

## ANNEXURE 'A'

### TECHNICAL SPECIFICATION AND SCOPE OF WORK FOR

### "DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF DATA MONITORING SYSTEM FOR BACK-TO-BACK TRACTION CONVERTER TEST FACILITY (IEC 61377-3)"

#### 1.0 Brief introduction of 3 phase Locomotives of Indian Railways

With advancement in AC drives technology Locomotives with induction motors were introduced in Indian Railways in 1995. These locomotives had GTO based traction converters. Further in 2010 IGBT based traction converters were introduced in these locomotives. At present these locomotives are the workhorses of Indian Railways. There are three variants of 3 phase locos –

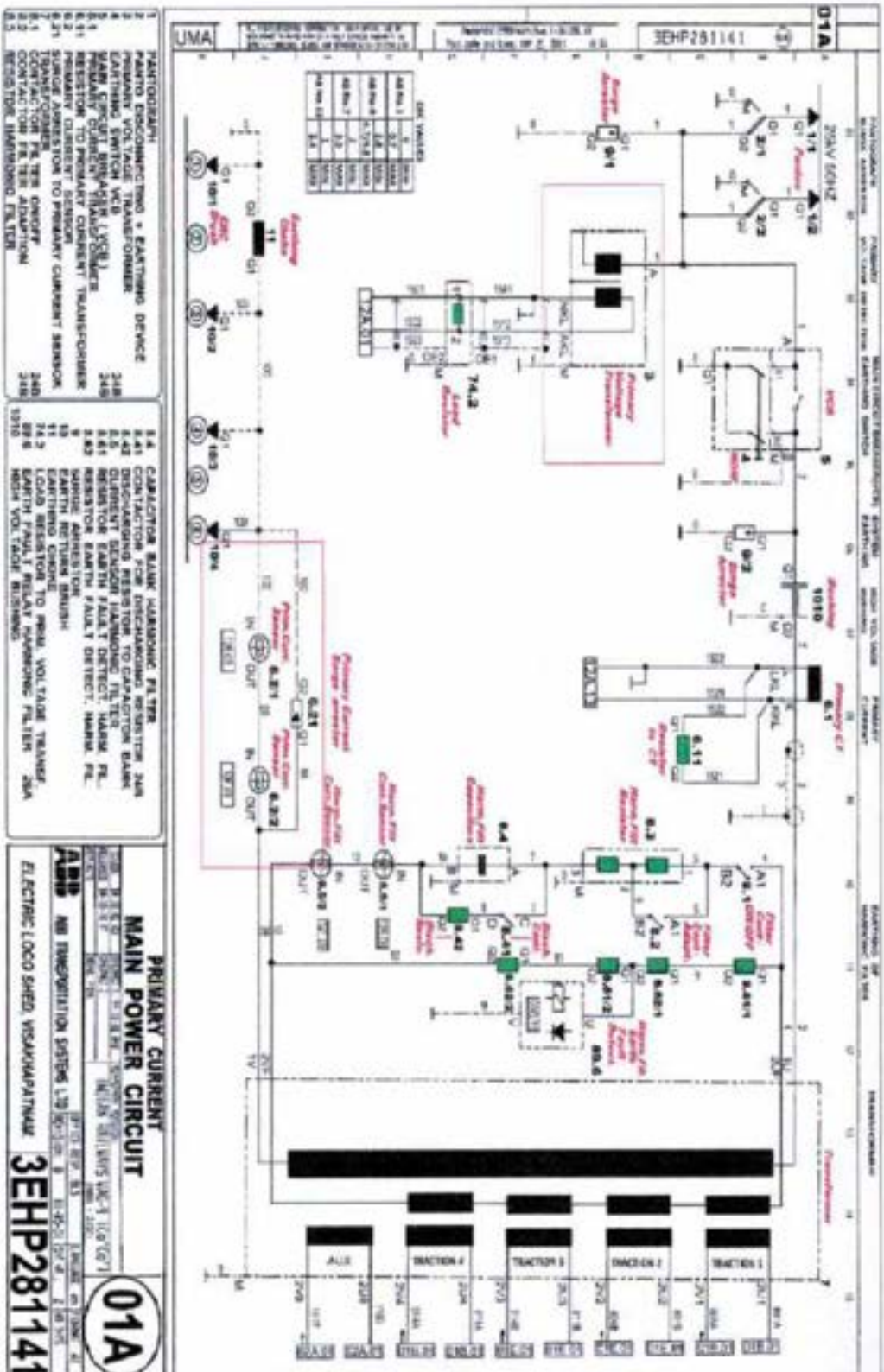
- WAG 9H – 6120 HP, Co-Co bogie, used for freight trains
- WAP 7 – 6120 HP, Co-Co bogie, used for passenger trains
- WAP 5 – 6000 HP, Bo-Bo bogie, used for passenger trains

#### 1.1 The basic architecture of these locos is as follows

- Traction Power Circuit - Locomotive fetch power from 25 kV 50 Hz single phase OHE by the means of pantograph. 25 kV supply then reaches traction transformer present in the underframe of loco with protective equipment VCB in between. Thereafter 25 kV is stepped down to 1.269kV. This stepped down supply is fed to traction converter which converts this single-phase AC supply to DC and then to controlled 3 phase AC. This supply feeds the induction motors present in the bogies.
- Auxiliary power circuit – The auxiliary supply of 3 phase 415 V powers various auxiliary machines in the loco. The major works of these machines are – cooling of power equipment like transformer, traction motors, traction converters, machine room etc, generation of compressed air for brake equipment and other functions & DC supply for control circuit and battery charging
- Pneumatic circuit – Compressed air is used for brakes operation in locomotive and trains. There are compressors which generate compressed air and feed it to pneumatic control panel. There after this panel control pressure in various pipe lines and application/releasing of brakes. VCB and Pantograph in loco require pneumatic pressure for their operation which is fed by this panel.
- Control circuit – The entire operation of VCB, Pantograph, Traction converters, Auxiliary converters, Traction motors, communication, pneumatic panel etc. is controlled by Vehicle control unit (VCU). There are two VCU in one loco.
- Bogies – The loco body rests on the bogie frame. It is suspended through helical springs. The loco body load is transferred to axles through bogie frame. The traction motors are supported on bogie frame. Half of the motor load is on bogie frame and remaining on the axle. The brake hangers are supported on bogie frame.

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## 1.2 HV circuit and Transformer



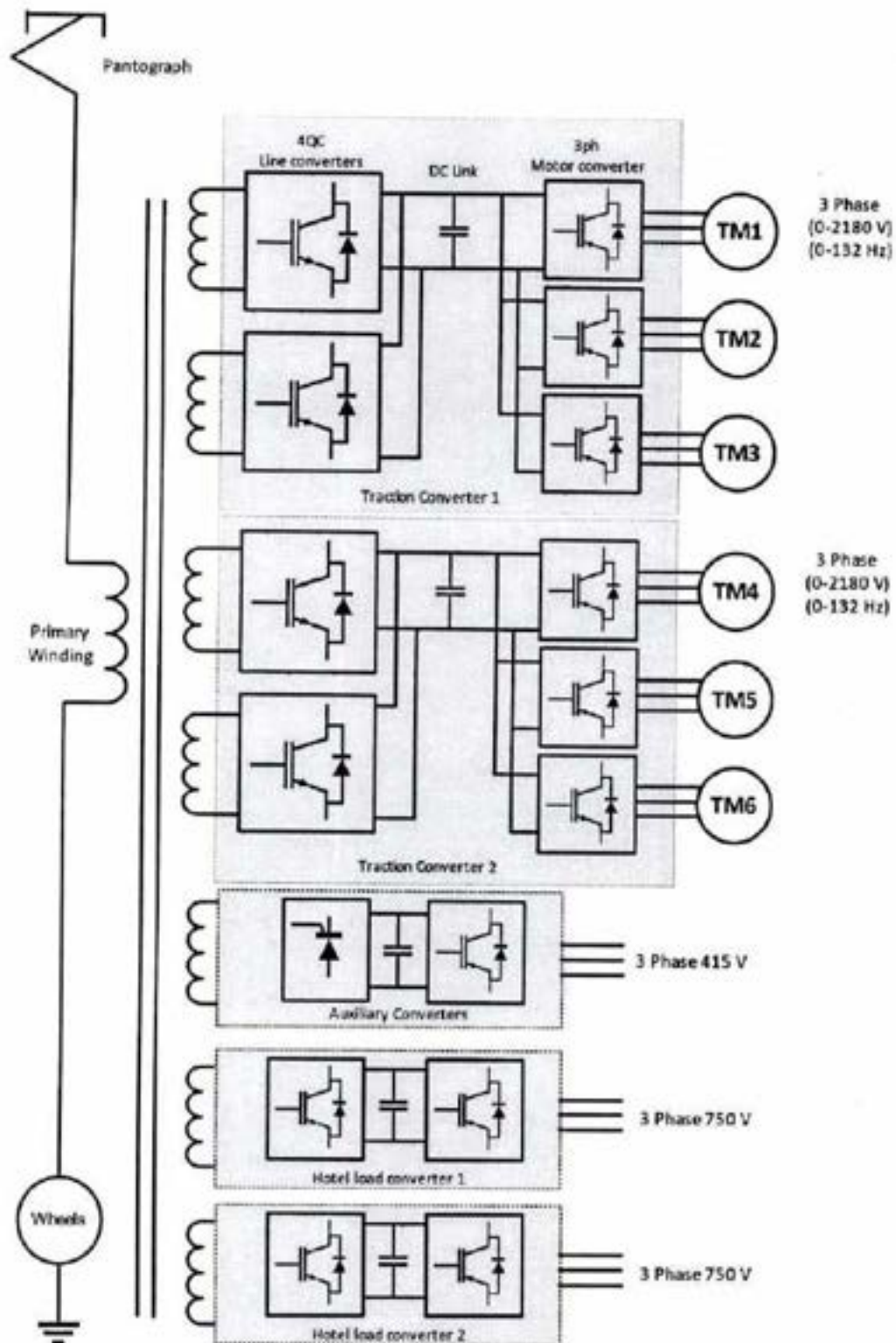
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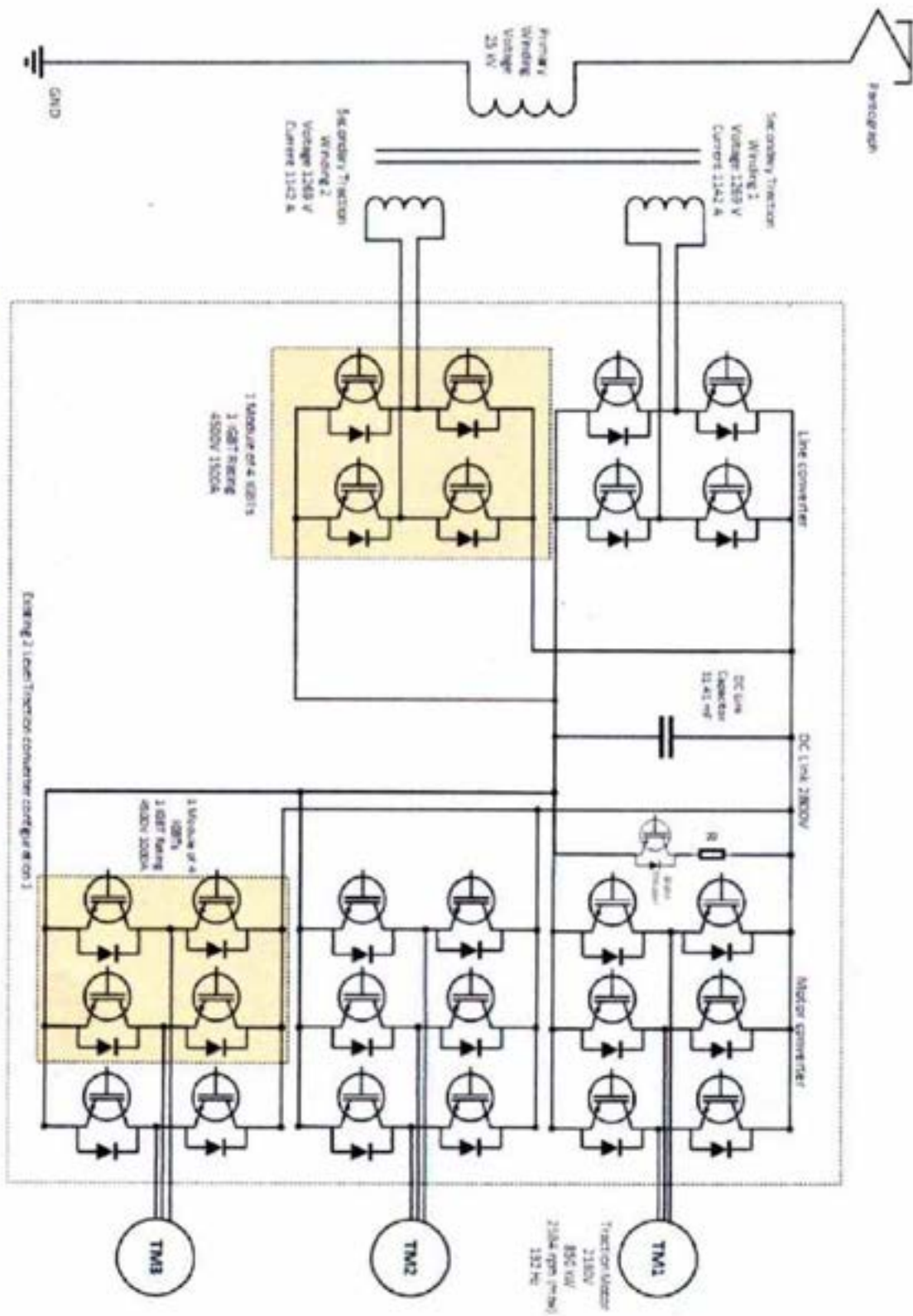


### 1.3 Overall structure of power circuit of 3 phase locomotives



<i>Marenda</i> SSE/PE LAB/ELS CNB	<i>Shrikant</i> DEE/RS/CNB	<i>Rahul</i> DEE/RS/CNB
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## 1.4 Details of IGBT traction converters and motors



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### 1.5 Ratings of equipment in WAG9H/WAP7 locomotives

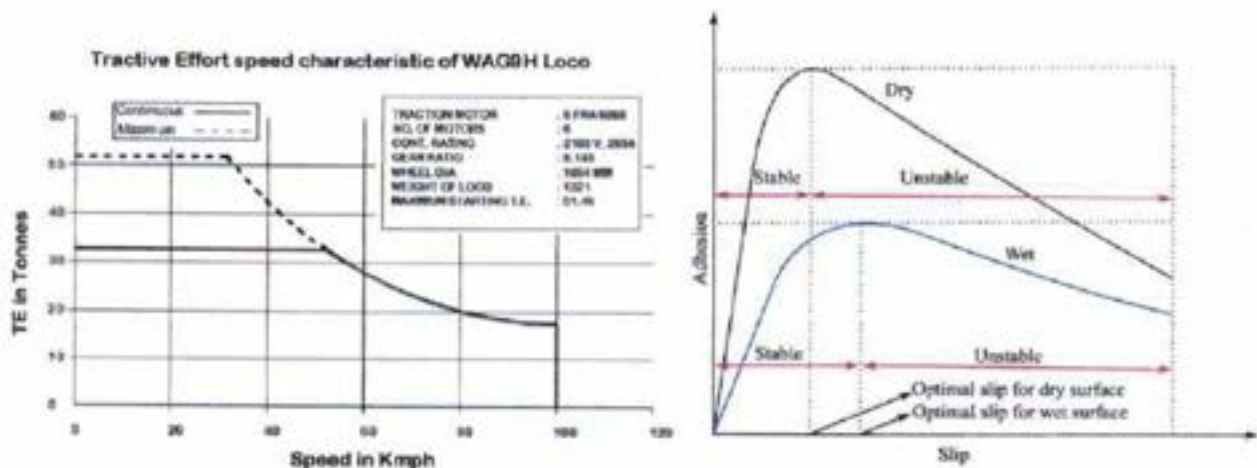
Equipment	Parameter	Value
Transformer	Power	6531 kVA
	Primary winding voltage	25 kV
	PT ratio	25000:200
	Secondary winding voltage	4 x 1269 V (4 traction windings)
	Auxiliary winding voltage	1000 V
	Primary current rating	261.25 A
	Primary CT (Near bushing)	500A/5 A
	Return path CT	5000:1
Traction converter	CT ratio 4QC	5000:1
	DC link voltage	2800 V
	Voltage sensor ratio	4200:7
	Inverter output voltage (3ph)	2180 V
	CT ratio	5000:1
	Inverter frequency	0-132 Hz
	Power	3000 kVA
Traction motor	Type	3-ph induction motor 6 pole
	Power	850 kW
	Speed	2584 RPM
	Voltage	2180 V
	Current	393 A (Max)
Auxiliary converter 1, 2 & 3	Power	3 x 130 kVA
	Input voltage	1000 V 1 ph
	DC link voltage	620 V
	Output voltage	415 V 3 ph
	Output current	180 A
	Output frequency	Aux 1 – 37 to 50 Hz Aux 2 – 37 to 50 Hz Aux 3 – 50 Hz
Traction motor blower 1&2	Power	2 x 25 kW
Oil Cooling Blower 1 & 2	Power	2 x 30 kW
Transformer pump 1 & 2	Power	2 x 4.7 kW
Converter pump 1 & 2	Power	2 x 1.5 kW
Machine room blower 1 & 2	Power	2 x 2.6 kW
Compressor 1 & 2	Capacity	2 x 1750 LPM (2 x 15 kW)
Battery charger	Power	12 kW
	Voltage	110 V DC

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## 1.6 Details of working of 3 phase locomotives

Power is drawn from OHE at 25 kV through pantograph. This supply is fed to main transformer. There are 4 secondary windings which feed the traction converters. Two secondary windings feed one traction converter. The transformer windings feeds 4Q converter which converts AC input to DC. It also maintains unity power factor and feeds power back to OHE during regenerative braking. 4Q converter generates a DC link voltage of 2800 V. There is a 100Hz filter on DC link side for filtering out 100Hz power component. To control overvoltage in the DC link there is a resistor fed by an IGBT present in DC link. The excess energy in DC link is dissipated through this resistor. DC link is utilized by inverters to generate 2100 V 3 phase supply for traction motors. 3 traction motors are present in one bogie. All the three motors are fed independently by inverters i.e. there are three inverters in one traction converter. In case of any fault in one of the motor the supply of only faulty motor is interrupted. Other inverters and motors continue to work. The frequency of inverters varies from 0 to 132 Hz. From 0 to 65 Hz the motors work in constant torque region and from 65 to 132 Hz they work in constant power mode.



Different manufacturers use different types of methods for controlling traction motors like BT uses Direct torque control technique while Medha uses field-oriented control. There is a slip slide algorithm implemented in the control system to optimize adhesion under various conditions which improves the tractive effort of loco.

Control unit is present in traction converter which controls both 4QC and inverters. There is an overall control unit called VCU which controls and monitors the overall loco operation and sub systems. The commands from driver desk are received by VCU and then are sent to traction converters and auxiliary converters and feedback is taken from them and displayed back to driver display unit.

There are auxiliary converters which generates 415 V 3 phase supply for feeding the auxiliary motors, compressor and battery charger. 1000 V is converted to 620 V DC with thyristor rectifier and then inverter uses this DC link to generate 415 V 3 phase supply. There

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are three auxiliary converters of 130 kVA each. The auxiliary blowers are all three phase induction motors and are used for cooling the power circuit equipment, generating pneumatic pressure and for 110 V DC supply.

## 2.0 Testing of traction converters

Power Electronics Lab is setup at Electric Loco Shed Kanpur and is undertaking repair of IGBT modules and various electronic cards of the traction converters, auxiliary converters, VCUs, other equipment. Testing of repaired IGBT modules and electronic cards under loaded condition is an important aspect to ascertain the quality of repair. IEC 61377-3 "Railway applications – Rolling stock –Part 3: Combined testing of alternating current motors, fed by an indirect convertor, and their control system" defines the setup for back-to-back traction converter testing on load.

### 2.1 Back-to-Back converter setup

Basic layout of back-to-back test setup is as follows.

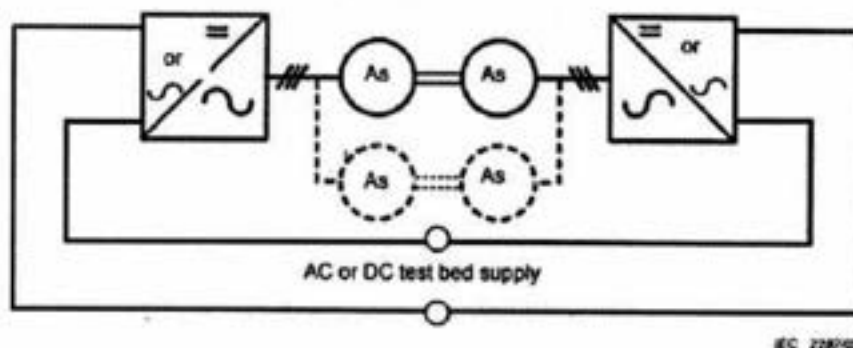

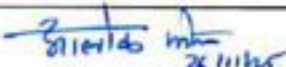
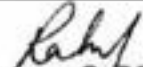


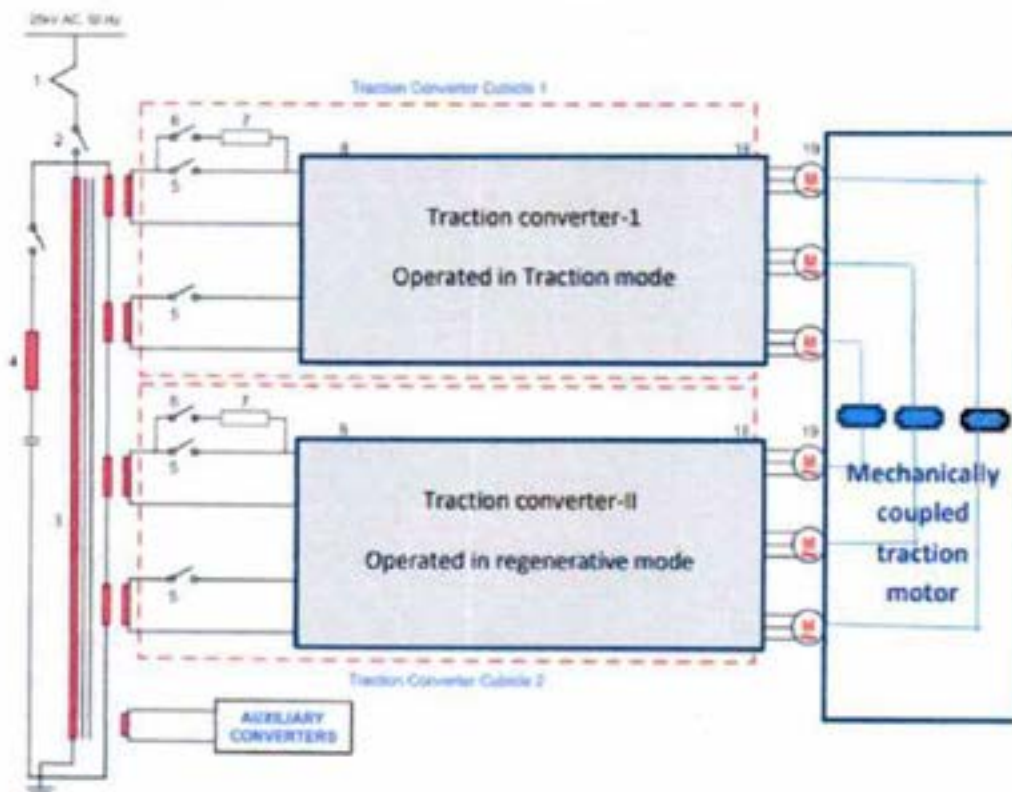
Figure 7 – Test bed arrangement for back-to-back test of an asynchronous combined system

Two traction converters are installed in this setup and 3 traction motors are connected electrically to each of these converters. Both of these traction converters will be connected to the traction transformer. One traction converter will draw power from the catenary through 2 transformer windings and will drive three traction motors (6FRA6068). These three traction motors will be coupled mechanically with other three traction motors. These three motors will be connected electrically with another traction converter. This traction converter will work in the regeneration mode. So, the other three traction motors will essentially act as mechanical load for the first three traction motors. The power consumed by the first traction converter will be regenerated by the second converter. The power consumed by the entire setup will be equal to the sum of all the losses in the converters and motors. The tentative setup is shown

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in the figure below. When the converters will be loaded the quality of the repaired module will be assessed with the help of the data monitoring setup.



## 2.2 Purpose of Back-to-Back Converter Test Setup

The Back-to-Back Converter Test Setup is being established to provide a fully controlled and repeatable load environment for validating traction converter components and traction motors under real operating conditions. The purpose of this setup includes the following:

### (a) Testing of Repaired IGBT Power Modules

- To verify the performance of repaired or newly supplied IGBT modules under full motoring and regenerative load conditions.
- To validate safe operating limits, switching characteristics, current handling, temperature rise, and thermal stability.
- To ensure the repaired modules can sustain long-duration load cycles as per IEC 61377-3.

### (b) Testing of Control and Protection Electronic Cards of propulsion system

- To ensure all traction converter cards (4QC, inverter, gate driver, DSP/control cards) continue to perform accurately inside a realistic load environment.

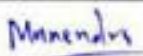
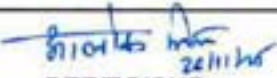

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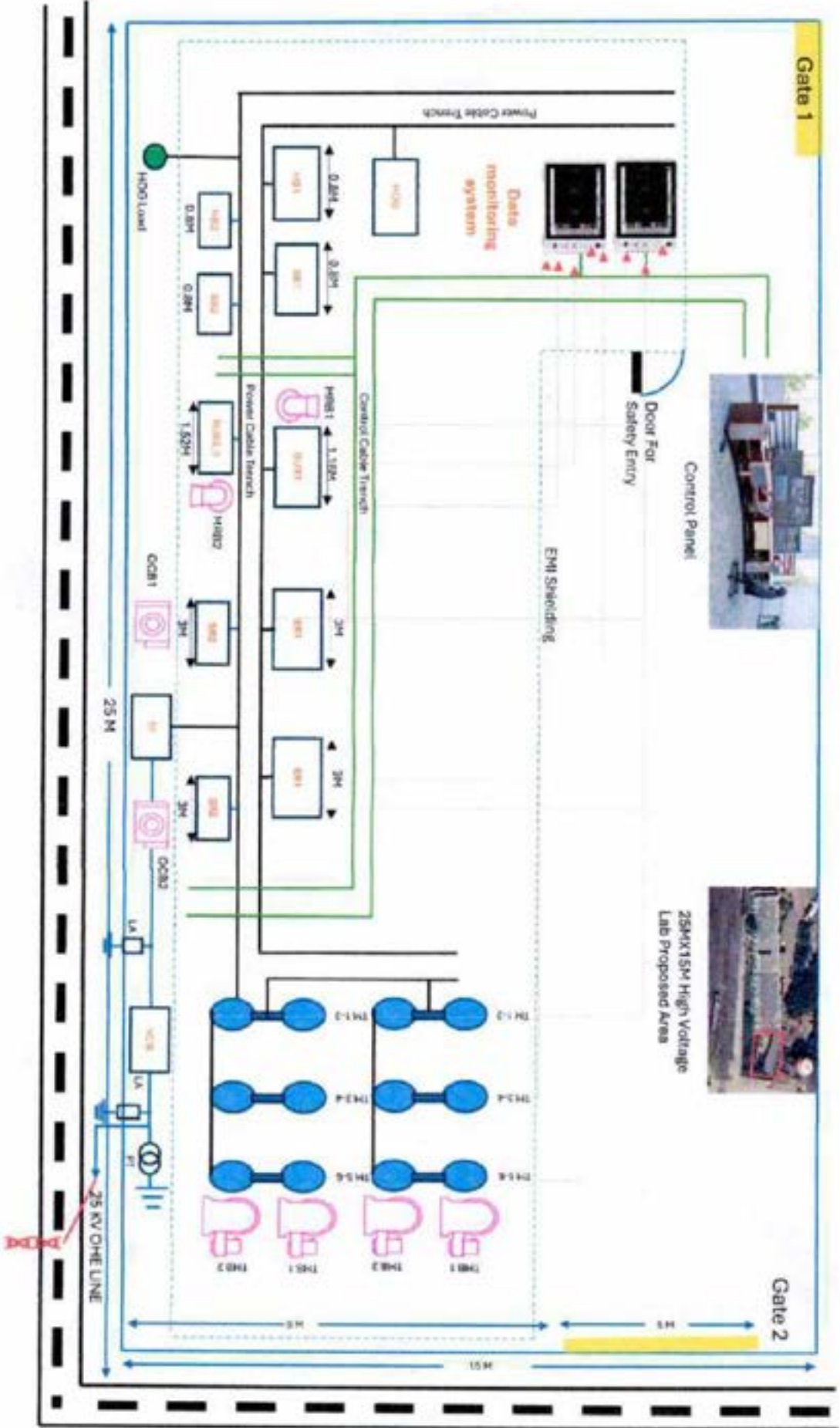
(c) Performance and Health Testing of Traction Motor Type 6FRA6068 and other traction motors

- To evaluate torque characteristics, efficiency, slip, harmonics, and temperature rise of traction motors.
- To verify motor behavior in constant torque and constant power regions (0–132 Hz).
- To compare motor test results against reference characteristic values as per IEC 61377-3.

Back-to-back converter testing setup is being developed in Electric Loco Shed Kanpur. Data monitoring setup and associated software for recoding and analysis of various signals in back-to-back converter setup is required to be developed in this work. The layout of back-to-back converter test setup is shown below

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# Tentative layout of back-to-back converter test setup lab



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### 2.3 Scope of testing defined in IEC 61377-3:

Following parameters will be measured with this setup (IEC 61377-3) in addition to the checking of quality of repaired modules and cards. The bidder should go through the IEC 61377-3 thoroughly to understand all the below mentioned tests. Software in the present data monitoring setup should cover all the tests.

- Temperature-rise tests of motors
- Torque characteristics, Motor Hot
- Torque characteristics, Motor cold
- Sweeping speed test at full torque
- Efficiency characteristics of the combined system
- Testing of power supply for the control equipment
- Testing of supply Voltage of Traction Drive
- Traction Supply Voltage Interruption test
- Sudden variation of the Traction supply voltage
- Harmonics in the input current of the converter
- Interference test
- Failure Condition tests
- Sudden variations of Load test

The bidders are advised to go through the entire document thoroughly and understand the working of 3 phase loco traction converters and IEC 61377-3 test requirements before participating this tender.

### 2.4 Characteristics curves required in Data Monitoring system as per IEC 61377-3

Following characteristics curves are required to measured. The contractor will develop and align the complete hardware and software for measurement and plotting of the following curves:

- Torque–speed curves at low, nominal and high supply voltage
- Motor current vs speed curve
- Inverter voltage given to motor vs speed curve
- Power factor vs speed
- DC link voltage characteristic
- Inverter RMS voltage and RMS current curves

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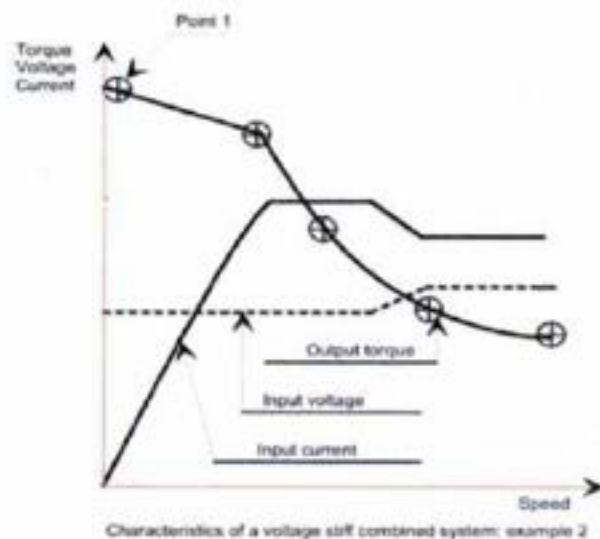
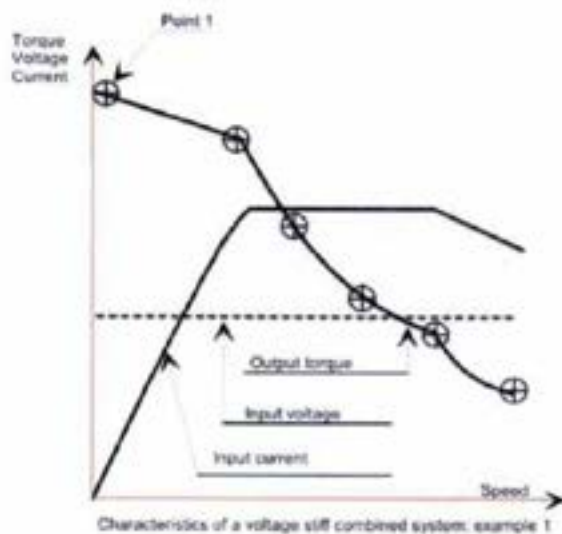
- Motor efficiency curve (cold condition)
- Motor temperature reference values (e.g., 150°C winding reference)
- Harmonic spectrum of voltage and current up to the 100th order. The system should have provision of recording/calculating higher order harmonics up to 1 MHz
- Efficiency curve for converter + motor

## 2.5 Combined System Characteristics (IEC 61377-3, Clause 5.3)

In accordance with IEC 61377-3, data monitoring software shall support generation and analysis of the following mandatory characteristics for the combined traction converter + motor system

### 2.5.1 Mandatory External Characteristics

- Torque vs speed (full operating range)
- Input voltage vs speed
- Input current vs speed
- Input power vs speed



### 2.5.2 Mandatory Internal Characteristics

- DC link voltage vs speed
- DC link 100 Hz ripple
- RMS inverter output current

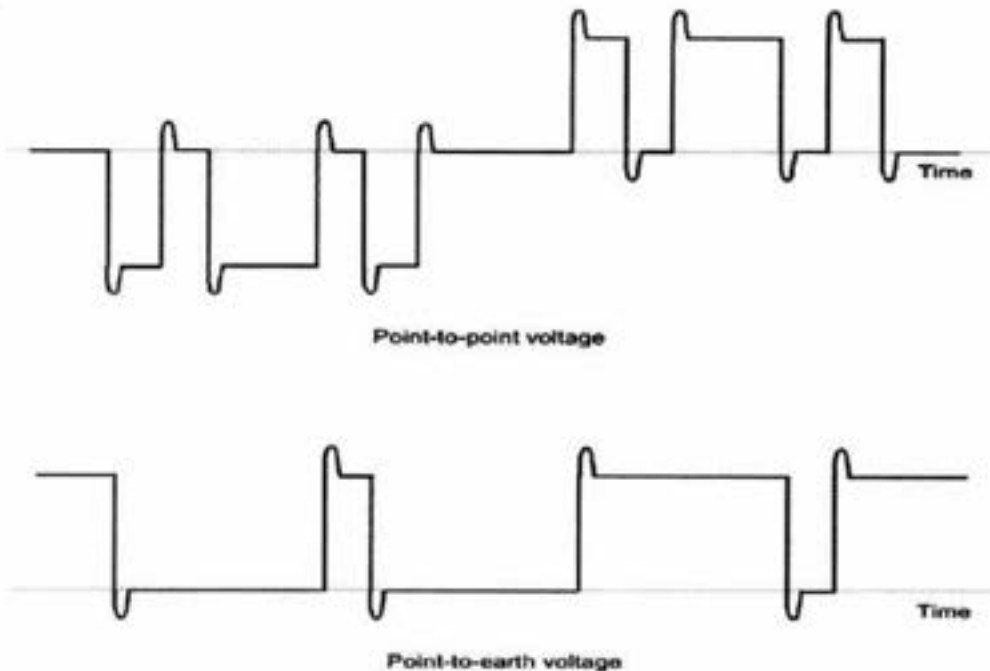
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- RMS fundamental component of output voltage & current
- Motor slip vs speed

### 2.5.3 Mandatory Switching Characteristics

- Switching voltage transients (point-to-point, point-to-earth)
- $dv/dt$  measurement
- Converter switching patterns
- Stress evaluation under dynamic conditions



All curves shall be compared with specified characteristics using IEC 61377-3 tolerance limits.

## 2.6 Parameter Measurement Requirements

Accurate measurement of voltage, current, temperature and converter parameters is essential for evaluating repaired IGBT modules, control cards and traction converter performance. The measurement system shall therefore include high-accuracy, isolated and calibrated sensors at the locations defined below:

### A. Measurement Points and Channel Requirements

#### 1. Primary (Input) Voltage & Current – 2 Channels

- Measurement point: traction transformer primary
- Purpose: Input power validation, harmonics, disturbance analysis

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## 2. Line Side Converter Voltages & Currents – 8 Channels

- Measurement point:
  - input voltage of both 4QC converter (4 channel)
  - input current of both traction converter 4QC converter (4 channels)
- Purpose: Converter input behavior, PWM verification, protections

## 3. DC Link Voltage – 1 Channel

- Measurement point: DC bus between line & motor converters
- Purpose: DC ripple measurement, stability, converter performance

## 4. Motor Side Converter Voltages & Currents – 9 Channels

- Measurement point: traction inverter output
- Purpose: Torque calculation, slip, efficiency, harmonics

## 5. Auxiliary Converter Voltages & Currents – 6 Channels

- Purpose: Auxiliary converter equipment power evaluation as per IEC

## 6. IGBT Module Temperature – 10 Channels

- temperature sensors mounted on heat sinks
- Purpose: Temperature-rise test, IGBT thermal stability, overheat analysis

## B. Accuracy & Quality Requirements

All electrical and thermal measurements shall meet the following minimum performance:

- Accuracy: 0.5% or better
- Electrical isolation: Mandatory on all voltage and current sensors
- Temperature sensors: Thermocouple Class A or better
- Calibration: All sensors must be factory calibrated with 1-year valid certificate

## C. Total Sensors & Channels Required

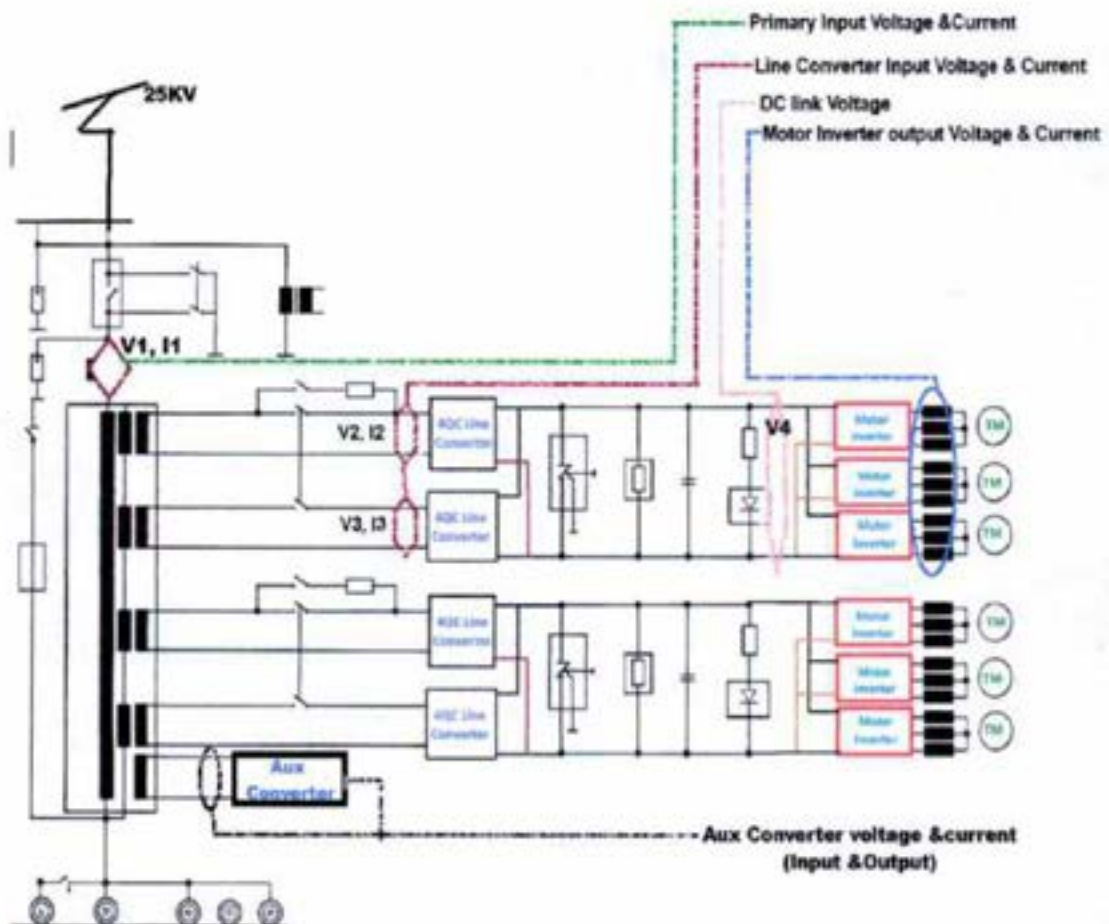
Sr. No	Sensor Type	Quantity (Nos.)
1	Current	13
2	Voltage	13
3	Temperature	10
Total Channels (DAQ)		36

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## D. Measurement Block Diagram

The following block diagram illustrates the placement of all voltage, current and DC link sensing points required for the 36-channel data acquisition system. The vendor shall use this diagram for sensor installation, wiring and channel mapping to ensure correct operation of all IEC 61377-3 test modules.



<i>Manan</i> SSE/PE LAB/ELS CNB	<i>St. DEE/RS/CNB</i> DEE/RS/CNB	<i>Rahul</i> St. DEE/RS/CNB
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### 3.0 Scope of work

Back-to-back converter testing setup is being developed in Electric Loco Shed Kanpur. Data monitoring setup and associated software for recoding and analysis of various signals in back-to-back converter setup is required to be developed in this work. The data for various tests as defined in IEC 61377-3 are required to be recorded, calculated, plotted, and analyzed through this data monitoring setup and associated software.

#### 3.1 Schedule of items

Sr. No.	Item	Specification
1	Design, supply, installation, testing and commissioning of DSO cum waveform recorder as per specifications defined in Para 3.5	Para 3.5
2	Design, supply, installation, testing and commissioning of Voltage Analog Modules as per specifications defined in Para 3.6	Para 3.6
3	Design, supply, installation, testing and commissioning of Current Modules as per specifications defined in Para 3.7	Para 3.7
4	Design, supply, installation, testing and commissioning of Voltage Divider modules as per specifications defined in Para 3.8	Para 3.8
5	Design, supply, installation, testing and commissioning of AC/DC Current Sensors as per specifications defined in Para 3.9	Para 3.9
6	Design, supply, installation, testing and commissioning of AC Current probes as per specifications defined in Para 3.10	Para 3.10
7	Design, supply, installation, testing & commissioning of Temperature Logger / Temperature Modules as per specifications defined in Para 3.11	Para 3.11
8	Design, supply, installation, testing and commissioning of Software for recoding and analyzing the back-to-back converter test setup data and results of tests as defined in Para 3.12	Para 3.12
9	Design, supply, installation, testing and commissioning of Display screens as per specifications defined in Para 3.13	Para 3.13

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10	Supply, installation & commissioning of Rack & Workstation System (Industrial Rack + High-Performance Workstation + UPS) as per specifications defined in Para 3.14	Para 3.14
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### 3.2 Installation & Commissioning Requirements

The contractor shall be responsible for:

- Installation and termination of all sensors (V/I/T).
- Proper shielding, grounding and cable routing.
- The Data monitoring system rack installation and integration with workstation.
- Software installation, configuration and test module validation.
- Completion of trial runs for channel verification.
- Ensuring compliance with all IEC 61377-3 requirements.

### 3.3 Environmental & Safety Requirements

- Operating temperature: 0–50°C
- Relative humidity:  $\leq 80\%$  (non-condensing)
- The setup is required to meet the accuracy standards given in the subsequent specifications under high EMI noise area. EMC compliance should be as per the applicable standards
- All high-voltage points shall be fully isolated and safe for operator use.

### 3.4 Training

- Minimum four days hands-on training to be provided by the contractor on topics: Instrument operation, waveform measurement, sensors and probe use, safety handling
- Minimum four days hands-on training to be provided by the contractor on topics: software use and data analysis.

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### 3.5 Detailed specification of DSO cum waveform recorder:

Sr. No.	Parameter	Specifications
1	Number of channel available	Minimum 32 channel (2x16 configuration)
2	No. of Modules	Minimum 16 modules (2 ports per module)
3	Bandwidth	Instrument should capable to operate for frequency range DC to 30MHz or more
4	Allowable input	Direct Measurement of 250V AC/DC or more without any attenuation Probe
5	Max. Sampling rate	200 MS/s, all channels simultaneously for analog channel
6	Storage words capacity	1 G words or more
7	Recording Method	Normal & Envelope
8	Current Measurement	Upto 6000A AC/DC or more with 16-bit ADC
9	Additional Feature	Instruments should calculate 10 or more waveforms with sampling of 1M points or more. Instrument should able to do basic power analysis calculation, FFT, Mathematics Functions etc.
10	Memory	256 GB or more by using internal/SSD Storage
11	Interface	USB 3.0, LAN, SD, SATA, Monitor Output
12	Operating Temperature	0 to 40 deg. Celsius
13	Electrical safety	The device must comply with IEC 61010.

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.6 Detailed specification of Voltage Analog Modules:

Sr. No.	Parameter	Specifications
1	Quantity	Minimum 7 modules (2x7=14 ports)
2	No. of Channels	2 for voltage measurement
3	Input terminals	Isolated BNC connector (input impedance 1 MΩ, input capacitance 22 pF) Max. rated voltage to ground:1000 V AC, DC (with input isolated from the unit)
4	Measurement range	100, 200, 400 mV f.s. 1, 2, 4, 10, 20, 40, 100, 200, 400 V f.s., 12 ranges AC voltage for possible measurement/display: 280 V rms Low-pass filter: 5/500/5 k/1 MHz
5	Measurement resolution	1/1600 of measurement range (using 12-bit A/D conversion)
6	Maximum sampling rate	200 MS/s (simultaneous sampling in 2 channels)
7	Measurement accuracy	±0.5% f.s. (with filter 5 Hz, zero position accuracy included)
8	Frequency characteristics	DC to 30 MHz -3 dB (with AC coupling: 7 Hz to 30 MHz -3 dB)
9	Input coupling	AC/DC/GND
10	Maximum input voltage	400 V DC (with direct input) without attenuation probe
11	Electrical safety	The device must comply with IEC 61010.

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.7 Detailed specification of Current Modules:

Sr. No.	Parameter	Specifications
1	Quantity	Minimum 6 modules (6x3=18 ports)
2	Measurement functions	Number of channels: 3 Channel, Current measurement with optional current sensor.
3	Input connectors	Sensor connector with ME15W terminal
4	Measurement range	Upto 1000A AC/DC, 6000A AC
5	Measurement resolution	1/32000 of measurement range (using 16-bit A/D conversion)
6	Frequency characteristics	DC to 2 MHz $\pm 3$ dB
7	Measurement accuracy	$\pm 0.3\%$ f.s. (with 5 Hz filter, add accuracy and characteristics of the current sensor to be used)
8	Highest sampling rate	5 MS/s (3 channel simultaneous sampling)
9	Low Pass Filter	5/ 500/ 5 k/ 200 kHz
10	Electrical safety	The device must comply with IEC 61010.

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.8 Detailed specification of voltage divider modules

Sr. No	Parameter	Specification
1	Quantity	13 Nos
2	Maximum rated voltage	5000 V rms, $\pm 7100$ V peak (*1)
3	Maximum rated voltage (line-to-ground)	Measurement category I: 2000 V AC/DC Measurement category II: 1500 V AC/DC
4	Voltage dividing ratio	1000 : 1
5	Measurement accuracy	$\pm 0.08\%$ (DC), $\pm 0.04\%$ (50/60 Hz), $\pm 0.17\%$ (50 kHz)
6	Frequency flatness	Band where amplitude falls within $\pm 0.1\%$ range: 200 kHz (typical) Band where phase falls within $\pm 0.1^\circ$ range: 500 kHz (typical) (*5)
7	Measurement bandwidth	DC to 4 MHz (Amplitude and phase accuracy specified up to 1 MHz)
8	Common-mode voltage rejection ratio (CMRR)	50 Hz/60 Hz: 90 dB (Typical) 100 kHz: 80 dB (Typical)
9	Measurement method	Differential input
10	Operating temperature and humidity level	-10°C to 50°C, 80% RH or less
11	Electrical safety	The device must comply with IEC 61010.
12	EMC safety	EMC: EN 61326 Class A
13	Power supply	100 V to 240 V AC (50/60 Hz)

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.9 Detailed specification of AC/DC current sensors:

Sr. No.	Parameter	Specification
1	Quantity	Minimum 9 probes
2	Rated current	1000 A AC/DC
3	Frequency bandwidth	DC to 100 kHz
4	Diameter of measurable conductors	Max. $\phi$ 50 mm (1.97 in.)
5	Max. allowable input	$\pm 1900$ Apeak
6	Output voltage	2 mV/A
7	Accuracy (amplitude)	DC: 0.2% + 0.02% DC < f $\leq$ 100 Hz: 0.2% + 0.01%
8	Linearity	$\pm 20$ ppm Typical
9	Common-Mode Voltage Rejection Ratio	DC to 1 kHz : 150 dB or greater 1 kHz to 10kHz : 130 dB or greater
10	Operating temperature, humidity	-40°C to 85°C (-40°F to 185°F), 80% RH or less
11	Electrical Safety	The device must comply with IEC 61010
12	EMC standard	IEC 61326-1:2012/EN 61326-1:2013
13	Cable length	20 meter or more
14	Withstand voltage	AC 4,260 V or more

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.10 Detailed specification of AC current probes:

Sr. No.	Parameter	Specification
1	Quantity	13
2	Rated measurement current	6000A AC
3	Bandwidth	10 Hz to 50 kHz ( $\pm 3$ dB)
4	Amplitude and phase accuracy	$\pm 1.5$ % rdg. $\pm 0.25$ % f.s
5	Max. rated voltage to earth	AC 600 V (CAT IV), AC 1000 V (CAT III)
6	Loop diameter	$\phi$ 180 mm or less
7	Dust and water resistance	IP54
8	Operating temperature range	-25 °C to 65 °C
9	Cable Length	20 Meter
10	Max. rated voltage to earth	AC 600 V (CAT IV), AC 1000 V (CAT III)
11	Electrical Safety	The device must comply with IEC 61010

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.11 Detailed specification of Temperature Logger / Temperature Module:

Sr. No.	Parameter	Specification
1	Connection Type	Plugin Module
2	No. of measurement channels	10 channels
3	Parameter	Can measure voltage upto 100V for each channel & temperature upto 1200 deg. Celsius. Should be compatible for all type of thermocouple
4	Accuracy	Voltage: $\pm 10 \mu\text{V}$ (Meas. Range: -10 mV to 10 mV), $\pm 50 \text{ mV}$ (Meas. Range: -100V to 100V), Temperature: $\pm 0.7^\circ\text{C}$ (Meas. Range: $500^\circ\text{C}$ to $1350^\circ\text{C}$ )
5	Recording intervals	10 ms to 1 hour, 22 selections (Data refresh interval can be set for each unit)
6	Data storage	Min. 2 GB (SD Memory Card/USB Drive)
7	Interface	LAN/USB
8	Display	7 inch TFT color liquid crystal display (WVGA 800 x 480 pixel)
9	Functions	Save waveform data in real time to the SD memory card or USB drive, numerical value calculations, waveform calculations, 8ch alarm output, voltage output x2 (5 V /12 V /24 V selectable)
10	Power supply	By AC adapter 100 to 240 V AC, 50/60 Hz), atleast 4 hours battery backup or more
11	Electrical Safety	The device must comply with IEC 61010

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.
- The bidder will have to attach the test report for this device as per IEC 61010-1/EN 61010 standard. Bids submitted without this document will not be considered for evaluation.
- The device must be capable of working with the specified accuracy in high electromagnetic noise area.

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### 3.12 Detailed specification of Software for recoding and analyzing the back-to-back converter test setup data and results of tests:

The contractor will develop a software for synchronized data acquisition, storage, calculation, analysis and plotting of various measured signals. Characteristics curves as per IEC 61377-3 are required from this software.

Following characteristics curves are required to be measured, recorded and plotted.

- Torque-speed curves at low, nominal and high supply voltage
- Motor current vs speed curve
- Inverter voltage given to motor vs speed curve
- Power factor vs speed
- DC link voltage characteristic
- Inverter RMS voltage and RMS current curves
- Motor efficiency curve (cold condition)
- Motor temperature reference values (e.g., 150°C winding reference)
- Harmonic spectrum of voltage and current up to the 100th order. The system should have provision of recording/calculating higher order harmonics upto 1 MHz.
- Efficiency curve for converter + motor

#### Combined System Characteristics (IEC 61377-3, Clause 5.3)

In accordance with IEC 61377-3, data monitoring software shall support generation and analysis of the following mandatory characteristics for the combined traction converter + motor system

##### External Characteristics

- Torque vs speed (full operating range)
- Input voltage vs speed
- Input current vs speed
- Input power vs speed

##### Mandatory Internal Characteristics

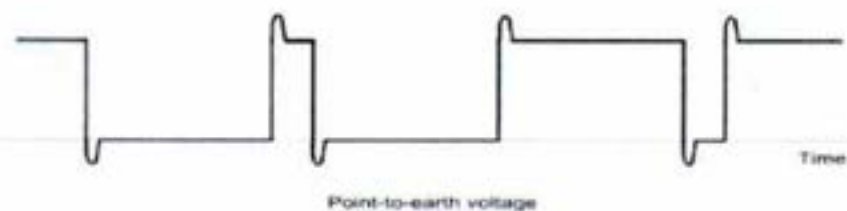
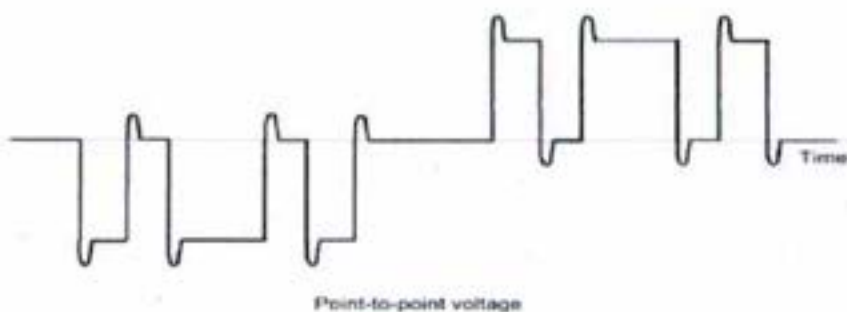
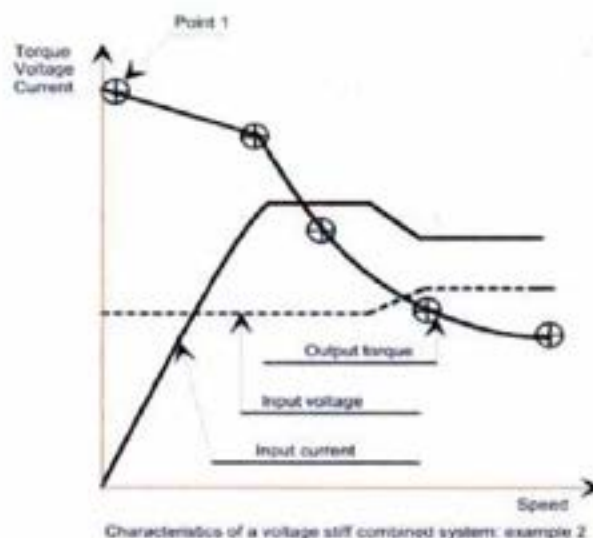
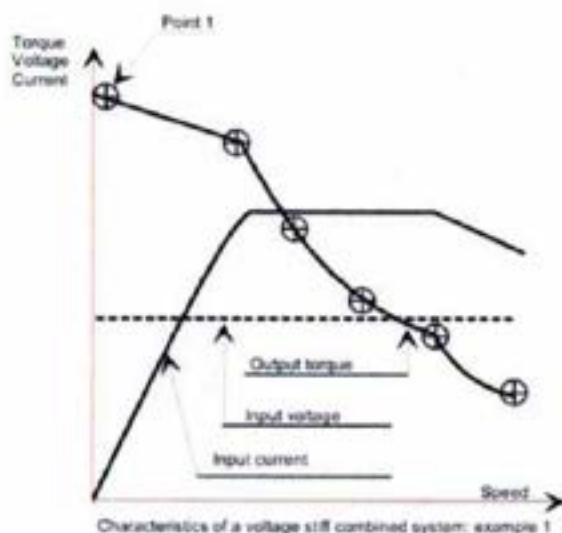
- DC link voltage vs speed
- DC link 100 Hz ripple
- RMS inverter output current
- RMS fundamental component of output voltage & current
- Motor slip vs speed

##### Mandatory Switching Characteristics

- Switching voltage transients (point-to-point, point-to-earth)
- dv/dt measurement
- Converter switching patterns
- Stress evaluation under dynamic conditions

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## The functional requirements the software must fulfill

### A. Real-Time Data Acquisition

- Minimum 26 channels data acquisition
- 200 MS/s sampling for voltage and current channels
- Synchronous sampling
- Long-duration continuous recording

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## B. Real-Time Calculations

- Motor torque
- Motor speed
- Slip
- Tractive effort
- RMS Voltage / current
- Active, reactive, apparent power
- Power factor
- Harmonics and THD
- DC link behavior
- Temperature rise

## C. IEC 61377-3 Test Modules

- Temperature rise module
- Torque-speed module
- Sweeping speed module
- Efficiency module
- Harmonic analysis module
- Supply disturbance module
- Sudden load/fault module

## D. Visualization Tools

- Oscilloscope-style waveforms
- FFT spectrum
- XY plots
- Multi-channel overlay
- Event markers

## E. Report Generation

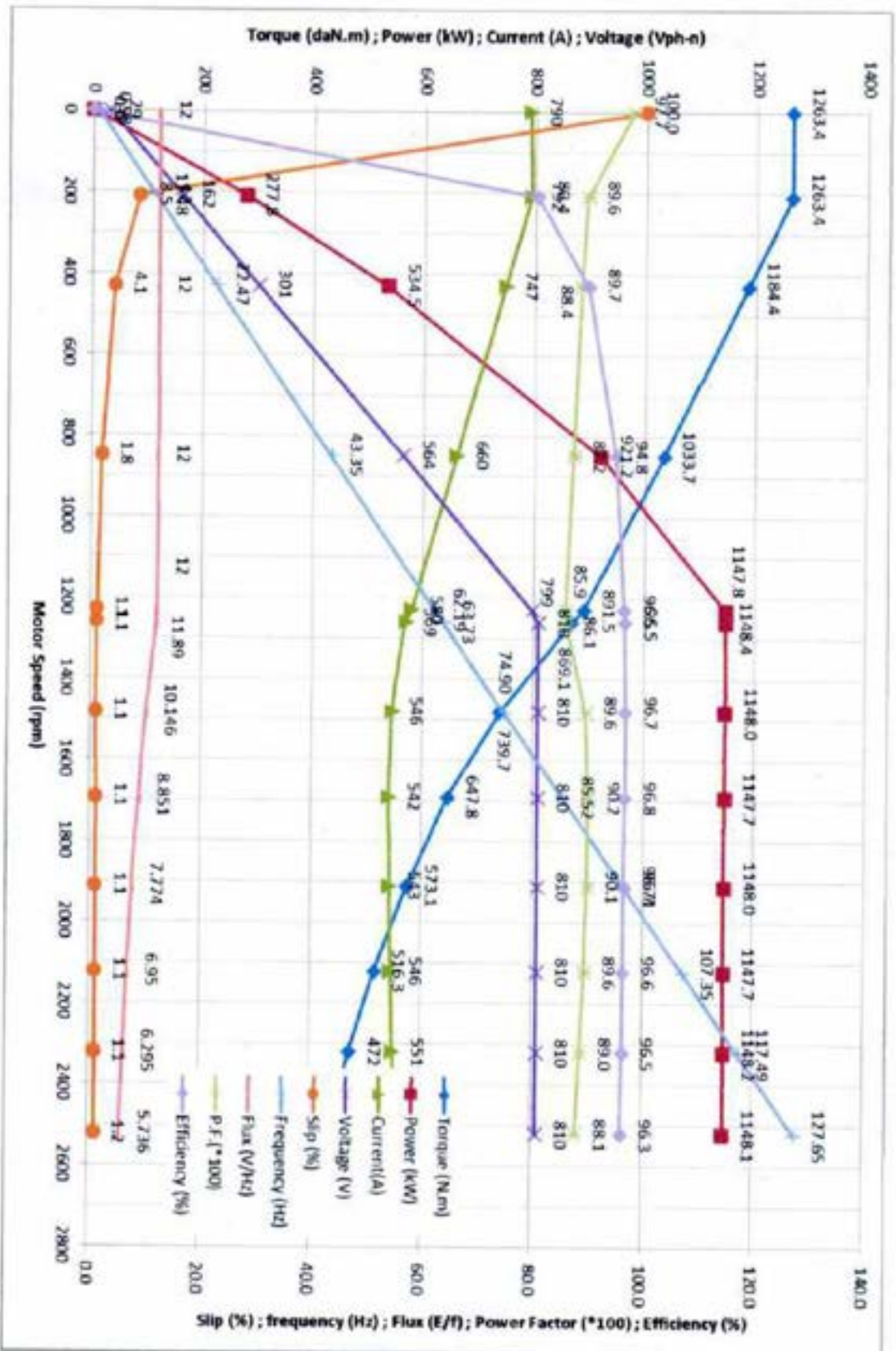
Software must auto-generate IEC 61377-3 compliant reports for:

- Temperature rise
- Torque-speed (hot/cold)
- Full torque sweep
- Efficiency
- Harmonics
- Supply disturbance

PDF, Excel, CSV export formats should be available in the software.

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F. Apart from the above mentioned modules, the software should have a feature to plot the following curve for the traction motor. Two sample plots are shown below



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THREE-PHASE ASYNCHRONOUS  
INDUCTION MOTOR OASX 240 0  
REV - 1 26-03-05  
TYPE 6 FRA 6068

BATH CONTINUOUS MAXIMUM  
PER MOTOR RATING VALUES

U1	2100	2100
I1	270	263
P2	850	850
T	8500	8500
a	2200	2200
cos φ	.88	.88
η	.95	.95
f1	50	50
f2	150	150

WARNING OF THE SYMBOLS:

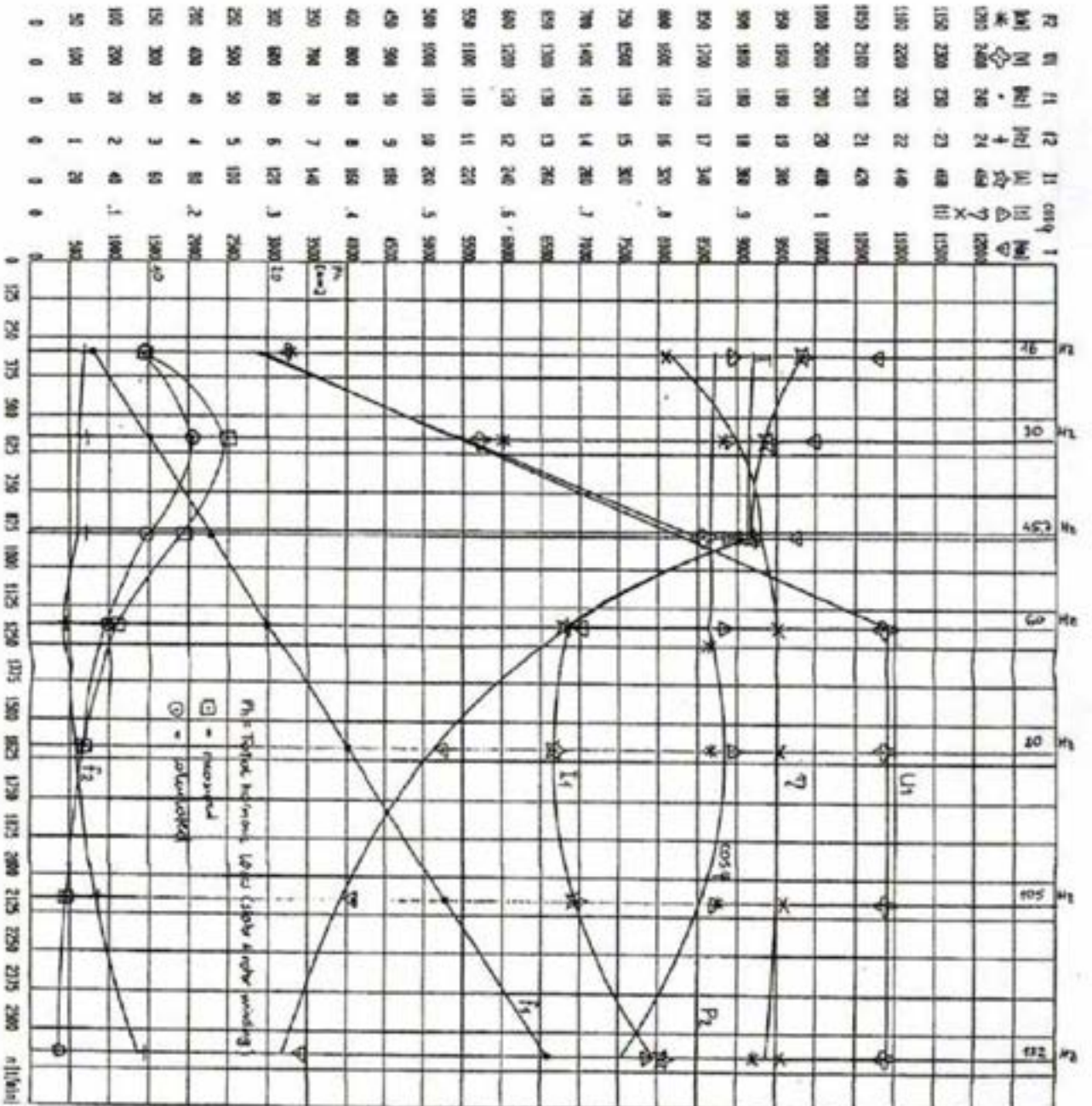
- U1 - PHASE-TO-PHASE VOLTAGE
- I1 - PHASE CURRENT
- P2 - OUTPUT AT THE MOTOR SHAFT
- T - TORQUE AT THE MOTOR SHAFT
- a - MOTOR SPEED
- cos φ - POWER FACTOR
- η - MOTOR EFFICIENCY
- f1 - STATOR FREQUENCY
- f2 - ROTOR FREQUENCY
- AT - AMBIENTAL TEMPERATURE

CALCULATED FROM A TEMPERATURE  
OF THE WINDINGS OF 120 °C

REVISION: a) 1993-09-07  
b) 1994-02-04

**ABB** DATE: 93-01-07  
VISEK Sie 45  
ASIA BROWN BOVERI

3EHM 426606



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### 3.13 Detailed specification of Display System Requirements

Two (02) 55-inch industrial-grade LED/IPS displays shall be supplied and installed as per below specification

Sr No.	Description	Technical Specification
1	Display Panel	<ul style="list-style-type: none"><li>• Screen Size: 55 inch (diagonal)</li><li>• Resolution: 4K UHD (3840 × 2160 pixels)</li><li>• Panel Type: IPS / VA / Industrial LED</li><li>• Brightness: ≥ 400 nits</li><li>• Contrast Ratio: ≥ 5000:1</li><li>• Viewing Angle: 178° horizontal &amp; vertical</li><li>• Refresh Rate: ≥ 60 Hz</li></ul>
2	Connectivity	<ul style="list-style-type: none"><li>• Minimum 2× HDMI</li><li>• Minimum 1× DisplayPort (DP)</li><li>• USB (for firmware / service)</li><li>• LAN / WiFi (optional for remote monitoring)</li></ul>
3	Power supply	<ul style="list-style-type: none"><li>• Input Voltage: 230 V AC ±10%, 50 Hz</li><li>• In-built surge protection</li></ul>
4	Mounting	<ul style="list-style-type: none"><li>• Vendor shall supply:</li><li>• Wall-mount brackets OR</li><li>• Table/stand mount (as per site requirement)</li></ul>
5	Software Compatibility	<ul style="list-style-type: none"><li>• Real-time waveform visualization</li><li>• Multichannel dashboards</li><li>• IEC 61377-3 torque-speed &amp; FFT plotting</li><li>• Split-screen and multi-window display</li><li>• Compatibility with supplied workstation GPU</li></ul>
6	Industrial Requirements	<ul style="list-style-type: none"><li>• Designed for continuous 12–16 hours operation</li><li>• Anti-glare, anti-reflective coating</li><li>• Suitable for high-temperature areas (0–50°C)</li></ul>

- OEM issued datasheet for this device is to be attached by the bidder. Bids submitted without this document will not be considered for evaluation.

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### 3.14 Detailed specification of Rack & Workstation System (Industrial Rack + High-Performance Workstation + UPS)

#### A. Rack System Requirements

1. All data monitoring modules, signal-conditioning units, voltage/current sensors, temperature modules and associated equipment shall be installed in an industrial rack.
2. The rack shall be constructed from **powder-coated CRCA steel** thickness 2.5 mm and shall include:
  - o Lockable front & rear doors
  - o Removable side panels
  - o Top and bottom cable-entry provision
  - o Anti-static floor contact
3. Internal layout shall be designed to accommodate the data monitoring system, power supplies, signal conditioning cards, communication modules and network switches.
4. All modules shall be mounted on **shock-resistant rails** to prevent vibration during traction converter operation.
5. Panel wiring shall comply with good engineering practices, including:
  - o Segregation of power and signal wiring
  - o Shielded control cables
  - o Ferrule marking on all terminations
6. The rack shall include:
  - o Internal cooling fans
  - o Dust filters
  - o LED internal lighting
  - o Earth bus-bar

#### B. Electrical Safety Requirements

1. All DAQ and workstation circuits must be isolated from traction converter high-voltage circuits.
2. The complete system shall meet applicable **EMI/EMC immunity requirements** for traction converter testing.
3. An **emergency shut-down switch** shall be provided on the rack front panel.

#### C. UPS System Requirements

1. A dedicated **online (double-conversion) UPS** shall be provided to supply the ATE system.

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2. Output: Pure sine-wave with automatic bypass and protection features.
3. UPS shall feed:
  - o Workstation
  - o DAQ rack
  - o Display monitors

#### D. Workstation Requirements

A high-performance workstation shall be supplied for real-time monitoring and IEC 61377-3 analysis with the following minimum specifications:

- **Processor:** Intel Core i9, 14th Gen or higher
- **Storage:** 1TB NVMe SSD + 9 TB SSD/HDD (minimum 10 TB total)
- **RAM:** 64 GB (expandable to 128 GB)
- **Graphics:** Dedicated GPU ( $\geq 6$  GB VRAM) for multi-display support
- **Connectivity:** 4 USB 3.0 ports, 1 GbE LAN, Wi-Fi, HDMI/DP ports
- **Backup:** 4 TB external USB drive with auto-backup software
- **OS:** Windows 10/11 Professional (64-bit), fully compatible with all supplied software

#### E. Desktop / HMI Interface

1. Desktop/HMI shall meet all performance requirements of the monitoring software.
2. Standard accessories shall include wireless keyboard, mouse, and surge-protected power supply.
3. The workstation shall run DAQ control, IEC test suite, report generator and database functions simultaneously without performance degradation.

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