

Electrode Line Monitoring

Training Manual Benmore Converter Station Haywards Converter Station

=10X91+S1

=20X91+S1

New Zealand Inter Island HVDC Pole 3 Project
Transpower New Zealand Ltd.

700 MW
Contract: P3/CT001

Index of Revisions

Rev.	Date	Revisions	Name of Reviser	Name of Approver
0	16 Feb 2013	First issue	C. Kittel	R. Zimmer
A	14 Mar 2013	For Construction	C. Kittel	R. Zimmer

Siemens AG, Energy Sector - Power Transmission Solutions

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1 General Information

This document describes the training for the Electrode Line Monitoring Systems installed in the following cubicles:

Haywards

=10X91+S1

Benmore

=20X91+S1

2 Reference Documentation

Hardware Design Report	Document No.: E_C2_0335_HAY
Hardware Design Report	Document No.: E_C2_0335_BEN
Design Specification	Document No.: E_D4_0335_XDC
System Information Manual	Document No.: E_B2_0335_XDC
Installation and Maintenance Manual	Document No.: E_B4_0335_XDC
Description of installed HW-components	Document No.: E_B4_0300_XDC
– Hardware and Software Manuals:	
– E_B4_0300_08_14_XDC_PEMO 2000 Installation Manual	
– E_B4_0300_08_15_XDC_PEMO 2000 Installation and Operating Manual	

3 Training Program

- Definitions
- Overview
- Hardware Components
- Software Description
- System Communications
- Fault Detection and Transmission
- Data Processing and Visualization
- Installation & Maintenance
- Troubleshooting
- Safety Instructions
- Practical Demonstrations



4 Appendices

Appendix	Title
E_B1_0335_App1_XDC	Training Presentation Electrode Line Monitoring

New Zealand
Inter Island HVDC Project Pole 3

SIEMENS

Training Electrode Line Monitoring PEMO 2000

E_B1_0335_App1_XDC

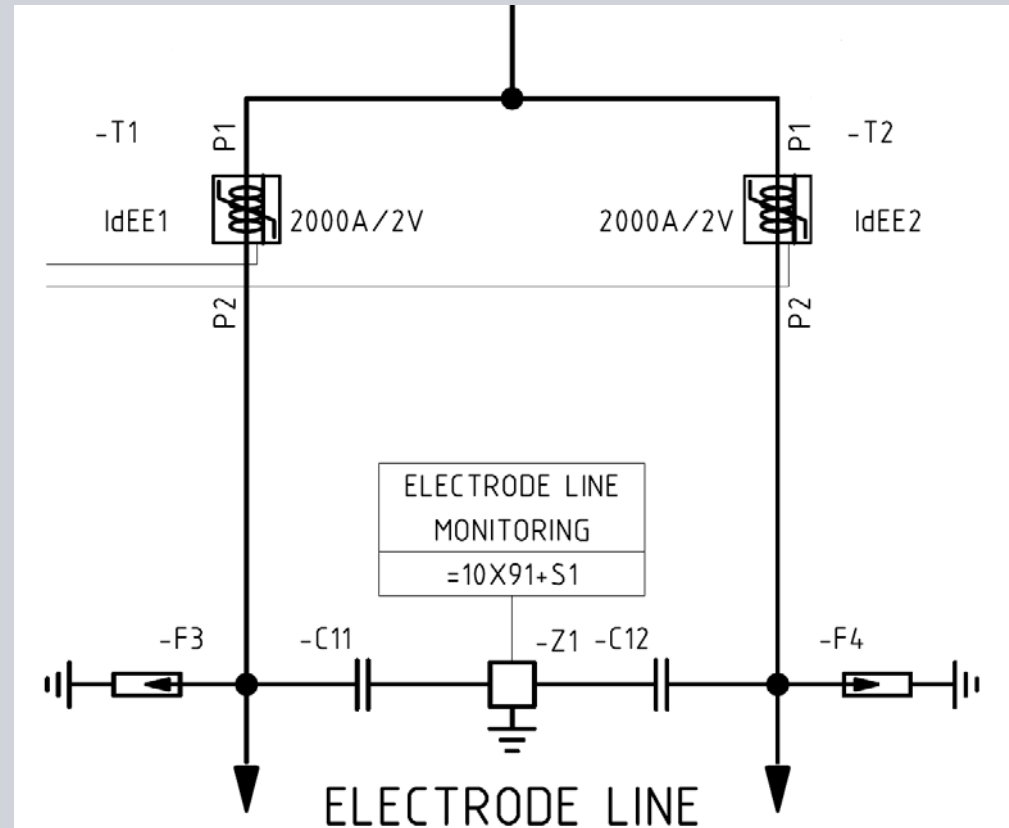


For Transpower internal use only

Disclaimer

Slides are for training purpose only, they are prepared on a general basis and may not in all cases cover all project specific aspects. Project specifics will also be shown in the direct on site training and in the manuals. The manuals also contain important safety instructions which need to be studied before beginning of the maintenance and inspection activities.

- Definitions
- Overview
- Hardware Components
- Software Description
- System Communications
- Fault Detection and Transmission
- Data Processing and Visualisation
- Installation & Maintenance
- Troubleshooting
- Safety Instructions
- Practical Demonstrations



- **PEMO** Pulse Echo Monitoring
- **AKE 100** Coupling Unit
- **TDR** Time Domain Reflectometry
- **EL** Electrode Line
- **C&P** Control and Protection Systems
- **SNTP** Simple Network Time Protocol
- **PC** Personal Computer
- **SW** Software
- **HW** Hardware
- **SER** Sequence of Events Recording
- **LAN** Local Area Network

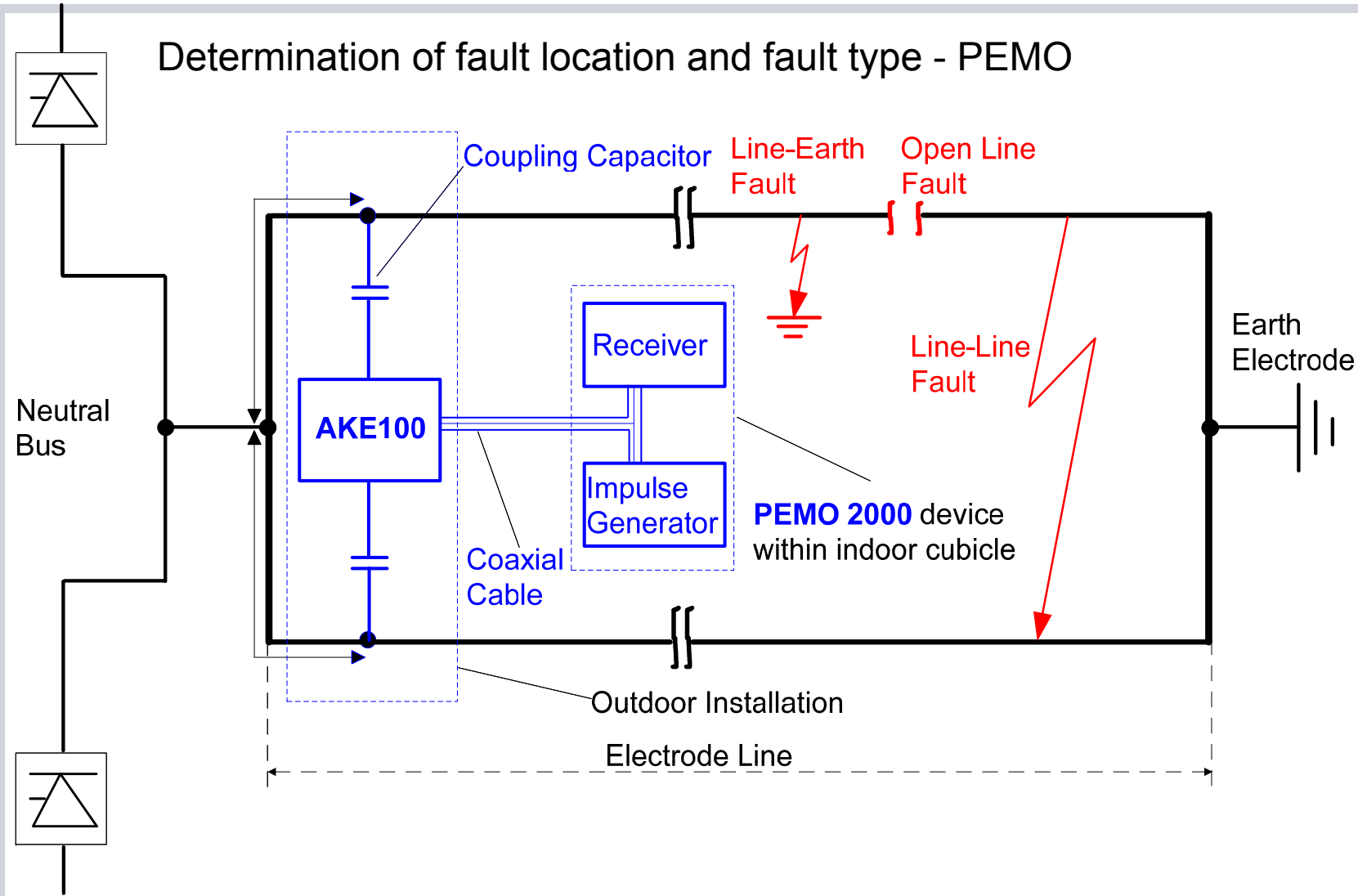
Overview

Purpose of the Electrode Line Monitoring System

- Detection of Line-Earth Faults on Electrode Line
- Detection of Open Line Faults on Electrode Line
- Both shall be detected by DC Protection Functions
60EL Electrode Line Unbalance Protection
- Problem:
 - ▶ If Electrode Line Current is low:
very low Line-to-Earth Voltage → fault current below protection threshold
 - ▶ If Electrode Line Current zero (e.g. in Bipolar Balanced Operation):
no Line-to-Earth Voltage → no fault current
 - ▶ 60EL can not detect the fault
- Solution: Pulse Electrode Line Monitoring
 - ▶ SER Message on the HMI to inform operator – NO TRIP

Overview

Pulse Echo Electrode Line Monitoring System



Hardware Components

PEMO 2000

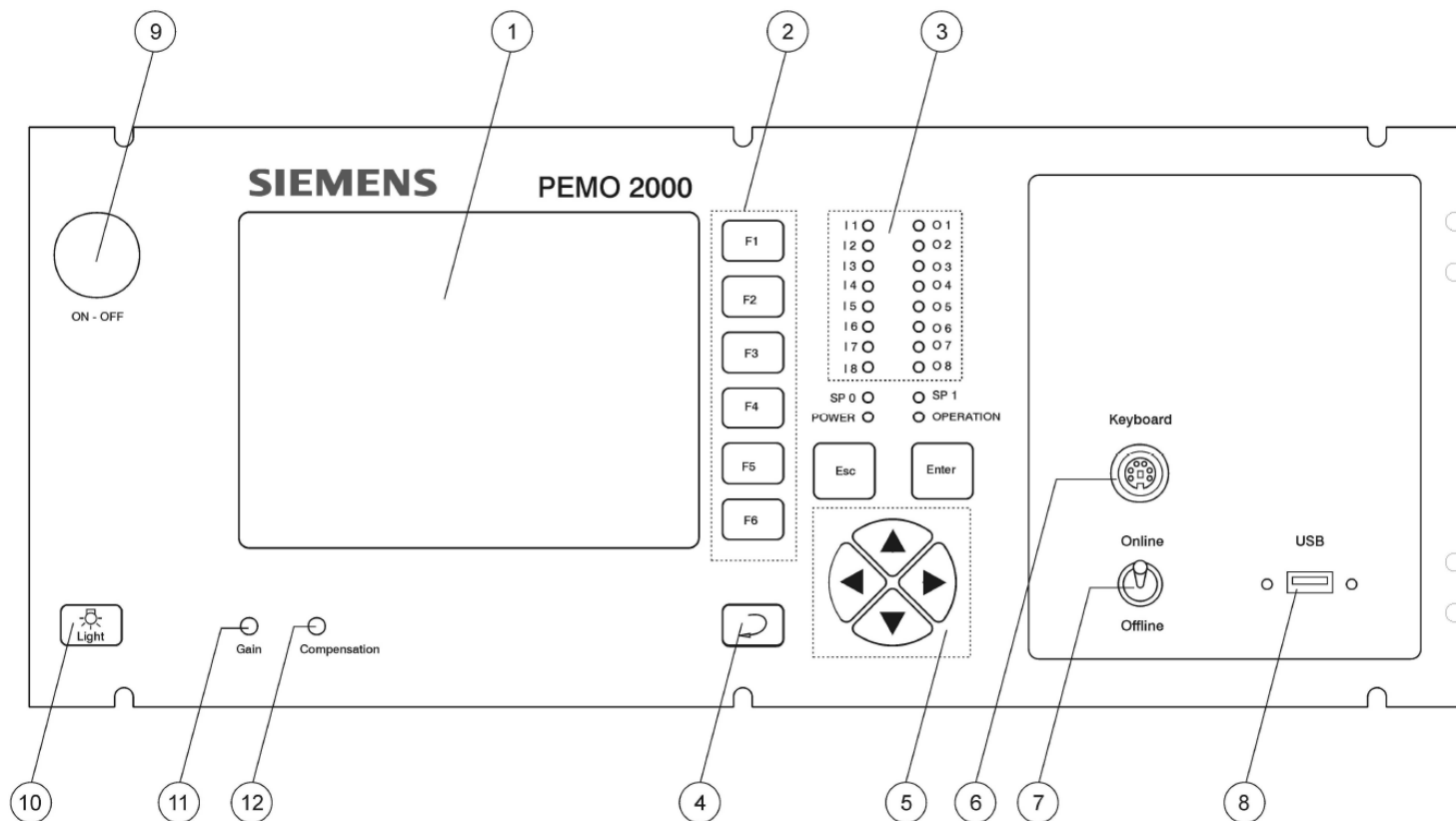


PEMO 2000, located in Pole 3 Control Room
=10X91+S1 -A10 =20X91+S1 -A10



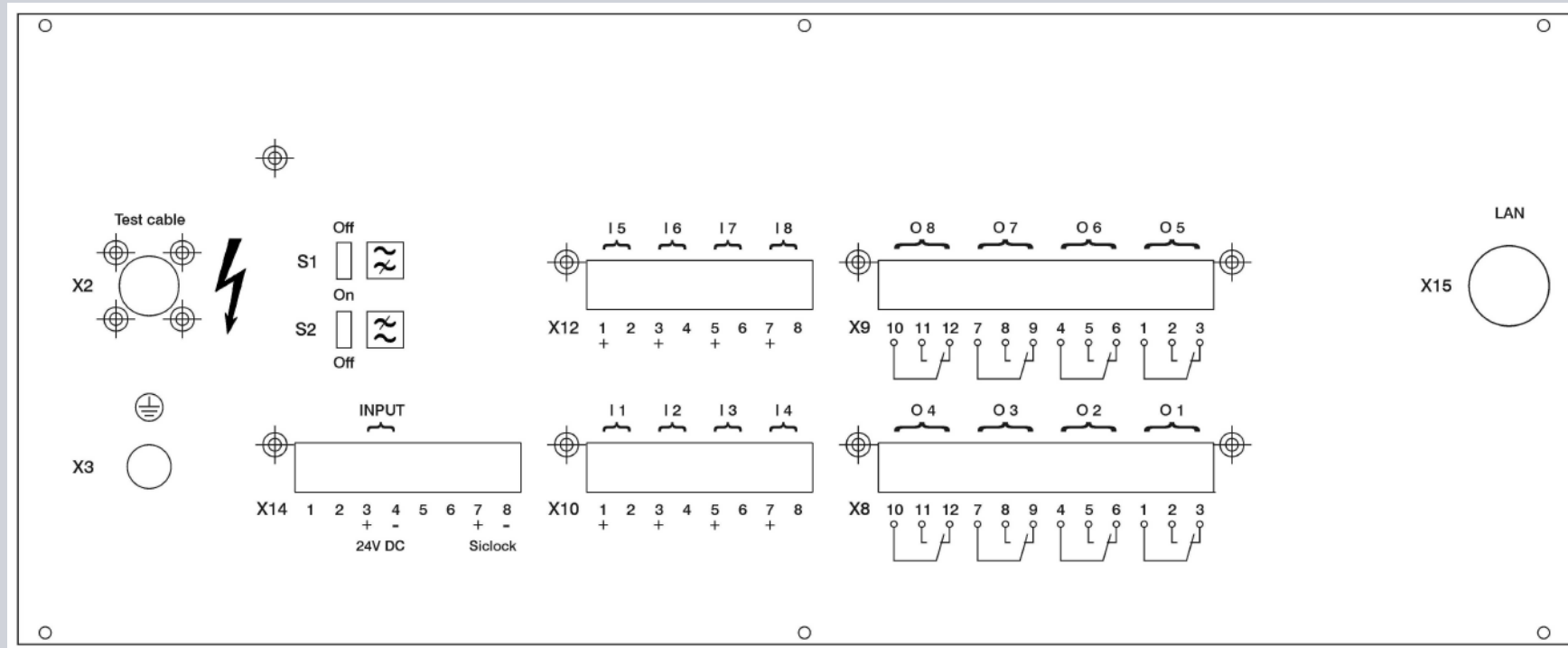
Hardware Components PEMO 2000

SIEMENS



- 1 Display
- 2 Softkeys F1....F6
- 3 Control LED's of the I/O – ports at rear panel
- 4 Continue for next page – key
- 5 Arrow key pads
- 6 Ext. keyboard connector PS / 2
- 7 Online switch – must be pulled out for operation
- 8 USB connector
- 9 ON-OFF switch
- 10 Light key. Activates the backlight
- 11 Adjustment of Gain
- 12 Adjustment of Compensation

Hardware Components PEMO 2000 - Interfaces



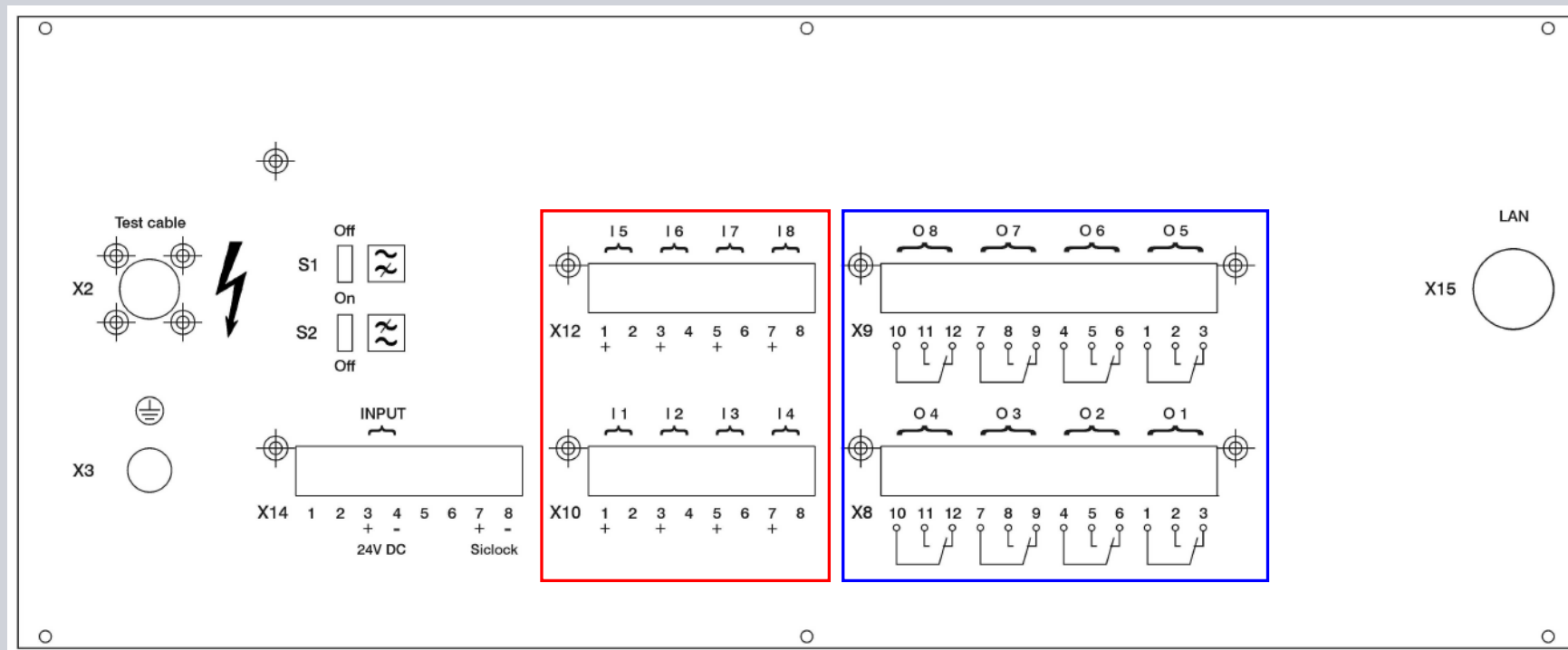
X2: Coaxial Cable to HF Connection Plate
 X3: Earth connection to cubicle frame
 X8, X9: Binary Outputs
 X10, X12: Binary Inputs (not used)
 X14: Input of 24V DC Power Supply
 X15: Ethernet Connection to LAN 3

S1: Analogue filter switch – low cut-off frequency
 S2: Analogue filter switch – high cut off frequency

Setting: S1: OFF, S2: OFF

Hardware Components

PEMO 2000 – Binary Inputs and Outputs

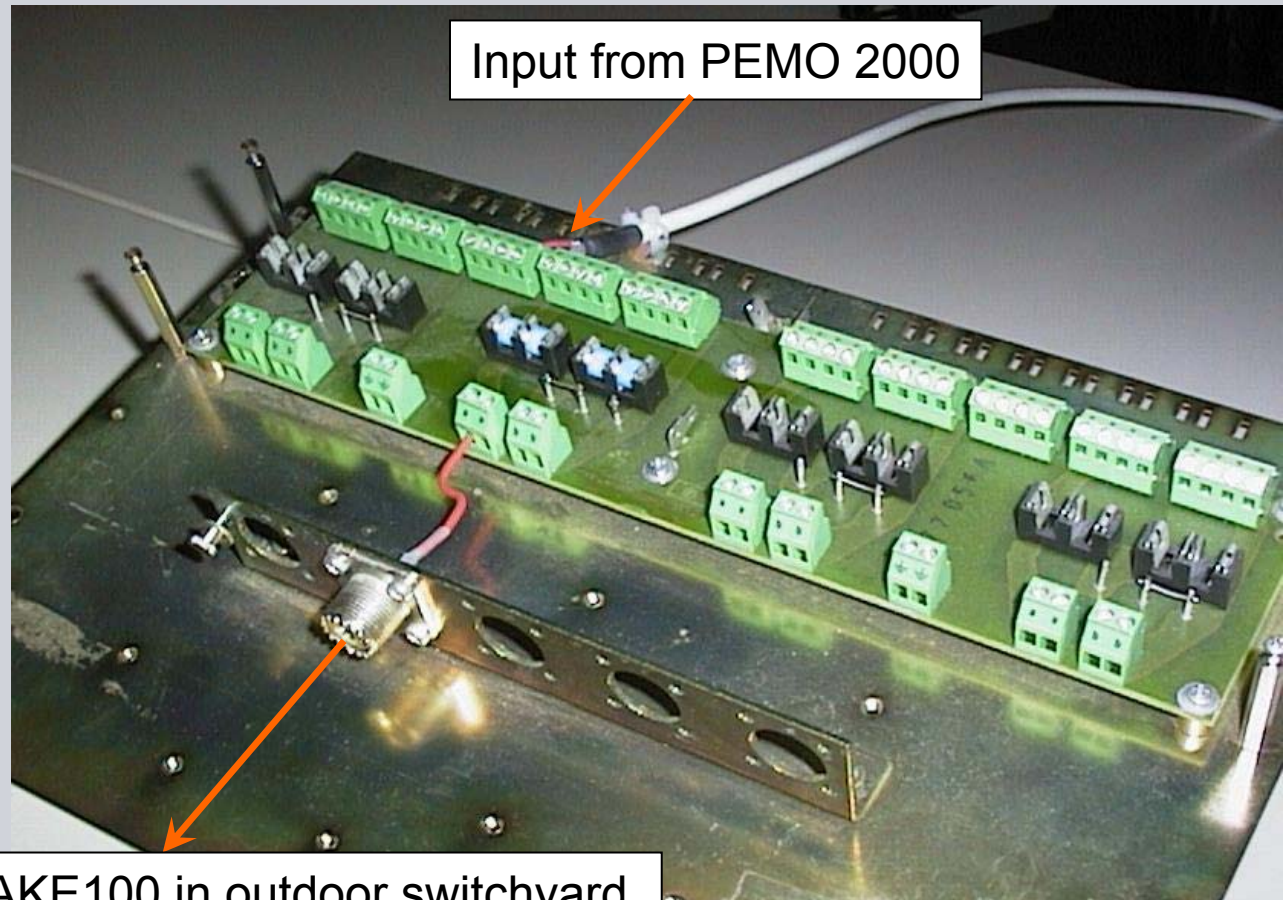


I1, I7, I8 Not used
 I2 Monitoring Interrupt Stage 1 (not used)
 I3 Monitoring Interrupt Stage 2 (not used)
 I4 Configuration Code Bit A0 (not used)
 I5 Configuration Code Bit A1 (not used)
 I6 Configuration Code Bit A2 (not used)

O1 PEMO 2000 Device OK
 O2 PEMO 2000 Online
 O3 System Warning
 O4 Alarm
 O5 Not used
 O6 GPS Clock Warning
 O7, O8 Not used

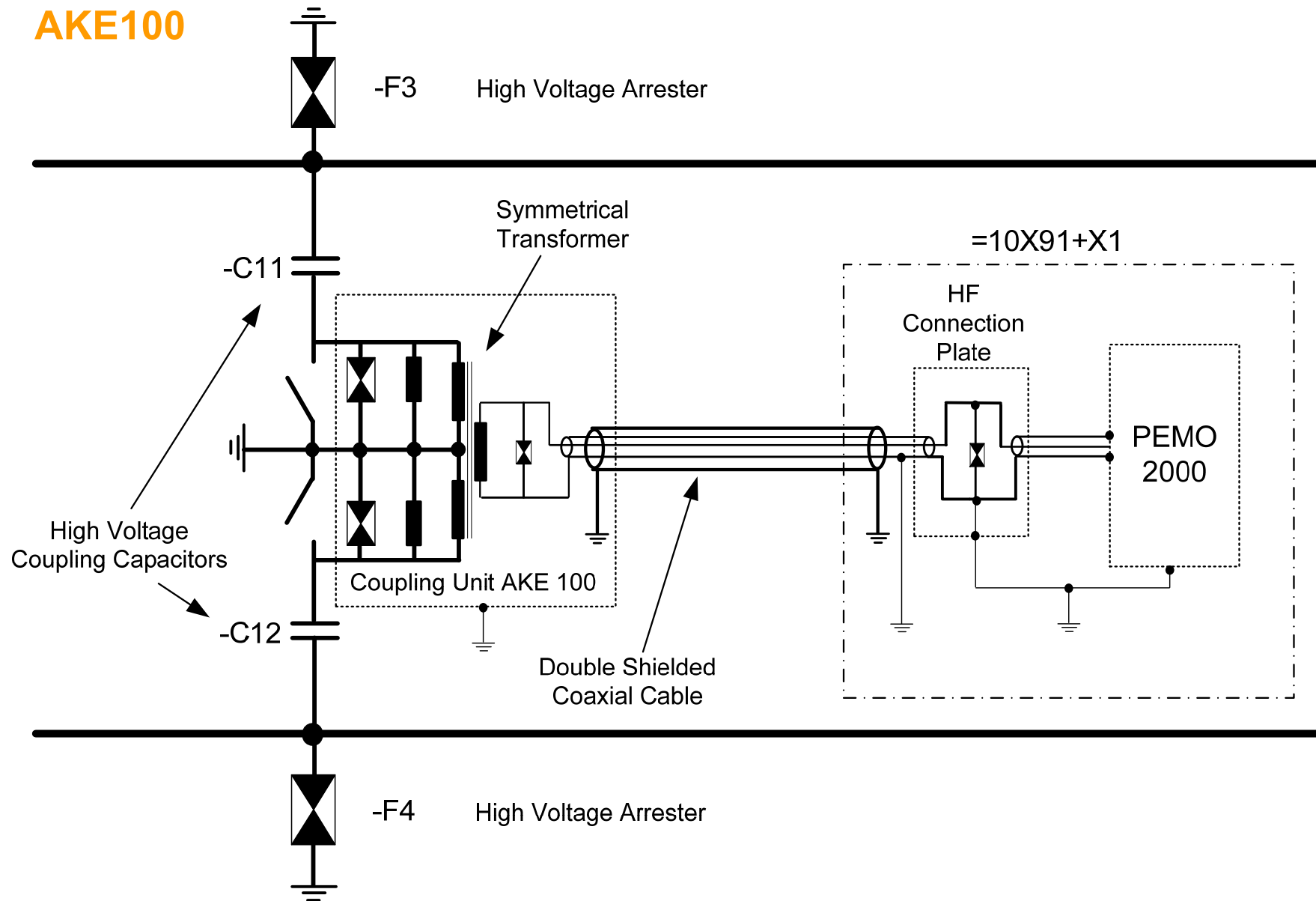
Hardware Components High Frequency Connection Plate

- Located in =10X91+S1 indoor cubicle between PEMO 2000 and AKE100
- Contains surge arresters to protect PEMO 2000 from transient overvoltage



Output to AKE100 in outdoor switchyard
via double shielded coaxial cable

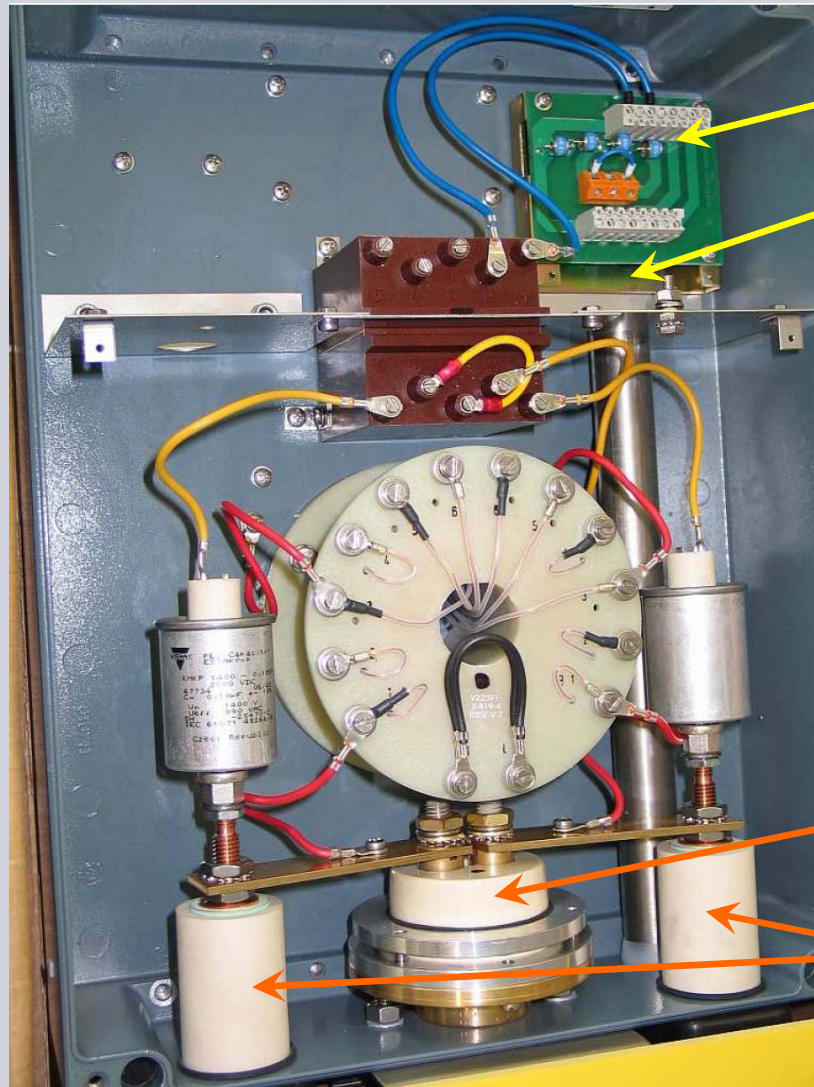
Hardware Components AKE100



Hardware Components AKE100



- AKE100
 - ▶ Analogue coupling unit
- Internal view of AKE100
- Located in outdoor switchyard below coupling capacitors
- Includes two manually operated earthing switches located at the bottom
 - ▶ for earthing of connection between AKE100 and HV coupling capacitors



Input:
Arresters

Incoming Coaxial cable

Internal:
Symmetrical Transformer

Coupling capacitors

Outputs:

Arrester

Connections to
-C11 and -C12
HV coupling capacitors

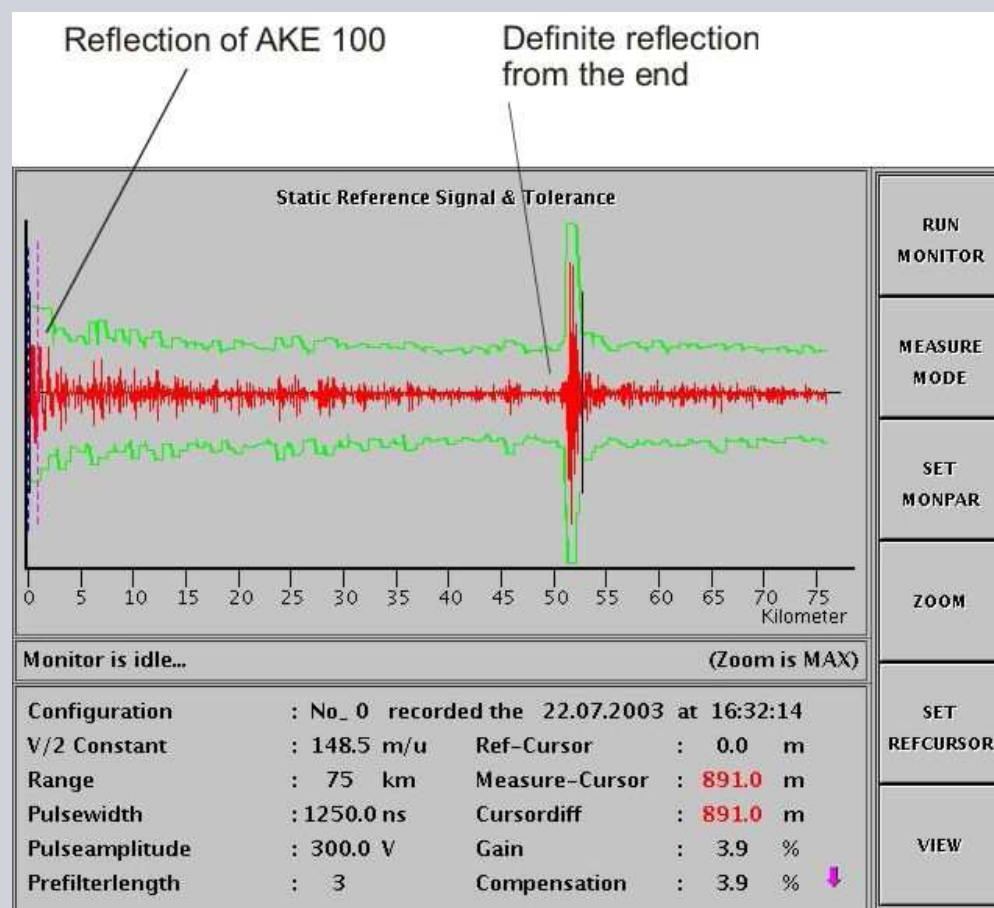
Software Description

PEMO 2000



Main Menu

- RUN MONITOR starts line monitoring
- MEAS MODE enters measuring mode
- SET MONPAR set tolerance and reference parameters
- ZOOM zoom into part of trace
- SET-REF set reference and measure cursor
- VIEW display alarm- and trace files – store alarm and trace files to USB Stick



Software Description

PEMO 2000



MEAS - Mode

- Mode for optimisation of parameters
- Observe effect of changed parameter on the trace immediately
- Parameters determined in measure mode shall be transferred to monitoring mode
- Allows location of line faults
- Manual storing of traces possible (.TRC File)
- Only Echo-Signal recorded
- Easy and fast to use for set-up

START	starts measure mode, does a single shot
SETPAR	set v/2, RANGE, PULSE WIDTH, PULSE HEIGHT and FILTER
ZOOM	zoom into part of trace
SET-REFCURS	set reference and measure cursor
STORE TRACE	stores trace visible on display
EXIT	exit to main menu

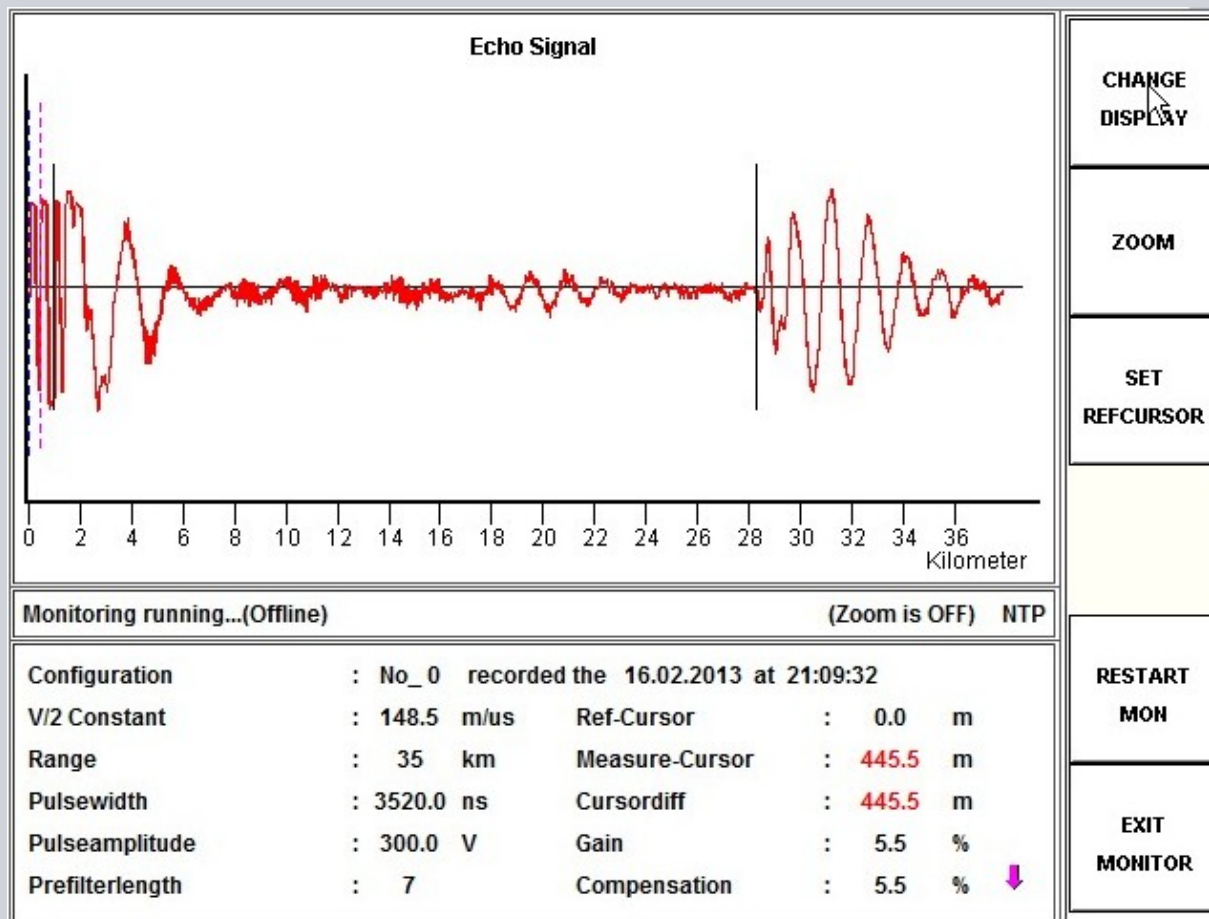
MONITORING - Mode

- Mode for constantly monitoring the line (ONLINE)
 - 4 different views:
 - ▶ Echo Signal
 - ▶ Difference Signal and Tolerance
 - ▶ Dynamic Reference Signal & Tolerance
 - ▶ Static Reference Signal & Tolerance
 - Alarm file automatically recorded upon line fault detection (.ALR File)
 - Trace file automatically recorded when long-term developing fault is detected (.TRC File)
- Settings evaluated in MEAS Mode have to be taken over to Monitoring Mode using the Menu SET-MONPAR
 - Settings have to be confirmed by ENTER and EXIT & STORE
 - Monitoring has to be started by pressing RUN MONITOR
 - 40 single shots are done to evaluate echo and calculate reference and tolerance signals
 - Single pulse is sent out every 2 seconds when monitoring is active
 - Echo is constantly evaluated

Software Description

PEMO 2000 – Monitoring Mode

Display View: Echo Signal



CHANGE DISPLAY

ZOOM

SET REFCURSOR

RESTART MON

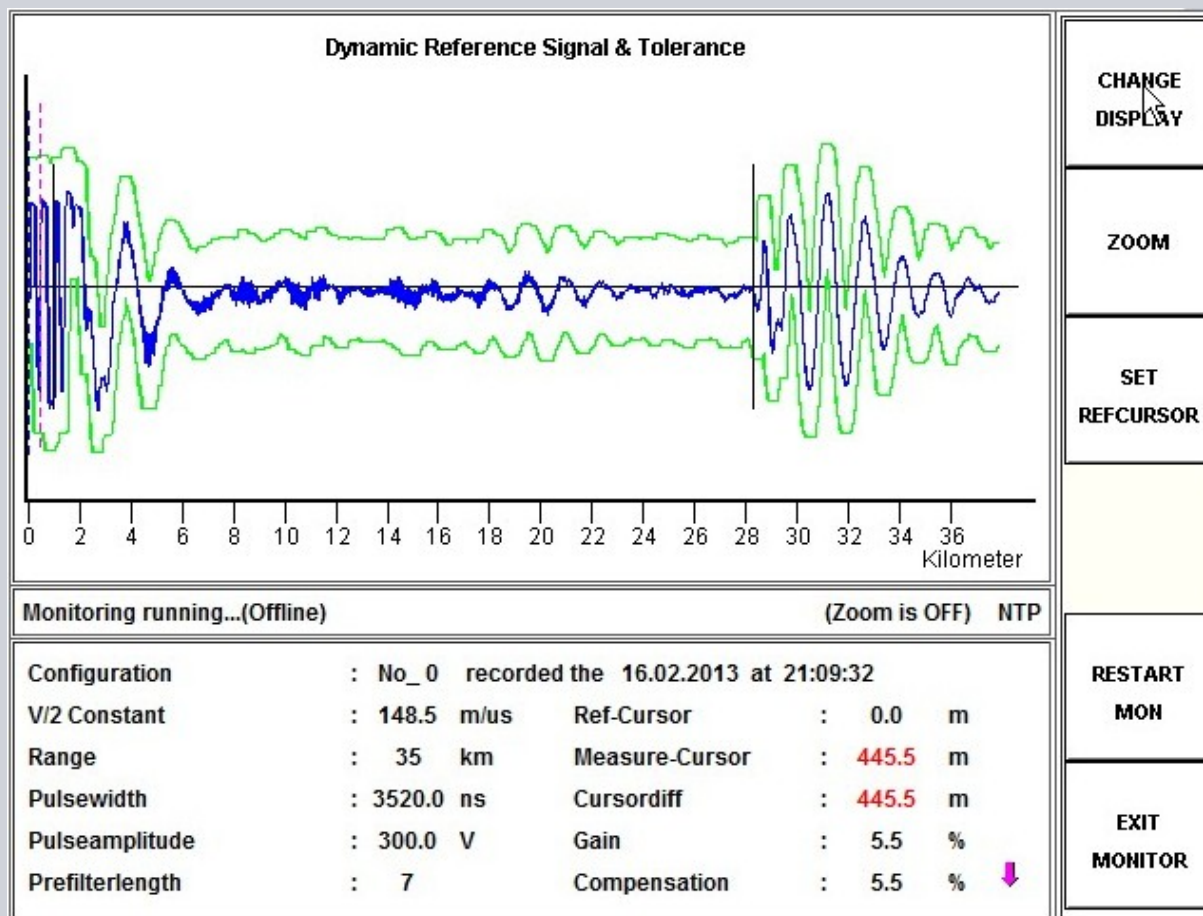
EXIT MONITOR

Software Description

PEMO 2000 – Monitoring Mode



Dynamic Reference Signal & Tolerance



CHANGE
DISPLAY

ZOOM

SET
REFCURSOR

RESTART
MON

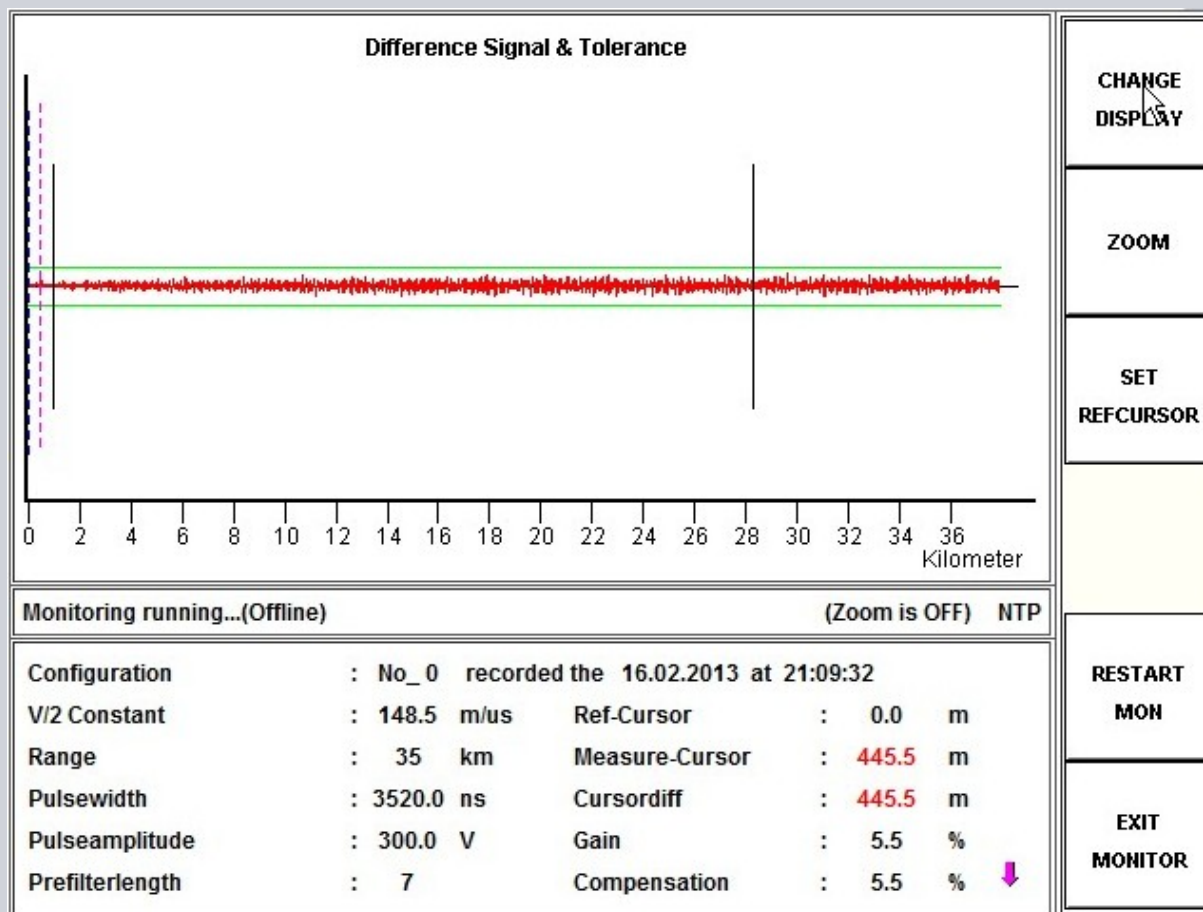
EXIT
MONITOR

Software Description

PEMO 2000 – Monitoring Mode



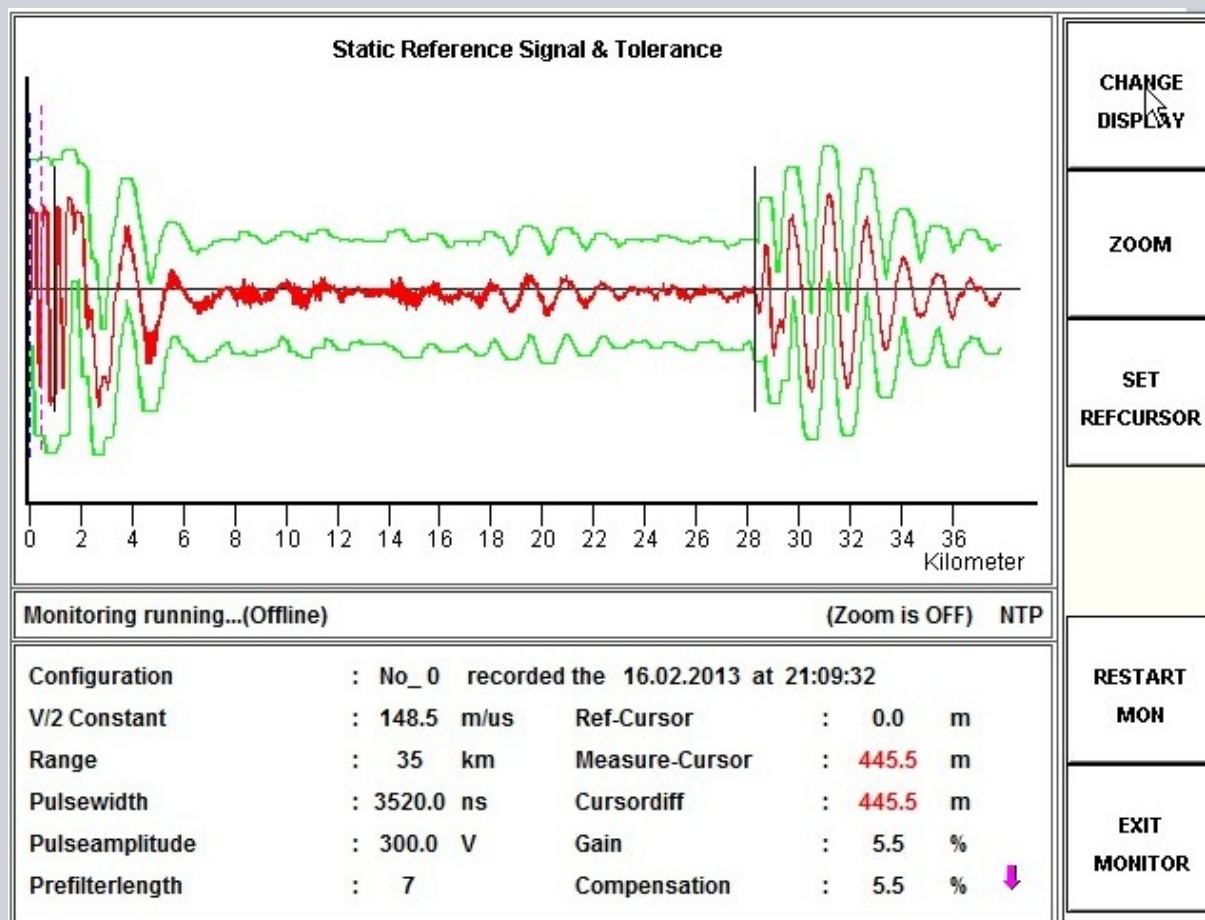
Static Reference Signal & Tolerance



Software Description

PEMO 2000 – Monitoring Mode

Difference Signal & Tolerance



Software Description

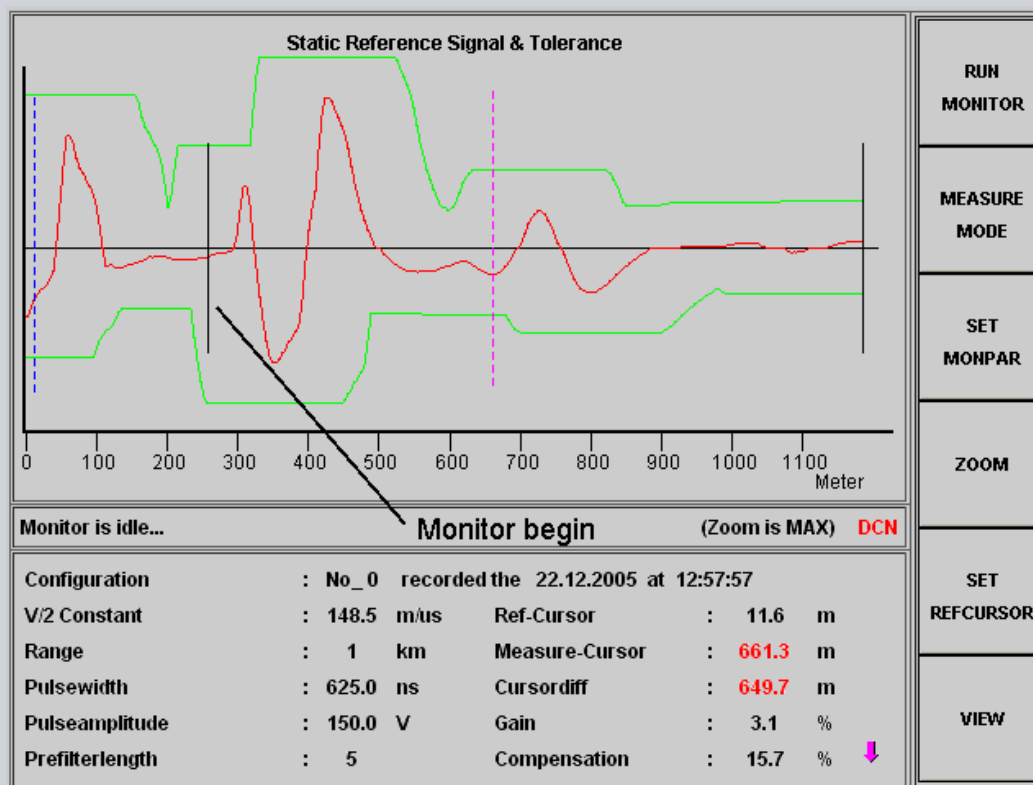
Set Monitoring Parameters

Setting the begin of electrode line monitoring

SET MONPAR

MON BEGIN set begin of line monitoring

- Non-relevant reflections before the electrode line are ignored
- Must be set between the end of primary output pulse and first reflection of AKE 100
- Moving of limit using arrow-keys



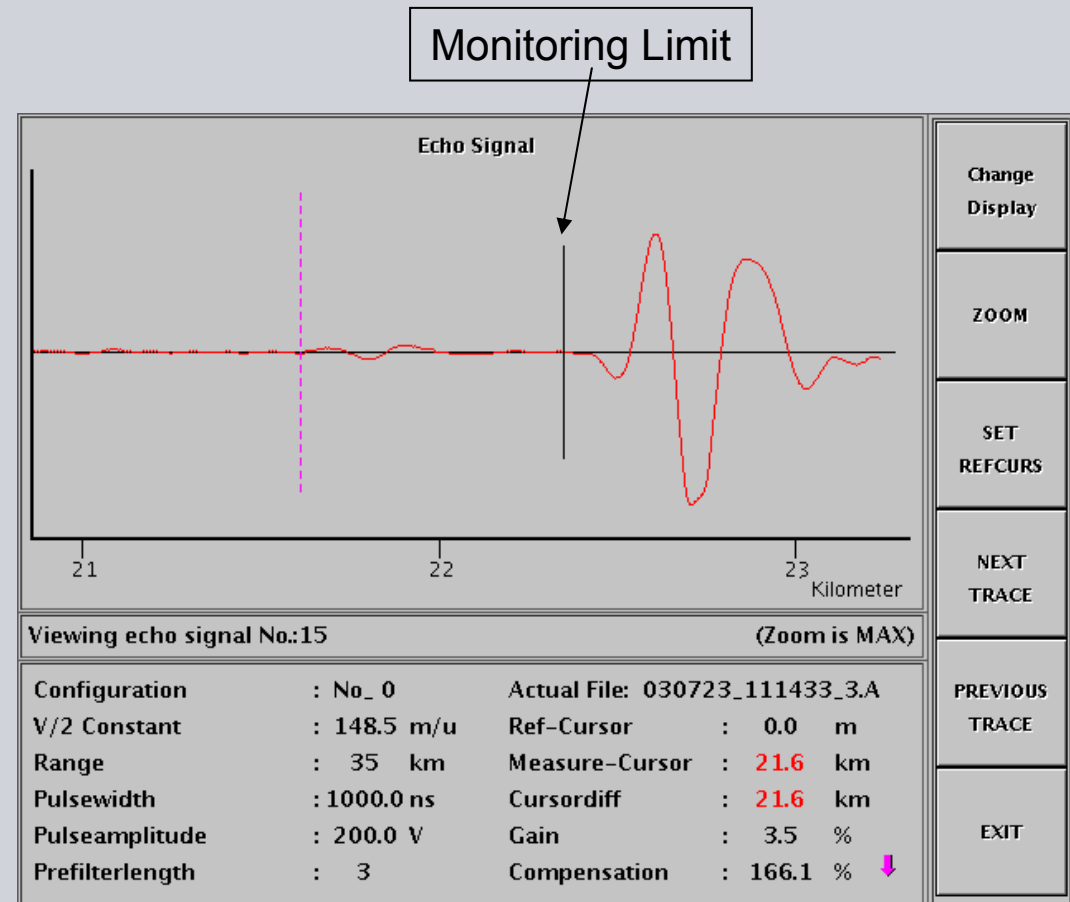
Software Description

Set Monitoring Parameters

SET MONPAR

MON LIMIT set end of line monitoring

- Non-relevant reflections after the earth electrode are ignored
- Must be set close to first reflection of the electrode line
- Moving of limit using arrow-keys



Setting the end point of electrode line monitoring

Software Description

PEMO 2000

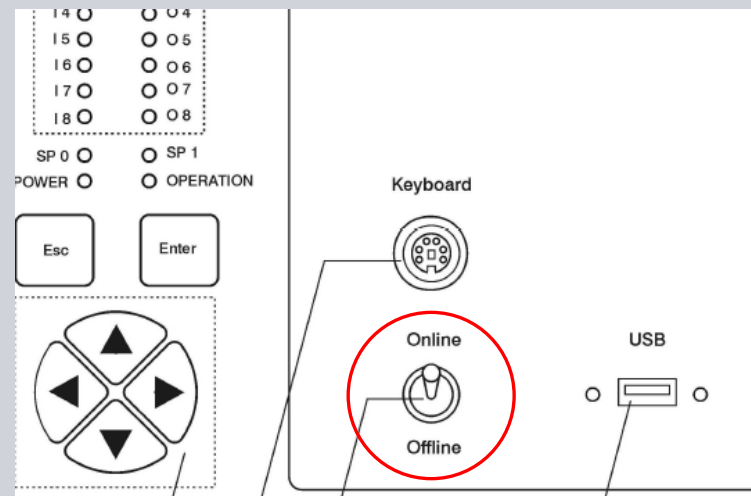
Online-Switch

ONLINE Outputs "Alarm" and "System Warning" are enabled

OFFLINE Outputs "Alarm" and "System Warning" are disabled

Note: Switch normally in ONLINE position, as outputs only activate SER message

Important! Switch has to be pulled out before operating to prevent inadvertent switching



- Keyboard connection on front panel to set up IP address (first time only)
- PEMO 2000 internal screen and keypad
- USB port to download alarm files
- Ethernet port for connection to LAN 3 (Office LAN)
 - ▶ http access via PEMO Applet, using web-browser
 - ▶ ftp access via windows explorer for updates
 - ▶ PEMOVIEW – Java based evaluation software

IP Addresses:

Haywards:

192.168.10.90

Benmore:

192.168.20.90

- Binary outputs for SER messages

System Communications

PEMO Applet – http Access



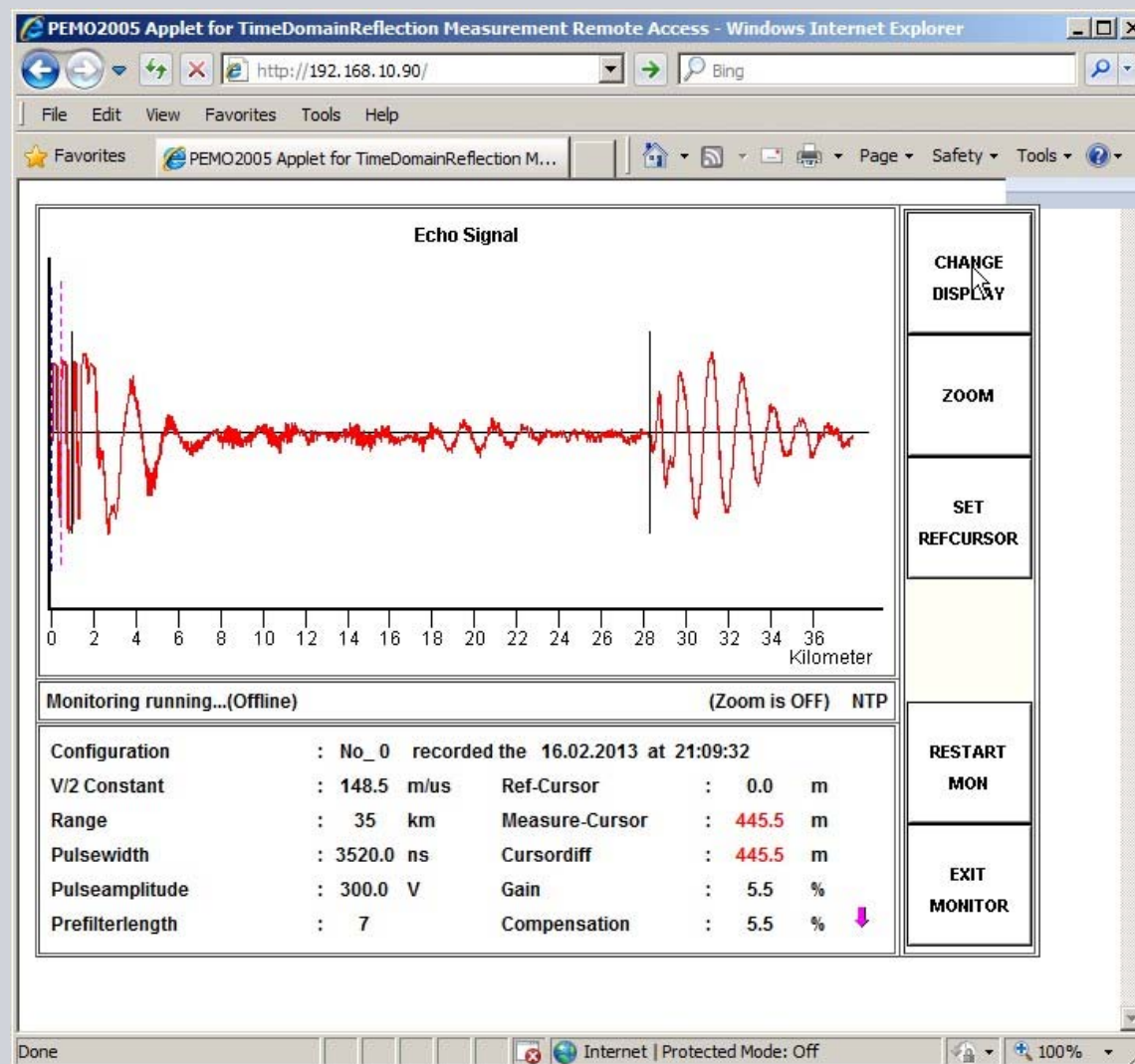
- Interface via LAN 3
- Online access to PEMO via web-browser
- Java based applet
- Full control and access
- Access: Enter IP Address in web-browser of TFR-Master PC or Terminal Server

Haywards:

<http://192.168.10.90>

Benmore:

<http://192.168.20.90>



System Communications ftp Access

- Interface via LAN 3
- Access to parameter files on PEMO via windows explorer
- ftp protocol
- read and write access if username and password is entered
- Access via windows explorer

Haywards:

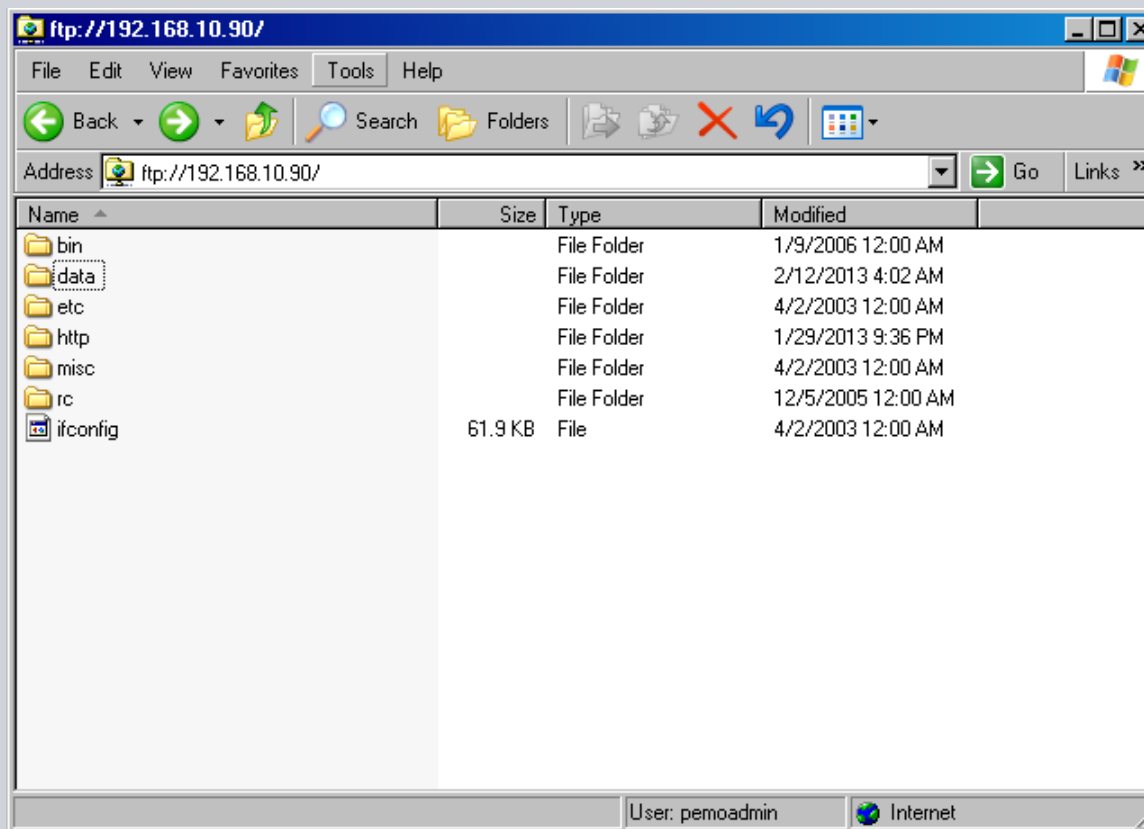
ftp://pemoadmin@192.168.10.90

password: siemensptd

Benmore:

ftp://pemoadmin@192.168.20.90

password: siemensptd

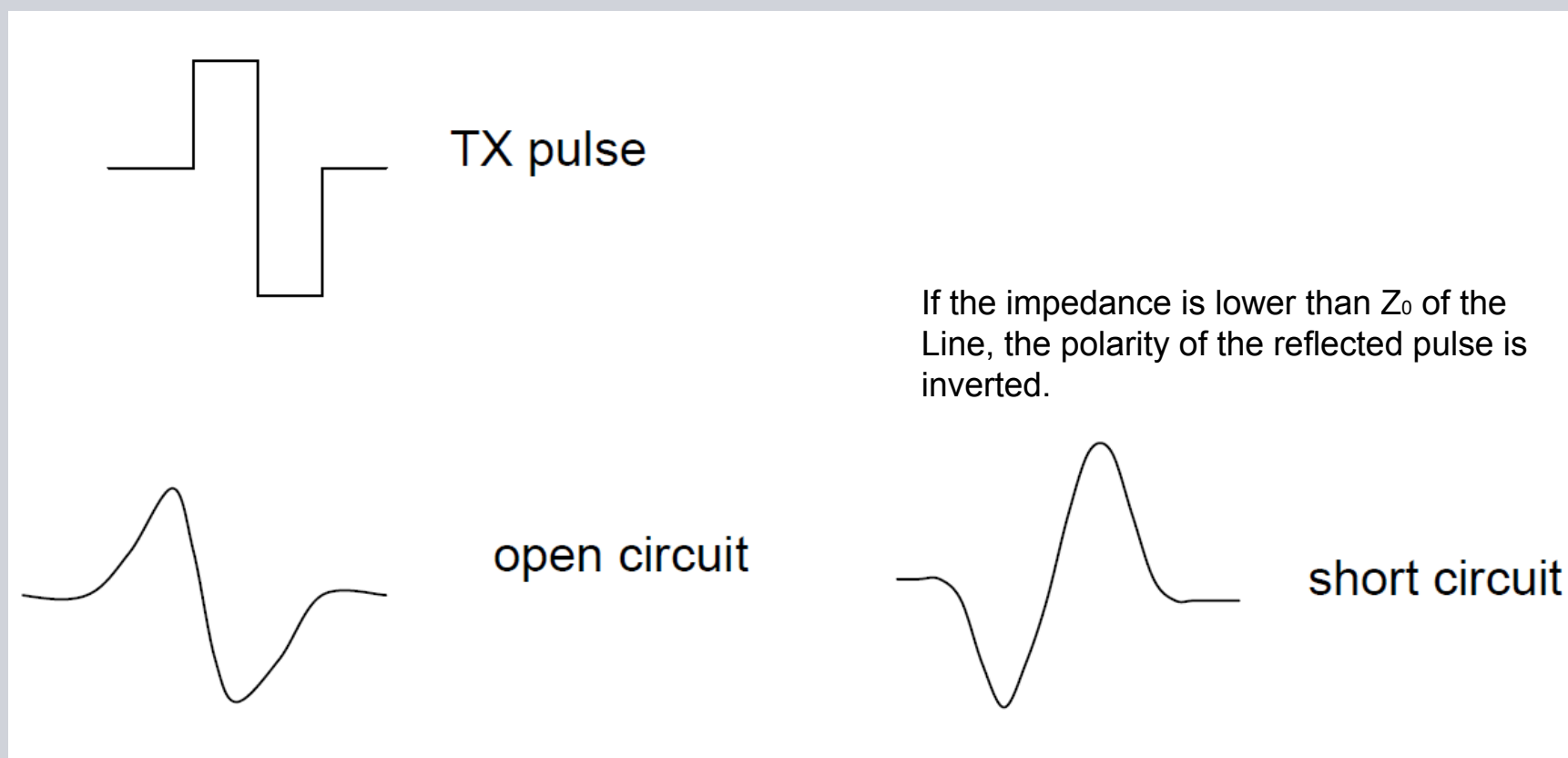


Attention: File system must not be modified, otherwise PEMO will not run up!
For more information please refer to E_B4_0300_08_15_XDC

Fault Detection and Transmission Transmit and Received Pulses

Basic Principle: **TDR: Time Domain Reflectometry**

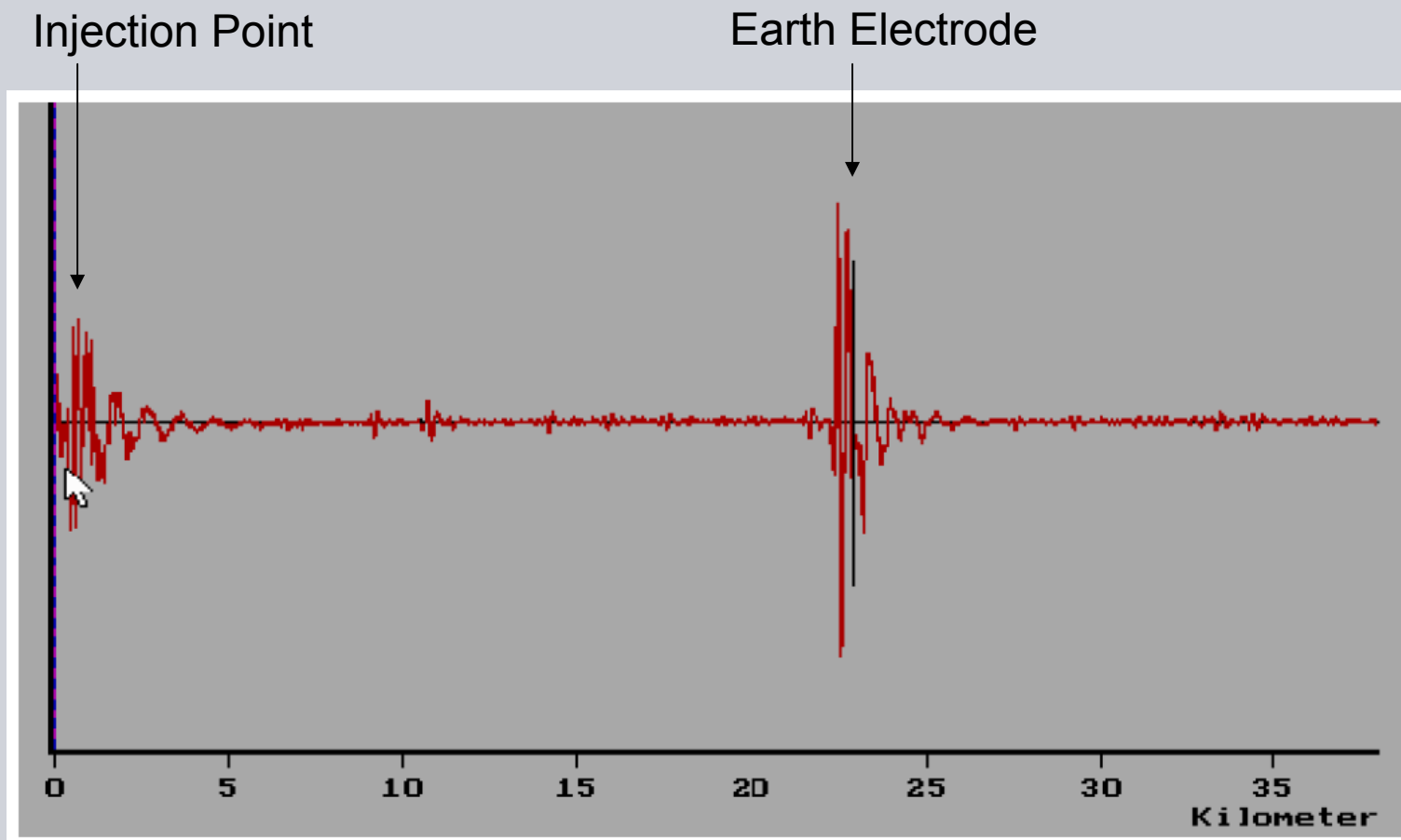
- Pulse sent out from the PEMO 2000 is reflected



For more information please refer to E_B4_0300_08_15_XDC

Fault Detection and Transmission

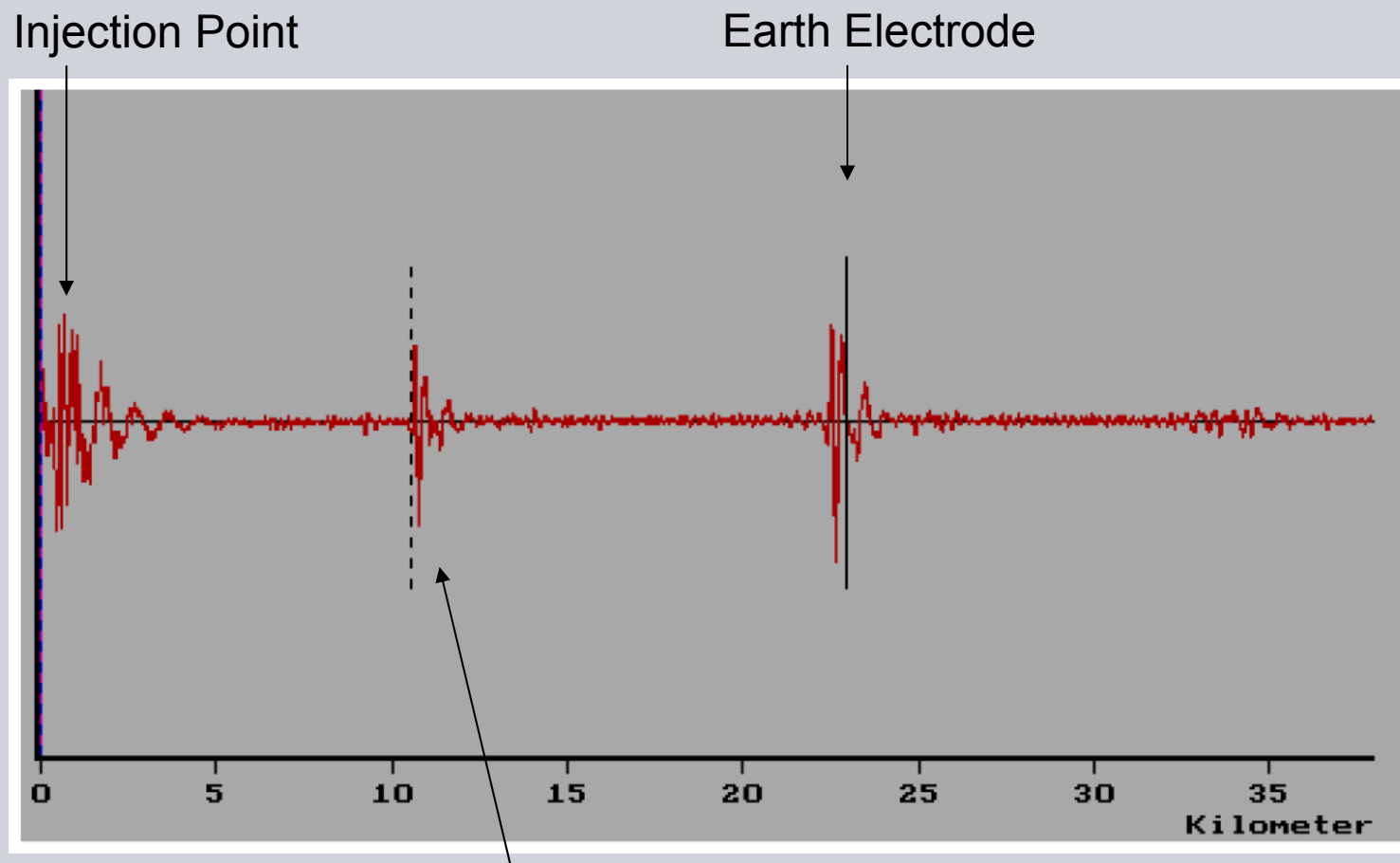
Line free of faults



Echo Signal of an Electrode Line free of faults

Fault Detection and Transmission Earth Fault on Line

SIEMENS



Echo Signal of a Line-Earth Fault on the Electrode Line

Fault Detection and Transmission Evaluation Types

SIEMENS

Steady State Evaluation - Warning

- Used for detection of long time developing faults (dirty insulator etc.)
- Steady State Evaluation monitors the reference echo
- Threshold values calculated when monitor starts the first time

Dynamic Evaluation - Alarm

- Dynamic average filter calculates dynamic reference signal of last healthy echo signal
- Dynamic Evaluation compares the actual incoming echo with the last reference echo
- Fault detected if difference signal exceeds threshold

Both Evaluation Types are running in parallel

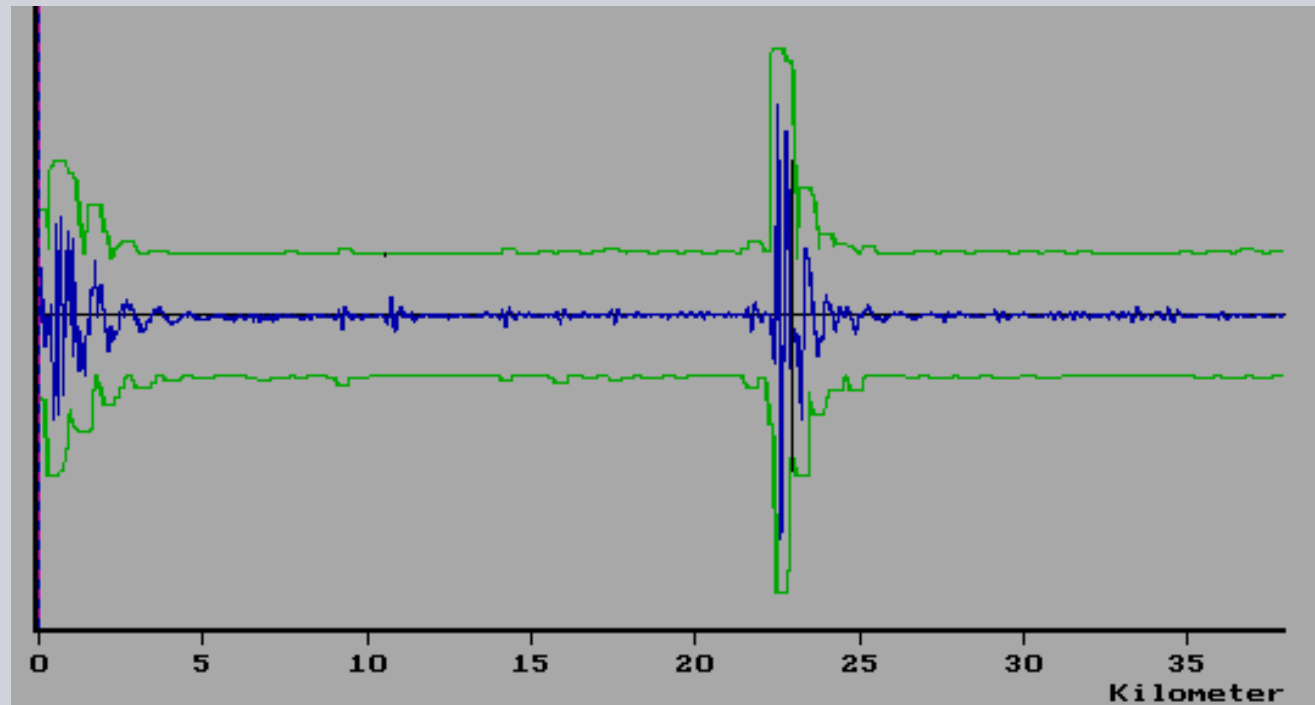
For more information please refer to E_B4_0300_08_15_XDC

Fault Detection and Transmission Steady State Evaluation

SIEMENS

Dynamic Reference Signal and threshold curves of the Steady State Evaluation

- Warning occurs when dynamic threshold is exceeded



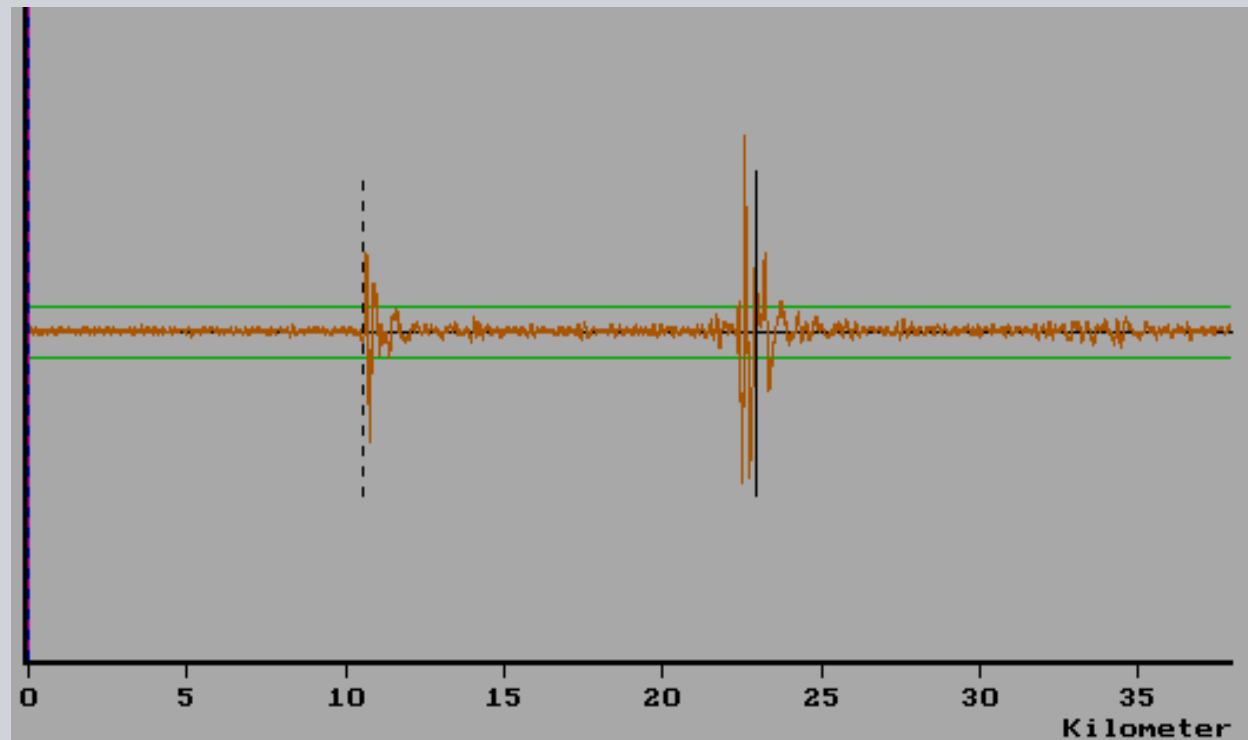
Dynamic Reference Signal and threshold curves of a healthy line
Earth Electrode at approx. 22.5 km

Fault Detection and Transmission Dynamic Evaluation

SIEMENS

Dynamic Reference Signal and threshold curves of the Dynamic Evaluation

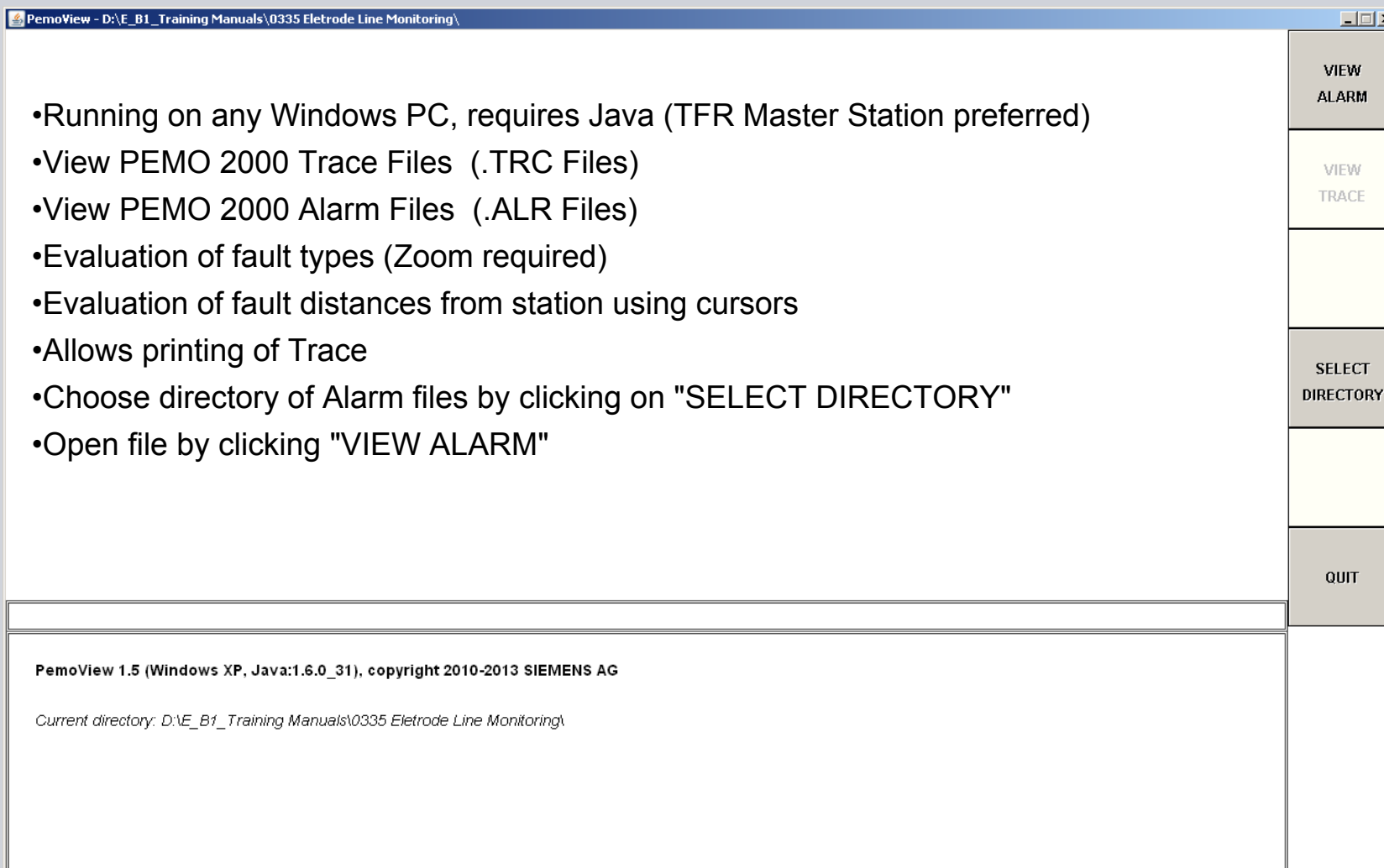
- Alarm occurs when thresholds are exceeded with a certain frequency.
- If an alarm occurs then the evaluation of the echo stops and the position of the exceeding tolerance is located.
- Alarm File is created



Line-Earth Fault at a Distance of app. 10.5 km off the Station

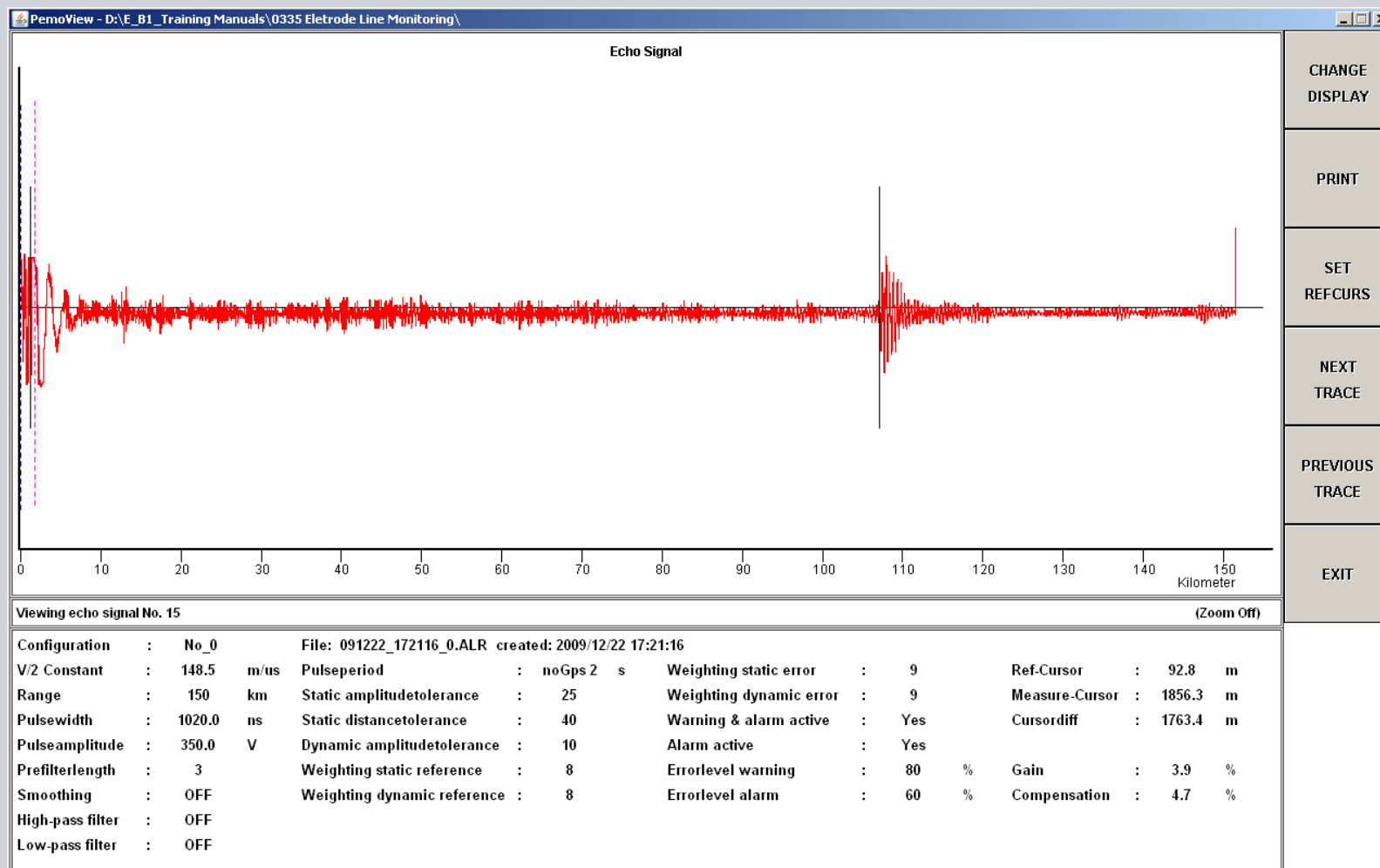
Data Processing and Evaluation Evaluation Software

Java based Evaluation Software: pemoview_v1.5



Data Processing and Visualisation Evaluation Software

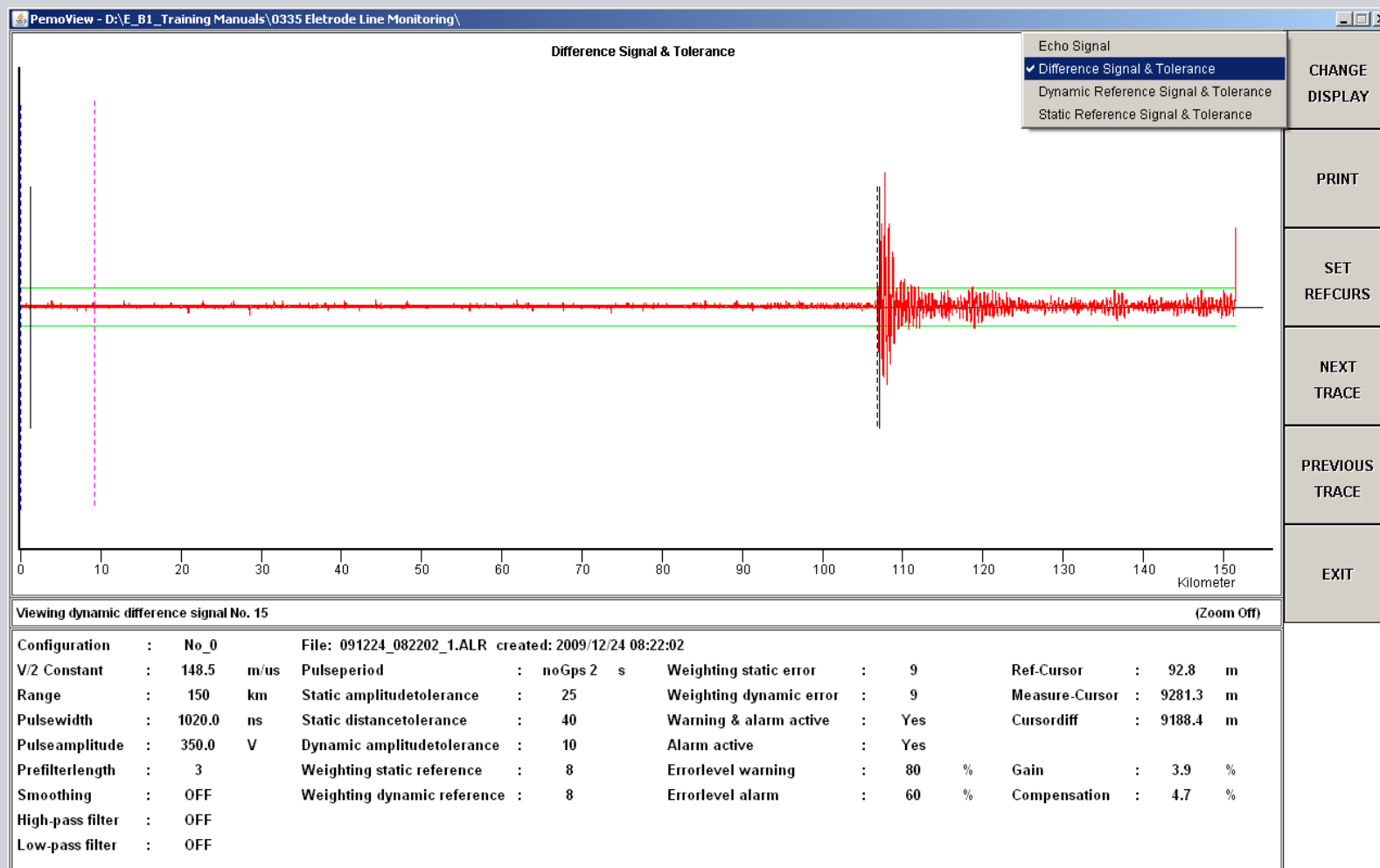
Default view after opening Alarm File: Echo Signal



Data Processing and Visualisation Evaluation Software



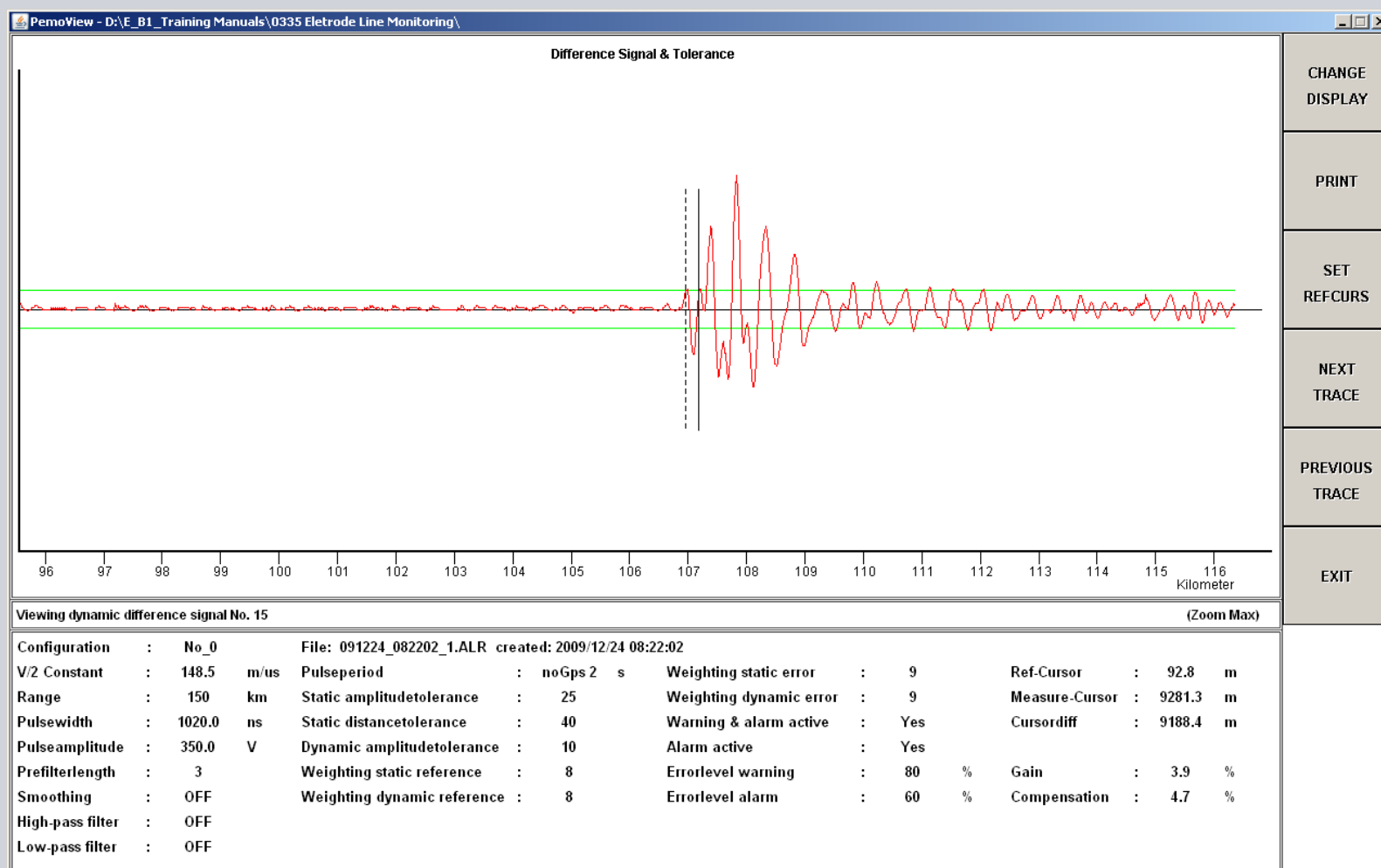
Change Display: Difference Signal & Tolerance



Data Processing and Visualisation Evaluation Software

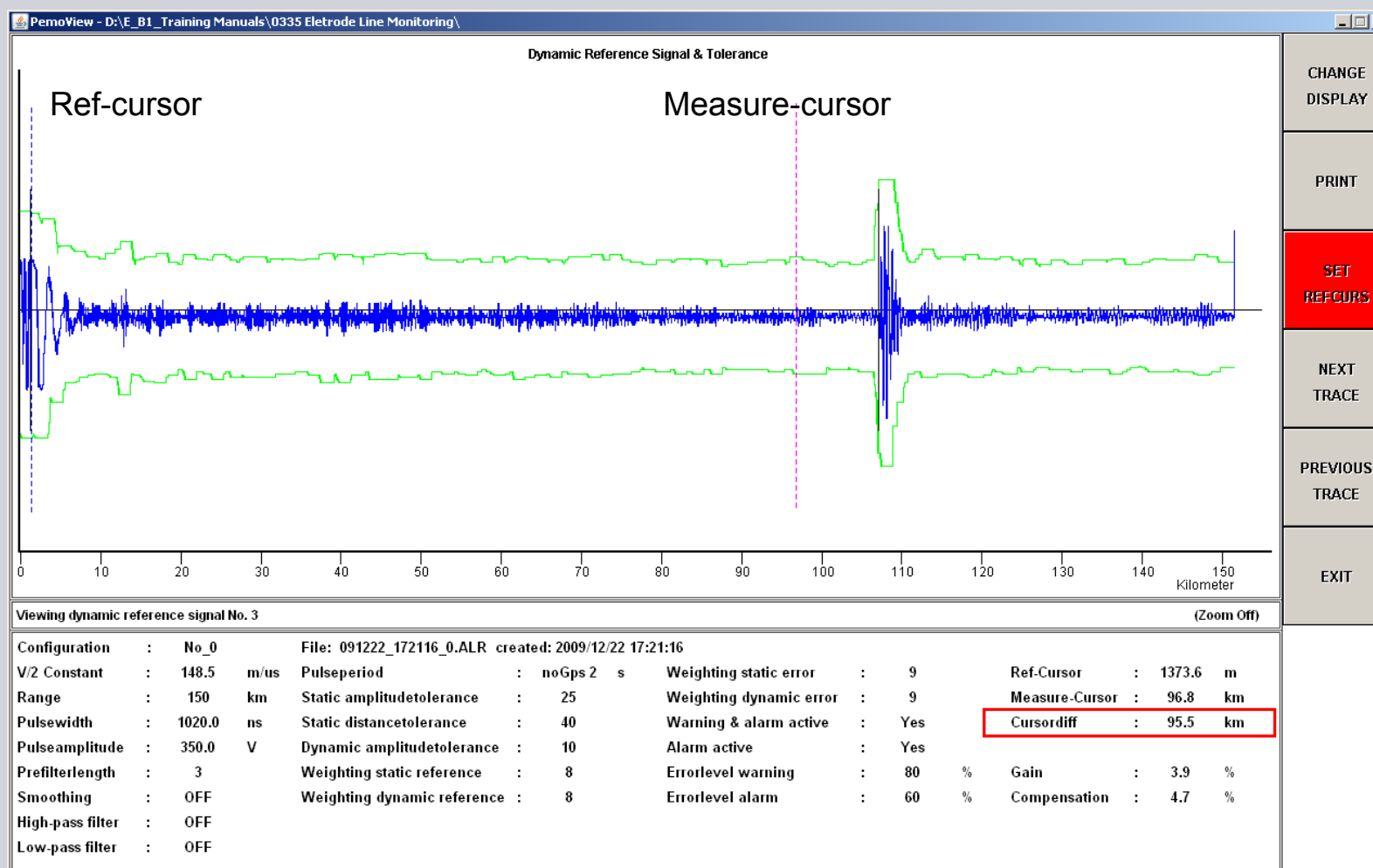


Zoom: Scroll Mouse wheel and drag to right position

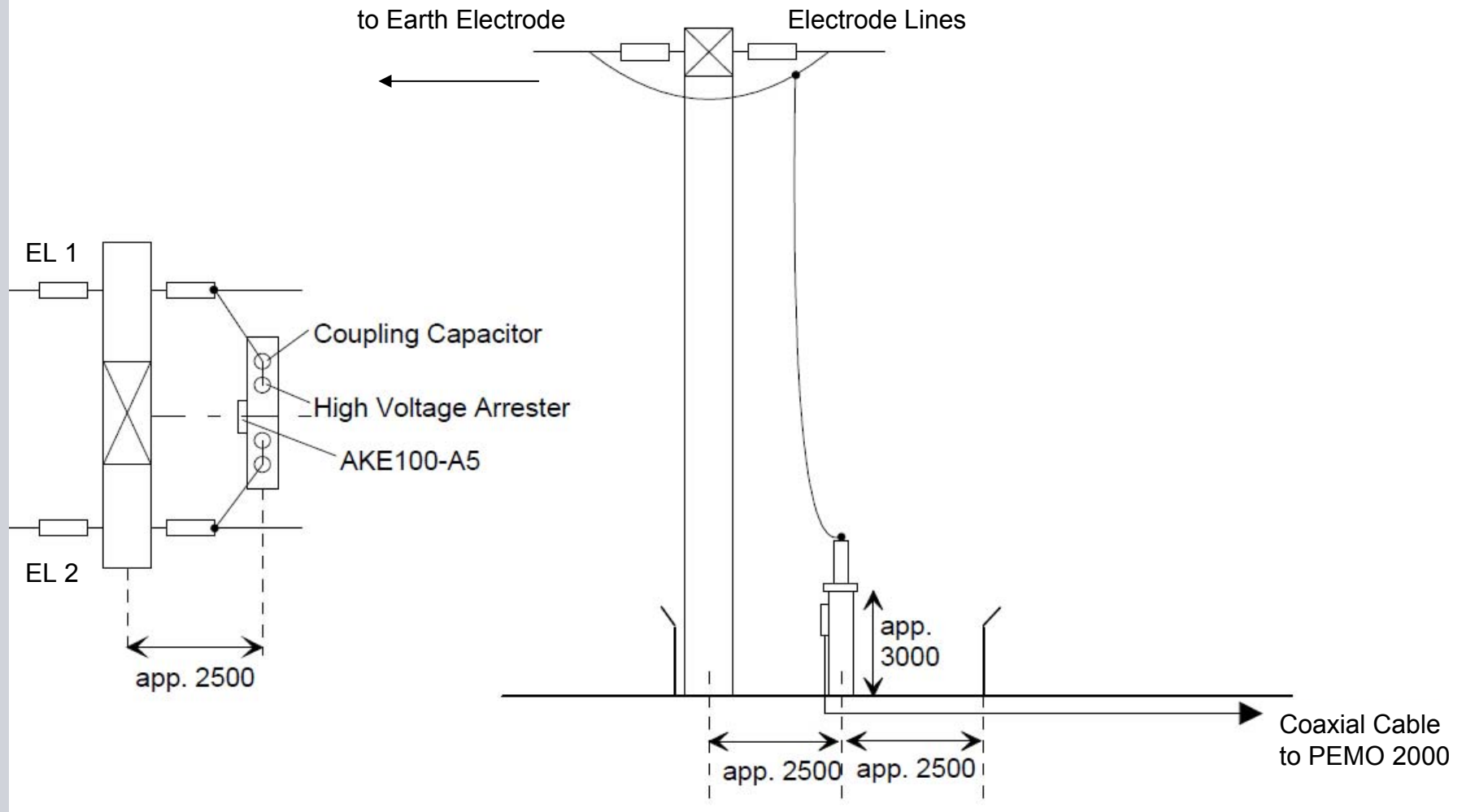


Data Processing and Visualisation Evaluation Software

Position Ref-cursor and Measure-Cursor using keyboard (arrow keys ← →)

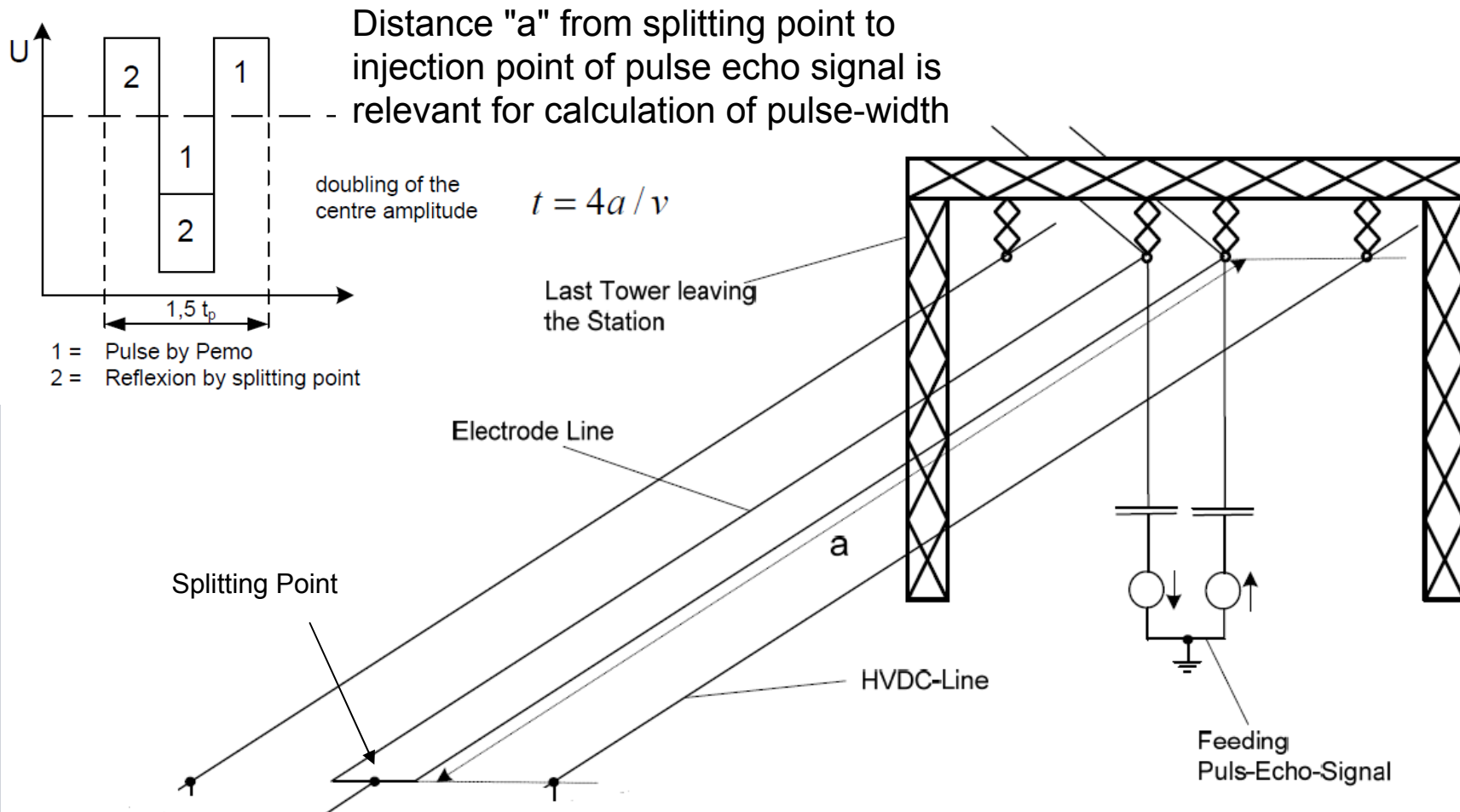


Installation and Maintenance Primary System Configuration



Installation and Maintenance

Distance a and pulse width



For more information please refer to E_B4_0300_08_15_XDC

Troubleshooting Signals to SER – System

SIEMENS

System Warning

- Long time developing fault is detected
 - ▶ Read out trace file, locate fault and check insulators of Electrode Line
- Damage or improper connection of the Coaxial Cable (before Monitoring Begin)
 - ▶ Check internal connections at HF Connection Plate and AKE-100
 - ▶ Check double-shielded Coaxial Cable
- One or both earth switches at the AKE-100 are closed
 - ▶ Open earthing switches at the AKE-100 for correct operation of PEMO-200

Electrode Line Faulty

- Electrode Line Fault detected
 - ▶ Read out Alarm file, locate fault and inspect electrode line
- One or both earth switches at the AKE-100 are closed
 - ▶ Open earthing switches at the AKE-100 for correct operation of PEMO-200

For more information please refer to E_B4_0300_08_15_XDC

Troubleshooting Signals to SER – System

SIEMENS

Cubicle Failure

- Internal Failure of PEMO 2000 or Power Supply Fault
 - ▶ Check MCBs or PEMO 2000 Device for faults
 - ▶ Check if PEMO 2000 Device is turned on

Pemo Offline

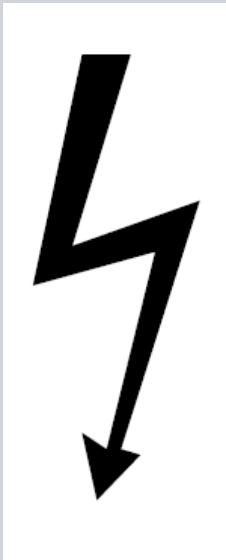
- Pemo 2000 is in Offline operation → the electrode line is not monitored
 - ▶ Check status of operation on PEMO display
- ONLINE-OFFLINE Switch in OFFLINE position
 - ▶ Switch has to be set to ONLINE position for monitoring of the Electrode Line

GPS Clock Warning

- PEMO 2000 can not detect a valid time synchronisation signal
 - ▶ Check LAN Communication

For more information please refer to E_B4_0300_08_15_XDC

Safety Instructions



- Dangerous voltages can be present on the output of the PEMO 2000
- Always deenergize and ground the equipment before maintenance or working at the line equipment of the Pulse-Echo Electrode Line Monitoring
- System is not permitted without grounding of the high-voltage section of the associated coupling capacitor
- Before working on the coax cable, make sure, that the centre conductor is grounded.
- Always use an earth stick to close or open earthing switches of the coupling Unit AKE 100.

For more information please refer to E_B4_0300_08_15_XDC

The Siemens logo is displayed in a large, bold, teal-colored sans-serif font. It is centered horizontally and positioned between two light gray rectangular bars that frame the top and bottom of the logo area.

SIEMENS

Leading in HVDC Technology