Digital Fault Recorder

FR947

ENEL* certified device

* ENEL is the italian electrical company

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Digital Fault Recorder FR947

High Performance fault and events recorder

Foreword

FR947 is a family of digital fault recorder. This is a flyer of base version of the DFR family, LogicLab portfolio is completed with EX version (Extended Signal Processor capability) and PMU version (Phasor Measurement Unit).

LogicLab has developed a high-performance device, achieving a fault recorder that has no comparison with the other ones on the market.

With up to 32 analog inputs (voltage and current) noise-free and 128 digital inputs, it provides great potential with high levels of precision and accuracy. **Each channel (analog or digital) is isolated from all the other channels, power supply and ground.**

The device is intended for power distribution medium and high voltage substations, and it is used to record currents, voltages and digitals input following the occurrence of a trigger condition which can be set both as analog or digital inputs, as you please. User can set trigger on analog inputs using threshold (Max, Min or rate) on RMS value, fundamental RMS value, THD, positive sequence, negative sequence, zero sequence, active and reactive power, frequency. All trigger conditions (analog and digital) can be enabled and used in logical OR with other triggers or used in logical AND equations.

Digital fault recorder FR947 uses the GPS signal for time synchronization and events timestamp. This feature provides a time value with resolution of ms and a µs accuracy. **GPS receiver is integrated** into the device and fault recorder is equipped with an external antenna. Other synchronization source, as NTP server or IRIG-B, are available.

Equipped with an ethernet 10/100 BASE-TX (100 BASE-FX on demand) and RS232 connection, the user, with a common PC, can obtain a fully parameterization, remote control over VPN network, and remote recording download. FR947 is equipped with an internal flash memory and, with automatic download, the device memory capability to the computer mass storage device.

FR947 is equipped with two user-friendly software:

1) SpyFR947 for a complete device management, providing realtime tools, recording management and parameterization;
2) LogOscillo: a complete set of tools for an effective, powerful and precise recording analysis.

LogicLab can supply tailored multi-device system based customer specification with multi-device and high performance industrial PC, complete of rack and cabling on terminal block based on to meet large demands of analog and digital inputs.

FR947 Power, precision and reliability.

Digital Fault Recorder FR947

Analog and digital acquisition unprecedented

Analog inputs

FR947 is equipped with **32 analog inputs**, with current/voltage partition in factory configurable in group of four (ex. 16 current inputs and 16 voltage inputs).

Each channel allows to acquire signals and perform many measures with bandwidth (-3 dB) DC ÷ 3.5 KHz and, thanks to the system architecture, ensure **flat band (± 0.005 dB) between DC÷3.25KHz** with an attenuation for frequencies greater than 3.5 KHz that exceeding 100 dB. For all analog inputs, the sampling frequency is 7.2KHz.

Each analog input is converted with high performance **24 bit ADC**, to obtain a resolution of 16 bits without noise (noise-free).

For each current input it is possible to measure up to $150A_{rms}$ for one second without loss of accuracy, and up to $40A_{rms}$ permanently with a resolution (worst case) that is better than 4.6 mA_{rms}. On client demand, LogicLab can supply devices with improved current capability **up to $300A_{rms}$**.

For each voltage input it is possible to measure up to $700V_{rms}$ permanently with a resolution, in the worst case, that is better then $21mV_{rms}$. With this fault recorder it is possible to obtain **excellent values of signal-noise ratio** up to 92dB regardless of the used full-scale range.

The user is able to set different full-scale range to obtain a better precision on small amplitude signals, both for voltage and current channels. This can be obtained through a software command that sets the system according to the user's needs.

The use of **purely resistive sensor** also ensures signals without delay, phase error and distortion.

Each channel is fully isolated from all other inputs, power supply and ground (3000V DC).

Digital inputs

FR947 is equipped with **128 digital inputs** that allow you to record events, alarms and commutations of signals with voltage from 18V to 150V.

FR947 performs a scan of every digital input with a frequency of 1KHz.

Each channel is isolated from all other inputs, power supply and ground (3000V DC).

Recordings

FR947-EX can perform two types of recordings:

DFR - Digital Fault Recording

All analog and digital inputs waveforms are recorded with programmable sample rate and stored in Compact Flash card memory. The recording is triggered by a minimum, maximum and rate (not available for all measures) condition on fundamental RMS value, RMS value, frequency, RMS value of the positive, negative and zero sequence, active power (P), reactive power (Q), THD or edge condition on digital input.

CSR - Continuous Slow Recording

With CSR user can store fundamental RMS value, RMS value, frequency, THD, RMS value of the positive, negative and zero sequence, apparent power (S), active power (P), reactive power (Q), cosφ, imbalance, with rate up to 100ms. The recording start after user software command, with a DFR recording, or with trigger based on programmed date and time.

The recordings consists of three "times" with user configurable lengths : pre-fault time, fault time, post-fault time (only for DFR recordings).

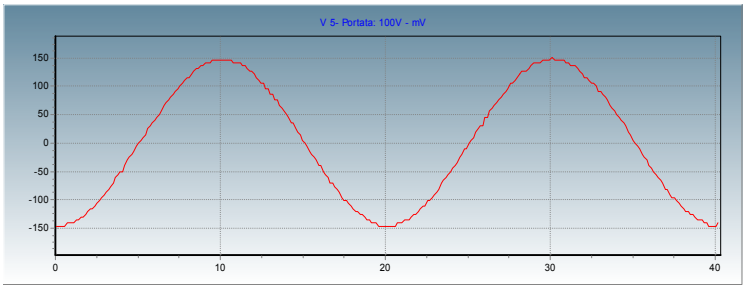
A single DFR recording length can reach 150s. The maximum number of recording stored in flash memory is related to the recording time configuration. With automatic download to PC user can store many recording (with 16GB of available space on hard disk it is passible to store over 35.000s). In CSR mode the user can store measure only directly on PC.

For all type of recording, using LogOscillo software, the user can perform multiple analysis.

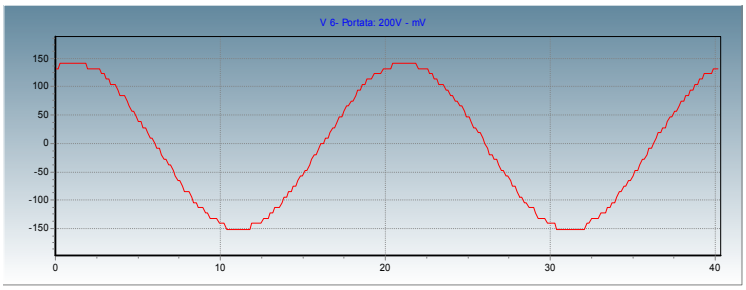
Digital Fault Recorder FR947

High accuracy noise-free analog inputs

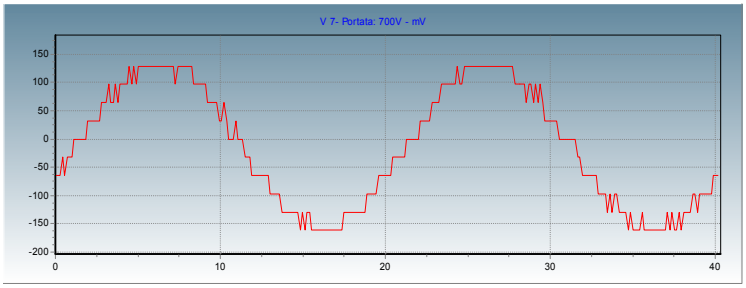
Analog inputs examples



The chart on the left shows a voltage sinusoidal signal with amplitude 100mV$_{rms}$ (282mV$_{pp}$) acquired by a voltage channel with 100V$_{rms}$ (282V$_{pp}$) full-scale.



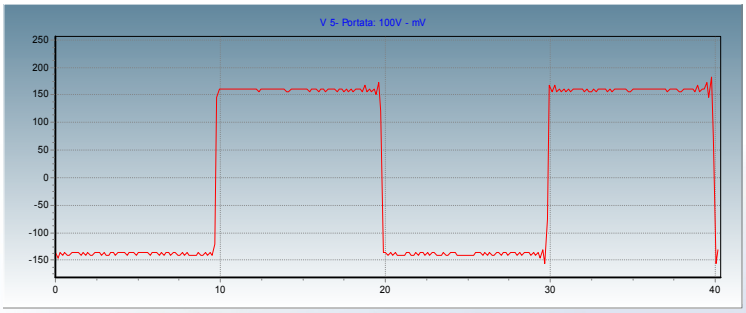
The chart on the left shows a voltage sinusoidal signal with amplitude 100mV$_{rms}$ (282mV$_{pp}$) acquired by a 200V$_{rms}$ (564V$_{pp}$) full-scale voltage channel.



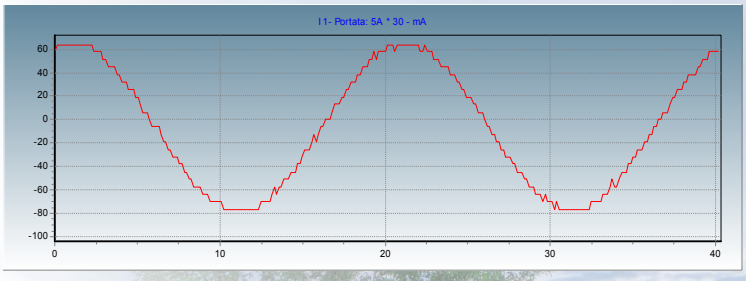
The chart on the left shows a voltage sinusoidal signal with amplitude 100mV$_{rms}$ (282mV$_{pp}$) acquired by a 700V$_{rms}$ (1974V$_{pp}$) full-scale voltage channel.

You can see here that the channel is noise-free: the only noise being quantization (± ½ LSB), which is intrinsic in analog to digital conversions.

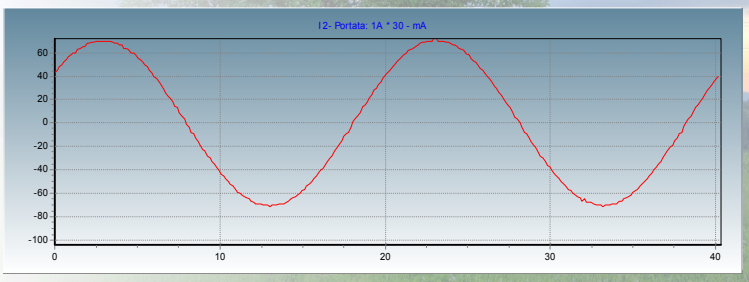
LSB = 1974V/2^{16} = 30mV
Noise = ± 15mV



The chart on the left shows a square waveform with amplitude 100mV$_{rms}$ (282mV$_{pp}$) acquired by a 100V$_{rms}$ (282V$_{pp}$) full-scale voltage channel.



The chart on the left shows a current sinusoidal signal with amplitude 50mA$_{rms}$ (141 mA$_{pp}$) acquired by a 150A$_{rms}$ (I_{MAX}=424A$_{pp}$) full-scale current channel.

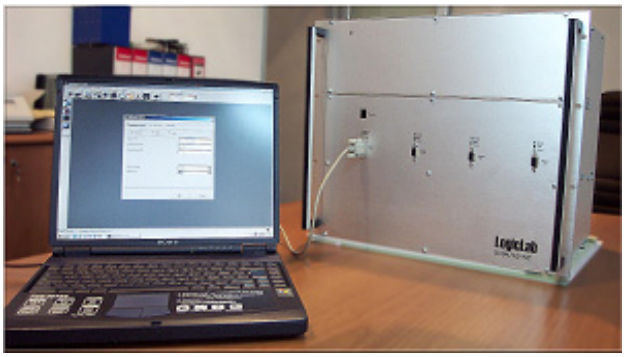


The chart on the left shows a current sinusoidal signal with amplitude 50mA$_{rms}$ (141 mA$_{pp}$) acquired by a 30A$_{rms}$ (I_{MAX}=84A$_{pp}$) full-scale current channel.

Digital Fault Recorder FR947

SpyFR947: Local and remote management

SpyFR947



LogicLab PC software SpyFR947, is provided with FR947 to perform setting and analysis functions:

- Communication settings;
- Access with user name and password;
- Analog inputs configuration;
- Digital inputs configuration;
- Device parameterization;
- Real-Time visualization of digital inputs;
- Real-Time visualization of analog waveform;
- Real-Time spectrum analysis of analog input;
- Real-Time measures;
- Measure waveforms;
- Manual trigger for DFR and CSR;
- Events setup and analysis;
- Self diagnostic;
- Recordings management;
- Off-line device configuration;
- Firmware upload.

Connection with the device can be done using RS232 or 10/100 Ethernet communication (UDP or TCP/IP). FR947 can configured as node on LAN/WAN network.

All analog inputs can be configured with a label for easy identification, full-scale for best fit the input to the signal that will be acquired, transformer ratio for visualization with value reported to the primary values.

All digital inputs can be configured with a label and acronym for easy identification, define a subsystem value to group different inputs and define if the inputs is active low or high.

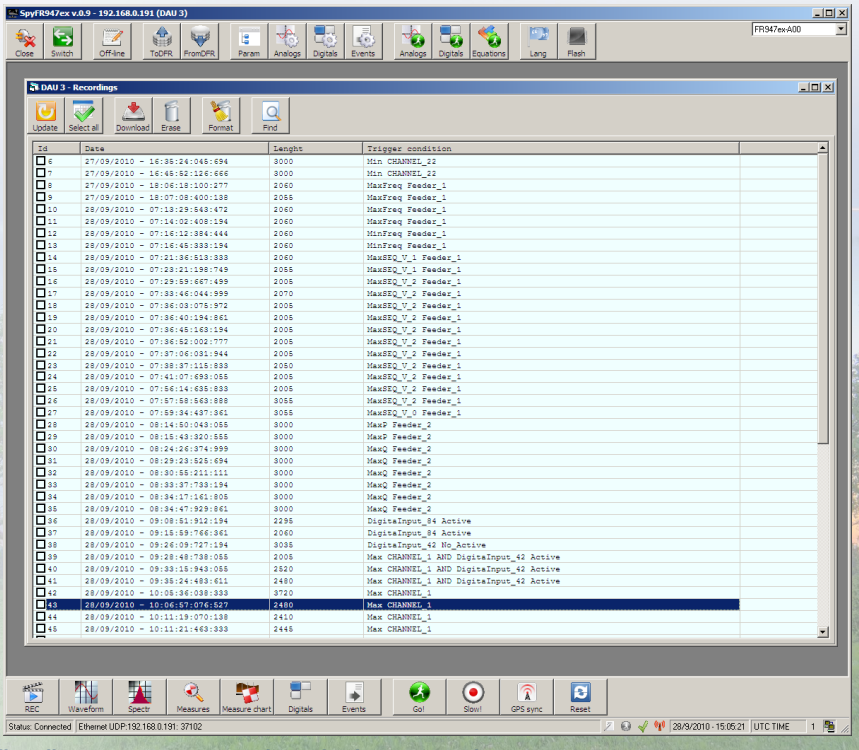
A powerful tool for recording management allow users to easy download, delete and search. Each recording is identified with an id, time and date of trigger, length, and trigger condition.

SpyFR947 is supplied with many tools for real time analysis. User can see in real time the waveform of the analog signals acquired by the device or their spectrum analysis. All measures performed by the device can be visualized both with numerical mode than in graphic mode to evaluate trend and system behavior.

FR947 is equipped with event recorder. It can be fully configured and a tool allow user to perform easy visualization, search and statistics.

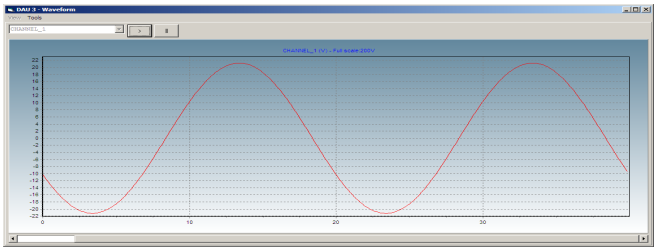
SpyFR947 allow user to perform manual trigger for DFR and CSR, force CPS synchronization, device reset, firmware upgrade, configuration file upload and download.

On the lower side of the window, a status bar inform user about communication status, device and recording status, date and time with synchronization status.

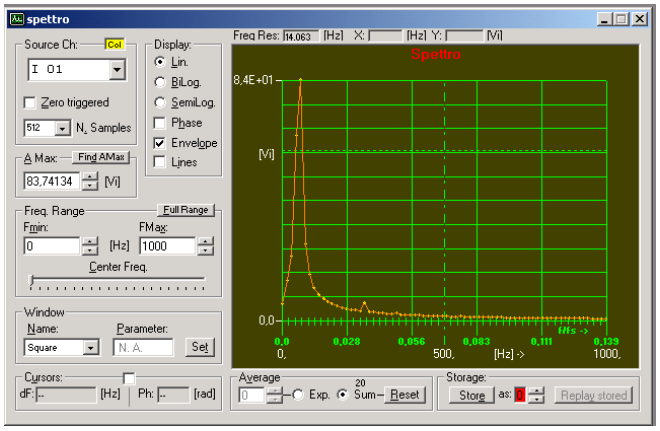


Digital Fault Recorder FR947

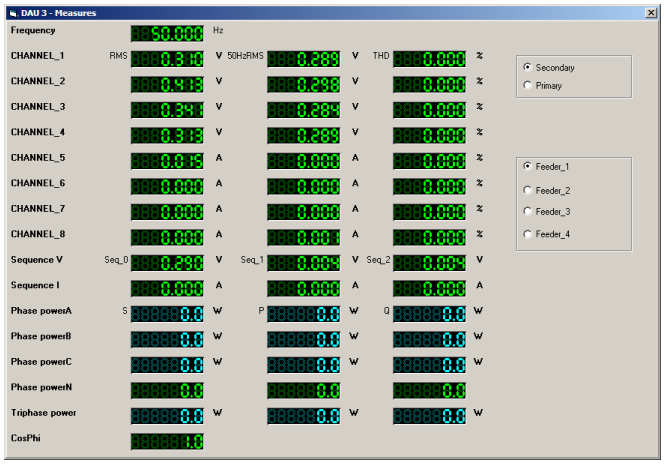
Exploring SpyFR947 in pictures



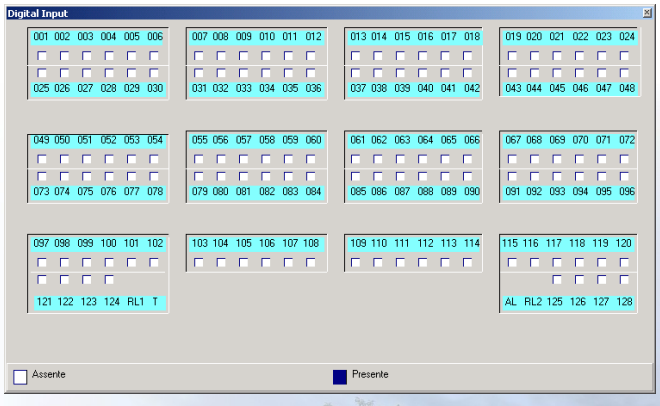
The image shows a Real-Time window for analog input visualization through a remote connection access to FR947. This valuable tool allows users to show the input signals at any time.



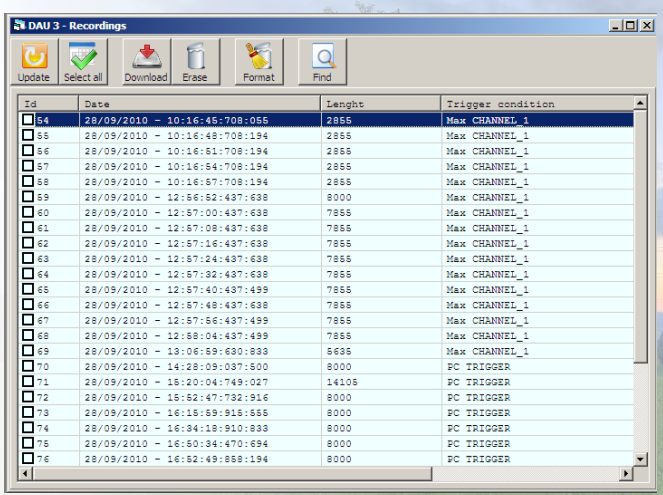
User can run the Real-Time spectrum analysis of an analog signal. With this tool, with many features, user can verify the presence of harmonics in real time.



Real-Time measures window provides an indispensable tool for monitoring the substation.



Real-Time digital inputs window provides a useful tool during maintenance. To help the operator, the window replies the physical layout of the device backside.



This is the recordings management window. Each recording is identified by a number, date and time of fault event (ms accuracy), duration and trigger condition. The recording can be downloaded and deleted by selecting only the records of interest, or acting on all records in memory. With search tool, the user can easily find the recording of interest within all recordings saved.

Digital Fault Recorder FR947

LogOscillo: the analysis software powerful and easy to use

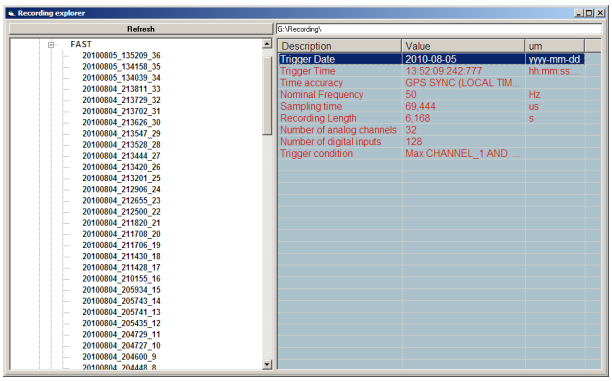
LogOscillo

LogOscillo is the LogicLab software for DFR and CSR recording analysis. Software is supplied with the device and with SpyFR947.

Each DFR recording collects all digital and analog inputs. User can choose which signal must be showed and the color of the related waveform.

Some screens filter make this selection easy and immediate. User can choose only channels that meet certain conditions (signals above a threshold, current inputs , voltage inputs, etc.).
On each analog signal user can perform many operations to get a deeper analysis of the waveform. Using the right mouse button, user can obtain RMS value, real RMS value, THD and spectral analysis. User can see the RMS value and fundamental RMS as a waveform overlapped to the signal selected.
To help users in recording analysis, in addition to the features explained above, many tools are included in LogOscillo:

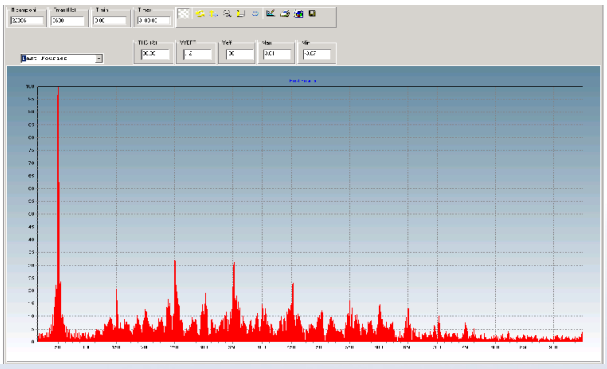
- Recording explorer
- Vertical and horizontal zoom;
- Window zoom;
- Waveform overlapping;
- Time cursors;
- Punctual amplitude and time value
- Amplitude and time value at cursor position;
- Zero crossing function;
- Maximum and minimum search;
- Decimation;
- Phase analysis with symmetrical components
- Waveform export (jpg, pdf, Comtrade);
- Waveform printing.

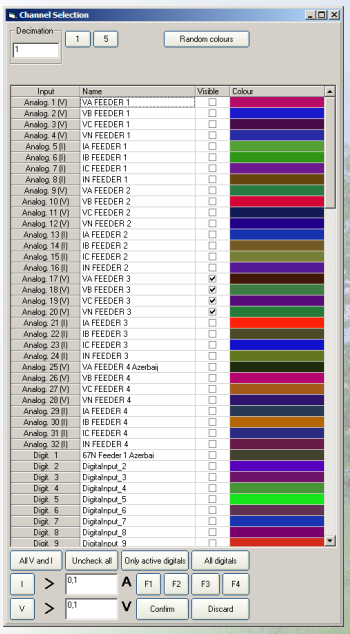


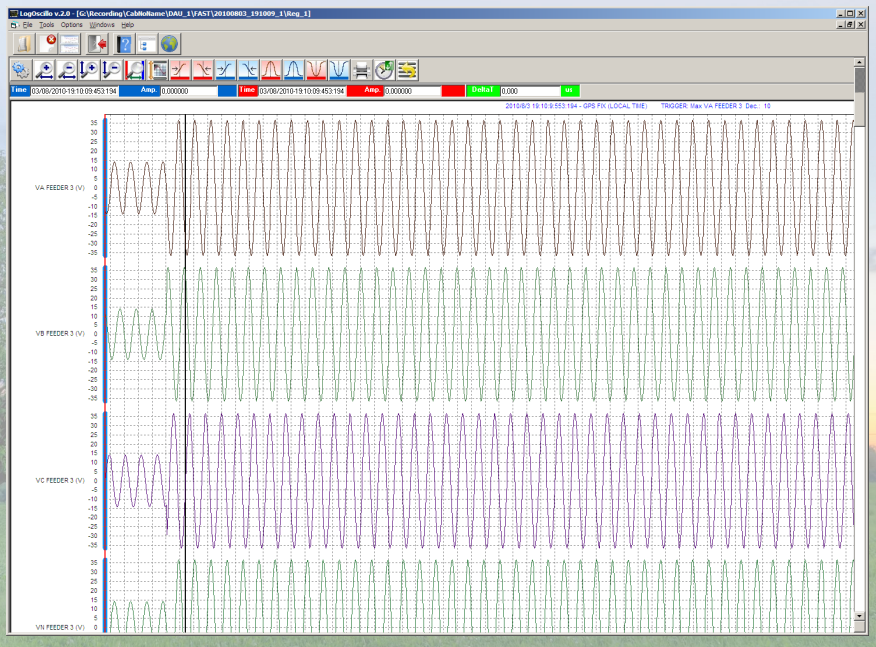
An helpful feature allow user to link different recordings in time. Software automatic adjust time axes for multiple analysis. Time cursor will be moved together over all recordings time linked. This feature helps users to make analysis of recordings downloaded from different device with occurrence of triggers at the same time that can be comparable.

This feature permits to LogicLab to supply complex system with multi device to satisfy customers with high demands of analog and digital inputs. Each FR947 can be configured to send an ethernet message for triggering another devices.

In the same way, this feature allow users to perform analysis in distributed system equipped with LogicLab devices.





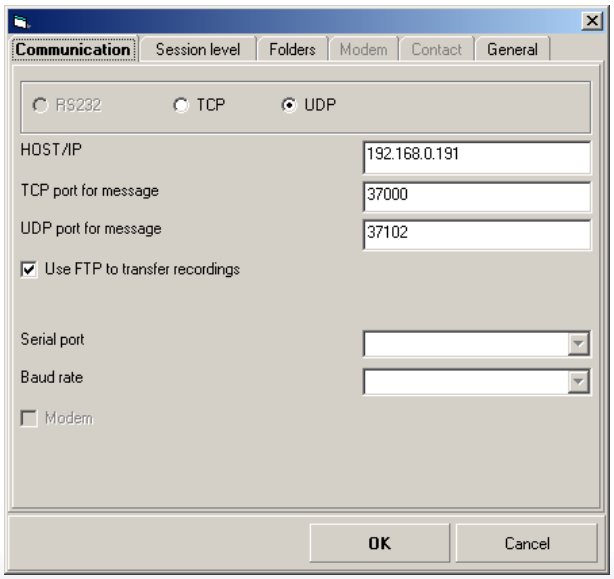


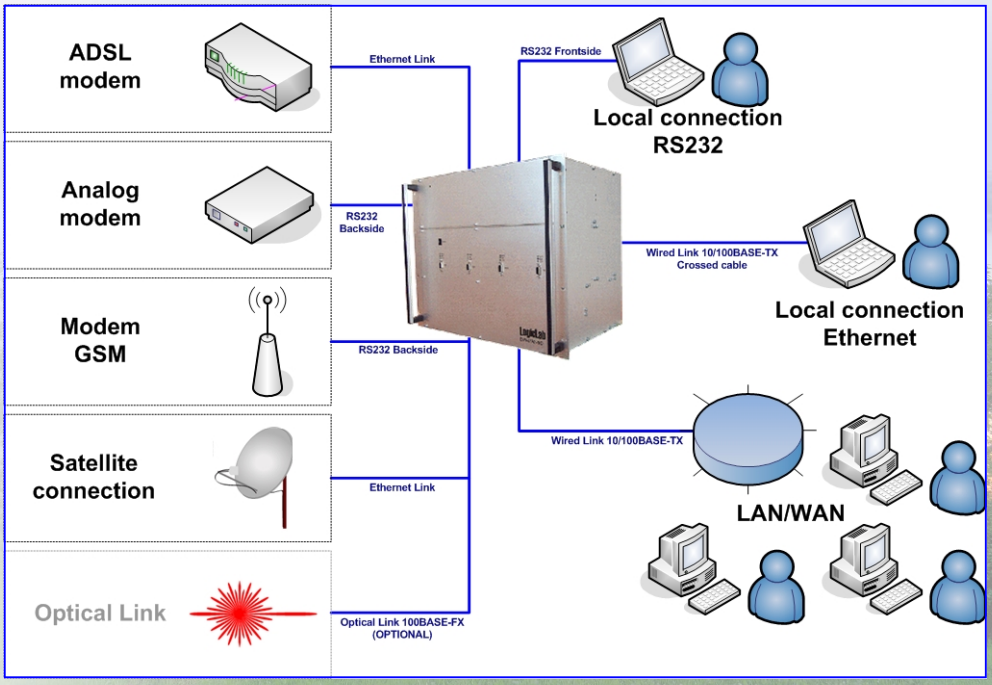
Digital Fault Recorder FR947

All local and remote connections that you need

Communication

FR947 is designed to interface with modern communication technologies and it meet all the requirements for monitoring and remote management.
With a front serial port, ethernet port and a rear serial port used for communication, FR947 can be connected locally or remotely. The communication ports, both front serial and ethernet, are isolated (Ethernet: 1500Vrms - RS232: 2500Vrms), ideal for applications with high safety standards. The rear serial port provide hardware flow control for modem communication.
Through the rear serial port is possible to connect an analog dial-up modem or GSM modem, which allows remote connection.
Ethernet 10/100BASE-TX compliant to IEEE 802.3 port is available on front.
With cross-over cable, user can establish an ethernet direct connection to FR947 with a PC without using additional network device (Hub or switch).
On client demand, FR947 can be equipped with an optional board that integrate multiple ethernet port with 100BASE-FX (fiber optic) capability.
FR947 can be configured as a node of a LAN/WAN network using TCP-IP or UDP transmission protocols. Once assigned the IP address and networked, any PC on the LAN can access the device using SpyFR947. The Ethernet port can be used to connect an ADSL modem or a satellite modem where standard connections are not available. Through these communication means, user can establish a remote connection quickly. It is also possible to create a VPN (Virtual Private Network).
With the VPN, remote device will be seen as directly connected to the LAN network.
For the operator working in the control center, FR947-EX will be appear as on his desktop and use the remote device as if it were local.
The connection allows user to remotely make any operation without limitation with all RealTime analysis tools that are available on SpyFR947. In addition, with the automatic download feature, user can use a common remote PC for storage data information.
By any communication ports, the connection with FR947-EX is always direct and automatic with no need for intermediate devices such as PCs or industrial units.





Digital Fault Recorder FR947

Power, accuracy and reliability at an affordable price

Hardware Technical data

Power supply
Power supply voltage: 110V DC ± 20%
Nominal power: 40W
AC version available on client demand
Different power supply voltage available on client demand

Dimensions and environmental specification
Height / Width / Depth: up to 9U / 19" / 31cm
Temperature range: -10 ÷ 55 ºC
Temperature range (Absolute maximum rating): -15 ÷ 70 ºC
Storage temperature: -40 ÷ 85 ºC
Relative Humidity: ≤ 95 %
Atmospheric pressure: 70 ÷ 106 kPa

Analog inputs *noise-free* isolated input
Dielectric strength: 3000V DC (1 min - 100% tested)
Sample rate: 14,4 KHz
Bandwidth (-3 dB): DC (0 Hz) ÷ 3,5 KHz
Flat bandwidth(±0,005 dB): DC (0 Hz) ÷ 3,25 KHz
Stop band attenuation: >100 dB
Different configuration of current/voltage analog input
Available options: 32V, 28V+4I, 24V+8I, 20V+12I, 16V+16I, 12V+20I, 8V+24I, 4V+28I, 32I
Under-equipped configuration for cost-saving solution

Current analog inputs
Rated current (I_n): $1A_{rms}$ / $5A_{rms}$
Full-scale range: 50 A_{rms} / 150 A_{rms} / 300 A_{rms}
Accuracy guaranteed range: $0,01 \cdot I_n \div 30 \cdot I_n$
Rated current setup by software command
Accuracy: <0,1% ± 1 mA
Permanent overload: 40A
Maximum overload: 300 A (1 second)
Input impedance: 1,5 mohm (purely resistive)
Power dissipation (1A): 0,005 VA @ I_n
Power dissipation (5A): 0,05 mVA @ I_n
Resolution (ENOB): 16 bit *noise-free*
SNR (Signal to noise ratio): 92 dB
Cross-over: < -92 dB

Voltage analog inputs
Full-scale range: $100V_{rms}$ / $200V_{rms}$ / $700V_{rms}$
Accuracy guaranteed range:
$14mV_{rms} \div 100V_{rms}$ @ $P_n=100V_{rms}$
$28mV_{rms} \div 200V_{rms}$ @ $P_n=200V_{rms}$
$0,1V_{rms} \div 700V_{rms}$ @ $P_n=700V_{rms}$
Rated voltage setup by software command
Accuracy: <0,1% ± 5 mV
Input impedance: 1 Mohm (purely resistive)
Power dissipation: 0,5 VA @ 400V
Resolution (ENOB): 16 bit *noise-free*
SNR (Signal to noise ratio): 92 dB
Cross-over: <-86 dB

Digital input 128 isolated input
Dielectric strength 3000V DC (1 min - 100% tested)
Threshold (min): 18V
Maximum voltage (max): 150V
Time resolution: 1 ms

Communication
Ethernet 10/100 BASE-TX
Configurable as knot of a net LAN/WAN
1 RS232 front side (19.200 baud fixed)
1 RS232 back side (up to 115.200 baud)
Remote connection with analog modem (not included)
Isolated communication port
(Ethernet: 1500Vrms – Serials: 2500 Vrms)
GPS satellite connection
HMI with display and keypad (optional)
IRIG-B synchronization (optional)

Signal outputs
Out of order relay
Recording in progress relay
-20mA/20mA current output with configurable range (optional)
Additional alarms with relay outputs (optional)

Elaboration
Multiprocessor architecture with 32 bit CPUs
Real Time Operating System RTEMS
32 MByte Flash memory
128 Mbyte DRAM
RTC with GPS synchronization

FR947 system
FR947 system with single or multiple device
42HE IP55 rack complete of cabling and terminal blocks
Rack accessories: power switch, fan, internal light
High performance Industrial Panel PC with SSD (Solid State Disk)
17" Touch screen Panel PC
Ethernet equipments
Printer

Standards and specifications compliance
IEC 61000 – 4 – 2 (Level 3)
IEC 61000 – 4 – 3 (Level 3)
IEC 61000 – 4 – 4 (Level 3)
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 – 29 (Level 3)
ENEL DV1047A2-NC
ENEL REMC01
ENEL REMC02
ENEL RMEC01
ENEL RCLI01
CEI 45-5
CEI 70-1 IP30 (front) IP20 (case)
COMTRADE standard IEEE Std C37.111-1991

Digital Fault Recorder FR947

Power, accuracy and reliability at an affordable price

Recording and Software Technical data

Fault Recording (DFR)

Recording on removable integrated flash memory
Automatic download to Personal Computer
Flash memory space available up to 250s recordings.
Three timer user selectable
- Pre-trigger time: 50 ms ÷ 5 s (10s on client demand)
- Fault time: 100 ms ÷ 60 s
- Post fault time: 50 ms ÷ 5 s

Retriggering during recording time available
Recording timeout (max): 150 s
Trigger on analog threshold of (max, min, rate)
- RMS (max, min, rate)
- Fundamental RMS (max, min,rate)
- Positive, negative and zero sequence ($I_{1,2,0}$,$U_{1,2,0}$)(max, min)
- Power and energy: P, Q (max, min)
- Frequency (max, min, rate)
- THD (max)

Trigger on digital edge (falling, rising, both)
Software trigger
Events timestamp
Data saved (data packet):
- ($I_{L,N}$,$U_{L,N}$) samples of all 32 channels inputs
- Digital input state of all 128 channel inputs

Continuous Slow Recording (CFR)

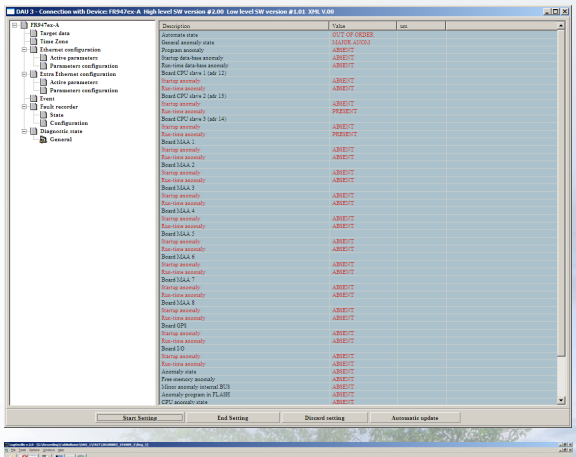
Recording on Personal Computer
Data pack rate: 100 ms ÷ 10 s
Trigger for continuous slow recording
- With DFR recording trigger
- Software (start and stop)
- Scheduled data and time (start and stop)

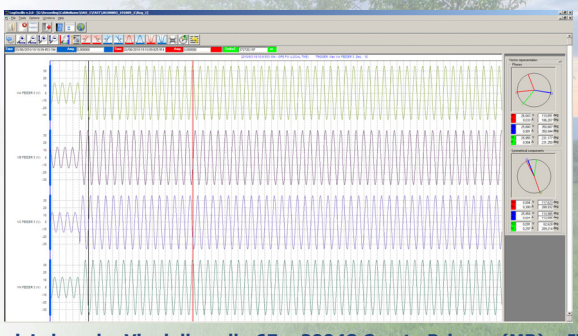
For trigger with DFR recording two timer user selectable
- Pre-trigger time: 0 s ÷ 3600 s
- Fault time: 1 s ÷ 3600 s

Data saved (data packet):
- RMS of all 32 channels inputs
- Fundamental RMS of all 32 channels inputs
- THD of all 32 channels inputs
- Frequency
- Power (S, P e Q)
- cosφ
- Positive, negative and zero sequence ($I_{1,2,0}$,$U_{1,2,0}$)
- Imbalance

Sequence event recording (SER)

128 Digital inputs event source
Time resolution: 1ms
Time precision: 1µs
200.000 events buffer on solid state disk
Enable on each input
Input description label
Programmable Off State description label
Programmable On State description label





Parameterization and device management software SpyFR947

Communication interface selection (RS232, UDP, TCP, modem setup)
Access with user name and password
Define up to 20 different users
Five security level access (Administrator, Expert user, Base user, restricted access, Guest)
Software access configuration and folder management
Analog inputs insertion definition
Analog inputs setup (label, full-scale, transformer ratio)
Digital inputs setup (label, acronym, active low/high)
Events setup (id, enable, enable store/send/print/, state labels)
Analog trigger setup (max, min, rate on RMS, fundamental RMS and max THD)
Calculated trigger setup (max, min on positive, negative and zero sequence, active and reactive power, frequency)
Digital trigger setup (falling, rising and both edge)
Equation trigger setup
Device labelling
Time zone correction
Full TCP/IP Ethernet configuration parameters
Backside RS232 throughput configuration
Event parameterization
Fault recording monitor (enabling, recording status, memory available)
Recording time setup (Pre-trigger time, fault time, post-fault time)
Memory configuration setup (circular buffer or full-fill buffer)
Recording extension setup (disable, on fault time, on post-fault time)
Self-diagnostic device state
Remote reset device
DFR recording trigger
CSR recording trigger wizard
Force GPS synchronization
Analog waveform real-time view tool
Spectrum real-time analysis tool
Analog measure real-time view tool (Frequency; RMS; Fundamental RMS; THD; positive, negative and zero sequences; Power P, Q, S; Cosφ)
Analog measure waveform real-time view tool
Waveform and measure can be reported to primary side of transformers
Digital inputs real-time view tool
Firmware update wizard
Recordings management with search and statistics tool
Events management with search and statistics tool
Device parameterization file management tools (off-line editing, download file, upload file)
Status bar with connection status, time and data, GPS link, device status, recording and event status, communication activity.

Recordings analysis software LogOscillo

Waveform selection wizard with colours assignment
Automatic selection filters for analog and digital inputs
Decimation value for waveform preview
Auto-decimation for best performance/details ratio
Absolute and complete date/time visualization on time axes
Recording explorer with summary display for each recording
Double time cursor
Time and amplitude value in time cursor position with time interval
Time and amplitude value in mouse cursor position
Window zoom tool (zoom between cursor)
Horizontal and Vertical zoom tool
Drag-and-Drop capability for waveform overlapping
Restore default visualization
Zero crossing search tool
Max/Min search tool
Amplitude normalization for graphical comparison
Signal processing for RMS waveform visualization
Signal processing for fundamental RMS waveform visualization
Signal processing for THD waveform visualization
Signal processing for spectrum visualization
Spectrum analysis with THD
Phase analysis with vector representation of three phase system complete with symmetrical components
Waveform export tool for image (JPG, BMP, MetaFile, PCX, PostScript, SVG)
Waveform export tool for Acrobat Reader (pdf)
Samples waveform export tool for Excel
ComTrade waveform import/export (ASCII/Binary, rel. 1.0 or 2.0)
Waveform print management
Time link capability, useful for simultaneous time analysis with different recording

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