

FTR-100 Fault Transient Recording System User Manual

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Safety Instructions

Safety Note: This user manual is the basic commissioning and on-site operation guide for the FTR-100 Fault Transient Recording System. All operators of the FTR-100 should read the contents of this manual in advance. The manufacturer of this product is not responsible for any loss caused by the operator's failure to comply with the operating procedures of this manual or for violation of the safe working procedures of the operator.

Meaning of the
manual symbolsImportant instructions concerning personal safety, operating procedures,
technical safety, etc., are marked with the following symbols:

Symbol	Meaning
A	Indicates a potential hazard that could result in serious or fatal injury
	Indicates a potential hazard which, if not avoided, may result in minor personal injury or property damage.
Í	Indicates that it contains important information and useful guidance for using this product. Failure to heed this information may result in the test not functioning properly.
÷Č;÷	Indicates that this is a useful guideline based on field practice.

Use of accessories:	Please be sure to use Kehui's spare parts to ensure the safe and reliable use of this instrument. Using accessories made by other companies will make any warranty null and void.
Repair and maintenance:	This instrument must be repaired and maintained by Kehui or an agent authorised by Kehui. If you have any questions concerning the product and its operation, please contact the company at info@kehui.com.
Terminology	Throughout the document, the word Earth has been used, this term is considered synonymous with Ground and is used as the electrical reference point.

1. General

The FTR power system fault transient recorder automatically and accurately records the electrical quantities on a system when it is triggered by an event such as a fault. Through analysis of the waveforms and the events, the correctness of the system's response, particularly the protection operation, can be verified. This provides information to improve the safe and reliable operation of the power system. Information provided by a single intelligent electronic device (IED), will only give information which is limited to the section of the system it is protecting. However, the transient fault recorder automatically records the complete event, showing variations in the electrical quantities when a fault or a disturbance occurs and the operation of all elements of the protection system.

The requirements for power system automation and supply quality continue to evolve and the introduction of optical transducers and intelligent switchgear, on-line monitoring of generators, transformers, transmission lines and circuit breakers have led to the power system becoming increasing sophisticated. Using Ethernet technology, the information transfer within the substation is becoming more network-based, so that the equipment required to capture information in the substation must be capable of working under the framework of IEC 61850.

The FTR-100 power system fault transient recorder is applicable to both conventional and digital substations. It supports the IEC 61850 standard, both for the process bus and the station bus. The recorder provides transient, steady state and continuous recording for primary equipment. For conventional substations, it can monitor AC/DC analogue quantities and digital status information through its associated interface unit (RAU) which converts them in to Goose and sampled value (SV) signals and communicates with the central unit via optical fibres. This allows them to be situated in convenient places which may be some distance away from the FTR. When used with digital systems, the FTR monitors, captures and records Sample Values (SV) and GOOSE messages on the process bus, and communicates using MMS messages on the station bus. The integrity of the messages is checked for abnormalities and error-reporting is performed. Through SV and GOOSE messages, it provides



2. FTR-100 Functionality and Technical Data

2.1 Description

2.1.1 Application

The FTR-100 power system transient fault recorder is applicable to conventional and digital substations. It supports IEC61850 standard, both for the process bus and the station bus. In a conventional substation, the recorder performs transient, steady state and continuous recording of the AC/DC analogue quantities and digital status from the primary equipment using up to three external interface units (RAU). In a digital substation, it monitors, captures and records Sample Values (SV) and GOOSE messages on the process bus, and communicates using MMS messages on the station bus. It checks the integrity of the messages for abnormality and perform error-reporting. Through SV and GOOSE messages, it provides monitoring of the analogue quantities and circuit breaker status information within the substation.

FTR-100 can monitor two or more 3-phase power systems simultaneously, even if they are not synchronous to each other, The FTR-100 uses the 3-phase voltages at a busbar to track the power system frequency. If the two three-phase systems are set up separately at two busbars independent from each other, the FTR-100 can monitor both of them

2.1.2 FTR-100 Design architecture

FTR-100 has a modular design architecture, using powerful embedded processors as the core to handle various real-time functions. It consists of the central control system (CSS), a data sampling unit (DSU) and a back stage local analysis system (LAS), see Figure 2.1.3-1. External remote data acquisition units (RAUs) are used to sample analogue quantities and digital status. The RAUs provide the interface to the primary equipment in a conventional substation.

2.1.3 Input signals

The device captures and records SV and GOOSE messages from the process bus of the digital substation. It checks for data abnormality and provides recording of such events. The size of the input data is as follows:

- Numerical data input: maximum 32 SV control blocks, 64 GOOSE Control blocks
- Analogue data input: Maximum 160 analogue input signals (including AC Voltages and currents, DC Voltages), maximum 576 digital status inputs
- Numerical and analogue data inputs can be mixed.



Local Analysis Station (LAS)

Figure 2.1.3-1 FTR-100 Topology Block diagram

2.2 Advanced Design

The device uses a distributed and modular design architecture. Efficient Linux real-time multitasking operating system

2.2.1 High Speed PCI Express Bus (PCI-e)

The core central control system (CCS) uses an advanced COM-Express embedded CPU module, provides the FTR-100 with an ideal solution for embedded application. Powerful FPGA technology is used for the front-end processor increasing the speed, reliability and stability of the device. Inter-processor communication is through the high-speed serial computer expansion bus standard PCI-e (Peripheral Component Interconnect Express), which provides high bandwidth point-to-point data transfer, supports active state power management, error reporting, reliable communications and quality of service. The design satisfies a digital substation's high-speed data through-put requirements

2.2.2 Operating System

The FTR-100 uses an embedded 64-bit Linux operating system, which improves the safety and reliability of the equipment. The Linux real-time multi-tasking system splits the software into several processes, which makes software development and maintenance easier and more secure. The rich network communication resources available with Linux, also make the communication of the FTR-100 with other work stations more efficient.

2.2.3 Mass Storage plus Server Level Communications

The network server IC, provides the FTR-100 with two optical and two electrical GHz Ethernet ports. It supports MMS and file service, supports station bus IEEE1588 time synchronisation, provides a maximum of two 2.5-inch hard disc and supports TByte data storage capacity. Substantial data storage for network messages and disturbance records results, ensuring integrity of the recording data.

2.2.4 Proprietary Database Engine

The FTR-100 supports sample data compression during storage, with sample data timing accuracy up to 60ns. Sample data is managed by a proprietary database engine, which controls storage of the hard disk directly. This avoids filing system control, thus increasing the storage efficiency.

2.3 Technical Data

- Recording and Monitoring

The FTR is capable of connecting with 3 RAU units. Each RAU can accommodate 32 analogue channels allowing the system to measure 96 analogue channels. On digital systems the FTR can accommodate up to 32 merging units, 64 GOOSE control blocks,

MMS messaging capable of connecting up to 512 IP addresses

SV continuous recording

No less than 24 hours

- Continuous recording of GOOSE and MMS messages

No less than 14 days

Types of message recording

MMS – Manufacturing Message Specification

SV – Sampled Values (IEC 61850-9-2)

GOOSE - Generic Object-Oriented Substation Event (IEC 61850),

PTP – Precision Time Protocol

Time tag resolution

Message received timing resolution 60ns

Real-time clock accuracy

Clock synchronisation resolution <±1us

Real-time clock accuracy <±50ms/24h

Time synchronisation method

The system supports an IRIG-B, optical signal and DC signal from an external clock source.

Sampling rate

DFR (Disturbance Fault Recording) : 4K/10K

CFS (Continuous fast Speed) recording: 1KHz.

CSS (Continuous slow speed) recording: 50Hz.

- Trigger method

Standard trigger method: threshold value, change value and window threshold, applicable to RMS values of voltages and currents.

Calculated value trigger method: threshold value, change value, window threshold, applicable to harmonics, phase angles, single phase P & Q, 3-phase P & Q, sequence components, power factor

Standard analogue value accuracy

0.5%, using 16-bit A/D converter

Standard digital input timing resolution

0.1ms

- Recording methods
 - i. DFR (Disturbance Fault recording)

Pre-fault trigger Time (A period): 100ms – 500ms

Post fault trigger time (B period): 1s to 10s. If a new trigger occurs within the B period, an additional B period is added. This is repeatable until the time limit is reached.

Record Time limit: Greater than twice the A and B period combined. The recording will stop at the record time limit under repeated trigger conditions.

ii. CSS - Continuous Slow Speed recording

The FTR100 continuously records the selected analogue values and the calculated values such as frequency, harmonics. sequence components, power, angle etc. The sampling rate is 50Hz

iii. CFS – Continuous Fast Speed recording

The functionality is the same as the CSS except that the sampling frequency is 1kHz.

File transfer format

Conforms to IEC61850 standard for information exchange in the power system

Storage capacity

>2000M Bytes

- Hard disc capacity

>2000GB (2TB)

- Communication method

RJ45 with 100M/1000M Ethernet

- Contact Rating

Resistive load (cosφ = 1); 5A @250VAC, 5A @ 30VDC, 1,250VA

Inductive load (cosφ = 0.4, L/R = 7ms); 1.5A @250VAC, 1.5A @ 30VDC, 375VA, 80W

- Power supply

AC: 85V - 264V DC: 88V - 264V

- Dimensions

800mm x 600mm x 2260mm(2360mm)

2.4 Model number definition

FTR - 100 – XX - X

Ι	Ι	Ι	۱	Designation
I	Ι	۱		Input signal type
I				Model number: 100
۱				Fault Transient Recorder

2.5 Models available

FTR-100-G:	Analogue Input Fault Transient Recorder
FTR-100-DA-G:	Numerical Input Fault Transient Recorder
FTR-100-DG-G:	Hybrid Input Fault Transient Recorder

3. FTR-100 Front Panel Functions

3.1 FTR-100 Front panel





FTR-100 front panel consists of an LCD display, LED indications and a rotary switch for functional selection. It can be used to examine the IP address setting, the date and time information, and to do a manual trigger.

3.2 Front panel functions

The rotary switch/push button adjacent to the LCD selects the required display function

3.2.1 LCD: date, time and IRIG B synchronisation

When the FTR is energised, the front panel LCD interface shows the date and the time. The "X" in the lower left corner indicates that the IRIG-B signal for clock-synchronisation is not available. The LCD defaults to the date and time display after 5 seconds of inactivity.



When the correct IRIG-B signal is connected, the "X" in the lower left corner changes to "b".



When the IRIG-B clock source is stable after approximately 5 minutes, the "b" in the lower left corner changes to "B".



3.2.2 LCD: Firmware and cyclic redundancy check (CRC) code

Pressing the rotary switch once, causes the firmware version number and a CRC code to appear on the LCD.



3.2.3 Ethernet port IP addresses

Rotate the switch clockwise, the LCD shows the IP addresses of the three Ethernet ports in FTR-100.

eth0 eth1	- 100 160 06 11	Δ
eth1 eth2		

3.2.4 Manual trigger

Rotating the switch further clockwise, results in "MANUAL TRIGGER" appearing on the LCD. At this point, press the switch for the recorder to start a manual trigger operation. Rotating the switch clockwise again, will return the screen to the IP addresses. This and the "MANUAL TRIGGER" screen will appear alternately as the switch is rotated.



3.2.5 LED status indication

The LEDs from left to right read as follows:

- RUN (Green): This is On when the unit is energised and is operational
- ALARM (Red): On provides a warning that a self-checking procedure has failed This means:
 - i. The communications with the RAU through the optical fibre is not available. In this case, the failure will also be logged in the ReplayD software's "Real-time events"
 - ii. The main processor of FTR-100 is not working normally.
- REC. (Green): When this is On, the unit is recording,
- SYNC. (Green): This LED is On when the unit is correctly time-synchronised

4. FTR-100 INPUT CONNECTIONS

4.1 SV, GOOSE and RAU input connections



Figure 4.1-1 Data Sampling Module

The data sampling unit can accommodate a maximum of 4 data sampling modules, each module consists of 8 x 100MHz Ethernet ports and 2 x GHz ethernet ports. The details of each data sampling module are as follows:

- 1. 8 x 100MHz SFP (Small Form-factor Pluggable) optical transceivers, applicable for IEC 61850 9-2, GOOSE and data from the RAU analogue input unit, representing the raw signals
- 2. 2 x 1GHz SFP optical transceivers, applicable for IEC 61850 9-2 and GOOSE. They are also applicable for multiple merging units amalgamated through routers to provide large amounts of data.

5. FTR-100 Backplane functions



FTR-100 backplane arrangement is as shown in Figure 5-1.

Figure 5-1 FTR-100 Backplane

The key modules are: hard disk module (HDD). CPU card (SYSTEM), data sampling cards (INPUT), alarm card (ALARM) and power supply module (POWER)

5.1 FTR-100 backplane functions

CPU card

- 1) Two optical and two electrical GHz Ethernet ports, support MMS model service and file service
- 2) Two USB ports, for USB mouse or memory stick

Data Sampling card(s):

8 x 100MHz, 2 x GHz Ethernet ports, suitable for sampling IEC61850 9-2 and GOOSE messages

Alarm card:

4 alarm outputs: (1) trigger alarm, (2) device failure alarm (3) reserved, (4) loss of power alarm.

6. RAU functions and backplane

Up to three RAU units (figure 3-3) are supported, providing analogue inputs to the FTR system.





6.1 RAU Functions

The RAU (Remote Acquisition Unit) samples the analogue input signals and digital status and converts them into data. The data is transmitted serially through optical fibres to the main data sampling module in the FTR.

The digital circuitry of the RAU is configured as a finite state device. When receiving a trigger, it executes all the sampling required and then stop and wait for the next trigger. It is designed such that it will still be capable of sampling all the inputs under the worst timing scenario,.

The data sampling unit is isolated from the RAU through optical fibres, which ensure that the core processing units are not affected by noise and disturbances from the external environment.

6.2 RAU backplane

The RAU is housed in a 4U case. The backplane is as shown in Figure 6.2-1.



Figure 6.2-1 RAU Backplane

From the backplane, terminal blocks TB5 to TB12 provide the analogue input channels CH01 to CH32.

The RAU backplane consists of TB1 - TB4 digital status input terminal blocks, TB5 - TB12 analogue input blocks, a pair of optical connections (TX and Rx), two indicators (Power and COMM) and the power supply switch.

In TB1 to TB4, each terminal block consists of 16 digital inputs and a common return. Figure 6.2- shows 64 digital inputs.

In TB5 to TB12, each terminal block consists of 4 analogue inputs. Figure 6.2- shows a total of 32 analogue inputs.

The optical fibre connections are used to connect to the data sampling unit.

The POWER indictor shows that the power is on and the COMM indicator shows that the optical fibre communications are working properly.

6.3 RAU connection diagrams

6.3.1 RAU Digital inputs

The digital inputs are grouped into groups of 16, accommodated by a terminal block with a common return.

Users can provide dry contacts to energise the inputs. The FTR-100 provides an internal 24V DC supply to drive the inputs.

Alternatively, users can select 110V DC or 220V DC as the source voltage.



Figure 6.3-1 Digital Input Arrangement

The detailed terminal arrangement is shown in figure 6.3-2

Signal processing and data analysis

To/from embedded system CPU



Figure 6.3-2(i): Data Acquisition Unit (RAU) digital arrangement



(RAU) digital arrangement (ii)



6.3.2 RAU terminals (Analogue and Digital) for the maximum three RAU units

Figure 6.3-3(i): Data Acquisition Unit (RAU unit 1) connection diagram



Figure 6.3-3(ii): Data Acquisition Unit (RAU unit 1) connection diagram



Figure 6.3-4(i): Data Acquisition Unit (RAU unit 2) connection diagram



Figure 6.3-4(ii): Data Acquisition Unit (RAU unit 2) connection diagram



Figure 6.3-5: Data Acquisition Unit (RAU unit 3) connection diagram - (i)



Figure 6.3-5(ii): Data Acquisition Unit (RAU unit 3) connection diagram

6.3.3 RAU input range jumper connection

To change the input range of the RAU, open the front panel of the RAU, 4 PCBs will be shown, each PCB consists of either 8 CTs or 8 VTs.



Figure 6.3-6 RAU input module PT/CT positioning

Numbers 01-32 are the jumpers corresponding to the analogue channels.



Figure 6.3-7 Analogue channel jumper connections

As shown in Figure 6.3-7 for PCB WH12-7501-01, each jumper lead has three positions; A, B and C, with D as the common return. Depending on whether this is a voltage channel or a current channel, the range selected by jumper positions A, B or C is as shown in Table 6.3.1.

The user should examine the jumper positions to ensure that the range is as expected.

Jumper Position	Voltage	Current
A	80V rms	-
В	130V rms	-
С	260V rms	20 (or 100) A rms

Table 6.3.1 Analogue Input Jumper Position

7. FTR Management System

7.1 Description

The FTR Management System is a powerful software package consisting of two software components: ReplayD and CmdView (COMTRADE Viewer), running under a Windows or Linux operating system. The software can be delivered as a Zip file.

It communicates with the FTR-100 to perform remote configuration and remote operation. It retrieves, processes, analyses and stores records from the FTR-100 and uploads and downloads its settings configuration files. It also performs real-time clock alignment and provides alarms, an events list and real-time monitoring.

7.2 Operating Environment

The software is compatible with Windows XP and above and Linux Mint 17.2 and above.

It runs on a Pentium 1GHz, 1G RAM, 320G hard disk or better PC environment.

Communication with the FTR-100 is through a high-speed Ethernet port using TCP/IP protocol.

7.3 FTR-100 connection to the Management System

7.3.1 Network Physical Connection

The PC communicates to the FTR-100 through one of the RJ45 port at the back of the CPU card.

7.3.2 Network Connection Testing

Step 1: Examine IP address of the FTR-100 through its front panel LCD display e.g., IP: 192.168.0.215

Step 2: set the PC's IP address to be within the same network segment as the FTR-100, for example, IP: 192.168.0.201, Subnet mask: 255.255.255.0, as shown in Figure 7.3.2-1.

Internet Protocol (TCP/IP) Prope	rties 🔹 🤶 🔀
General	
You can get IP settings assigned autor this capability. Otherwise, you need to a the appropriate IP settings.	
O Dbtain an IP address automatically	,
O Use the following IP address: —	
IP address:	192.168.0.201
S <u>u</u> bnet mask:	255 . 255 . 255 . 0
Default gateway:	192.168.0.120
O Dbtain DNS server address autom	atically
● Use the following DNS server add	resses:
Preferred DNS server:	202.103.24.68
<u>A</u> lternate DNS server:	
	Ad <u>v</u> anced
	OK Cancel

Figure 7.3.2-1 Setting up IP address at the PC

Step 3: at Windows <start> menu, type in a <cmd> command to open a DOS box. Execute <ping 192.168.0.,215> to check the Ethernet connection is operational.

🔤 C:\WINDOWS\system32\ping.exe	
Pinging 192.168.0.215 with 32 bytes of data:	
Reply from 192.168.0.215: bytes=32 time<1ms TTL=128	
Reply from 192.168.0.215: bytes=32 time<1ms TTL=128 Reply from 192.168.0.215: bytes=32 time<1ms TTL=128	

FIG.FTR01.C.0017.GIF



7.4 Install and run

The FTR Management system consists of two sets of applications software: ReplayD and CmdView. Figure 7.4-1 is the main window of the applications software ReplayD.

evice View	a 🛛 🥥 Monito	DFR	CFS/CSS	Man Trig	Version	Others				
	Mappin	g Configuration	Record	Monitor						
lame Descriptio	n FaultNo.	Filename			Trigger time		Cause			
HERTFORD	712	KEHUI_RCD_71	2 20171207	105537 930 S		0:55:37.930568	inst1:No fault BUS1 U	Over BUS1	UB:Over BUS1 UC:0	Over
- Carlondo	9711	KEHUI_RCD_71				0:55:32.970561	inst1:No fault BUS1_U/			_
ware ware	9710	KEHUI_RCD_71	0_20171207	105507_813_S	2017-12-07 10	0:55:07.813226	inst1:No fault BUS1_U/	Delta BUS1	_UA:Over BUS1_UB:0	Delta Bl
MILL STUDIO 192.168.26.	11 🔴 709	KEHUI_RCD_70	9_20171207	105454_701_S	2017-12-07 10	0:54:54.701307	inst1:No fault BUS1_U/	Delta BUS1	_UA:Under BUS1_UB	3:Delta i
	9708	KEHUI_RCD_70	8_20171207_	105414_254_S	2017-12-07 10	0:54:14.254051	inst1:No fault BUS1_U/	A:Delta BUS1	_UA:Over BUS1_UB:	Delta Bl
	😝 707	KEHUI_RCD_70	7_20171207_	105407_988_S	2017-12-07 10	0:54:07.988242	inst1:No fault BUS1_U	B:Delta BUS1	_UC:Delta BUS1_UC:	Over Bl
	06	KEHUI_RCD_70	6_20171207_	105401_990_S	2017-12-07 10	0:54:01.990434	inst1:No fault BUS1_U	B:Delta BUS1	_UC:Delta	
	05	KEHUI_RCD_70	5_20171207_	105345_404_S	2017-12-07 10	0:53:45.404011	inst1:No fault BUS1_U/	A:Delta BUS1	_UA:Under BUS1_UB	3:Delta I
	04	KEHUI_RCD_70	4_20171207_	105249_130_S	2017-12-07 10	0:52:49.130832	inst1:No fault BUS1_U/	A:Delta BUS1	_UA:Over BUS1_UA:U	Under E
	03	KEHUI_RCD_70	-		2017-12-07 10	0:52:22.228594	inst1:No fault BUS1_U			
	< 702	KEHUI RCD 70	2 20171207	105214 095 S	2017-12-07 10	0:52:14.095383	inst1:No fault BUS1 U/	uDelta BUS1	UA:Under BUS1 UB	l:Delta I >
	Fault/File	Filename			Trigger time		Cause			
	712/723	KEHUI_RCD_71	2_20171207_	105537_930_S	2017-12-07 10	0:55:37.930568	inst1:No fault BUS1_U	Over BUS1	_UB:Over BUS1_UC:0	Over
	711/721	KEHUI_RCD_71	1_20171207_	105532_970_S	2017-12-07 10	0:55:32.970561	inst1:No fault BUS1_U	Over BUS1	_UB:Over BUS1_UC:0	Over
	DFR	CFS/CSS								
utput										ņ
rigger time	trigger element			trigger ty	rpe trig	ger cause	search	restore	ilij event: record	d:
2@2017-12-7 10:51:48.819					🔵 Tim	neSyncLoss: <i>reset</i>				
1@2017-12-7 10:51:32.834					🔵 Tim	neSignalLoss: <i>reset</i>				
0@2017-12-7 10:51:31.881					😐 Tim	neSyncLoss: trigge	r			
0@2017-12-7 10:51:31.881					• Tim	neSignalLoss: <i>trigg</i>	er			
3@2017-12-7 10:48:43.763					 Tim 	neSyncLoss: <i>reset</i>				
7@2017-12-7 10:48:27.767					 Tim 	neSignalLoss: <i>reset</i>				

Figure 7.4-1 ReplayD software – main window interface

ReplayD software performs communications and allows the configuration of the FTR-100. It performs file transfers and displays disturbance records and also facilitates manual triggers, real-time clock alignments and real-time monitoring of measurements and events. For digital substations, it handles IEC 61850 SCD files. Connection of the PC to the FTR-100 is controlled by the <connect> icon highlighted in the main window interface.

CmdView is a general purpose COMTRADE viewer. It displays the COMTRADE records, and performs functions such as editing, merging, transforming, analysis and printing etc. The CmdView (COMTRADE Viewer) main window is shown in Figure 7.4-2.



Figure 7.4-2 CmdView (COMTRADE Viewer) main window

7.5 ReplayD Introduction

The ReplayD software consists of the following four main functions:

i) Channel mapping

This configure the SV and the GOOSE control blocks from the SCD file. It also configures the analogue and digital channels from the RAU, including channel naming and setting CT/VT ratios and overload conditions.

ii) Configuration - consisting of 5 sub-modules

Basic: Configures the fundamental settings for the transient records, including pre-fault and post fault duration (A period and B period), trigger threshold settings (overcurrent and under voltage), abnormal input threshold settings (e.g. dual A/D threshold trigger)

Analogue: Using tick boxes, this selects the analogue channels to be recorded and the trigger methods.

Digital: Using tick boxes, select the digital channels to be recorded and the trigger methods (i.e., Open and/or close states).

Elements: This define the elements within a substation (busbar, line, CB, transformer) with identities. These elements will be used for defining the subsequent calculated (or derived) values.

Calculated values: Consisting of sequence components, power (P, Q, S, Power Factor), frequency, harmonics, differential current etc. The measuring location for each "instance" of the calculated value is selected from the Elements sub-module already defined.

iii) Records - consisting of two types:

DFR Disturbance fault records - These are triggered recordings.

CSS/CFS Continuous Slow Sample and Continuous Fast Sample records - These are continuous recordings stored inside a 7-day rotating buffer.

iv) Monitor - consisting of 6 sub-modules

Waveform: Providing the real-time waveform of each analogue channel

Vector: Gives the real-time 3-phase vector information of voltages and currents, including sequence components

Power: Shows the real-time 3-phase and single-phase Watts, VARs and power factor

Harmonics: Displays the real-time harmonic contents of each channel

Flow status: Provides the data flow status (e.g., bytes/s) of the SV and GOOSE messages, including error statistics. It also gives the analogue calibration parameters for the RAU.

Original value: Indicates the real-time RMS values of voltages and currents plus their phase angles.

7.6 Add Substation and Device

In the <Device View> window, right click and select the <Add station> option. A folder will be created for the new substation. Select the folder and right-click, a pop-up window will appear. Select Properties and the resulting window allows the user to change the name of the substation. This is shown in Figure 7.6-1

File Edit Ope	erate Tool Security La							
Device View	Þ≡ ₽ ≣≣B				_			
	B	4 🔼	Monitor	DFR CFS/CSS	Man Trig	Version	Others	
🔁 🗔 🗔 🎤			Mapping	Configuration Record	Monitor			
Name	Description		FaultNo.	Filename		Trigger time	Cause	
Station_1 HERTFORD			l duitivo.	- nenome		ngger time		couse
KEHUI								
- D WARE								
- @ MIL	Default							
	Collapse others							
	Add station							
	Add device							
	Delete							
	Properties							
	Restore old config							
	Output setting list							
	Open config folder							
	View UID info.		DFR	CFS/CSS				



Right-click at the new station and select <add device>, a new device will be created. Right-click on the device and select <properties>, a pop-up window appears allowing the user to edit the device name and to enter its IP address. The default password in the pop-up window can be used. This is shown in Figure 7.6-2.

🍓 ReplayD ver2.2.0.2 - WA	RE, MILL STUDIO								
File Edit Operate T	ool Security Langu	age View Help							
💕 🛃 🖺 🛅 🗮	🛃 📑 📑 📑 🤇	0							
Device View		д 🗙	Monitor	DFR	CFS/CSS	Man Trig	Version	Others	
🛤 🗔 🙀 🔑 🛍				V	V Y				
Name	Description		Mapping	Configuration	Record	Monitor			
			FaultNo.	Filename			Trigger time		Cause
HERTFORD									
i ⊷i Kehui									
MILL STUDIO	192.168.0.215								
		Device			×				
		Station: W	ARE						
		Device:	ILL STUDIO						
		Device:							
		IP address:	192 . 168 . 0	. 215					
		FT code: 40	jetb4long						
		_							
Output			Г	ОК	Cancel				
Time	Source	Infomat							

Figure 7.6-2 Add a new device

7.7 ReplayD Channel mapping

7.7.1 SCD file import

Using ReplayD, the user can import the SCD file for a substation. By selecting the required SV and GOOSE control blocks, the necessary configuration file for the FTR-100 can be created.

Click the Button and open an SCD file from the PC.

After importing the SCD file, go to the <SCL model mapping> window, the necessary SV and GOOSE control blocks can be selected, as shown in Figure 7.7.1-.

vice View			a 🛤 [c] 👘	i.	.10	3.0 3.0 3.		
3 🖬 👒 🌽 🛍	- 22		44		SCL Mappi	ng		×
ame	SMV	GOOSE					Extend name Find AppID:	
C Station 1	No.	AppID.	Desc(IED + AP)		AC	SvID	DataSet	^
Device 1		0x4007	Integrated Installation Merging Unit	IECGOOSE	01-0C-CD-04-00-07	DTI816MUSV01/LLN0.smvcb0	DTI816MUSV01/LLN0\$dsSV1	
HERTFORD	2	0x4044	SMV Service Function IED	IECGOOSE	01-0C-CD-04-00-44	PRS-7395MUSV/LLN0\$MS\$Smvcb0	PRS-7395MUSV/LLN0\$dsSV0	
	3	0x4006	Switchgear IED	IECGOOSE	01-0C-CD-04-00-06	ZNKMU3PMUSV/LLN0\$MS\$sv1	ZNKMU3PMUSV/LLN0\$dsSV0	
KEHUI	4	0x400A	Merging Unit A2	IECGOOSE	01-0C-CD-04-00-0A	PSSC601MUSV/LLN0\$MS\$MSVCB01	PSSC601MUSV/LLN0\$dsSV1	
🦢 WARE	5	0x4008	Integrated Installation 2 Merging Unit	IECGOOSE	01-0C-CD-04-00-08	X783AM1MU/LLN0\$MS\$sv1	X783AM1MU/LLN0\$dsSV	
MILL STUDIO	6	0x400C	Switchgear IED	IECGOOSE	01-0C-CD-04-00-0C	PSIU6211MUSV/LLN0\$MS\$MSVCB01	PSIU6211MUSV/LLN0\$dsSV1	
	7	0x4011	Integrated Installation 1 Merging Unit	IECGOOSE	01-0C-CD-04-00-11	PSIU6212MUSV/LLN0\$MS\$MSVCB01	PSIU6212MUSV/LLN0sdsSV1	
	8 🗆	0x4045	Integrated Installation A	IECGOOSE	01-0C-CD-04-00-45	PCS222EAMUSV01/LLN0\$MS\$smv	PCS222EAMUSV01/LLN0\$dsSV	
	19	0x400F	Integrated Installation B	IECGOOSE	01-0C-CD-04-00-0F	PCS222EAMUSV02/LLN0\$MS\$smv	PCS222EAMUSV02/LLN0\$dsSV	
	10	0x400E	Integrated Installation 1 Merging Unit	IECGOOSE	01-0C-CD-04-00-0E	PCS222CGMUSV01/LLN0\$MS\$smv	PCS222CGMUSV01/LLN0\$dsSV	
	11	0x4010	Bay Level Merging Unit B1	IECGOOSE	01-0C-CD-04-00-10	PCS222CGMUSV02/LLN0\$MS\$smv	PCS222CGMUSV02/LLN0\$dsSV	
	12	0x4005	Busbar Merging Unit BB1	IECGOOSE	01-0C-CD-04-00-05	NSR387BMUSV01/LLN0\$MS\$MSV	NSR387BMUSV01/LLN0sdsSV1	
	13	0x4001	Bay Level Merging Unit B2	IECGOOSE	01-0C-CD-04-00-01	IL0001MU/LLN0\$MS\$SVOUT	IL0001MU/LLN0\$dsSV1	
	14	0x4004	Merging Unit A1	IECGOOSE	01-0C-CD-04-00-04	E3158agentMUSV/LLN0\$MS\$SVCB0	E3158agentMUSV/LLN0\$dsCB0	
	15	0x400D	Busbar Merging Unit BB2	IECGOOSE	01-0C-CD-04-00-0D	UDM502GMMUSV/LLN0\$MS\$MSV	UDM502GMMUSV/LLN0sdsSV1	
	16	0x4032	Busbar Merging Unit BB4	IECGOOSE	01-0C-CD-04-40-32	4032	ML2251BMUSV/LLN0\$dsSV	
	17	0x4033	Merging Unit A6	IECGOOSE	01-0C-CD-04-40-33	4033	MMX220AMUSV/LLN0\$dsSV	
	18	0x4022	Integrated Installation 5 merging Unit	IECGOOSE	01-0C-CD-04-40-22	SAC Bay 220MU/LLN0\$MS\$MSVC	SAC Bay 220MU/LLN0\$dsSV1	
	19	0x4023	Integrated Installation 7 merging Unit	IECGOOSE	01-0C-CD-04-40-23	SAC PT 220MU/LLN0\$MS\$MSVCB	SAC PT 220MU/LLN0\$dsSV1	
	20	0x4002	Merging Unit 9	IECGOOSE	01-0C-CD-04-40-02	ML4002MU/LLN0.smvcb0	ML4002MU/LLN0sdsSV0	
	21	0x4003	Bay Level Merging Unit B9	IECGOOSE	01-0C-CD-04-40-03	MM4003MU/LLN0.smvcb1	MM4003MU/LLN0\$dsSV1	
tput	22	0x4082	Bay Level Merging Unit B11	IECGOOSE	01-0C-CD-04-40-82	PG Bay 220MU/LLN0\$MS\$MSVCB01	PG Bay 220MU/LLN0\$dsSV1	
ne	23	0x4083	Merging Unit A11		01-0C-CD-04-40-83	PG_PT_220MU/LLN0\$MS\$MSVCB01	PG_PT_220MU/LLN0\$dsSV1	
	24	0x4092	Merging Unit A15	IECGOOSE	01-0C-CD-04-40-92	MUnn01	SM11LN1MU1MU/LLN0\$dsSV3	
17-12-07 11:08:28	25	0x4038	Merging Unit A21		01-0C-CD-04-40-3B	TEMPLATEMU01	PSMU_Bay_220MU/LLN0\$dsSV1	
17-12-07 11:08:28	26	0x403C	Merging Unit A25	IECGOOSE	01-0C-CD-04-40-3C	1MU1/LLN0sSVsSmvcb0	PRS739X1MU1/LLN0sdsSV0	
17-12-07 11:08:37	27	0x403D	Merging Unit A27		01-0C-CD-04-40-3D	2MU1/LLN0\$SV\$Smvcb0	PRS739X2MU1/LLN0\$dsSV0	v
7-12-07 11:08:37			11-11-1 -1 -1-11-11-11-11-11-11-11-11-11-11-11-1					
7-12-07 11:08:37						Select	Inselect Add Cancel	
17-12-07 11:08:37	Select all	(Ctrl+A)				Select	Inselect Add Cancel	
7-12-07 11:08:37								
17-12-07 11:11:38	192.168.		Mill Studio: Disconnecting the device					

Figure 7.7.1-1 Selecting SMV and GOOSE control blocks

The selected SV and GOOSE control blocks will appear in the <Channel mapping> module of the ReplayD software.

Each SV and GOOSE node should be configured according to the actual situation e.g., cbName, MsvID

The channel for recording can be chosen by selecting the associated tick box. Afterwards, the primary and secondary ratios can be set, together with the overload conditions. This is as shown in Figure 7.7.1-.

🧉 🖬 📓 🗃 🗃		0.													
Device View	4 	O Monitor	DFR	CFS/C	SS Man Tri	g Version	. 0t	her 5							
🛤 🗔 🙀 🌽 🛅					d Monitor				1	_					
Name	Description	Mapping	Configuration	Recor	d Monitor							1.			
E G Station_1		AppID	Description												
Device_1	192.168.26.1	SV SV 30	0	^	IED	XX1C INTEGR	ATED IED			~	refreshTime	Input m	net		
HERTFORD		4007	INTEGRATED I	EI	cbName	smvcb0			1	~	sampleSynchroniz	Samplin	4000		
		4044	INTEGRATED I	EI	MsvID	DTI816MUSV	01/LLN0.s	mvcb0	1	~	sampleRate				
🖻 🦢 WARE		4006	INTEGRATED I	EI	DataSet	DTI816MUSV	01/LLN0\$	dsSV1		~	security				
MILL STUDIO	192,168,26,1	400A	INTEGRATED I	EI	ConfRey	1	1				dataRef				
STANSTEAD	192.100.20.1	4008	INTEGRATED I	EI	Mac Address	01-0C-CD-04	00.07			-	o o control				
STANSTEAD	100 450 0 04	400C	INTEGRATED I	EI	APPID		-00-07								
SUUKV	192.168.0.21	4011	INTEGRATED I	EI		0x4007									
		4045	INTEGRATED I		VLAN Priority	4									
		400F	INTEGRATED I				12	-1						12112	
		400E	INTEGRATED I	- L	Name		Туре	Ph.	Primar	y	Secondary	Overload	Prefix	Instance	
		4010	INTEGRATED I	E1		IME DELAY									
		4010	INTEGRATED		2 [4007_1_		ACC	A	600A		5A	50.00	PA	1	
		4003			3 [4007_1_		ACC	A	600A		5A	50.00	PA	1	
		1. (1. (1. (1. (1. (1. (1. (1. (1. (1. (INTEGRATED I		4 [4007_1_	PB] INTEGRAT	ACC	в	600A		5A	50.00	PB	1	
		4004	INTEGRATED I		5 [4007_1	PB] INTEGRAT	ACC	в	600A		5A	50.00	PB	1	
		400D	INTEGRATED I	EI I		PC] INTEGRAT	ACC	с	600A		5A	50.00	PC	1	
<	>	< .	INTECRATED I						6004		54	50.00	PC	1	
Dutput															ą
Time	Source	Infomation													
2017-12-07 11:08:28	192.168.26.11	WARE: MILL S	TUDIO The order was	performe	ed successfully										
2017-12-07 11:08:28	192.168.26.11	WARE: MILL S	TUDIO Receiving DFR	record fil	e (2D3)										
2017-12-07 11:08:37	192.168.26.11	WARE: MILL S	TUDIO The order was	perform	ed successfully										
2017-12-07 11:08:37	192.168.26.11	WARE: MILL S	TUDIO Receiving DFR	record fi	le (2D3)										
2017-12-07 11:08:37	192.168.26.11	WARE: MILL S	TUDIO The order was	perform	ed successfully										
2017-12-07 11:08:37	192.168.26.11	WARE: MILL S	TUDIO Receiving DFR	record fi	le (2D3)										
2017-12-07 11:08:37	192.168.26.11	WARE: MILL S	TUDIO The order was	perform	ed successfully										
2017-12-07 11:11:38	192.168.26.11	WARE: MILL S	TUDIO Disconnecting	the devic	e										
2017-12-07 11:11:38	192.168.26.11	WARE: MILL S	WARE: MILL STUDIO Device disconnected!												

Figure 7.7.1-2 Selecting analogue channels for recording

The individual GOOSE messages in the GOOSE control block can be selected in the same way.

After the configuration is complete, <send configuration> is selected in the menu bar, to send the configuration to the FTR-100.

🥥 Mon	itor DFR CFS/CSS	Man Trig	Version	Others
Мар	pping Configuration Record	Monitor		Send configuration
序号	Source	Туре	Flag	Get configuration
R _1	[8000]Digital1	Other	General	Clock
R 2	[8000]Digital2	Other	General	Reset
R _3	[8000]Digital3	Other	General	Backup records
R _4	[8000]Digital4	Other	General	
R _5	[8000]Digital5	Other	General	
R _6	[8000]Digital6	Other	General	
R _7	[8000]Digital7	Other	General	
R_8	[8000]Digital8	Other	General	
R 9	[8000]Digital9	Other	General	
R _10	[8000]Digital10	Other	General	
R _11	[8000]Digital11	Other	General	
R _12	[8000]Digital12	Other	General	
R _13	[8000]Digital13	Other	General	
R _14	[8000]Digital14	Other	General	
R 15	[8000]Digital15	Other	General	

7.7.2 Adding a RAU

Analogue recording requires the Remote Acquisition Unit (RAU) to be installed to provide the analogue channels data. Go to <File> pull-down menu and select <ADD RAU>. A pop-up window will appear, as shown in figure 7.7-3.

The application identifier (APPID), sampling rate, phase sequence and the number of analogue and digital channels are set up according to the requirements of each RAU.



Figure 7.7.2-3 Adding an RAU unit

8. ReplayD Configuration

If the FTR-100 has already been configured, it is only necessary to select the device, go to <Others> tab, and select <Get configuration>. The configuration of FTR-100 will then be uploaded into the PC. If the FTR-100 has not been configured previously, it is necessary to go through the following process.

Select <Configuration> tab. There are 5 sub-modules at the bottom of the page within this tab: Basic, Analogue, Digital, Elements, Calculation. They are explained in details below.

All configuration changes will need to be sent to the FTR-100 for it to accept the changes. This is done in the <send configuration> command under the <Others> pull-down menu. After executing the <Send configuration> command, the FTR-100 will self-reset. This may disrupt the communications of the PC to the FTR-100. The communications can be re-established by clicking the <Connect> icon again.

🥚 Mon	itor DFR CFS/CS	S Man Trig	Version	Others
Мар	ping Configuration Record	1 Monitor		Send configuration
序号 R 1	Source [8000]Digital1	Type Other	Flag General	Get configuration Clock
R ₂	[8000]Digital2	Other	General	Reset
R _3	[8000]Digital3	Other	General	Backup records
R _4	[8000]Digital4	Other	General	
R _5	[8000]Digital5	Other	General	
R _6	[8000]Digital6	Other	General	
R 7	[8000]Digital7	Other	General	
R _8	[8000]Digital8	Other	General	
R 9	[8000]Digital9	Other	General	
R 10	[8000]Digital10	Other	General	
R 11	[8000]Digital11	Other	General	
R 12	[8000]Digital12	Other	General	
R 13	[8000]Digital13	Other	General	
R 14	[8000]Digital14	Other	General	
R 15	[8000]Digital15	Other	General	

8.1 Basic Configuration

The basic configuration page is shown in Figure 8.1-1. Each setting is explained below.

8				ReplayD ver2.	.1.0.1 - STA	NSTEAD 500KV		- 0 ×
File Edit Operate 1								
💕 🖬 🛛 🗂 🗮 🗮	3 B B B	0.						
Device View	џ 🔀	Monitor DFR	CFS/	CSS Han Trig	Version	Others		
🛤 🖬 🙀 🤌 🛍		Mapping Configura	ation Rec	ord Monitor				
Name	Description							
E 🎦 Station_1		Item_1	Value_1	Item_2	Value_2	Item_3	Value_3	
Device_1	192.168.26.1	System Frequenc	50	IEDname	KEHUI	Record unsubscrib		
HERTFORD		Clock source	IRIGB	OverCurr	1.1	Record unsubscrib		
- 🗀 KEHUI		A section time(ms)	100	UnderVolt	0.85	Record MMS mes		
🖻 🦢 WARE		B section time(ms)	3000	3I0 over	0.1	Record PTP messa		
- @ MILL STUDIO	192.168.26.1	Longest time(ms)	6400	SV loss sample		GO frame lost		
📄 🦢 STANSTEAD		Record sampleR	4000	SV jitter(us)	15	GO invalid PDU		
- 100 500KV	192.168.0.21	Dual A/D differen		SV overtime(us)	50	GO model not mat		
		Volt thresh	100	SV max delay(500	GO mis-sequence		
		Curr thresh	100	SV invalid PDU		GO reset		
		A/D abnormal sa		SV model not		GO abnormal chan		
		Volt thresh	100	SV repeated p		GO fake change		
		Curr thresh	100	SV out of order		GO test		
		Sample loss seq		SV delay chan		GO ndscom		
		Abnormal sampl		SV delay abno		GO overtime		
		RAU phase comp	0	SV input meth	net	GO abnormal inter		
		Activate setting g	1			GO repeated pack		
		Num of Setting g	1					
		Noise immunity						
		SFP frequency sp						
		Digital debounce	5					
		GOOSE_t0 tolera	3					
c .	>	Basic Analog I	Digital Ca	Iculation Element				•
utput								ņ
line	Source	Infomation						
2017-12-07 11:08:28	192. 168. 26. 11	WARE: MILL STUDIO The ord	ler was perform	ed successfully				
2017-12-07 11:08:28	192. 168. 26. 11	WARE: MILL STUDIO Receivi	ng DFR record f	ile (2D3)				
Comms sta	atus / Event /		^					
Ready								CAP NUM S

Figure 8.1-1 Basic ReplayD configuration

- Clock source: NONE, IRIG-B, PPS (Pulse per second), IEEE 1588 precision time protocol
- A period recording time: DFR (disturbance transient recorder) pre-trigger time
- B period recording time: DFR post-trigger time
- Longest recording time: The longest time allowable for a DFR record
- Record Sample rate (Hz): DFR record sampling rate
- Dual A/D sample difference trigger threshold: This triggers a record if the difference between the dual A/D samples exceeds the threshold.
- Dual A/D abnormal sample threshold: This triggers a record if either one of the dual A/D samples is abnormal and exceeds the threshold.

- Sample sequence lost trigger: Triggers a record if there are lost samples or the sample sequence is abnormal
- Sample quality abnormal trigger: Triggers a record if the sample quality flag is up
- RAU phase compensation: Compensates for the phase angle difference between the voltage and current measurement due to sample delays
- Activate setting group: Selects a setting group to activate (fixed at 1 for FTR-100)
- Number of setting groups: 1
- GOOSE_t0, GOOSE_t1 tolerance: This selects the allowable to and t1 tolerance range in GOOSE
- Fault detection trigger: Overcurrent, under voltage, neutral overcurrent.
- SV abnormal detection: SV lost, SV jitter, SV time-out
- GOOSE, MMS and PTP messages subscription and abnormal detection: recording MMS messages PTP messages, lost frame Goose messages, abnormal frame Goose messages etc.

8.2 Analogue Data configuration

In the <Channel mapping> function, the analogue channels are selected as either SV control blocks, a 1.5 breaker scheme or the RAU. These channels will now appear in this page to allow the user to select the trigger method and the trigger threshold.

vice View						_		_		_						
8 🖬 🙀 🤌 🐘	Ф 🔀	🥥 Moni	tor DFR	CFS/CSS	Man 1	riz	Vers	ion	Others							
	D	Mapp	ing Configuration	n Record	Monitor]										
ame	Description	Seq.No.	Source		RMS		Over		Under		Delta	Ph.	Primary	Secondary	Overload	
Station_1	192.168.26.1		[4007_1_PA] INTEL				5,500		0.000		0.500	A	600A	5A	50.00	
HERTFORD	192.108.20.1	SV 2	[4007_1_PA] INTEL [4007_1_PA] INTEL		a second s	_	5.500	H	0.000	-	0.500	A	600A	5A	50.00	
		SV 3	[4007_1_PA] INTEL				5.500	H	0.000	_	0.500	B	600A	54	50.00	
WARE		SV 4	[4007_1_PB] INTEL			_	5.500	H	0.000	_	0.500	B	600A	5A	50.00	
MILL STUDIO	192,168,26,1		(4007_1_PB) INTEL (4007_1_PC) INTEL			_	5.500	H	0.000	-	0.500	c	600A	5A	50.00	
STANSTEAD	1021100i20i1	100	[4007_1_PC] INTEL [4007_1_PC] INTEL				5.500	H	0.000		0.500	c	600A	5A	50.00	
500KV	192,168.0.21	SV 7	[4007_1_PC] INTEL [4007_1_MA] INTEL				5.500	Н	0.000	_	0.500	A	600A	5A	50.00	
_		SV 8	[4007_1_MB] INTEL [4007_1_MB] INTEL			_	5.500	H	0.000	_	0.500	B	600A	5A	50.00	
		SV 9	[4007_1_MB] INTE			_	5.500	H	0.000	-	0.500	C	600A	5A	50.00	
			[4007 1 UA] INTEL				63.510	H	51,963		2.887	A	110kV	100V	2.00	
		SV 11	[4007_1_UA] INTEL			H		H	51.963		2.887	A	110kV	100V	2.00	
		SV 12	(4007 1 UB) INTEL			Н	63.510	Н	51,963	_	2.887	B	110kV	100V	2.00	
		SV 13	[4007_1_UB] INTEL			H		H	51.963		2.887	B	110kV	100V	2.00	
		SV 14	[4007 1 UC] INTEL			-	63.510	H	51,963		2.887	c	110kV	100V	2.00	
		SV 15	[4007 1 UC] INTEL			_	63.510	H	51.963	_	2.887	c	110kV	100V	2.00	
		SV 16	[4007 1 UX] INTEL			_	63.510	H	51,963	_	2.887	-	110kV	100V	2.00	
		SV 17	[4007 1 UX] INTEL		-	-	63,510	E I	51,963		2.887		110kV	100V	2.00	
		SV 18	[4007 2 UB] INTEL			-	63.510	H	51,963		2.887	В	110kV	100V	2.00	
		SV 19	[4007 2 UB] INTEL			-	63.510	H	51.963		2.887	В	110kV	100V	2.00	
		SV 20	[4007 2 UC] INTEL			Н		H	51.963		2.887	c	110kV	100V	2.00	
			[4007_2_UC] INTEL			-	63.510		51.963		2.887	c	110kV	100V	2.00	
	>	Basic	Analog Digit	al Calculati	on Elen	nent	J									
utput																1
ine	Source	Infons	tion													
017-12-07 11:08:28	192. 168. 26. 11	WARE:	MILL STUDIO The order v	ras performed suc	cessfully											

Figure 8.2-1 Analogue data configuration

<Channel source> represents the name of each SV analogue channel. It is formed by APPID + device name + phase information

The triggered quantity calculation is based on the <RMS value> selection. If the <RMS value> is selected, RMS values (including all the harmonics) will be used. If de-selected, magnitudes based on fundamental frequency will be used.

<Over>, <Under> <Delta>, if selected, they will be activated.

The example in Figure 8.2-1 shows that Channel 1 has been configured with 5.5A overcurrent, delta value 0,5A, phase A, CT ratio 600 to 5, Overload ratio 50

The above process will be repeated until all the channels have been configured.

Select <Send configuration> in the 'Others' pull-down menu to send the new settings to the FTR-100.

8.3 Digital input Configuration

FTR-100 uses either GOOSE control blocks or signals obtained through the RAU to select and configure the digital inputs, see Figure 8.3-1.

Explanations of the pull-down selections for each channel are as follows:

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Device View	д 🔀	Monitor DFR CFS/0	SS Man Trig	Version	Others.		
🗟 🗔 🙀 🌽 🛅							
Name	Description	Mapping Configuration Reco					
- 🗁 Station_1		Seq.No. Source	Туре	Flag	Close	Open	·
Device_1	192.168.26.1	R 1 [8000]Digital1	Other	General			
HERTFORD		R 2 [8000]Digital2	Other	General	V	V	
🛛 🗀 KEHUI		R 3 [8000]Digital3	Other	General		V	
🖶 🦢 WARE		R 4 [8000]Digital4	Other	General		V	
	192.168.26.1	R 5 [8000]Digital5	Other	General		V	
🗄 🗁 STANSTEAD		R 6 [8000]Digital6	Other	General	V	V	
	192.168.0.21	R 7 [8000]Digital7	Other	General	V	V	
		R 8 [8000]Digital8	Other	General	V	V	
		R 9 [8000]Digital9	Other	General		V	
		R 10 [8000]Digital10	Other	General		V	
		R 11 [8000]Digital11	Other	General		V	
		R 12 [8000]Digital12	Other	General		V	
		R 13 [8000]Digital13	Other	General			
		R 14 [8000]Digital14	Other	General			
		R 15 [8000]Digital15	Other	General			
		R 16 [8000]Digital16	Other	General			
		R 17 [8000]Digital17	Other	General			
		R 18 [8000]Digital18	Other	General			
		R 19 [8000]Digital19	Other	General			
		R 20 [8000]Digital20	Other	General			
		R 21 [8000]Digital21	Other	General			
<	>	Basic Analog Digital Cal	ulation Element				•
Output		,					д
Time	Source	Infonation					
2017-12-07 11:08:28	192.168.26.11	WARE: MILL STUDIO The order was performed	successfully				
	192.168.26.11	WARE: MILL STUDIO Receiving DFR record file					

Figure 8.3-1 Digital input configuration

Type: types of digital inputs, consisting of <Protection operation>, <CB position>, <Switch position>, <Alarm>, <Others>

Labels: allow the users to enter labels for each digital input to make them more meaningful.

Flag: depending on the <Type> selected, as follows.

- <Protection operation> includes <Protection trip>, <Trip A>, <Trip B>, <Trip C>, <Three phase trip>, <Auto-reclose>, <Lockout>, <Send signal>, <Receive signal>
- <CB position>: includes <three phase CB close>, <three phase CB open>, <A phase CB close>, <A phase CB open>, <Transformer HV CB close>, <transformer MV CB close>, <transformer LV close>.
- <Switch Position>: includes switch open and closed
- <Alarms> include <VT failure>, <CT failure>, <communications alarm>, <other alarm>

Close: If selected, a closing digital input will trigger the recording
Open: if selected, an opening digital input will trigger the recording

After the configuration, press <Send Configuration> to send the settings to the FTR-100.

8.4 System Elements Configuration

Before configuring calculated (or derived) values, it is necessary to configure the power system elements, which include busbar, single breaker line, 1.5 breaker line, 2-winding and 3-winding transformers. See Figure 8.4-1

Busbar: The busbar typically provides Va, Vb, Vc and Vn for the substation. They are mapped to the corresponding voltage channels.

Line: This represents a typical transmission line with a breaker at each end. The voltages are obtained from the busbar, whilst Ia, Ib, Ic and In from the line, are mapped to the corresponding current channels. Line length and positive, negative and zero sequence impedances are parameters used for the fault location calculations.

One-and-a-half (1.5) circuit breaker line: The Ia, Ib, Ic and In currents on the line are the summation of two branch currents. The branch currents will need to be mapped to their corresponding current channels.

2-winding/3-winding transformer: the source of currents of each winding is coming from the line already configured. The user needs to set up the mode of connection (e.g., DY1, DY11) and the earthing arrangement of the transformer.

The following is an example of the 1.5 breaker line :-

Line name: AtoB Busbar: A-BUS Line current branch 1: Ia, Ib, Ic, In Line currrent branch 2 : Ia, Ib, Ic, In Line length : 100km Primary/secondary: secondary R1(ohm/km), X1(ohm/km) R2(ohm/km), X2(ohm/km) R0(ohm/km), X0(ohm/km)

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🐱 🗔 屎 🤌 🛍 🖉			·		
Name	Description	Mapping Configuration	Record Monitor		-
📄 🦢 Station 1		😑 🜄 System element	Item	Value	^
- Device_1	192.168.26.1	Busbar	Name	jiangxia	
HERTFORD		□ • • inst1	Conn. Busbar	inst1	
B- 🛄 KEHUI		une ∳ inst1			
- 🔤 WARE		- V Insti	Branch 1Dir	Positive	
- 👦 MILL STUDIO	192.168.26.1	Ware	Branch 1Ia	[4007_1_PA] PHASE A INTELLIGENT	
🔤 🔤 STANSTEAD		2-winding Transform	Branch 1Ib	[4007_1_PB] PHASE B INTELLIGENT	
		3-winding Transform		[4007_1_PC] PHASE C INTELLIGENT	
		Branch 1In	Dummy Curr		
		Branch 2Dir	Positive		
			Branch 2Ia	[4007_1_PA] PHASE A INTELLIGENT	
			Branch 2Ib	[4007_1_PB] PHASE B INTELLIGENT	
			Branch 2Ic	[4007_1_PC] PHASE C INTELLIGENT	
			Branch 2In	Dummy Curr	
			Enable DTF	V	
			Length(km)	100.000000	
			Primary/Second	Second	
			r1(Ω/km)	1.000000	
			x1(Ω/km)	1.000000	
		< >	r0(Ω/km)	1.000000	~
C	>	Basic Analog Digital	Calculation Element		•
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line	Source	Infomation			1
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2017-12-07 11:08:28	192.168.26.1	1 WARE: MILL STUDIO Receivin	ig DFR record file (2D3)		
Comms sta	tus Event				
eady					CAP NUM SC

Figure 8.4-1 Systems elements configuration

8.5 Calculated (Derived) Values Configuration

Calculated values are based on one cycle of instantaneous samples from one or multiple channels, e.g., harmonics, angle, sequence components, power, power factor, etc. These values can be used to trigger recordings.

8.5.1 Calculated value configuration

In the <calculation> page, the calculated values are: Positive sequence, negative sequence, three-times zero sequence, single-phase active power, 3-phase active power, single-phase reactive power, 3-phase reactive power, power factor, frequency, harmonics, angle difference, differential current, over-excitation current and transformer differential current.

In the example in Figure 8.5.1-1, the positive sequence voltage is selected as the trigger criterion, with an over-voltage threshold set at 63.51V, with the under-voltage at 51.963V.

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🛤 🗔 🙀 🤌 🛍		Mapping Configuration	Record Monitor	
Name	Description			
		⊟ Calculation type	No. Source Over Under	
Station_1	192.168.26.1	Positive sequence		
Device_1		••••••••••••••••••••••••••••••••••••	<u>, </u>	
HERTFORD		Zero sequence * 3	,3	
🗄 🛅 KEHUI			4	
🖻 🦢 WARE	192.168.26.1		5	
- 👦 MILL STUDIO		30	6	
🗄 խ STANSTEAD	*192.168.0.21	Power factor	.7	
- 500KV		3-ph. Power factor	.8	
		T Frequency	9	
		Harmonic	10	
		Angle Diff.	11	
		Current Diff.	12	
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2017-12-07 11:08:28	192.168.26.	11 WARE: MILL STUDIO TH	e order was performed successfully	~
2017-12-07 11:08:28	192.168.26.	11 WARE: MILL STUDIO Re	ceiving DFR record file (2D3)	
Ready				CAP NUM SCR



8.6 Date and time setting

The date and time of the FTR-100 can be set to be synchronised to the clock of the PC by the command <Clock> under <Others> pull-down menu.

O Mon:	itor DFR CFS/CSS	Man Trig	Version	Others
Мар	ping Configuration Record	Monitor		Send configuration
序号	Source	Туре	Flag	Get configuration
R _1	[8000]Digital1	Other	General	Clock
R 2	[8000]Digital2	Other	General	Reset
R 3	[8000]Digital3	Other	General	Backup records
R 4	[8000]Digital4	Other	General	
R 5	[8000]Digital5	Other	General	
R _6	[8000]Digital6	Other	General	
R .7	[8000]Digital7	Other	General	
R_8	[8000]Digital8	Other	General	
R _9	[8000]Digital9	Other	General	
R_10	[8000]Digital10	Other	General	
R_11	[8000]Digital11	Other	General	
R_12	[8000]Digital12	Other	General	
R _13	[8000]Digital13	Other	General	
R _14	[8000]Digital14	Other	General	
R_15	[8000]Digital15	Other	General	

8.7 Password protection

Under <Security> pull-down menu, select <Set authority>. A list of tick boxes appears allowing the user to enable or disable access to certain functions. For example, unticking all the boxes except 'Device View window functions" allows the user to view information, but not to change any settings. The default password for <set Authority> is 111111. This can be changed through <Change pwd> button.

Tool Security	y Language View Help	
B	E EE 👩 Authority 🔅	<
	Additionary	Man Trig
	Password: ••••• Change pwd	
Descr	Device View window functions Control Block (SV, GO, RAU) add or delete	e
192.168	Channel mapping change	er
192.168	Basic configuration, channel setting, element setting modify	er
	Send configuration	er
	Man trig, reset, dock, get configuration, FT code	er
		er
	OK Cancel	er
L	R 12 [8000]Digital12 (Other
	R 13 [8000]Digital13 0	Other

9. FTR-100 Recording

The FTR-100 has three types of recording:

Fault Transient Recording (FTR) - for transient waveform recording, sampling rate is 4kHz for sample value inputs and 10KHz for analogue inputs.

Continuous Slow Speed (CSS) recording - for continuous long duration trace recording of calculated (or derived) values.

Continuous fast speed (CFS) recording - for continuous waveform recording at a lower sampling rate of 1kHz.

9.1 Digital Fault Recording (DFR)

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evice View	A 🛛			ana (aaa			0.1					
a 🖬 🙀 🤌 🛍 🛛		Monitor	DFR	CFS/CSS	Man Trig	Version	Others.	••				
lame	Description	Mapping	Configuration	Record	Monitor							
- by Station 1	boompaon	FaultNo.	Filename			Trigger time		Cause				
Device 1	192.168.26.1	9 718	KEHUI_RCD_71	8_20171207_	134339_464_S	2017-12-07 13	:43:39.4646	i38 ManualTrigger				
HERTFORD		9717	KEHUI_RCD_71	7_20171207_	134333_084_S	2017-12-07 13	3:43:33.0846	i29 ManualTrigger				
- 🔁 KEHUI		716	KEHUI_RCD_71	6_20171207_	134327_204_S	2017-12-07 13	3:43:27.2046	21 ManualTrigger				
- 🗁 WARE		715	KEHUI_RCD_71	5 20171207	134317_224_S	2017-12-07 13	3:43:17.2246	i07 ManualTrigger				
- 🕣 MILL STUDIO	192.168.26.1	714	KEHUI_RCD	1anualTrigge	14313_324_S	2017-12-07 13	3:43:13.3246	i02 ManualTrigger				
- 🦢 STANSTEAD		713	KEHUI_RCD_71	3_20171207_	134309_344_S	2017-12-07 13	3:43:09.3445	96 ManualTrigger				
	192.168.0.21	712	KEHUI_RCD_71	2_20171207_	105537_930_S	2017-12-07 10	:55:37.9305	i68 inst1:No fault B	US1_UA:Over BU	IS1_UB:Over I	3US1_UC:Over	
		711	KEHUI_RCD_71	1_20171207_	105532_970_S	2017-12-07 10	:55:32.9705	i61 inst1:No fault E	US1_UA:Over BL	S1_UB:Over I	BUS1_UC:Over	
		710	KEHUI_RCD_71	0_20171207_	105507_813_S	2017-12-07 10	:55:07.8132	26 inst1:No fault B	US1_UA:Delta Bl	JS1_UA:Over	BUS1_UB:Delta BI	US1_UB:Over B
		709	KEHUI_RCD_70	9_20171207_	105454_701_S	2017-12-07 10	:54:54.7013	07 inst1:No fault B	US1_UA:Delta Bl	JS1_UA:Unde	BUS1_UB:Delta	BUS1_UB:Under
		708	KEHUI_RCD_70	8_20171207_	105414_254_S	2017-12-07 10	:54:14.2540	51 inst1:No fault B	US1_UA:Delta Bl	JS1_UA:Over	BUS1_UB:Delta BI	US1_UC:Delta B
		707	KEHUI_RCD_70	7_20171207	105407_988_S	2017-12-07 10	:54:07.9882	42 inst1:No fault B	US1_UB:Delta BU	JS1_UC:Delta	BUS1_UC:Over BI	US1_UC:Under
		706	KEHUI_RCD_70	6_20171207	105401_990_S	2017-12-07 10	:54:01.9904	34 inst1:No fault B	US1_UB:Delta BU	JS1_UC:Delta		
		705	KEHUI_RCD_70	5_20171207	105345_404_S	2017-12-07 10	:53:45.4040	11 inst1:No fault B	US1_UA:Delta Bl		BUS1_UB:Delta	8US1_UC:Delta
		704	KEHUI_RCD_70	4_20171207	105249_130_S	2017-12-07 10	:52:49.1308	32 inst1:No fault B	US1_UA:Delta Bl	JS1_UA:Over	BUS1_UA:Under E	3US1_UB:Delta
		703	KEHUI_RCD_70	3_20171207	105222_228_S	2017-12-07 10	:52:22.2285	94 inst1:No fault B	US1_UA:Delta Bl	JS1_UA:Over	BUS1_UB:Delta BI	US1_UB:Over B
		702	KEHUI_RCD_70			2017-12-07 10):52:14.0953				BUS1_UB:Delta I	
		701	KEHUI RCD 70	-		2017-12-06 16	5:35:12.7005		-	-	-	-
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2@2017-12-7 10:51:48	3.819						•	TimeSyncLoss: reset				
1@2017-12-7 10:51:32	2.834						•	TimeSignalLoss: reset				
40@2017-12-7 10:51:31	1.881							TimeSyncLoss: trigger				
39@2017-12-7 10:51:31								TimeSignalLoss: trigger				

Figure 9.1-1 Digital Fault Recording (DFR)

The digital fault recording (DFR) window contains all the FTR records. As in Figure 9.1-1, in the <Record> window, right-click to select <refresh directory>, the fault record index will be refreshed.

The fault record index consists of the fault number, file name, trigger time and cause. The cause consists of the fault channel or line, fault type and fault location.

To download the fault record, double-click the file name, or right-click and select "download fault record", the fault record can be opened and downloaded into the local PC (Figure 9.1-2).

Right-click the record and select <download all records> to download all the records into the PC. Selecting <filter records> will display the <record filter> dialogue box. There are three types of filter: filter based on trigger time period, filter on the digital I/O trigger and filter on fault trigger.

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Name	Descriptior	1		Record	Monitor						
Generation_1		FaultNo.	Filename			Trigger time			Cause		^
E DI HERTFORD		9718	KEHUI_RCD_71	8_20171207	_134339_464_S	2017-12-07	13:43:39.464		ManualTrigger		- 1
😥 🛅 KEHUI		9 717	KEHUI_RCD_71	7_20171207	_134333_084_S	2017-12-07	13:43:33.084	1629 N	ManualTrigger		
🖶 🦢 WARE		9716	KEHUI_RCD_71	6_20171207	_134327_204_S	2017-12-07	13:43:27.204	1621 N	ManualTrigger		
- 🕡 MILL STUDIO	192.168.26.1	9715	KEHUI_RCD_71	5_20171207	_134317_224_S	2017-12-07	13:43:17.224	607 N	ManualTrigger		
🗄 🇁 STANSTEAD		9714	KEHUI_RCD_71	4_20171207	_134313_324_S	2017-12-07	13:43:13.324	1602 N	ManualTrigger		
		0713	KEHUI_RCD_71	3_20171207	_134309_344_S	2017-12-07	13:43:09.344	596 N	ManualTrigger		
		712	KEHUI_RCD_71	2_20171207	_105537_930_S	2017-1	Refresh dired	ton	st1:No fault BUS1_UA:Over BUS1_UB:O	ver BUS1_UC:Over	
		9711	KEHUI_RCD_71	1_20171207	_105532_970_S	2017-1	Download to		st1:No fault BUS1_UA:Over BUS1_UB:O	/er BUS1_UC:Over	
		9710	KEHUI_RCD_71	0_20171207	_105507_813_S	2017-1		· ·	st1:No fault BUS1_UA:Delta BUS1_UA:O	ver BUS1_UB:Delta BUS1_UB:Ove	ar Bl
		09 709	KEHUI_RCD_70	9_20171207	_105454_701_S	2017-1	Options		st1:No fault BUS1_UA:Delta BUS1_UA:U	nder BUS1_UB:Delta BUS1_UB:Ur	nder
		0708	KEHUI_RCD_70	8_20171207	_105414_254_S	2017-1	Filter		st1:No fault BUS1_UA:Delta BUS1_UA:O	ver BUS1_UB:Delta BUS1_UC:Del	ta Bl
		0707	KEHUI RCD 70	7 20171207	105407 988 S	2017-1	View director	y info.	st1:No fault BUS1_UB:Delta BUS1_UC:D	elta BUS1_UC:Over BUS1_UC:Unc	der F
		0 706	KEHUI RCD 70	6 20171207	105401 990 S	2017-1	Open split file		inst1 IS1 UB:Delta BUS1 UC:D		
		0705	KEHUI_RCD_70	5 20171207	105345 404 S	2017-1	Download sp	lit file 🕨	hst1:No fault BUS1_UA:Delta BUS1_UA:U	nder BUS1 UB:Delta BUS1 UC:De	elta I
		0704	KEHUI RCD 70	-		2017-12-07	10:52:49.130		nst1:No fault BUS1 UA:Delta BUS1 UA:O		
		9703	KEHUI RCD 70	-			10:52:22.228		nst1:No fault BUS1 UA:Delta BUS1 UA:O		
		0702	KEHUI RCD 70				10:52:14.095		nst1:No fault BUS1 UA:Delta BUS1 UA:U		
		0701	KEHUI_RCD_70	-			16:35:12.700		ManualTrigger		
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trigger time		trigger elem	ent			trigger	type	trigger ca	use search r	restore 🗤 event: record:	
42@2017-12-7 10:51:48.81	.9							TimeSyncl	Loss: reset		
41@2017-12-7 10:51:32.83	34							TimeSigna	alLoss: reset		
40@2017-12-7 10:51:31.88	31						•	TimeSyncl	Loss: trigger		
39@2017-12-7 10:51:31.88								TimeSiona	lLoss: triaaer		
Ready											IUM SC

Figure 9.1-2 Download DFR records

A "red" indication at the beginning of the fault record indicates that this is a new record. The last letter of the file name contains information about the record; the letter "F" indicates a fault and "S" indicates a non-fault record.

9.2 Continuous Slow Recording (CSR)

Continuous Slow Speed (CSS) recording does not record the actual waveforms. It records the calculated (or derived) values such as magnitudes, harmonics, sequence components, phase angle, active and reactive power etc. The recording is continuous and does not require a trigger. It is used to monitor the stability of the power system. The FTR-100 can record up to 7 days of CSS records.

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🗏 🦢 Station 1		No. ID			End		Length	Information	
- Device_1	192.168.26.1	5 00		10:19:42.568865		07 10:38:42.5703			
E Carlord		6 00	06 2017-12-07	10:39:38.809779	2017-12-	07 10:41:38.8098	52 00-00:02:0	00	
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🖹 🦢 WARE		8 00	08 2017-12-07	10:43:52.509973	2017-12-	07 10:47:52.5102	24 00-00:04:0	00	
- 🖅 MILL STUDIO	192.168.26.1	9 00	09 2017-12-07	10:48:28.070184	2017-12-	07 10:50:28.0702	57 00-00:02:0	00	
📄 🦢 STANSTEAD		10 00	0A 2017-12-07	10:51:32.730325	2017-12-	07 13:49:32.7451	46 00-02:58:0	00	
- 00 500KV	192.168.0.21	<		_			×		>
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41@2017-12-7 10:51:32.8 40@2017-12-7 10:51:31.8							TimeSyncL	Loss: trigger	

Figure 9.2-1 Continuous Slow Recording (CSR)

As shown in the figure, the green bar shows a continuous recording. A discontinued recording can only be due to the FTR100 resetting or switching off.

9.3 Continuous Fast Recording (CFR)

A continuous fast speed (CFS) recording is a continuous waveform recording using a lower sampling rate than the DFR (but faster than the CSS).

The process to download a CFS record is the same that for the CSS record. Right-click to select "download CFS record'. Each file will not exceed 40s.

Users can also select their own time to obtain the required record. Select <Customize >, then select the date and time, select CSS or CFS and then download the record.

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lame	Description	Mapping	Configuration	Record	Monitor								
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E KEHUI		9716	KEHUI_RCD_71	6_20171207	134327_204_S	2017-12-07 13	43:27.2	04621	ManualTrigger				
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		06	KEHUI_RCD_70	-		Open split file		90434	inst1:No fault BUS1_UB:D	-			
		05	KEHUI_RCD_70			Download split fil	e ▶	04011	inst1:No fault BUS1_UA:D	-			-
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		02	KEHUI_RCD_70	2_20171207	_105214_095_S	2017-12-07 10	52:14.0	95383	inst1:No fault BUS1_UA:D	elta BUS1_U	A:Under BUS1	_UB:Delta BUS1_	UB:Unde
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Figure 9.3-1 Continuous fast Recording (CFR)

10. Using CmdView for record analysis

10.1 Open a disturbance record

A disturbance record can only be opened after the record has been registered in the record index in the PC thorough data transfer. The record to examine is selected in the local record index, which is arranged based on substation IDs and device IDs.

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Hertford		9 717	KEHUI_RCD_71			2017-12-07 13:			ManualTrigger	
Ware		9716	KEHUI_RCD_71			2017-12-07 13:			ManualTrigger	
MILL STUDIO	192,168,26,1	9715	KEHUI_RCD_71			2017-12-07 13	43:17.224		ManualTrigger	
Stanstead		9714	KEHUI_RCD_71	4_20171207_1	134313_324_S	2017-12-07 13:	43:13.324	4602	ManualTrigger	
Stanstead		9713	KEHUI_RCD_71	3_20171207_1	134309_344_S	2017-12-07 13:	43:09.344	4596	ManualTrigger	
		6 712	KEHUI_RCD_71	2_20171207_1	105537_930				inst1:No fault BUS1_UA:Over BUS1_UB:Over BUS1_UC:Over	
		9711	KEHUI_RCD_71	1_20171207_1	105532_97	Refresh directory		0664	installo fault BUS1_UA:Over BUS1_UB:Over BUS1_UC:Over	
		9710	KEHUI_RCD_71	0_20171207_1	105507_81	Download to	•	Local	o fault BUS1_UA:Delta BUS1_UA:Over BUS1_UB:Delta BUS1_UB:O	/er B
		- 709	KEHUI RCD 70	9 20171207 1	105454 70	Options		Specifie	ed o fault BUS1 UA:Delta BUS1 UA:Under BUS1 UB:Delta BUS1 UB:	Jnde
		9708	KEHUI_RCD_70	8 20171207 1	105414 25	Filter	54	4051	inst1:No fault BUS1_UA:Delta BUS1_UA:Over BUS1_UB:Delta BUS1_UC:D	elta B
		9707	KEHUI_RCD_70	7 20171207 1	05407 98	View directory info	. 8	8242	inst1:No fault BUS1 UB:Delta BUS1 UC:Delta BUS1 UC:Over BUS1 UC:U	nder
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1@2017-12-7 10:51:3	2.834							TimeSigr	nalLoss: <i>reset</i>	
40@2017-12-7 10:51:3	1.881							TimeSyn	icLoss: trigger	
9@2017-12-7 10:51:3	1.881							TimeSiar	nalLoss: <i>triaaer</i>	_

Figure 10.1-1 Open a disturbance record

As shown in Figure 10.1-1, select "Ware" \rightarrow "MILL STUDIO" and double-click the fault record to be to examined. The record will be downloaded to the PC and opened. Alternatively, rightclick the record and select <Download to local> from the pop-up menu. The fault record waveform is viewed through the software CmdView.



Figure 10.1-2 CmdView for viewing a disturbance record

Figure 10.1-2 shows the CmdView main window and the fault recording waveforms. In the CmDView window, the user can display, edit, print and analyse the waveforms.

10.2 Tool bar functions

The tool bar has a number of short-cut keys, their functions are as follows:

- 🗃 Open file
- Store file in COMTRADE format
- Output fault report
- Examine CFG file
- Examine DMF file
- Trigger cause analysis
- Digital input status time line
- 🕉 Select Analogue channel
- 🚰 Select digital channel
- Swap dual AD display
- Expand horizontally using red cursor as the centre
- Q Contract horizontally using red cursor as centre
- 😔 Show the entire waveform record
- Zoom into the selected area
- Expand on the Y axis
- Contract on the Y axis
- Restore the y axis magnification ratio
- Fill the Y-axis boundary
- Swap red and blue curser
- Lock the red and blue cursers relative positions and drag
- Copy the selected area
- Manually set time zero
- Connect the sample points
- Display the actual sample points
- Selected shows the absolute time, deselected shows the relative time
- Selected shows the RMS value, de-selected shows the instantaneous value
- Swap primary and secondary values
- Fault location
- Differential analysis
- Sequence component analysis
- Harmonic analysis
- Decay time constant measurement
- Restore channel selection scheme 1
- Restore channel selection scheme 2
- Save the existing channel selection as scheme 1
- Save the existing channel selection as scheme 2

10.3 Channel selection

CmdView displays the Active Channel, allowing the user to select only the analogue and digital signals which are active and relevant. This allows useful information to be displayed.

The icons \bigotimes and \bigotimes allows the user to select the active analogue and digital channels respectively. Selecting the icon, a pop-up window appears allowing the user to perform the active channel selection.



Figure 10.3-1 Active analogue channel selection

The left-hand window shows the available channels to be selected, the right-hand window shows the selected channels. Use "Add" to move the channel from left to right, and "Delete" to move the channels from right to left. Alternately, double-click a channel to move it to the opposite window. "All" means selecting all the channels to be active, "Reset" means deselecting all the active channels. Finally, use "OK" to confirm the selection, or use "Cancel" to abort the operation.

10.4 Channel exchange positions

In the CmdView record display window, move the cursor over the title of a channel, the cursor changes to a "hand" symbol. Left click, hold and drag the channel to the position you want. This allows for flexible re-arrangement of the channel positions for ease of analysis.

10.5 Line parameter definition (Define lines)

In order to perform sequence components, impedance loci and distance to fault calculations, it is necessary to configure the line parameters. Go to <Edit> pull-down menu, select <Define lines>, a pop-up window appears allowing the parameters of each line to be entered.



Figure 10.5-1 Entering line parameters

<Save as> allows the line parameters to be saved into a .pam file which can be named and stored according to user's choice. Select <default> will store the parameters into a <default.pam> file.

10.6 Changing waveform colours and background

As shown in Figure 10.6-1, right-click a channel ID, select <change trace colour> from the menu, a pop-up window appears allowing the user to change the colour of the trace.



Figure 10.6-1 Changing waveform colours

10.7 Channel scaling harmonisation and superposition

When the scaling of the channels differs, it is difficult to compare their magnitudes visually. Select a channel by clicking its ID, hold down the "Cntr" key and select another channel. Repeat this process until a group of channels have been selected. Right-click one of the channels from the group and select "equalize scale". The scaling of all the channels within that group will be equalised.



Figure 10.7-1 Equalise scale



Figure 10.7-2 Superposition (overlapping)

Similarly, if the user wants to superimpose all the channels of the same group onto the same time axis, "overlap channels" is selected in the menu selection.

10.8 Moving the cursors

There are two cursors, red and blue, which allow the user to measure the time difference between two points on the record. Clicking anywhere on the record will set the red cursor to that point. The icon III allows this control to be swapped between red and blue. To lock the two cursors together with a fixed time difference of, say 20ms, position the two cursors at the required separation and then click the icon III. The cursors will be locked and will move together on the record.

Sys Freq:50.00Hz	Sample:10000.00	Red:0.000ms	Blue:-20.000ms	Red-Blue:20.000ms
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Figure 10.8-1 Status bar showing the red and blue cursor positions

10.9 Record sequence and record search

FaultNo.	Filename	Trigger time	Cause
718	KEHUI_RCD_718_20171207_134339_464_S	2017-12-07 13:43:39.464638	ManualTrigger
717	KEHUI_RCD_717_20171207_134333_084_S	2017-12-07 13:43:33.084629	ManualTrigger
716	KEHUI_RCD_716_20171207_134327_204_S	2017-12-07 13:43:27.204621	ManualTrigger
715	KEHUI_RCD_715_20171207_134317_224_S	2017-12-07 13:43:17.224607	ManualTrigger
714	KEHUI_RCD_714_20171207_134313_324_S	2017-12-07 13:43:13.324602	ManualTrigger
713	KEHUI_RCD_713_20171207_134309_344_S	2017-12-07 13:43:09.344596	ManualTrigger
712	KEHUI_RCD_712_20171207_105537_930_S	2017-12-07 10:55:37.930568	inst1:No fault BUS1_UA:Over BUS1_UB:Over BUS1_UC:Over
711	KEHUI_RCD_711_20171207_105532_970_S	2017-12-07 10:55:32.970561	inst1:No fault BUS1_UA:Over BUS1_UB:Over BUS1_UC:Over
710	KEHUI_RCD_710_20171207_105507_813_S	2017-12-07 10:55:07.813226	inst1:No fault BUS1_UA:Delta BUS1_UA:Over BUS1_UB:Delta BUS1_UB:Over E
709	KEHUI_RCD_709_20171207_105454_701_S	2017-12-07 10:54:54.701307	inst1:No fault BUS1_UA:Delta BUS1_UA:Under BUS1_UB:Delta BUS1_UB:Unde
708	KEHUI_RCD_708_20171207_105414_254_S	2017-12-07 10:54:14.254051	inst1:No fault BUS1_UA:Delta BUS1_UA:Over BUS1_UB:Delta BUS1_UC:Delta I
707	KEHUI_RCD_707_20171207_105407_988_S	2017-12-07 10:54:07.988242	inst1:No fault BUS1_UB:Delta BUS1_UC:Delta BUS1_UC:Over BUS1_UC:Under
706	KEHUI_RCD_706_20171207_105401_990_S	2017-12-07 10:54:01.990434	inst1:No fault BUS1_UB:Delta BUS1_UC:Delta
705	KEHUI_RCD_705_20171207_105345_404_S	2017-12-07 10:53:45.404011	inst1:No fault BUS1_UA:Delta BUS1_UA:Under BUS1_UB:Delta BUS1_UC:Delta

Figure 10.9-1 Record sequence

ReplayD organises the records according to the substations and the devices. After a device has been selected, the records are displayed on the right-hand window in chronological order, with the newest record at the top.

10.10 Exporting Records in Excel format

To export the data between the red and the blue cursors to EXCEL, go to the <File> pull-down menu and select <Export to Excel>. A pop-up window appears allowing the user the allocate the EXCEL columns to the channels. Click <Output> to export the data.

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Figure 10.10-1 Exporting disturbance record data to Excel

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Figure 10.10-2 Disturbance record data in Excel

10.11 Export records in COMTRADE format

Go to the <File> pull-down menu and select <save as>. The record will be saved in the COMTRADE format.

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My Network	Save as type:	Comtrade file(*.cfg)				~		Cancel
💿 Binary	◯ ASCII	Selected						

Figure 10.11-1 Exporting disturbance records in COMTRADE format

10.12 Printing the records



ReplayD uses the printer from the Windows operating system. To print hard copies, it is necessary to configure the printer in Windows first.

Arrange the waveforms on the screen according to the user's requirements. Go to "File' and select <print> for a hardcopy of the record.



11. FTR Record analysis

11.1 Sequence Components analysis

To perform the sequence components analysis, click the <Analysis> pull-down menu in the CmdView window and select <Sequence Components>.

The pop-up window allows the user to group the channels into separate three-phase (A, B, C) groups. After the grouping is confirmed, the sequence components window will appear. By moving the red cursor, the sequence components at any point in the waveform, can be observed.

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Figure 11.1-1 Sequence components analysis

11.2 Harmonics Analysis

To perform harmonics analysis, click the <Analysis> pull-down menu in the CmdView window and select <Harmonic Analysis>.

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Figure 11.2-1 Harmonics analysis

CmdView allows three channels to be selected at one time for the harmonic analysis. The sampling rate of FTR-100 for triggered recording is 4kHz. According to Nyquist Criterion, the harmonics measured can be up to the 40th, although in practice the fidelity will be lost for harmonics above 28th.

11.3 Distance to Fault Location

There are two methods to perform distance to fault location. The first method is according the DMF file. Select the icon in the toolbar to obtain a pop-up window, as shown in Figure 11.3-1. Select the faulty line and click "DFL" button at the tip right to initiate an automatic distance to fault location.

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Figure 11.3-1 Distance to fault location using DMF file

The second method is to use pre-defined line parameters to perform a fault location analysis. In the <analysis> pull-down menu, select <Distance to fault>. Select one of the pre-defined lines to perform a fault location analysis.



Figure 11.3-2 Distance to fault location using pre-defined line parameters

11.4 Impedance Locus Analysis

In the "Analysis" pull-down menu, select "Impedance Locus Plot". In the pop-up window, select the line to be analysed. The positive sequence impedance locus for the line between the red and the blue cursors will be displayed.



Figure 11.4-1 Impedance locus

11.5 Combination channels

In the <Analysis> pull-down menu, select <Combination Channels>, a pop-up window appears allowing the user to combined several channels together with different scaling factors if desired.



For example, by adding Ia, Ib and Ic together, 3I₀ will be formed.

Figure 11.5-1 Combination channels

11.6 Calculated value presentation

In the <Analysis> pull-down menu, select <Calculation Channels>, a pop-up window appears. Select two channels as variables and select the calculated method (e.g., Watts, Vars, Phase angle difference etc.). The calculated values from the two channels will appear.

File Edit Graphics Analysis View Window Help Image: Second Sec	~	CmdView ver3.1.6.9	- 8 ×
BINARY Ware, MILL STUDIO, KEHULRCD_712_20171207_105537_930_5.cfg D017_12_07_106537_930685 mill 0 1/00 <td></td> <td></td> <td></td>			
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1014 421 0000 <t< td=""><td>2017-12-07 10-56 37 330568 \$ 79 18 56 489 V ≤ 23 350 54 489 V ≤ 23 350 54 489 V ≤ 25 350 34 BUSL UK = 79 201 55 503 V ≤ -56 549 55 503 V ≤ -56 549 55 503 V ≤ -56 476 55 503 V ≤ -156 476 55 503 V ≤ -156 476 54 901 V ≤ -156 476 1001 A ≤ 4271 1001 A ≤ 4271 1001 A ≤ 4271 1000 A ≤ -155 702 1000 A ≤ -155</td><td>Calculation channels Calc. 1 Calc. 2 Calc. 3 Calc. 4 Variable1: 33:2051, UA ↓ Variable2: 35:2051, 30 ↓ Output: PhasD ↓ Rating: 57.74</td><td></td></t<>	2017-12-07 10-56 37 330568 \$ 79 18 56 489 V ≤ 23 350 54 489 V ≤ 23 350 54 489 V ≤ 25 350 34 BUSL UK = 79 201 55 503 V ≤ -56 549 55 503 V ≤ -56 549 55 503 V ≤ -56 476 55 503 V ≤ -156 476 55 503 V ≤ -156 476 54 901 V ≤ -156 476 1001 A ≤ 4271 1001 A ≤ 4271 1001 A ≤ 4271 1000 A ≤ -155 702 1000 A ≤ -155	Calculation channels Calc. 1 Calc. 2 Calc. 3 Calc. 4 Variable1: 33:2051, UA ↓ Variable2: 35:2051, 30 ↓ Output: PhasD ↓ Rating: 57.74	
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Figure 11.6-1 calculation channels

11.7 Differential current analysis

There are two methods to perform differential current analysis. The first method is to select the <DMF information> icon in the menu bar current> button to perform the analysis.

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Figure 11.7-1 Differential current analysis

The second method is to select <Transformer differential currents> in the <Analysis> pulldown menu, or to click the "transformer differential currents" icon 🕎 the menu bar. A popup window appears allowing the user to manually set-up the channels and transformer configuration for differential current analysis.

File Edit Graphics Analysis Vie		_ 0 ×
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Figure 11.7-2 Transformer differential current analysis using the <Analysis> menu option

12. Real-Time Monitoring

12.1 Waveforms, phasors, power, harmonics

In ReplayD software, select <Monitor> in the toolbar. The screen shows a number of options at the bottom, allowing real-time monitoring of the channels in different formats:

<Wave> shows the real-time waveforms

<Vector> shows the positive, negative and zero sequence components in vectoral format.

<Power> shows the real-time single-phase and three-phase P and Q.

<Harmonics> shows the real-time harmonic contents up the tenth harmonics.

12.2 Fundamentals

At the bottom of the Monitor window, select the <Fundamentals> submodule, the real-time information of the analogue channels' original values (magnitudes and phase-angles), digital channel status, combined values and calculated values will all be displayed.

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MILL STUDIO	8000	36	BUS1_UN	0.003V	122.96				
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	Ca Calculation	38	HP_IB	1.000A	120.95				
		39	HP_IC	1.001A	-118.84				
		40	HP_IN	0.000A	168.51				
		41	[8001]Analog9	0.001V	46.01				
		42	[8001]Analog10	0.001V	-46.48				
		43	[8001]Analog11	0.001V	167.99				
		44	[8001]Analog12	0.001V	15.13				
		45	MP_IA	0.000A	81.30				
		46	MP_IB	0.000A	-33.99				
		47	MP_IC	0.000A	129.83				
		48	MP_IN	0.000A	116.25				
		49	LP_IA	0.000A	75.92				
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		52	LP_IN	0.000A	163.52				
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Figure 12.2-1 Real-time analogue channels' original values



Figure 12.2-2 Real-time phasor information and harmonics

12.3 Data Traffic and Device Status

At the bottom of the Monitor window, select the <Status> submodule, the real-time information of the communications traffic and the status of the FTR-100 can be displayed.

There are seven groups of information available: <Recorder info>, <SV info>, <Goose info>, <Port Info>, <Abnormal message>, <Calibrate analog> and <Network card info>.

<Recorder info> includes the working voltage, device temperature, software version, verification code, overall warnings (SV disconnect, GOOSE disconnect, RAU disconnect, time sync info etc.). Red indicates an abnormal condition.

<SV info> and <GOOSE info> include real-time indication of SV and GOOSE message abnormality, e.g. disconnect, lost packages, configuration incorrect, PDU invalid, loss of sequence, jitter, sync loss, abnormal dual A/Ds, bad data quality, abnormal single-point, value change, time-out etc. Each control block has an APPID, describing message traffic information, terminal information etc. Red indicates an abnormal condition.

<Port info> indicates the real-time data traffic in each network port of the device's process bus, wrong packages, data traffic for each data sampling card and the total data traffic. A green light before the <Port no.> indicates that there is data, grey means no data. <Message disconnect> with a red light means there is no GOOSE/SV messages at the terminal, see Figure 12.2-1.

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WARE		• 1-2	•	0	0	0	0	0	
- STANSTEAD	GOOSE info.	• 1-3	•	0	0	0	0	0	
	port info.	• 1-4	•	0	0	0	0	0	
		• 1-5		0	0	0	0	0	
	abnormal message	• 1-6		0	0	0	0	0	
	calibrate analog	• 1-7	•	0	0	0	0	0	
		1-8	•	0	0	0	0	0	
	network card info.	• 1-9	•	0	0	0	0	0	
		• 1-10	•	0	0	0	0	0	1,160,227
		• 2-1	•	1,161,478	10,012	0	0	0	
		• 2-2	•	1,161,478	10,012	0	0	0	
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Figure 12.3-1 Port Information

<Abnormal message>: If an abnormality occurs with the SV or GOOSE messages, the FTR-100 records a packet of the abnormal messages over a time period, as shown in Figure 12.3-2.

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	-		28	2017-1-3 14:30:35.893205	SV(4002)	frame lost:	open download	
WARE	-	SV info.	27	2017-1-3 14:30:35.893179	SV(4001)	frame lost;	open download	
			26	2017-1-3 13:29:48.343854	SV(4001)	Dual A/D difference	open download	
- STANSTEAD	1	GOOSE info.	25	2017-1-3 10:50:53.836960	SV(4001)	Dual A/D difference	open download	
			24	2017-1-3 08:15:30.318092	SV(4001)	Dual A/D difference	open download	
		port info.	23	2017-1-3 08:12:46.715509	SV(4001)	Dual A/D difference	open download	
		abnormal message	22	2017-1-3 08:11:58.173411	SV(4001)	Dual A/D difference	open download	
		aonormai message	21	2017-1-1 13:03:33.054293	SV(4001)	Dual A/D difference	open download	
		calibrate analog	20	2017-1-1 10:16:21.579583	SV(4001)	Dual A/D difference	open download	
			19	2016-12-30 16:44:28.510709	SV(4001)	Dual A/D difference	open download	
		network card info.	18	2016-12-30 16:25:31.330490	SV(4001)	Dual A/D difference	open download	
			17	2016-12-29 11:19:35.418493	SV(4001)	Dual A/D difference	open download	
			16	2016-12-29 08:24:00.449259	SV(4001)	Dual A/D difference	open download	
			15	2016-12-29 08:23:56.183002	SV(4001)	Dual A/D difference	open download	
			14	2016-12-29 08:23:50.796494	SV(4001)	Dual A/D difference	open download	
			13	2016-12-29 08:23:43.554733	SV(4001)	Dual A/D difference	open download	
			12	2016-12-29 08:23:38.918726	SV(4001)	Dual A/D difference	open download	
			11	2016-12-29 08:23:33.235967	SV(4001)	Dual A/D difference	open download	
			10	2016-12-29 08:23:28.369460	SV(4001)	Dual A/D difference	open download	
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Figure 12.3-2 Abnormal Messages

When opening one of the message packets, a window appears showing all the messages in chronological order, see Figure 12.3-3. By clicking the <fault time> an option is available for the message time to be displayed as real-time, the offset time from the first message (PI), or as the time between consecutive messages (P2P).

Through the <Fault info>, the user can use the green curser to quickly move to the next abnormal message.

ce View 📮 🖪	Monitor DF	R CFS/CSS	Man Trig	Version	Others					
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ne	No.	port		ength	P1		trigger inf	ormation		return
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KEHUI	2997	1-5		263	0,749					
WARE	2998	1-5	2	263	0.7493					
B MILL STUDIO	2999	1-5	2	263	0.7493	751	frame lost;			
	TPID:8100 TCI:800 IEC 61850 Sample			10	0	010h: 88 ba 40 02 0020h: a2 91 e4 30 0030h: 55 35 62 62 040h: 02 02 7 83 0050h: 00 00 00 0070h: 00 00 00 0060h: 00 00 00	81 e1 80 17 4c 4c 4e 30 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	5a 4e 4b 4 24 4d 53 2 01 85 01 0 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00 0	1 ea 80 01 01 4 55 33 50 44 4 73 76 31 82 1 87 81 88 00 0 00 00 00 00 0 00 00 00 00 0 00 00 00 00 0 00 00 00 00 0 00 00 00 0 00 00 00 0 00 00 00	
		J3PMUSV/LLN0\$MS\$s	v1			00c0h: 00 00 00 00 00d0h: 00 00 00 00 00c0h: 00 00 00 00	00 00 00 00 00 00 00 00	00 00 00 0	0 00 00 00 00 0 00 00 00 00 0 00 00 00 0	
3	Wave Vector	Power Harmonic	Status 0	riginalValue						
ut							_			
jger time	9 trigger e	lement			trigger type	trigger cause TimeSyncLoss: <i>reset</i>	S	earch restore) און event:) r	ecord:

Figure 12.3-3 Message packet information

13. Real-time Events

Select the "Events" window to examine recording logs and event logs. Fault records are shown in red. Non-fault records are shown in black.

Failures or abnormality of the FTR-100 itself are also displayed, e.g. RAU disconnected, abnormal SV/GOOSE messages etc.

Output							ņ
trigger time	trigger element	trigger type	trigger cause	search	restore	event: record:	
42@2017-12-7 10:51:48.819			TimeSyncLoss: reset				
41@2017-12-7 10:51:32.834			TimeSignalLoss: reset				
40@2017-12-7 10:51:31.881			TimeSyncLoss: trigger				
39@2017-12-7 10:51:31.881			TimeSignalLoss: trigger				
38@2017-12-7 10:48:43.763			TimeSyncLoss: reset				
37@2017-12-7 10:48:27.767			TimeSignalLoss: reset				
36@2017-12-7 10:48:27.235			TimeSyncLoss: trigger				
35@2017-12-7 10:48:27.235			TimeSignalLoss: trigger				
34@2017-12-7 10:44:07.778			TimeSyncLoss: reset				
33@2017-12-7 10:43:51.783			TimeSignalLoss: reset				
32@2017-12-7 10:43:51.673			TimeSyncLoss: trigger				
31@2017-12-7 10:43:51.673			TimeSignalLoss: trigger				
H 4 + H Comms status	Bvent						
Ready						CAP NU	UM S

Figure 13-1 Real-time events indicating trigger cause

Through the event search function, it is possible to quickly retrieve warning messages. By selecting the type of warning messages required, the message logs will be displayed.

Output																			ą
trigger time				trigger el	ement					trigger	type	trigger cau	se		search	restore	ili 🤇	event: erecor	d:)
42@2017-12- 41@2017-12-	event:															×			
40@2017-12- 39@2017-12- 38@2017-12-	sv	Disconnec	Bad Bad	Model Mismatch		Dual AD Diff	Duplicate Packet	Packet Loss	Out Of Order	🔲 Jitter	Time Out	Quality Alter	Glitch	Delay Alter	Delay Abnormal				
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34@2017-12															subr	nit			
													loss: <i>reset</i>						
												TimeSyncLo							
31@2017-12-7	10:43:5	51.673										TimeSignalL	.oss: <i>trigger</i>						

Figure 13-2 sample values (SV) and Goose messages (GO) abnormality indication

In the [cause of trigger] window's pull-down menu, the records' cause of trigger and distance to fault location results can also be displayed.

14. Commissioning Instructions



The FTR-100 is connected to the live electricity network, only authorised personnel, trained in working on such systems should undertake this work. It must be ensured that all the correct working precautions are taken before connecting the unit and that the testing will not interfere with the normal operation of the network. The commissioning engineer should ensure that safety signs and safety protection measures are in place on site before installing the equipment.



In addition, the engineer should be aware of simple procedures in handling electronic equipment to avoid damage due to electrostatic discharge. With the equipment in its original case and all the modules plugged-in, it is completely safe from discharges. However, if it is necessary to remove a module for inspection, simple procedure should be taken. For example, touching the earthed panel or the earthed equipment case before removing the module ensures the engineer is at the same electrostatic potential as the equipment. Modules should be handled by their front plate, frame or the edges of the printed circuit board. Touching the electronic components, printed circuit tracks or connectors should be avoided.

The following steps should be taken in the commissioning process:

- i. Check the shipping list against the equipment received to ensure that all the items on the list are accounted for (see section 15).
- ii. Carefully inspect the equipment to ensure that no damage has occurred during transit. If damage has been sustained during transit, a claim should be made to the transport contractor and the Kehui representative should be notified.
- iii. The commissioning engineer should be familiar with the overall hardware architecture and the operation of the ReplayD software before commissioning. This information is detailed in this User Manual.
- iv. Check that the FTR-100 host, RAU Remote Acquisition Unit, LAS-100 Local Analysis Station, Video display Unit (VDU), keyboard and the sealing plate (if applicable) are correctly installed on to the panel, according to the connection diagram as shown in figure 14.1 (n.b. figure 14 is for illustration purposes only, individual schemes may vary). Check that the following are connected:
 - the optical fibre between the FTR host and the RAU acquisition unit(s).
 - the network cable between the FTR host and LAS analysis station.
 - the VDU and the keyboard to the LAS analysis station.
 - the power supply cables to the power supplies.
- v. Tidy-up all optical fibres, network cables, and power supply cables. Check all connecting cables to ensure that each connection is correct and reliable.



Figure 14.1 System connections

- vi. After the check on the installation and wiring is completed, power-on the FTR-100 recorder system equipment for testing.
- vii. Execute the ReplayD software on the LAS system according to Section 8 of the manual. Input the line name, line attribute, trigger value and other information of each channel into the FTR-100 host. After checking with the field staff that the settings are correct, each channel is individually tested by secondary injection as explained below.
- viii. The inputs and outputs of the FTR-100 system needs to be isolated from the primary equipment during secondary injection testing.



Warning: During the isolation process, the secondary circuit of the current transformer must not be open-circuited since the high voltage produced may be lethal and could damage insulation.

- ix. A relay tester is used to inject a fixed value AC voltage or current into each channel to ensure that the magnitude measurement of each channel is accurate. The Monitor feature of the ReplayD software allows the real-time signals of the channels to be viewed
- x. After the channel testing is completed, perform a fault recording tests by triggering each individual channel by applying a signal in excess of its threshold setting. Ensure that the channel can trigger according to the intended value. Retrieve the waveform file, check the start threshold, phase sequence, amplitude, and recording duration to ensure that the recording is correct.

- xi. If the recorder is to be connected to the Scada system or to a central computer in the control centre, set up the recorder's IP address network gateway and communication port assigned by the network engineer. Conduct joint testing with the network engineer for communications with the central computer. Ensure that the network communication is working well and the central computer can retrieve the recorded data smoothly.
- xii. After the testing of the recorder is completed, the on-site staff can release the equipment safety measures and restore the equipment to a normal state. After the equipment is on-line and connected to the power system, manually trigger the recorder, check the waveform file, and confirm that the waveform is consistent with the power system steady state.
- xiii. The field staff put the FTR-100 fault recorder device into normal operation.

15. Transportation and Storage

15.1 Transportation considerations

Use the transport boxes provided and observe the environmental conditions specified in the technical data sheet.

15.2 Storage conditions, storage period and precautions

Observe the environmental conditions specified in the technical data sheet when storing the instrument. The instrument should be stored in a dry environment providing suitable protection against mechanical damage and dust. Where the instrument is not used on a regular basis, it should be stored indoors using the original packaging, and should not be exposed to the sun or rain. The room should be air-conditioned and should not contain corrosive gas. The instrument should not be subjected to severe mechanical vibration or shock and there must not be a strong electromagnetic field. If the instrument is not used for a long time, make sure that the Receiver and Clamp are turned off and the battery removed from the Clamp. Fully charge the Receiver every 10 months.

15.3 Unpacking and Inspection

Before unpacking for the first time, follow the steps below.

- i) Take out the document bag containing the instructions and packing list.
- ii) Check the packing list to ensure that the contents are complete and intact.
- iii) Check that the serial number is consistent with the instrument and the factory number of the warranty card.

16. Packing List

No.	Description	Photo	Quantity
1	FTR-100 Power System Transient Fault Recorder		1
2	Remote Acquisition Unit	RAU	1-3
3	LAS-100 local storage unit		1
4	ReplayD software	Provided electrtonically	
5	Display unit, 19"		1
6	Manual	ξebw) · · · · · · · · · · · · · · · · · · ·	1