CAEN
Tools for Discovery

DT4810

One-channel Micro Digital Detector Emulator

WEB INTERFACE

USB 2.0

1 GbE

Developed in collaboration with Nuclear Instruments

Highlights

Function

Single-channel compact Digital Detector Emulator (DDE) based on a 14-bit DAC with an effective 500 Msps output rate. The instrument generates detector-like signals in real time with programmable timing, amplitude, shape and noise.

Applications

- Validation and characterisation of digital pulse processors
- Calibration and benchmarking of nuclear and high-energy physics acquisition chains
- Replacement of radioactive sources in laboratory, educational and demonstration setup
- Test bench for pile-up handling, dead-time characterisation and rate linearity studies
- Emulation of signals from HPGe, semiconductor detectors and scintillators with PMT, etc...

Operability

The DT4810 reproduces both the time structure and the energy distribution of radiation events. Two pulse-shape families are available:

- **Digital-RC (exponential):** programmable rise time from ~2 ns to 10 µs and decay constant τ from ~10 ns to 100 µs, with optional semi-Gaussian low-pass smoothing.
- **Pulse (rectangular/trapezoidal):** programmable rise time, width and fall time with 8 ns resolution.

Features

- BNC connector for Analog Output
- LEMO-00 connectors for Programmable Digital Input (GPI) and Digital Output (GPO)
- Front-panel LCD display for device status and parameter editing
- Front-panel diagnostic LEDs
- On-board 64 GB MMC storage with a 20 GB user-accessible partition for data, spectra and scripts
- On-board ARM CPU running Linux®, accessible to the user for custom scripting
- Comprehensive Web Interface and JupyterLab application for control and development

Communication

- 1 Gbit Ethernet (RJ-45) and USB 2.0 (USB-C) readout interfaces

Web Interface

Web-based GUI provides intuitive and exhaustive access to all device features, without additional software or installation. It supports:

- Setup and retrieval of all generation, shaping and I/O parameters
- Real-time visualization of the generated waveform (oscilloscope view) and energy spectrum
- Spectrum composition tool based on the periodic table, with selectable isotopes, gamma and X-ray lines, editable activity and resolution

Web Interface - Home page

- Catalogue of pre-defined spectra (e.g. Cobalt-60, Actinium-225, and many others, measured with HPGe detector) and import from .txt files
- Statistics panel with ICR, OCR, generated counts, saturation, dead-time and live-time
- Saved configurations management (load, save, export, import)
- Software and firmware upgrade with Online-Update and Manual-Upload procedures (.DUP and .nsys files)
- Recovery Mode for factory restore, OS upgrade and IP reset
- Integrated JupyterLab environment and dual-panel File Explorer for custom scripting and data management

Overview

The DT4810 is a compact, desktop module that emulates the analog output of a radiation detector in real time. Each event is computed on the FPGA according to the configured statistical model, with no precomputed waveform buffer involved. As a consequence, the acquisition duration is not limited by an internal memory length, and the statistical properties of the stream (event arrival times, energy distribution, noise) are preserved over arbitrarily long runs.

Operating Modes

The DT4810 can be configured to generate two types of output signals:

- Exponential pulses, which mimic the shape of real detector signals;
- Rectangular pulses, useful for calibration, linearity tests and deterministic measurements.

For both signal types, the following parameters can be configured independently:

- Amplitude: either fixed (expressed in LSB) or sampled event-by-event from a 16384-bin energy distribution via inverse-CDF sampling. The distribution can be composed on the device through the periodic-table tool, imported from file, or loaded from the on-device catalogue.
- Inter-arrival time: either constant (fixed rate) or randomly drawn from a Poisson process at a configured mean rate.

I/O Equipment

The DT4810 is equipped with one BNC connector for the analog signal output and two LEMO-00 connectors for the digital input (GPI) and digital output (GPO). The function of each digital connector is configurable through the Web Interface. The GPI supports trigger and output gate/veto, as well as the external trigger mode, in which pulse generation is driven by the rising edge of an external signal. The GPO can echo internal events (output enable, accepted trigger, saturation, output enable) or replicate the digital input (GPI loopback). An LCD display and four front-panel LEDs provide visual feedback on the device status.

Connectivity

The DT4810 is reachable either through a point-to-point USB-C link (the device exposes a virtual network interface at a fixed IP address) or through Ethernet RJ-45 (factory default static IP 192.168.50.20, configurable to DHCP). All device control is performed through the Web Interface; no host-side software is required.

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Web Interface

The Web Interface is the unique control point for the DT4810. It is organized into pages reachable from the left navigation sidebar.

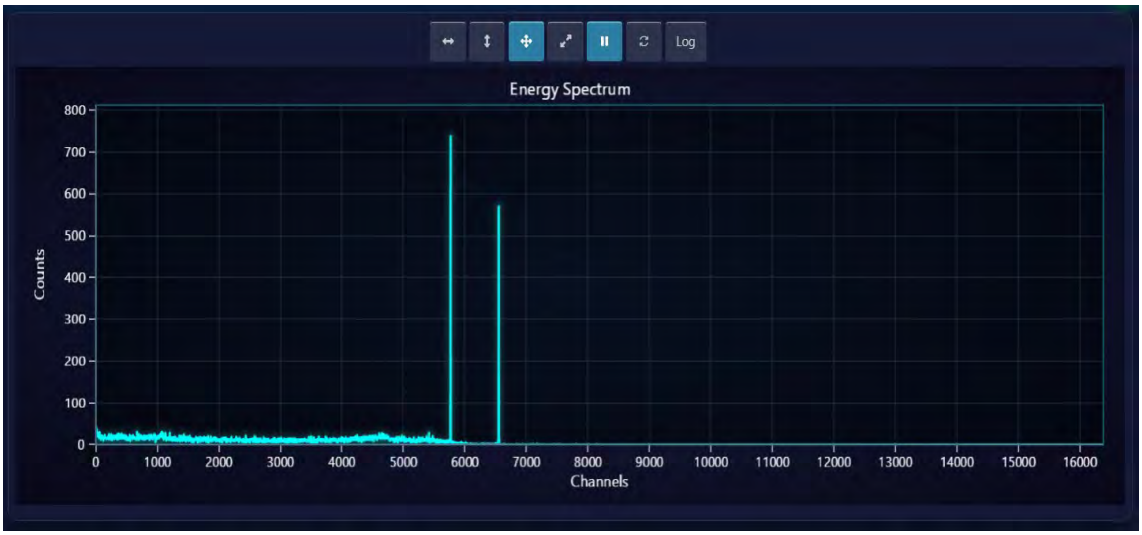
The Home page provides the device dashboard: system status (FPGA temperature, CPU load, RAM and free disk space), network status (Ethernet, USB), version information, saved configurations, real-time spectrum and oscilloscope plots, statistics counters.

Supported by the most used web browsers:

Home Page

The One Touch page groups in a single layout the Energy (Fixed/Spectrum), Time (Constant/Poissonian rate), Shape (Exponential/Pulse) and Inverter controls, with simultaneous display of the spectrum and oscilloscope plots.

The Energy/Spectrum page loads a 16384-bin energy distribution from one of three sources: a custom composition built from the periodic-table tool (isotope selection, gamma and X-ray lines, editable activity and resolution); a file upload (with Scale and Offset adjustments); or the on-device catalogue.



Energy/Spectrum Page

The I/O Config page programs the analog output conditioning (DC offset, gain, inverter) and the GPI/GPO functions.

The Noise page enables or disables the additive Gaussian-like white noise, with magnitude controlled as a percentage of the maximum level.

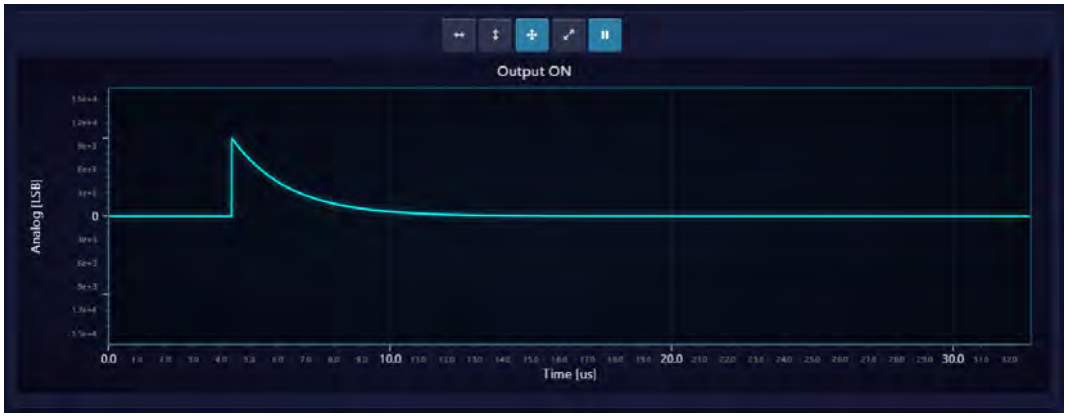
The Advanced Tools page provides access to the embedded JupyterLab environment and to the dual-panel File Explorer for custom scripting, data management and offline analysis directly on the device.

Monitoring and Acquisition

The DT4810 provides some real-time monitoring tools accessible from the Web Interface.

Digital Oscilloscope

Captures a segment of the generated waveform (up to 4096 samples), triggered on any accepted event. The captured trace represents the fully processed signal, including additive noise, as it appears at the DAC input. The waveform can be exported as .json for offline analysis.



Digital Oscilloscope

Spectrum Analyzer

Real-time energy histogram with 4096 bins and 32-bit counters per bin, covering the full output amplitude range. The histogram can be exported as .txt and saved as image.

Rate and Statistics Counters

Updated every 250 ms and reported in the Statistics panel:

- ICR/OCR: input and output count rates (cps)
- Total Counts/Generated Counts: cumulative
- Saturated Counts and Overloaded Events
- Lost Events %: (Total − Generated)/Total × 100
- Running/Live/Dead Time: auto-scaled units (µs, ms, s or hh:mm:ss)

All cumulative counters are 64-bit and can be reset from the Web Interface.

Unattended operation

The JupyterLab application and File Explorer allow local storage and processing of spectra, configurations and scripts on the 20 GB user partition, as well as transfer to the host PC for offline analysis.

Periodic Table page.

Technical Specifications

Signal Generation Performance

Throughput	
Maximum event rate	up to 5 MCPS
Real-time generation	no preloaded waveform limitation; continuous pile-up supported
DAC	
Resolution	14-bit
Sampling rate	500 MSPS effective
Output dynamic range	2.0 Vpp @ 50 Ω load / 4.0 Vpp @ high-impedance load
Energy Emulation	
Fixed amplitude mode	single line, 16 384 selectable LSB levels
Spectrum mode	16384 bins, inverse-CDF sampling from user-defined or catalogue spectrum
Time Emulation	
Constant rate	deterministic period generator
Poisson rate	seeded LFSR-based Poisson generator
Pulse Shaping	
Exponential (Digital-RC)	rise time from ~2 ns to 10 µs; decay constant τ from ~10 ns to 100 µs; optional semi-Gaussian low-pass cascade
Pulse (Rectangular/Trapezoidal)	programmable rise time, width and falling time with 8 ns resolution; width = 0 yields triangular shape; total duration ≤ 32744 ns
Noise Emulation	
Type	White Gaussian noise
Programmable amplitude	0% → ~ 0.2 mV RMS residual; 100% → ~200 mV RMS at the analog output

On-board CPU and Memory

CPU
ARM Cortex-A9 MPCore, Dual-Core, up to 1 GHz, with 1 GB DDR3-800 SDRAM, running Linux Ubuntu 20.04.
The embedded CPU is accessible from the Web Interface (JupyterLab) for the development of customized scripts and unattended operations
Memory
64 GB embedded MMC, non-detachable, with a 20 GB user-accessible partition dedicated to data, spectra and script storage.

Outputs

ANALOG OUT (front panel)	
Connector	BNC type
Dynamic range	2.0 Vpp @ 50 Ω load / 4.0 Vpp @ high-impedance load
Polarity	programmable inverter (positive / negative)
Conditioning	programmable DC offset (±16 000 LSB) and gain (≥ 1)

LED Indicators

Front Panel LEDs			
Power:	Power LED	color green	illuminated when the board power is on
ANALOG OUT:	Analog Output LED	color green	turns on when the analog output is enabled
GPO:	Digital Output LED	color green	turns on when a digital output signal is generated
GPI:	Digital Input LED	color green	turns on when a digital input signal is provided

Technical Specifications (continued)

General Purpose I/Os

GPI - Genaral Purpose Input (front panel)	
Connector	LEMO-00 type
Standard	TTL, Z_{in} = 50 Ω, threshold ~0.7 V, max input voltage 5 V
Programmable modes	Disabled, Trigger Gate, Trigger Veto, Output Gate, Output Veto, External Trigger

GPO - General Purpose Output (front panel)	
Connector	LEMO-00 type
Standard	TTL, Zout = 50 Ω (50 Ω load required), 3.3 V logic level
Programmable modes	Disabled, Run, Trigger, Trigger Valid, Saturation, GPI Loopback
Pulse Width	8 ns to 524 280 ns, 8 ns step
Pulse Delay	mode-dependent (Trigger / Trigger Valid: −320 to 16 095 ns; Saturation: −64 to 16 351 ns; Loopback: −344 to 16 071 ns)

Communication Interfaces

USB (rear panel)	
USB connector; USB 2.0 compliant;	type C
USB-C (multi-function): the USB-C connector provides both a serial communication port for debug and a virtual network connection (when connected to the host PC the device is automatically recognized as an RNDIS-compatible device, enabling USB-to-Ethernet networking)	
USB cable included in the kit	
10/100/1000 T (rear panel)	
Ethernet female connector;	RJ-45 type
10, 100 or 1000 Mbit/s connection to a PC or ETH hub	
FTP cable included in the kit	

Active Buttons

Power/Navigation Switch (front panel)	
Short press when device is OFF	Power ON
Long press (~5–6 s) when device is ON	Power OFF (shutdown sequence)
Press and lever left/right while powering ON	Power on in Recovery Mode
Lever (left/right) when device is ON	Display navigation between screens
Press when device is ON	Open the menu of the displayed parameter / confirm selection

Technical Specifications (continued)

Monitoring Display

Graphic Display (front panel)

262K-color 0.96" LCD display for monitoring usage and IP reset operation.

The display shows static screens during boot, shutdown and Recovery Mode. During normal operation it cycles through the following screens, navigated through the Power/Navigation Switch lever:

Screen 1: HOME	Device model, Ethernet IP and USB IP
Screen 2: STATUS	OC, OCR, LIVE time and Run indicato
Screen 3: RATE MODE	Constant or Poisson selection
Screen 4: RATE	Rate selection among preset values, from 1 Hz to 5 MHz
Screen 5: ENERGY MODE	Fixed (LSB) or Spectrum (name)
Screen 6: SHAPE MODE	Exponent or Pulse
Screen 7: TAU / PULSE WIDTH	Shape parameter, ns or µs
Screen 8: CONFIG	Stored configuration selection
Screen 9: RESET IP	Restore the default static IP 192.168.50.20

Mechanical

Enclosure:	Aluminium with solid plastic bezel and four rubber feet	Weight:	420 g
Size:	106.5 W x 34.0 H x 189.0 L mm³ (including connectors)	106.5 W x 34.0 H x 166.5 L mm³ (without connectors)	

Power In

12V DC power jack on rear panel	Operating current: 1.5 A @ 12 VDC.	Rated current: 3.5 A max.
AC Adaptor (12 V, 3.75 A) included in the kit		

Device Upgrade

The device software and firmware can be upgraded through the Web Interface, either online or via manual upload of a .DUP file (Incremental upgrade, Minor Version) or a .nsys file (Full Install, may change the Major Version). Factory System Restore, IP Reset and other advanced functions are available in Recovery Mode. Upgrade files are distributed through the CAEN website at www.caen.it/download/.

Environmental

Environmental	Indoor use	Storage Humidity	5% ÷ 90% RH non condensing
Operating Temperature	0°C ÷ +50°C	Pollution Degree	2
Storage Temperature	-10°C ÷ +60°C	Overvoltage Category	II
Operating Humidity	10% ÷ 90% RH non condensing	EMC Environment	Commercial and light industrial
IP Degree	IPX0 Enclosure , not for wet location		

Regulatory

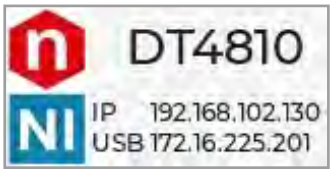
Compliance	EMC:	CE 2014/30/EU Electromagnetic compatibility Directive
	Safety:	CE 2014/35/EU Low Voltage Directive

Screen Examples

Screen Loading

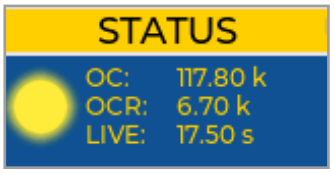
Screen Loading Recovery

Screen Recovery



Screen 1 Home

Screen 2 - output OFF STATUS



Screen 2 - Running mode STATUS (Less than one minute)

Screen3 - Rate mode: Constant

Screen 4 - output rate (Rate mode: Poisson)

Screen 5 - Energy Mode Spectrum

Screen 5 - Energy Mode Fixed

Screen 6 - Pulse mode (PULSE WIDTH).

Screen 6 - Exponent mode (TAU)

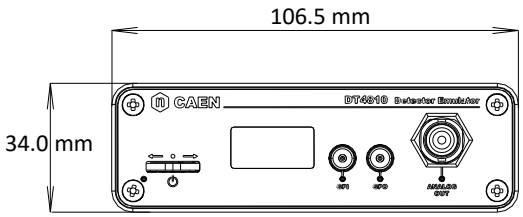
Screen 8 - Configuration

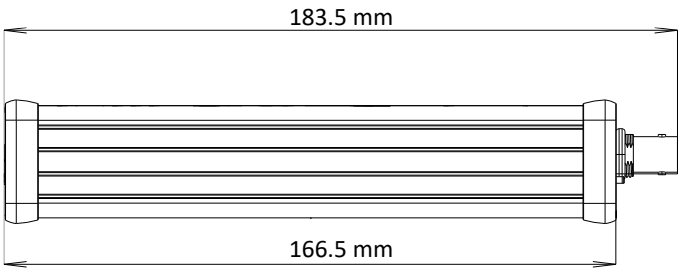
Screen 9 - RESET IP screen

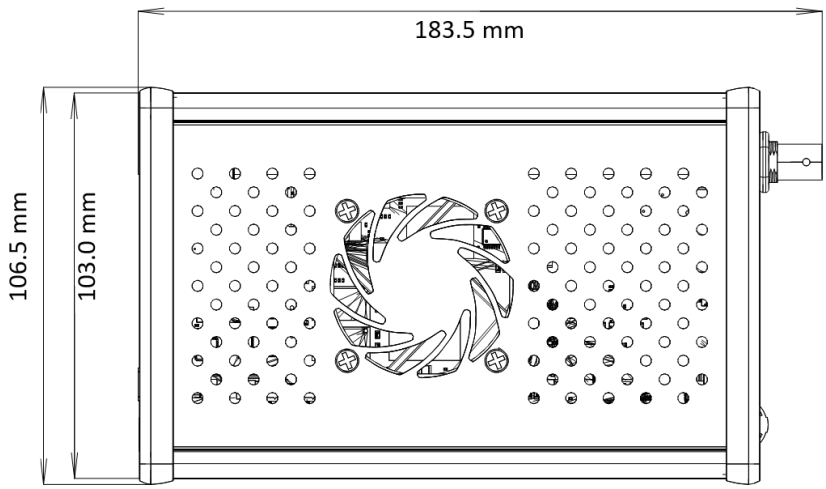
Screen 9 - RESET IP confirmation

Screen Shutdown

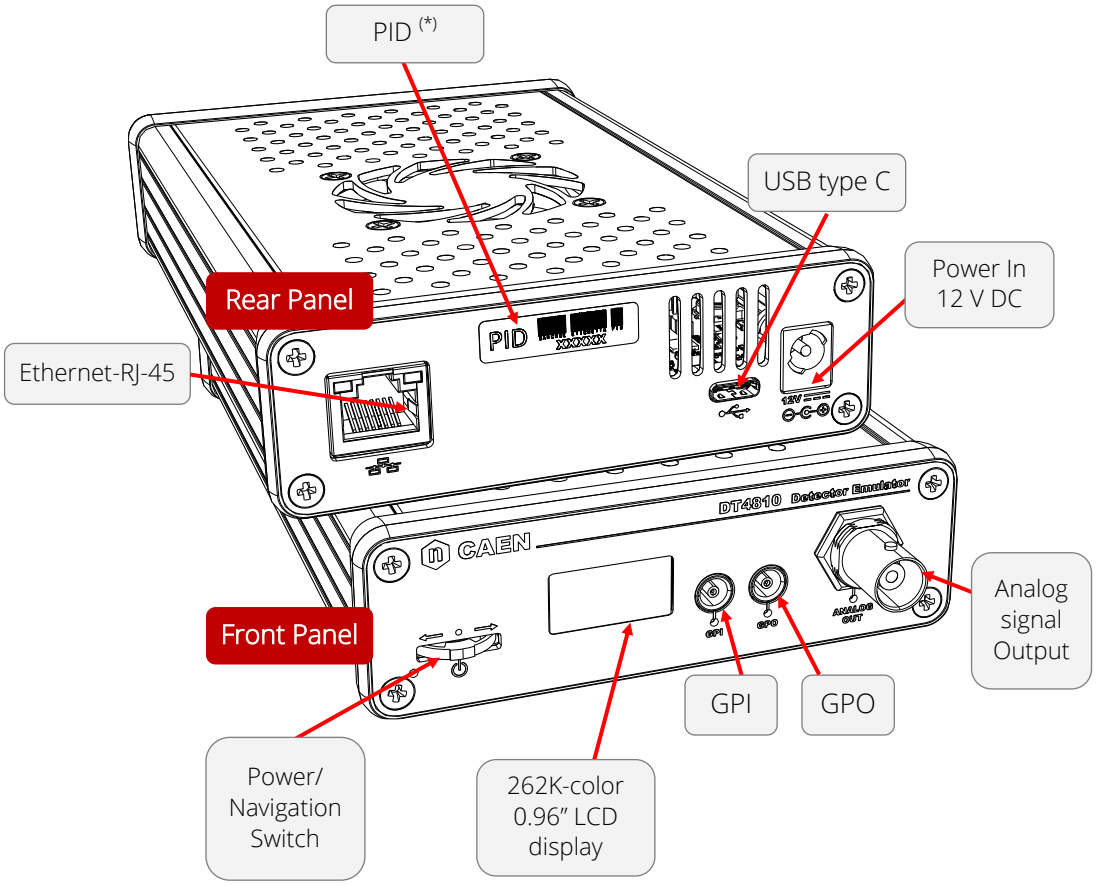
DT4810 Mechanical Dimension

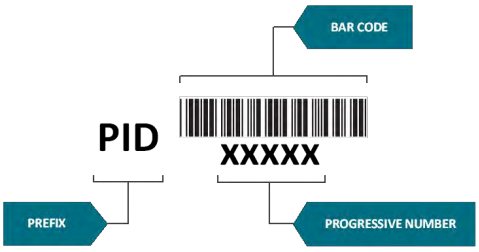






DT4810 Panels Description





(*) PID (Product IDentifier)

The PID is a unique, incremental number greater than 10000 assigned to every CAEN product. This unique identifier is affixed to the product on an adhesive label composed of the "PID" prefix followed by the incremental number. The PID can also be read by the attached CODE39 barcode.

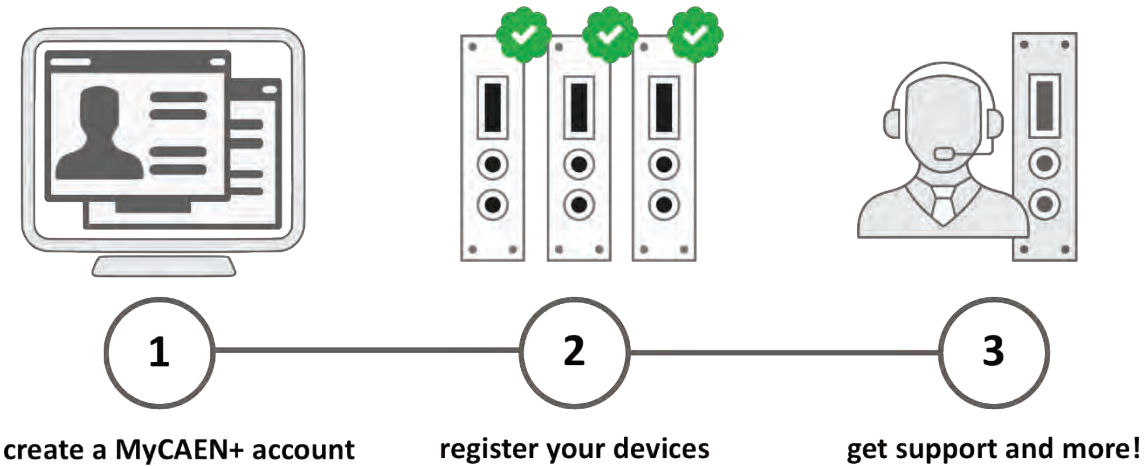
Ordering Option

DT4810 – 1 Channel Micro Digital Detector Emulator	Ordering code: WDT4810XAAAA

Register your device

Register your device to your **MyCAEN+** account and get access to our customer services, such as notification for new firmware or software upgrade, tracking service procedures or open a ticket for assistance. **MyCAEN+** accounts have a dedicated support service for their registered products. A set of basic information can be shared with the operator, speeding up the troubleshooting process and improving the efficiency of the support interactions.

MyCAEN+ dashboard is designed to offer you a direct access to all our after sales services. Registration is totally free, to create an account go to https://www.caen.it/become-mycaenplus-user and fill the registration form with your data.



https://www.caen.it/become-mycaenplus-user/

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