST-PS-1K5 unit and its I/O connections can be easily seen in **Figure 1** (front view),

Figure 2 (rear view for high-current models) and **Figure 3** (rear view for high-voltage models).

Figure 1: FAST-PS-1K5 front view

On the front side of the FAST-PS-1K5 unit there are placed respectively: a power switch, a colour graphic display with navigation switch for the local control of the module, three communication sockets (2 SFPs and one Ethernet ports), four status LEDs and one USB device connector.

Figure 2: FAST-PS-1K5 rear view for the 100-A and 50-A models

Figure 3: FAST-PS-1K5 rear view for the 30-A and 15-A models

On the rear side of the unit are placed: AC power line input, fuse holders (two for AC input and one for the earth leakage), the output connections, the D-Sub 15 Female Pin I/O connector. A separate connector for the voltage remote sensing is also present below the I/O connector.

Two BNC connectors on the left side, reserved for the Trigger Input, the Analog Control and an Auxiliary Input for Custom developments of the unit are also provided on the rear panel of the unit.

The BNC connector CB is a Crowbar TTL signal that is needed for paralleling different units.

1.3 Modes of Operation

The FAST-PS-1K5 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 FAST-PS-1K5 can be used as current-controlled or voltage-controlled bipolar units. The regulation types are:

- **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 that allow regulating the output voltage directly on the load thus compensating the voltage drops on the output cables. The maximum voltage drop that the power supply is able to compensate is of 0.5V.

1.3.2 Control Mode

The FAST-PS-1K5 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 from the remote interface 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;
- **FAST-INTERFACE** control: this interface allows controlling the unit via a proprietary protocol over the SFP/SFP+ interfaces (optical or electrical) and it is meant to be used for very fast applications. Update rates of more than 10 kHz are reachable using this communication channel.

1.3.3 Update Mode

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

- **NORMAL**: the update of the set-point (current or voltage, depending on the operation mode) 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 on the *Waveform* section) 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. This option is only available in units that have been factory configured (ordering option).

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

1.4 External Interlocks and Status

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) 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 described.

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. Also the NO-TAP changes its state consequently.

External Interlocks and Status are available on a D-Sub 15 Pin Male type on the rear panel of the FAST-PS-1K5, **Figure 4.**

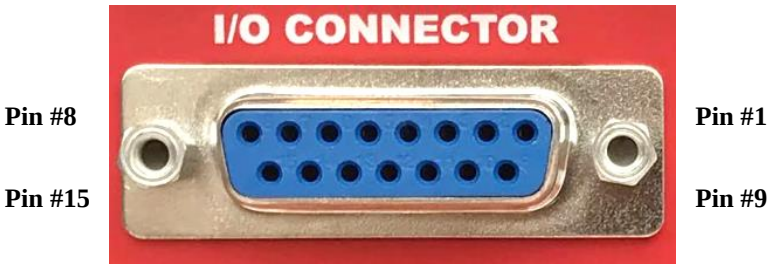


Figure 4: I/O Connector

1.4.1 Interlock Enable/Disable Mask

The FAST-PS-1K5 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. The value to be written is in ASCII format, representing the corresponding bit mask, as shown in the following table:

Bit #4 (INT #4)	Bit #3 (INT #3)	Bit #2 (INT #2)	Bit #1 (INT #1)
Enabled (1) Disabled (0)	Enabled (1) Disabled (0)	Enabled (1) Disabled (0)	Enabled (1) Disabled (0)

Table 2: Enable/Disable Mask Parameter

Example: if only interlock #2 and interlock #3 need to be enabled, it is necessary to write 0x6 (it is ASCII representation to the bit mask 0110) to the feild #90. The following command has to be se sent to the power supply (after having un-locked the password protection): "MWG:90:0x6\r".

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 the low level that 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). The value to be written is an ASCII format representing the corresponding bit mask, as shown in the following table:

Bit #4 (INT #4)	Bit #3 (INT #3)	Bit #2 (INT #2)	Bit #1 (INT #1)
High (1) **Low (0)**	**High (1)** **Low (0)**	**High (1)** **Low (0)**	**High (1)** **Low (0)**

Table 3: Activation Level Mask Parameter

***Example*:** if interlock #1 and interlock #4 need to have a high activation level (trip when the interlock input signal is shorted), it is necessary to write 0x9 (it is ASCII representation to the bit mask 1001) to the field #91. The following command has to be se sent to the power unit: "MWG:91:0x9\r". This setting has no effect if the interlock is not enabled.

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 in the field #92 for Interlock #1, in field #94 for interlock #2, in field #96 for interlock #3 and in field #98 for interlock #4. The value to be set is in ASCII format, representing the intervention time in milliseconds. The minimum settable value is 0 (immediate generating of fault condition) and the maximum value is 10.000 ms (corresponding to 10 seconds).

***Example*:** if interlock #1 needs to have an interlock intervention time of 750 ms, the following command has to be se sent to the power unit: "MWG:92:750\r". This setting has no effect if the interlock is disabled.

1.4.4 Interlock Identification Name

The FAST-PS-1K5 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, field #97 for interlock #3 in field #99 for interlock #4. The value to be set is in ASCII format, representing the interlock name.

***Example*:** if the interlock #1 is associated to the cabinet door open, the following command can to be se sent to the power unit: "MWG:93:Cabinet door\r". This setting has not effect if the interlock is disabled.

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. The solid state relay has the same behaviour (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

The interlock pins are galvanically isolated from ground and outputs terminal, nevertheless the absolute maximum voltage, referred to ground, that pins can sustain is 48V. 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. Do not apply voltage between any input interlock and its corresponding return.

The configurability of the FAST-PS-1K5 series allows users to decide what interlock are enabled or not, set the interlock "trip" level (i.e. low or high), the time of intervention (the time that an interlock signal has to be at the trip level before generating a fault condition) and an associated interlock name. This configuration can be set and read using the VISUAL PS graphic software (provided with the power module) or using the low-level MRG and MWG commands, which allows setting the advanced configuration parameters. The interlocks are disabled by default.

1.4.5 Output Status Signal – *user-defined application*

The solid state relay signal (please refer to the I/O connector section for more information) can be remotely commanded by the user in order to change its state (open/shorted) for any specific customer application.

Solid State Relay Terminals (Terminal #1 & #2, pins #7-#8) shall not float more than ±60 VDC above/below chassis ground and its maximum current rating should never exceed 400 mA.

1.5 Remote Sensing

The FAST-PS-1K5 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. Connector is shown in **Figure 5**.

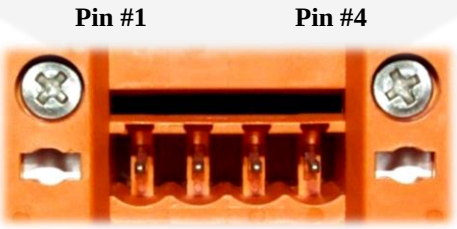


Figure 5: Remote Sensing connector

The FAST-PS-1K5 is provided as **factory-default** with a mating connector already shorting the pins 1-2 and 3-4 in order to have direct sensing at the output terminals.

Figure 6: Factory mating Remote Sensing connector

The two remote sensing terminals are present on the corresponding connector on the rear panel:

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

Table 5: Remote sensing pinout

By using these 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 FAST-PS-1K5 is shipped with a mating connector for the remote sensing that short-circuits the +S and + pins and the –S and – pins respectively. This configuration performs the remote sensing directly at the output connector of the power unit. Leaving +S and –S pins disconnected will make the power supply sense the output voltage directly at the output terminal connections. When using the remote sensing feature leave pins #2 (+) and #3 (–) disconnected.

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**:

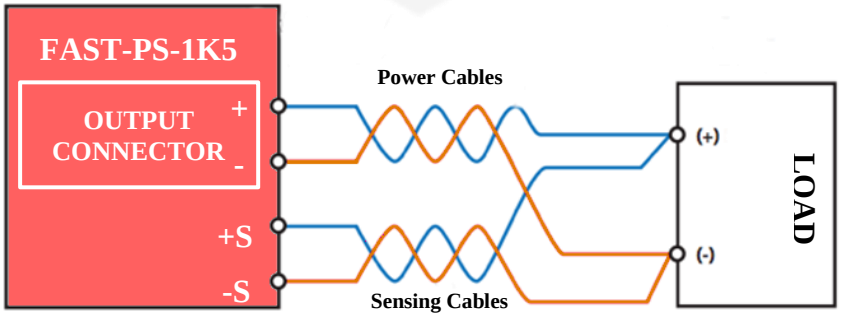


Figure 7: Example of Remote Sensing

1.6 Persistent Switch

The FAST-PS-1K5 is equipped with a Persistent Switch output connector (see **Figure 8**) capable of sourcing up to 500 mA with a fixed output voltage of 24 V.

To place the power supply in persistent switch mode, firstly use the dedicated remote command [**SETPS:0**] in order to reset to 0 V the Persistent Switch output. To definitely turn-on the persistent switch mode, use then the remote command [**SETPS:1**] in order to set the Persistent Switch output to 24 V, heating the connected load.

Figure 8: Persistent Switch connector

CAUTION

The Persistent Switch Output is not limited by any resistor so, in case the Persistent Switch would require less than 24 V, an external resistor may be required to reduce the voltage on the load.

CAUTION

The Persistent Switch Output is not floating but it is referred to the Chassis Earth. Connect only to floating Persistent Switch.

A fuse holder is present on the rear panel (see **Figure 2** and **Figure 3**) to protect the output from a short circuit (the fuse is rated as Class F at 0.5A). Anyway, the blowing of this fuse is not monitored by the power supply firmware.

1.7 Trigger, Analog Control and AUX inputs

The standard version of the FAST-PS-1K5 includes inputs for a trigger signal, for an analog control and for an additional conversion (ADC) AUX channel on the rear panel as shown in the following **Figure 9**. The AUX connector is also used for the 4-Quadrant Option (**Chapter 6**).

Figure 9: BNC input connectors

A brief description of these features and their functionalities is presented hereafter.

1.7.1 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 that allows for these recognized values that guarantee correct operation of the trigger 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 the following **Figure 10**:

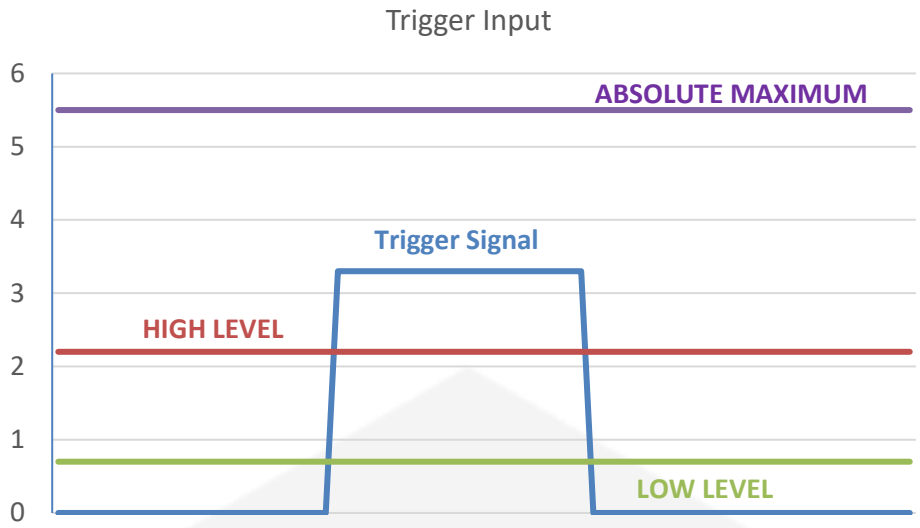


Figure 10: Trigger Thresholds

1.7.2 Analog Control Input

An input that allows the FAST-PS-1K5 to be controlled as an "amplifier" is provided on the rear panel on a BNC connector. This input is labelled as "ANALOG CONTRL".

This input accepts signals ranging from -10V to +10V and generates an output which is proportional to the input signal, meaning a –Full-Scale for a -10V input, 0 for a 0V input and +Full-Scale 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) is shown in Errore. L'origine riferimento non è stata trovata..

In order to avoid drifts, offset and external noise pick-up it is always suggested to use the digital interface – e.g. Ethernet – to control the power unit in order to get the best performance.

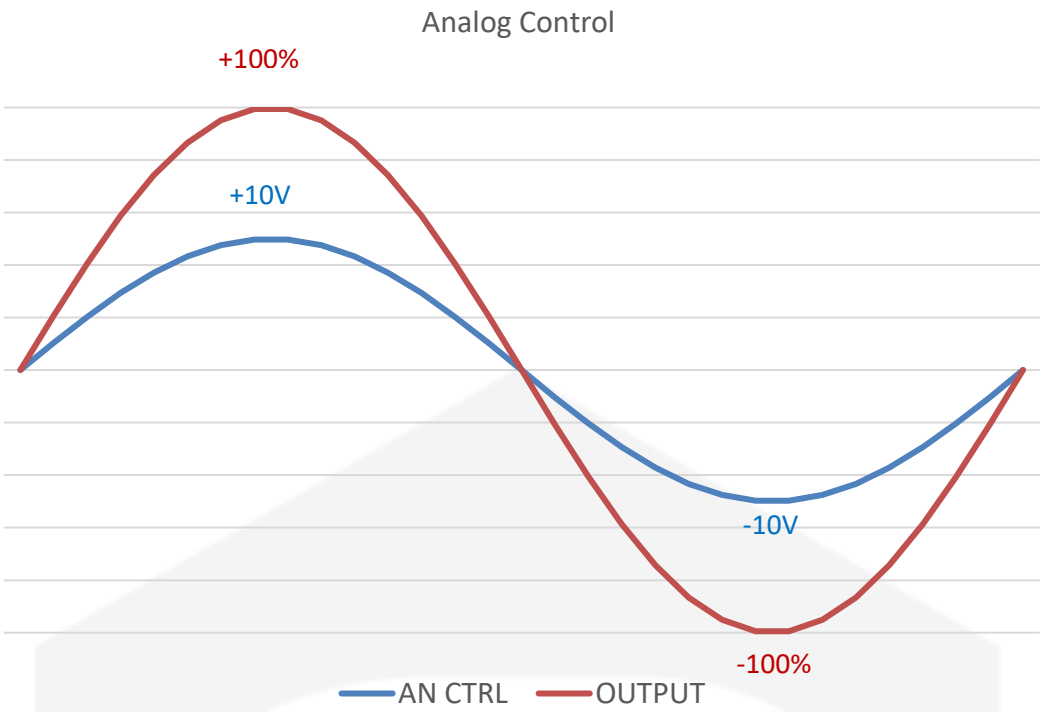


Figure 11: ANALOG CONTRL vs OUTPUT dependence

Please note that the bandwidth of the analog control input is internally limited to 1 kHz.

1.7.1 Configurable AUX Input

The FAST-PS-1K5 has an additional input connector on the rear panel on a BNC connector that allows connecting an external signal source or sensor that needs to be monitored.

Examples of application of this input are temperature sensors and field (Hall) probes.

The standard input range for the signal is 0-5V and the conversion value, identified by a scale-factor, can be stored in the power supply in order to have the correct reading from it.

Example: for a temperature sensor having a 20 mV/°C gain, the input scale-factor needs to be configured considering that the equivalent temperature at a potential ADC full-scale of 5 V would be the following:

$$T_{FULL-SCALE} = \frac{5\ V}{20\ mV/°C} = 250\ °C$$

Having the ADC a 16-bit resolution, the LSB value, equivalent to the scale-factor that needs to be saved to the power supply for a correct reading is:

$$K_{LSB} = \frac{T_{FULL-SCALE}}{2^{16} - 1} \cong 0.0038\,°C$$

1.8 Output connectors

The load needs to be connected to the output connector placed on the rear panel of the unit. Two types of connectors are provided depending on the maximum output voltage of the power supply.

1.8.1 Models up to 59 V

Busbars terminals are shown in **Figure 12**. This type of connector offers a convenient and reliable form of connection.

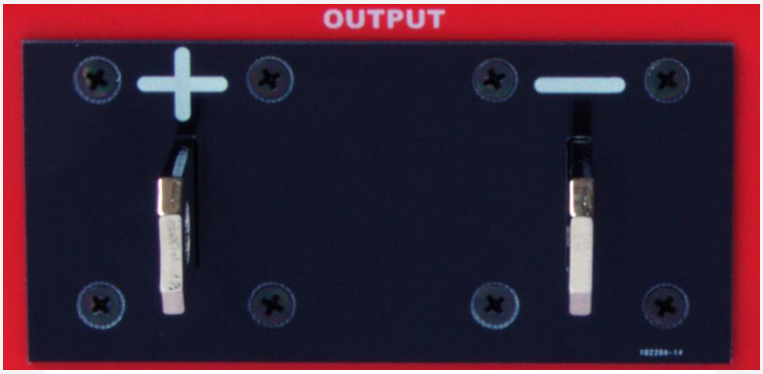


Figure 12: Output Connector high current

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

1.8.2 Models from 60 V to 100 V

Screw terminals are shown in **Figure 13**. This connector is suitable for connecting cables from 2.5 mm^2 up to 10 mm^2.

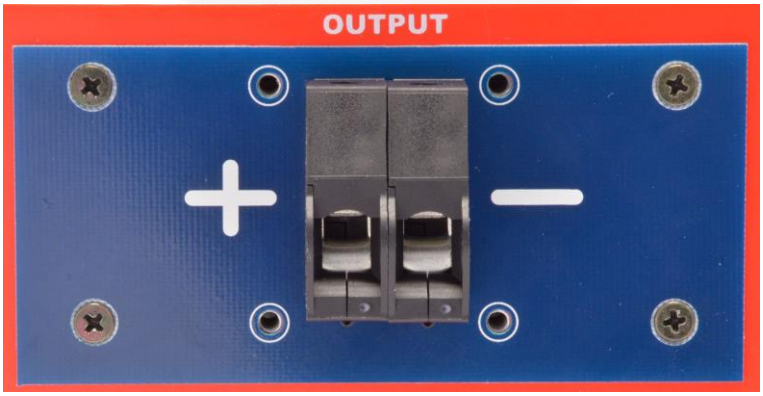


Figure 13: Output Connector high voltage, with cover removed

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

1.9 Front Panel Indicators

The FAST-PS-1K5 has four (4) front panel LED indicators as shown in the following **Figure 14**.

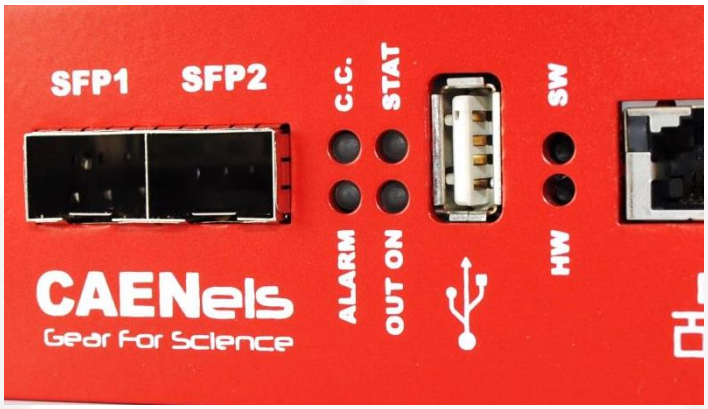


Figure 14: Front panel indicators

The front panel indicators and their behaviour are hereafter listed (clockwise starting from top-left):

- **C.C.**: Constant Current mode (**blue**). If turned on, the FAST-PS-1K5 is working in constant-current mode. When off, it is regulating the ouput voltage;
- **STAT** (**green**): 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 if the output is enabled and it is regulating output current or voltage;
- **ALARM** (**red**): if turned on signals that the power unit has experienced a fault condition. It is necessary to perform a "reset fault" command in order to turn off this LED and to turn to module output again (only if the fault condition/cause has been removed).

1.10 Internal Protections

The FAST-PS-1K5 is equipped with several internal protections that allow configuring the unit for optimal operation. These protections have the dual use of

protecting the unit and the connected load/device from unwanted damages or undesired operation conditions.

A brief description of the FAST-PS-1K5 internal protections is hereafter presented with some more basic considerations on their operation and use.

1.10.1 Earth Leakage Current

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

1.10.2 Earth Fuse

An earth fuse is present on the rear side of each FAST-PS-1K5 and it is rated at 5A Class F. 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 FAST-PS-1K5 internal status register. The fuse housing is shown in **Figure 15**.

Figure 15: Earth fuse housing

1.10.3 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. and C.V. mode respectively).

Different thresholds 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 10-Ω load on a FAST-PS-1K5 3050 for example where the maximum power supply output voltage is 50 V. By setting a current of 10 A to the load, the output voltage should reach a value of 100 V which obviously is not feasible: once the power unit supplies 5 A to the load it already reaches the maximum output voltage condition. The power unit recognizes this difference between the set-point – i.e. 10 A – and the actual output current, thus generating a "regulation fault" condition.

The tripping of this fault implies an automatic turning off of the FAST-PS-1K5 unit. A status reset – i.e. reset faults – needs to be performed in order to turn the unit back on.

1.10.4 Input OVerCurrent - OVC

The internal current drawn from the AC/DC power section of the unit is sensed by a hall transducer that, in conjunction with a comparator, generates a signal that turns off the device.

The threshold value of intervention depends on the FAST-PS-1K5 specific model and cannot be changed by the user.

The tripping of this fault generates a latched fault condition that needs to be reset by the user before turning the power supply output back on again.

1.10.5 OVerPower - OVP

The FAST-PS-1K5 can work continuously at a 2% over its power rating as expressed in the specifications.

The module is able to work at a power comprised between 2% and 5% over its rating – i.e. between 102% and 105% – for a 20-second period before turning off on an over-power fault.

If the actual output power drawn from the power supply is more than 5% above its nominal ratings the power unit will shut down after 1 second.

This behaviour is summarized in the following Table 7 (an example of a FAST-PS-1K5 10015 unit is also listed):

Output Power	Time of Operation
< 102% of P_N ***e.g. FAST-PS-1K5 10015: < 1530 W***	**Continuous**
< 104% of P_N ***e.g. FAST-PS-1K5 10015: < 1560 W***	**20 s**
≥ 104% of P_N ***e.g. FAST-PS-1K5 10015: ≥ 1560 W***	**1 s**

Table 7: FAST-PS-1K5 Output Power on 230 Vac Mains

where P_N is the rated nominal output power of the power supply unit, as indicated in the technical specifications.

In a similar way, also energy from the load to the power supply has upper limits. Over these thresholds the power supply may risk hardware issues and thus, it will automatically trip an "OVerPower" fault.

The limits are listed in the table below.

Limits for modules with current full scale ≥ 50 Amp:

Input Power (Load to Power Supply)	Time of Operation
< 100W	Continuous
≥ 100 W and < 120W	20 s
≥ 120 W and < 200W	1 s

Table 8: FAST-PS-1K5 Input Power limits for modules with current full scale ≥ 50 Amp

Limits for modules with current full scale < 50 Amp:

Input Power (Load to Power Supply)	Time of Operation
< 50W	Continuous
≥ 50 W and < 60W	20 s
≥ 60 W and < 100W	1 s

Table 9: FAST-PS-1K5 Input Power limits for modules with current full scale < 50 Amp

1.10.6 Crow-Bar

The energy stored in reactive loads – e.g. inductors – needs to be dissipated in order to protect the power supply from damages when, for example, the output stage gets suddenly disconnected.

A hardware circuit, with some voltage suppressors triggering Semiconductors, is present on each FAST-PS-1K5 model with different triggering thresholds. This circuit allows protecting the unit from unwanted and dangerous over-voltage conditions.

Being a hardware protection, the Crow-Bar is fixed for every model and the intervention thresholds are different based on the FAST-PS-1K5 maximum voltage rating.

The Crowbar can be triggered also by the user with a specific remote command.

1.10.6.1 *Crowbar Unwanted Triggering, Please Read*

In the case of a sudden absence of the main power, the power supply needs to be secured against current flowing from the magnet to the power supply, which means that crowbar needs to be triggered.

The crowbar is triggered when a critical voltage is detected:

FAST-PS-1K5 model	Critical Voltage
15-100	120 V
30-50	65 V
50-30 (both standard and 4Q-Ready)	45 V
100-15 (both standard and 4Q-Ready)	25 V

In the FAST-PS-1k5 the crowbar is an hardware feature, software activated, so power needs to be present to trigger the crowbar.

To overcome this problem, electrolytic capacitors are used to deliver current and so to open a circuit as an hardware feature, resulting in:

If the power supply has been ON for at least one minute and the power supply is turned off, the crowbar will be activated for about 5-10 minutes, so the load will be shorted.

It is possible to monitor the crowbar status thanks to a NC (if crowbar is not intervening) contact easily accessible (BNC C.B. connector in **Errore. L'origine riferimento non è stata trovata.**).

1.10.7 Quench Protection

This protection makes the FAST-PS-1K5 unit a perfect fit for superconducting magnet operation. The power supply continuously monitors the output voltage and current at the output of the power supply and as soon as a quench condition is recognized it turn the power supply off and trigger the crow-bar protection. Time windows and values are configurable by the user in order to perfectly match the connected specific load. The schematic operation of the protection is hereafter presented:

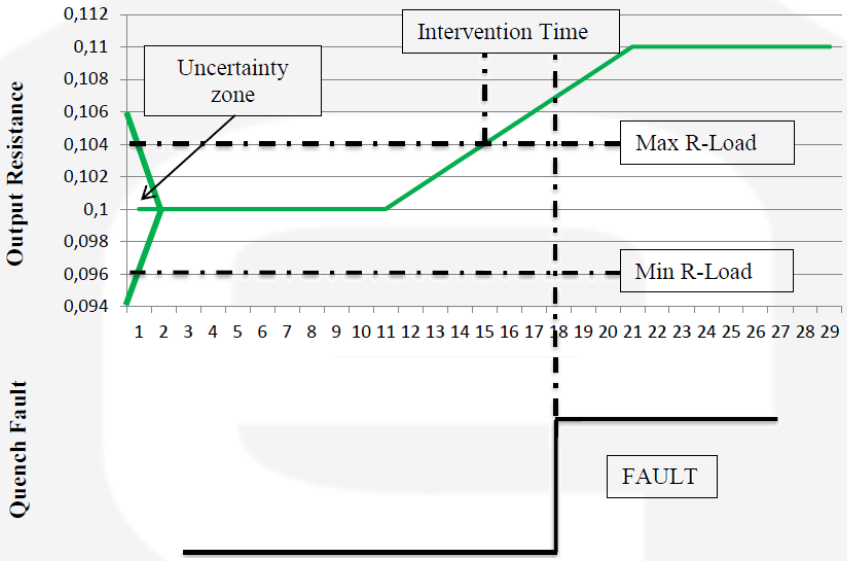


Figure 16: Quench detection Operation, Schematic

The power supply continuously monitors the load resistance, triggering a fault when a specific value is exceeded.

Refer to "Quench Detector Setting" in the "Remote Control Manual" for further information.

1.10.8 OVerTemperature - OVT

Internal monitoring of temperature is performed in different places inside the FAST-PS-1K5 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 set by experienced users. A reset fault operation needs to be executed on the status register of the FAST-PS-1K5 before turning the output off again.

1.10.9 DC-Link Undervoltage

The FAST-PS-1K5 is composed internally by a power AC-DC section cascaded with a DC-DC stage. The voltage generated by the AC-DC section is also called DC-Link and it is proportional to the maximum rated voltage for the specific model. Usually the DC-Link voltage is about 20% higher than the rated output of the FAST-PS-1K5.

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 regulate correctly or some faulty conditions have arisen so that a fault condition is generated.

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

1.11 Waveform

The FAST-PS-1K5 is able to act as a waveform generator both in current and in voltage regulation modes.

The waveform is stored internally in a point-by-point manner and it gives a lot of flexibility since the maximum number of points of the waveform can be defined as well as the sampling period (of the waveform execution).

The minimum time interval for the waveform execution period is rated at 0.1 ms = 100 µs, giving an equivalent output waveform update rate of 10 kHz.

In order to correctly execute the output waveform it is necessary to "tune" the PID regulator parameters of the power supply to the specific load (and have an adequate load at the output).

More information on the waveform feature can be found in the corresponding command section.

2. Installation

This chapter contains instructions for initial inspection and preparation for use.

2.1 Preparation for use

In order to be operational, the power supply must be connected to an appropriate AC source. The AC source voltage should be within the power supply specification. Do not apply power before reading **Section 2.2** and **2.7**. **Table 10** below, describes the basic setup procedure. Follow the instructions in **Table 2.1** in the sequence given to prepare the power supply for use.

Step	Checklist	Description
1	**Initial inspection**	Physical inspection of power supply
2	**Mounting**	Installing the power supply, ensuring proper ventilation
3	**AC Input Power Connection**	Connect the power supply to the AC source
5	**Load connection**	Wire size selection, Remote Sensing
4	**First switch-on**	Switch-on checkout procedure

Table 10: Installation checklist

2.2 Initial inspection

Prior to shipment this power supply was 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 such as broken switch or connectors and that the all panel and display are not scratched or cracked. Keep all packing material until the inspection has been completed. If damage is detected, compile the RMA form available to the CAEN ELS web site.

2.3 Mounting

The FAST-PS-1K5 module can be used either as a desktop unit or as a rack-mount device since the unit form factor is designed to be installed in a standard 2U 19-inch cabinet.

CAUTION

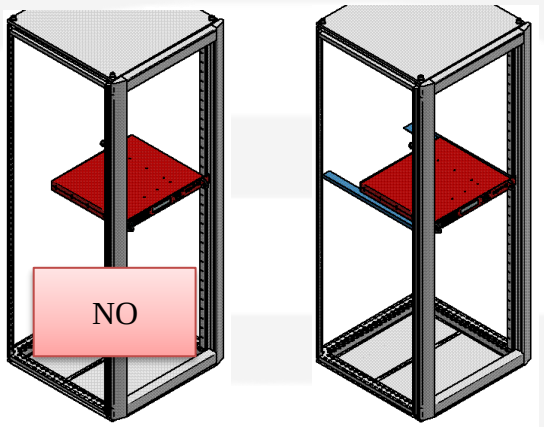
This power supply is fan cooled, the air intake is at the front panel and the exhaust is at the rear panel. Upon installation allow cooling air to reach the front panel ventilation inlets. Allow minimum 10 cm of unrestricted air space at the front and the read of the unit.

2.3.1 *Rack Mounting*

The FAST-PS-1K5 power supply series is designed to fit in a standard 19" equipment rack.

CAUTION

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



2.3.2 Desktop use

The FAST-PS-1K power supply series can be used as desktop unit but all the precaution must be chosen to avoid touching the output connectors because of the high energy source.

WARNING

Users shall protect output contacts by placing the FAST-PS-1K5 inside a closed rack or by restricting the access to the back side of the power supply.

2.4 AC Input Power Connection

The AC line input connector on the rear panel is a standard IEC 60320 C20 male inlet socket. Mains fuse holders are on the right side of the connector; required fuses characteristics for all the models are (**T20AL250V**):

- Size: **3AG**
- Current rating: **20 A**
- Blow characteristic: **Time delay**
- Breaking Capacity: **35 A**
- AC Voltage rating: **250V**

Figure 17: AC Power Line input socket

2.4.1 AC Source requirement

The FAST-PS-1K5 power supplies are designed for universal AC input range since it can operate with voltage from 90V to 240V and input frequency ranging of 50 Hz or 60 Hz. Installation Category shall be **CAT II** so maximum impulse voltage on the network mains must be below 2500 V.

Output power derating is required for low input voltage. Maximum output power derating is specified in the following Table.

Input Voltage Range [V]	Maximum Output Power [W]
180 – 240	1500
115	1450
100	1300
90	1100

Table 11: Installation checklist

2.4.2 AC Input Cord

All the FAST-PS-1K5 power supplies are directly shipped with the corresponding power cord (suitable for the destination country of the purchase). Power supply side

connector is a standard IEC 60320 C19 plug. Current rating for the connector is 20A. Wire size for detachable power supply cord, not longer than 2 m, shall be at least 2.50 mm^2 (suggested 4 mm^2). Wire size for fix installation shall be at least 2.5 mm^2.

WARNING

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!

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

Two factors must be considered for the selection of the wires:

- Current carrying capacity -> Cross section area
- Maximum wire length.
- Insulation voltage

Wire cross section and length

Wire size should be selected to enable voltage drop per lead to be less than 1 V at the maximum power supply current to prevent excessive output power consumption. Suggested wire size are listed in the following table:

Wire Cross Section Area [mm^2]	Resistivity [Ω/km]	Maximum Cable length in meters to limit voltage drop to be less than 2 V (1 V per lead)			
		15 A	30 A	50 A	100 A
2.5	8.21	8	-	-	-
4	5.09	13	6	-	-
6	3.39	19	9	-	-
10	1.95	34	17	10	-
16	1.24	53,5	26,5	16	8
25	0.795	83,5	42	25,1	12,5
35	0.565	118	59	35	17,5

Table 12: Wire selection

If **Table 12** values are used the maximum voltage to the load will be limited to:

FAST-PS nominal output voltage + Maximum compensation Voltage if Remote sensing is used – Cable Drop Voltage

Maximum compensation Voltage for all models is 0.5 V

For instance, the FAST-PS-1K5 100-15 that have a nominal output voltage of 15 V connected to a load at 8 meter of distance using 2x16 mm^2 cable can drive at maximum 15 + 0.5 - 2 = **13.5 V** at 100 A on the load.

FAST-PS-1K5 model with nominal output voltage < 60 V

For those models the load has to be connected directly to the Busbars using lug terminals for M6 screws. Always use spring washer and plane washer for a reliable connection.

Tightening torque shall be about 10 – 15 Nm.

FAST-PS 1K5 models from 60 V to 100 V nominal output voltage

FAST-PS 1K5 power supplies which have output voltage above 60 V shall be connected to the load with a double insulation cables which have voltage rating adequate to the maximum output voltage.

WARNING

Hazardous voltage exist at the outputs and the load connections. To protect personnel against accidental contact with hazardous voltage, ensure that the load and its connections have no accessible live parts. Ensure that the load wiring insulation ratings is greater than or equal to the maximum output voltage of the power supply.

For safety reason a safety cover box is required on the rear panel that is protecting the output screws terminals. Follow the below instruction for connection of the load cable to the power supply:

1. Insert the cable in the Spiral Gland **Figure 18**
2. Remove the O-Ring from the Gland if the cable diameter is bigger than 10 mm, **Figure 19**
3. Insert the cable into the Gland and the safety cover box; install the appropriate size Ferrule Terminal in the appropriate size wire, **Figure 20**
4. Strip the wires and connect the wires to the screw terminal **Figure 21**. Tightening torque shall be between 1.2 to 2.4 Nm
5. Fix the Safety cover to the rear panel using the four M3x10 mm screw provided with the safety cover, **Figure 22**. Tight the Cable Spiral Gland to hold the cable in position.

Figure 18: Cable in Spiral Gland

Figure 19: O-Ring from Cable Gland

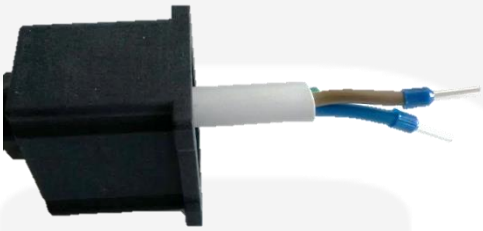


Figure 20: Ferrule Terminal crimp wire

Figure 21: Connect the wire to the output connector

Figure 22: Install the safety cover

2.6 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. Ensure that the connections at the load end are shielded to prevent accidental contact with hazardous voltages.

CAUTION

A short from **VSENS+** or **VOUT+** to **VSENS–** or **VOUT–** 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 **+.**

Use remote sense where the load regulation at the load end is critical. In remote sense the power supply will compensate for voltage drop on load wires. Refer to the power supply specification for maximum voltage drop on load wires. The voltage drop is subtracted from the total voltage available at the output.

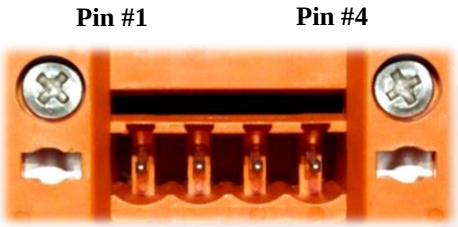


Figure 23: Remote Sensing Connector

The two remote sensing terminals are present on the corresponding connector on the rear panel:

Description	Pin	Name
VSENSE +	#1	+S
VOUT +	#2	+
VOUT –	#3	–
VSENSE –	#4	–S

Table 13: Remote sensing pin-out

The FAST-PS-1K5 is provided as **factory-default** with a mating connector already shorting the pins 1-2 and 3-4 in order to have direct sensing at the output terminals, **Figure 24**.

This configuration performs the remote sensing directly at the output connector of the power unit. Leaving +S and –S pins disconnected will make the power supply sense the output voltage directly at the output terminal connections. When using the remote sensing feature leave pins #2 (+) and #3 (–) disconnected.

Figure 24: Factory mating connector

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. 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 26.**
4. **For FAST-PS-1K5 with output voltage rating > 60 V,** fix the Safety cover to the rear panel using the four M3x10 mm screw, **Figure 25**.

Figure 25: Remote Sensing Cover

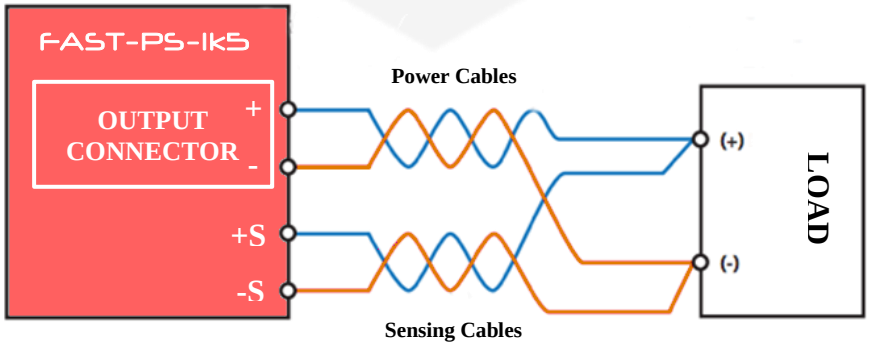


Figure 26: Example of Remote Sensing

2.7 Grounding Outputs

By factory default configuration the FAST-PS-1K5 minus 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 called Earth Fuse (E.F.) is accessible form the back panel. With this configuration 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 switching the power supply Off. Refer to Earth Fuse Fault and Earth Leakage Fault.

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.
When the FAST-PS is configured to operate in floating mode either the positive or 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 shall not float outputs more than ±200VDC above/below chassis ground.

2.8 Interlock and status Signals

The FAST-PS-1K5 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 27**).

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

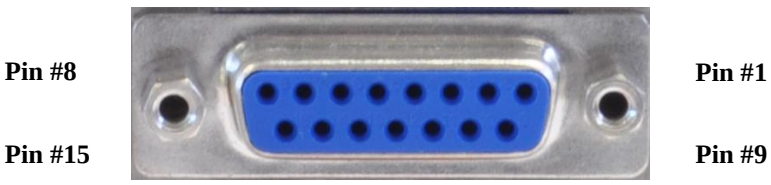


Figure 27: I/O Connector

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 14: 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 0.4A.
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, referred to ground, that pins can sustain is

48V. 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.

2.9 Parallel Operation

FAST PS 1K5 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.

CAUTION

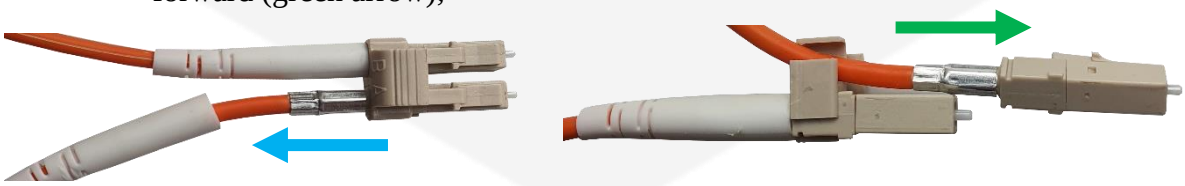
- Up to 4 PS can be connected in parallel configuration.
- Only PS of the same model and same firmware version can be connected in parallel configuration.
- Interlocks have to be connected only to the MASTER PS.

To configure correctly the PSs for the parallel mode follow the next steps:

- Remove the caps from the optical cable (**Figure 28**);

Figure 28

- 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 29**);

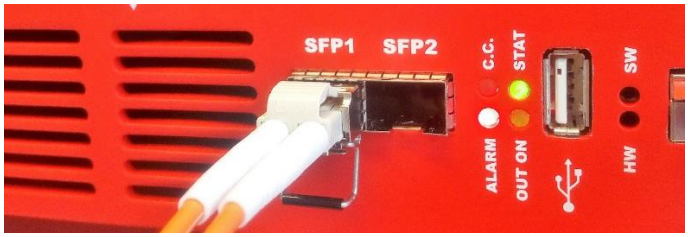


Figure 29

- Insert the SFP/SFP+ optical cables into the optical transceivers following the connections reported in **Figure 30** (orange lines);

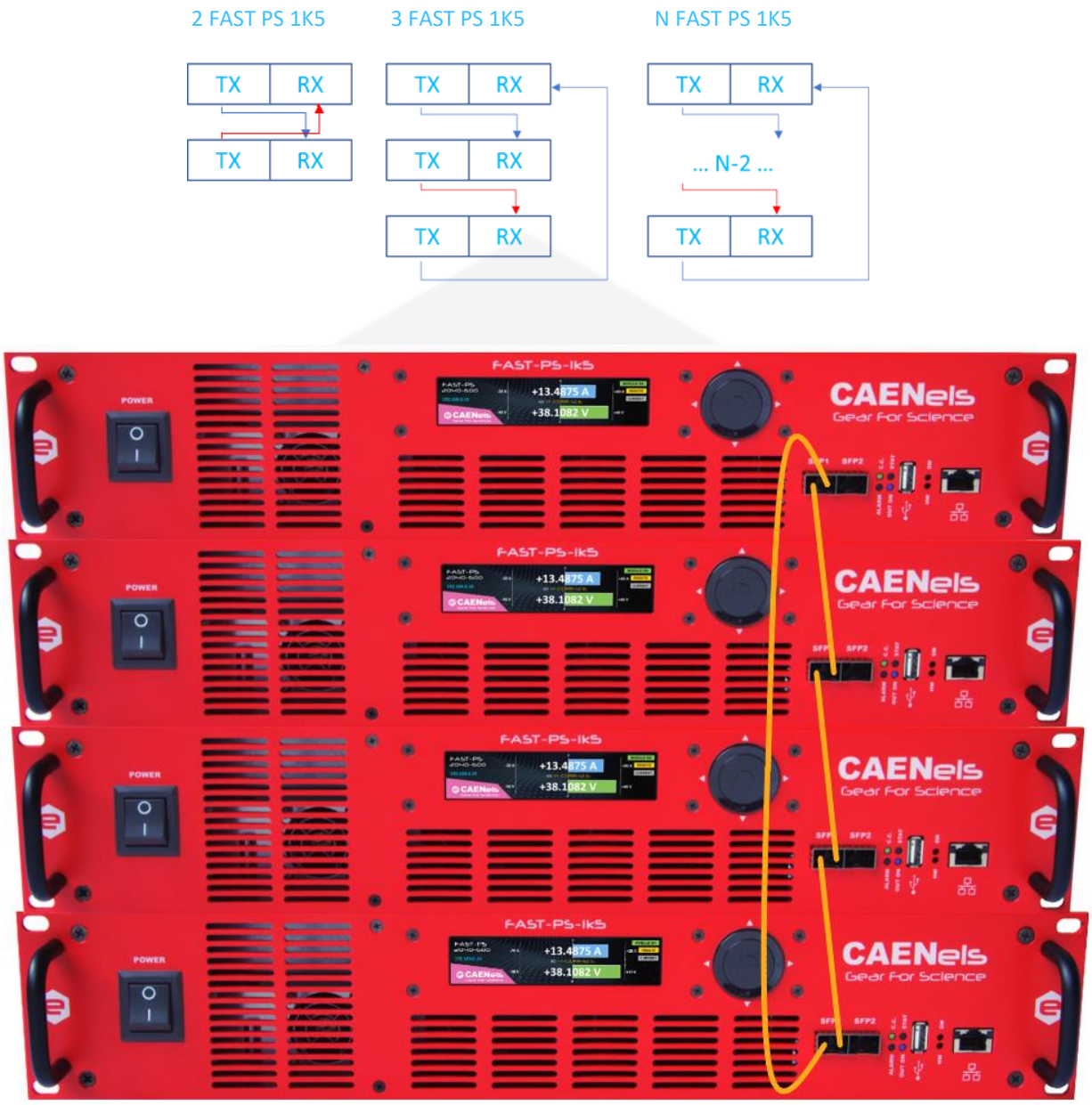


Figure 30: Parallel configuration, front panel.

- Connect PS output terminals with proper cables or busbars in order to put the PSs in parallel configuration following the connections reported in **Figure 31** (blue and red lines);

- Connect the crow-bar cables on the rear panel following the connections reported in **Figure 31** (orange lines);

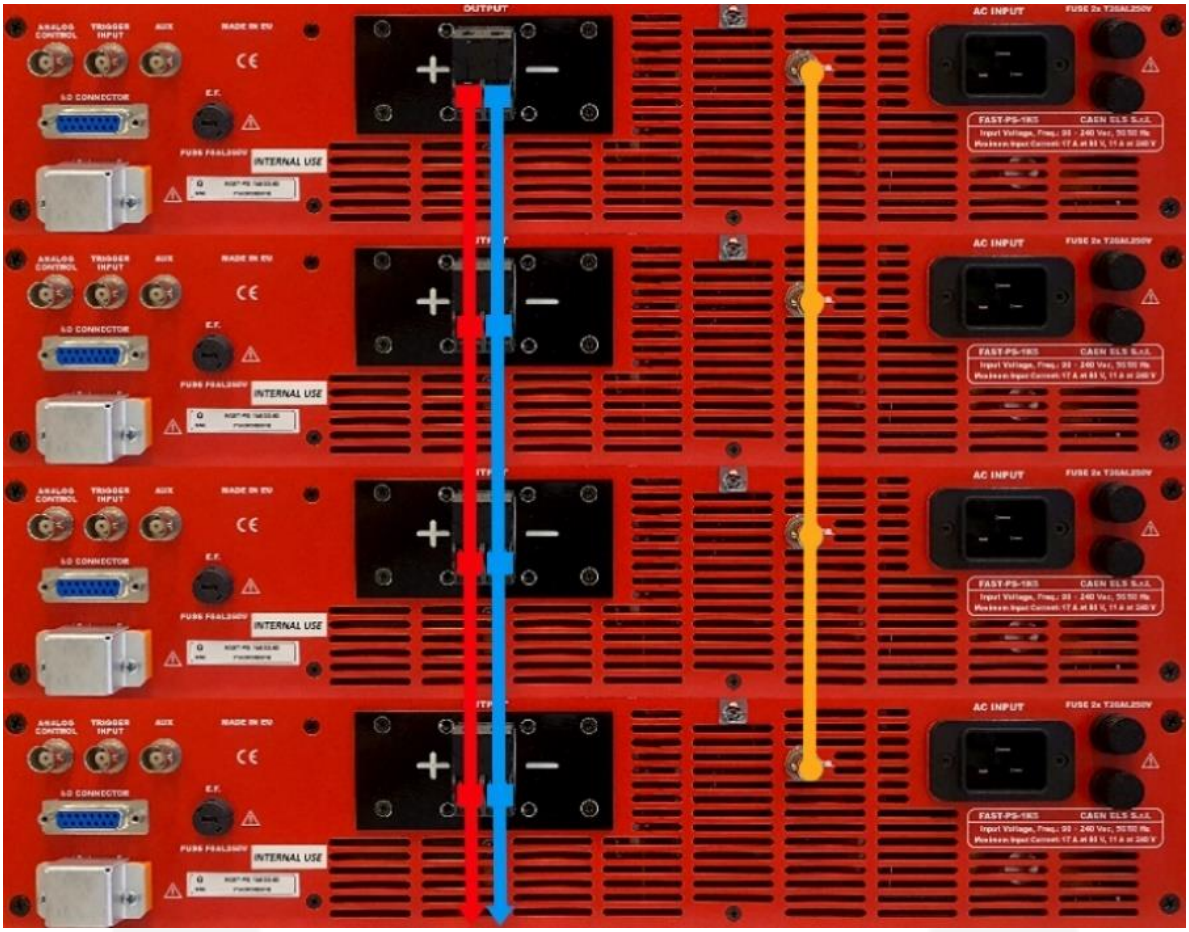


Figure 31: Parallel configuration, rear panel.

- The PSs designated as SLAVE must be configured as floating (use the remote control GUI; see **Figure 32). <u>When configuring a PS as floating, remove the earth fuse</u>** (see **Section 1.10.2**).

- The PS designated as MASTER can be configured as either floating or grounded, depending on the application. **<u>Leave the earth fuse in place when grounded and remove it when floating</u>**;

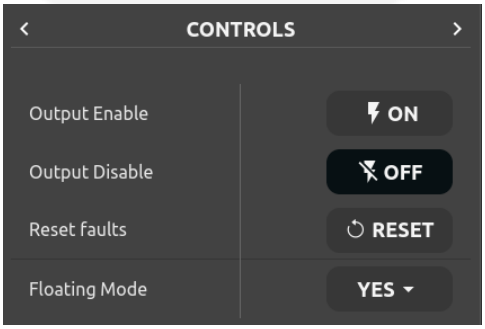


Figure 32: Floating mode.

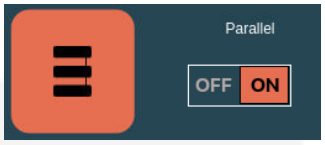
- Power-on the PSs;
- From the Local Control, enable parallel mode on all the PSs, assigning the Master role to the chosen one and the Slave role to all the others. To do this press Enter to the Navigation Switch and select:

Advanced →

Next Page →

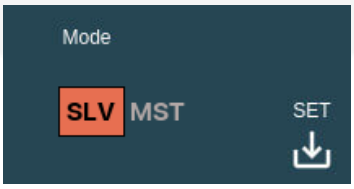
Parallel →

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.



Once these steps are completed the PSs operate as a single unit, which is the MASTER PS.

3. Local Control

This chapter describes the local control functionalities that are provided by the FAST-PS-1K5 power supply and some useful information on how to use it.

The power supply can work either in LOCAL mode or in REMOTE mode. The control mode (LOCAL or REMOTE) can be set on the configuration page of the local display. Please note that only readbacks are allowed from the remote communication interfaces when the unit is in LOCAL mode (i.e. settings are inhibited).

3.1 Navigation Switch

Each FAST-PS power supply module is equipped with a Navigation Switch on the front panel of the unit as shown in the following **Figure 33**:

Figure 33: Navigation switch

There are multiple actions that can be performed via this front navigation switch:

- Rotary encoder with central pushbutton (it will be referred as "Enter") ;
- Left and Right arrow pushbuttons;
- Back pushbutton.

3.2 Display

The colour display on the FAST-PS-1K5 power supply unit allows users to visualize information about the power supply status and to control the unit in order to use it locally. Screens and pages of the display can be navigated from the navigation switch though user friendly menus and sub-menus.

By default, the display will be automatically turned off after 30 minutes either 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; for more information, please refer to the "Remote Control Manual".

3.2.1 *Power-up*

The FAST-PS-1K5, 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 FAST-PS-1K5 home screen is the first loaded page upon power-up or power-cycling of the module (**Figure 34**) 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 34: Home Screen

The *Home screen* presents four indications on the bottom side of the Local Display (**Figure 35**) 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 35: 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 36)**.

Figure 36: 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 FAST-PS-1K5 power supply unit. There are four different options that can be selected as shown in **Figure 37**:

Figure 37: 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 FAST-PS-1K5 power supply unit. An example of a *Control Page* visualization is shown in **Figure 38**:

Figure 38: 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 39**:

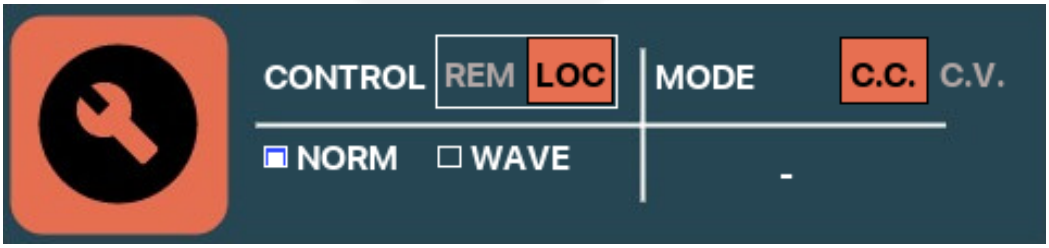


Figure 39: Config Page

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 40**:

Figure 40: 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 41**.

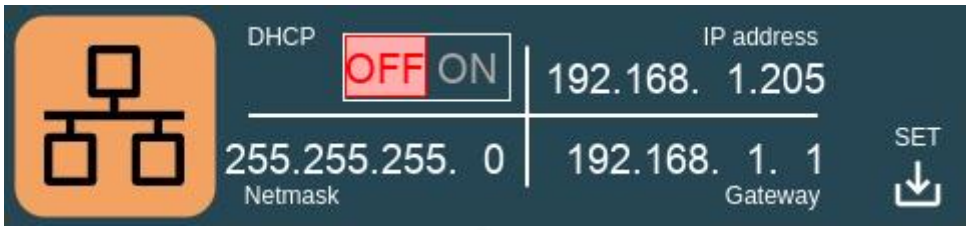


Figure 41: Network sub-page

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. Mechanical Dimensions

The mechanical dimensions of the FAST-PS-1K5 unit are hereafter presented in **Figure 42**:

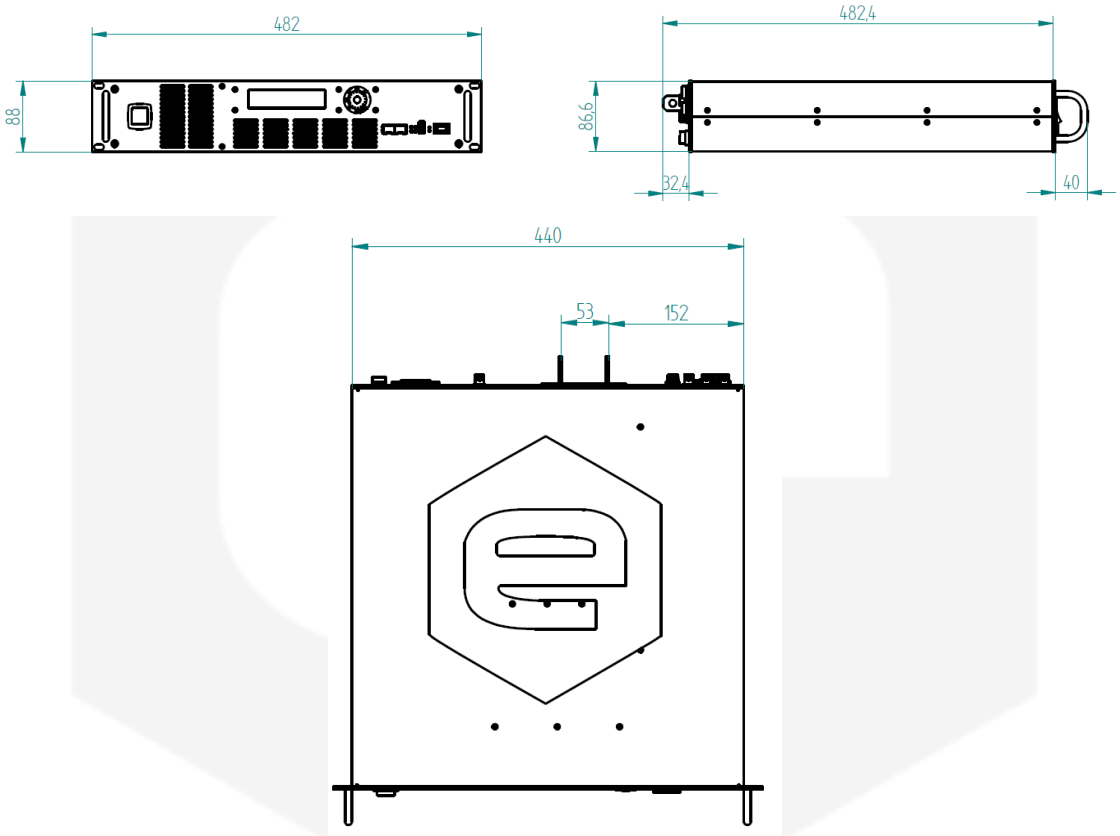


Figure 42: FAST-PS-1K5 Mechanical Drawings

5. Technical Specifications

The main technical specifications for the standard FAST-PS-1K5 models are hereafter presented:

Technical Specifications	FAST-PS-1K5			
	15-100	30-50	50-30	100-15
Output Current	±15 A	±30 A	±50 A	±100 A
Output Voltage	±95 V	±50 V	±30 V	±15 V
Output Power for 180 – 240 V_{AC}	1.500 W (for 180-240 VAC input) 1.450 W (for 115 VAC input) 1.300 W (for 100 VAC input) 1.100 W (for 90 VAC input)			
Topology	Bipolar			
Control Mode	Current (CC) and Voltage (CV) Control			
Floating Output	Up to 200 V			
Remote Sensing	Up to 500 mV			
Current Sensing	LEM High-Precision Current Transducers			
Analog Control Input	Yes			
Current Setting Resolution	150 µA	250 µA	400 µA	800 µA
Voltage Setting Resolution	1 mV	500 µV	300 µV	150 µV
Output Readback Resolution	24-bit			
Noise + Ripple (RMS)	< 0.01 % on resistive load < 0.005 % on 1 mH load			
Temperature Coefficient	< 0.0002 % / K (CC mode) < 0.005 % / K (CV mode)			
Long Term Stability (8 h)	< 0.0005 % / K (CC mode) < 0.005 % / K (CV mode)			
Accuracy RMS	< 0.05 % (CC mode) < 0.05 % (CV mode)			
Analog Bandwidth (-3 dB)	> 2 kHz			
Max Input power (Load to Power Supply)	< 50 W (continuous) < 100 W (20 s) ≥ 100 W (1 s)		< 25 W (continuous) < 50 W (20 s) ≥ 50 W (1 s)	

Control/Communication Interface	Ethernet TCP-IP SFP/SFP+			
Local Control	Color display with multi-function navigation switch			
External Signals	4 External Interlocks 2 Status signals – 1 magnetic and 1 solid state Trigger Input Analog Control Input Additional Configurable ADC Input			
Extra Features	Waveform execution Quench Protection Remote Firmware Update Linux OS on-board			
Mechanical Dimensions (L×W×H)	19" x 2U x 500 cm (*without connectors*)			
Input Nominal Voltage	100-240 V_{AC} 50-60 Hz			
Input Range Voltage	90-260 V_{AC} 50-60 Hz			
Weight typ.	13.5 kg	13.5 kg	14.3 kg	14.3 kg
Operating Temperature	0 … 45 °C			

Table 15: Standard Models Technical Specifications

The main technical specifications for the FAST4R100015 and FAST4R050030 models are hereafter presented:

Technical Specifications	FAST-PS-1K5	
	50-30 – 4Q Ready	100-15 – 4Q Ready
Output Current	±50 A	±100 A
Output Voltage	±30 V	±15 V
Output Power for 180 – 240 V_{AC}	1.500 W (for 180-240 VAC input) 1.450 W (for 115 VAC input) 1.300 W (for 100 VAC input) 1.100 W (for 90 VAC input)	
Topology	Stand-alone with the F1K5D4050030 Bipolar 4-Quadrant	Stand-alone With the F1K5D4100050 Bipolar 4-Quadrant
Control Mode	Current (CC) and Voltage (CV) Control	
Floating Output	Up to 200 V	
Remote Sensing	Up to 500 mV	
Current Sensing	LEM High-Precision Current Transducers	
Analog Control Input	Yes	
Current Setting Resolution	400 µA	800 µA
Voltage Setting Resolution	300 µV	150 µV
Output Readback Resolution	24-bit	
Noise + Ripple (RMS)	< 0.01 % on resistive load < 0.005 % on 1 mH load	
Temperature Coefficient	< 0.0002 % / K (CC mode) < 0.005 % / K (CV mode)	
Long Term Stability (8 h)	< 0.0005 % / K (CC mode) < 0.005 % / K (CV mode)	
Accuracy RMS	< 0.05 % (CC mode) < 0.05 % (CV mode)	
Analog Bandwidth (-3 dB)	> 2 kHz	
Max Input power (Load to Power Supply)	Stand-alone with F1K5D4050030 as per Table 15 1.500 W	Stand-alone with F1K5D4100050 as per Table 15 1.500 W
Control/Communication Interface	Ethernet TCP-IP SFP/SFP+	
Local Control	Color display with multi-function navigation switch	

External Signals	4 External Interlocks 2 Status signals – 1 magnetic and 1 solid state Trigger Input Analog Control Input Additional Configurable ADC Input
Extra Features	Waveform execution Quench Protection Remote Firmware Update Linux OS on-board
Mechanical Dimensions (L×W×H)	19" x 2U x 500 cm (*without connectors*)
Input Nominal Voltage	100-240 VAC 50-60 Hz
Input Range Voltage	90-260 VAC 50-60 Hz
Weight typ.	14.3 kg
Operating Temperature	0 … 45 °C

Table 16: FAST4R100015 and FAST4R100015 Models Technical Specifications

The main technical specifications for the custom FAST-PS-1K5 models are hereafter presented:

Technical Specifications	FAST-PS-1K5	
	FAST1K5C01XA	FAST1K5C02XA
Output Current	±10 A	±1 A
Output Voltage	±95 V	±15 V
Output Power for 180 – 240 V_{AC}	1.000 W (for 90-240 V_{AC} input)	15 W (for 90-240 V_{AC} input)
Topology	Bipolar	
Control Mode	Current (CC) and Voltage (CV) Control	
Floating Output	Up to 200 V	
Remote Sensing	Up to 500 mV	
Current Sensing	CLCS High-Precision Current Transducers	
Analog Control Input	Yes	
Current Setting Resolution	100 µA	10 µA
Voltage Setting Resolution	1 mV	150 µV
Output Readback Resolution	24-bit	
Noise + Ripple (RMS)	< 0.01 % on resistive load < 0.005 % on 1 mH load	
Temperature Coefficient	< 0.0002 % / K (CC mode) < 0.005 % / K (CV mode)	
Long Term Stability (8 h)	< 0.0005 % / K (CC mode) < 0.005 % / K (CV mode)	
Accuracy RMS	< 0.01 % (CC mode) < 0.01 % (CV mode)	
Analog Bandwidth (-3 dB)	> 2 kHz	
Max Input power (Load to Power Supply)	< 25 W (continuous) ≥ 25 W and < 50W (20 s) ≥ 50W (1 s)	
Control/Communication Interface	Ethernet TCP-IP SFP/SFP+	
Local Control	Color display with multi-function navigation switch	
External Signals	4 External Interlocks 2 Status signals – 1 magnetic and 1 solid state Trigger Input Analog Control Input Additional Configurable ADC Input	
Extra Features	Waveform execution Quench Protection	

	Remote Firmware Update Linux OS on-board			
Mechanical Dimensions (L×W×H)	19" x 2U x 500 cm (*without connectors*)			
Input Nominal Voltage	100-240 V_{AC} 50-60 Hz			
Input Range Voltage	90-260 V_{AC} 50-60 Hz			
Weight typ.	13.5 kg	13.5 kg	14.3 kg	14.3 kg
Operating Temperature	0 … 45 °C			

Table 17: Custom Models Technical Specifications

6. Full 4-Quadrant Operation - *optional*

The standard FAST-PS-1K5 modules are, by definition, true bipolar power converters. As the power stage is based upon a full H-bridge architecture, these modules are able to work in the positive current/positive voltage and negative current/negative voltage quadrants.

During transients, these modules are also able to work in the negative current/positive voltage and positive current/negative voltage quadrants, for a short period of time (they can sink up to 200W for 1 second, or up to 100W continuously).

For some application, such as superconducting magnets or battery testing, it is required to work continuously in sink mode for an un-defined period of time, thus operating the unit as a controlled load.

For this reason, CAEN ELS has designed an external unit (**optional**) which can be coupled to the FAST PS 1K5 (100A or 50A full scale models), which enables the system to work both as a source and as load – i.e. a full 4-quadrant system.

With such an upgrade, the FAST-PS-1K5, together with this external unit, is able to work continuously in all the 4 quadrants in a 19"-3U total space occupation (i.e. 19"-2U for the FAST-PS-1K5 unit and 19"-1U for the external dissipative unit).

Figure 43: FAST-PS-1K5 with Dissipative Unit

6.1 Installation

In order to access full 4-quadrant operation, the following items are mandatory:

- **FAST4R100015 or FAST4R050030**
- **F1K5D4100015 (for FAST4R100015) or F1K5D4050030 (for FAST4R050030)**

On the rear panel of the FAST4R100015/FAST4R050030 two connectors (light blue framed in the **Figure 44**) are dedicated to the connection to the F1K5D4100015/ F1K5D4050030:

Figure 44: FAST4R100015/FAST4R050030 connectors for F1K5D4100015/F1K5D4050030

In the same way, on the rear panel of the F1K5D4100015/F1K5D4050030 two connectors (light blue framed in the **Figure 45**) are dedicated to the connection to the FAST4R100015/FAST4R050030:

Figure 45: F1K5D4100015/F1K5D4050030 connectors for FAST4R100015/FAST4R050030

The cables needed for these connections are shipped with the F1K5D4100015/F1K5D4050030.

Once the connections are made, the system is ready for 4-Quadrant operation, and the user may control the FAST4R100015/FAST4R050030.

Here below the system ready to be used is presented:

Please note that when a full 4-Quadrant system is delivered, i.e. a FAST4R (100015 or 050030) coupled to a F1K5D4 dissipative unit (100015 or 050030), the FAST4R unit cannot be turned ON without the F1K5D4 connected to it.

In order to use the FAST4R unit ONLY (without the dissipative unit), memory cell #54 needs to be set to "0".

When the cell #54 is set to "1" (i.e. when the FAST4R is delivered coupled to a F1K5D4), the FAST4R has to be connected to the F1K5D4 unit in order to be turned ON.

If the above instructions are not followed a fault will happen ("DISS NOT OK"), and won't allow to be reset until the correct configuration will be used.

PLEASE REFER TO THE "REMOTE CONTROL MANUAL" FOR FURTHER INFORMATION.

6.2 Mechanical Dimensions

Here below the mechanical dimensions of the F1K5D4100015/F1K5D4050030 are reported (in mm):

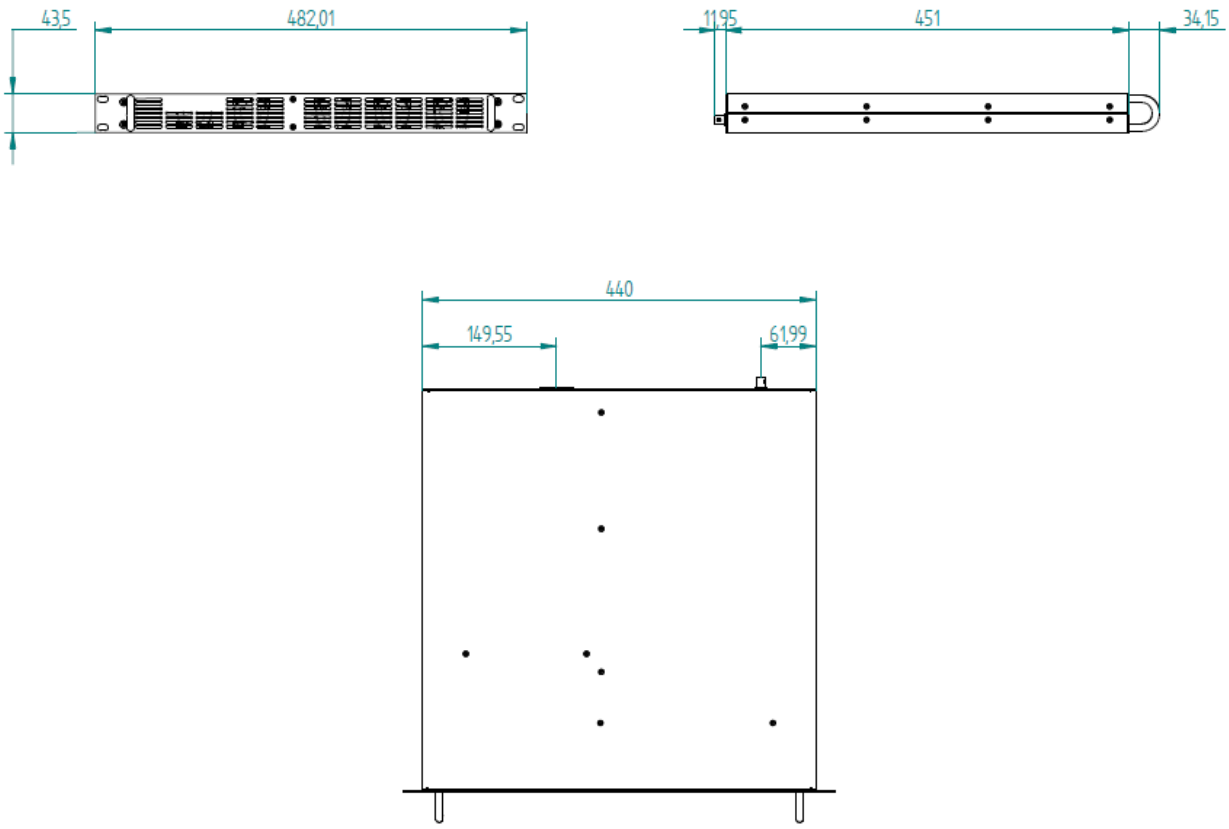


Figure 46: F1K5D4100015/F1K5D4050030 Mechanical Drawings

The mechanical dimensions of the FAST4R100015/FAST4R050030 are the same of the standard FAST-PS-1K5 instead (**Figure 42**).