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CAENels

Gear for Science

Company Presentation

2022

Member of DPG

Member of MicroTCA Technology Lab

Overview

CAENels
Gear For Science

- The CAEN Group
- CAEN, CAEN RFID and CAEN SyS
- History of CAEN ELS
- Custom Made Projects
- Product Lines
- Outlook New Developments
- References
- Distribution Network

The CAEN Group

- **CAEN S.p.A.** (Costruzioni Apparecchiature Elettroniche Nucleari, Società per Azioni) seated in Viareggio/Italy was founded in 1979 from Marcello Givoletti, Piero Salvadori and Luigi Pardini, who were former employees at the INFN (Istituto Nazionale di Fisica Nucleare) in Pisa.
- Initiator of the founding was **CERN,** which cooperates closely with the INFN. Hence CERN was the first customer of CAEN and up to today CERN is still the biggest customer of the CAEN group with thousands of installed electronic boards.
- The CAEN Group has **nearly 10.000 customers** in more than 50 countries in public research as well as in private organizations.
- Locations and **distributors in more than 30 countries.**
- More than 150 employees generated a **direct turnover** of **25 M€** in 2020.
- CAEN and its spin-offs are **100% self-financed.**
- Core Areas: High Energy Physics, Astrophysics, Neutrino Physics, Dark Matter Research, Nuclear Physics, Particle Physics , Radio Frequency Identification, Nuclear Security and Safety, Didactics, Material Sciences, Medical Applications, Industrial Applications, Calibration Technologies.

CAEN Company Network

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Company Profile

Trieste - Italy

CAENels
Gear For Science

CAEN
Tools for Discovery

CAEN SyS
Systems and Spectroscopy Solutions

CAENRFID
THE ART OF IDENTIFICATION

Viareggio - Italy

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Locations

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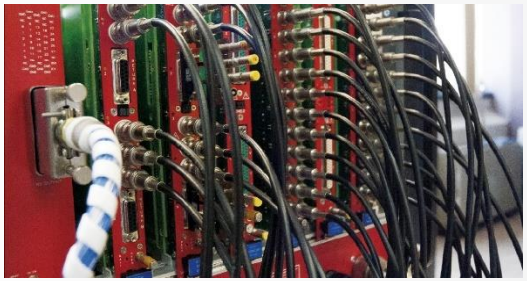
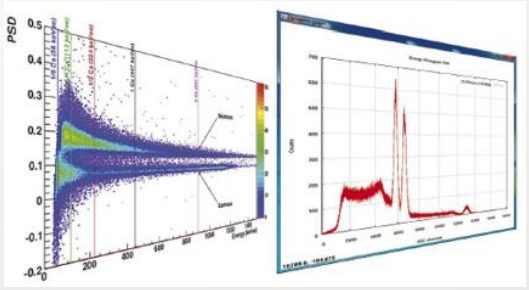
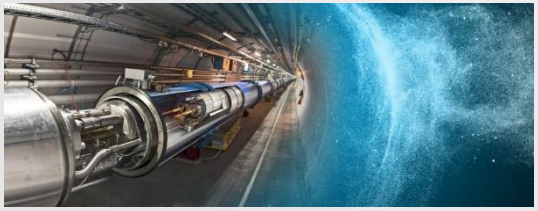
CAEN

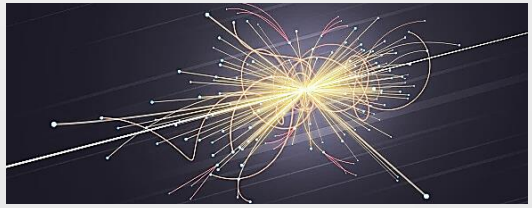
CAEN
Tools for Discovery

- **CAEN** is the world leader with the most advanced electronic instrumentation for any **particle, radiation and low light detectors**.
- Nearly all **world major research laboratories and institutes** are using **the high end products of CAEN** for the detection and data acquisition in **particle physics experiments**.
- R&D division of **50 high level Physicists and Engineers**.
- High Voltage and Low Voltage Power Supplies
- Signal Conditioning, Read Out Electronics and Emulation
- Acquisition Systems
- Spectroscopy Solutions
- Powered Crates and Chassis
- Educational Kits









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CAEN RFID

CAENRFID
THE ART OF IDENTIFICATION

- **CAEN RFID** was founded in 2006 and is a **key player in the European RFID Market** with **worldwide customers** in manufacturing, logistics, transport, healthcare, fashion, retail…
- **Radio frequency identification (RFID) is a form of wireless communication** that uses radio waves to identify and track objects.
- RFID takes the barcoding concept and digitizes it for the modern world
- **UHF RFID Readers, Loggers, Custom Products, Integration**
- Uniquely identify an individual item beyond just its product type
- Identify items without direct line-of-sight
- Identify many items simultaneously
- Identify items within a vicinity of between a few centimeters to several meters

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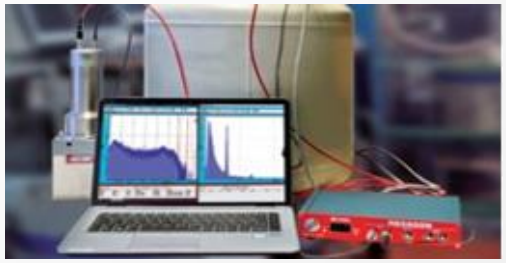
CAEN SyS

CAEN SyS
Systems and Spectroscopy Solutions

- **CAEN SyS** provides nuclear measurement solutions and technical expertise for **Nuclear Safety, Nuclear Security and Laboratories**.
- Health Physics , Spectroscopy and Radiation Measurements Systems
- Custom Nuclear Measurement Systems, Nuclear Waste
- Identification of gamma and neutron sources
- Networking of radiation detectors and robotics
- Safeguard and security products for non-proliferation and threats
- Fuel cycle process monitoring characterization Fresh & Spent Fuel Burn-up solutions
- Nuclear emergency preparedness
- Site remediation studies, products and solutions for mitigation plans



Location

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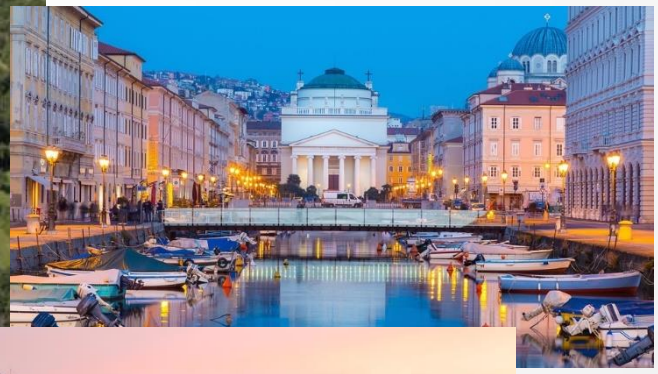
Gear For Science



- Founded 2009 as a spin-off from CAEN S.p.A.
- Developer and manufacturer of high-performance digital bipolar and monopolar power sources, high-precision current transducers and current measurement systems, electronic components for beamlines in accelerators and FMC and MicroTCA equipment
- **Headquarters** in Basovizza, **Trieste - Italy** at the location of Elettra-Sincrotrone Trieste S.C.p.A.

History

CAENels - from foundation to today…

2009: CAEN acquires three leading developers (Denis Molaro, Enrico Braidotti, Mitja Guštin) from Elettra Sincrotrone in Trieste/Italy who are dedicated in custom specific power sources and electronic instrumentation. **Founding of** the spin-off **CAEN ELS** with the target of providing institutes in the accelerator technology (e.g. CERN, DESY) with high-end electronic equipment.

2011: **First turnovers** with worldwide partners inside the accelerator technology developing and selling custom specific digital bipolar power sources.

2013: Development of the high precision **o-FLUCS-Current-Transducer** series (accuracy < 30 ppm/FS).

2014: Development of **new bipolar and monopolar** standard power sources for reactive (inductive and capacitive) loads with **digital control loop** – currently from few W up to 10-kW for all kinds of high-end applications.

Entering the high-end industrial, automotive, battery, medical markets and further.

2015: Founding of the **US American Branch Office** in New York City (at **CAEN Technologies, Inc.**)

2016: Founding of the **German Branch Office** near Karlsruhe. Entering the calibration market.

2018: ISO 9001:2015 certification (see next folder)

2021: Acquisition of a building with 2.200 sqm walkable space in the harbor of Trieste (renovation works).

Ongoing: Continuous development of further custom-made solutions as well as standard sources and electronic instrumentation with state-of-the-art technology.

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ISO Certificate

CISQ is a member of IQNet

www.imq.it

CERTIFICATO N. / *CERTIFICATE N.* 1734.2018

SI CERTIFICA CHE IL SISTEMA QUALITA' DI
WE HEREBY CERTIFY THAT THE QUALITY SYSTEM OPERATED BY

CAEN ELS SRL

VIA VETRAIA 11 - 55049 VIAREGGIO (LU)

UNITA' OPERATIVE / *OPERATIVE UNITS*

SS 14, KM 163,5 C/O AREA SCIENCE P. LOC. BASOVIZZA - 34149 TRIESTE (TS)

E' CONFORME ALLA NORMA / *IS IN COMPLIANCE WITH THE STANDARD*

ISO 9001:2015

PER LE SEGUENTI ATTIVITA' / *FOR THE FOLLOWING ACTIVITIES*

Progettazione, fabbricazione e collaudo di apparecchiature elettroniche
Design, manufacture and testing of electronic equipment

Ulteriori informazioni riguardanti l'applicabilità dei requisiti ISO 9001:2015 possono essere ottenute consultando l'organizzazione
Further clarifications regarding the applicability of ISO 9001:2015 requirements may be obtained by consulting the organization

IL PRESENTE CERTIFICATO E' SOGGETTO AL RISPETTO DEL REGOLAMENTO PER LA CERTIFICAZIONE DEI SISTEMI DI GESTIONE
THE USE AND THE VALIDITY OF THE CERTIFICATE SHALL SATISFY THE REQUIREMENTS OF THE RULES FOR CERTIFICATION OF MANAGEMENT SYSTEMS

DATE:	PRIMA CERTIFICAZIONE / *FIRST CERTIFICATION*	EMISSIONE CORRENTE / *CURRENT ISSUE*	SCADENZA / *EXPIRY*
	2018-12-06	2018-12-06	2021-12-05

IMQ S.p.A.- VIA QUINTILIANO, 43 - 20138 MILANO ITALY
Management Systems Division - Flavio Ornago

ACCREDIA
SGQ N° 005 A

IAF: 19

IMQ

FEDERAZIONE CISQ
www.cisq.com

IQNet

THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

***CISQ/IMQ** has issued an IQNet recognized certificate that the organization:*

CAEN ELS SRL
SS 14, KM 163,5 C/O AREA SCIENCE P. LOC. BASOVIZZA - 34149 TRIESTE (TS)

has implemented and maintains a
Quality Management System
for the following scope:

Design, manufacture and testing of electronic equipment
Further clarifications regarding the applicability of ISO 9001:2015 requirements may be obtained by consulting the organization

which fulfills the requirements of the following standard:

ISO 9001:2015

Issued on: ***2018 - 12 - 06***
Expires on: ***2021 - 12 - 05***

This attestation is directly linked to the IQNet Partner's original certificate and shall not be used as a stand-alone document

Registration Number: IT - 118358

IQNet

Alex Stoichitoiu
President of IQNET

CISQ

Ing. Claudio Provetti
President of CISQ

IQNet Partners*:
AENOR *Spain* AFNOR Certification *France* APCER *Portugal* CCC *Cyprus* CISQ *Italy*
CQC *China* CQM *China* CQS *Czech Republic* Cro Cert *Croatia* DQS Holding GmbH *Germany* FCAV *Brazil*
FONDONORMA *Venezuela* ICONTEC *Colombia* Inspecta Sertifiointi Oy *Finland* INTECO *Costa Rica*
IRAM *Argentina* IQA *Japan* KFQ *Korea* MIRTEC *Greece* MSZT *Hungary* Nemko AS *Norway* NSAI *Ireland*
NYCE-SIGE *México* PCBC *Poland* Quality Austria *Austria* RR *Russia* SII *Israel* SIQ *Slovenia*
SIRIM QAS International *Malaysia* SQS *Switzerland* SRAC *Romania* TEST St Petersburg *Russia* TSE Turkey YUQS *Serbia*
IQNet is represented in the USA by: AFNOR Certification, CISQ, DQS Holding GmbH and NSAI Inc.

* The list of IQNet partners is valid at the time of issue of this certificate. Updated information is available under www.iqnet-certification.com

Where it started

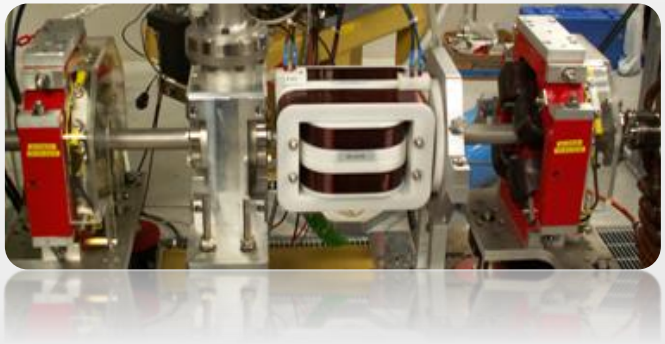
FERMI@Elettra

- Linear accelerator – FEL (400 meters length)
- about 400 magnets of **5 A** up to **750 A**
- 24 hours/day – 365 days/year
- Reliability and Efficiency

FERMI basic installations

X-FEL requirements for the power sources:

- 180 power sources of ±20A @ ±20V (A2620BS)
- 210 power sources of ±5A @ ±10V (A2605BS)
- Correction and Quadrupole Magnets



Custom Design Example

Tsukuba - Japan

- Custom specific **bipolar linear** power sources rated at **±5 A** and **±60 V**
- Start of design in December, delivery and installation after **4 months** in March

Customer Projects

Project Examples on basis of the NGPS

	RACK 1	RACK 2
NGPS Power supplies	420A/80V 200A/50V	450A/40V 450A/40V

RACK 3	RACK 4	RACK 5	RACK 6...15
450A/40V	5x 160A/30V 2x 160A/60V	5x 160A/30V 2x 160A/60V	200A/30V 200A/40V

15 Racks / about 50 sources / about 350kW

Developed for the upgrade of a large accelerator facility in the US.

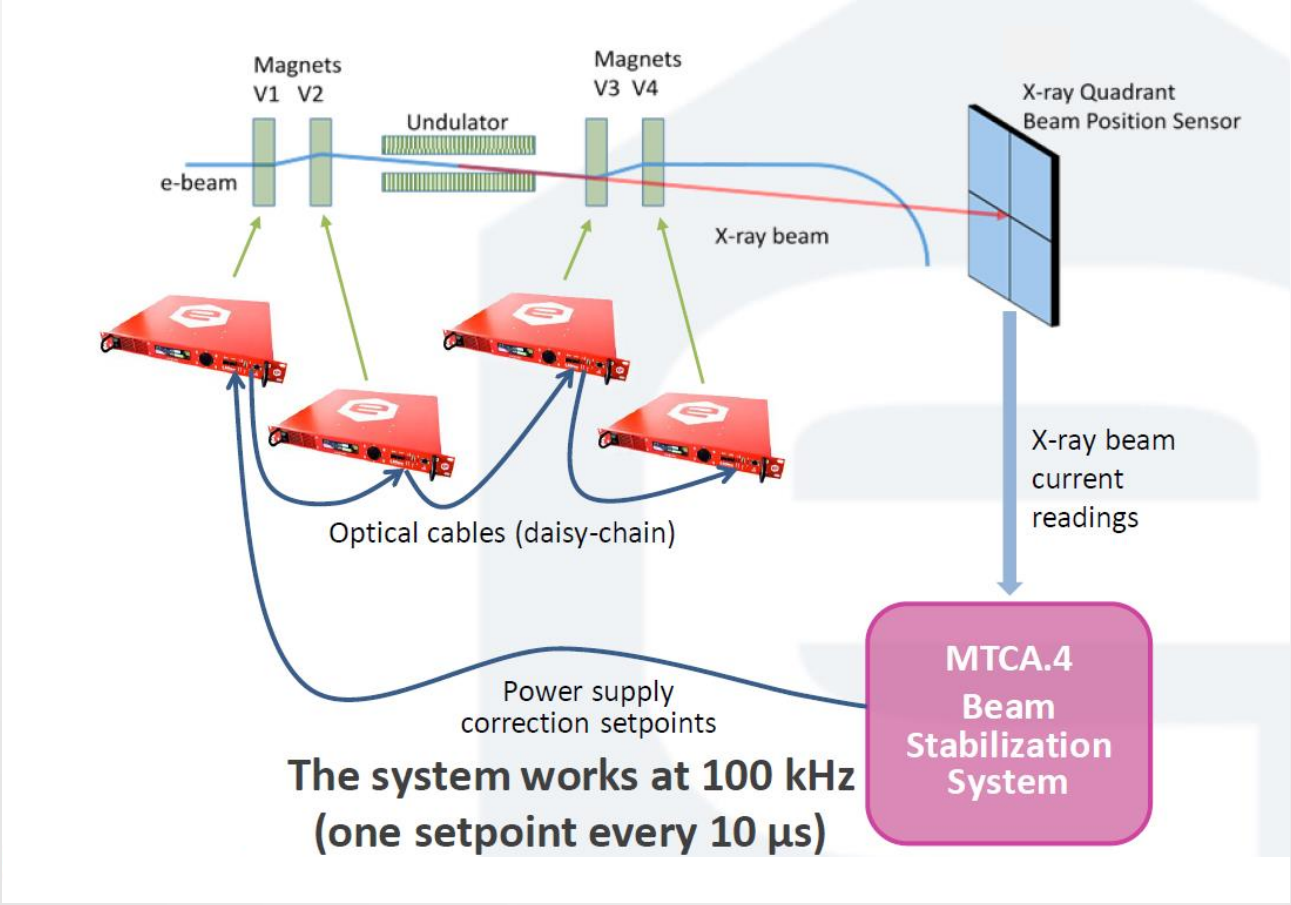
Installation of >1.000 devices at 250A/50V water cooled (>12,5 MW total), started in 2020.

Paralleled to 500A/50V

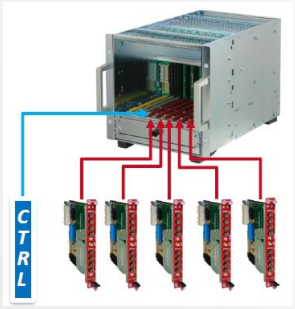
10 ppm pk-pk stability over 7 days!

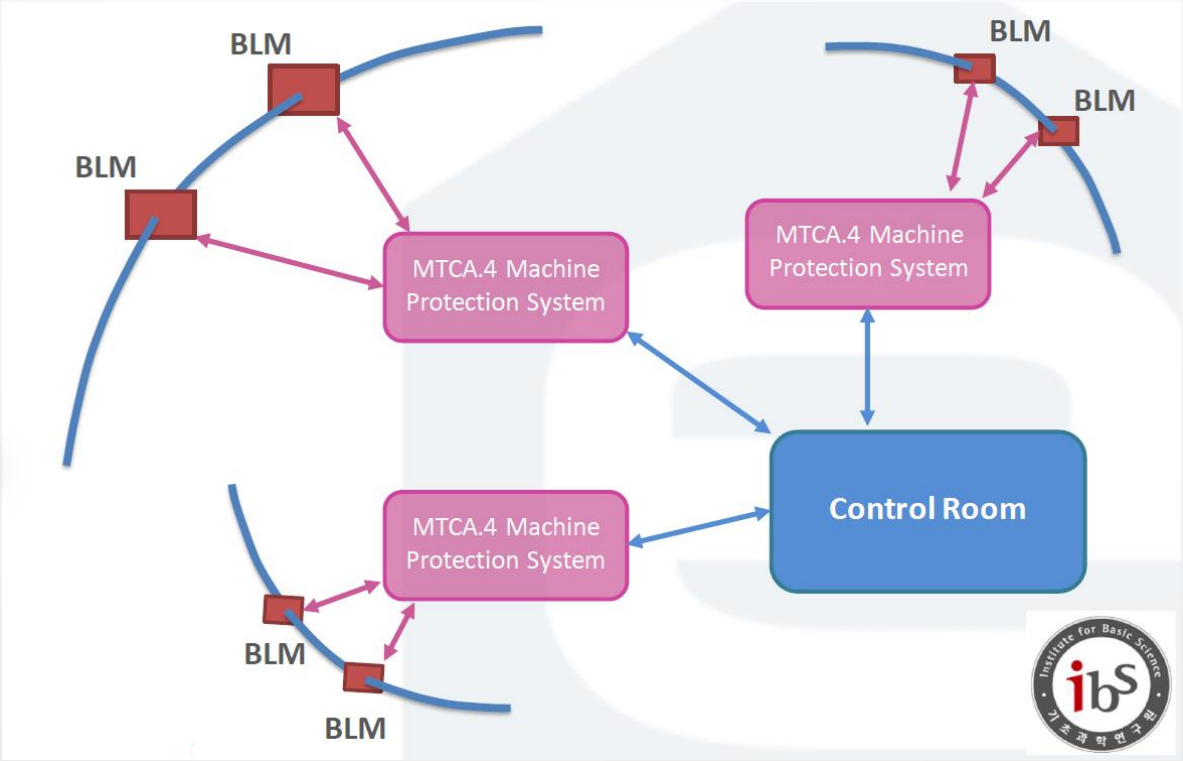
5 ppm pk-pk stability over 24 hours!

Beam Stabilization with MicroTCA and Fast-PS



Machine Protection with MicroTCA Architecture





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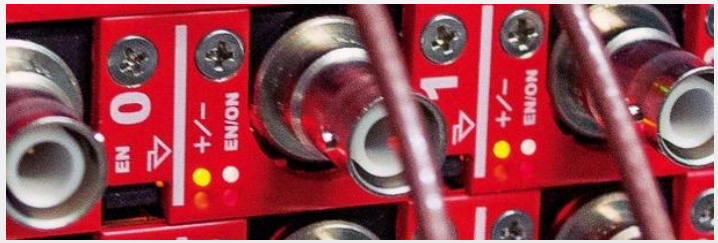
Product Lines

Power Supply Systems

Precision Current Measurements

Beamline Electronic Instrumentation

FMC MicroTCA



Power Supply Systems

Power Supply Systems

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Power Supply Systems

Catalogue
Power Supply
Series

CAENels Power Sources – A novel digital magnet power supply approach

ABSTRACT

Programmable logic and integrated technologies, as **SoC, FPGA and DSP**, have became mature enough to be employed in **high performance magnet power supply applications**.

The use of a configurable **mixed current and voltage digital control**, combined with adaptable complex algorithms for protections (e.g. **quench** in superconducting magnets) and auxiliary integration (e.g. transverse flux density in a dipole gap) allows obtaining the **perfect fit for each specific magnet application**.

An entire series of power supplies, coming from a background of particle accelerator applications, has been developed for both **bipolar and monopolar operation with high bandwidth** (fast fields as in corrector magnets and steerers) and high adaptability with a **user-friendly interface** and an **embedded Linux OS** that allows users to implement their own applications directly on the power supply.

The use of **24-bit ADCs and state-of-the-art PWM generation** (with possible application of dithering techniques to reach **65-ps resolution**) enables to obtain fields **actuations in the ppm-level range**.

Some of the CAENels power converters, for specific applications (usually dipoles or superconducting), are equipped with our **closed-loop zero flux transducers** that feed their signals to temperature-stabilized electronics to reach **current temperature coefficient values of lower than 1 ppm/K**.

CAENels Power Sources – A novel digital magnet power supply approach

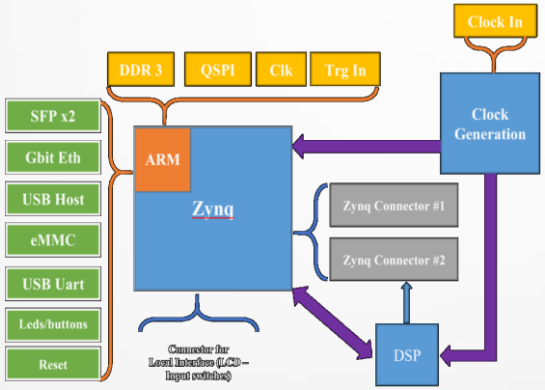
Control Board

Digital Control Board including:
- **FPGA (Zynq)**
- **DSP (Texas Instruments)**

Interfaces included are the following:
- **10/100/1000 Ethernet**
- **2 x SFP+ (6.5 Gbps/channel)**
- **USB Host**
- **eMMC**
- **display and encoder control**

FPGA is used for digital output control algorithms and **DSP for High-Resolution PWM generation.**

Linux OS (Yocto Project) is embedded in the **ARM**.



Carrier Board

The **Digital Control Board** is plugged onto the **Carrier Board** with two 100-pin high-speed FCI connectors. The Carrier Board is provided with:

- **2 x 24-bit@100 ksps ADCs** for current and voltage readout (Temperature-stabilized)
- **DC-Link, Temperature and Auxiliary analog readings (16-bit@100 ksps)**
- **I/O signals** for interfacing with external protections (e.g. **quench**)
- **interlocks** and **status signals**
- connector for future expansions.

The Carrier Board also embeds the power section to supply the **active CAENels DCCT transducer** with low-noise power at ±15V in order to have a direct, accurate, stable and precise current readout.

CAENels Power Sources – A novel digital magnet power supply approach

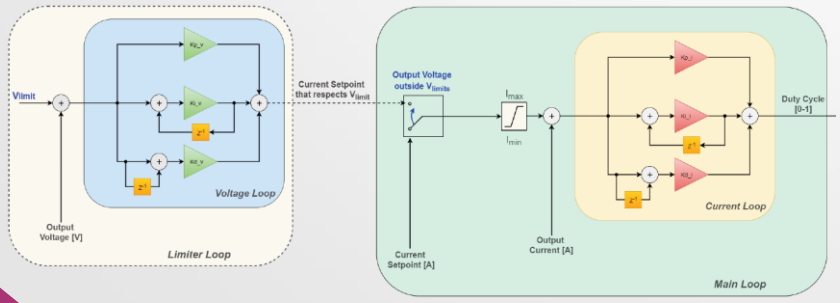
Output Control Loop

The on-board programmable logic allows for complex algorithms to be performed on the current and voltage output values.

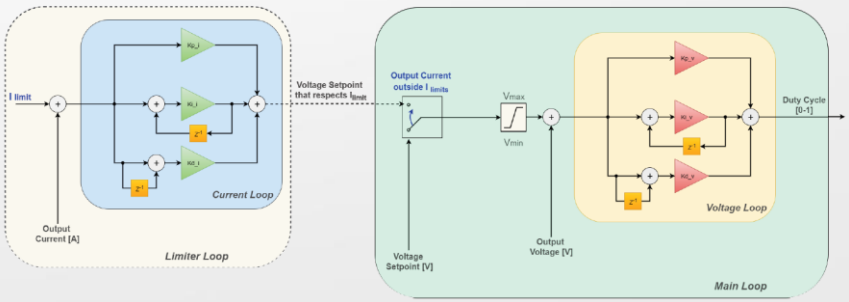
A lot of different feedback control loops have been implemented but standard ones are modified versions of **Proportional Integral Derivative (PID). PID-Autotuning optionally available (Automatic tuning of PID parameters for any resistive, inductive or capacitive load - or a mix of it)!**

Two examples are hereafter shown:

Constant Current (CC) Output Control



Constant Voltage (CV) Output Control



Application Example: a user can implement a slower closed loop directly on the Linux OS by using the readings of the magnetic field from a Hall probe fed to the auxiliary input of the carrier board.

CAENels Power Sources – A novel digital magnet power supply approach

Power Stage Control

The **on-board FPGA** performs all the **control loop algorithms at a hardware-level** to maximize speed and computing power.

The **DSP** is used as a **multi-channel PWM generator** with a **65-ps PWM resolution**. For bipolar stages **(H-Bridge topologies)**, this resolution can be halved.

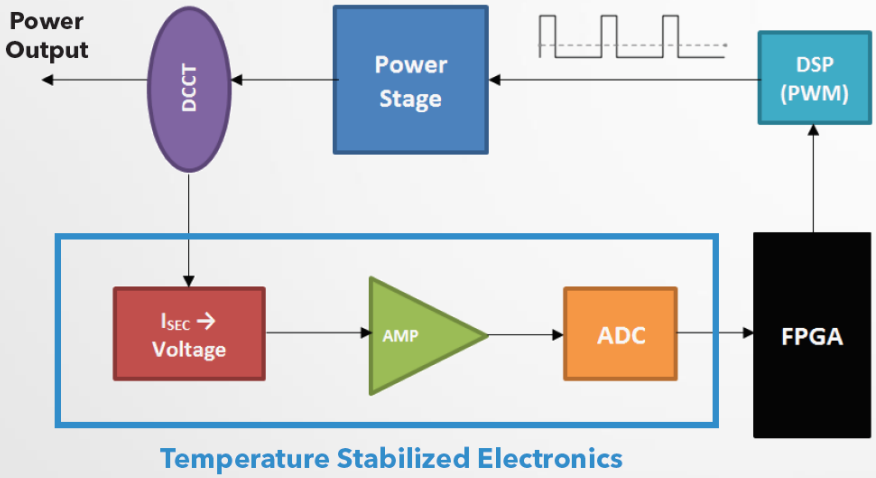
The equivalent setting resolution for a **15-kHz switching monopolar power stage** can be computed as:

$$Resolution = log_2\left(\frac{1}{T_{PWM} \cdot f_S}\right) = log_2\left(\frac{1}{65 \cdot 10^{-12} \cdot 15 \cdot 10^3}\right) \cong 20\ bit$$

This resolution can be increased to 21 bit for bipolar stages.

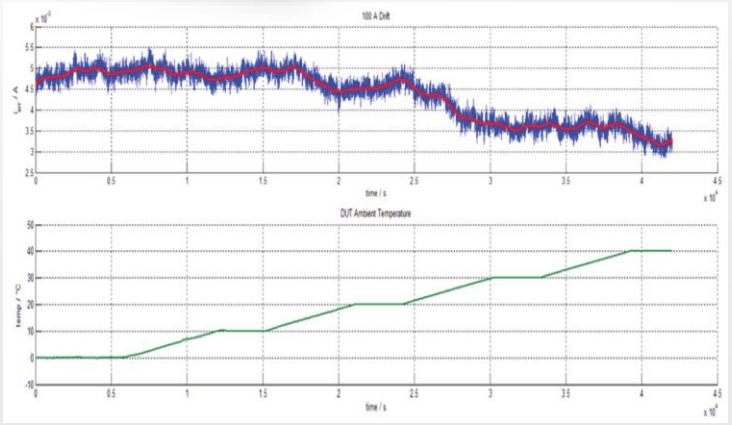
CAENels Power Sources – A novel digital magnet power supply approach

Current Sensing



Temperature Stabilized Electronics

CAENels o-FLUCS DC Current Transformer

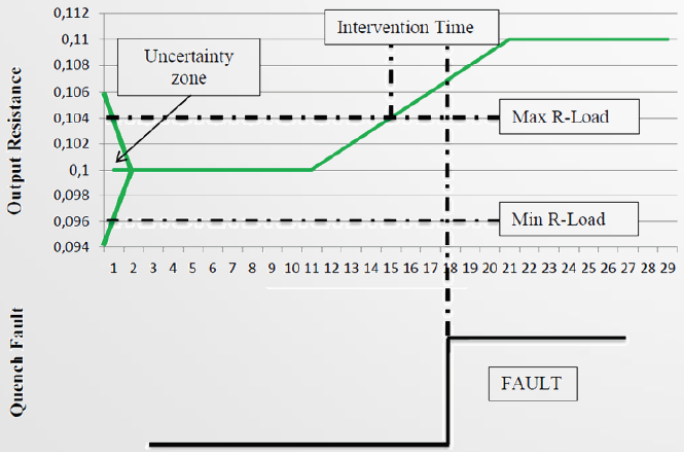


The current sensing is made using a proprietary closed-loop **Zero Flux DCCT** (DC Current Transformer) and fed **to the ADC via a temperature-stabilized signal** conditioning section to reach a **TC < 1 ppm/°C.**

CAENels Power Sources – A novel digital magnet power supply approach

Quench Detection

A **quench protection procedure is running on the FPGA** and it is configurable.



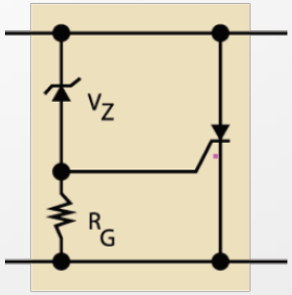
Auxiliary Inputs

External analog control input (e.g. to use the power supply **as an amplifier**) is provided by using another **ADC at 16-bit 100 ksps.**

An external input can also be used **to read**, for example, **the magnetic field** generated by the magnet - e.g. Hall probe. A slow loop can be closed on the field value.

Crowbar

Active circuits to protect against back-energy are designed for monopolar and bipolar power supplies.

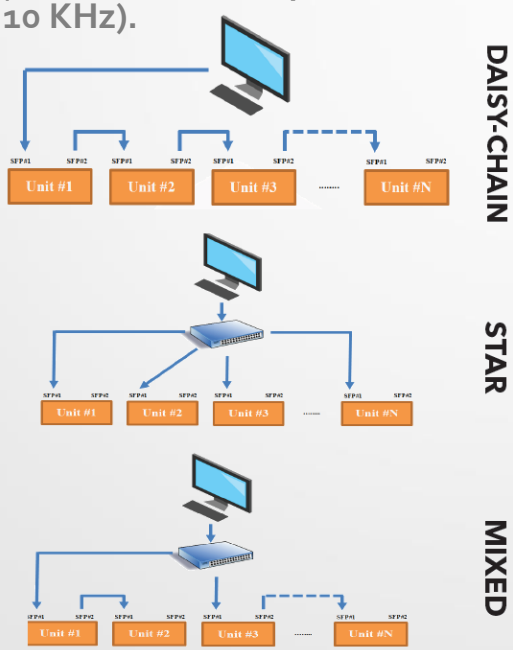


A specific circuit that **remains active for > 10 min after an AC mains failure** has been integrated also for superconducting magnets.

CAENels Power Sources – A novel digital magnet power supply approach

Fast Connections

Two 6.5 Gbps SFP+ links are provided for **fast update rates (> 10 KHz).**



Paralleling is also performed using the **SFP+.**

Embedded Webserver

Embedded **Oscilloscope** and **Waveform Generator. PID Parameters, Interlocks, Protections,** etc. can be configured remotely.

CAENels Power Sources – A novel digital magnet power supply approach

CONCLUSIONS

- Control of different types of power topologies - i.e. **different magnet types** with different requirements
- **Remote optimization of the current dynamic behaviour** using the digital control loop - no oscillations or slow response
- **Fast connectivity** (Gigabit Ethernet + SFP/SFP+): optimized for single module or for large installations
- **Extreme high-stability at 1 ppm/°C** with matched o-FLUCS DCCTs + temperature stabilization
- **Easy software development**/integration directly on the power unit using the embedded **Linux OS** - Yocto Project
- **Paralleling of modules** via SFP/SFP+ optical links
- **Remote configuration of waveforms, triggers, interlocks and protections configurations** for the specific application
- Implementation of **different control schemes** - e.g. IIR filters, adaptive algorithms, etc.

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Power Supply Systems

Easy-Driver

Compact Digital Bipolar Power Supply

- 19" – 1U stand-alone crate
- **±5A@±20V** and **±10A@±20V**
- 10/100 Mbit Ethernet interface
- Digital Current regulation loop
- Low noise
- Internal protections and
- Auxiliary Readbacks
- External Interlock and Status Signal
- Extended input range (90-260VAC)
- Local display for monitoring
- "VISUAL" free software available

	"0520" Model	"1020" Model
Output current range	± 5 A	± 10 A
Output voltage range	± 20 V	
Maximum output power	100 W	200 W
Topology	Bipolar	
Current setting resolution	160 µA	320 µA
Output current readback	20 bit	
Output voltage readback	20 bit	
Output current ripple*	< 40 ppm / FS	
Output current stability	< 40 ppm / FS	
Output Current TC	< 40 ppm / °C	
Switching Frequency	> 100 kHz	
Closed Loop Bandwidth	> 1 kHz	
Efficiency	up to 84 %	
External Interlocks/Status	1 Input: External Fault 1 Output: Power Supply Status	
Internal Interlocks	DC Link Under-Voltage MOSFETs Over-Temperature Shunt Over-Temperature	
Hardware Protections	Input Fuses Passive Crowbar (Over-Voltage)	
Cooling	Forced Air Convection – Front-to-Rear	
Control System Drivers	EPICS IOC	
Connectivity	Ethernet 10/100 Mbit TCP-IP	
Extra-Features	User-settable Slew Rate Value Firmware Remote Update	
Mechanical Dimensions	19" × 1U × 264 mm 19" × 1U × 295 mm - *with output connectors*	
Input Ratings	90/260 VAC) 47-63 Hz	

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Power Supply Systems

FAST-PS

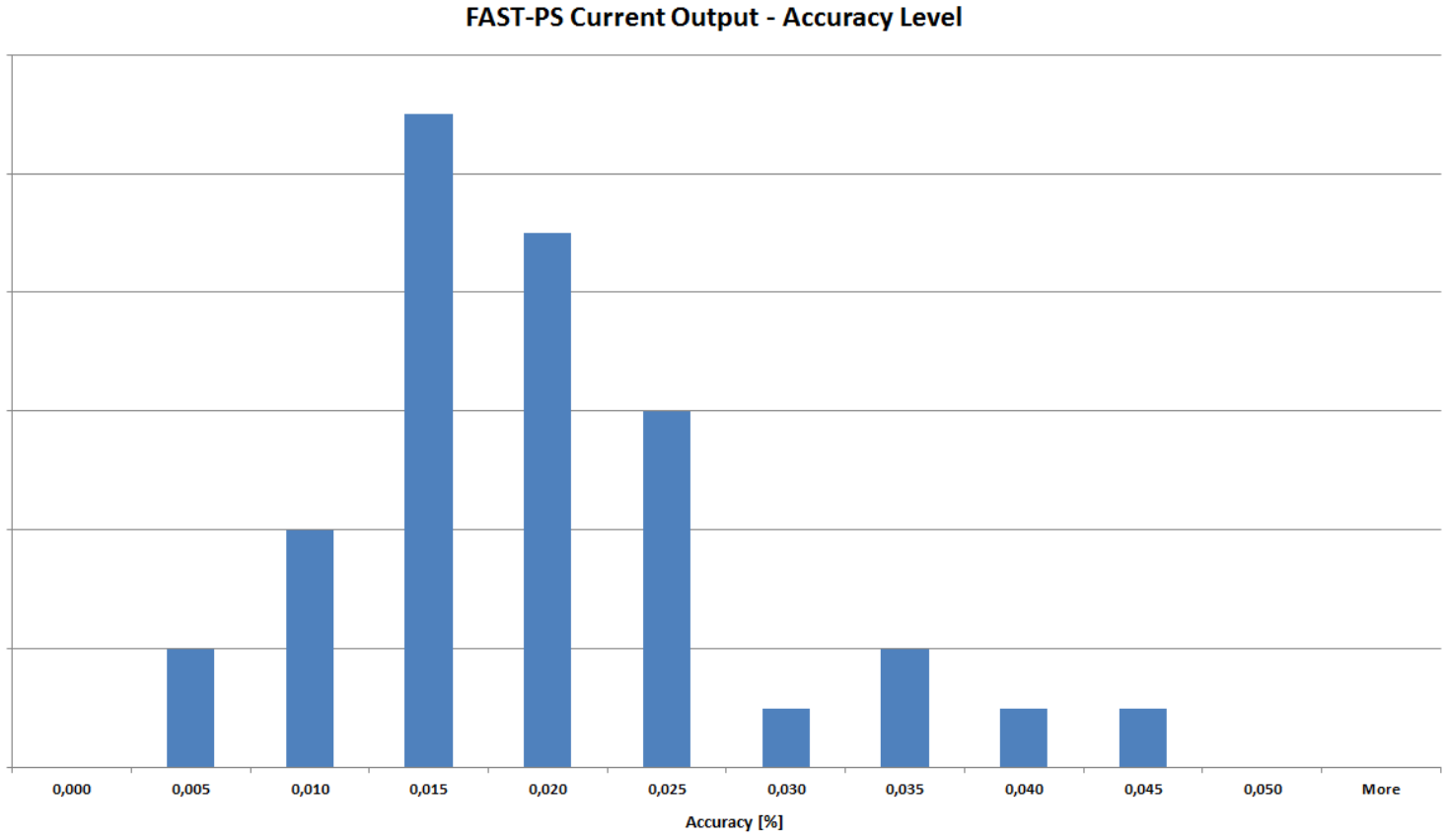
High-Performance Bipolar Power Supply

- 19" – 1U stand-alone crate
- Different current and voltage ratings
- 10/100/1000 Ethernet
- 2x Fast SFP interface (10 kHz update)
- Current or Voltage regulation
- High analog bandwidth
- Analog control and Trigger Input - optional
- Low noise
- Configurable Digital control loop
- Internal protections and auxiliary readbacks
- Local display and control

Regulation Type	Current- or Voltage- Control
Output current range	± 5 A, ± 10 A, ± 20 A, ± 30 A
Output voltage range	± 20 V, ± 40 V, ± 80 V
Maximum output power	up to 600 W
Setting resolution	18 bit
Output readbacks	20 bit
Output current ripple*	30 ppm / FS
Output current stability	< 50 ppm / FS
Output voltage stability	< 50 ppm / FS
Switching Frequency	100 kHz
Max Current/Voltage update rate	10 kHz
Accuracy	0.05%
External Interlocks/States	2 Inputs: user-configurable "dry" contacts 1 Outputs: relay (2 magnetic contacts)
Internal Interlocks	DC Link Under-Voltage MOSFETs Over-Temperature Over-Current and Over-Voltage Earth Fault Current Regulation Fault and Excessive Current Ripple
Hardware protections	Input Fuses Earth Fuse Over-Voltage
Auxiliary ADC Read-Backs	DC Link Voltage Ground Leakage Current Temperature
Cooling	On-Module Self-Regulated Fans
Control System Drivers	EPICS
Connection	1 x Ethernet 10/100/100 2 x SFP ports
Extra-Features	Point-by-Point Current Waveform Loading User-definable interlock thresholds, active levels and timings Firmware Remote Updates
Input Voltage	90/260 V(AC) (47-63 Hz)
Efficiency	up to 84 %
Power Factor	> 0.95

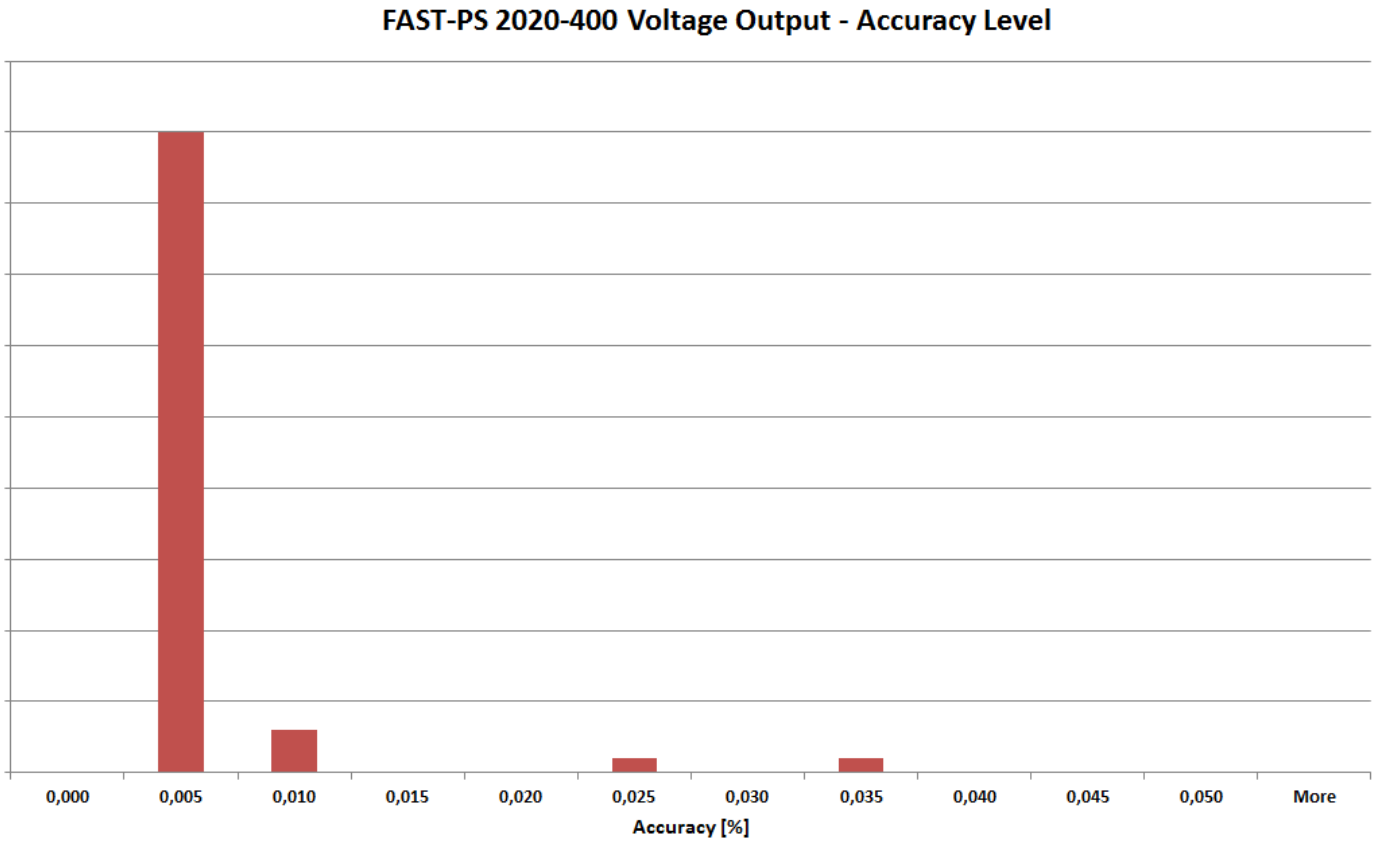
Fast-PS

Statistical Accuracy Spreading over all produced quantities



Fast-PS

Statistical Accuracy Spreading over produced quantities



Easy-Driver and FAST-PS (bipolar version)

Comparison

	Easy-Driver	Fast-PS
Output Current	*up to ±10A*	*up to ±30A*
Output Voltage	*up to ±20V*	*up to ±80V*
Output Power	*up to 200W*	*up to 600W*
Local Display	*yes*	*yes*
Local Control	*no*	*yes*
Embedded Waveform Generator	*no*	*yes*
Embedded Oscilloscope Monitor	*no*	*yes*
High Stability Option (DCCT)	*no*	*yes*
Analog Input Option	*no*	*yes*
Trigger Input Option	*no*	*yes*
Digital Control loop(s)	*Current*	*Current + Voltage*
External interlocks	*1*	*2*
Status Signals	*1 solid state relay*	*1 solid state relay + 1 magnetic relay*
Remote Sensing	*no*	*yes*
Remote Interface	*10/100 Ethernet*	*10/100/1000 Ethernet + SFP Fast Interface*
Remote Update Rate	*250 Hz*	*1 kHz – Ethernet / 10 kHz SFP Fast Interface*
Other Features	*Firmware Remote Update* *Configurable Thresholds/Limits* *Internal Protections*	*Firmware Remote Update* *Configurable Thresholds/Limits* *Internal Protections* *Waveform loading and execution* *Embedded Linux OS* *USB host*

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Power Supply Systems

FAST-PS-M

High-Performance Monopolar Power Supply

- 19" – 1U stand-alone crate
- **100A-6V, 75A-8V, 60A-10V** ratings
- 10/100/1000 Ethernet
- 2x Fast SFP interface (10 kHz update)
- Current or Voltage regulation
- High switching frequency – 300 kHz equivalent
- Analog control and Trigger Input - optional
- High-stability and low TC
- Configurable Digital control loop
- Internal protections and auxiliary readbacks
- Local display and control

Regulation Type	Current- or Voltage- Control		
Output current range	60 A	75 A	100 A
Output voltage range	10 V	8 V	6 V
Maximum output power	up to 600 W		
Setting resolution	> 18 bit		
Output readback	24 bit		
Output current ripple*	30 ppm / FS		
Output current stability	50 ppm / FS		
Output voltage stability	50 ppm / FS		
Switching Frequency	300 kHz (equivalent)		
Max Current/Voltage update rate	10 kHz		
Accuracy	< 0.05%		
External Interlocks/States	2 Inputs: user-configurable "dry" contacts 1 Outputs: relay (2 magnetic contacts)		
Internal Interlocks	DC Link Under-Voltage Over-Temperature Over-Current & Over-Voltage Earth Fault Current Regulation Fault & Excessive Current Ripple DCCT OK		
Hardware protections	Input Fuses Earth Fuse Over-Voltage		
Auxiliary ADC Read-Backs	DC Link Voltage Ground Leakage Current Temperature		
Cooling	On-Module Self-Regulated Fans		
Connection	1 x Ethernet 10/100/100 2 x SFP ports		
Extra-Features	Point-by-Point Current Waveform Loading User-definable interlock thresholds, active levels and timings Firmware Remote Updates		
Dimensions	19"– 1U – 365 mm (W x H x D)		
Input Voltage	90/260 V(AC) (47-63 Hz)		
Efficiency	up to 85 %		
Power Factor	> 0.95		

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Power Supply Systems

FAST-PS-1K5

1.5-kW High-Stability Bipolar Power Supply

- 19" – 2 U stand-alone unit
- Models **up to ±100 A** and **up to ±100 V**
- Configurable digital control loop
- 10/100/1000 Ethernet interface
- Current or Voltage regulation
- Low noise and Ripple
- < 1 ppm/K temperature dependence
- Excellent long-term stability
- Quench protection for SC magnets
- External Analog Control, Trigger and
- Configurable ADC Inputs
- Fast SFP interface (10 kHz update)

	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
Maximum Output Power	1.500 W			
Topology	Bipolar			
Control Mode	Current (CC) and Voltage (CV) Control			
Floating Output	Up to 200 V			
Remote Sensing	Up to 0.5 V			
Current Sensing	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)			
Analog Bandwidth (-3 dB)	> 2 kHz			
Control/Communication Interface	Ethernet TCP-IP SFP/SFP+			
Local Control	Colour display with multi-function navigation switch			
External Signals	2 External Interlocks 2 Status signals – 1 magnetic relay 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 x W x H)	19" x 2U x 550 cm			
Operating Temperature	0 ... 45 °C			

FAST-PS-1K5 Full-4-Quadrant

1.5-kW High-Stability Bipolar Power Supply

4-Quadrant Optional Units

Ordering Code	Acronym
F1K5D4050030	F1K5-DISS-50-30
Description: 4-Quadrant Operation Crate for FAST-PS-1K5 50 A - 30 V	

Ordering Code	Acronym
F1K5D4100015	F1K5-DISS-100-15
Description: 4-Quadrant Operation Crate for FAST-PS-1K5 100 A - 15 V	

QDS

Quench Detection System

Front

Rear

The QDS is a 4-channel multi-range precision **digital quench detection system for superconducting magnets.**

The QDS is the new solution for any type of quench detection on superconducting magnets. It is composed by 4 independent channels, each one floating up to 100 V, that can be connected to voltage taps. The quench detection can be **performed both in an absolute or differential way** and the detection window can be configured from 1 ms to 1 s.

Each channel has **eleven (11) different full-scale ranges**, the largest one up to ±20 V (2.4 uV resolution) and the smallest one up to ±20 mV (2.5 nV resolution). The range of each channel can be set independently.

Each channel can float up to 100 V from ground and it is fed to a signal conditioning network that converts it with a **24-bit resolution and a 100-kHz sampling rate**.

Interlock signals as well as output status signals are available for different uses - e.g. interfacing to a power supply for the **superconducting magnet**.

Two power outputs, one rated at 12 V and the other one at 24 V, can be used to drive a **persistent switch**. A **10/100/1000 Mbit Ethernet** connection allows for very fast data transmission and easy instrument control with several operating systems and programming languages. The internal firmware can be remotely updated.

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Power Supply Control

QDS

Quench Detection System

Front

Rear

- 4-channel simultaneous sampling
- Integration time configurable from 1 ms to 1 s
- 11 full-scale ranges for each channel, ranging from ±20 V to ±20 mV
- 24-bit ADC internal conversion
- Absolute and differential quench thresholds
- 10/100/1000 Ethernet Connectivity
- 12-V and 24-V persistent switch drivers
- Interlocks and output status signals
- Firmware Remote Update
- Auto-ranging functionality
- On-board FPGA and soft-processor computations
- Compact mechanical dimensions
- Oscilloscope software available

Technical Specifications	QDS
Input Channels	4
Input Polarity	Bipolar
Input Channel Type	Floating - up to 100 V
Voltage Measuring Range	RNG0 ±20 V RNG1 ±10 V RNG2 ±5 V RNG3 ±2.5 V RNG4 ±1.25 V RNG5 ±625 mV RNG6 ±312.5 mV RNG7 ±156.25 mV RNG8 ±78.125 mV RNG9 ±39.0625 mV RNG10 ±19.53125 mV
Voltage Resolution (LSB)	RNG0 2.4 µV ... ... RNG10 2.5 nV
Internal Sampling Frequency	100 kHz
Sampling Resolution	24 bit
Integration Time (T)	from 1 ms to 1 s
Equivalent Input Bandwidth	T = 10 ms 45 Hz T = 50 ms 9 Hz T = 100 ms 5 Hz T = 500 ms 1 Hz T = 1 s 0.55 Hz
Temperature Coefficient	0.0025 %/FS/K
Communication Interface	Ethernet 10/100/1000 TCP-IP or UDP
Internal Processing Unit	FPGA and soft-processor
External Signals	2 x External Interlocks 12-V and 24-V persistent switch power Magnetic Relay
Input Connectors	Twin ("Twinax") BNC
Interlock/Status Connector	Weidmüller 1290260000 (mating: Weidmüller 1277900000)
Additional Features	Auto-Ranging Firmware Remote Upgrade Configurable Integration Time Configurable absolute and differential quench thresholds
Cooling	Blower Fan
Dimensions	174 x 175 x 44 mm
Weight	< 850 g
Supply Voltage	+12 V
Status Indicators	5 LEDs

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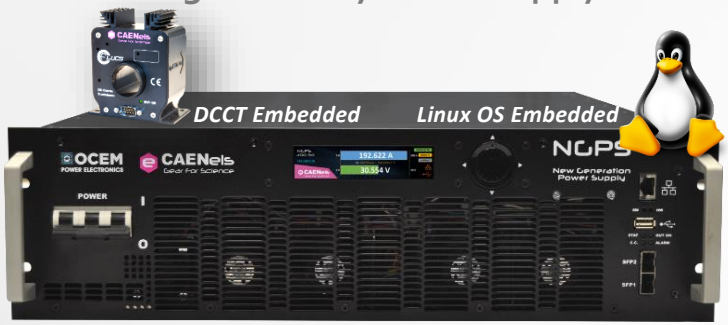
NGPS Information and Data

NGPS

10-kW High-Stability Power Supply



- 19" – 3U stand-alone unit
- Different current and voltage ratings
- Versions: **200A/50V, 100A/100V (both 10 kW) + 140A/50V (7kW)**
- 10/100/1000 Ethernet interface
- 2x Fast SFP interface (10 kHz update)
- Current or Voltage regulation
- Low noise and Ripple
- 1 ppm/K grade ("HS" version)
- High temperature and long-term stability
- Configurable digital control loop
- Internal protections and auxiliary readbacks
- Local display and control

powered by OCEM POWER ELECTRONICS

Input Ratings	208 VAC ('E') Three-phase 50/60 Hz 400 VAC ('A') Three-phase 50/60 Hz	
Regulation Type	Current-control (C.C.) or Voltage-control (C.V.)	
Output current range	NGPS 120-50 NGPS 200-50	120 A 200 A
Maximum output voltage	50 V	
Maximum output power	up to 10 kW	
Output Isolation	500 V	
Power Factor	> 0.9	
Efficiency	> 90 %	
Current and Voltage Setting	18 bit	
Current and Voltage Readback	20 bit	
Max Current/Voltage update rate	10 kHz *(over SFP)*	
Closed-loop Bandwidth	C.C. mode C.V. mode	> 100 Hz > 200 Hz
Accuracy	C.C. mode C.V. mode	< 0.01 % (0.005% *upon request*) < 0.05 %
Line Regulation	±5 ppm/FS	
Load Regulation	±5 ppm/FS	
Remote Sensing Compensation	up to 2 V	
Cooling	Forced Air Convection (front-to-rear)	
Temperature Stability	C.C. mode C.V. mode	5 ppm/K (1 ppm/K – *"HS" version*) 50 ppm/K
Interfaces	10/100/1000 TCP-IP Ethernet Two (2) SFP *other interfaces available upon request*	
Internal Interlocks/Protections	Over-Temperature MOV Input Over-Voltage Main circuit-breaker for Over-Current Output Free-wheeling diodes Output Over-current and Over-Voltage Earth current leakage Input Phase-Loss	
External Interlocks/States	user-configurable "dry" contacts relay (magnetic contacts, NO and NC)	
Other Features	Firmware remote update Interlock configurabilty Adaptable thresholds for trips and interlocks	
Modularity	Parallel connection Series connection	up to 4 up to 2
Mechanical Dimensions	19" x 3 U x 600 mm *including connectors*	
Weight	28 kg	
Operating Temperature	0 ... 50 °C	

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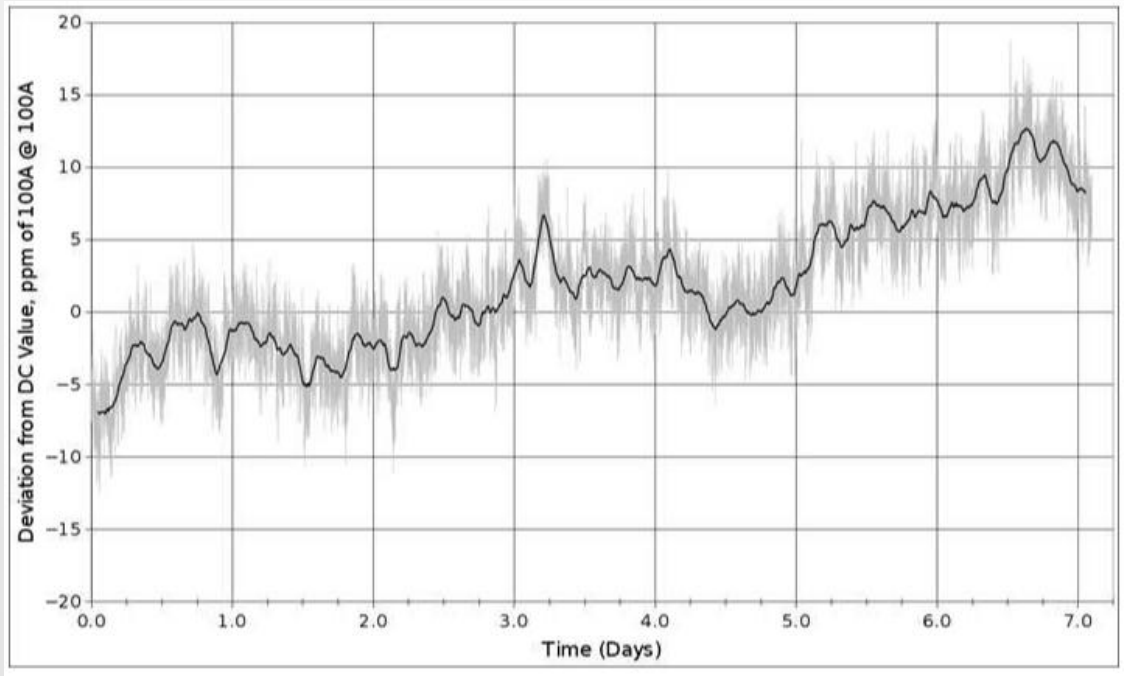
NGPS Long Term Stability

NGPS

Accuracy Performance over 7 days – tested from one of our customers



- Measured at 100A CC
- Guaranteed accuracy in the datasheet: 100 ppm
- Measured Long Term Stability – **Maximum Deviation in 7 days: 13 ppm (0,0013%)**
- Measured Long Term Stability – **Maximum deviation in 1 day: 6 ppm (0,0006%)**

Polarity Inverters

200A, 400A, 600A

- 19" – 6U crate
- Current ratings up to 630A
- Perfect fit for the NGPS, both in single or paralleled configurations
- Controlled via the NGPS (no separate control needed)
- Adaptable to further sources from the market

	200 A	400 A	600 A
Rated Current	200 A	420 A	630 A
Rated Voltage	250 V	250 V	250 V
Auxiliary Input Voltage	100 – 240 V_{AC} @ 50 – 60 Hz		
Auxiliary Input Power	350 W		
DC Input/Output Connection	Phoenix Contact HDFKW-95-F/7	Phoenix Contact HKH240F	Bus-bars
Max Interlock Rating (pin 6 – 7)	240 V – 16 A		
Max Enable Rating (pin 8, 9 & 10)	240 V – 10 A		
Total weight	28 kg	35 kg	
Dimensions	19" × 6U × 550 mm *w/out output connections*		
Input Fuses Mains 230 V	2 x IW 1421002 2 A – 500 V (38 x 10.3 mm)		
Input Fuses Mains 24 V	2 x IW 1421010 10 A – 500 V (38 x 10.3 mm)		

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Power Supply Control

REGUL8OR

Universal High-Precision Power Supply Controller

- 19" – 1U stand-alone crate
- Voltage and Current control
- STANDARD and FAST control loop
- STANDARD: 100 ksps – 20 kHz BW
- FAST: 4 Msps – 1 MHz BW
- Up to ± 200 V and ± 1.000 A
- o-FLUCS current transducer included
- Digital output regulation loop
- Waveform Generation at 100 ksps
- Embedded 4-channel Oscilloscope
- Embedded Web-Server
- External Interlock and Status Signals
- Local Display and Controls
- 10/100/1000 Mbit Ethernet

REGUL8OR		
Technical Specifications	"LV" Model	"HV" Model
Output current ranges	± 100 A ± 150 A ± 200 A ± 300 A ± 400 A ± 600 A ± 1.000 A	
Output voltage ranges	± 5 V ± 10 V ± 20 V ± 50 V ± 100 V ± 200 V	± 200 V ± 400 V ± 600 V ± 800 V ± 1.000 V
Maximum output power controlled	200 kW	1 MW
Output regulation	Constant Current (CC) or Constant Voltage (CV)	
Current setting resolution	24 bit	
Voltage setting resolution	24 bit	
Current readback resolution	24 bit	
Voltage readback resolution	24 bit	
Line regulation (±10 % variation)	< 0.0005 %	
Load regulation (±10 % variation)	< 0.0005 %	
Temperature Coefficient (TC) in CC	< 2 ppm / °C	
Temperature Coefficient (TC) in CV	< 5 ppm / °C	
Long-term stability (8 h) in CC	< 10 ppm / FS	
Long-term stability (8 h) in CV	< 10 ppm / FS	
Output current accuracy	< 0.01 %	
Output voltage accuracy	< 0.01 %	

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Power Supply Control

REGUL8OR

Universal High-Precision Power Supply Controller

- 19" – 1U stand-alone crate
- Voltage and Current control
- STANDARD and FAST control loop
- STANDARD: 100 ksps – 20 kHz BW
- FAST: 4 Msps – 1 MHz BW
- Up to ± 200 V and ± 1.000 A
- 0-FLUCS current transducer included
- Digital output regulation loop
- Waveform Generation at 100 ksps
- Embedded 4-channel Oscilloscope
- Embedded Web-Server
- External Interlock and Status Signals
- Local Display and Controls
- 10/100/1000 Mbit Ethernet

Output Control Interfaces	Analog Voltage Output: ± 5 V or ± 10 V Analog Current Output: 4 - 20 mA 8 x High-Resolution optical PWM outputs
Regulation speed modes	«STANDARD»: 100 ksample/s «FAST»: 4 Msample/s
Current and Voltage bandwidth (-3 dB)	«STANDARD»: 20 kHz «FAST»: 1 MHz
External Interlocks	4 inputs accepting dry-contracts 2 inputs accepting +24 V_{DC} (e.g. from PLC)
External Hardware Interfaces	2 x output magnetic relay 2 x output solid-state relay 2 x output isolated TTL (0 - 5 V) signals
External Signals	1 x analog input sampled at 100 ksps @ 16-bit (e.g. Hall Probe) +5 V or 20 mA supply available (e.g. to supply Hall Prove) 1 x analog control input at 100 ksps @ 16-bit (± 10 V) 1 x SPI isolated interface (4-wire) 1 x Ext. Temperature Sensor Input (with +3.3V supply) 2 x Optical "Fault" signals (e.g. from IGBT modules) 1 x Trigger Input 1 x Sync Output + 1 x Sync Input (to sync different controllers)
Cooling	Fanless
Connectivity	1 x Ethernet 10/100/1000 Mbit TCP-IP or UDP 2 x SFP+ (6.25 Gbps)
Extra-Features	Embedded Web-Server 4-channel Oscilloscope function at 100 ksps Waveform Generator Embedded EPICS IOC Firmware Remote Update Paralleling and sync of multiple units
Mechanical Dimensions	19" × 1U × 230 mm
Weight	< 2 kg
AC Input ratings	90/264 V_{AC} 47-63 Hz
Local Indicators	LCD Display LEDs

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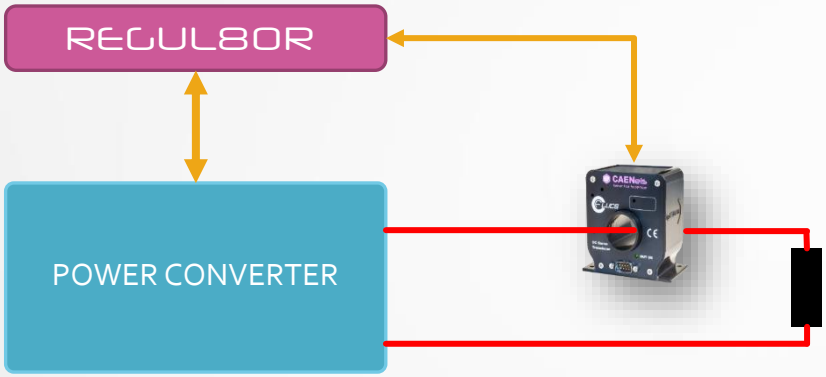
Power Supply Control

REGUL8OR

Universal High-Precision Power Supply Controller



Project with TDK Lambda for 30 devices
500A/50V controlled by REGUL8OR

	TDK Lambda Genesys+ - stand alone	with REGUL8OR
Line Regulation	0,1%	0,0005%
Load Regulation	0,1%	0,0005%
Control Mode	CC+CV	CC+CV
Accuracy CC-Mode	0,5%	<0,01%
Accuracy CV-Mode	0,3%	<0,01%
Setting Resolution	0,02% (CV), 0,04% (CI)	24 bit (ca. 0,000025%)
Readback Resolution	0,02% (CV, CI)	24 bit (ca. 0,000025%)
Temperature Stability	<0,02%/K (CC- + CV-Mode)	<0,0002% (CC-Mode) <0,005% (CV-Mode)
Long Term Stability (8h)	<0,02% (CC- + CV-Mode)	<0,0005% (CC-Mode) <0,005% (CV-Mode)
Adaption to different loads by	additional hardware - capacitors or inductors	software regulation per PID parameter / Autotuning

Precision Current Measurements

Precision Current Measurements

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Precision Current Measurements

High-Precision Current Measurement System

Comparison of Current Measurement Technologies

The **ZERO-FLUCS** principle was already discovered in the 1930 years and is up to today the most complex and overall most precise, most stable and most versatile current measuring method.

Characteristics/Capability	Shunt	Hall Effect Sensor	Current Transformer	Rogowski Coil	CAENels ZERO FLUCS DCCT
DC Currents	Yes	Yes	No	No	Yes
Bandwidth	Medium	Very poor	High	Very high	High
Insulation	No	Yes	Yes	Yes	Yes
Linearity	Medium	Very poor	Poor	Medium	Very high
Accuracy	Medium	Medium	Medium	Medium	Very high
Offset	Yes	Yes	No	No	No
High Currents	No	Medium	Medium	High	Very high
Magnetical Saturation	No	Yes	Yes	No	No
Temperature Stability	Medium	Poor	High	Very high	Very high
Power Consumption	High	Low	Low	Low	Medium
Dimension	Very small	Small	Small	Medium	Medium
Long Term Stability	Poor	Poor	Poor	Very good	Very good
Automotive Interface Ability	Difficult	Possible	Difficult	Possible	Possible

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FLUCS
DCCT SERIES

Precision Current Measurements

CT-13 CT-26 CT-52
(PCB Mountable)

CT-100 CT-150

CT-200 CT-300 CT-400
CT-600 CT-1000

System CT-BOX plus CT

The Features

- **AC- and DC-** measurements separately or combined
- Standard Accuracy: **< 100 ppm (< 0,01%) FS** / High-Accuracy Calibrated System: **< 50 ppm (< 0,005%) FS**
- **Voltage Output Versions:** Standard Accuracy: **< 2.500 ppm (< 0,25%) FS**, Optional Accuracy: **< 500 ppm (0,05%) FS**
- Temperature Coefficient: **< 1 ppm/K FS**
- High-Linearity: **< 3 ppm/FS**
- Input Noise: **< 1.5 ppm at 200 Hz, < 10 ppm at 50 kHz**
- Excellent AC-Amplitude and Phase response **up to 500 kHz**
- **24-bit @ 100 kSPS** sampling
- Current Transformer Ratio: **I_S/I_P from 1:250 up to 1:2000** as standards
- Display: **7 1/2 Digits**

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FLUCS
DCCT SERIES

Precision Current Measurements

CT-13 CT-26 CT-52
(PCB Mountable)

CT-100 CT-150

CT-200 CT-300 CT-400
CT-600 CT-1000

System CT-BOX plus CT

The Features

- Galvanic Insulation Primary to Secondary
- External Temperature Sensors (for temperature monitoring)
- Fanless
- **microSD** for data storage (also for long-term measurements)
- Analog Monitoring (±10 V)
- **CT-Viewer Software** free and included
- Trigger Input/Output and Alarm Output
- Interfaces: **Ethernet 10/100 Mbps TCP-IP, USB 2.0, RS-232**
- All Cables **included**

PS1215 bipolar power source for DCCTs available!

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FLUCS
DCCT SERIES

Precision Current Measurements

CT-13 CT-26 CT-52
(PCB Mountable)

CT-100 CT-150

CT-200 CT-300 CT-400

CT-600 CT-1000

System CT-BOX plus CT

Customization Services - *higher quantities or additional charge*:

- Custom Specific Transformer Ratios, i.e. 1:423 (primary current = 42.3 A / secondary current = 100 mA)
- Custom Specific Current Values > 1 kA: up to 30 kA
- Expansion of primary hole diameter up to 80 mm
- Up to 150 A PCB-mountable versions possible

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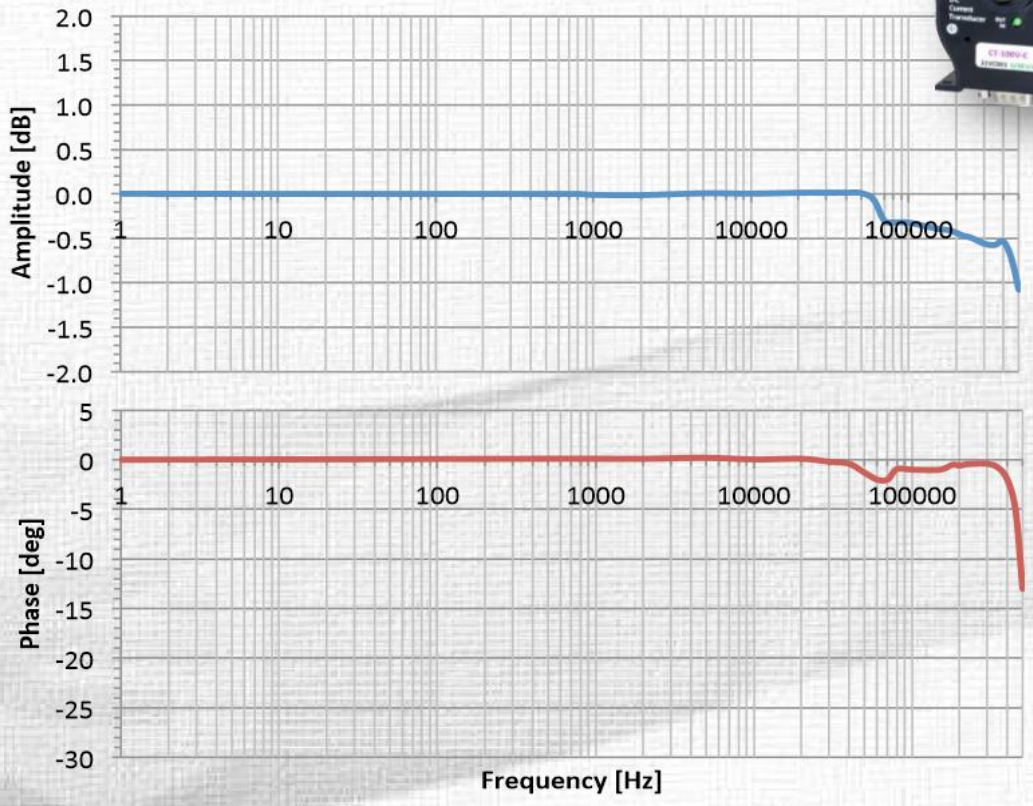
FLUCS
DCCT SERIES

Precision Current Measurements

AC Performance

- CT-150 Amplitude and Phase Response



Amplitude Response

Frequency	Amplitude
DC ... 50 kHz	< 0.02 dB
50 ... 200 kHz	< 0.5 dB
200 ... 400 kHz	< 1 dB

Phase Response

Frequency	Phase Shift
DC ... 2 kHz	< 0.1°
2 Hz ... 40 kHz	< 0.5°
40 ... 400 kHz	< 2°

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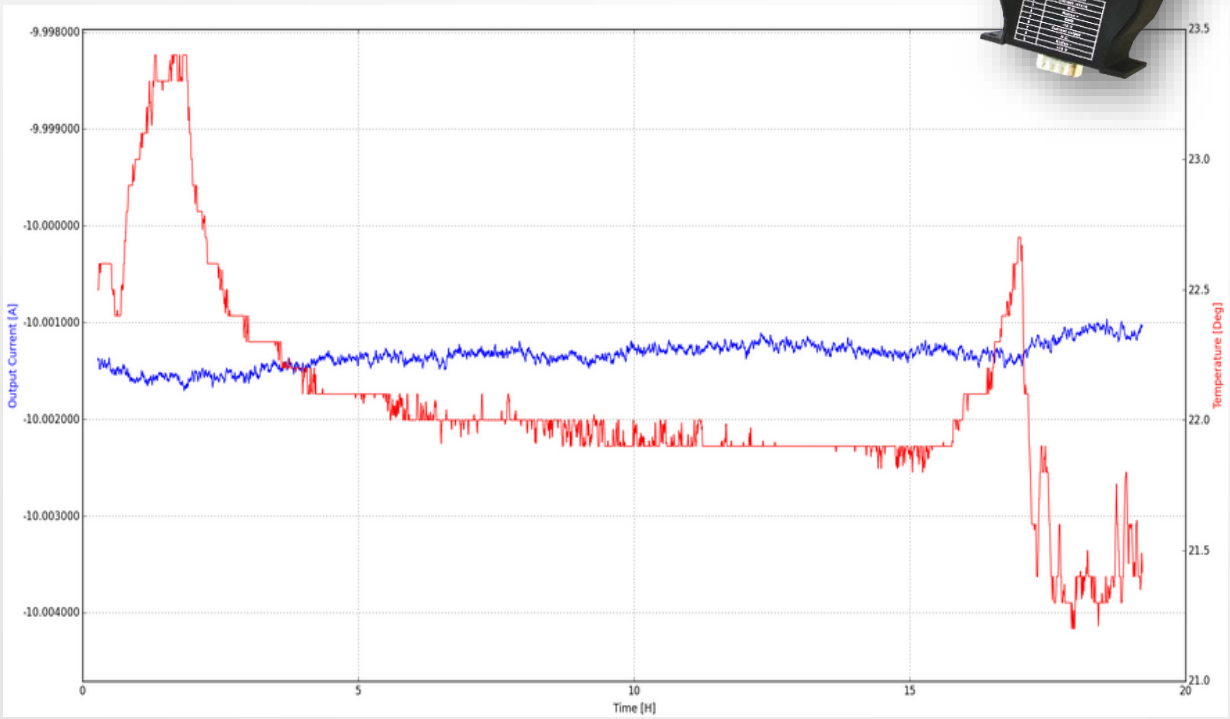
DCCT SERIES

Precision Current Measurements

Temperature Stability (Example):



Temperature Stability over 19 hours:

Temperature
21.2 °C to 23.4 °C

Current Measurement
-10.0023A to -10.0030A

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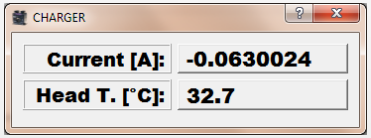
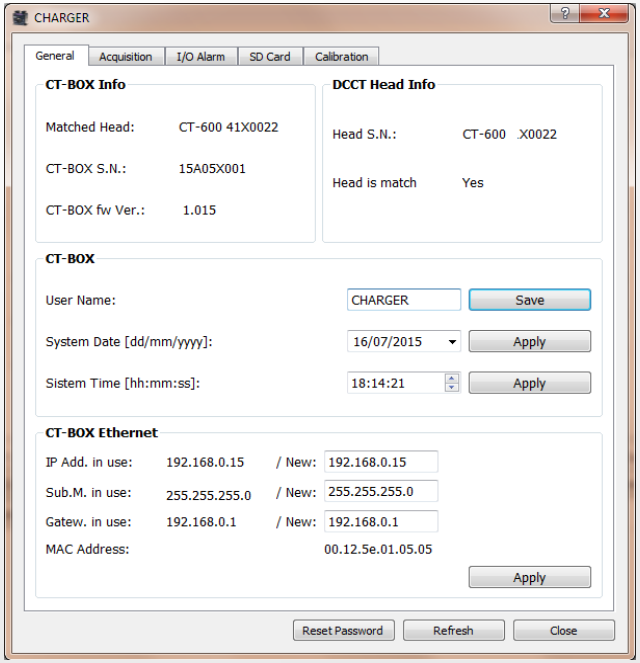
FLUCS
DCCT SERIES

Precision Current Measurements

CT-BOX

CT-Viewer Software





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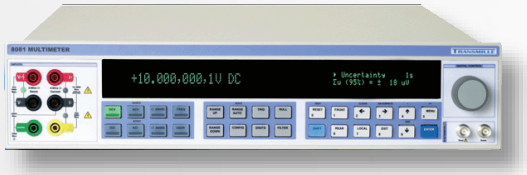
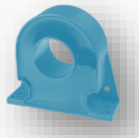
FLUCS DCCT SERIES

Innovation

Usual Measuring System

Digital Multimeter (7,5 digits or higher) + DCCT





- ✗ several times higher costs
- ✗ non-calibrated system – imprecise measurements
- ✗ high quality cables must be purchased separately
- ✗ lower frequencies up to max. 100kHz possible
- ✗ no data storage possible
- ✗ no easy transportation
- ✗ no easy installation
- ✗ no specific software solution

CT-BOX System

- ✓ lower costs
- ✓ system calibrated
- ✓ cables included
- ✓ frequencies up to 500 kHz
- ✓ data storage via SD (included)
- ✓ compact system
- ✓ 19”- rack mount available
- ✓ monitoring software inclusive

Beamline Electronic Instrumentation

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Beamline Electronic Instrumentation

AH401D

4-channel Charge Integration Picoammeter

Photon BPM applications:

- *Quad-diode BPM´s*
- *Diamond detectors readout*
- *ion chambers*
- *blade gap monitors*
- *radiation monitors*

- 7 different ranges – from 50 pC to 2 nC (monopolar)
- settable integration time: from 1ms to 1s
- 20 bit + low-noise
- Ethernet connectivity
- User-friendly software for photon BPM applications provided
- TTL trigger/gate input signal and output conversion signal → external events

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AH501D

4-channel Bipolar Picoammeter with Bias Voltage Source

- 3 different ranges - ±2.5 mA , ±2.5 µA, ±2.5 nA
- sampling frequency – up to 26 kHz (1 channel @ 16-bit)
- 16- or 24-bit resolution
- Ethernet connectivity
- Bias up to 30V (sub-mV RMS noise)
- User-friendly software for photon BPM applications
- TTL gate input signal and output conversion signal → external events

Photon BPM applications:

- *Quad-diode BPM´s*
- *Diamond detectors readout*
- *ion chambers*
- *blade gap monitors*
- *radiation monitors*

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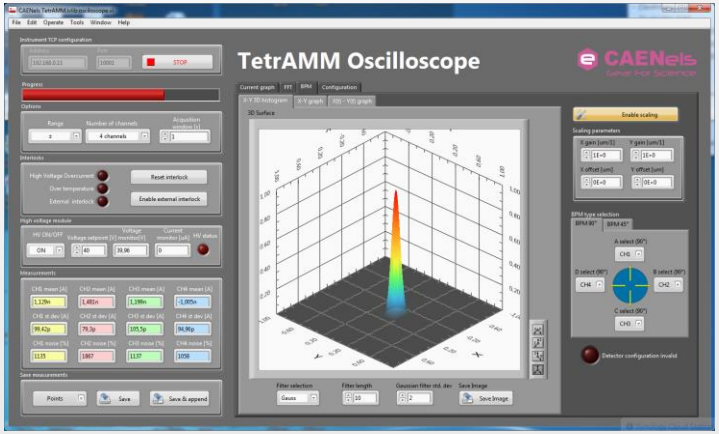
TetrAMM

4-channel Fast-Interface Bipolar Picoammeter (with Integrated HV upon request)

- 2 different full-scale ranges: ±120 µA and ±120 nA (configurable)
- Internal sampling: 100 kHz@24 bit
- Firmware Remote Update
- Configurable Sampling Frequency
- Automatic independent ranging
- Gigabit Ethernet connectivity
- 500V standard HV bias (up to 4 kV)
- Factory calibration
- FPGA and soft-processor computations
- User-friendly software for photon BPM applications
- Different trigger/gate and configuration → external events



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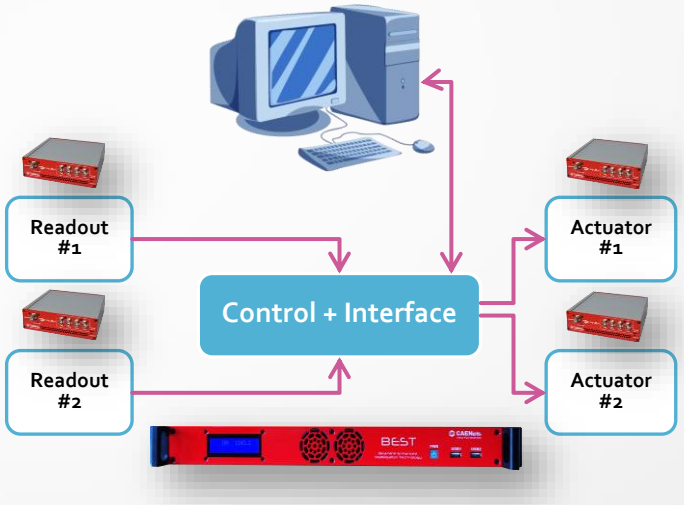
TetrAMM and AH501D - Comparison

	TetrAMM	AH501D	
Input Channels	4	4	
Sampling bits	24	16	24
Sampling Frequency	100kHz (max.)	1 channel: 26kHz | 2 channels: 13kHz | 4 channels: 6,5kHz	1 channel: 13kHz | 2 channels: 6,5kHz | 4 channels:3,2kHz
Ranges	Range 0: ±120 nA Range 1: ±120 µA	Range 0: ±2.5 nA Range 1: ±2.5 µA Range 2: ±2.5 mA	
Resolution	Range 0: 15 pA Range 1: 15 fA	Range 0: 76 nA | Range 0: 300pA Range 0: 76 pA | Range 0: 300fA Range 0: 76 fA | Range 0: 300aA	
Ranges customizable	YES	NO	
Independent Ranging	YES	NO	
Auto Ranging	YES	NO	
Data Rate	Up to 100kSamples/s **per channel**	up to 26 kSamples/s | up to 13 kSamples/s	
Analog Input Bandwidth	5 kHz (customization upon request)	5 kHz	
Monitoring	Digital, Plug & Play GUI	Voltage Analog Monitoring (±5V)	
BIAS Voltage	500V up to 6kV (plus or minus) upon request	0 to 30V (integrated)	

Beamline Electronic Instrumentation

BEST

Beamline Enhanced Stabilization Technology



- Powerful **Instrumentation and Software Suite** for stabilization and optimization of photon beam (X, Y, Io)
- System composed by three main building blocks:
- readout block - **TetrAMM**
- control and interface block – **BEST** Central Unit
- actuator block – **PreDAC**
- Expandability → up to two phBPMs and two piezoelectric actuators (monochromators)
- Low-latency and high speed guarantees higher frequency compensation respect to "standard" local feedback implementations (software based)

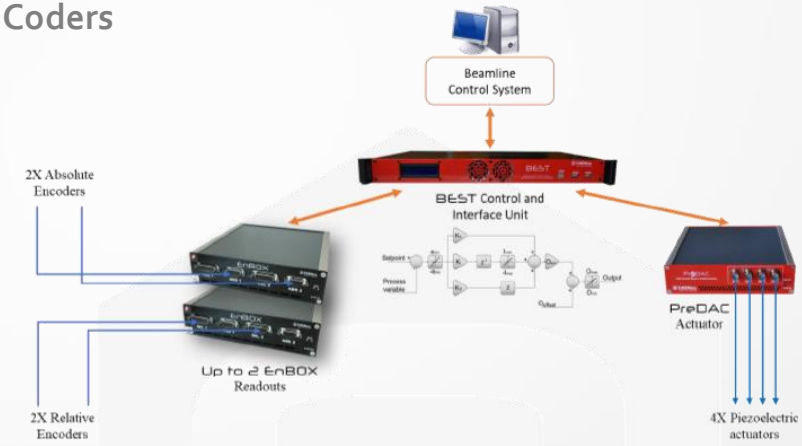
EnBOX

Two Encoder Channels Readout Box

- Compatible encoders: RENISHAW TONiC™, RENISHAW RESOLUTE™
- Supported encoder protocols: BiSS-C (for RESOLUTE™), Quadrature encoder (for TONiC™)
- Encoder power supply: +5V (max 3W per channel)
- Sampling Frequency: 5 kHz
- Communication: Ethernet 10/100/1000 TCP-IP
- Extra Communication interface: SFP – Small form-factor pluggable
- External Signals: Configurable Trigger/Gate, Trigger Output, External Interlock
- Input connectors: DE-9 (for RESOLUTE™), DA-15 (for TONiC™)
- Firmware Remote Update
- Input Power Supply: +12V

BEST-ENC

Beamline Enhanced Stabilization Technology - ENCoders

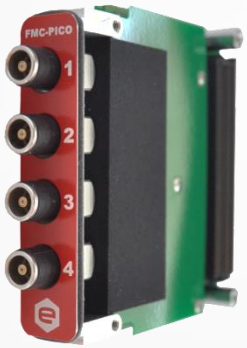


- Powerful **Instrumentation and Software Suite** for stabilization and optimization of photon beam (X, Y, Io)
- System composed by three main building blocks:
- readout block – **EnBOX** (digital signal input for RENISHAW TONiC™, RENISHAW RESOLUTE™ encoders)
- control and interface block – **BEST** Central Unit
- actuator block – **PreDAC**
- Expandability → up to two EnBOX (4 encoders) at one PreDAC (4 piezoelectric actuators)
- Fast and low delay SFP links

FMC and MicroTCA

MicroTCA.4 for Physics

FMC and MicroTCA



What is FMC and MicroTCA?

FMC (FPGA Mezzanine Card) is an **ANSI/VITA standard** that defines **I/O mezzanine modules** with connection to an **FPGA** or other device with re-configurable I/O capability. **It specifies a low profile connector and compact board size** for compatibility with several **industry standard** slot card, blade, low profile motherboard and mezzanine form factors.

MicroTCA or **µTCA** is an environment originated from the development of telecommunications hardware architectures.

It is a standard describing **a new class of modular computer systems** that is **more energy-efficient, compact and economical** than the **ATCA (Advanced TCA)**.

MicroTCA was developed exploiting many of the advantages of ATCA/AMC and was designed with maximum re-usability, so that **many AMC boards originally developed for ATCA can also be used in MicroTCA systems**.

The system uses serial high-speed connections (e.g. PCIe protocol, Gigabit Ethernet), system monitoring and efficient cooling as well as redundancy concepts, representing **the highest-performance solution for applications in telecommunication, industry, medical and military technology**.

ATCA

Innovation

MicroTCA

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FMC and MicroTCA

MicroTCA TECHNOLOGY LAB
A HELMHOLTZ INNOVATION LAB

driven by DESY

Development, Manufacturing and Distribution Partners:

BEVATECH

CAENels Gear For Science

elspec group GmbH

EMCOMO

nVent SCHROFF

PICMG®

powerBridge Computer

ROHDE&SCHWARZ

struck innovative systeme

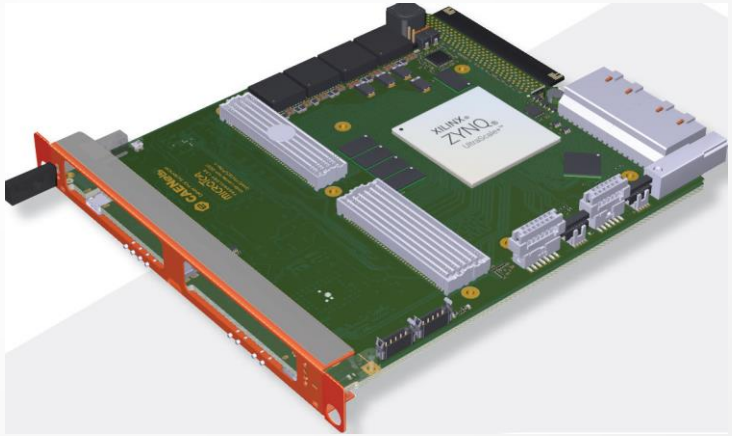
TELEDYNE SP DEVICES Everywhereyoulook™

vadatech THE POWER OF VISION

WIENER Power Electronics

DAMC-FMC2ZUP1 - MTCA.4 ZYNQ UltraScale+ FMC+ Carrier

- FPGA Low-Power Xilinx UltraScale+ MPSoC XCZU**11**EG-L2FFVC1760E or XCZU**19**EG-L2FFVC1760E
- 653k Logic Cells, 2.928 DSP Slices, PCIe Gen. 4 x8, 100G Ethernet MAC
- 1.5 GHz Quad-Core ARM Cortex-A53, MALI-400 GPU
- 16 GTY transceivers (28.21 Gbps) routed to FMC+ transceivers
- 32 GTH Transceivers (16.375 Gbps / 12.5 Gbps low-power) routed to FMC HPC, backplane, Front Panel, Zone3
- 4 GTR Transceivers (6.0 Gbps) routed to SATA links and USB Type-C connector
- 21.1 MB of BlockRAM, 22.5 MB of UltraRAM
- C1760 package is compatible to ZU17EG (926k logic cells) and ZU19EG devices (1143k logic cells)
- FPGA core voltage can be set to low-power (0.72V) or standard power operation via MMC user command allowing to switch between low-heat dissipation or highest transceiver performance



Available from automn 2020 – SOP in July 2020.

DESY

µTCA®

License Agreement between DESY and CAEN ELS

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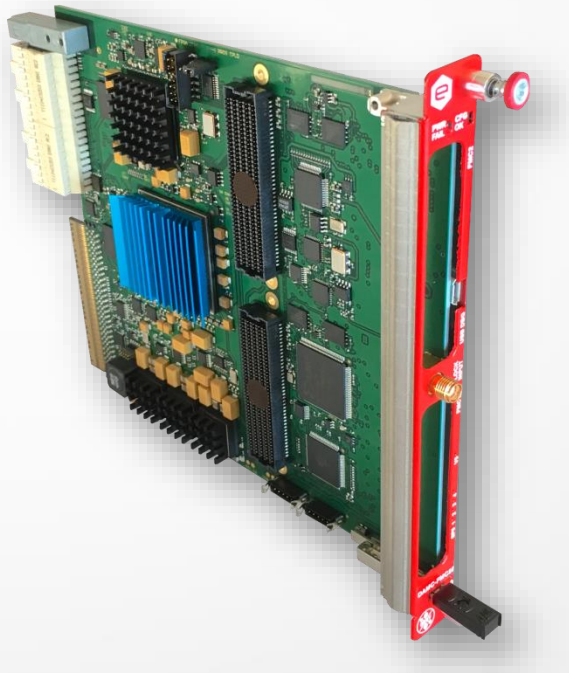
FMC and MicroTCA

DAMC-FMC25

AMC Dual High-Pin Count FMC Carrier Board

- Double width AMC board – MTCA.4 carrier
- Two HPC FMC slots
- Data processing on Virtex-5 FPGA
- Board management on Spartan-6 FPGA
- RTM D1.1 connectivity
- DDR2 memories on both FPGAs
- External clock input on front panel SMA connector
- 6.5 Gbps ("-2") transceiver board options



DESY

µTCA®

Turnkey solution with dual 4-channel (8-channel) floating picoammeter AVAILABLE!

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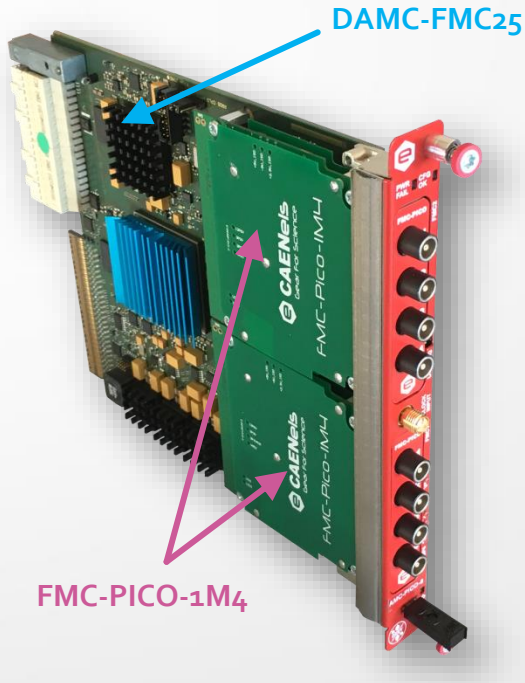
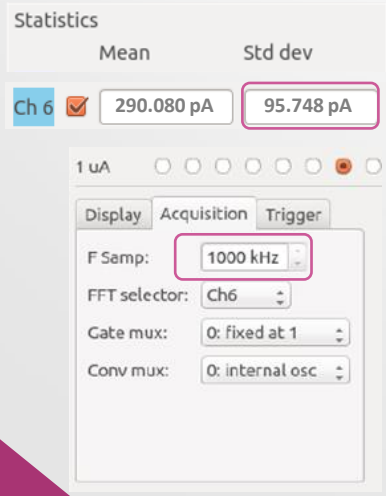
AMC-PICO-8

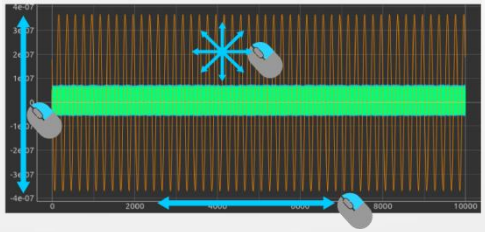
8-channel 20-bit 1 MSPS bipolar current-input AMC picoammeter

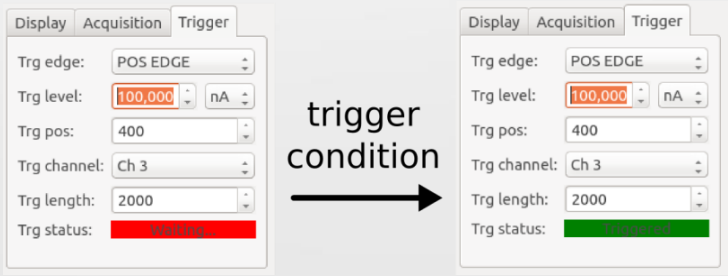
- 1 MSPS 20-bit simultaneous sampling (8-channels)
- Inputs floating up to 300 V
- Trigger/Oscilloscope functionality
- Based on the DAMC-FMC25 carrier designed by DESY
- 2 picoammeter FMC-Pico-1M4 supported
- BSP, GUI and drivers available



Avoids ground loops if two different detectors are connected
to the same DAMC-FMC25 - e.g. quadrature detectors







HV-PANDA

HV Positive And Negative Double-width AMC

- Double-Width AMC Board – Full Size
- MTCA.4 carrier
- Four High-Voltage channels
- Output ratings:
  - 500 V @ 1.5 W
  - 4 kV @ 7 W
  - 6 kV @ 6 W
- Polarity selectable
- Provides infrastructure for management of optional Rear Transition Module (RTM) boards – class D1.1
- DDR3 On-board Memory (up to 4 Gbit)
- Separate Interlock for each channel and global one
- Stand-by voltage, Ramping, Current Monitoring and Current Limit

DESY

Cooperation with DESY in the Helmholtz Validation Fond Project «MTCA.4 for Industry» (**HVF-0016**)

FMC-PICO-1M4

4-channel 20-bit 1 MSPS bipolar FMC picoammeter

- Standard FMC - Vita 57.1
- Bipolar current-input stage
- **Two standard measuring ranges** (±1 mA and ±1 µA)
- **CUSTOMIZATION of ranges** upon request
- 20-bit resolution
- Up to 1 MSPS
- **Floating up to ±300 V**
- Extremely low unbalance between channels (by analog design)
- I2C EEPROM calibration

FMC-Pico-1M4-20

Equivalent Input Noise		
	RNG0: ±1 mA	**RNG1: ±1 µA**
F_S = 2 ksps	1 ppm/FS -120 dB	2.5 ppm/FS -112 dB
F_S = 20 ksps	2 ppm/FS -114 dB	7 ppm/FS -103 dB
F_S = 200 ksps	5 ppm/FS -107 dB	10 ppm/FS -100 dB
F_S = 1 Msps	8 ppm/FS -102 dB	15 ppm/FS -96 dB

FMC-SFP+

Dual- and Quad-channel SFP/SFP+ FMC Adapter

- Dual-channel and Quad-channel versions
  - **FMC-2SFP+**
  - **FMC-4SFP+** (w/out FMC bezel)
- Wide I/O operating range: VADJ can vary from 1.5V to 3.3V
- Tested **up to 10 Gbps / channel**
- True level conversion of all SFP+ module pins including I2C lines
- I2C-controlled Oscillator (10-280 MHz)
- Compatible with the DAMC-FMC25 carrier board
- Produced and supported by CAEN ELS
- Designed by DESY

2-channel version

4-channel version

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between DESY and CAEN ELS

FMC-MOTDRV22

Dual-channel FMC Stepper Motor Driver

- Dual-channel stepper motor driver
- Supports up to **1.8 A motor coil current**
- Three different versions
  - 12-V internal supply
  - 12-V external supply
  - 24-V external supply
- Compatible with the DAMC-FMC25 carrier board
- Produced and supported by CAEN ELS
- Designed by DESY

FMC-MOTDRV22 and cable

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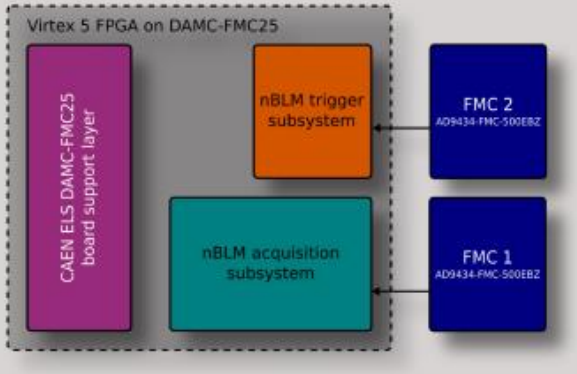
Custom Developments - Examples

DAMC-FMC25 with AD9434-FMC-500EBZ boards



The two AD9434-FMC-500EBZ boards provide two analog inputs sampled at 500 MS/s and 12-bit resolution.
A custom FPGA application was developed to identify and capture specific events.

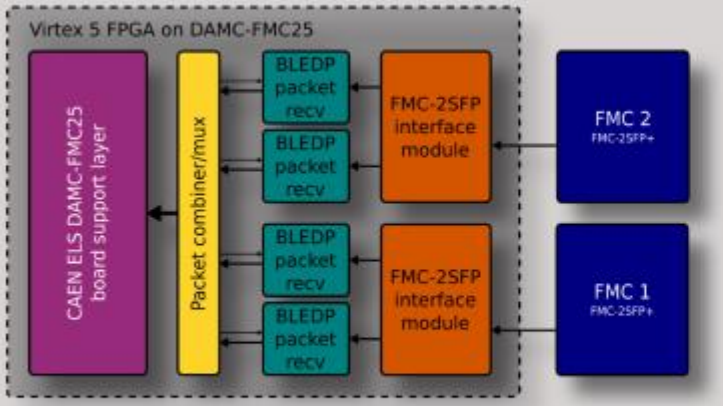
DAMC-FMC25 with 16-channel 125 MS/s ADC and GPIO boards

The 16-channel 125 MS/s ADc board with 14-bit precision can be used to monitor the status of the system, while the GPIO board can be used as an interface to various external devices.

Combined with the advanced processing power of the FPGA, this system can be used in all applications where a fast response time of entire system is needed.

Custom Developments - Examples

DAMC-FMC25 with FMC-2SFP+ boards



The two FMC-2SFP+ boards allow communication with up to four (4) fast links at 6.25 Gbps on the DAMC-FMC25. These links can be used to develop a data aggregation board together with post-processing on the FPGA.

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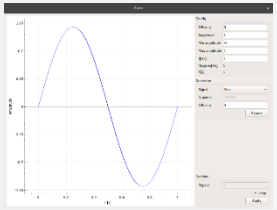
Newest Developments

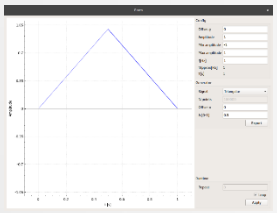
Water cooled modules up to 200A up to 60V (based on the NGPS architecture). Realized in 2018.

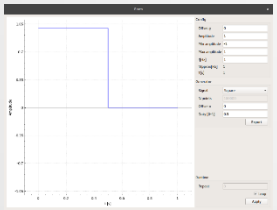
Water cooled systems at 420A with polarity inverter switch (bipolar architecture, based on the NGPS). Realized in 2018.

Paralleling of up to 4 Fast-PS-1K5. Available since 2018.

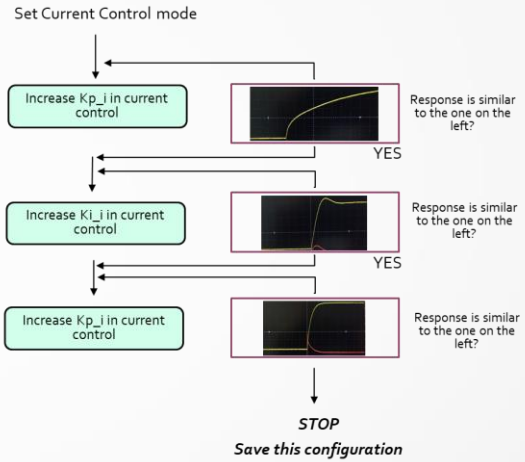
Newest Developments





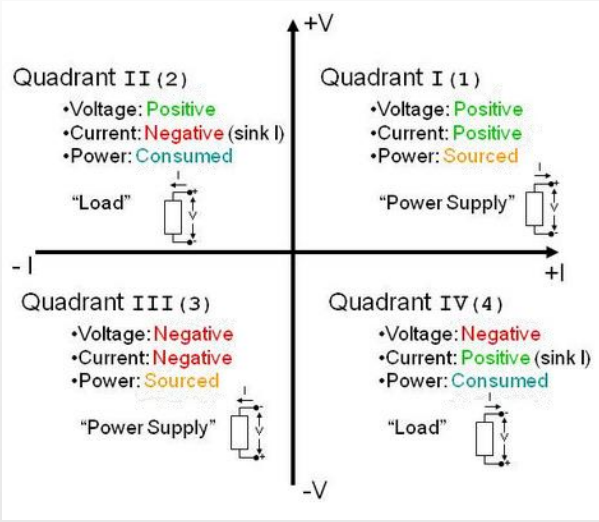


Autotuning function for the Fast-PS family and NGPS. Available since summer 2022.



Arbitrary Waveform Generator + Embedded Oscilloscope for the Fast-PS family and NGPS. Available since 2018.

Full-4-Quadrant Fast-PS-1K5 (optional Dissipation Module). Available since 2020.



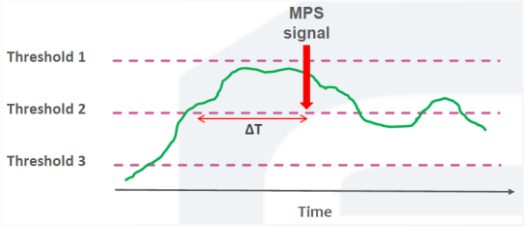
Newest Developments

REGUL8OR

REGUL8OR

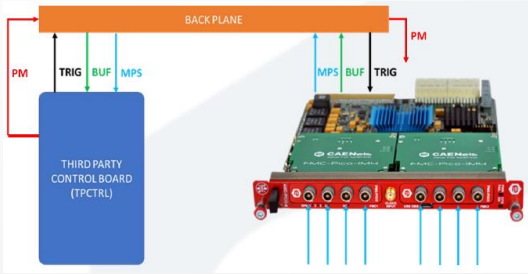
1 HU Full 4-Quadrant Control Board – for the adaption to and control of any power stage.

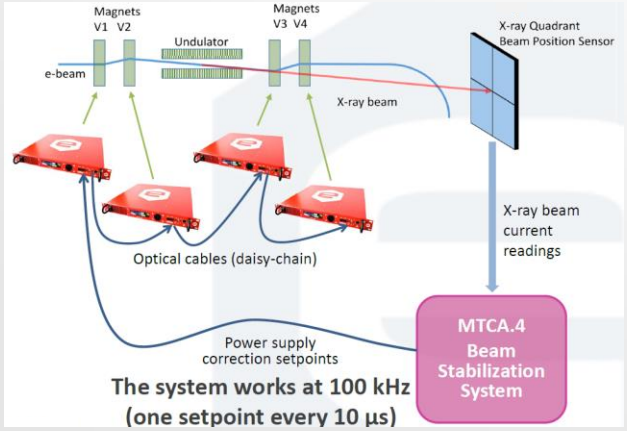
Available since 2020.



Beamline Machine Protection System based on MicroTCA technology.

Realized in 2019.





Beamline Stabilization System based on MicroTCA technology in combination with Fast-PS .

Under test at Diamond Light Source.

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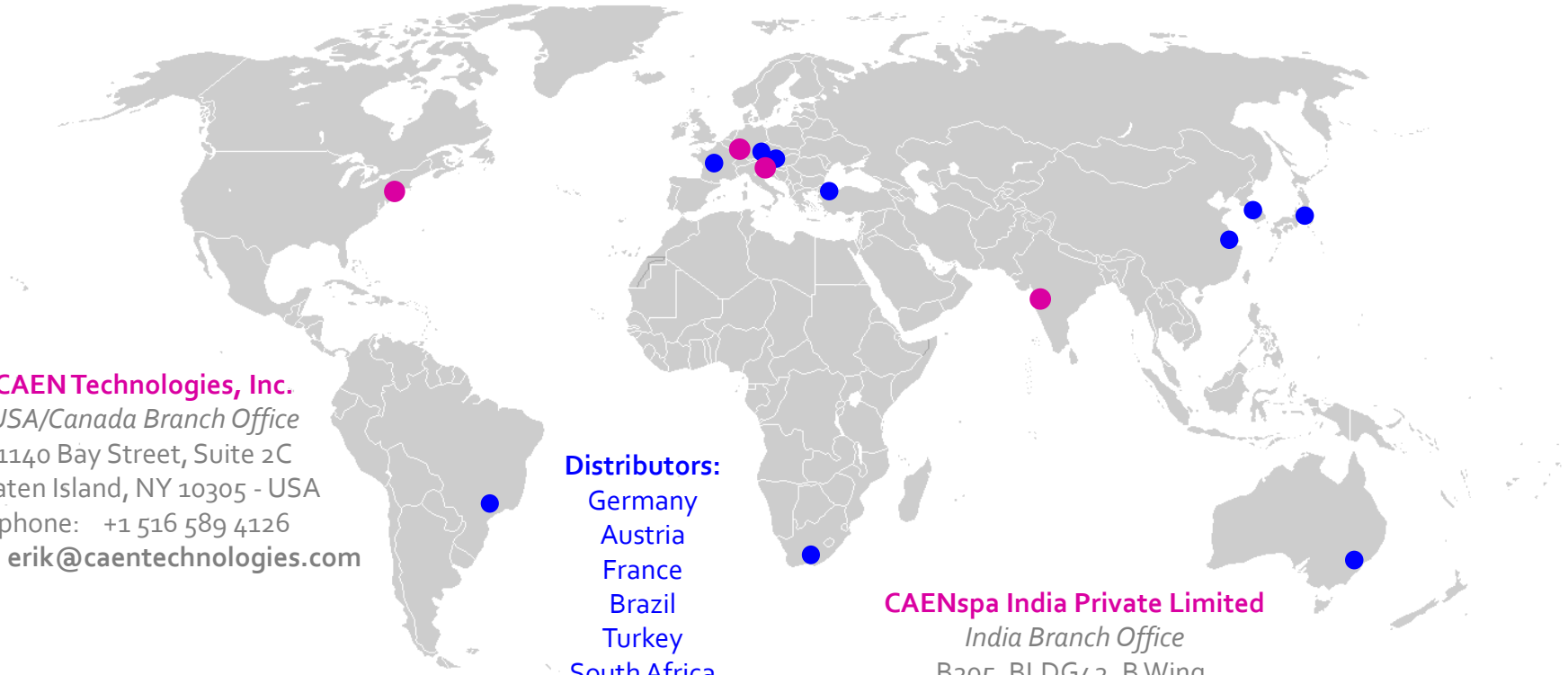

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