Modern Man-Machine Interface for HVDC Systems

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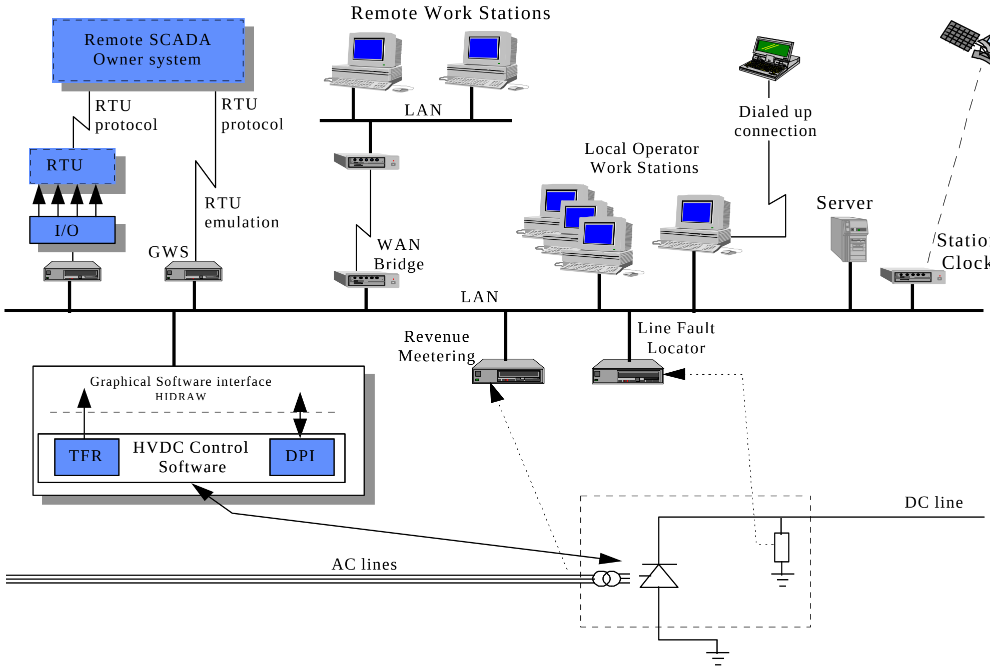
Abstract

The relevance of a well designed and flexible Man Machine Interface (MMI) is obvious when it comes to more demanding application areas such as HVDC power transmission. Conveying the information to the operator in a comprehensive yet systematic way is of great importance.

The new generation of integrated MMI adopted by ABB Power Systems, the Station Control and Monitoring (SCM) System, employs the most advanced software concepts with regard to system openness and flexibility as well as ergonomic aspects. Distributed over an Ethernet LAN, the SCM system comprises several operator workstations (OWS) and SQL servers. The Windows NT based OWS-s are characterized by high performance and an open software architecture based on the latest trends in data engineering supporting TCP/IP, SQL and DDE.

The SCM system integrates a large number of features such as:

- Control of the HVDC from process images.
- Sequence of Event Recorder
- Archiving of events
- Powerful alarm handling via list windows
- Effective user defined data filtering
- Flexible handling of both on-line and historical trends
- on-line help functions and direct access to plant documentation
- TFR analysis
- Remote control
- Instant access to standard applications such as e-mail, word processing, spreadsheet, Internet.
- Automatic performance report generation
- developed with the most versatile graphical package on the market, InTouch.



Introduction

Efficient tools for control, monitoring and analysis of HVDC transmission systems is of great importance due to the fact that power outages can be very costly. The requirements on these types of tools are high.

It is for example necessary to handle several thousands of measurands, indications and alarms of different types. All changes of state of these signals must be recorded with high time resolution for accurate real time and post fault analysis. Time resolution down to one millisecond between the stations is often required even if an event deluge occurs simultaneously in more than one converter station.

These systems must also in all parts be easy to use in order to avoid human errors. It must be able to announce alarms and perform operator controls in a safe and reliable way. Wrong operator actions due to a bad Man Machine Interface is not acceptable and could be very costly.

Another important aspect is the use of standard components available on the open market. Since the development pace of computer based equipment (such as Personal/Industrial Computers, Video Display Units etc.) is very high it is important that future equipment can replace parts in systems developed today.

ABB Power Systems have developed an experience is this field since the end of the 70's. The goal have been to develop an integrated system that can meet all these requirements and in the same time be flexible to fulfill various customer requirements. The great number of different utilities with their different aspects in this area have been of great importance in this work.

This document briefly describes the systems and function blocks that together form the composite Man Machine environment for the HVDC systems.

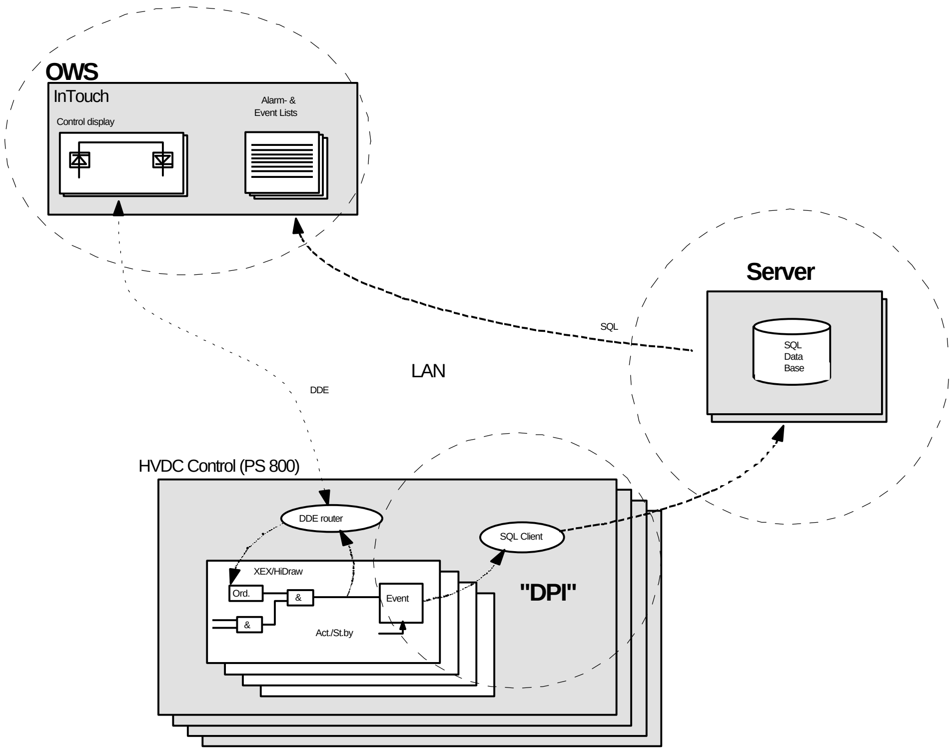
Overall System Overview

A system with all types of function parts can be found in the figure on the previous page. Obviously a great number of variations exist.

SCM System

General

The principle functional overview for the SCM system is shown in the figure below. The system is built up around three main parts: OWS, DPI and Server. These parts communicate over the LAN using standard data exchange mechanisms and query languages which are supported by the TCP/IP protocol.

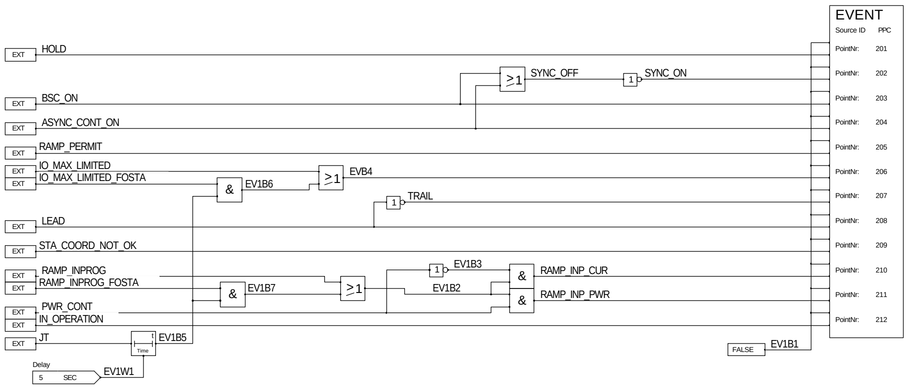


Server

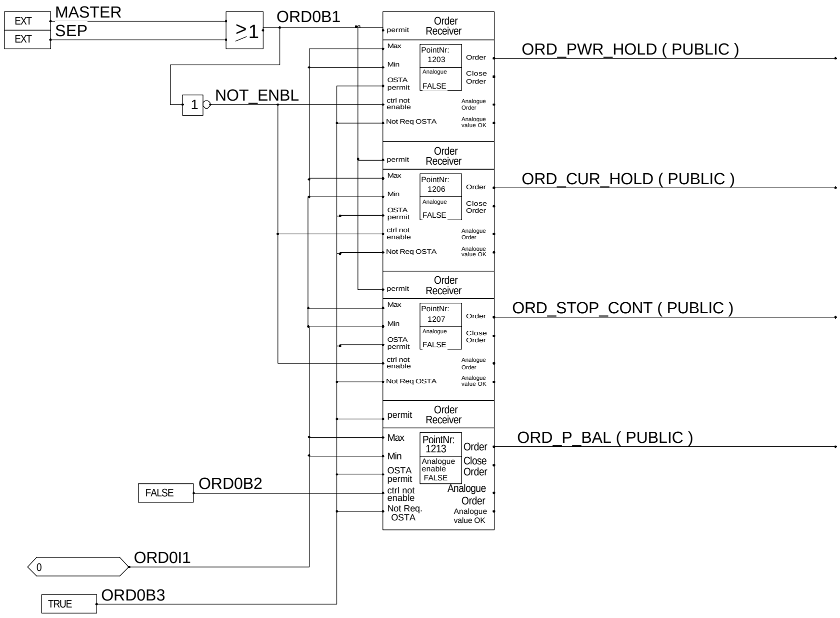
The task for the database Server located on the LAN is to keep record of all historical data generated in the HVDC control equipment. Events generated in the PS800 (HVDC Control Computer system) will immediately be sent by the SQL client to the SQL server. Mechanisms in the server ensures that all events are properly stored in the SQL database. Efficient and well proven protocols in conjunction with the standby server handling system assures that no events are lost.

Decentralized Process Interface, DPI

Unlike a conventional RTU, where all signals to/from the process is hard wired, the DPI is totally software based. The HVDC process software is programmed in the Hidraw language. The Hidraw symbol library includes symbols which serves as a direct interface between the HVDC control and the SCM system.



A typical event interface is shown. DPI symbols for set point adjustments and mode shift ordering are also shown below.



Operator Work Stations, OWS

General

In the Operator Work Station environment all necessary tools for configuration and operation are included. All special functions needed which are outside the standard configuration can easily be created and implemented by the user. By means of standard symbols and so called Wizards it is possible to easily modify the functionality and layout of the MMI.

The environment is Windows NT and the MMI is developed with the most versatile graphical package on the market, InTouch. This enables the great flexibility and openness in the system.

Operation

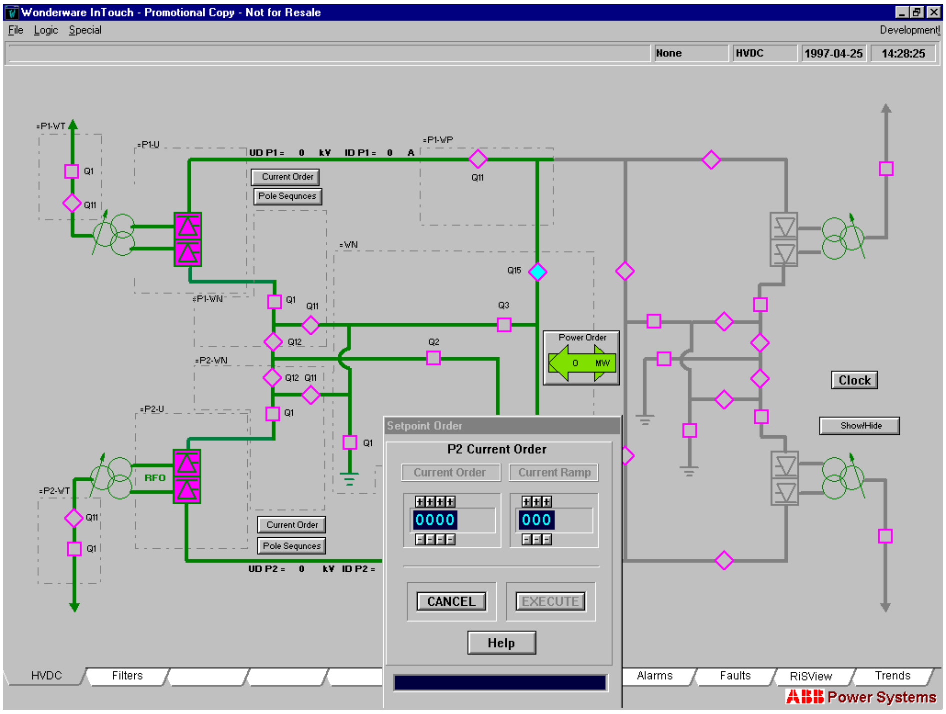
The “main” windows in the workstation are the **Control** and **List** windows. Together they support the operator with all the important on-line information for control of the HVDC system. In addition to those a number of pre-defined windows are provided in the basic OWS configuration such as:

- Trend curves
- TFR analyzing
- Line fault location presentation

The setup of other useful windows such as historical data, reports, special sorted lists etc. is easy in the Windows NT environment and is a matter of the ingenuity of the engineer.

Control

Below is shown a typical control window where an ongoing control action is indicated by the “pop-up” window in the lower center of the image. The image contains a lot of information which is hidden but can be displayed upon request from the operator.



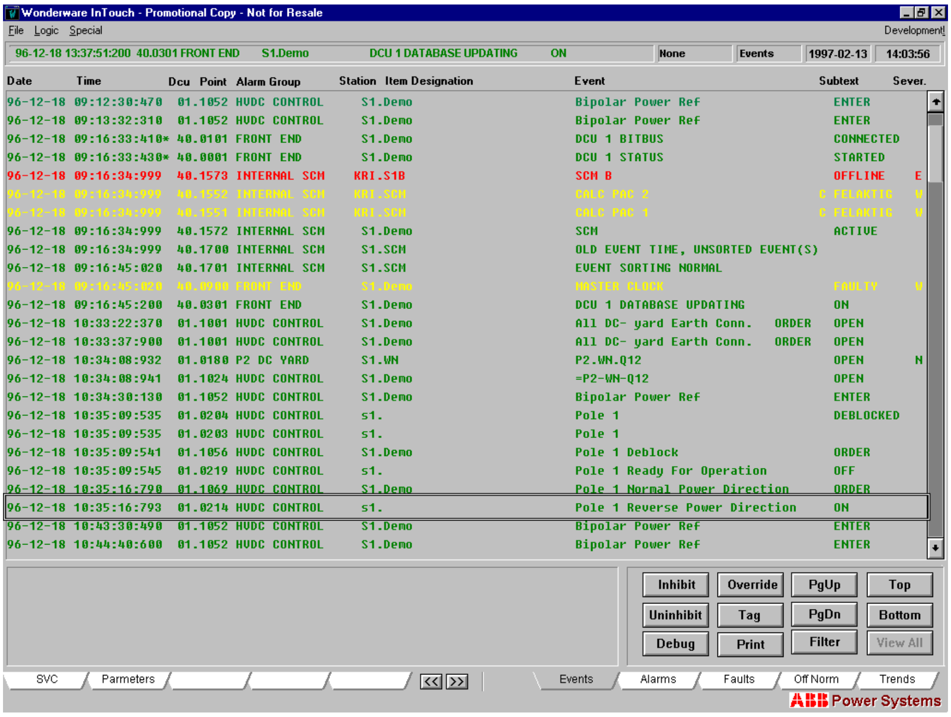
Alarm Handling

Alarms are handled in the so called List window. Also here the appearance of alarms/events is a matter of how the user would like to see it. This list shows all events/alarms generated during the day including order log. When the list is selected there is a choice of displaying all predefined events/alarms or a selected part of the events. This is useful when only a special category of alarms are of interest to study.

Acknowledgment procedures of alarms are initiated from the pre-defined “buttons” in the right hand side lower corner. The procedures themselves are user definable.

To each individual alarm there is an alarm reference database including detailed description of the alarm, consequences and instructions on how to trace and correct the fault. This alarm reference is simply accessed by clicking on the specific alarm.

Below is a typical alarm list window shown.



OWS Remote Control

The OWS can also be located at remote locations. A remote OWS can have exactly the same functionality as a locally connected OWS. There are two types of possible connections:

- Extended LAN by means of a WAN bridge or router
- Dialed-up connection.

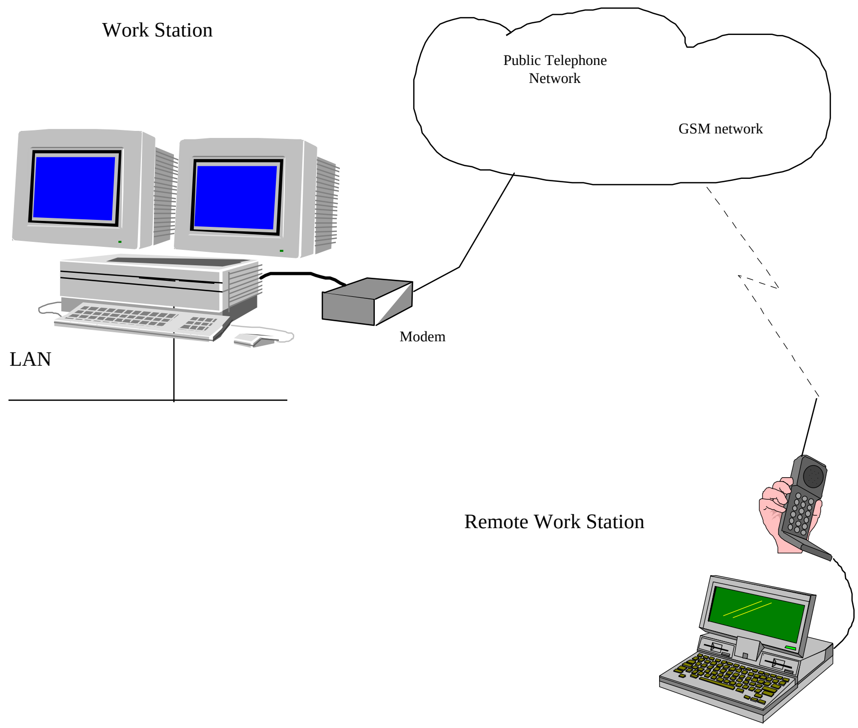
In section **Overall System Overview** the two possible connections can be identified.

Extended LAN

In this implementation the local LAN is extended to a remote location by a WAN bridge. At the remote location one or more work stations can be connected.

Dialed-up connection

When a dialed-up connection is desired only one workstation can be active. However exactly the same functionality is achieved. This method is meant for maintenance purposes and for remote viewing of the HVDC station. For security passwords, call back, etc. are used.



RTU Emulator

Often there are different utility SCADA systems involved in a project which shall gather information from and send control actions to the HVDC control system. The Gate Way Station (GWS) is the interface (RTU emulator) between the HVDC control equipment and the owner SCADA system.

The GWS is connected to the process via the LAN together with the other workstations. The communication to a remote SCADA system is performed via a serial link (RS232). The protocol that is implemented in the GWS for this communication link is RP570 which is a RTU protocol based on IEC 870-5-1 (Transmission Protocols).

In cases where the owners SCADA/RTU systems have other interfaces than RP570 so called protocol converters will be put between the GWS and the SCADA/RTU.

RTU Interface

As an option the SCM system can support a conventional I/O interface for connection of foreign RTU:s. In this interface it is possible to have access to all supervised signals in the HVDC equipment and to receive orders from a remote SCADA system. Normally the interface provides potential free relay contacts for indications and a current (selectable range) interface for analogue measurands and calculated values.

GPS Clock System

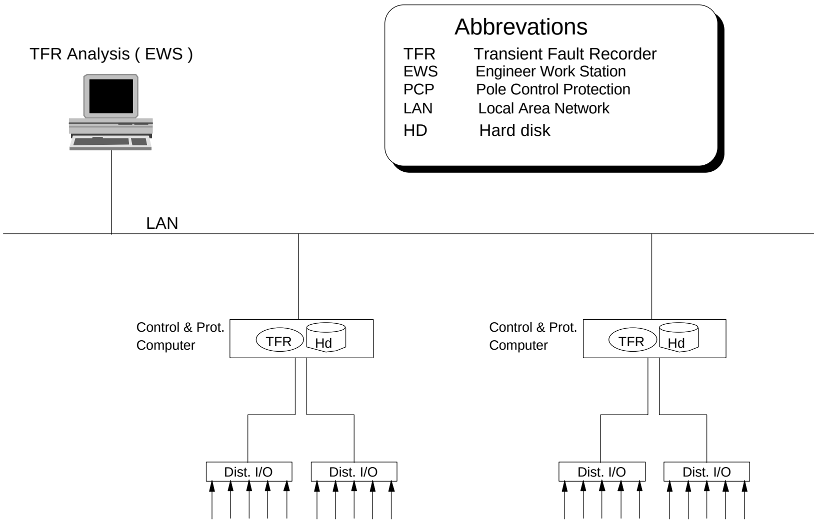
For time synchronization and distribution of precise time the system used in HVDC applications is the Global Positioning System, GPS. This system is at the present time the most competent system in this area. The 24 satellite constellation enables users, worldwide, to achieve the correct time with reference to the Universal Time Code, UTC.

By using the GPS system several advantages are achieved:

- Exact synchronization between different locations
- Worldwide coverage
- Satellite redundancy (necessary to “see” only 1 of 4 satellites)

Transient Fault Recorder

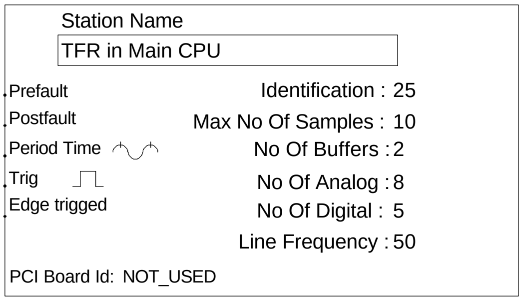
For post fault transient analysis the Transient Fault Recorder, TFR, is used. It is a system with the recorder part integrated with the HVDC control software and the analyzer part included as a window in an OWS.



Data acquisition

In a HVDC station all measured quantities and indications can be found in the control software. The “wiring” of signals into the integrated TFR is therefore simple and requires only programming. The graphical software tool (HiDraw) for HVDC control software includes symbols for connection of signals to the TFR function. In rare cases there may be signals that must be “hard wired” into the system.

The setup of all the normal TFR parameters such as: Pre-trig, Sample rate, Signal identifications etc. is done in graphic symbols. Only the system limitations and practical aspects are decisive for how many TFR:s and the amount of supervised signal that can be configured. A normal configuration for a HVDC station is 32 analogue and 16 digital indications.



The graphic interface for digital and analogue signals are shown below. The small dots on the left hand side on the symbol are the connection points for the desired signals.

Id : 25

No	Channel Name	State
1	Digital 1	1
2	Digital 2	1
3	Digital 3	1
4	Digital 4	1

Id: 1

No	Ch Name	Fas Id	ccc	Unit	Scale a	b	Skew	Min	Max
1	ULAM	A		kV	1.0	0.0	0.0	0	4096
2	ULBM	B		kV	1.0	0.0	0.0	0	4096
3	ULCM	C		kV	1.0	0.0	0.0	0	4096
4	ILINEAM	A		A	1.0	0.0	0.0	0	4096

When a trig of the TFR has taken place the data will be stored as a file on the hard-disk. Files are stored in the COMTRADE standard format. This format can be handled by most disturbance analyze tools available on the market.

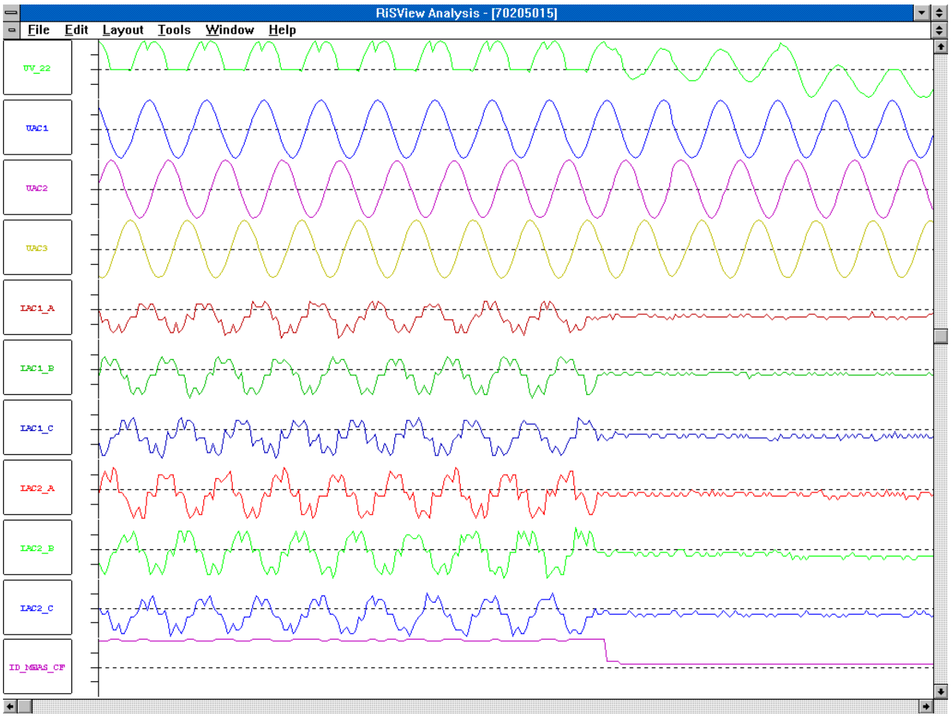
(IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems (IEEEC37.111-1991).

Disturbance analysis

The disturbance analyze is performed in any of the Operator Work Stations by means of a standard software tool. The ABB integrated TFR has successfully been used together with the following analyzing tools:

Program	Manufacture
Reval	ABB Network Partner AB
RiSView	Rochester Instrument Systems Ltd
WinRep	Hathaway Systems Ltd
DADiSP	DSP Development Corporation

The tool offers possibilities to examine the disturbance in various ways. This together with the standard Windows environment the operator can analyze and store/present the data in the way he/she wants.



Abbreviations

SCM	Station Control and Monitoring system
DPI	Distributed Process Interface
OWS	Operator Work Station
GWS	GateWay Station
RAS	Remote Access Service
LAN	Local Area Network
MMI	Man Machine Interface
SQL	Structured Query Language
DDE	Dynamic Data Exchange
TCP/IP	Transmission Control Protocol/Internet Protocol
Hidraw	HIDRAW is a functional block program language and code-generator developed by ABB Power Systems AB
WAN	Wide Area Network