ANNEXURE-I

Technical Specification of
Data Acquisition System (DAS)

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1 FOREWORD

Central Power Research Institute (CPRI) intends to establish/augment the test facilities of the High Power Laboratory in Bangalore in order to meet the growing demand for high power testing by adding two 2500 MVA Short-circuit generators (G2 and G3). These two generators are to be configured in order to operate in parallel operation with the existing 2500 MVA short-circuit generator (G1) so that the overall short-circuit power available for the laboratory shall amount to 7500 MVA.

The total available short-circuit power shall be used to increase the testing capability of the laboratory (by running the generators in parallel) and to improve the efficiency of testing activities making use the generators individually to supply tests carried out simultaneously in different test facilities like MV/HV circuit breaker testing facility, MV/HV transformer testing facility etc.

Within the framework of this augmentation of the test facilities, the implementation of a new Data Acquisition System (DAS) is requested in order to cope with the new measurement requirements determined by the envisaged new High Power Laboratory configuration.

2 SCOPE OF SUPPLY

This technical Specification applies to 32-channel Data Acquisition system (DAS) foreseen in High Power Laboratory (HPL), CPRI Bengaluru. Each Control Room (refer clause no 5.1) of HPL will have its own Data Acquisition system (DAS), for executing, storing and presenting measurements during tests in the various tells cells.

The scope of supply includes

a) One no. of 32-channel Data Acquisition System, it mainly consists of:

- A mainframe based Control Unit for the management of the data acquisition and the execution of DAS control functions, including transmission of recorded data to the HMI workstation, time and trigger synchronisation of multiple Acquisition Cards, etc; the mainframe shall have a convenient number of acquisition slots for housing the envisaged number of Acquisition cards and future expansions;
- The Acquisition cards, with the specified number of input channels and hardware characteristics (sample rate, resolution, on-board memory, etc);
- A number of fiber-optic channels connected to separated measuring modules & transmitters by digital fiber-optic cables;
- A Software tool with Human machine interface (HMI) installed on a workstation in the Control Rooms, that provides a full range of functions for the set-up of measurement parameters, the control, acquisition and storage of measured data, the display of test results in the form of oscillograms and the evaluation of relevant parameters, the reporting of data.

b) All associated wiring/cabling, auxiliary supplies, interface panels, DAS placement panel, battery charging system etc.;

c) A computer system to view measurement results (one no.) and it's configuration as per DAS requirements;

d) Mandatory spares required

e) Calibration certificate of 32-channel DAS

f) Transmitter shield boxes for outdoor placing on live part

g) Weather proof boxes for placing transmitter

3 REFERENCE STANDARDS

All laws, technical standards, regulations and decrees issued by entities in force in India at the date of order are considered binding. Where applicable, it will be referred to IEC publications. In any case, the requirements set out by Laws and Regulations issued by the Authority and Local entities under whose jurisdiction the Laboratory will be installed must be respected. The unit of measure must comply with the International System (SI).

The Bidder shall give a list of all the standard followed. The minimum list is given here below.

Electrical Safety

- IEC 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements
- IEC 61010-2-030 Particular requirements for testing and measuring circuits

Electromagnetic Compatibility

- IEC 61326-1 Electrical equipment for measurement, control and laboratory use EMC requirements - Part 1: General requirements

Emission

- IEC 61000-3-2 Limits for harmonic current emissions
- IEC 61000-3-3 Limitation of voltage changes, voltage fluctuations and flicker in public low voltage supply systems

Immunity

- IEC 61000-4-2 Electrostatic discharge immunity test (ESD);
- IEC 61000-4-3 Radiated, radio-frequency, electromagnetic field immunity test;
- IEC 61000-4-4 Electrical fast transient/burst immunity test
- IEC 61000-4-5 Surge immunity test
- IEC 61000-4-6 Immunity to conducted disturbances, induced by radio-frequency fields
- IEC 61000-4-11 Voltage dips, short interruptions and voltage variations immunity tests

4 CLIMATIC CONDITIONS

32-channels Data Acquisition System (DAS) and their accessories shall be designed for satisfactory operation under tropical climatic conditions prevailing in India.

The climatic conditions prevalent at the site of the operation are as follows;

Altitude above Mean Sea Level	: 920 m
Maximum ambient temperature	: 50°C
Minimum ambient temperature	: 10°C
Average Humidity	: 81%
Special corrosion conditions	: Nil
Solar Radiation (DNI)	: 4.5-5.0 kWh/Sq. m/Day
Atmospheric UV radiation	: High
Pollution level	: Moderate
Snow fall	: Nil
Seismic Zone	: Zone-II

Wind Speed : Average 5.6 km/h
Annual rainfall : 1000mm-1500mm

The site location is situated in the CPRI campus located adjacent to Indian Institute of Science. The site can be approached

By Train: Nearest Railway station: Yeshwanthpur

By Air: Kempegowda International airport 33 km away from site.

Nearest Sea Port: Chennai

5 FUNCTIONAL DESCRIPTION OF HPL AUTOMATION SYSTEM

The overall HPL Laboratory management system, that manages the set-up and execution of tests in HPL Test Facilities, consists mainly in three parts:

- Control and Monitoring System (CMS);
- Data Acquisition System (DAS);
- Synchronisation system needed to operate the different equipment (laboratory equipment and equipment under test) during the tests: Test Sequencer (TS).

The Control and Monitoring System (CMS) performs several tasks:

- Access Control and Safety: the CMS watches over safety of people working in the Laboratory and over access in the various Laboratory areas, for example to perform circuit connections and maintenance on the installed equipment ;
- Test Circuit Configuration: the CMS configures the test circuit (at least partially, being some of the operations carried out manually);
- Test Process Control: the CMS, operating together with the dedicated Control Systems of the HPL power sources (short circuit generators, DC voltage generators of the Synthetic Test Facility, etc.), prepares the selected power sources for the test, monitors the status of tests circuit equipment and of some of the test parameters (voltage and current) and interacts with the DAS and TS;
- Protection: the CMS controls HPL protection relays and related alarms.

When the test circuit is ready to provide power to object under test, then the CMS enables the Test Sequencer to perform the defined Test Sequence (the Test Sequence is a sequence of commands required for the performance of the test, intentionally started by the operator, and carried out automatically according to a pre-established timing, independently from the operator control).

The Test Sequencer will perform the test sequence and will trigger the Data Acquisition System (DAS) which acquires the defined quantities (current, voltage, etc.) for the test duration.

At the end of the test, the Test Sequencer releases the control of the plant that is resumed by the CMS.

Figure 1 shows a simplified interconnection diagram of the above mentioned systems. A more detailed interconnection diagram is in Appendix - I.

One CMS will manage all the Testing Facilities, while it is assumed that each Test Facility will be provided with its own TS and DAS. The present document provides the Data Acquisition system specifications.

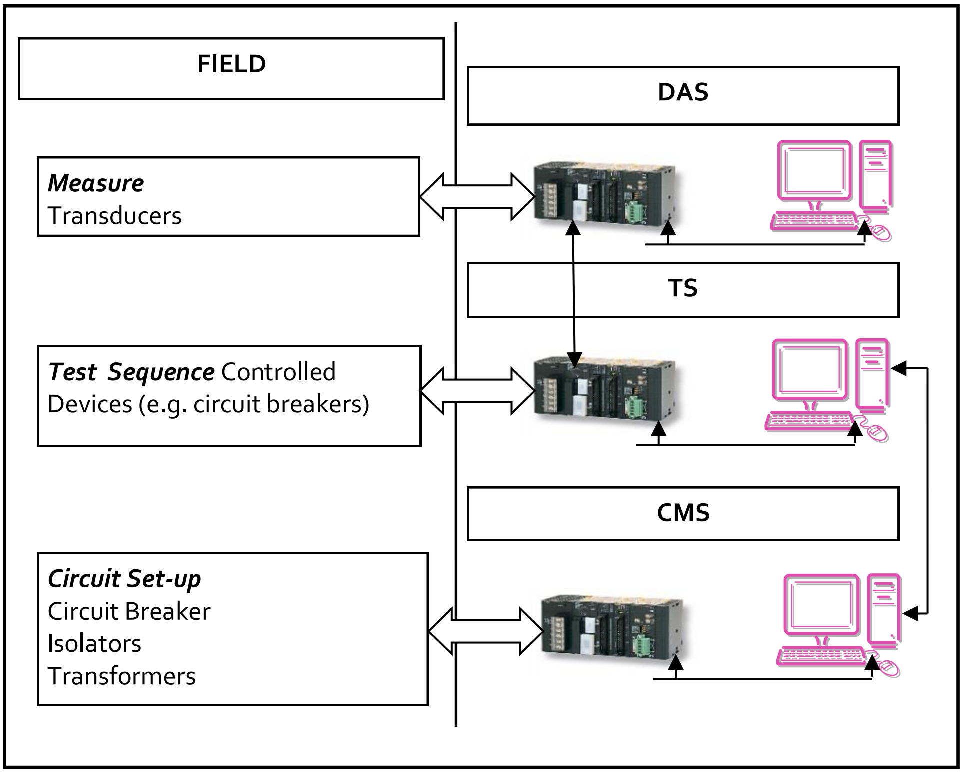


Figure 1 – Systems involved in the management of testing activities

Test Execution

Briefly the test execution is a process which involves the Three Systems.

Before starting test the operator has to perform:

- set of the test circuit with CMS;
- set the TS, preparing the correct sequence of commands to be executed (out of the scope of this document);
- set data acquisition system and display system (DAS), preparing input ranges (full scale) table, parameters to display output data and sampling rate (out of the scope of this document).

When all these activities are achieved and all the equipment are ready to start, the operator can start the Test Sequence.

At the end of the Test Sequence:

- The CMS resumes the control of the laboratory configuration,
- The TS is disabled,
- The DAS processes the acquired data and display the test results.

5.1 Number and role of each control room

Within the HPL augmentation project, the existing Control Building will be rearranged in order to efficiently conduct the foreseen testing activities, including the performance of simultaneous tests in different test bays. The proposed SLD allows a flexible selection of different configurations which can be arranged for supply simultaneously different test cells. Theoretically three test cells can work at the same time as follows:

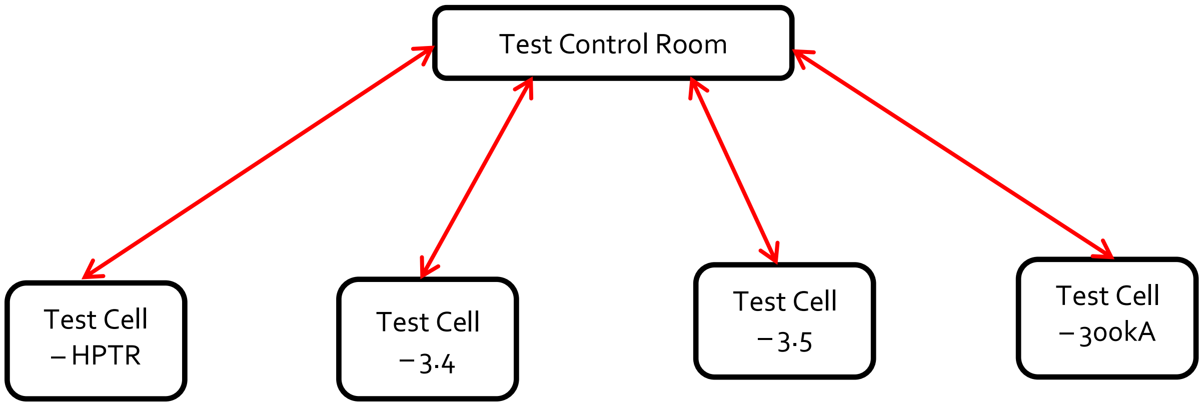
1. One of the test cells fed by the 72.5 kV feeder;
2. One of the test cells fed by the 245 kV feeder;
3. One of the test cells fed by the 600 kV feeder.

Each one of the above cases can be substituted with a test in the 300 kA test cell.

Based on the above possibilities, on the types of tests carried out in the various test facilities and on the relevant number of feeders, the proposed Control Rooms configuration is the following, and each Control Room will be equipped with its own Data Acquisition system;

- Control Room no. 1 (situated in the Control Building), usually dedicated to control the tests in High Power Transformer (HPTR) Test Cell;
- Control Room no. 2 (situated in the Control Building), usually dedicated to control the tests in the existing MV Test Cell 3.4 and in the new Test Cell 3.5 and power Arc Test Cell;
- Control Room no. 4 (situated in the Control Building), usually dedicated to control the tests in the 300 kA Test Cell.
- Generators Control Room (situated in the Generators Building), specifically devoted to control the operation of the new generators G2 and G3, including their auxiliary systems, and the synchronisation between the generators when they are used in parallel, including the existing generator G1. No Data Acquisition System is required for the Generators Control Room.

In below it shows the DAS interface between Test control room and various test cells along with no. of DAS inputs from each test cell.



Test Cell	Total no. of DAS inputs	No. of insulated DAS inputs (Transmitters installation on an insulated support)*
HPTR Test Cell	17	7
3.4 Test Cell	17	0
3.5 Test Cell	16	4
300kA Test Cell	17	0

*In this case, the transducer is outdoor type and the transmitter shall be placed in a shield box (three layer) as shown in fig. 3 & 4 and its performance free from electromagnetic and electro static field effects, the supply of weather proof transmitters shield box is in the scope of Bidder. Insulation column is not in the scope of Bidder.

6 DAS GENERAL SPECIFICATION

Mainframe	
Number of slots	To be defined by the Supplier based on selected number of cards and it shall be expandable for future requirements.
Power Supply	230Vac (±10%), 50Hz
Acquisition Cards	
fiber-optic channels	
Total number of input channels	32
Number of input channels per transmitter module	up to 3
Channel input type (TX)	Differential, isolated
Maximum Sampling rate per channel	26 channels : 25 MS/s: 12.5 MHz @ – 3 dB (2) 6 channels : 100 MS/s: 25 MHz @ – 3 dB (2)
Sampling type	Simultaneous (1)
Resolution	≥ 14 bit (0.006 %)
Minimum Memory for each channel	≥ 100 Msample
Transmitter Input Impedance	≥ 1 MΩ
Operating Temperature of Transmitter	From 0 to 40 °C
Data Transmission medium between Transmitter and Receiver	Fiber Optic
Data Transmission Bandwidth	1 MHz
Transmitter Power supply	No. 2 rechargeable batteries
Input range	From 0.1 Vpeak up to 100 V peak
Accuracy	0.1 % full scale
Offset error	0.1 % full scale
CMRR	>60 dB @ 80Hz
Overvoltage Protection	±250 V peak 800 Vpeak transient (impulse spark-over voltage at 1 kV/µs)
Trigger	External/Internal (3)
Output signals	Reference clock (4)

Notes:

(1) all channels shall be sampled at the same time, this means that the sample clock has to be propagated to the remote channels simultaneously (error less than the minimum sampling interval).

(2) Digital Anti-Aliasing filters dynamically adapt the bandwidth, according to sampling rate, to perfectly adjust the effective noise reduction.

(3) Usually the trigger will be an external signal coming from the Test Sequencer; for diagnostic purpose and calibration, the trigger can be internal coming from the configuring software.

(4) The DAS shall provide the internal time base output in TTL form through BNC connector. The output might be made available, for example, to a high speed camera to synchronise the videography of the equipment during test with reference to the short-circuit current flow.

6.1 Input channels

6.1.1 Type of Measurement Signals

Typical measurement signals to be acquired by DAS are the following:

Measurements data	**Source**
Test currents in all phases	Shunts
Test voltages on all phases	Voltage dividers
Circuit breaker under test: registration of contact separation and movement	Position transducers
Circuit breaker under test: operating current of closing/opening coils	Current transducers in Test Cells
Various analogue measurements from other transducers (e.g. pressure, temperature, etc.);	Various types of sensors (typically analog output 0-10 V);

- During test execution, high frequency acquisition up to the maximum sampling rates of Acquisition cards is requested for transient recordings in specific time windows of the test sequence (TRV, arc voltage, etc.), while for the remaining parts of the test time interval a lower frequency acquisition rate (up to about 200 kS/s) is sufficient. Therefore the proposed measuring boards shall preferably support the possibility to switch between at least 2 rates values during the acquisition period.
- For Acquisition cards, the measurement signals will be acquired by digital optical links as described in par.6.2. In Appendix - II it is specified whether they require transmitters with insulated power supply or with normal power supply (230 V ac); the latter shall preferably have a reinforced voltage isolation.

6.1.2 Number of input channels and selection of Measurement Signals

DAS shall have 32 number of channels that will be activated during the test. In each Control Room, all measurement signals from the Test Cells and Laboratory installations managed by that Control Room shall be available. Selection of Measurements signals will be made differently depending on the type of test.

Selection of Measurements signals will be made differently depending on the selected configuration (Minimum or Maximum)

- Minimum Configuration:

  The number of input channels of the Minimum Configuration is sufficient for acquiring all the measurements and signals during a test in one of the (two) Test Cells controlled by the Control Room (e.g. Control rooms no. 2 and 3), but is lower than the total number of transducers/sensors. Selection of measurement signals is done through an interface panel in the Control Room which allows to make, before each test, the association of DAS input channels to measurement devices of the Test Cell where the test will be carried out.

The interface panel is basically a panel with chassis connectors where all measurement signals from the field are made available. For acquisition cards, the selected signals will be connected to DAS input channels by means of short fiber optic cables;

- Maximum Configuration:

  The number of DAS input channels is sufficient to cover all the measurements signals in the Test cells managed by the Control Room. Therefore, a fixed association between all transducers/sensors in the controlled Test Cells and one of the input channels of DAS can be made.

Association of DAS channels to measurement devices shall be done by the CPRI. Preliminary lists of the input measuring signals that shall be made available in the Control Rooms are given in Appendix - II (intended to demonstrate that the specified number of DAS channels is enough to cope with the foreseen tests).

6.2 Data Acquisition and Transmission with optical links

The use of digital optical links is foreseen at least for voltage and current measurements as well as for other measuring signals coming from the Test Cells, when Acquisition cards are foreseen.

The analog signal input shall be converted in digital bit pattern directly on the transmitter side (very close to the transducer): in this way the data transmission is made of a train of packed bits. Digital fiber optics assure galvanic insulation and noise immunity. The data will be stored in the acquisition channel memory directly. Acquisition channel will be located in the acquisition rack (mainframe).

Connection between the Transducer and the Transmitter is done by a shielded (i.e. Triaxial) cable, wiring and grounding shall be done to avoid internal current loops. Typical connection for Voltage Dividers and Shunts are shown in Figures 3 and 4. All measurement signals are outdoor installation, connectors shall be for external application, a protection degree IP67 is required and also weather proof.

Usually there are two optical fibers between the Transmitter and the Receiver card. One fiber is dedicated to data transmission, the other is dedicated to control remote transmitters. By means of this control fiber the operator, via dedicated software, can set all the possible options and receive diagnostic information.

Transmitters are installed very close to the transducers, on an insulated support if requested by the transducer position on live circuits (see Appendix - II).

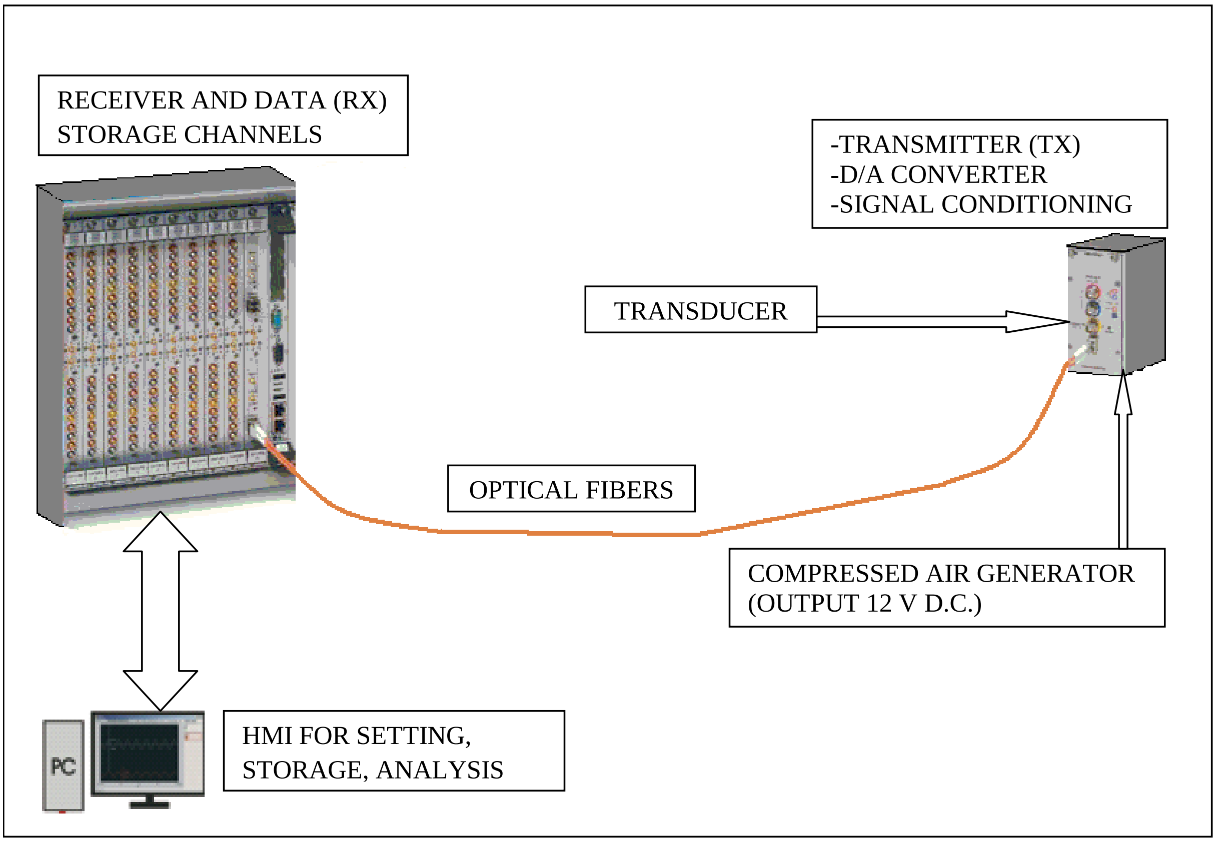


Figure 2 – Data Acquisition and Transmission with optical links

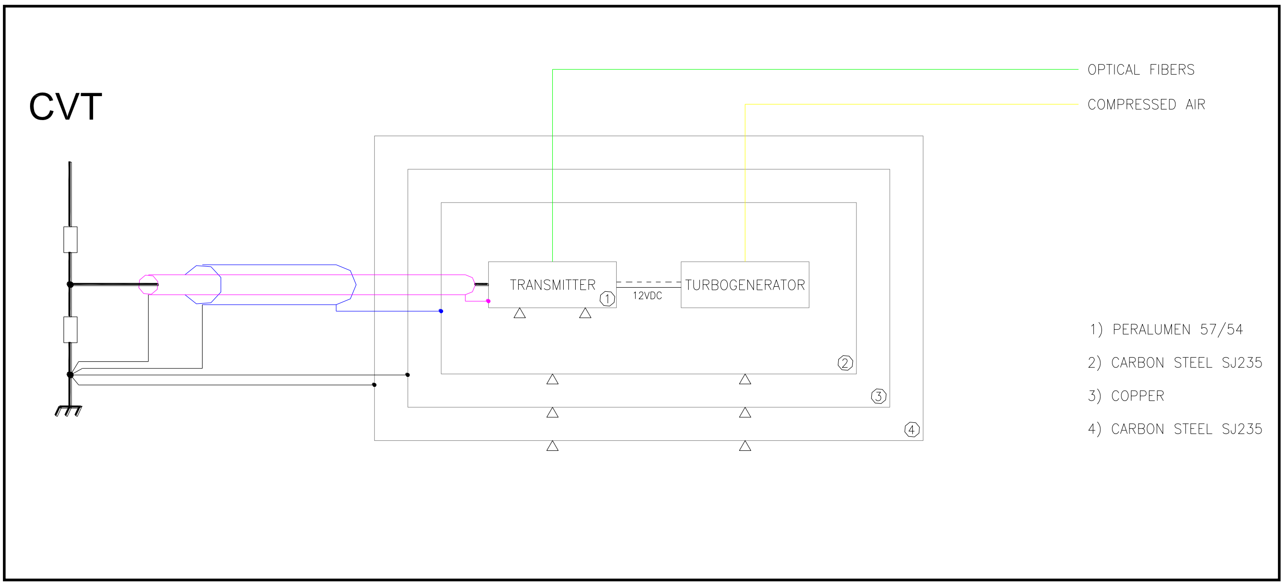


Figure 3 - Typical connection for Voltage Dividers

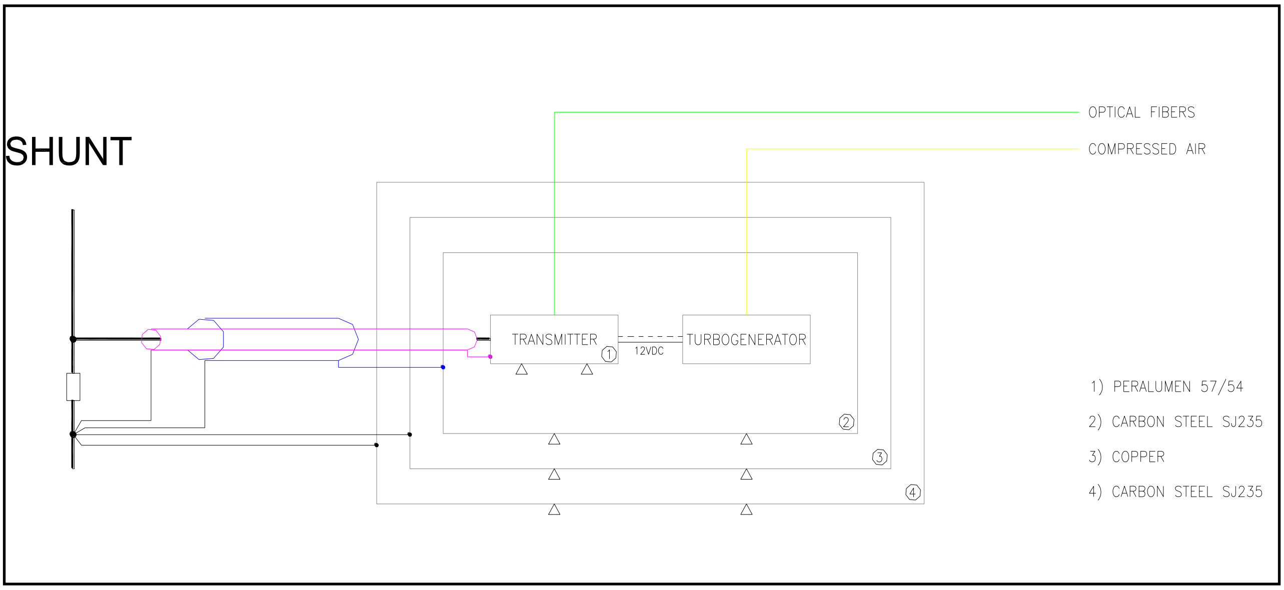


Figure 4 - Typical connection for Shunts

The optical fiber should be laid, if required, inside the hollow insulator to assure protection from dust and avoid fiber damage (see Figure 5). The insulator shall be permanently washed with air flow.

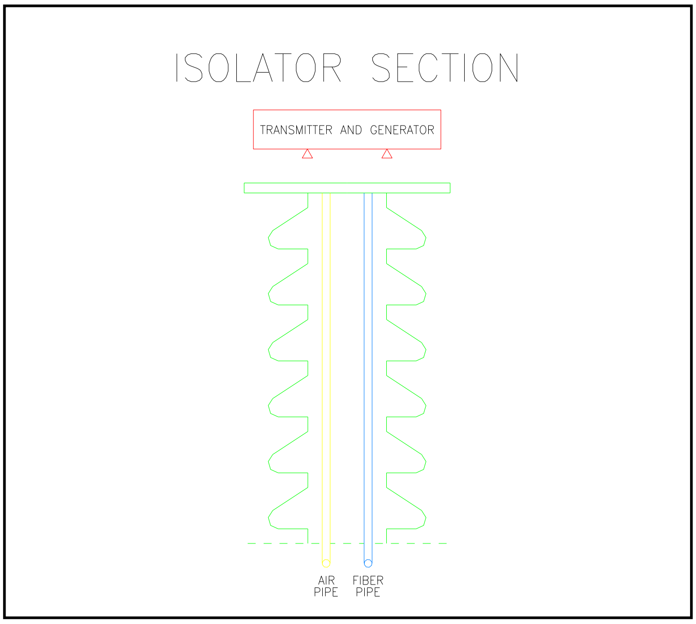


Figure 5 – Transmitters installation on an insulated support

*In this case, the transducer is outdoor type and the transmitter shall be placed in a shield box (three layer) as shown in fig. 3 & 4 and its performance free from electromagnetic and electro static field effects. The required number of shield boxes are mentioned in Appendix – II and it is in the scope of Bidder. Insulation column is not in the scope of Bidder.

6.2.1 Optical fiber type

The following characteristic should be met:

- Multimode Fiber 50/128 µm
- Connector type ST made of special alloy for rough measuring environments

- Transfer Rate 2 GB/S
- Maximum cable length 300 m but the actual length of the cable would be based on the actual distance between various test cells and Test control room DAS. The selection of optical fiber cable shall consider the redundant for all measurements from each test cell. The payment shall be made to Bidder as per the actual cable length. The bidder shall quote the optical fiber cable per meter length basis.

6.2.2 Transmitter input scale

Signal source is variable according to the transducers output, then it is necessary to adapt this output signal to the input of the Transmitter. Indicatively, the selectable input full scale can be:

- ±100-50-20-10-5-2-1-0.5-0.2-0.1 V peak.

These values will be selected by the operator (HMI software) according to the measuring range, this selection will be made available to the transmitter by means of the remote control fiber optic.

6.2.3 Transmitter commands

As stated above, from the operator interface it will be possible to send command to the remote Transmitter.
At least the following command shall be implemented:

- Range Set,
- Offset acquisition,
- Status acquisition,
- Switch ON/OFF the Transmitter,
- Reset,
- Address set,
- General Diagnostic.

6.2.4 Power Source for Data Transmission

Where it is requested to have transmitters with insulated power supply (see Appendix - II), the transmitter will be powered either by an air turbogenerator or batteries.

In case the power source comes from an electric generator compressed air driven, the generator shall be located very close to the measuring point as shown in Figure 3 and Figure 4. In case transmitters are installed very close to the transducers on an insulated support, then the air plastic tubing should be installed inside the insulator, if required, to assure insulation, protection from dust and avoid damage (see Figure 5).

A simplified block diagram of Transmitter power source is shown in Figure 6. It is important to note that the supply air has to be filtered and dried.

Information concerning the maximum consumption of compressed air per generator shall be included in the bid.

Alternatively, transmitter can be battery powered: in this case a configuration with at least 2 removable, rechargeable (Li-ion) and hot swappable battery sets are recommended, to allow for a continuous deployment. After discharging one set, the transmitter operates on the second set.

The supplier shall ensure suitable duration of batteries (Operation Time: > 24 Hours). Also monitoring of battery charge status shall be provided on DAS Human Machine Interface, with an estimation of remaining operation time per battery.

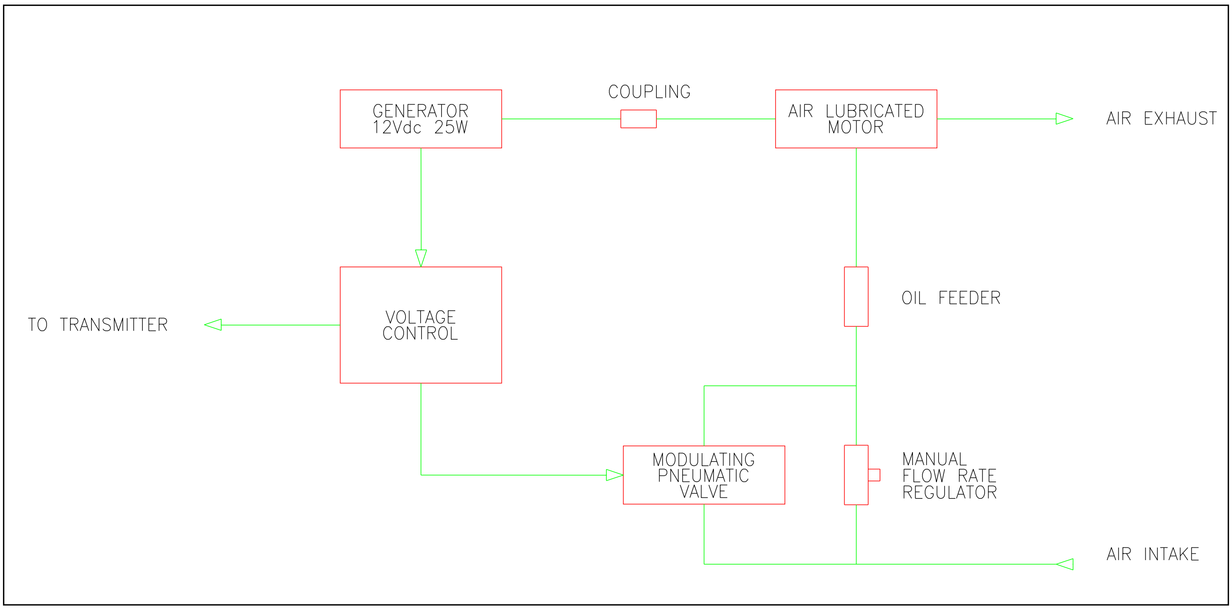


Figure 6 - Simplified block diagram of compressed air driven generator

6.3 DAS Human Machine Interface (HMI)

The HMI software shall be designed to give a modern, reliable an easy–to-use interface to the operator. Typically a Windows based interface meets these requirements. An example of HMI is shown in Figure 7. Equivalent solutions granting the same performance are acceptable.

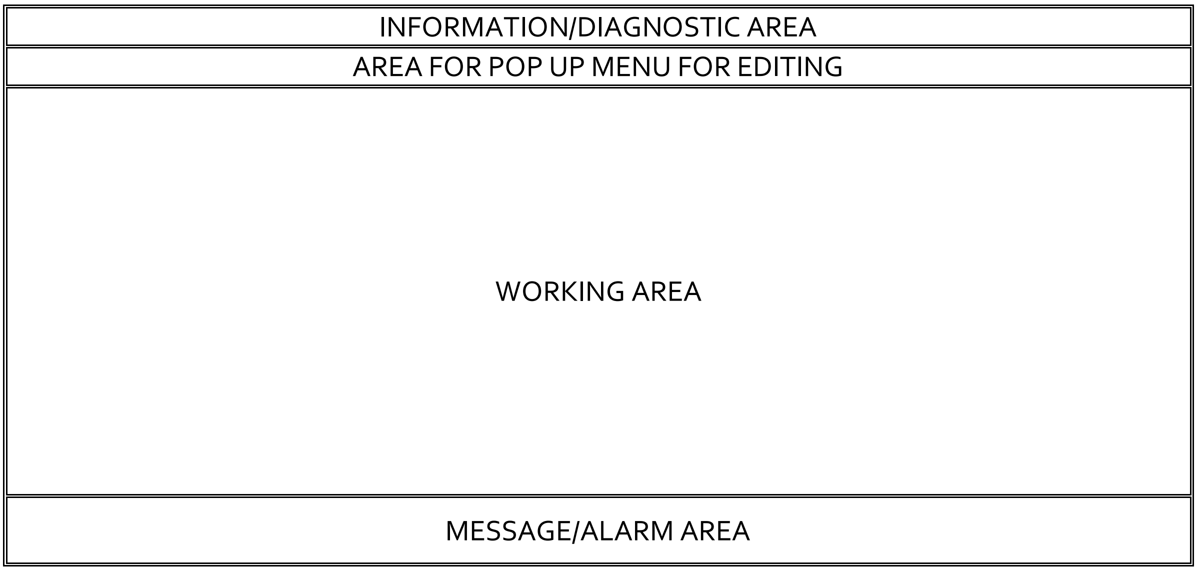


Figure 7 DAS Human Machine Interface

The screen should be divided as follow:

- ***Information/Diagnostic Area on the top:***
  In this area the HMI Software will show the main information about DAS status, what test is going to be executed, DAS READY, DAS ARMED, DAS FAULT.

- ***Working Area where it is possible to set all the DAS parameters:***

  In this area the operator can perform the following activities:

  A) Edit, save and recall all the set-ups related with the test data acquisition.
  B) Get Test Data and graphical output .
  C) Recall Archived Information
  D) Get diagnostic information from DAS.
  E) Get a Complete List of Active Alarms.
  F) Get an Alarms Historical List.

- ***Alarm Area at the bottom of the screen:***

  In this area the HMI Software will show the last incoming alarms.

6.3.1 Data acquisition setting

Before starting the test, the Operator shall set all the parameters necessary to perform a correct acquisition of test quantities.

In the working area menu there will be a dedicated pop up area where the operator can insert the main test parameters, such as input range (full scale), display scales, sampling rate and data acquisition duration.

The software will warn the operator in case of wrong input.

The following Table shows an example of the information that each input channel should have. Equivalent solutions granting the same performance are acceptable.

FULL SCALE TABLE						
Channel Name	**Type**	**Input Range**	**Link Factor**	**State**	**Enabled**	**Auto**
VD-1-L1	Voltage	50	4600	ON	Y	Y
VD-1-L2	Voltage	50	4400	ON	Y	Y
VD-1-L3	Voltage	50	4360	ON	Y	Y
SH-1-L1	Current	50	0.1	ON	Y	Y
SH-1-L2	Current	50	0.1	ON	Y	Y
SH-1-L3	Current	50	0.1	ON	Y	Y
Master breaker	Current	50	1	ON	Y	N

Table 1 information about each input channel

By means of these data, before starting the test sequence, the DAS software will set all the enabled channels. In case a channel is not responding an alarm will warn the operator and the channel will be marked OFF in the table.

The input range field for test voltage and test current is automatically chosen by the DAS software for the channel where the field **Auto** is marked Y (Yes).

The **link factor** is the multiplication factor for engineering units conversion (kV, kA), DAS software will also take into account the measure offset and the measure actual gain obtained during channel calibration (see par. 6.6).

6.3.2 Data display scales and format

At the end of the test, or upon operator request, the DAS software shall be able to recall the data stored during the acquisition process. The DAS software shall allow the operator to choose in what way the data has to be displayed.

An example of display parameters which shall be selectable is listed hereinafter. Equivalent solutions granting the same performance are acceptable.

Start time/End time: it is the data display duration, usually it covers all the test duration however the operator shall have the possibility to select any duration to display only a part of the test (these function is done with zooming as well; see data analysis software in the next par.6.4).

Channel Name: it is the symbolic name of the acquisition channel (an help will show more information concerning the channel description).

Measure: is the type of the measure, i.e. current, voltage, pressure, temperature.

Position: is the measure location on the display and also in the hardcopy (within a predefined display format, see Figure 8 for example).

Colour: is the trace colour on the display and also in the hardcopy.

Scale: the display will be divided in a XY plot, this means that in the selected position of axis Y will be placed the measure, while the time is placed in the X axis. The scale is related with the marker of the Y axis. An example of display format is shown in Figure 8.

Coeff: is an eventual free multiplication factor.

Add offset: is an eventual free additional offset.

Enabled: enable/disable the measure display:

Auto: if selected (Y), DAS software will automatically calculate the scale according to test parameters.

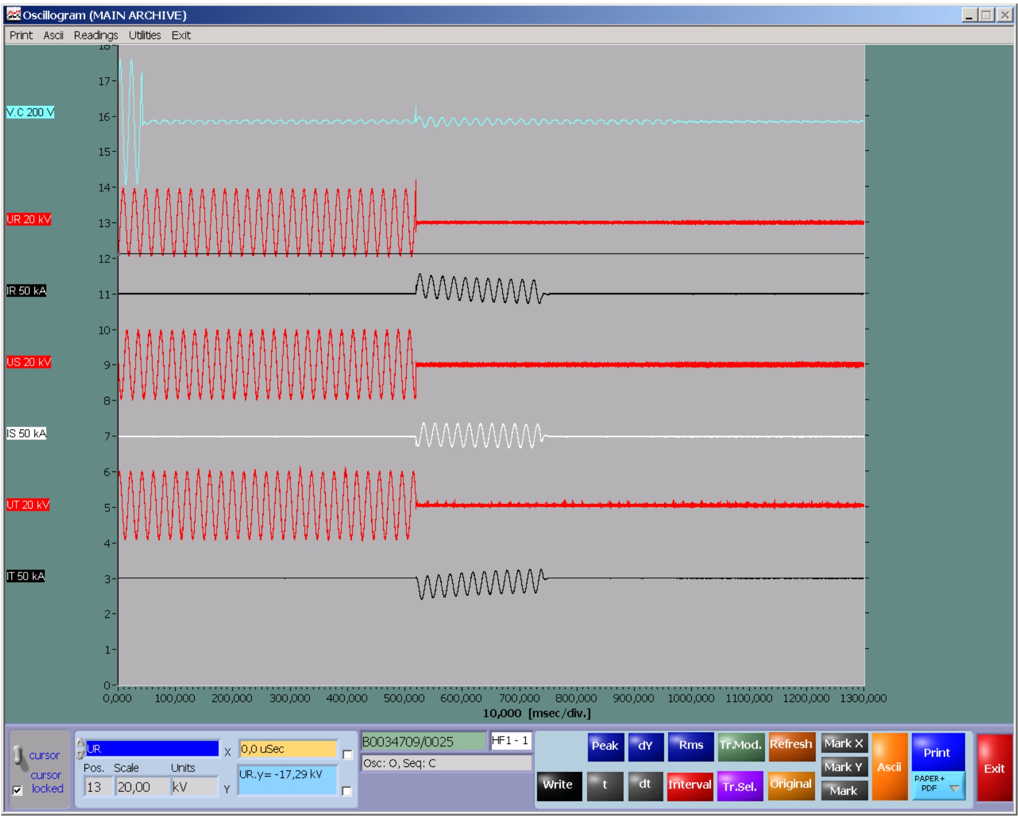


Figure 8 Data display scales and format

6.4 Data Analysis Software

The Data Analysis software shall include at least the following features:

- Acquired Data Display as described in par. 6.3, the operator can easily view the test data with dedicated help for the functionality;
- Calculation of RMS values, Peak values, TRV: The calculation functions shall implement algorithms and methods according to STL Technical Report "Harmonisation of data processing methods for High Power Laboratories";
- Calculation of time values - Using cursor related with X axis (difference between two cursor position);
- Calculation of difference between two different cursor position related with Y axis (after measure selection);
- Zooming - Using XY cursor;
- Data export in MS Excel format or equivalent;
- Data export in Acrobat PDF format.

6.5 Client Access

The Data Acquisition System shall have a PC for Clients (connected with a printer and other PCs via LAN) with dedicated parts of DAS software: this allows the clients to analyse test results immediately after test execution. The allowed functions are a subset of those available to the operator. Client Access to the system is restricted by a dedicated password. The supplied PC configuration (latest technology and model) shall suits to operational requirements of DAS.

Client PC functionality are:

- view only the test results that the operator select for client PC;
- data analysis of test (see par.6.3);
- print the data displayed;
- export and save data to a PDF file for future use.

6.6 Calibration

Data acquisition system shall be calibrated by an ILAC Accredited, ISO/IEC 17025 laboratory. It is in the scope of Bidder and also DAS Software validation material shall be provided.

6.7 Test Reports

Oscillograms and calculation results shall be archived in a dedicate storage area in order to be easily found and ready to use by the operator to fill in the Test Reports.

6.8 Diagnostic

DAS system shall have a dedicated diagnostic system.

➢ ***Hardware Diagnostic***

The following Diagnostic Signals should be displayed with dedicated indicators on the front of DAS panel:

- DAS General Fault,
- DAS Channel Fault,
- DAS Power Fault.

- ***Software Diagnostic***

  Status of Data Communication Links, channels, power shall be displayed in a dedicated diagnostic page which can be recalled from HMI. Furthermore, inside the dedicated HMI screen zone (alarm and information/diagnostic zones) there will be:

  - ***Information/Diagnostic***

    Special software indicators that summarize equipment fault or status;
  - ***Alarms***

    Dedicated alarm messages to inform the operator about the fault equipment.

7 GLOBAL TEST MANAGEMENT

As already mentioned at the beginning of this document, test execution involves several activities. Concerning the Test Sequence and the Data Acquisition System these activities can be carried out with a global dedicated software. Actions of this software are summarized below.

Preliminary Operator actions:

- Prepare the Test Sequence according to the test that has to be carried out and related standard;
- Set-up the Data Acquisition System, configuring measurement channels and data display;
- Execute a measure channel calibration (one per daily shift).

At this point the operator can start the test. The software should act as follow:

- Set Transmitters inputs according to the test configuration;
- Set the Data Acquisition sampling rate as required by the operator;
- Set the acquisition duration according to the test cycle;
- Arm Data Acquisition Hardware;
- Compile and Load the Test Sequence in the Test Sequencer.

When the CMS signals that the Test Circuit is ready for the test, the operator can push the button START TEST SEQUENCE. This will trigger the Test Sequencer and the sequence is performed, including Data Acquisition (DAS trigger comes from the Test Sequencer).

When the end of the test is reached and all the acquired data is in the DAS Hardware memory, the software will act as follow:

- Download sampled data from DAS memory;
- Execute all the required calculations to display the data;
- Display the data.

The operator can then perform data analysis on displayed data and perform all the operation of saving and recalling as described in the previous paragraphs.

8 TESTS ON DAS

The Data Acquisition System shall be subjected to following tests to establish compliance with the applicable Standards.

The Bidder shall define the test procedures to verify the performances required by the present technical specification. Such procedures shall be approved by the CPRI before the execution of the tests.

The CPRI representatives shall be allowed to inspect the production process in the factory.

Factory Acceptance Tests performed by the Bidder to verify the compliance of the components and/or the integrated system are not to be repeated after on-site installation.

8.1 Type Tests (indicative list)

a) Accuracy Tests:

i. Operational Measured Values (currents, voltages, time, etc.)

ii. Derived/integrated Values obtained by formulas, calculations, algorithms (power, energy, peak and average values, etc.)

b) Insulation Tests:

i. Dielectric Tests;

ii. Impulse Voltage withstands Test.

c) Influencing Quantities on power supply:

i. Limits of voltage fluctuations;

ii. Permissible ripples;

iii. Interruption and dips of voltage.

d) Electromagnetic Compatibility Test:

i. 1 MHz burst disturbance test;

ii. Electrostatic Discharge Test;

iii. Radiated Electromagnetic Field Disturbance Test;

iv. Electrical Fast transient Disturbance Test;

v. Conducted Disturbances Tests induced by Radio Frequency Field;

vi. Magnetic Field Test;

vii. Emission (Radio interference level) Test;

viii. Conducted Interference Test.

e) Functional Tests:

i. Indicators;

ii. Commands;

iii. Measured Values Acquisition;

iv. Operations and sequences;

v. Storage and retrieval;

vi. Display Indications.

f) Environmental tests:

i. Cold Temperature;
ii. Dry Heat;
iii. Wet heat;
iv. Humidity (Damp heat Cycle);
v. Vibration;
vi. Bump;
vii. Shock.

8.2 Factory Acceptance Test (FAT)

The Bidder shall inform the CPRI of the Factory Acceptance Tests program 60 days in advance and shall allow the CPRI representatives to witness them.

The Bidder shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the DAS for approval by the CPRI.

The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test laboratory. During FAT the complete DAS to be supplied under the present scope shall be tested for complete functionality and configuration in the factory itself. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

The Bidder shall provide for each supplied component, proper calibration certification, with the evidence of the measurement traceability to the national standards, through a calibration center recognized by a national accreditation body in compliance with ISO/IEC 17025.

If the complete system consists of parts from various suppliers, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

8.2.1 Hardware Integration Test

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The supplier specifically demonstrates how to add a device in future in DAS during FAT.

8.2.2 Software validation procedure

Because of its complexity, software should be divided in functions that can be tested and debugged separately. In this way validation process can be carried out and documented following step by step the software architecture.

a) General review to validate software requirements;
b) Validation of user interface requirements (e.g. functionality test of user access, user input to the DAS software, simulating wrong input to validate implemented error handling and diagnostic);
c) Validation of communication with Data Acquisition Devices (e.g. download/upload tests, signal attenuation tests, sampling rate tests and communication errors simulation);
d) Data acquisition validation using precise calibration signals to be acquired by DAS (analysis of acquired data considering attenuation, time duration, sampling rate and memory usage);

e) Validation of LAN/WAN connection (e.g. data exchange between computers and connection errors);
f) Calculation and Data Analysis Algorithms validation by means of data simulation and/or simulated signals to be acquired and processed;
g) Validation of output results, data display, data archiving and data export.

Every step of the validation process shall be documented. In case of anomaly in the developed software, a dedicated Anomaly Report Form shall be filled, errors shall be fixed and removed according to a defined time schedule. As soon the error is removed the Anomaly Report Form shall be updated accordingly.

8.2.3 Integrated System Test

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate without errors and malfunctioning for a continuous period (duration of the tests shall be approved by the CPRI). The integrated system test shall ensure that the DAS is free of improper interactions between software and hardware while the system is operating as a whole.

8.3 Site Acceptance Test

The site acceptance tests (SAT) shall completely verify all the features of the DAS, hardware and software. The Bidder shall submit the detailed SAT procedure to the CPRI for approval.

Site Acceptance Tests shall verify either normal operations (start-up, measure links management, calibrations, acquisition of measurements, storage and retrieval of settings, data analysis and storage, back-up, shut-down, etc.) or abnormal but expected situations (for example cycle interruption, loss of data, human errors, system faults).
The complete measuring chains (from TX to RX and DAS output) accuracy for different ranges shall be verified by the Bidder and shall be submitted to the CPRI for approval.

9 DOCUMENTATION

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings shall be provided in "dwg" format.

- Data Acquisition System architecture and Block Diagram;
- Guaranteed technical parameters, Hardware Specifications and Guaranteed availability and reliability;
- Assembly drawings, schematic diagrams, List of Apparatus, List of Labels;
- Test Specification for Factory Acceptance Test (FAT) and Site Acceptance Test (SAT);
- Product Manuals;
- Operator's Manual;
- Listing of software and loadable in CD ROM;
- Other documents as may be required during detailed engineering.

10 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

The Bidder shall arrange on its own cost all hardware training platform required for successful training. The Bidder shall provide all necessary training material: each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to the CPRI before the scheduled commencement of the training course.

The Bidder shall quote training prices. The schedule, location, and detailed contents of the training course will be finalized during CPRI and Bidder discussions.

10.2 DAS Hardware Course

A course focused on DAS hardware shall be offered, to give CPRI's personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with Bidder's maintenance personnel. The following subjects shall be covered:

a. System Hardware Overview.
b. Configuration of the DAS hardware equipment.
c. Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the system.
d. System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
e. Hands on Training: this training shall be provided on CPRI equipment, or on similarly configured systems.

10.3 Application Software Course

The Bidder shall provide a comprehensive course on DAS application software, covering all functions. The training shall include:

a. Overview of the application software and data flows.
b. Data acquisition setting procedures: start-up, measure links management, calibrations, acquisition of measurements, storage and retrieval of settings, back-up, shut-down.
c. Data Analysis Functions: functional capabilities and major algorithms. Associated programming techniques.
d. Hands-on Training: this training shall be provided on CPRI equipment, or on similarly configured systems.

10.4 Maintenance during the Guarantee Period

During the Guarantee Period as specified in tender documents, the Bidder shall take continual actions to ensure the guaranteed system availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

10.5 Reliability and Availability

The DAS shall be designed so that the failure of any single component, processor, or device shall not render, as far as possible, the system unavailable. The DAS shall be designed to satisfy the very high demands for reliability and availability concerning:

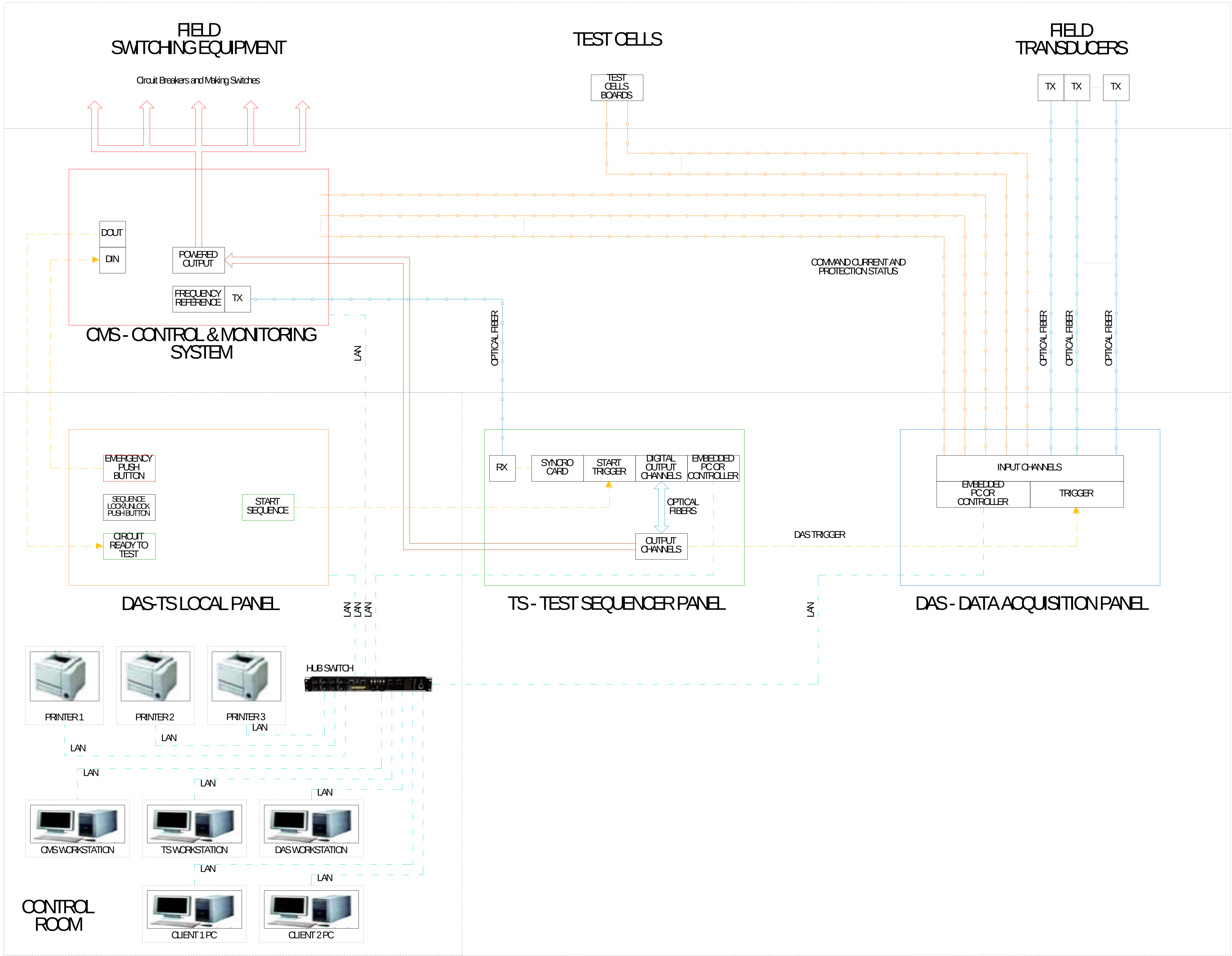
- Mechanical and electrical design;
- Security against electrical interference (EMI);
- High quality components and boards;
- Modular, well-tested hardware;
- Thoroughly developed and tested modular software;
- Easy-to-understand programming language for application programming;
- Detailed graphical documentation and application software;
- Built-in supervision and diagnostic functions;
- Security;
- Distributed solution;
- Independent units connected to the local area network;
- Back-up functions;
- Panel design appropriate to the harsh electrical environment and ambient conditions;
- Panel grounding immune against transient ground potential rise.

The availability for the complete DAS shall be guaranteed by the Bidder. The Bidder shall include in the offer the detailed calculation for the availability.

10.6 Mandatory Spares

The Bidder is required to list the suggested mandatory spares for the DAS, as well as the spares which may be required for ensuring the guaranteed availability. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the Bidder and shall be considered in the evaluation of the bid.

APPENDIX - I– INTERCONNECTION DIAGRAM BETWEEN CMS-TS-DAS


FIELD
SWITCHING EQUIPMENT
Circuit Breakers and Making Switches
TEST CELLS
TEST
CELLS
BOARDS
FIELD
TRANSDUCERS
TX
TX
TX
DOUT
DIN
POWERED
OUTPUT
FREQUENCY
REFERENCE
TX
CMS - CONTROL & MONITORING
SYSTEM
LAN
OPTICAL FIBER
COMMAND CURRENT AND
PROTECTION STATUS
OPTICAL FIBER
OPTICAL FIBER
OPTICAL FIBER
EMERGENCY
PUSH
BUTTON
SEQUENCE
LOCK/UNLOCK
PUSH BUTTON
START
SEQUENCE
CIRCUIT
READY TO
TEST
DAS-TS LOCAL PANEL
RX
SYNCRO
CARD
START
TRIGGER
DIGITAL
OUTPUT
CHANNELS
EMBEDDED
PC OR
CONTROLLER
OPTICAL
FIBERS
OUTPUT
CHANNELS
TS - TEST SEQUENCER PANEL
DAS TRIGGER
INPUT CHANNELS
EMBEDDED
PC OR
CONTROLLER
TRIGGER
DAS - DATA ACQUISITION PANEL
LAN
LAN
LAN
LAN
HUB SWITCH
PRINTER 1
PRINTER 2
PRINTER 3
LAN
LAN
LAN
LAN
LAN
LAN
CMS WORKSTATION
TS WORKSTATION
DAS WORKSTATION
LAN
LAN
CONTROL
ROOM
CLIENT 1 PC
CLIENT 2 PC

APENDIX II – PRELIMINARY LIST OF DAS INPUTS

The following tables provide the preliminary lists of DAS inputs coming from the measurement devices, along with their description. The list of channels is indicative purpose.

General Notes:

- Channels numbers beginning with T (T.1, T.2, etc.) are relevant to signals coming from measurement transducers in a Test Cell; if the Control room manages testing in two Test Cells, the signals relevant to each Test cell will be identified with the same index (T1.1, T1.2 refer to a Test Cell, T2.1, T2.2 refer to the other Test Cell);
- Insulated supply means that the transmitter will be powered either by air turbogenerator/batteries (Y) or with the normal power supply (N);
- Insulated column means that the transmitter will be placed on a support with a dedicated insulated column.

HPTR Test Cell

DAS CHANNELS						
Channel Nr.	*Channel name*	*Description*	*Acquisition card type*	*Transmitter*		*Note*
				Insulated supply (Y/N)	*Insulated column (Y/N)*	
T.1	SH(600)1_U	Shunt (HV supply side)		Y	Y	
T.2	SH(600)1_V	Shunt (HV supply side)		Y	Y	
T.3	VD(600)1_U	Voltage Divider (HV supply side)		Y	N	
T.4	VD(600)1_V	Voltage Divider (HV supply side)		Y	N	
T.5	SH(36)1_U	Shunt (short-circuit side)		Y	Y	
T.6	SH(36)1_V	Shunt (short-circuit side)		Y	Y	
T.7	SH(36)1_W	Shunt (short-circuit side)		Y	Y	
T.8	VD(36)1_U	Voltage Divider (short-circuit side)	Digital optical link	Y	N	
T.9	VD(36)1_V	Voltage Divider (short-circuit side)		Y	N	
T.10	VD(36)1_W	Voltage Divider (short-circuit side)		Y	N	
T.11	Tank Current	Tank Current Measurement		Y	N	
T.12		Free Measure 1 in HPTR		Y	N	
T.13		Free Measure 2 in HPTR		Y	N	
T.14		Free Measure 3 in HPTR		Y	N	
T.15		Free Measure 4 in HPTR		Y	N	
T.16		Free Measure 5 in HPTR		Y	N	
T.17		Free Measure 6 in HPTR		Y	N	

Test Cell 3.4 and New Test Cell 3.5

DAS CHANNELS						
Channel Nr.	*Channel name*	*Description*	*Acquisition card type*	*Transmitter*		*Note*
				Insulated supply (Y/N)	*Insulated column (Y/N)*	
T1.1	SH(72.5)1(a)_U	Shunt (New Test Cell 3.5 supply side)		Y	Y	
T1.2	SH(72.5)1(a)_V	Shunt (New Test Cell 3.5 supply side)		Y	Y	
T1.3	SH(72.5)1(a)_W	Shunt (New Test Cell 3.5 supply side)		Y	Y	
T1.4	VD(72.5)1_U	Voltage Divider (MV supply side)		Y	N	
T1.5	VD(72.5)1_V	Voltage Divider (MV supply side)		Y	N	
T1.6	VD(72.5)1_W	Voltage Divider (MV supply side)		Y	N	
T1.7	SH(72.5)1(b)_U	Shunt (Mobile - New Test Cell 3.5)		Y	N	
T1.8	SH(72.5)1(b)_V	Shunt (Mobile - New Test Cell 3.5)	Digital optical link	Y	N	
T1.9	SH(72.5)1(b)_W	Shunt (Mobile - New Test Cell 3.5)		Y	N	
T1.10	Tank Current	Tank Current Measurement (New Test Cell 3.5)		Y	N	
T1.11		Free Measure 1 in New Test Cell 3.5		Y	N	
T1.12		Free Measure 2 in New Test Cell 3.5		Y	N	
T1.13		Free Measure 3 in New Test Cell 3.5		Y	N	
T1.14		Free Measure 4 in New Test Cell 3.5		Y	N	
T1.15		Free Measure 5 in New Test Cell 3.5		Y	N	
T1.16		Free Measure 6 in New Test Cell 3.5		Y	N	
T2.1	Existing SH1_U	Shunt		Y	N	

DAS CHANNELS						
Channel Nr.	*Channel name*	*Description*	*Acquisition card type*	*Transmitter*		*Note*
				Insulated supply (Y/N)	*Insulated column (Y/N)*	
		(Test Cell 3.4 supply side)				
T2.2	Existing SH1_V	Shunt (Test Cell 3.4 supply side)		Y	N	
T2.3	Existing SH1_W	Shunt (Test Cell 3.4 supply side)		Y	N	
T2.4	Existing SH2_U	Shunt (Mobile - Test Cell 3.4 load side)		Y	N	
T2.5	Existing SH2_V	Shunt (Mobile - Test Cell 3.4 load side)		Y	N	
T2.6	Existing SH2_W	Shunt (Mobile - Test Cell 3.4 load side)		Y	N	
T2.7	Existing VD1_U	Voltage Divider (Test Cell 3.4 supply side)		Y	N	
T2.8	Existing VD1_V	Voltage Divider (Test Cell 3.4 supply side)		Y	N	
T2.9	Existing VD1_W	Voltage Divider (Test Cell 3.4 supply side)		Y	N	
T2.10	TB_CL	Circuit-breaker under test in Test Cell 3.4:operating current of closing coil		N	N	
T2.11	TB_OP	Circuit-breaker under test in Test Cell 3.4: operating current of opening coil		N	N	
T2.12		Free Measure 1 in Test Cell 3.4		Y	N	
T2.13		Free Measure 2 in Test Cell 3.4		Y	N	
T2.14		Free Measure 3 in Test Cell 3.4		Y	N	
T2.15		Free Measure 4 in Test Cell 3.4		Y	N	
T2.16		Free Measure 5 in Test Cell 3.4		Y	N	
T2.17		Free Measure 6 in Test Cell 3.4		Y	N	

300kA Test Cell

DAS CHANNELS						
Channel Nr.	*Channel name*	*Description*	*Acquisition card type*	*Transmitter*		*Note*
				Insulated supply (Y/N)	*Insulated column (Y/N)*	
T1.1	Existing SH1_U	Shunt (Test Cell 300 kA supply side)		Y	N	
T1.2	Existing SH1_V	Shunt (Test Cell 300 kA supply side)		Y	N	
T1.3	Existing SH1_W	Shunt (Test Cell 300 kA supply side)		Y	N	
T1.4	Existing SH2_U	Shunt (Mobile - Test Cell 300 kA load side)		Y	N	
T1.5	Existing SH2_V	Shunt (Mobile - Test Cell 300 kA load side)		Y	N	
T1.6	Existing SH2_W	Shunt (Mobile - Test Cell 300 kA load side)		Y	N	
T1.7	Existing VD1_U	Voltage Divider (Test Cell 300 kA supply side)		Y	N	
T1.8	Existing VD1_V	Voltage Divider (Test Cell 300 kA supply side)		Y	N	
T1.9	Existing VD1_W	Voltage Divider (Test Cell 300 kA supply side)		Y	N	
T1.10	TB_CL	Circuit-breaker under test in Test Cell 300 Ka :operating current of closing coil		N	N	
T1.11	TB_OP	Circuit-breaker under test in Test Cell 300 kA: operating current of opening coil		N	N	
T1.12		Free Measure 1 in Test Cell 300 kA		Y	N	
T1.13		Free Measure 2 in Test Cell 300 kA		Y	N	
T1.14		Free Measure 3 in Test Cell 300 kA		Y	N	
T1.15		Free Measure 4 in Test Cell 300 kA		Y	N	
T1.16		Free Measure 5 in Test Cell 300 kA		Y	N	
T1.17		Free Measure 6 in Test Cell 300 kA		Y	N	