Rev. 2 - February 28th, 2024

DT5215

Concentrator Board for FERS-5200

CAEN
Tools for Discovery

User Manual
UM8977

Purpose of this Manual

This document contains the hardware description of the DT5215 Concentrator Board for FERS-5200, its principle of operation as well as all the instructions to start using it in a correct and easy way. This User Manual is compliant with the Web Interface System Version 2023.12.1.1 (Software release: 2023.11.30.1, Firmware release: 23.12.01.01-2-2).

Change Document Record

Date	Revision	Changes
Apr 20th, 2023	00	Initial Release
Oct 20th, 2023	01	Updated Sec. **2**, **7.1**, **8.1.2**, **8.1.3**, **8.3.1**, **9.1** and Chap. **10**
Feb 28th, 2024	02	Updated Chap. **2** and Sec. **8.2.1**, **8.3.1.1**

Symbols, Abbreviated Terms and Notation

ADC	Analog-to-Digital Converter
ASIC	Application Specific Integrated Circuit
DAQ	Data Acquisition
DCR	Dark Count Rate
FERS	Front-End Readout System
FERS-CB	FERS Collector Board
FPGA	Field Programmable Gate Array
FSR	Full Scale Range
GEM	Gas Electron Multiplier
GUI	Graphical User Interface
HG	High Gain
HV	High Voltage
INL	Integral Non-Linearity
LG	Low Gain
LSB	Least Significant Bit
LVTTL	Low Voltage TTL
MUX	Multiplexer
OS	Operating System
PC	Personal Computer
PCB	Printed Circuit Board
PHA	Pulse Height Analysis
QD	Charge Discriminator
RF	Radio-Frequency
RMS	Root-Mean-Square
SiPM	Silicon Photo-Multiplier
TDC	Time to Digital Converter
ToA	Time of Arrival
TCP	Transmission Control Protocol
TD	Time Discriminator
ToT	Time over Threshold
USB	Universal Serial Bus
ZS	Zero Suppression

Reference Documents

[RD1] UM7946 – Janus User Manual

[RD2] UM9636 – Janus 5203 User Manual

[RD3] UM7945 - A5202/DT5202 User Manual

[RD4] UM9085 – A5203(B)/DT5203 User Manual

All CAEN documents can be downloaded at:
`www.caen.it/support-services/documentation-area`

Manufacturer Contacts

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Limitation of Responsibility

If the warnings contained in this manual are not followed, CAEN will not be responsible for damage caused by improper use of the device. The manufacturer declines all responsibility for damage resulting from failure to comply with the instructions for use of the product. The equipment must be used as described in the user manual, with particular regard to the intended use, using only accessories as specified by the manufacturer. No modification or repair can be performed.

Disclaimer

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Made in Italy

We remark that all our boards have been designed and assembled in Italy. In a challenging environment where a competitive edge is often obtained at the cost of lower wages and declining working conditions, we proudly acknowledge that all those who participated in the production and distribution process of our devices were reasonably paid and worked in a safe environment (while this is true for the boards marked ”MADE IN ITALY”, we cannot guarantee for third-party manufactures).

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Safety Notices

N.B. Read carefully the "Precautions for Handling, Storage and Installation document provided with the product before starting any operation.

The following HAZARD SYMBOLS may be reported on the unit:

	Caution, refer to product manual
	Caution, risk of electrical shock
	Protective conductor terminal
	Earth (Ground) Terminal
	Alternating Current
	Three-Phase Alternating Current

The following symbol may be reported in the present manual:

	General warning statement

The symbol could be accompanied by the following terms:

- **DANGER**: indicates a hazardous situation which, if not avoided, will result in serious injury or death.
- **WARNING**: indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**: indicates a situation or condition which, if not avoided, could cause physical injury or damage the product and / or the surrounding environment.

THIS DEVICE MUST NOT BE USED BY UNTRAINED PERSONNEL

CAUTION: Do Not Operate without Covers

TO AVOID ELECTRIC SHOCK OR FIRE HAZARD, DO NOT OPERATE THIS PRODUCT WITH COVERS OR PANELS REMOVED

CAUTION: Do Not Operate in Wet/Damp Conditions

TO AVOID ELECTRIC SHOCK, DO NOT OPERATE THIS PRODUCT IN WET OR DAMP CONDITIONS

CAUTION: Do Not Operate in an Explosive Atmosphere

TO AVOID INJURY OR FIRE HAZARD, DO NOT OPERATE THIS PRODUCT IN AN EXPLOSIVE ATMOSPHERE

CAUTION: Avoid potential hazards

USE THE PRODUCT ONLY AS SPECIFIED.
SERVICE PROCEDURES CAN BE PERFORMED BY QUALIFIED PERSONNEL ONLY

Please, contact the Techincal Support in case Service Procedures are required.

DO NOT OPERATE WITH SUSPECTED FAILURES.
IF YOU SUSPECT THIS PRODUCT TO BE DAMAGED, PLEASE CONTACT THE TECHNICAL SUPPORT

See Chap. **14** for the Technical Support contacts.

IT IS UNDER THE RESPONSIBILITY OF THE CUSTOMER AN IMPROPER USE OF THE PRODUCT

1 Introduction

FERS-5200 is a front-end readout system designed for the readout and time counting measurements of large detector arrays, such as SiPMs, multi-anode PMTs, Silicon Strip detectors, Wire Chambers, GEMs, Gas Tubes and others.
FERS-5200 is a distributed and scalable system, where each unit can be a small card or a desktop module that houses 64 or 128 channels. In most cases, the front-end is based on ASIC chips that allow for high density, cost effective integration of multi-channel readout electronics into small size and low power consumption.
FERS-5200 units can be used stand alone, without any additional hardware, or take part in a flexible and scalable network of units by means of TDlink high speed optical links, of which the DT5215 is the data collector board connected to the PC.

The DT5215 (also named FERS *concentrator board*) works as bridge and synchronization module for FERS-5200 units, providing data readout, synchronization between the units and broadcasting of commands (e.g. triggers, time resets, etc.). It houses 8 TDlink masters that make possible to manage up to 16 FERS-5200 units in daisy chain (ring) per TDlink, for a total of 128 FERS-5200 units, i.e. 8192 detector channels, connected.
For large readout systems, multiple DT5215 modules can be synchronized by means of a dedicated daisy chainable S-link (RJ45 connector), where the 1st module acts as a master, generating the sync clock and the time stamp reset for the other modules in the chain (**COMING SOON**).
The synchronization of one, or more, DT5215 with an external clock reference or GPS source is possible too (**COMING SOON**).
The synchronization procedure, that is performed once after the power up, runs through the S and TD links in order to synchronize the local time counters of each FERS unit. The procedure takes into account the propagation delay within the network to compensate for the time skew. Eventually, all the channels in the system will be synchronized, meaning that all the 64 bit local times (absolute time) are locked and aligned, with a fixed residual skew of less than one clock cycle (typically 6.4 ns). The skew, being stable, is then measured and compensated at software level. The affecting synchronization jitter is around 20 ps[1].

In addition to the TDlink connections, the DT5215 has 8 LEMO digital inputs, 8 LEMO digital outputs, and 2+2 LEMO configurable digital I/Os connected to the FPGA. Thanks to this, a trigger logic can be defined and distributed among different FERS-5200 units and concentrator boards, thus avoiding the trigger propagation delay introduced by the usage of the Tdlinks. Furthermore, the digital I/Os can propagate asynchronous common reference signals for timing measurements and other programmable functionalities.

The DT5215 board has an embedded ARM processor (Quad Core) running Linux®, and provides a 4 GB of DDR memory for local data storage.
The DT5215 can be connected to the Host computer through 1 Gb Ethernet, 10 Gb Ethernet or USB 3.0.
The control and configuration of FERS-5200 units connected to the DT5215 concentrator board is fully supported by the CAEN Janus software on Windows®and Linux®**[RD1] [RD2]**.

[1] Measured between two A5203 FERS-5200 units synchronized by means of a single DT5215 concentrator board.

2 Technical Specifications

OPTICAL I/Os	8 Small Form Factor Pluggable (SFP+) transceiver components for optical connection (3.125 Gbit/s). TDlink CAEN proprietary protocol allows for multi-board synchronization, slow control and data readout	
FRONT PANEL I/Os	**F IN** 8 digital Input LEMO connectors LVTTL signals accepted Z_{in} = 50 Ω **FA/FB** 2 digital Input/Output LEMO connectors: - NIM/LVTTL Input signals, Z_{in} = 50 Ω - LVTTL Output signals, must be terminated to 50 Ω	**F OUT** 8 digital Output LEMO connector LVTTL signals Must be terminated to 50 Ω
REAR PANEL I/Os	**RA/RB** 2 digital Input/Output LEMO connectors: - NIM/LVTTL input signals, Z_{in} = 50 Ω - LVTTL output signals, must be terminated to 50 Ω **CLK-IN/OUT** Input/Output LEMO connectors for the clock signal propagation: - AC Coupled LVTTL Input, Z_{in} = 50 Ω - AC Coupled LVTTL Output, must be terminated to 50 Ω	**SYNC IN/OUT** 2 RJ-45 connectors for the transmission of the clock/sync signal in case of multi-boards synchronization (**COMING SOON**)
FERS-5200 UNITS SYNCHRONIZATION VIA TDLINK	**Clock Propagation** Via the TDlink: - Clock jitter = 20 ps (Typ.) - Clock skew = fixed < 6.4 ns, depending on the optical fiber and daisy chain ring lengths. Measured and compensated at software level	**Acquisition Synchronization** Sync signal propagated through the TDlink for simultaneous reset of the timestamps. Broadcast commands executed at the same time in all boards for Run Start/Stop, Trigger, etc.
	NOTE: After the synchronization command, a fixed clock skew of less than 1 clock cycle (6.4 ns) is present between the first group of four TDlinks 0-1-2-3 and the second group, 4-5-6-7. The clock skew may vary from run to run.	
DT5215 BOARDS SYNCHRONIZATION VIA S-LINK	**Clock Propagation** - LEMO CLK-IN/-OUT (10.000 MHz, e.g. from GPS) - RJ45 SYNC IN/OUT (A line) - LEMO RA (15.625 MHz) The SYNC A clock signal can be propagated (OUTPUT ONLY) via the front/rear panel I/Os	**Acquisition Synchronization** (**COMING SOON**) Timestamp reset and Run Start/Stop through: - RJ45 SYNC IN/OUT (B/C lines) - SYNC via software command sent to all the boards that need to be synchronized - PPS, from GPS

COMMUNICATION INTERFACES	**USB** USB3.0 connector, type C MAX Readout Rate: 300 MB/s (tested with iPerf)	**Ethernet** • Ethernet connector, type RJ-45. Supports 1 Gbps connection to the PC MAX Readout Rate: 80 MB/s. • Optical connector, type SFP+. Supports 10 Gbps connection to the PC MAX Readout Rate: 280 MB/s.
FIRMWARE	Firmware can be upgraded via USB or Ethernet connection through the Web Interface	
SOFTWARE	**Readout SW** The data acquisition of FERS-5200 units via the DT5215 is controlled by the Janus software on Windows®and Linux®. **Web Interface** Board configuration and monitoring, Ethernet configuration.	
MECHANICAL	**Dimensions** 262 W $\times$ 66.2 H $\times$ 171.6 L mm^3 (without connectors)	**Weight** 1210 g
ENVIRONMENTAL	**Environment**: Indoor use **Operating Temperature**: 0°C to +40°C **Storage Temperature**: –10°C to +60°C **Operating Humidity**: 10% to 90% RH non condensing **Storage Humidity**: 5% to 90% RH non condensing **Altitude**: < 2000m **Pollution Degree**: 2 **Overvoltage Category**: II **EMC Environment**: Commercial and light industrial **IP Degree**: IPX0 Enclosure, not for wet location	
REGULATORY COMPLIANCE	**EMC** CE 2014/30/EU Electromagnetic compatibility Directive	**Safety** CE 2014/35/EU Low Voltage Directive
POWER REQUIREMENTS	Single power supply: +12 V. Accepted voltage range: MIN +7 V, MAX +15 V	
POWER CONSUMPTIONS	750 mA @ +12 V, i.e. $\approx$ 9 W	

Tab. 2.1: Specification table.

3 Packaging and Compliancy

The DT5215 is avaiable as a Desktop module housed in an aluminum case and two external stand up rubber frames, one on the front and one on the rear panel (module dimensions: 262 W $\times$ 66.2 H $\times$ 171.6 L mm^3).

The device is inspected by CAEN before the shipment, and it is guaranteed to leave the factory free of mechanical or electrical defects.

The content of the delivered package standardly consists of the part list shown in the table below **Tab. 3.1**.

	Part	Description	Qt
	DT5215	8 TDLink Concentrator for FERS-5200	x1
	Power supply cable and adapter	Standard C13 Power Supply chord L=2MT and AC-DC 12V-45W Adapter	x1
	Ethernet cable	2MTCat6 S-FTP Ethernet Cable	x1
	USB cable	USB-C to USB-A 3.1 GEN 1 cable, L=1.8MT	x1
	Documentation	UM8977 - DT5215 User Manual	-

Tab. 3.1: Delivered kit content.

3.1 Unpackaging Instructions

CAUTION: to manage the product, consult the operating instructions provided.

When receiving the unit, the user is strictly recommended to:

- Inspect containers for damage during shipment. Report any damage to the freight carrier for possible insurance claims.

- Check that all the components received match those listed on the enclosed packing list as in **Tab. 3.1**. (CAEN cannot accept responsibility for missing items unless any discrepancy is promptly notified.)
- Open shipping containers; be careful not to damage contents.
- Inspect contents and report any damage. The inspection should confirm that there is no exterior damage to the unit such as broken knobs or connectors and that the front panel is not scratched or cracked. Keep all packing material until the inspection has been completed.
- If damage is detected, file a claim with carrier immediately and notify CAEN service (see Chap. **14**).
- If equipment must be returned, carefully repack equipment in the original shipping container with original packing materials, if possible. Please contact CAEN service.
- If equipment is not installed when unpacked, place equipment in original shipping container and store in a safe place until ready to install.

DO NOT SUBJECT THE ITEM TO UNDUE SHOCK OF VIBRATIONS

DO NOT BUMP, DROP OR SLIDE SHIPPING CONTAINERS

DO NOT LEAVE ITEMS OR SHIPPING CONTAINERS UNSUPERVISED IN AREAS WHERE UNTRAINED PERSONNEL MAY MISHANDLE THE ITEMS

USE ONLY ACCESSORIES WHICH MEET THE MANUFACTURER SPECIFICATIONS

For a correct and safe use of the module, refer to Chap. **5** and **6**.

4 PID (Product Identifier)

PID is the CAEN product identifier, an incremental number greater than 10000 that is unique for each product. The PID is on a label affixed to the product (**Fig. 4.1**), and stored in an on-board non-volatile memory readable via the Web Interface (see Sec. **8.2**).

Fig. 4.1: PID location on DT5212 (the number in the picture is purely indicative).

5 Power Requirements

The CAEN DT5215 module is powered by an external 220 V-12 V AC/DC stabilized power supply. The AC/DC power supply is provided with the DT5215 board and included in the delivered kit, together with an adapter cable to easily connect the power supply jack to the DT5215 (see **Fig. 5.1**).

Fig. 5.1: AC/DC power supply adapter.

In **Fig. 5.2**, the datasheet of the AC/DC stabilized power supply included in the DT5215 kit is shown.

THE CORRECT FUNCTIONING AND SAFETY OF THE MODULE ARE NOT GUARANTEED IF THE POWER REQUIREMENTS SPECIFICATIONS ARE NOT FOLLOWED

Switchbox FRA030/045/050 Series

30-50W SINGLE OUTPUT AC/DC DESKTOP ADAPTOR

Features

- Universal input
- IEC320 receptacle 2P or 3P
- Optional output connector
- OVP, OCP, OPP, auto recovery
- CEC compliance

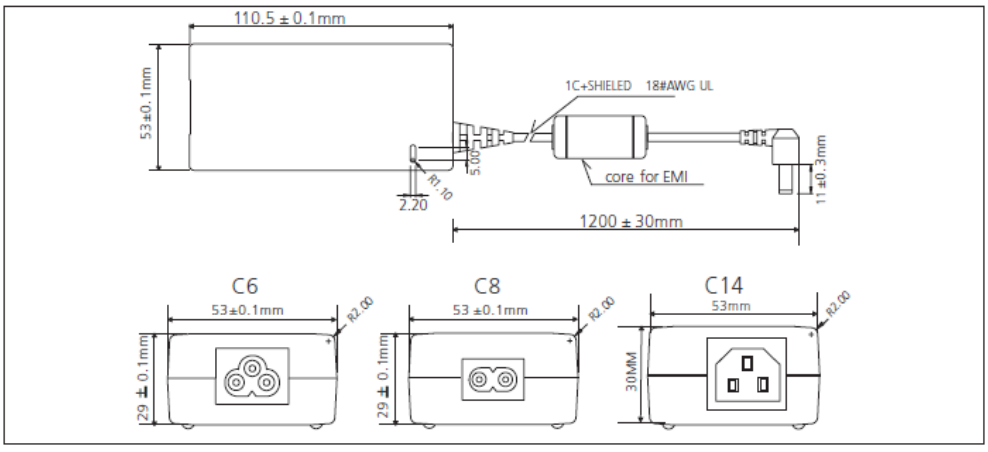
Specifications

INPUT	
Voltage range	100-240VAC.
Inrush current	40A at 115VAC / 80A at 230VAC max.
Dielectric withstand	Input/output 3,000VDC.
OUTPUT	
Output voltage	5-48V.
Ripple and noise	2% p-p max.
Load regulation	±5% max.
No load stand by power	<0.5W @ 230VAC.
Efficiency	>=85% for CEC requirement.
Hold up time	10mS at nominal line.
Protections	OCP, OVP, over power & short circuit.
GENERAL	
Std output connector	Dc barrel jack.
Std output cable/length	UL1185, #18AWG / 5 ft.
ENVIRONMENTAL	
Operating temperature	0°C to +40°C.
Storage temperature	–20°C to +85°C.
STANDARDS	
Safety standards	IEC/UL/EN60950-1, CE, CB.
EMC	EN55022 (CISPR 22) class B, FCC class B.

MODEL NUMBER	OUTPUT VOLTAGE	OUTPUT CURRENT	MAX WATTS	CEC*
FRA030-S05-X	5~7 V	6.00~4.30 A	30 W	
FRA045-S09-X	7~9 V	6.00~5.00 A	45 W	IV
FRA045-S12-X	12~15 V	3.75~3.00 A	45 W	IV
FRA045-S15-X	15~18 V	3.00~2.50 A	45 W	IV
FRA045-S24-X	18~24 V	2.50~1.88 A	45 W	IV
FRA050-S12-X	12~15 V	4.17~3.33 A	50 W	IV
FRA050-S15-X	15~18 V	3.33~2.87 A	50 W	IV
FRA050-S24-X	18~24 V	2.78~2.08 A	50 W	IV
FRA050-S36-X	30~36 V	1.67~1.38 A	50 W	IV
FRA050-S48-X	40~48 V	1.25~1.04 A	50 W	IV

*CEC compliance model provide under customer's request.
*CEC compliance model standby power (@ no load) <0.5W.

Note:
X = Inlet type code
X = 4, IEC320 C14 X = 6, IEC320 C6 X = 8, IEC320 C8



powerbox
www.powerbox.info
20081029

Fig. 5.2: AC/DC power supply provided with the DT5215 module.

6 Environmental Operating Conditions

The DT5215 concentrator board can operate in the temperature range of 0°C ÷ +40°C. Proper airflow fans are mounted on the device to ensure an adequate heat dissipation. CAEN recommends to occasionally check the status of the fans: lint, dust, and other foreign matter can block or limit the airflow.

THE BOARD MUST BE PROPERLY VENTILATED

The User must pay attention to not block the fans. The User must provide proper cooling with an external fan if the device is used in an enclosure or if it is placed in a setup with poor airflow.
An excessive temperature reduces the performance and the quality of the measurements and can also damage the device.

If the device is stored in cold environment, the user is recommended to check for water condensation before power on.

The device has not been tested for radiation hardness. High energy particles can be source of errors and can damage the FPGA. If used in strong proton or neutron beams, arrange proper shielding, or remote the sensors with a custom cable.

7 Panels Description

Fig. 7.1: DT5215 front panel view.

Fig. 7.2: DT5215 front panel view.

Fig. 7.3: DT5215 lateral view.

Fig. 7.4: DT5215 top view.

Fig. 7.5: DT5215 back panel view.

7.1 Front Panel

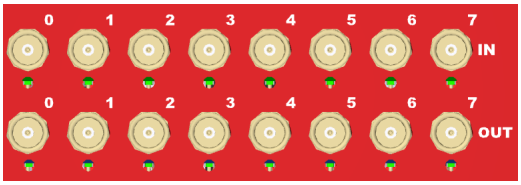
POWER ON LED

PWR (GREEN): The led turns on as soon as the board has been powered on

DIAGNOSTIC LEDs

RDY (ORANGE): Indicates that the board is ready to operate. It turns on at the end of the boot

DIGITAL I/Os - F-IN/F-OUT



FUNCTION
Digital software programmable input/output connectors. From left to right, from top to bottom: F-IN (0,...,7), F-OUT (0,...,7)

ELECTRICAL SPECS
Signal level: LVTTL (input, 50 Ω terminated), LVTTL (output, requiring 50 Ω termination)

MECHANICAL SPECS
Series: LEMO 00
Type: EPL 00 250 NTN
Manufacturer: LEMO

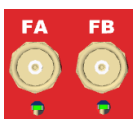
TDLINK

FUNCTION
Optical link connector for data readout and flow control in multiboard configuration. Daisy chainable. Compliant with optical fibers 50/125 µm OM2 and OM3 (back-compliant with 62.5/125 µm OM1) cable featuring LC connectors on both sides.

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
Series: SFP Transceivers
Type: FTLF8524P2BNV (LC connectors)
Manufacturer: FINISAR

MULTI-PURPOSE I/Os - FA/FB



FUNCTION
Digital software programmable input/output connectors (see Sec. **8.3**)

ELECTRICAL SPECS
Signal level: LVTTL/NIM (input, 50 Ω terminated),
LVTTL (output, requiring 50 Ω termination)

MECHANICAL SPECS
Series: LEMO 00
Type: EPL 00 250 NTN
Manufacturer: LEMO

7.2 Rear Panel

POWER ON BUTTON

FUNCTION
Power ON/OFF button

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
N.A.

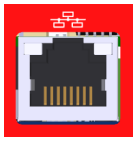
DC INPUT

FUNCTION
Input connector for DC input mating to a CLIFF$_F$C681465P adapter connector (already inserted in the DT5215 kit)

ELECTRICAL SPECS
Typ. Input voltage: +12 V DC

MECHANICAL SPECS
Manufacturer: CLIFF
Internal number: FC681465P

ETHERNET PORT



FUNCTION
1 Gb Ethernet connector for DT5215 configuration and data readout

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
Series: RJ45 female connector

USB PORT

FUNCTION
USB 3.0 connector for DT5215 configuration and data readout

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
Series: USB connectors
Connector type: USB 3.1 Type C
Manufacturer: Würth Elektronik
Internal number: 632712000011

FACTORY

FUNCTION
Reset button

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
N.A.

STORAGE

FUNCTION
t.b.d.

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
t.b.d.

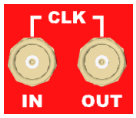
GPS

FUNCTION
Source of PPS (**COMING SOON**)

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
Series: DB9 Male Type Connector
Type: CD5125PA100
Manufacturer: CviLux

CLK I/Os



FUNCTION
Connectors for clock signal propagation

ELECTRICAL SPECS
Signal level: LVTTL (10 MHz frequency)

MECHANICAL SPECS
Series: LEMO 00
Type: EPL 00 250 NTN
Manufacturer: LEMO

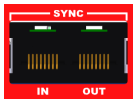
10 GbE PORT

FUNCTION
10 Gb Ethernet connector for DT5215 configuration and data readout

ELECTRICAL SPECS
N.A.

MECHANICAL SPECS
Series: SFP+ Transceiver
Type: AFBR-710DMZ
Manufacturer: AVAGO

SYNC I/O



FUNCTION
RJ45 connectors used to propagate synchronization signals between DT5215 boards (**COMING SOON**)

ELECTRICAL SPECS
Signal level: LVDS

MECHANICAL SPECS
Series: RJ45 female connector

MULTI-PURPOSE I/Os - RA/RB

FUNCTION
Digital software programmable input/output connectors (see Sec. **8.3**)

ELECTRICAL SPECS
Signal level: LVTTL/NIM input, (50 Ω terminated), LVTTL output (requiring 50 Ω termination)

MECHANICAL SPECS
Series: LEMO 00
Type: EPL 00 250 NTN
Manufacturer: LEMO

8 Getting Started

The aim of this chapter is to guide the user through the installation of the DT5215 board, the navigation in the Web Interface (WI) and the connection of the FERS-5200 units to the DT5215 via the WI or the Janus software **[RD1][RD2]**. The basic instructions necessary to get familiar with the board and the software are also provided in the other FERS-5200 User Manuals **[RD3] [RD4]**.

8.1 Hardware Installation

8.1.1 Installation and Power ON/OFF

To properly install and power ON/OFF the device the user is kindly suggested to follow the instructions below:

- Connect the AC/DC adapter to the DC power jack.
- Connect the power supply to the +12V connector of the DT5215.
- Press the ON/OFF button on the board's back panel (see Sec. **7.2**). When pressed, the PWR green LED turns on.
- After the initialization process (that may take around half a minute) the PWR and RDY front panel LEDs are on, as shown in **Fig. 8.1**).

Fig. 8.1: DT5215 front panel status at power ON.

- To power OFF the DT5215, press the PWR button on the module back panel (see **Fig. 7.5** of Chap. **7**).

8.1.2 FERS-5200 Units Connection

FERS-5200 units can be connected via optical fibers to the DT5215's TDlinks. Each TDlink can be connected to a single FERS-5200 unit or to a daisy chain of units, for a maximum of 16 units connected to a single TDlink (see **Fig. 8.2**). The synchronization of FERS-5200 units via the DT5215 is described in Sec. **9.1**.

Note: The compliant optical fibers are 50/125 µm OM2 or OM3 (back-compliant with 62.5/125 µm OM1) cables featuring LC connectors on both sides.

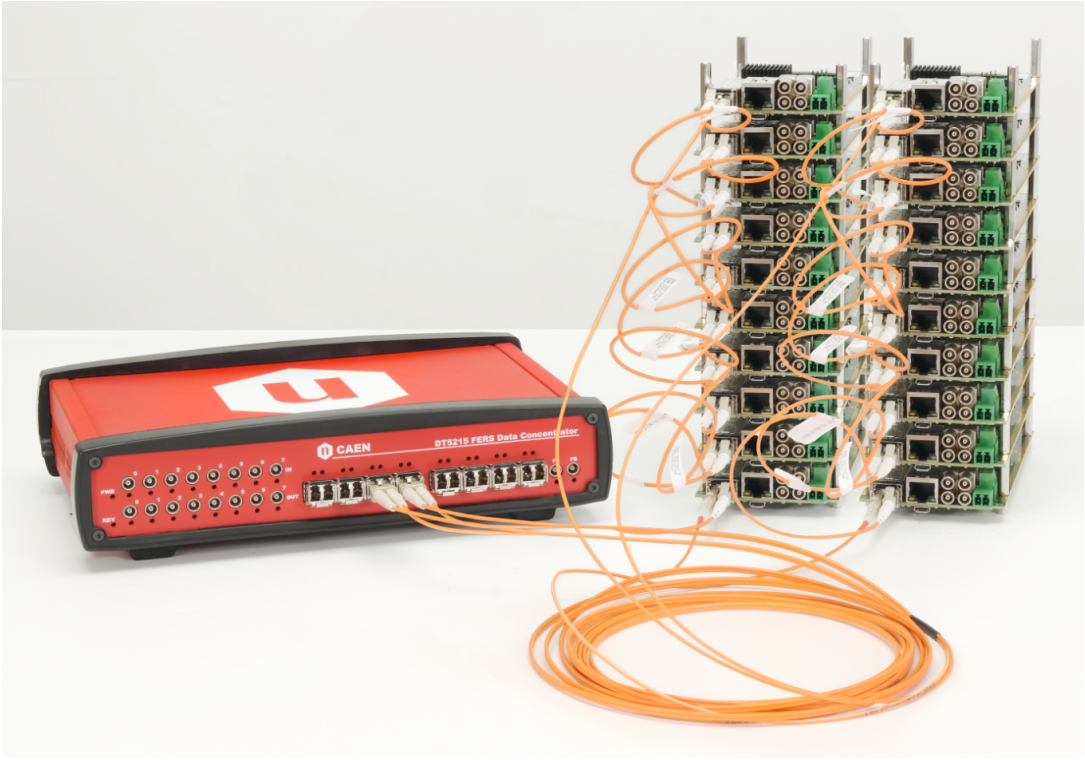


Fig. 8.2: Example of FERS5200 units connected to the DT5215.

8.1.3 Reset

The FACTORY button on the back panel allows to reset the DT5215 device (see **Fig. 8.3**).

1. *Soft Reset:* By pressing the FACTORY button for around 10 seconds before release, and power cycling the device after the F-IN/OUT LEDs blink for 3 times, a basic reset takes place: all the active I/Os are disabled and the IP addresses are restored to the original ones; the FPGA and the embedded CPU are reset. This type of reset is usually performed to restore the IP addresses.
2. *Hard Reset:* If the FACTORY button is pressed just before and during the power ON of the device (without releasing it), a complete factory reset is preformed: the FPGA and CPU are reset to their factory configuration. In order to make the factory reset effective,the user needs to maintain pressed the FACTORY button until the F-OUT LEDs turn on one by one, and then start blinking all together. Afterwards, a power cycle of the device is needed. This type of reset is mainly used for downgrading the board firmware and software, if new ones have been installed on the board.

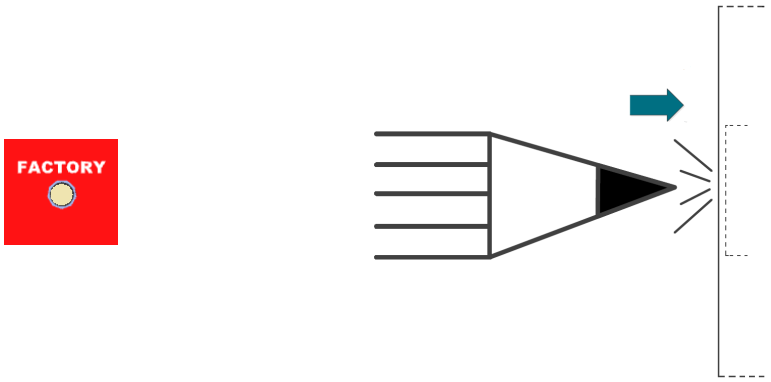


Fig. 8.3: Board Reset

8.2 Hardware Detection

The physical connection of the Concentrator Board to the PC is done via Ethernet (1 Gbit or 10 Gbit) or via USB. The configuration of the Ethernet and USB connections are described in the following lines.

8.2.1 Ethernet Connection to the PC

8.2.1.1 1 Gigabit Ethernet

The 1 GbE connection to the DT5215 is a standard TCP/IP connection, performed as point-to-point connection between the host PC and the module[1] or via a LAN network (using the DHCP protocol).

The default IP Address of DT5215 for the 1 GbE connection is: **192.168.50.125**.

In order to properly configure the network for the first point-to-point Ethernet connection the user should follow the instructions below:

1. Connect the Ethernet cable from the DT5215 to the PC.
2. Configure the Ethernet network of the PC.
   a. Open the path:
   `Control Panel - Network and Internet - Network and Sharing Center`
   as in **Fig. 8.4**.
   b. Click on ”Change adapter settings”.
   c. Right click on the Ethernet icon and select ”Properties”, as in **Fig. 8.5**.
   d. Click on ”Internet Protocol Version (TCP/IPv4)” and select ”Properties”, as in **Fig. 8.6**.
   e. Copy the configuration in **Fig. 8.7** on the ”Internet Protocol Version (TCP/IPv4) Properties” window and press ”OK”.

[1] The connection can be done using a PC with a Gigabit Ethernet port, a switch or a crossed cable. The connection is not guaranteed using a PC with a 10/100T Ethernet port.

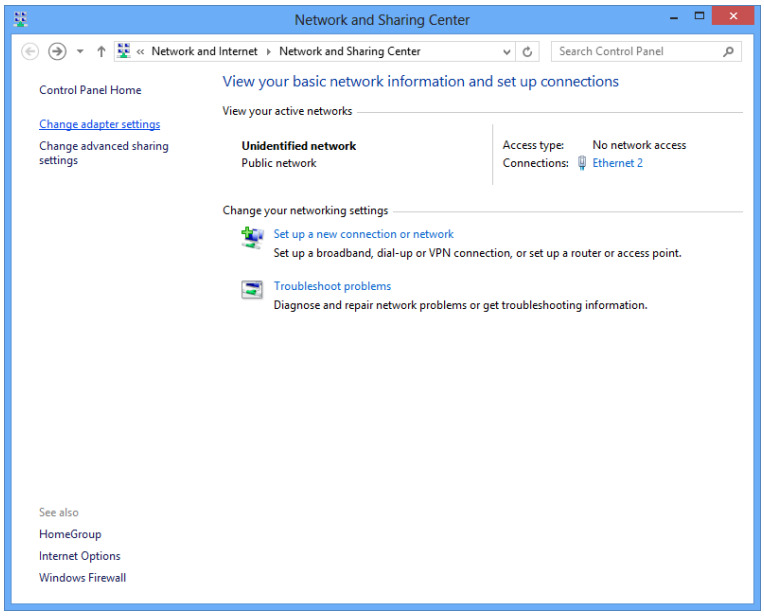


Fig. 8.4: The Network and Sharing Center window.

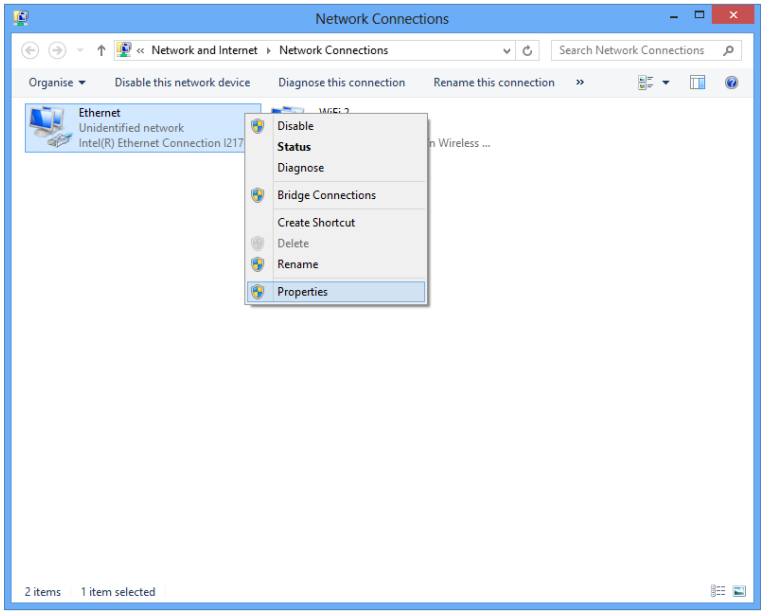


Fig. 8.5: Property window of the Ethernet network.

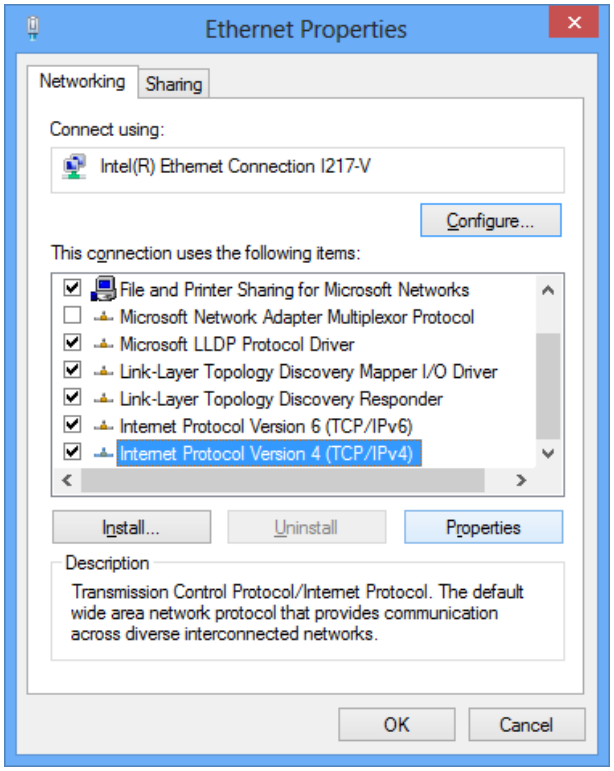


Fig. 8.6: Property window of the ”Internet Protocol Version (TCP/IPv4)”.

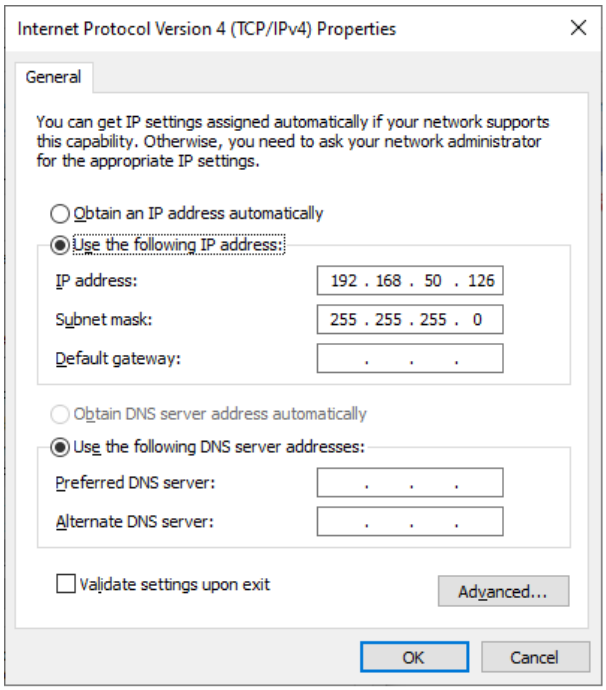


Fig. 8.7: "Internet Protocol Version (TCP/IPv4) Properties" window.

If the IP Address is already in use, try with another one of the same Subnet mask.

3. The user can test if the communication between the PC and the DT5215 is established by opening the "Command Prompt" and typing the same command as in **Fig. 8.8**. If the communication is correctly established, the output message should be similar to that in **Fig. 8.8**.

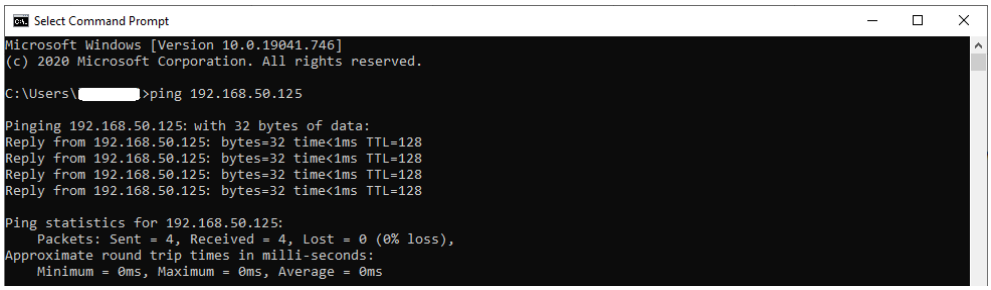


Fig. 8.8: Command prompt window with the command for testing the communication.

In order to configure the DT5215 for a DHCP connection, the user should follow the instructions below:

1. Perform a point-to-point connection between the PC and the DT5215.
2. Select the DHCP connection in the Web Interface (see **Fig. 8.20**).
3. Connect the DT5215 to the LAN and reboot it.
4. The connection can be tested as in **Fig. 8.8**, this time using the IP address assigned via the DHCP.

8.2.1.2 10 Gigabit Ethernet

The 10 GbE connection to the DT5215 is a standard TCP/IP connection, performed as point-to-point connection between the host PC and the module.

Note: The connection requires the installation of a 10 GbE network adapter on the host PC, and the usage of compliant SFP+ transceiver and optical fiber cable.

The default IP Address of DT5215 for the 10 GbE connection is: **192.168.250.125**.

In order to properly configure the network for the first point-to-point Ethernet connection the user should follow the instructions below:

1. Enable the 10 Gbps Ethernet connection in the Settings Tab of the Web Interface (refer to Sec. **8.3** and **8.3.1.3**) by previously connecting to the DT5215 via 1 GbE.
2. Connect the optical fiber cable from the DT5215 to the PC.
3. Configure the 10 Gb Ethernet network of the PC, as described in the previous subsection.
4. Set the MTU to 9000 (default setting in the Web Interface, see Sec. **8.3.1.3** for further information).
5. Check the connection to the DT5215 as described in the previous subsection. This time, the IP address to use is the 192.168.250.125.

8.2.2 USB Connection to the PC

The USB connection of the DT5215 has an Ethernet network interface (USB gadget implementation). The connection to the PC is configured as in the case of the Ethernet connection, but using a different IP address.

The default IP Address for the USB connection of the DT5215 is: **172.16.0.11**.
In case of Linux OS, the IP Address for the USB3.0 connection of the DT5215 is: **172.16.1.11**.

In order to properly configure the network for the first USB connection, the user should follow the instructions below:

1. Connect the USB cable from the DT5215 to the PC.
2. A new Ethernet connection should appear in the Device Manager, as shown in **Fig. 8.9**.
3. Configure the new Ethernet network.
    a. Open the path:
    `Control Panel - Network and Internet - Network and Sharing Center`
    as in **Fig. 8.10**.
    b. Click on ”Change adapter settings”.
    c. Right click on the Ethernet icon and select ”Properties”, as in **Fig. 8.11**.
    d. Click on ”Internet Protocol Version (TCP/IPv4)” and select ”Properties”, as in **Fig. 8.12**.
    e. Copy the configuration in **Fig. 8.13** on the ”Internet Protocol Version (TCP/IPv4) Properties” window and press ”OK”. If the IP Address is already in use, try with another one of the same Subnet mask.

The user can test if the communication between the PC and the DT5215 is established by opening the ”Command Prompt” and typing the same command as in **Fig. 8.14**. If the communication is correctly established, the output message should be similar to that in **Fig. 8.14**.

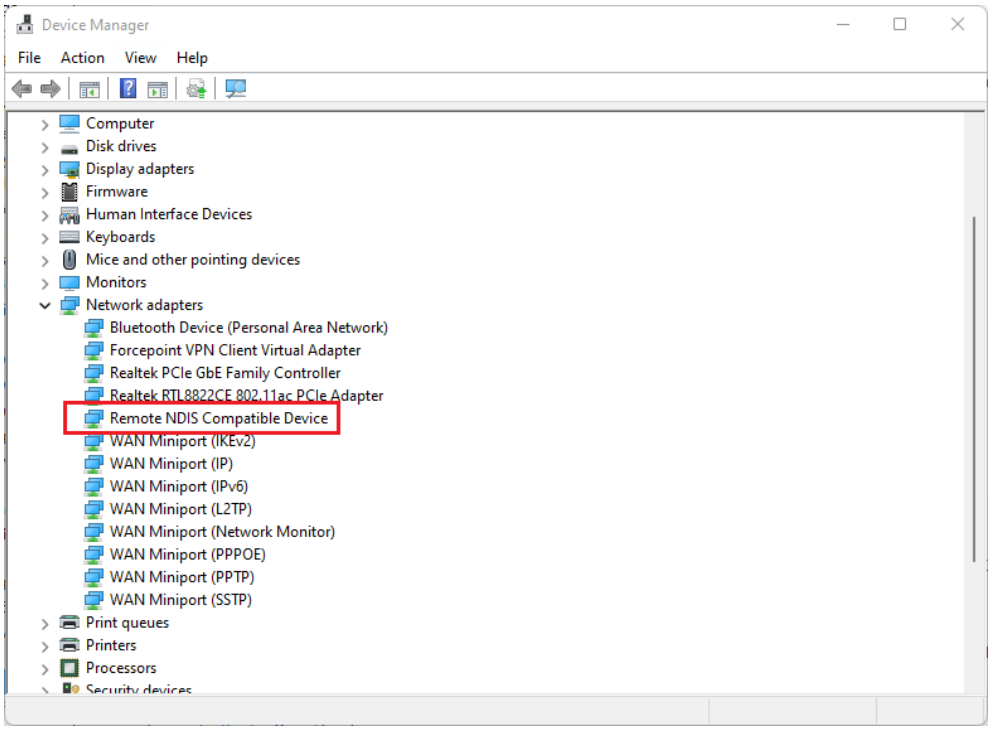


Fig. 8.9: Device manager window showing the USB gadget connection.

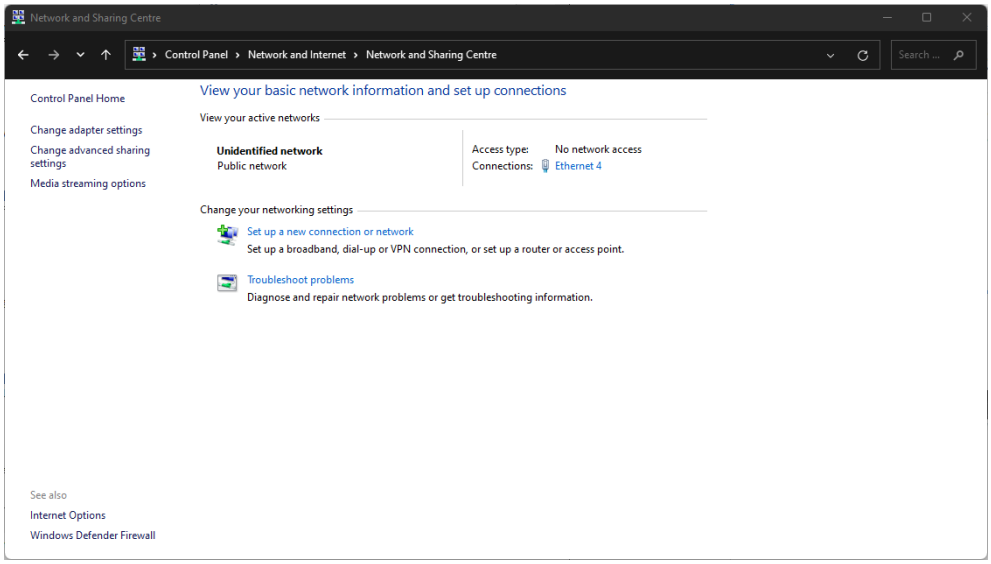


Fig. 8.10: The Network and Sharing Center window.

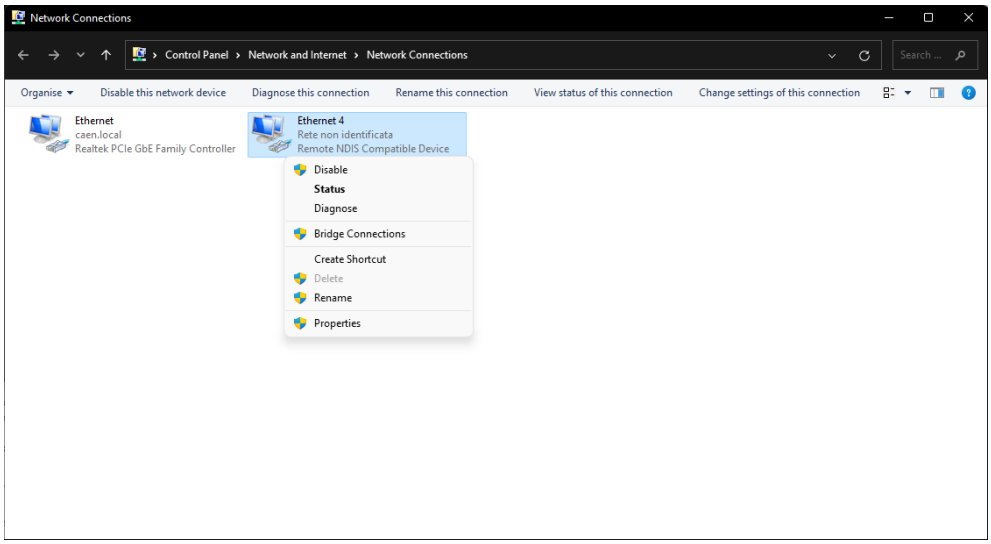


Fig. 8.11: Property window of the Ethernet network.

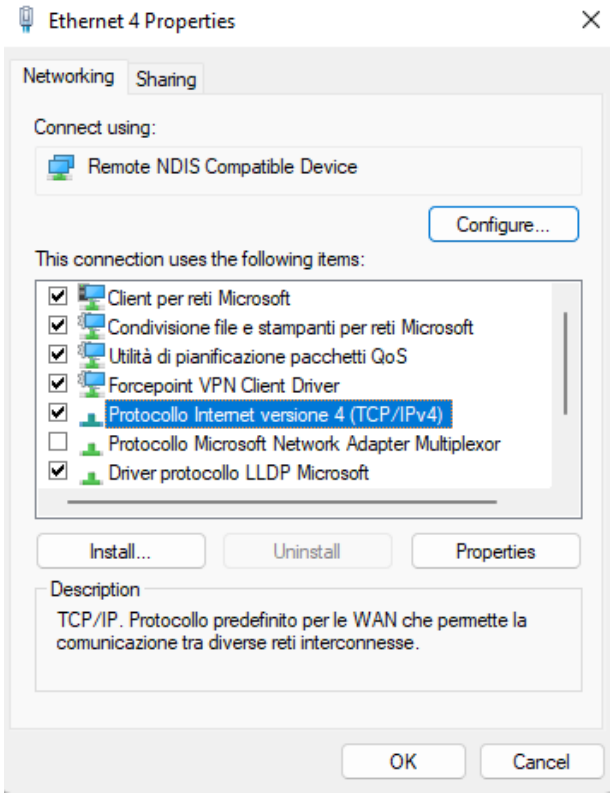


Fig. 8.12: Property window of the ”Internet Protocol Version (TCP/IPv4)”.

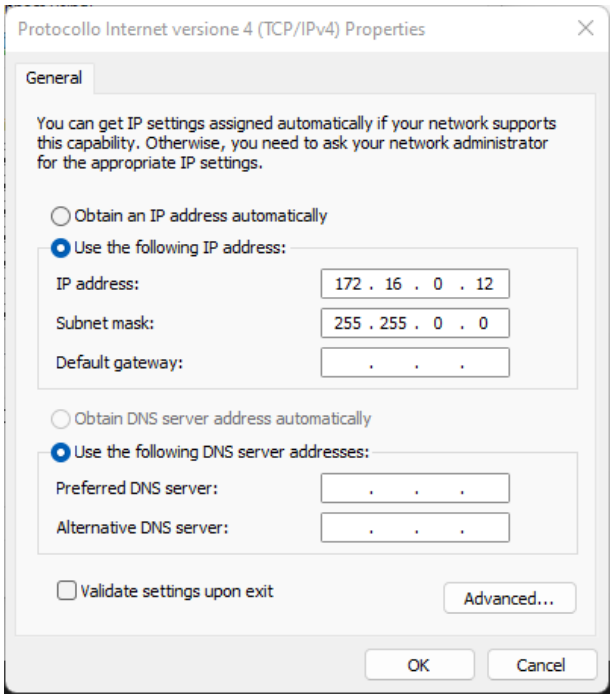


Fig. 8.13: ”Internet Protocol Version (TCP/IPv4) Properties” window.

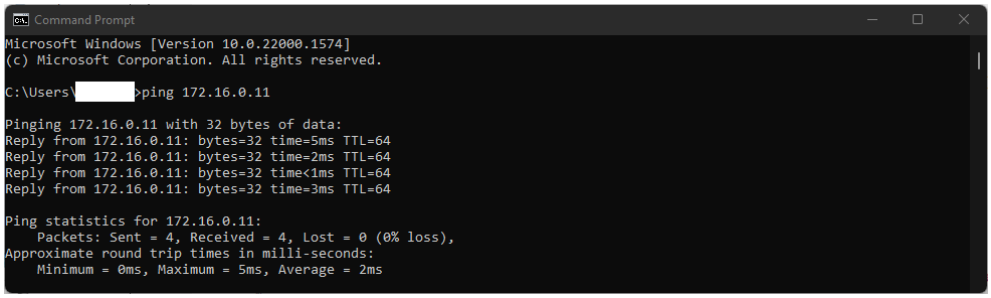


Fig. 8.14: Command prompt window with the command for testing the communication.

8.3 Software Connection

The DT5215 Concentrator Board is used as connection and synchronization point for multiple FERS-5200 units, without modifying their operating modes. For this reason the Janus Software supports and fully manages the connection and data acquisition via the DT5215, once the latter is connected and properly configured.
The TDlink enabling must be performed in the Web Interface, while their connection to the Concentrator Board can be managed either by the Web Interface or by the Janus Software, as described in the following subsections.

THE DT5215 GETS STUCK IF ANY OF THE ENABLED TDLINKS IS NOT CONNECTED TO AT LEAST ONE FERS-5200 UNIT. MAKE SURE TO ENABLE ONLY THE TDLINKS ACTUALLY USED!

8.3.1 Web Interface: Connection to the DT5215 and Configuration

The Web Interface allows to configure the DT5215 board, and to enable/disable the TDlink connections with the FERS-5200 units.
In order to access it, the user should open a browser and enter the IP address of the desired Ethernet/USB connection. The login page of the graphical Web Interface will open (see **Fig. 8.15**).

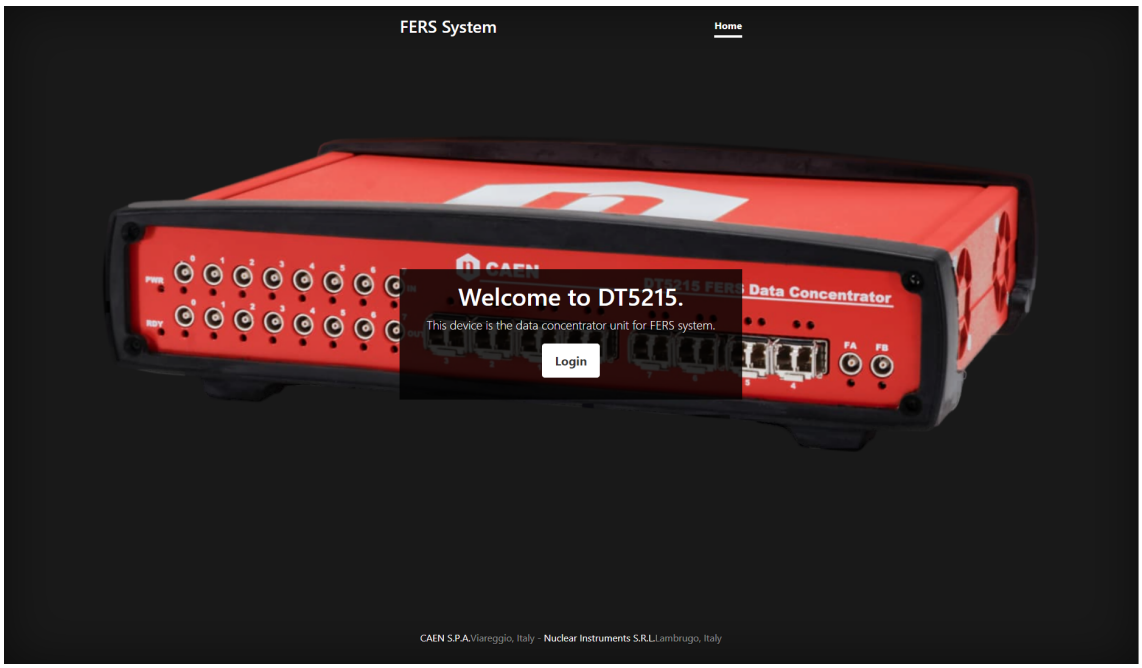


Fig. 8.15: Web Interface opening view.

After pressing the *Login* button, the pop-up shown in **Fig. 8.16** will appear on the top of a white page. The access credentials are:

Username `user`
Password `user`

After the first access, the login credentials can be changed in the System Settings Tab, as explained in

Subsec. **8.3.1.3**.

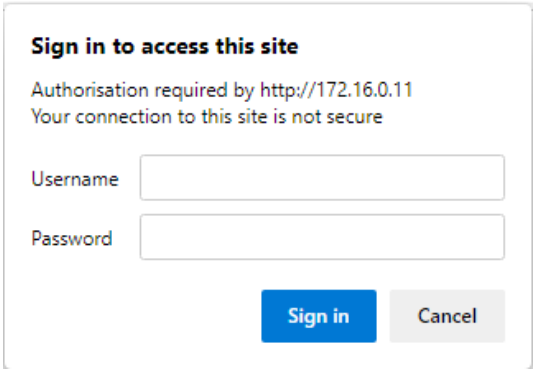


Fig. 8.16: Web Interface login pop-up window.

8.3.1.1 Device Status Tab and FERS Units Connection

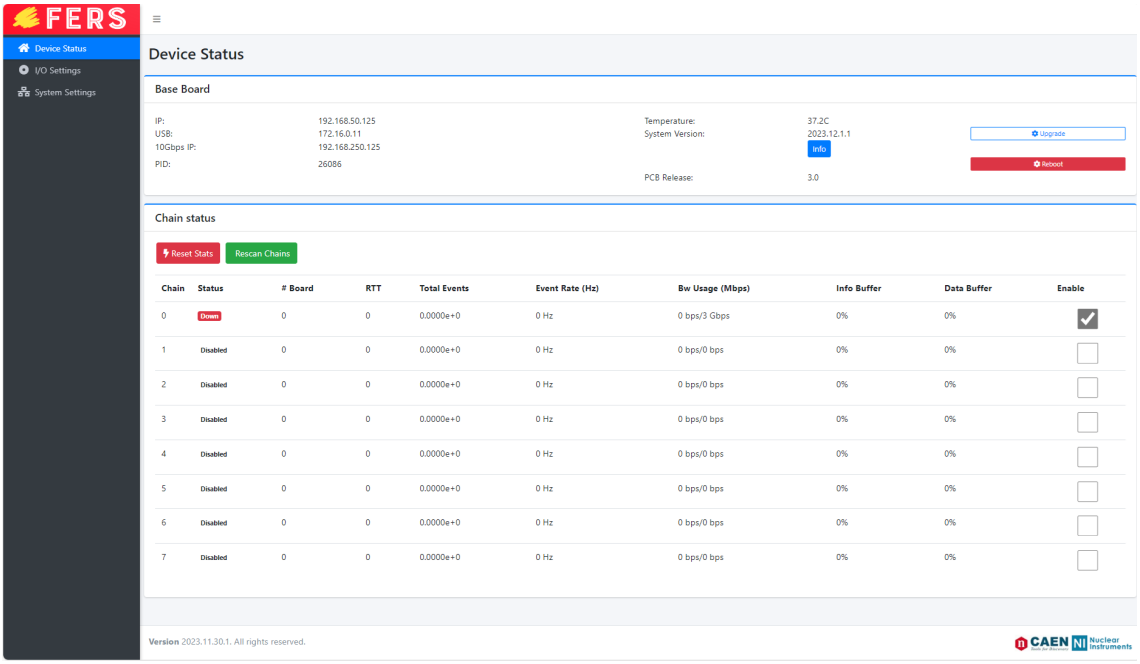


Fig. 8.17: Web Interface Device Status Tab.

In the Device Status tab (**Fig. 8.17**), and in particular in the *Base Board* section, it is possible to read the IP addresses (Ethernet, USB and 10 Gbps Ethernet) and other board information, such as the board Product IDentifier (PID), the board temperature, and the System Version (board Software and Firmware releases) and PCB Release.
A button for the Firmware upgrade is available next to the System Version information. By pressing it, the Firmware upgrade procedure will start, as described in Chap. **10**.
Under the Upgrade button, the red Reboot button is placed. By pressing it, a reboot of the DT5215 is performed.

The *Chain Status* section of the Device Status Tab is devoted to the FERS-5200 units to DT5215 connection details. The 8 possible TDlink connections are reported, with the relative information:

- *Chain*: chain number;
- *Status*:

Disabled	TDlink connection disabled
Down	FERS-5200 unit connection not found (TDlink enabled)
Link ON	FERS-5200 unit connection found, but still not enumerated
Ready	FERS-5200 unit in the enumeration process
Running	FERS-5200 unit enumerated

- # *Board*: number of daisy-chained boards connected to the single TDlink;
- *RTT*: data packet propagation delay along the TDlink ring;
- *Total Events*: total number of events read;
- *Event Rate (Hz)*;
- *Bw Usage (Mbps)*: Bandwidth usage in Mbit per second;
- *Info Buffer*: percentage of occupancy of the data info memory buffer. In other words, this percentage gives an estimate of the total number of triggered events over the maximum memory buffer size;
- *Data Buffer*: percentage of occupancy of the data memory buffer, i.e. the total amount of data over the maximum memory buffer size;
- *Enable*: enable/disable link.

In order to enable the connection of FERS-5200 units with the concentrator board, the user must enable the desired TDlinks (TDlink 0 is enabled by default) and press the Rescan Chains button.

Note: The TDlinks must be sequentially enabled, starting from TDlink 0!

Note: Disable all TDlinks not connected to FERS-5200 units!

Once pressed the Rescan Chains button, if correctly configured, the status of the TDlinks considered will switch to Link ON and Ready during the enumeration process, and to Running when the enumeration process is completed. At this moment, the light of the blinking green LED over the connection link on the board will be fixed, as shown in **Fig. 8.18**.

Note:The green LED above the TDlink blinks only when the TDlink is enabled.

Fig. 8.18: DT5215 front panel status at power ON.

After the physical disconnection of the fiber cables from the DT5215, the TDlinks remain enabled, waiting for a new connection. If a different FERS-5200 unit is connected to the same TDLink, or if a clear of the statistics of the previous acquisition is needed, it is possible to reset the statistics in the Web Interface by pressing the Reset Stats button.

8.3.1.2 I/O Settings Tab

The I/O Settings Tab is used to configure the general DT5215 settings, as shown in **Fig. 8.19**:

- Clock Reference
- Internal Pulser
- Front/Rear Lemo Config
- Multi Function Config
- Multi Board Synchronization.

Note: Press the Apply button on the top right corner of the I/O Settings tab to make effective the changes made.

Clock Reference

The reference Clock Source can be Internal or External. In the case of a synchronization with an external clock (see Chap. **9**), the clock signal can be given via:
- the CLK LEMO connection (CLK-IN), at a frequency of 10.0 MHz.
- the SYNC IN connection (SYNC A). See Sec. **9.2** for more details.
- the RA LEMO connection, at a frequency of 15.625 MHz.

The reference PPS Source is disabled by default. If enabled (**COMING SOON**), it can be taken by the GPS connection, or by the RB LEMO connection (1 Hz frequency).

The underlying LEDs are used for debugging purposes and are described as follows:

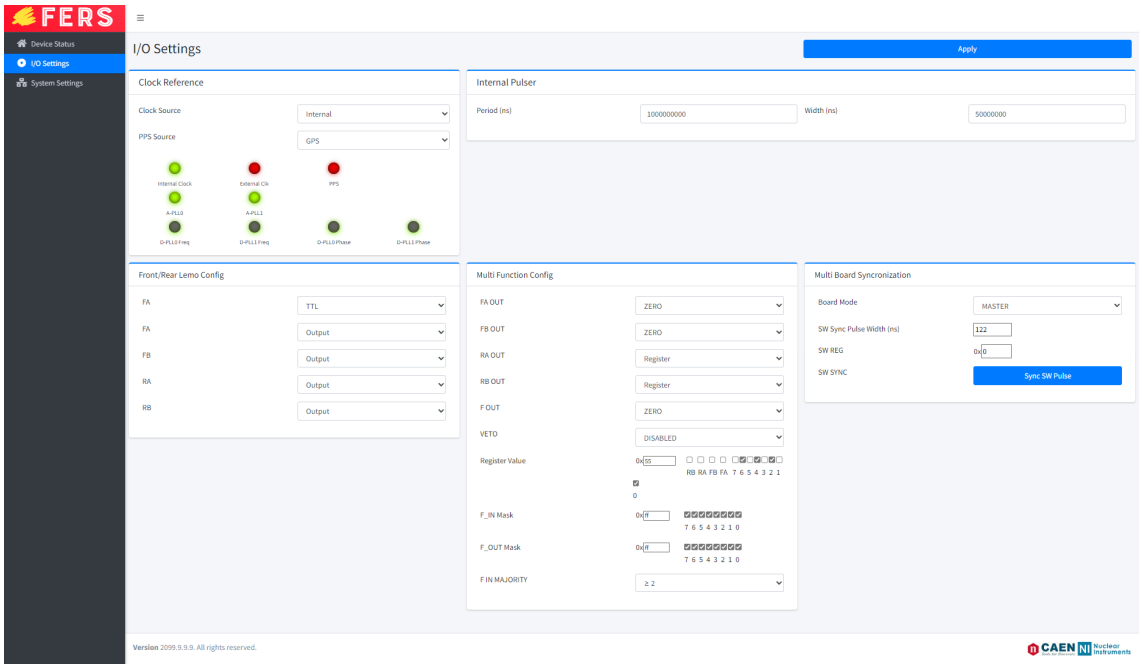


Fig. 8.19: Web Interface I/O Settings Tab.

Internal Pulser

The DT5215 houses a pulse generator, which pulse period and width can be set in the Internal Pulser section of the I/O Settings Tab. Both parameters measurement unit is ns.
The generated pulse can be propagated via the I/O LEMO connectors of the DT5215 (Test Pulse option) to other external units.

Front/Rear Lemo Config

The front/rear LEMO connectors FA, FB, RA, RB can be configured to accept/emit TTL or NIM signals. The Front/Rear LEMO connectors work on the same signal type: it is not possible to set one of the LEMO connectors to accept/emit TTL signals, and another one to accept/emit NIM signals.
In case these connectors are configured as inputs, the user can choose between 50 Ω (Input 50R) or high input (Input High) impedance.

Multi Function Config

This section of the I/O Settings Tab is intended to be used for configuring the LEMO connectors function. FA, FB, RA, and RB LEMO connector outputs (FA OUT, FB OUT, RA OUT, RB OUT) can be:

- *Register*: a TTL/NIM signal which level is defined via a control register, settable/resettable with the related Register Value check box;
- *Logic OR (fin)*: a logic signal OR of F-IN enabled channels;
- *Logic AND (fin)*: a logic signal AND of F-IN enabled channels;
- *Majority (fin)*: a majority logic signal of F-IN enabled channels (majority level defined in the F IN MAJORITY drop down menu);
- *Test pulse*: a signal generated by the internal pulser, which pulse period and width are defined in the Internal Pulser section;
- *Sync*: a synchronization signal, defined in the Multi Board Synchronization section;

Internal Clock		The Internal Clock generator is correctly working
		The Internal Clock generator is not working properly (failure status)
External Clk		The Clock Reference Source has been set to CLK LEMO, SYNC IN or RA LEMO, and the correct external clock frequency source has been detected
		The external clock source is not at the frequency requested for the clock connection used (CLK LEMO, SYNC IN or RA LEMO)
		The Clock Reference Source is Internal (the PLL digital ring is not used)
PPS		The PPS has been set to GPS, or RB LEMO (1 Hz), and the corresponding PPS signal has been detected
		The PPS is Disabled, or the PPS signal on GPS or RB LEMO has not been detected
A-PLL0 A-PLL1		The PLL analog ring is correctly locked
		The PLL analog ring is not locked
D-PLL0 Freq D-PLL1 Freq		The PLL digital ring is correctly locked in frequency
		The PLL digital ring is not locked in frequency
		The PLL digital ring is not used (Clock Source: Internal)
D-PLL0 Phase D-PLL1 Phase		The PLL digital ring is correctly locked in phase
		The PLL digital ring is not locked in phase
		The PLL digital ring is not used (Clock Source: Internal)

- *FA*: the FA input signal. It can be set in FB OUT, RA OUT or RB OUT;
- *FB*: the FB input signal. It can be set in FA OUT, RA OUT or RB OUT;
- *RA*: the RA input signal. It can be set in FA OUT, FB OUT or RB OUT;
- *RB*: the RB input signal. It can be set in FA OUT, FB OUT or RA OUT;
- *SYNC IN A*: the signal propagated in the A line of the SYNC connection;
- *SYNC IN B*: the signal propagated in the B line of the SYNC connection;
- *SYNC IN C*: the signal propagated in the C line of the SYNC connection;
- *ZERO*: a zero logic signal.

F_OUT LEMO connectors output signals can be set to be the signals in F_IN, in addition to the options valid for all the other LEMO connectors. The signals on F_OUT LEMO connectors are TTL type only.
The F_OUT signals can also be vetoed. VETO options are:

- *DISABLED*;
- *FA*;
- *FB*;
- *RA*;
- *RB*.

A F_IN Mask and a F_OUT Mask can be defined to enable/disable the input and output channels. The mask can be set by selecting/unselecting the box related to the respective input or output channel.

Multi Board Synchronization

t.b.d. (**COMING SOON**)

8.3.1.3 System Settings Tab

The System Settings Tab, shown in **Fig. 8.20**, provides information on the DT5215 1/10 Gbps Ethernet connections, and permits to enable the 10 Gbps Ethernet interface. In both cases, the IP address, the Netmask, the Gateway and the DNS are specified. The respective fields can be changed according to the needed Ethernet interface settings. The Current IP and MAC addresses are also shown. The DHCP option is available for both the connections, and can be activated by clicking on the check box. For the 10 Gbps Ethernet connection, the Maximum Transmission Unit (MTU) is set to 9000 bytes by default, but can be changed in the respective box.

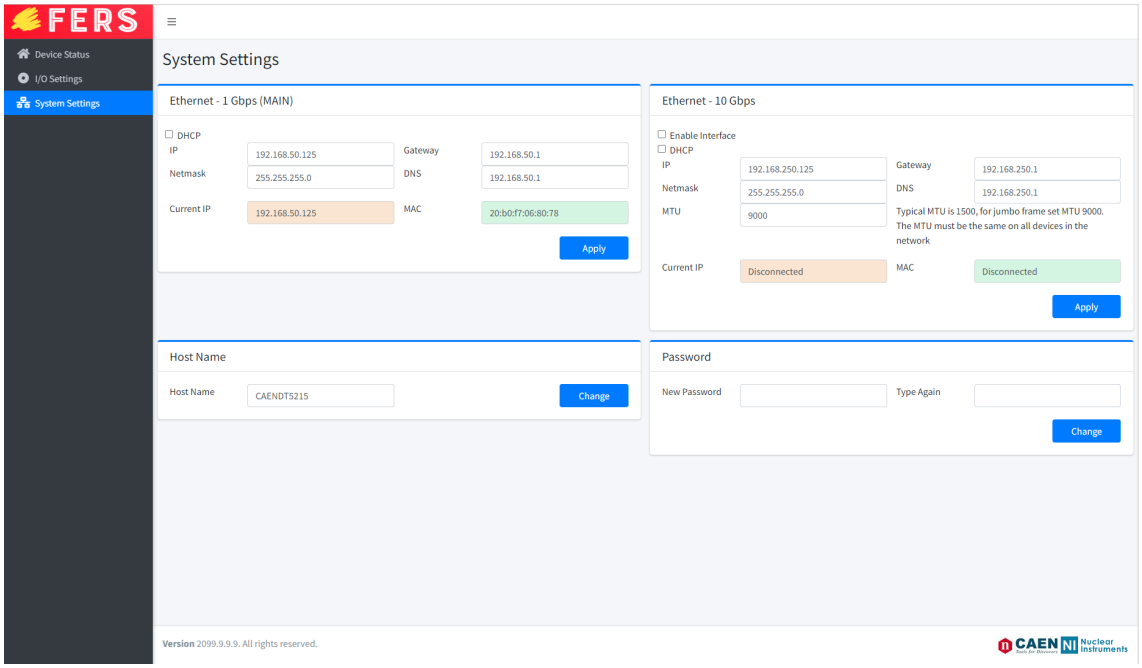


Fig. 8.20: System Settings Tab of the Web Interface for Ethernet settings and user account configuration.

It is possible to set an IP address of the instrument different with respect to the default one. This last operation can be particularly useful in case the user wants to perform a multi-board Ethernet connection and, therefore, needs to associate a different IP address to each board. The change of the IP address can be done by writing the new address in the respective box and, successively, press the Apply button. Once done, the board has to be rebooted to make effective the IP address change.

Note: Press the Apply button on the top right corner of each subsection of the System Settings tab to make effective the changes made.

To restore the original IP address, the user needs to reset the board as described in Sec. **8.1.3**.

The Host Name and login Password can be changed in the respective sections of the System Settings tab. The change of the Host Name is made effective after a reboot of the board.

8.3.2 First Janus Connection via the DT5215

Once installed the Janus software (see Janus User Manuals **[RD1][RD2]**), that permits to configure and acquire data with FERS-5200 units, the user can connect to the DT5215 up to 8 groups of daisy-chained boards.
The instructions for the connection with the Janus Software are here reported for a single board:

1. Install and open the Janus Software.
2. Below the ”PATH” field in the Janus Connect tab, the user has to write down the type of connection he/she is using to connect to the board. In case of a connection via the DT5215 the available options are:
   - ”usb:IP:tdl:x:y” (as it is shown in**Fig. 8.21**), where IP is the IP address for the USB connection to the DT5215, tdl is the type of FERS-5200 board connection to the DT5215, and x and y the link number and board number, respectively.
   - ”eth:IP:tdl:x:y”, where IP is the IP address for the Ethernet connection to the DT5215, tdl is the type of FERS-5200 board connection to the DT5215, and x and y the link number and board number, respectively.
3. Press on the Apply button in order to make the changes effective.

Note: Every time a change in the parameter settings is performed, the Apply button becomes red. The user has to press the button in order to make the changes effective.

4. Click on the Connect button on the top left part of the Janus window .
   The connection between the software and the FERS-5200 units, passing via the DT5215, is established as shown in **Fig. 8.21** for the case of a A5203 connection.

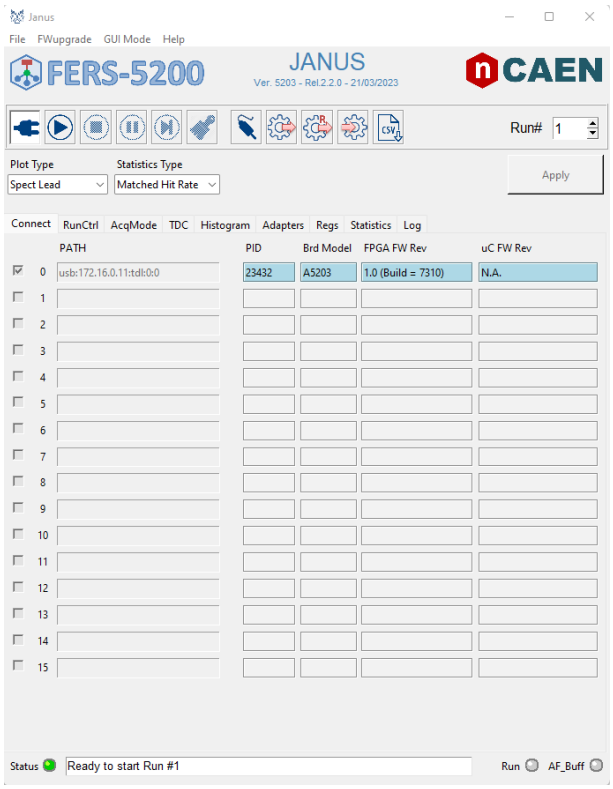


Fig. 8.21: Janus GUI starting interface when the connection is correctly established. Case of A5203 connection.

In case the connection is not established, an error message will be displayed in the status bar in the bottom part of the Janus GUI. In **Fig. 8.22** is shown the error message appearing when there is a connection error between the PC and the DT5215 board. In **Fig. 8.23** is shown the error message appearing when there is a connection error between the DT5215 board and the FERS-5200 unit connected via the TDlink. If any of these errors happens, the user is kindly suggested to re-check all the instructions in Sec. **8.3**.

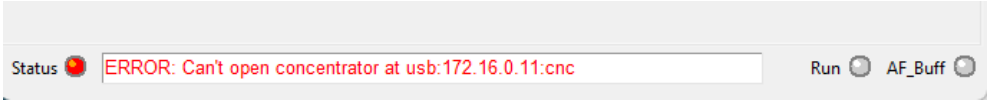


Fig. 8.22: Message displayed in the Janus application in case of a not working USB connection to the DT5215.

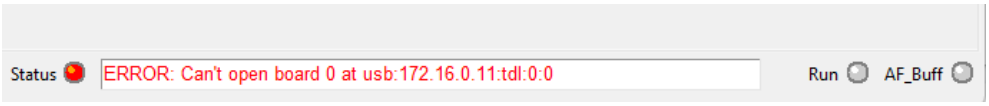


Fig. 8.23: Message displayed in the Janus application in case of a not working TDlink connection to a A5203.

9 Synchronization

9.1 FERS-5200 Units Synchronization

FERS-5200 units synchronization is performed by connecting the units to the DT5215 concentrator board. The TDlink connection is performed in the following way:

1. Once the FERS-5200 units are connected via optical fibers to the DT5215, their internal clocks are locked to the clock (156.26 MHz frequency) of the DT5215 , with a jitter of 20 ps and a maximum fixed skew of 6.4 ns.
2. During the units enumeration process, the clock skew and start run delay, introduced by the cable or daisy-chain ring lenght, are calculated and compensated by the software. As a result, the zero time is defined and aligned for all the units connected to the DT5215.
3. The acquisition is ready to start. If using Janus software, the TDL option must be chosen as StartRunMode. In this way, a broadcast synchronous Run Start is sent to all the connected FERS-5200 units.
4. To stop the acquisition, a broadcast synchronous Run Stop is sent by Janus to all the connected FERS-5200 units

Note: The clock skew between different TDlinks of the same 4 links group (TDlinks 0-1-2-3 or 4-5-6-7) is fixed, and can be estimated with a precision of 1 clock cycle, and, possibly, compensated at software level. On the other hand, the clock skew between TDlinks of different link groups is not deterministic, and a phase shift of less than 1 clock cycle is present and not resettable.

Note: If the ASYNC StartRunMode option is selected instead of the TDL in the Janus settings, a broadcast asynchronous Run Start (and Run Stop) is sent to all the connected FERS-5200 units.

9.2 Multi-Board Synchronization

t.b.d. (**COMING SOON**)

10 Firmware Upgrade

The DT5215 board hosts one Zynq MPSoC that combines an FPGA with an arm (processing system).
The FPGA firmware and arm software are stored onto the on-board FLASH memory. At power-on, the microcontroller reads the FLASH memory page and programs the module automatically loading both the FPGA firmware and the arm software copies.
It is possible to upgrade the FPGA firmware and arm software contemporaneously, via USB or Ethernet, with a .niu file provided in our website, and taking advantage of the Web Interface.
By clicking the Upgrade Button in the Device Status Tab. (see **Fig. 8.17**), the window in **Fig. 10.1** will appear.

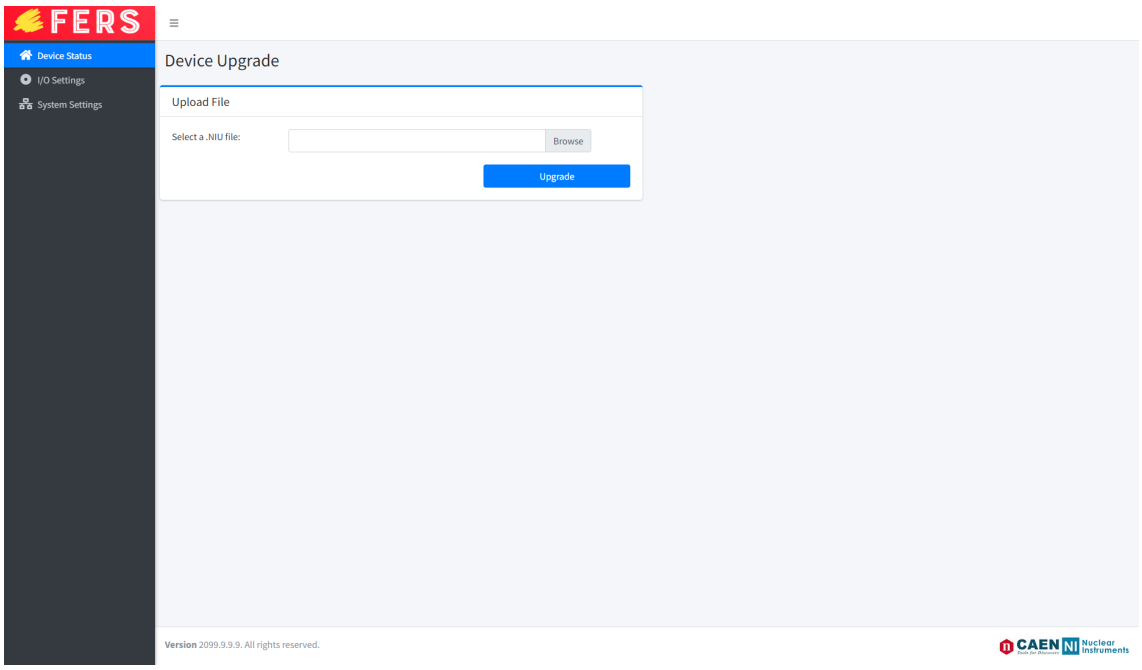


Fig. 10.1: Web Interface Device Upgrade window.

After browsing the desired .niu file and clicking on the *Upgrade* button, a pop-up window asking for the confirmation of the upgrade will appear. Pressing the *Ok* will make the upgrade process start (see **Fig. 10.2**).

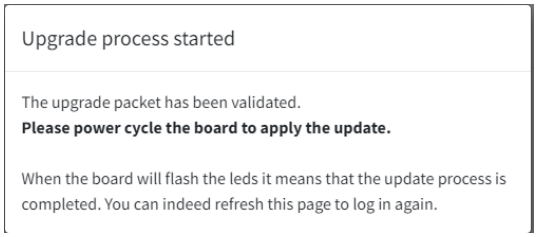


Fig. 10.2: Device Upgrade process pop-up window.

In this phase, the new firmware and software are copied onto the FLASH memory, but still not installed. To install them, the user needs to reboot the board, and wait until the F_OUT LEDs blink.

Note: The installation process may take several minutes, and various automatic reboots of the board (that can be noticed by the different fan speeds). Do not turn off the board until the LEDs start blinking.

11 Instructions for Cleaning

The equipment may be cleaned with isopropyl alcohol or deionized water and air dried. Clean the exterior of the product only.
Do not apply cleaner directly to the items or allow liquids to enter or spill on the product.

11.1 Cleaning the Air Vents

It is recommended to occasionally clean the air vents (if present) on all vented sides of the board. Lint, dust, and other foreign matter can block the vents and limit the airflow. Be sure to unplug the board before cleaning the air vents and follow the general cleaning safety precautions.

11.2 General Cleaning Safety Precautions

CAEN recommends cleaning the device using the following precautions:

- Never use solvents or flammable solutions to clean the board.
- Never immerse any parts in water or cleaning solutions; apply any liquids to a clean cloth and then use the cloth on the component.
- Always unplug the board when cleaning with liquids or damp cloths.
- Always unplug the board before cleaning the air vents.
- Wear safety glasses equipped with side shields when cleaning the board.

12 Device Decommissioning

After its intended service, it is recommended to perform the following actions:

- Detach all the signal/input/output cable
- Wrap the device in its protective packaging
- Insert the device in its packaging (if present)

THE DEVICE SHALL BE STORED ONLY AT THE ENVIRONMENT CONDITIONS SPECIFIED IN THE MANUAL, OTHERWISE PERFORMANCES AND SAFETY WILL NOT BE GUARANTEED

13 Disposal

The disposal of the equipment must be managed in accordance with Directive 2012/19 / EU on waste electrical and electronic equipment (WEEE).

The crossed bin symbol indicates that the device shall not be disposed with regular residual waste.

14 Technical Support

To contact CAEN specialists for requests on the software, hardware, and board return and repair, it is necessary a MyCAEN+ account on www.caen.it:

https://www.caen.it/support-services/getting-started-with-mycaen-portal/

All the instructions for use the Support platform are in the document:

A paper copy of the document is delivered with CAEN boards.
The document is downloadable for free in PDF digital format at:

https:/www.caen.it/safety-information-product-support

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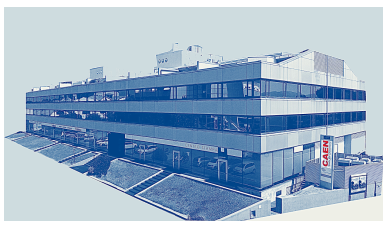

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