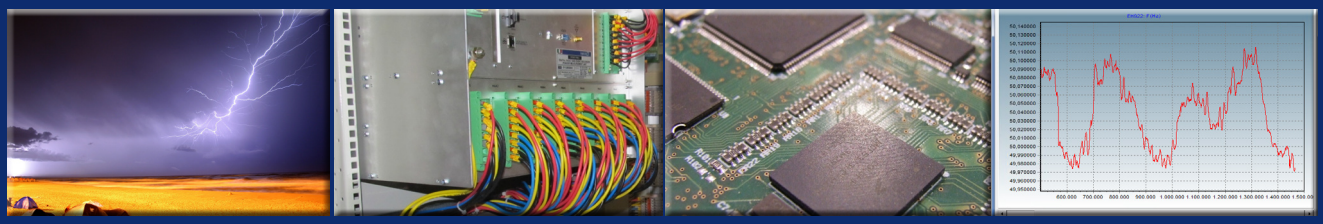
FR947 - DFR Family

Digital Fault Recorder

with Phasor Measurement Unit capability



Fault → 24 bit acquisition → Digital Processing → Analyse and Solve

LogicLab solution for WAMS applications and modern needs for substation monitoring

LogicLab

Research & Development

Up to 32 Analog inputs and 128 Digital inputs

Input range up to $400A_{rms}$ and $700V_{rms}$

24 bit Analog To Digital Conversion

Up to 360 samples per period with FR947-HS

Dual Floating Point DSP and 32 bit CPU

Up to 234 different measures at 50Hz or 60Hz

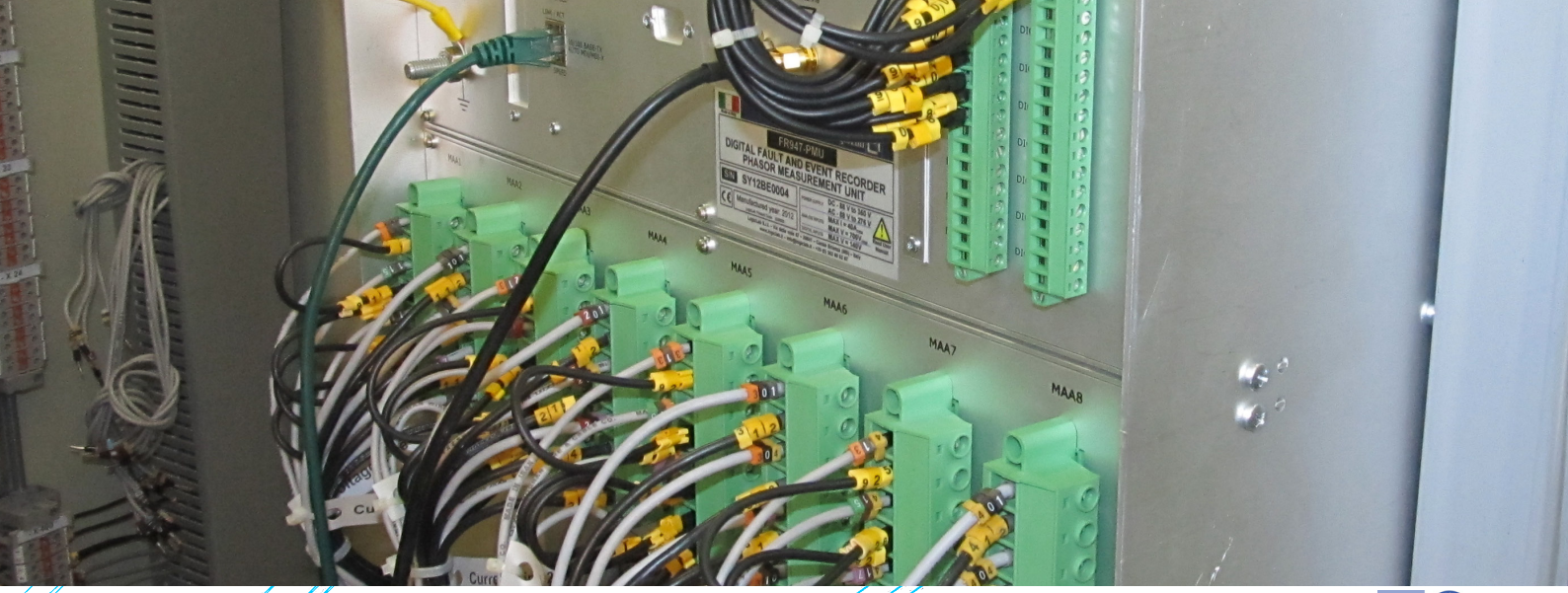
Integrated GPS receiver for synchronization

GPS synchronized sampling and measurements

Storage on Solid State Disk

Phasor Measurement Unit capability

Pharos System for Synchrophasors Management



LogicLab Company

LogicLab s.r.l. is a company specialized in hardware, firmware and software design of protection and control devices for the power distribution market. Thanks to the efforts and experience achieved over the years, LogicLab can offer innovative solutions, always placing the best performance as a target in compliance with safety requirements. LogicLab S.r.l. quality management system, compliant to ISO9001:2015, has been certified by CSQ (a brand of CESI S.p.A. and IMQ S.p.A). LogicLab has obtained also the qualification by ENEL Italia S.p.A. for power system protection and control devices. ENEL qualification certifies only companies with proved high technical and economical score.

LogicLab Digital Fault Recorder Overview

FR947 is a family of Digital Fault Recorders with a signal processing unit capable of performing advanced measuring algorithms. LogicLab developed an high-performance device, with state of the art hardware that include a **32bit CPU and 3.6 GFLOPS DSPs parallel architecture**.

LogicLab can provide three different models: FR947-EXb, FR947-EX and FR947-HS. **FR947-EXb** is an entry level version of the device with **ENEL S.p.A. Certification**. It is a device designed for customers with limited requirements looking for a cost effective solution, but with the possibility of future expansion. **FR947-EX** is the top level DFR with full hardware capabilities and complete software tools. **FR947-HS** is a special version of FR947-EX with high speed capability.

The device is intended for power distribution medium and high voltage substations. With up to 32 analog inputs (voltage or current) at **24 bit resolution**, and up to 128 digital inputs, this device provides the best solution for substation monitoring with high levels of precision and accuracy. Each channel (analog or digital) is isolated from all other channels, to power supply and ground.

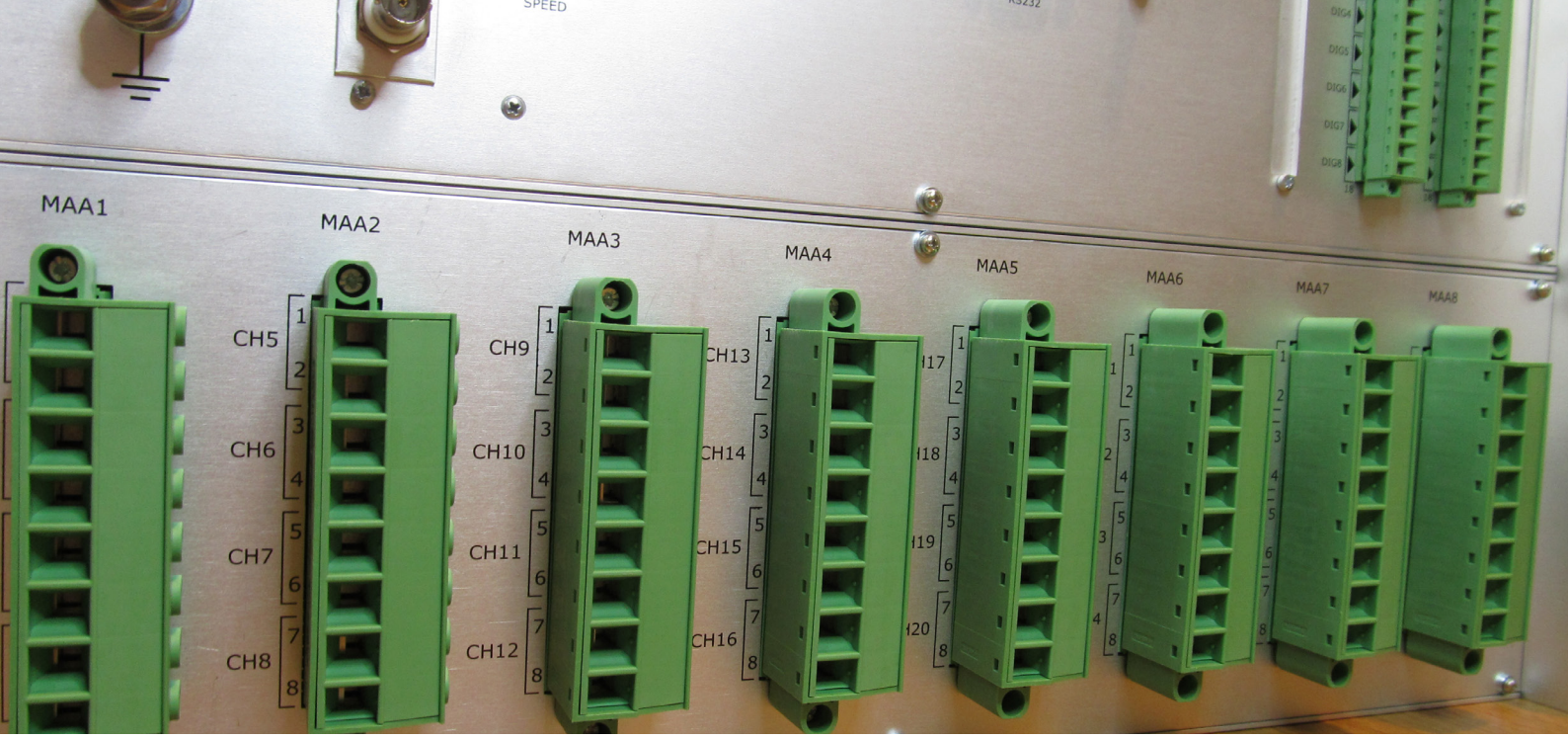
FR947 is capable to perform different types of recording and stores them on Compact Flash card:

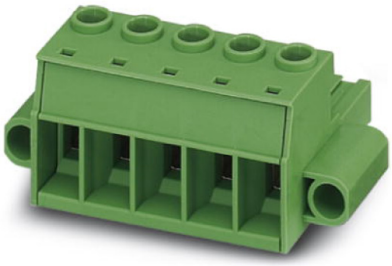
- **TAR (Transient Analog Recording)**: transient recording. It includes all analog and digital input signals (waveforms).
- **TMR (Transient Measure Recording)**: disturbance recording. It includes all measures performed by FR947 and digital status. If enabled, recording starts simultaneously with TAR recording.
- **SMR (Slow Measure Recording)**: slow recording. It includes all measures performed by FR947.

TAR/TMR and SMR have **two different sets of trigger** user configurable and **SMR can be configured as continuous slow recording**. FR947 is capable to manage up to **six recordings simultaneously** (one TAR, one TMR and four SMR) without loss of data. For FR947-EXb, only TAR is available.

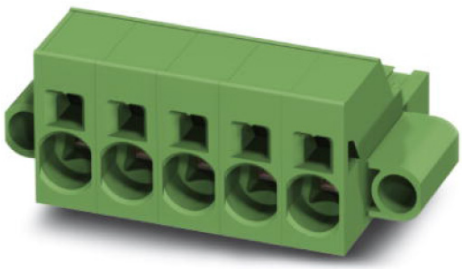
FR947 is delivered with two user-friendly software: SpyFR947 that allows a complete management of the device by providing real time tools, records management tool, parametrization tool and LogOscillo that incorporates a complete set of tools for an effective, powerful and precise recordings analysis. Configuration and monitoring can be also managed via integrated web-server with protected access.

Phase Measurement Unit for synchrophasors management. PMU software is an optional licens that can be included on FR947-EX and FR947-HS device at any time and doesn't require hardware upgrade.

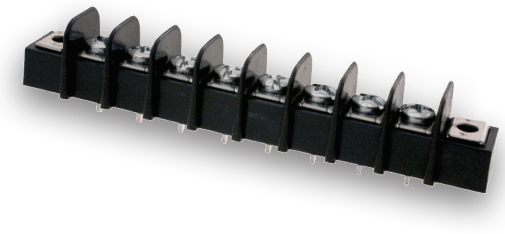




Standard removable screw fixing connector



Optional removable spring (cage-clamp) fixing connector for highest reliability wiring



Optional fixed barrier strip connector for ring terminal cables

Analog inputs with 24 bit ADC

FR947 is equipped with **up to 32 analog inputs,** factory configurable in group of 4 voltage/current inputs. Three different types of connectors are available to satisfy all wiring needs and, for current inputs, it is possible to use split core transformers for easy DFR installation. Analog input is converted with **high linearity 24bit ADC** and recordings can be saved using 16 bit or 24 bit format (FR947-EXb only with 16 bit format). Each analog input is equipped with a dedicated ADC.

Each sample and each measure calculated are tagged with absolute time received from GPS integrated receiver or optional IRIG-B board.

For all analog inputs, the common sampling frequency (fs) is software configurable up to 168 samples per period and up to 360 samples per period for FR947-HS. For FR947-EXb the sampling frequency is fixed at 144 sample per period at 16 bit. Each channel is DC capable and it acquires the analog signal in a wide range pass bandwidth (-3 dB) DC ÷ 0.49•fs and the system ensures **flat bandwidth (±0.0005 dB) in range DC ÷ 0.45•fs** with an attenuation for frequencies greater than 0.55•fs exceeding 100 dB*.

FR947 is equipped with current input boards with different full-scales **up to 400Arms** with a resolution that is 70 µA (400Arms @24bit). Accuracy for current input is better than ±(0,1% of the reading + 0.005% of the Full-Scale). Voltage inputs can be permanently supplied with signals **up to 700Vrms,** with a resolution better than 120 µV (700Vrms @24bit). Accuracy for voltage input is better than ±(0,1% of the reading + 0.005% of the Full-Scale).

Using configuration software, up to five different full-scales can be set to obtain a better precision on small amplitude signals, both for voltage and for current channels. Each configuration is changeable at any time without activity interruptions. Inputs for low amplitude DC signals (4-20mA or 0-10V) with accuracy better than 1 µA or 1 µV are available on demand. The use of purely resistive inputs also ensures signals with small latency, no phase error and ultra low distortion.

Each channel is isolated from all other inputs, to the power supply and ground (3300V DC).

(*) Typical configuration with 144 samples per period, 24 bit resolution and 50Hz system:
*f_s = 144*50 = 7200 Hz; Bandwidth (-3dB) = 0 Hz ÷ 3500 Hz; Flat Bandwidth (±0.0005 dB) = 0 Hz ÷ 3200 Hz; Stop Bandwidth (-100dB) = f > 4000 Hz*

High Performance CPU and DSPs

FR947 is powered by a **32-bit Microprocessor** with 240 MHz clock frequency and **dual Floating Point Digital Signal Processor** with 300 MHz clock frequency and up to 3.6 GFLOPs.

The DFR is equipped with **integrated flash memory** and a **Compact Flash** Card reader (up to 32 GByte) for data and recording storage.

Digital Fault Recorder firmware are based on state-of-art Real Time Operating System used for scientific and industrial high performance embedded designs.

Time synchronization

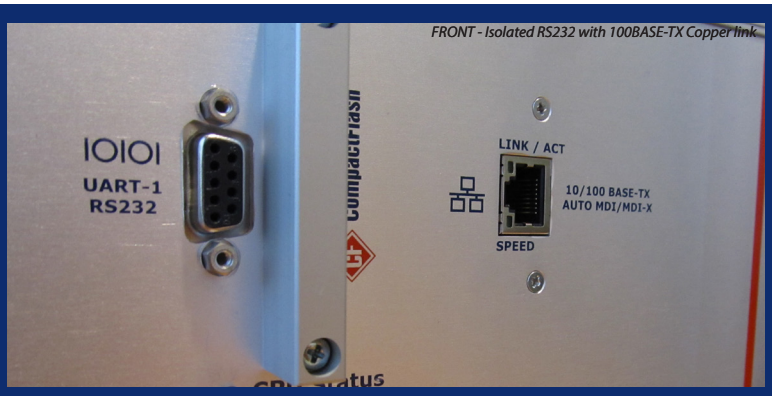
FR947 is equipped with time synchronization unit powered by high precision **integrated GPS receiver**. Automatically, the unit selects which is the best synchronization source among those available. The ultra high sensitivity GPS receiver supplies 1 PPS (Pulse Per Second) signal for synchronization with time accuracy better than **20ns RMS**. With up to –148dBm (Cold Start Acquisition) and **–165dBm (tracking) sensitivity**, the GPS receiver ensures high performance timing and tracking in harsh environments.

Fault recorder can be equipped with optional IRIG-B receiver board with inputs for modulated and unmodulated signal. FR947 is also equipped with internal clock backup and SNTP synchronization capability.

Communication

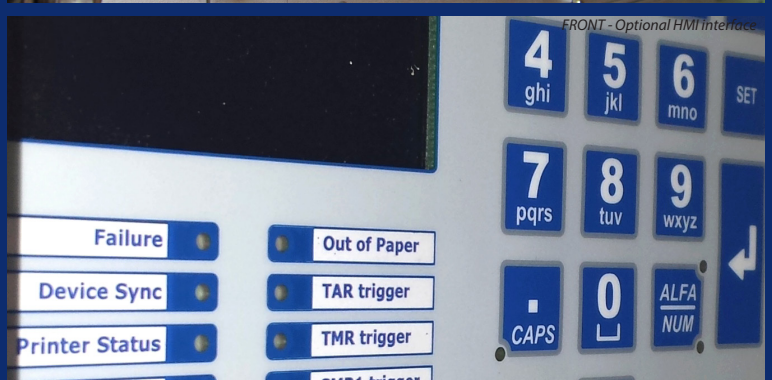
FR947 is equipped with **two RS232 ports** (one on the front, isolated at 2500Vrms, and one on the back panel) and **three isolated Ethernet** links (one on the front and two on the back panel).

Ethernet port on the front is a copper link 10/100 BASE-TX with auto MDI/MDI-X capability; on the rear panel there are Ethernet copper link and a fibre optic link 100 BASE-FX with SC connector (not available on EXb model). Device can be configured as a node of a LAN/WAN network using TCP or UDP transport layers.

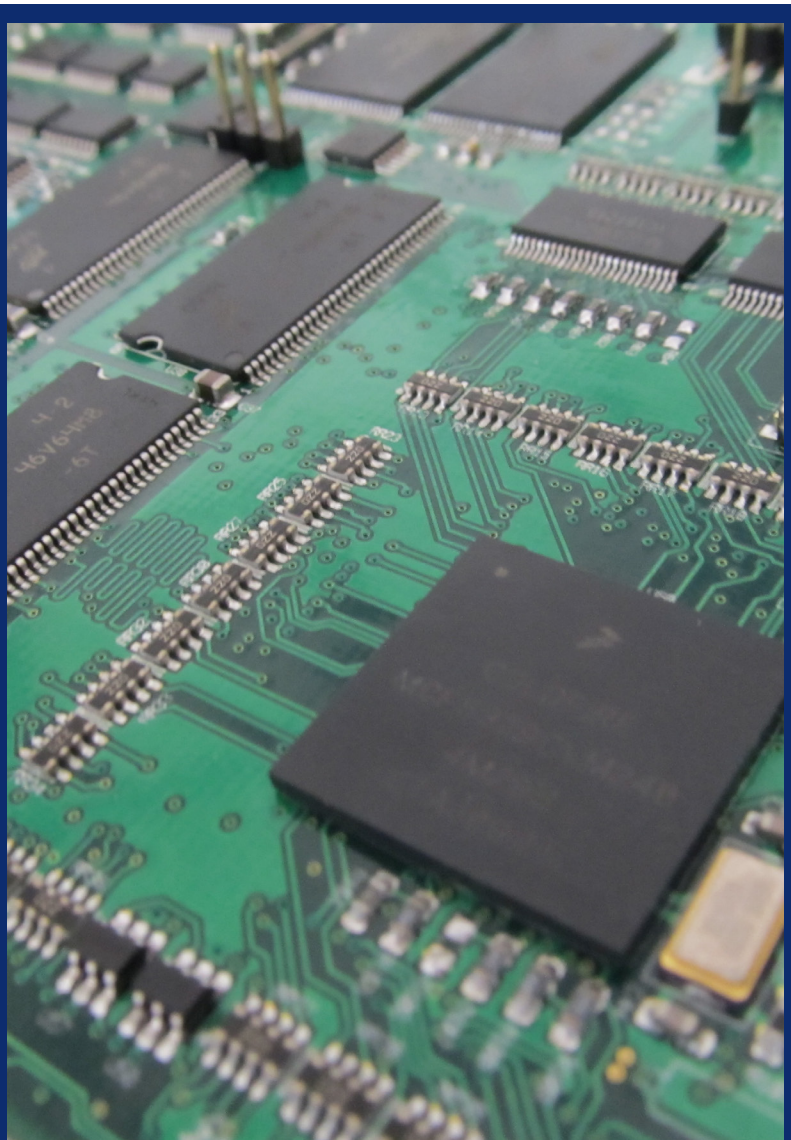


FRONT - Isolated RS232 with 100BASE-TX Copper link

BACK - IRIG-B with Copper and Fibre optic Ethernet



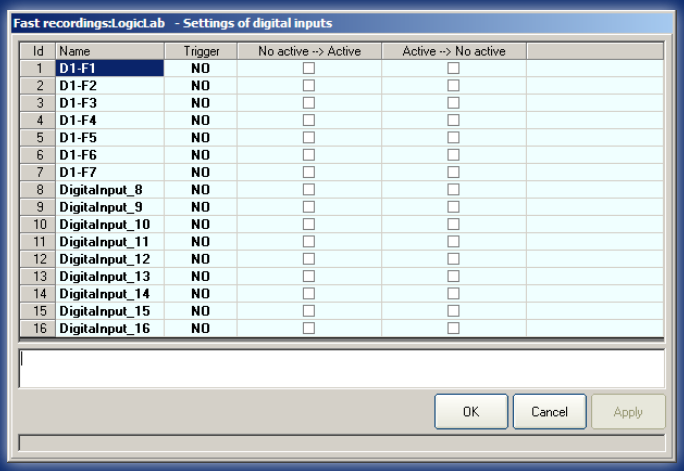
FRONT - Optional HMI interface



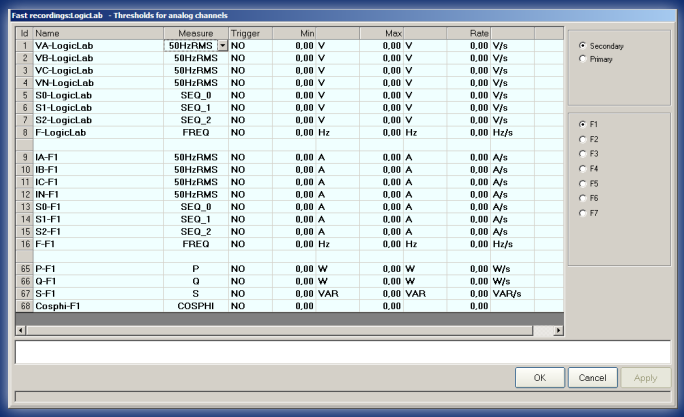
Recording capabilities

FR947 is capable of performing three different types of recording: TAR (Transient Analog Recording), TMR (Transient Measure Recording), and SMR (Slow Measure Recording). With FR947-EXb only TAR is available while for FR947-EX and FR947-HS, SMRs require additional license.

It is possible to assign labels to each inputs and define feeders, with a configurable label. Feeder is a group of 3 phases + residual voltage and 3 phases + residual current. It is possible to configure up to 7 different feeders. With voltage selection logic, it is possible to configure feeder dinamically.



TAR is a transient recording that stores the waveform of each analog channel at the sampling rate set by user with a resolution up to 24 bit. Also digital inputs status is stored. Recording can start for a trigger condition on analog inputs (Min, Max, Rate-Of-Change on RMS, Fundamental RMS, voltage frequency and current frequency; Min, Max on Positive, Negative and Zero sequence for voltage and current, on Apparent Power, Reactive Power and Active Power, Cosφ); a trigger condition on digital inputs (rising edge, falling edge, both edges) and via local or remote command. Each trigger condition can be enabled one by one and will be active at the same time (logic OR). All trigger conditions on analog and digital inputs can be used to build a trigger equation in logic AND: in this case all conditions in equation must be true to trigger a new recording. All trigger can be set using a threshold level at primary or secondary side of the transformer. User can set pre-fault time, fault time, post fault time. It is possible to configure the device to extend recording time if a new trigger condition happens during recording.



TMR is a disturbance recording that stores all the measures calculated by the device. In addition to all measures listed above, used for triggering TAR, energy and synchrophasors can be saved. This recording starts, if enabled, simultaneously with TAR. User can set pre-fault time, fault time, post fault time and a data period from 10ms (1 cycle for 60Hz system) up to 600s. It is possible to configure the device to extend recording time if a new trigger condition happens during recording as happens for TAR. The purpose of this recording is to analyse the behaviour of the grid before and after a fault condition with a slow recording that store data for a longer time than TAR.

SMR is a slow recording that stores all the measures performed by the device. SMR is very similar to TMR but the trigger conditions can be also scheduled for automatic start. The maximum recording length is a function of data period and can be changed up to 365 days. To ensure proper store operation of the recording, it is possible to configure device to perform intermediate backup with a recording length that is a fraction of the maximum length. SMR can be configured to save instantaneous measure or the average measure and it is possible to configure it as continuous slow recording. In addition, it is possible to enable the synchronized time option to store measures at the exact time (e.g. at the second zero of each minute). This option helps user when it is needed to compare slow recordings from different devices. With Power Quality module, SMR can store harmonics of analog inputs for long term analysis.

FR947 is capable to manage up to six recording simultaneously (one TAR, one TMR and four SMRs). The storing space capability is related to the dimension of Compact Flash installed.

If device is a part of fault recording system, it is possible to send a trigger command to other FR947 using Ethernet connection. Thanks to GPS synchronization, it is possible to extend the acquisition capability of a single device to a FR947 System (cooperating units), composed by multiple devices.

FR947-EXb

This model is the basic device in the FR947 family. EXb model is a cost-saving solution with full set of tools for analysis and real time monitoring.

FR947-EXb is equipped with 4GB of solid state memory, 8 voltage inputs and 24 current inputs. The resolution is 16 bits and the frequency sampling is fixed to 7200 Hz. Recording capability is limited to TAR recording only. The maximum number of recordings is 150 with FIFO auto deletion policy.

Digital I/O capability is fixed to 128 digital inputs and 2 relay outputs.

Communication includes two RS232 and two 10/100 BASE-TX Ethernet.

ENEL / e-distribuzione certified product, compliant to ENEL DV1047A2-NC specification.

Considering that this product is certified, the configuration hardware and software is provided with limited expansion and upgrading capabilities. In this case, it is preferable to move to FR947-EX model with extended configuration and options.

FR947-EX

This model is the high level device in the FR947 family. FR947-EX is equipped with up to 32GB of solid state memory and up to 32 analog inputs, in factory configurable as current or voltage inputs. Additional features can be added using optional boards and license tool can enable different software pack to extend the digital fault recorder analysis and monitoring capability.

The resolution is 16 bit or 24 bit and the frequency sampling is configurable up to 168 samples per cycle. Enhanced measurement with frequency tracking algorithm and full recording capability, including TAR and TMR. With additional licenses, it is possible to have up to 4 SMR recordings and event recorder. It can be equipped with PMU software pack compliant to IEEE C37.118:2014. The maximum number of recordings is 2000 TAR, 2000 TMR and 1000 SMR.

This model is fully compatible with IEC 61850 protocol, feature that is provided with separated license.

Digital I/O con be configured on factory up to 128 digital inputs and up to 32 relay outputs. Communication includes dual RS232, dual 10/100 BASE-TX and fibre optic 100 BASE-FX Ethernet.

FR947-HS

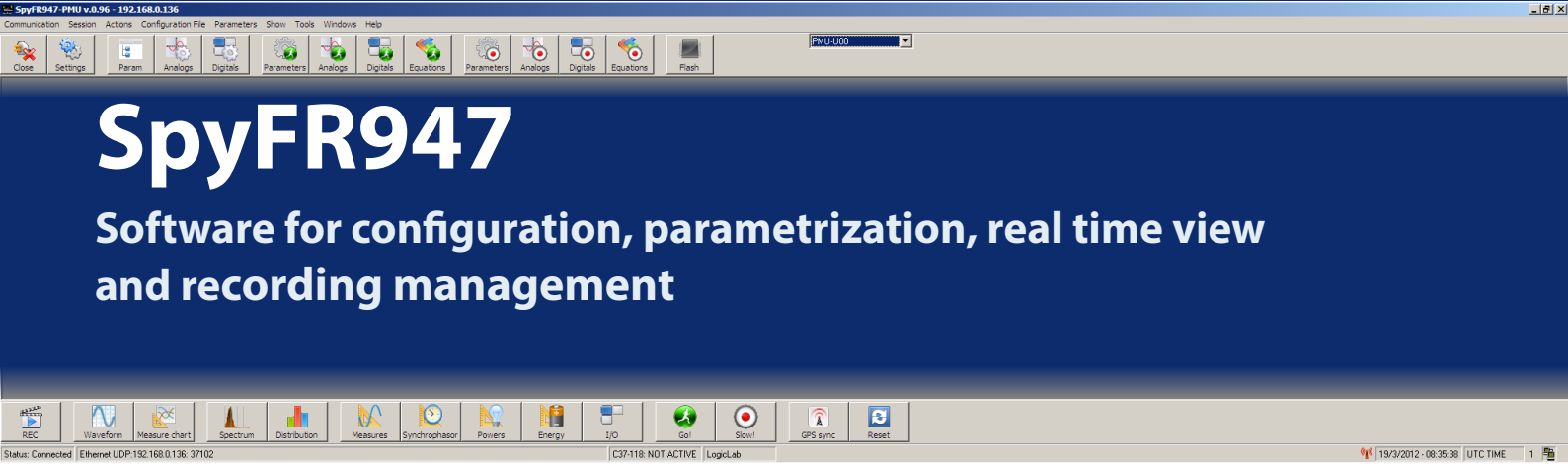
This model is a special version of digital fault recorder in FR947 family, with high speed capability in 6U compact solution.

It inherits all features from high level model FR947-EX. With a resolution of 16 bit or 24 bit, it is possible to configure the frequency sampling up to 360 samples per period. The number of analog inputs is up to 16, in factory configurable as current or voltage inputs.

Digital I/O con be configured on factory up to 64 digital inputs and up to 6 relay outputs.

Communication includes dual RS232, dual 10/100 BASE-TX and fibre optic 100 BASE-FX Ethernet. Optionally, it is possible to install up to six fibre optic Ethernet ports 100 BASE-FX.

It is possible to integrate 2 units FR947-HS in a single 9U case with up to 128 digital inputs, 32 analog inputs and 32 digital outputs.



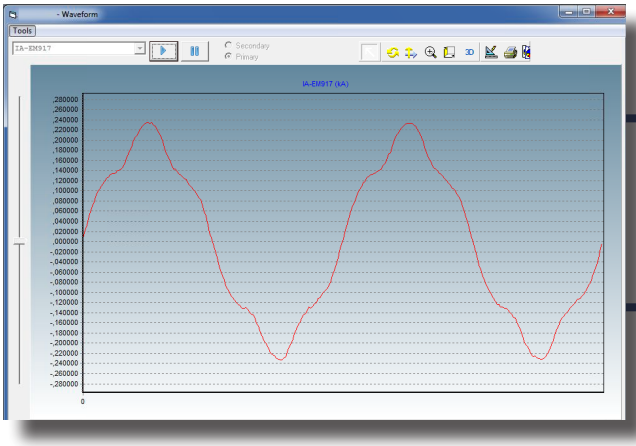
SpyFR947

Software for configuration, parametrization, real time view and recording management

Here below main and common features of SpyFR947 software.

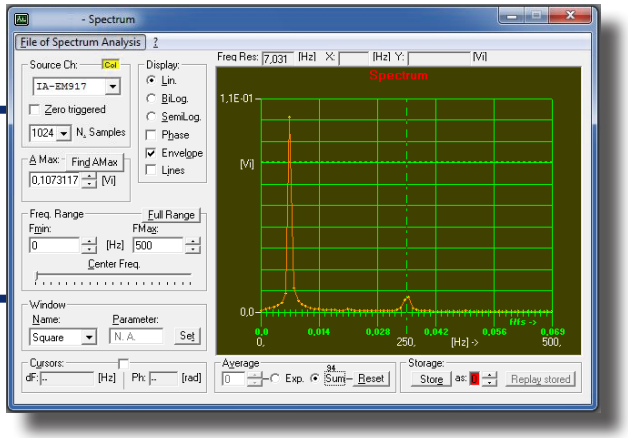
Custom tools or new features can be developed by LogicLab on client demand.

- Communication configuration (RS232, Ethernet UDP, Ethernet TCP)
- Device status analysis and self diagnostic check
- Feeder and analog acquisition configuration with voltage selection logic
- Analog inputs configuration
  (Input label identification, Full-scale setup, software reverse input, CT/CVT ratio, gain/phase correction)
- Digital inputs configuration
  (Input label and subsystem identification, active and no-active level, anti-bounce filter)
- TAR (Transient Analog Recording) configuration
- TMR (Transient Measure Recording) configuration
- TMR/TAR analog trigger condition setup (triggers enable, thresholds configuration)
- TMR/TAR digital trigger condition setup (triggers enable, thresholds configuration)
- TMR/TAR trigger equation builder
- SMR (Slow Measure Recording) configuration (Four different recording configuration)
- SMR1/SMR2/SMR3/SMR4 scheduled trigger condition
- CPU/DSP firmware upgrade wizard
- Recordings management
- Event log management
- Real time tool to show analog waveform
- Real time tool to show analog measure trend
- Real time tool to show spectrum analysis
- Real time tool to show statistic distribution of the analog measure
- Real time tool to show analog measure (RMS, Fundamental RMS, THD, Sequences, Frequency)
- Real time tool to show synchrophasors
- Real time tool to show power (Active, Reactive, Apparent and cosφ)
- Real time tool to show energy
- Real time tool to show digital inputs status
- Manual trigger for TMR/TAR/SMR
- Device and recording status monitoring
- Command to force GPS synchronization
- Reset of the device
- Off-line configuration with XML file builder
- Compact Flash partitions manager with FIFO/depletion configuration
- Sampling frequency configuration
- Feeder configuration
- C37-118 configuration (Only with PMU license enabled)
- User/password access with 5 different level of security
- Tool for complex DFR system management:
  - Management of all DFR units connected to the system
  - Automatic IP scan or manual operation to add/remove units
- Automatic recording download service



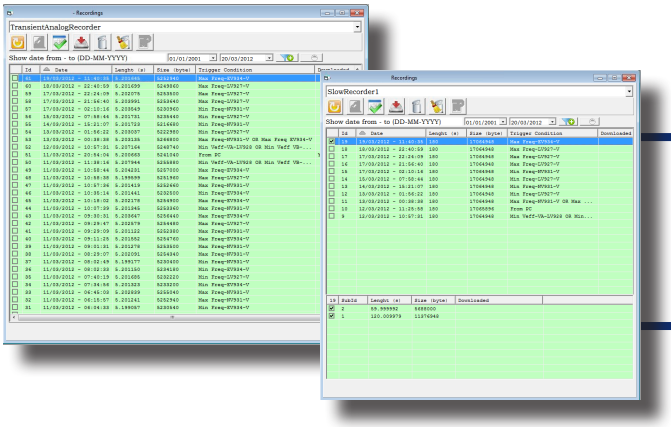
Waveform Real Time tool

It shows the waveform in real time and using FR947 like an oscilloscope. Value can be shown at primary or secondary level using 24 bit resolution.



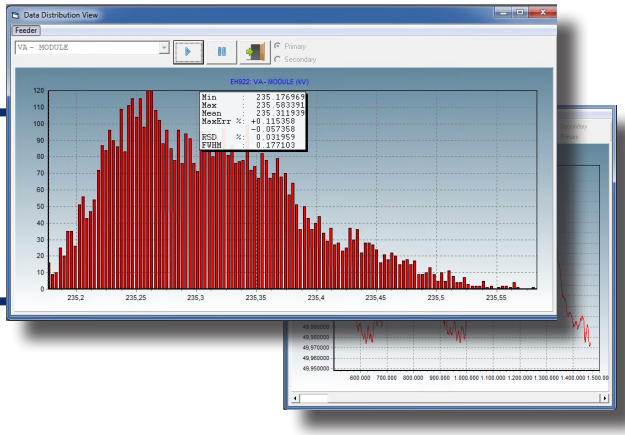
Spectrum Real Time tool

It performs a qualitative analysis of the harmonic components of an analog input in real time.



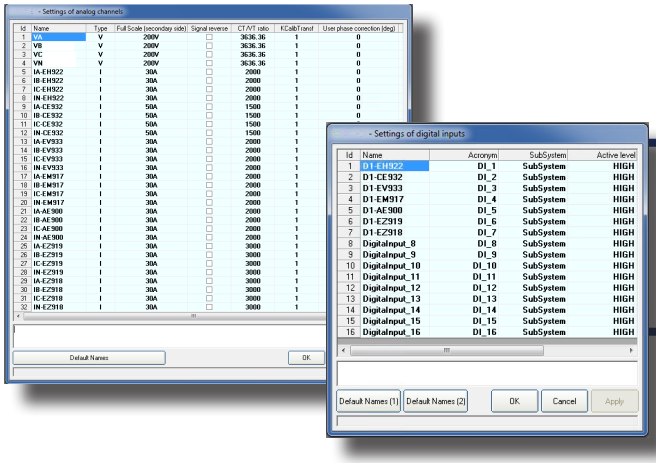
Recording management

User can manage the stored recording using this tool: it is possible to download, erase and search the desired recording



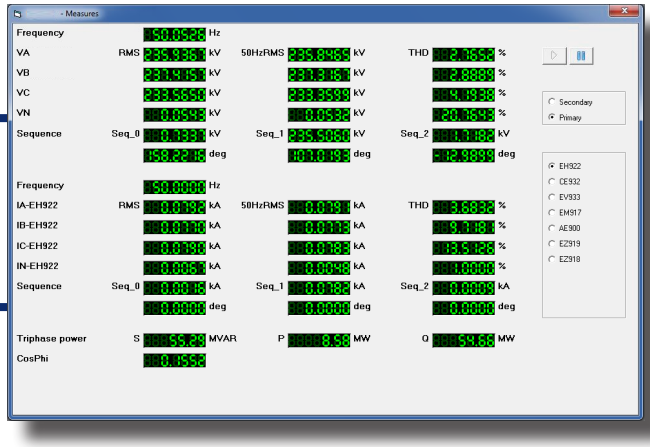
Measures statistic and trend

With Statistic and measure trend tools it is possible to evaluate in real time the grid behaviour over the time. Value can be shown at primary or secondary level.



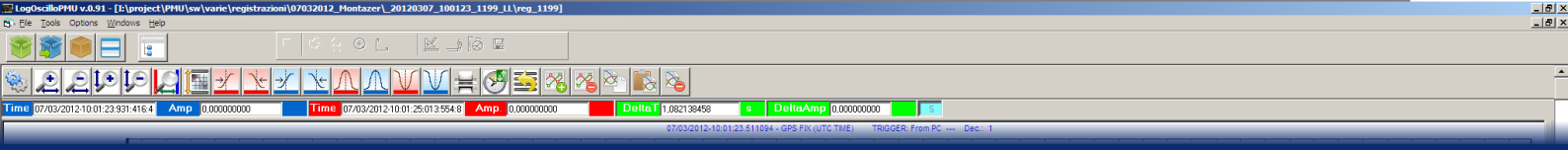
Analog and digital inputs setup

User can configure analog and digital inputs to obtain the best performance of the device.



Measure Real Time tool

It shows the measures performed by FR947 in real time. Values can be shown at primary or secondary of transformers.



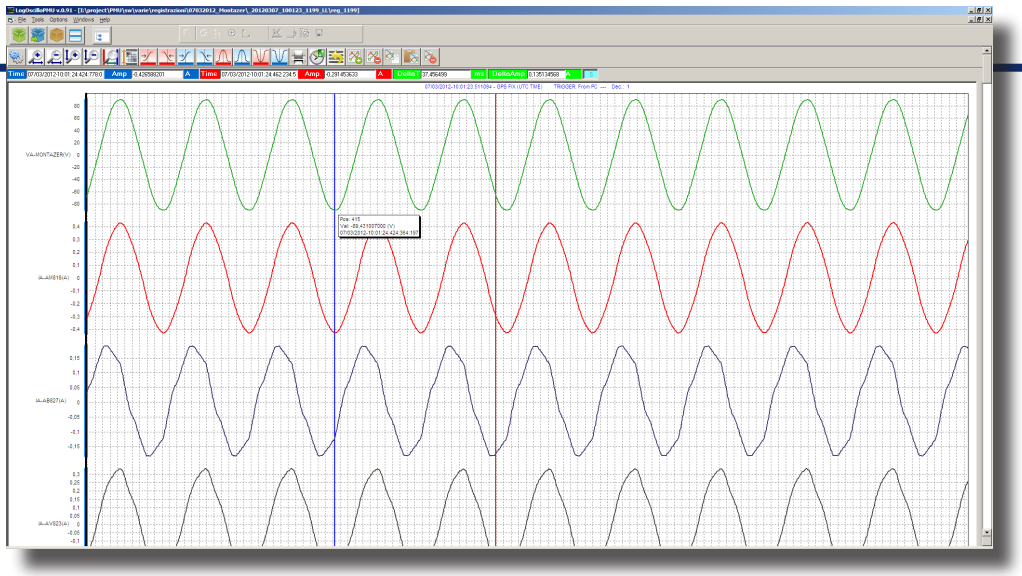
LogOscillo

Software for recording analysis

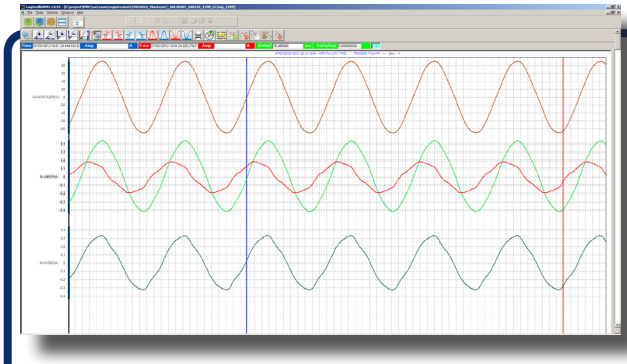
Here below the main and common features of LogOscillo software.

Custom tools or new features can be developed by LogicLab on client demand.

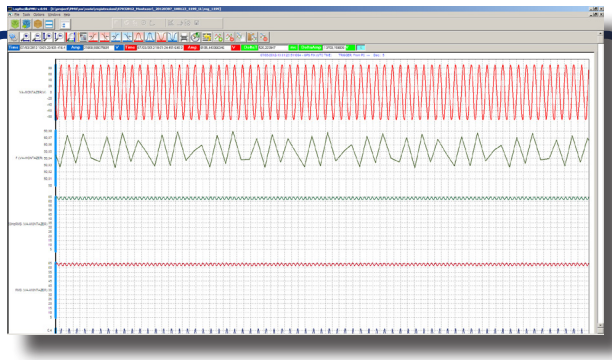
- Recording view of TAR/TMR/SMR
- Secondary or primary value selectable
- Import/Export in COMTRADE format
- Signal selection and waveform colour assignment
- Two time cursors (blue and red)
- Trigger cursor position (fixed)
- Amplitude and time value on cursor position
- Amplitude and time difference between blue and red cursor
- Frequency calculation using time cursor positions
- Rate of change of measure using time cursor positions
- Amplitude and time value on mouse pointer position
- Zoom in/out on X-axis, Y-Axis, Window, zoom area between cursors
- Find zero crossing on rising and falling transition
- Find max/min value for analog signal
- Print waveforms
- Show/Hide samples measurements
- Multiple recording view with time link capability
- Waveform management tools (copy, paste and delete signal)
- Export waveform on other recording using copy/paste tool
- Move waveforms over Y-Axis to overlap other waveforms
- TVE (Total Vector Error) analysis
- Vectorial representation
- Export waveform in Excel, pdf, image
- Specific tool for TAR:
    - Add waveform of frequency trend
    - Add waveform of RMS value trend
    - Add waveform of Fundamental RMS value trend
    - Add waveform of phase value trend
    - Add waveform of THD trend
    - Interpolate signal
    - Sum two or more waveforms
    - Compare two waveforms
    - Spectrum analysis
    - Edit waveform
- Specific tool for TMR/SMR:
    - Statistic distribution
    - Sum two or more measure trends
    - Compare two measure trends
    - Edit waveform



High quality waveform representation using 24 bit resolution with full set of tools for recording analysis. Two time cursors and many options for waveform manipulation.

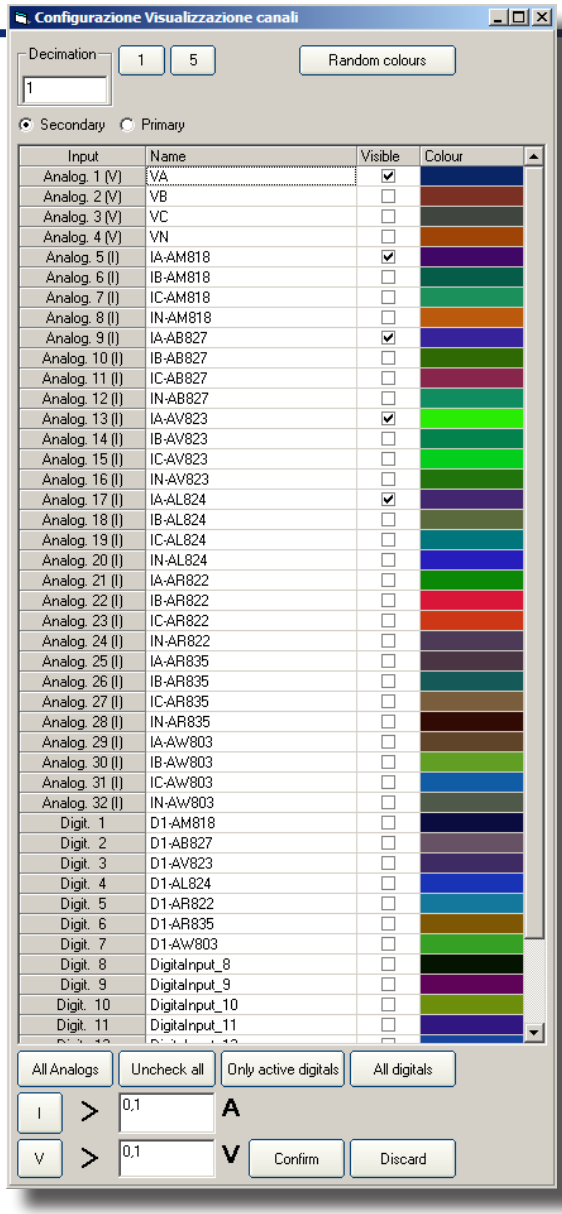


Overlapping waveforms help user to analyse the behaviour in specific situation. It is very useful overlapping digital input to analog input to quick understand the behaviour of protection relay.



It is possible to add waveforms with frequency, RMS value, Fundamental RMS value spectrum and THD, to help user in fault analysis.

This operation can be performed on each analog input present in the recording.



Analog and digital input selection with capability to show signal at primary or secondary level. Filters help user with quick signal selection.

FR947 Family - Models Comparison Table

	Analog Inputs	Low DC Inputs	24 bit Resolution	Full Scales	Sampling rate	Digital Inputs	Digital Outputs	Ethernet Interfaces	HMI	Frequency Tracking	IRIG-B	TAR	TMR	SMR (*)	WADC Pack (*)	Event Recorder (*)	IEC-61850 (*)	Fault Locator (*)	Supervisor functions (*)	WebServer (*)	Cybersecurity
FR947-EXb	8V+24I	NO	NO Default 16 bit	2 Currents 3 Voltages	Fixed 144 samples/ period	128	2	100 BASE-TX 100 BASE-TX	NO	NO	NO	YES MAX 150 recordings	NO	NO	NO	NO	NO	NO	NO	NO	NO
FR947-CSb	8V+24I	NO	NO Default 16 bit	2 Currents 3 Voltages	Fixed 144 samples/ period	128	2	100 BASE-TX 100 BASE-TX	NO	NO	NO	YES MAX 150 recordings	NO	NO	NO	NO	NO	NO	NO	NO	YES
FR947-EX	8 to 32 V or I	OPTIONAL	OPTIONAL Default 16 bit	5 Currents 3 Voltages	18-168 Samples/period	16-128	2 / 6 8 - 32	100 BASE-TX 100 BASE-TX 100 BASE-FX	OPTIONAL	YES	OPTIONAL	YES MAX 2000 recordings	YES MAX 2000 recordings	1-4 SMRs MAX 200 recordings	YES	YES	YES	YES	YES	YES	OPTIONAL
FR947-HS	8 to 16 V or I	OPTIONAL	OPTIONAL Default 16 bit	5 Currents 3 Voltages	18-360 Samples/period	16-128	2 / 6 8 - 32	100 BASE-TX 100 BASE-TX 100 BASE-FX	OPTIONAL	YES	OPTIONAL	YES MAX 2000 recordings	YES MAX 2000 recordings	1-4 SMRs MAX 200 recordings	YES	YES	YES	YES	YES	YES	OPTIONAL

(*) Requires additional licence

FR947-EX DFR Typical Configuration: Analog Inputs: 32 Analog inputs (16 voltage inputs + 16 current inputs); Resolution: 24 Bit resolution; Sampling rate: 144 samples per period; Digital Inputs: 128 inputs; Digital Outputs: 2 Relays; Synchronization: Integrated GPS + GPS Antenna with 20m RF cable; Recordings: TAR, TMR and 4 SMR; Event Recorder.

FR947-EX PMU Typical Configuration: Analog Inputs: 32 Analog inputs (16 voltage inputs + 16 current inputs); Resolution: 24 Bit resolution; Sampling rate: 144 samples per period; Digital Inputs: 128 inputs; Digital Outputs: 2 Relays; Synchronization: Integrated GPS + GPS Antenna with 20m RF cable; Recordings: TAR, TMR and 3 SMR; Event Recorder; PMU; Fault Locator.

FR947-HS DFR Typical Configuration: Analog Inputs: 16 Analog inputs (8 voltage inputs + 8 current inputs); Resolution: 24 Bit resolution; Sampling rate: 360 samples per period; Digital Inputs: 128 inputs; Digital Outputs: 2 Relays; Synchronization: Integrated GPS + GPS Antenna with 20m RF cable; Recordings: TAR, TMR and 4 SMR; Event Recorder.

FR947 Family - Part Number

FR947-EX6-PMU-M1-P-W-R-LV-LA-X-PS-H

Digital Fault Recorder with Phasor Measurement Unit
- 19" industrial rack 6U
- TAR/TMR Recording
- Internal GPS receiver with GPS Antenna
- 16 Digital Inputs
- 2 Alarms output (2 relays)
- 3 Ethernet Ports [2x 100BASE-TX + 1x 100BASE-FX]
- PMU compliant to IEEE C37.118:2014 / 60255-118:2018 **[Optional License]**
- IEC61850 protocol **[Optional License]**

Analog Inputs Hardware configuration
[M1] – One Feeder configuration – 4 Voltage Inputs + 4 Current Inputs
[M2] – Two Feeders configuration – 8 Voltage Inputs + 8 Current Inputs
[M4] – Four Feeders configuration – 16 Voltage Inputs + 16 Current Inputs
[T1] – Single Busbar configuration – 4 Voltage Inputs + 24 Current Inputs
[T2] – Dual Busbar configuration – 8 Voltage Inputs + 20 Current Inputs
[MX] – Custom configuration

IEEE1588v2 – PTP – Energy Profile
[P] - IEEE1588 Synchronization Board +additional 100BASE-FX LC ethernet port
[Blank] – Feature not included

WADC controller
[W] - SRM board with 4 driver 0-20mA for WADC application
[Blank] – Feature not included

Relay output expansion
[R] - Additional 8 Alarm outputs (8 Relay outputs board)
[Blank] – Feature not included

Low Voltage Analog Inputs +/-10V DC
[LV] - Add or Replace a voltage input board with DC low voltage input board
[Blank] – Feature not included

(*) Multiple LV option can be defined. In case it is needed 2 boards, use LV-LV.

Low Current Analog Inputs 4-20mA DC
[LV] - Add or Replace a current input board with DC low current input board
[Blank] – Feature not included

(*) Multiple LA option can be defined. In case it is needed 2 boards, use LA-LA.

HMI - Human Machine Interface
[H] - Add HMI board with Display, LEDs and keyboard
[Blank] – Feature not included

Redundant Power Supply
[PS] - Add redundant power supply with alarm board
[Blank] – Feature not included

Extended Recording Capability
[X] - Add SRM (Slow Recording Measure) capability
[Blank] – Feature not included

FR947-EX9-PMU-M1-P-W-R-LV-LA-X-PS-H-D###

Digital Fault Recorder with Phasor Measurement Unit
- 19" industrial rack 9U
- TAR/TMR Recording
- Internal GPS receiver with GPS Antenna
- 2 Alarms output (2 relays)
- 3 Ethernet Ports [2x 100BASE-TX + 1x 100BASE-FX]
- PMU compliant to IEEE C37.118:2014 / 60255-118:2018 **[Optional License]**
- IEC61850 protocol **[Optional License]**

Analog Inputs Hardware configuration
[M1] – One Feeder configuration – 4 Voltage Inputs + 4 Current Inputs
[M2] – Two Feeders configuration – 8 Voltage Inputs + 8 Current Inputs
[M4] – Four Feeders configuration – 16 Voltage Inputs + 16 Current Inputs
[T1] – Single Busbar configuration – 4 Voltage Inputs + 24 Current Inputs
[T2] – Dual Busbar configuration – 8 Voltage Inputs + 20 Current Inputs
[MX] – Custom configuration

IEEE1588v2 – PTP – Energy Profile
[P] - IEEE1588 Synchronization Board +additional 100BASE-FX LC ethernet port
[Blank] – Feature not included

WADC controller
[W] - SRM board with 4 driver 0-20mA for WADC application
[Blank] – Feature not included

Relay output expansion
[R] - FR947 with 8 Alarm outputs (8 Relay outputs board)
[Blank] – Default configuration with 2 Alarm outputs (2 Relay outputs board)

Low Voltage Analog Inputs +/-10V DC
[LV] - Add or Replace a voltage input board with DC low voltage input board
[Blank] – Feature not included

(*) Multiple LV option can be defined. In case it is needed 2 boards, use LV-LV.

Low Current Analog Inputs 4-20mA DC
[LV] - Add or Replace a current input board with DC low current input board
[Blank] – Feature not included

(*) Multiple LA option can be defined. In case it is needed 2 boards, use LA-LA.

Number of Digital Inputs
FR947 can be equipped with 16 to 128 digital inputs with steps of 16 inputs
[D016] – 16 Digital Inputs
[D032] – 32 Digital Inputs
[D048] – 48 Digital Inputs
[...]
[D128] – 128 Digital Inputs

HMI - Human Machine Interface
[H] - Add HMI board with Display, LEDs and keyboard
[Blank] – Feature not included

Redundant Power Supply
[PS] - Add redundant power supply with alarm board
[Blank] – Feature not included

Extended Recording Capability
[X] - Add SRM (Slow Recording Measure) capability
[Blank] – Feature not included

Technical Specifications

General

Standard 19" rack mount

Height / Width / Depth:	3U or 6U or 9U / 19" / 31 to 40 cm
Operating temperature range:	-10 ÷ +55°C
Storage temperature range:	-40 ÷ +85°C
Relative Humidity:	<95 %
Atmospheric pressure:	70 ÷ 106 kPa
Intrusion Protection:	IP20
System frequency:	50/60Hz

Power supply

Power supply voltage (Vaux): 🛠
- Universal AC/DC power supply
  - AC 88-264V 48-62Hz
  - DC 88-350V
- DC Power supply
  - DC 60-350V

Maximum power consumption: <40W

Voltage dips and short interruptions
- Insensitive to 100% of Vaux for 50 ms (min)
- Insensitive to 50% of Vaux for 100ms (min)

Analog inputs

Hardware features

8 to 32 analog inputs

Four different connections:
- Screw fixing removable connector (standard)
- Spring-clamp connectors for high reliability wiring 🛠
- Barrier strips connectors for cables with ring terminals 🛠 ⃠ *EXb*
- Current inputs with split-core transformer 🛠 ⃠ *EXb*

Analog to digital conversion:	24 bit

One ADC per analog input

Sigma-Delta ADC with sampling frequency up to 5.7 MHz

PGA Amplifier for up to 5 different measuring range

Channel typology (voltage/current) in factory configurable

Diagnostic on residual current/voltage measurement

Dielectric strength:	3300V DC (1 min)
Configurable sample rate (fs):	up to 168 samples/period @16bit up to 144 samples/period @24bit up to 360 samples/period @16bit (HS)
Fixed sample rate (fs):	144 samples/period @16bit (Only EXb)
Bandwidth (-3 dB):	DC (0 Hz) ÷ 0.49·fs
Flat bandwidth(±0,005 dB):	DC (0 Hz) ÷ 0.45·fs
Stop band attenuation:	>100 dB (f>0.55·fs)
Resolution:	16 bit or 24 bit 🛠 ⃠ *EXb*
SNR (Signal to noise ratio):	>92 dB
Cross-over:	< -92 dB

Software features

Feeder (3+1current and 3+1 voltage inputs) configuration

Feeder VLS (Voltage Selection Logic) ⃠ *EXb*

Up to 10 different feeders

Primary/secondary transformer side representation

CT/CVT transformer ratio management

Software phase reversal (±180° angle)

User configurable Gain and Phase correction

Up to 5 different full scale values for each channel ⃠ *EXb*

Analog input full scale singly configurable by software setup

Current analog inputs

Max Full-scale:	up to 400Arms
Full-scales (FSI):	15A, 30A 50A, 150A, 400A ⃠ *EXb*
Low amplitude DC input on client demand (i.e. ±20 mA_{DC}) 🛠	
Accuracy guaranteed range:	0A ÷ FSI
RMS Accuracy:	(0.1% of Reading + 0.0005%*FSI)
Accuracy (Low DC input):	(0.01% of Reading + 0.0005%*FSI)
Overload capability:	40A permanently 500A (1 second)
Input impedance:	1,5 mohm (Standard)
Power dissipation max:	37,5 mVA @ In

Voltage analog inputs

Max Full-scale:	700Vrms
Standard full-scales (FSV):	200V, 400V, 700V
Low amplitude DC input on client demand (i.e. ±10V_{DC}) 🛠	
Accuracy guaranteed range:	0A ÷ FSV
RMS Accuracy (Standard):	(0.1% of Reading + 0.0005%*FSV)
Accuracy (Low DC input):	(0.01%of Reading + 0.0005%*FSV)
Input impedance:	1 Mohm
Power dissipation:	12 mVA @ 110V

Measure calculated and accuracy

FR947 calculates each half period up to 234 different measures:

RMS value *	0.1%
50/60 Hz RMS value *	0.1%
Absolute Phase *	±0.02°
Frequency **	±0.3 mHz
ROCOF **	±1 mHz/s
THD *	±0.5%
Positive, negative and zero sequences RMS **	0.4%
Positive, negative and zero sequences Phase **	±0.1°
Active, reactive and apparent powers ***	0.4%
Power factor ***	±0.005
Partial and total Energy ***	0.5%

** up to 32 measures (one for each analog inputs)*
*** up to 8 measures (one for each group of 4 voltage or 4 current inputs*
*** up to 7 measures (one for each feeder)*

Digital inputs

Up to 128 single channel isolated inputs 🛠

Up to 64 single channel isolated inputs (HS)

Input rated voltage configurable with jumpers

Available rated voltage (Vi):	24V, 48V, 110V, 220V ⃠ *EXb* Wide input 24-132V

AC input capability on request

Dielectric strength:	3300V DC (1 min)
Thresholds (typ):	High - 60% Vi Low - 40% Vi
Maximum voltage (max):	1.2*Vi

Digital Inputs with IEC 61850 Goose Message

Time resolution:	1 ms

Anti-bounce filter ⃠ *EXb*

Alarm outputs

Alarms board with 6 or 8 relays (Only 2 relays for EXb model)

Up to 32 relay outputs ⃠ *EXb*

Relay Technical Data

Rated carry current:	12A
Maximum switching voltage DC:	300V
Maximum switching voltage AC:	440V
Maximum switching current:	12A
Maximum switching power:	3000VA
Contact resistance (max):	100 mohm
Maximum operating frequency:	18000 operation/hour
Minimum endurance:	$20 \cdot 10^6$ operations

Communication and interfaces

Three Ethernet ports:

Configurable as node of a net LAN/WAN

Front 10/100 BASE-TX with auto MDI/MDI-X

Connection:	RJ45 8/8
Isolation:	1500VRMS

Rear 10/100 BASE-TX with auto MDI/MDI-X

Connection:	RJ45 8/8
Isolation:	1500VRMS

Rear 100BASE-FX (Fibre optic with SC connector) ⃠ *EXb*

Transmitter Centre Wavelength:	1310 nm
Operating Receiver Centre Wavelength:	1270nm÷1380nm
Sensitivity:	-24 dBm

Adapters for ST and LC connectors 🛠

Optional Rear 6 Ports 100BASE-FX (Fibre optic with LC connector) (HS)

2 RS232

Front RS232

Plug Type:	DB9
Baud rate (Fixed):	19200 bit/s
Isolation:	2500VRMS
Typical use:	Local communication

Back RS232

Plug Type:	DB9
Baud rate:	9600 bit/s to 115200 bit/s
Isolation:	NO
Typical use:	GSM/Dial-up modem (modem not included)

RS485 External Connection Link 🛠 ⃠ *EXb*

SMA connector for satellite antenna

Multiple simultaneous connections over serial and Ethernet

Webserver for monitoring and configuration ⃠ *EXb*

HMI with display and keypad 🛠 ⃠ *EXb*
- Alphanumeric display 4 rows x 20 columns
- 16 LEDs: 2 red for alarms and 14 green for information
- Keypad and four arrow keys
- Isolated and shielded membrane

Time synchronization

Integrated GPS unit

Channels:	22 tracking / 66 acquisition
Sensitivity:	

🛠 - *This features is an option for all models of FR947 DFR family.*
⃠ *EXb - This features is not available for FR947-EXb model*
▞ - *This features requires additional license*

Acquisition (cold): -148dBm
Re-Acquisition: -160dBm
Tracking: -165dBm
1PPS accuracy: ±20ns
Standard active GPS antenna with 20m RF cable SMA connector
Optional active GPS antenna with up to 100m RF cable SMA connector 🛠
IRIG-B synchronization board: 🛠 ⃠EXb
I/O isolation: 2500VRMS
Available connections:
AM IRIG-B IN: Modulated IRIG-B input
IRIG-B / 1PPS IN (Mux): Unmodulated IRIG-B input
1PPS input
IRIG-B OUT: Unmodulated IRIG-B output
1PPS OUT: 1PPS output
Voltage levels:
AM IRIG-B IN: Max $12V_{PP}$
IRIG-B / 1PPS IN (Mux): 5V TTL
IRIG-B OUT: 5V TTL
1PPS OUT: 5V TTL
1PPS IN to 1PPS OUT max propagation delay: <50ns
Unmodulated IRIG-B IN frame to 1PPS out delay: <50ns
Modulated AM IRIG-B IN frame to 1PPS out delay: <20µs
1PPS signal: Normally low
High for 8ms
Supported IRIG-B Format (All formats supported)
Available formats: IRIG-B000, B001, B002 ... B007
IRIG-B120, B121, B122 ... B127
IEEE 1588v2 PTP (power profile)
SNTP synchronization
Internal clock backup with accuracy drift better than 5ppm
Synchronization source priority definition with automatic restore

Architecture

Multiprocessor architecture: 32 bit CPU + dual 3.6 GFLOPS DSPs
Up to 32 GByte Compact Flash/SD card for storage data (4GB for EXb model) 🛠
Compact Flash/SD class 10, Temperature range -40 °C to +85 °C
Compact Flash partitioning utility with FIFO capability ⃠*EXb*
Self diagnostic with Watch Dog capability
User/password access with 5 different level of security (optional) ⃠*EXb*

Transient Analog Recording (TAR)

Transient analog waveforms and digital status recording

Three timers user configurable
- Pre-trigger time: 100 ms ÷ 10 s
- Fault time: 100 ms ÷ 60 s
- Post fault time: 100 ms ÷ 10 s

Re-triggering during recording time available
Record time out (max): 100 s
Trigger on analog thresholds (Max, Min, Rate-Of-Change):
- RMS
- Positive, Negative and Zero sequence ($I_{1,2,0}$,$U_{1,2,0}$)
- Residual signal to Zero sequence comparison 🛠
- Power: P, Q, S, cos φ
- Frequency
- THD

Trigger on digital edge (falling edge, rising edge, both edges)
Software trigger
Cross triggering capability for FR947 system

Transient Measures Recording (TMR) ⃠EXb

Disturbance slow recording

Up to 234 different measured and calculated channels

Three timers and data period configurable
- Pre-trigger time: 100 ms ÷ 60 s
- Fault time: 100 ms ÷ 6000 s
- Post fault time: 100 ms ÷ 1200 s
- Data period: 0.5 ÷ 50 cycles @50Hz
1 ÷ 60 cycles @60Hz

Configurable stored data packet (Measures and feeders)
Trigger on TAR
Re-triggering during recording time available
Record time out (max): 7300 s

Slow Measure Recording (SMR) ▞ ⃠EXb

Disturbance and trend slow recording

Up to four different configurable SMR 🛠 ▞
With PMU software pack SMR4 is used as backup
Up to 234 different measured and calculated channels
Single parameter set for each SMR (4 different configuration available)
Fault timer and data period configurable
Fault time: up to 365 d : 23 h : 59 m
- Data period: 0.5 ÷ 3000 cycles @50Hz
1 ÷ 3600 cycles @60Hz

Configurable stored data packet (Measures and feeders)
Configurable intermediate backup
Configurable measure stored: average/instantaneous
Configurable as continuous slow recording
Time scheduled trigger
Software trigger
Maximum Number of SMR stored in Compact Flash:
- Not available on FR947-EXb
- 200 (FR947-EX and FR947-HS)

Synchrophasor (PMU) ▞ ⃠EXb

Software pack for FR947-EX and FR947-HS
Compliant to IEEE C37.118-2014 and IEC/IEEE 60255-118:2018
Up to 32 synchrophasors (all analog inputs)
P and M class (configurable)
Polar / Rectangular (configurable)
3 different frame destinations (PDCs/Control Centers)
Total vector error: <1%
Data transfer rate (frame/s): 10,25,50,100 @50Hz
10,12,15,20,30,60 @60Hz
Synchronization error between different channels: <100ns
Maximum error on UTC synchronization time: <1µs
Working with intenal GPS or IEEE1588 PTP

Fault Locator ▞ ⃠EXb

LogOscillo software pack for FR947-EX and FR947-HS

Supervisor functions ▞ ⃠EXb

Open Phase Detection (Broken wire)
Voltage Zero Sequence Monitoring
Voltage imbalance
Voltage Phase Angle Correctness Supervision
Current Zero Sequence Monitoring
Current imbalance
Current Phase Angle Correctness Supervision

WADC Pack ▞ ⃠EXb

Adaptive Wide-Area Damping Controller by Terna

Software pack for FR947-EX and FR947-HS
4 Driver outputs 4-20mA SRM board

Event Recorder ▞ ⃠EXb

Sequence of event recorder for disturbance events and diagnostic

Dual event logs (disturbance and diagnostic)
Each log is capable to collect up to 1000 events
Time tag with millisecond accuracy

Standards and specifications compliance

IEC 61000 – 4 – 2 (Level 4)
IEC 61000 – 4 – 3 (Level 3)
IEC 61000 – 4 – 4 (Level 4)
IEC 61000 – 4 – 5 (Level 4)
IEC 61000 – 4 – 6 (Level 3)
IEC 61000 – 4 – 8 (Level 5)
IEC 61000 – 4 – 10 (Level 3)
IEC 61000 – 4 – 12 (Level 3)
IEC 61000 – 4 – 16 (Level 4)
IEC 61000 – 4 – 17 (Level 3)
IEC 61000 – 4 – 18 (Level 3)
IEC 61000 – 4 – 29 (Level 3)
IEC 61000 - 6 - 4
IEC 60529 (IP20)
IEEE C37.118-2014 ▞
COMTRADE standard IEEE Std C37.111
Naming Time Sequenced Data Files compliant to IEEE C37.232-2007 ▞
Communication networks and systems in substations IEC 61850 ▞
Telecontrol equipment and systems protocol IEC 60870-5-104 ▞

Certified by
Terna
e-distribuzione

🛠 - *This features is an option for all models of FR947 DFR family.*
⃠*EXb - This features is not available for FR947-EXb model*
▞ - *This features requires additional license*

Product designed and manufactured in Italy

LogicLab
Research & Development

FR947-EXb/EX/HS | 029_02_BRO_I | Rel. I.01 - July 2024

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ISO9001:2015
ISO14001:2015
ISO45001:2018