REQUEST FOR PROPOSAL (RFP)
SUPPLY, INSTALLATION AND COMMISSIONING OF AUTOMATED
CHECKOUT SYSTEM FOR
TESTING OF PS1 INTEGRATED CONTROL ELECTRONICS (PICE)
AT LPSC VALIAMALA

LIQUID PROPULSION SYSTEMS CENTRE
INDIAN SPACE RESEARCH ORGANISATION
DEPARTMENT OF SPACE, GOVERNMENT OF INDIA
VALIAMALA 695 547
THIRUVANANTHAPURAM
KERALA, INDIA

Contents

Abbreviations:

1. DMM   -   Digital Multimeter
2. PS1   -   First stage of PSLV
3. PS0   -   Stage Zero of PSLV
4. AI   -   Analog Input
5. AO   -   Analog Output
6. Ch   -   Channel
7. FRA   -   Frequency Response Analyzer
8. PTFE   -   Polytetrafluoroethylene
9. HDD   -   hard disk drive
10. VGA   -   video graphics array
11. Cmd   -   command
12. Cmm   -   command monitoring
13. Fbk   -   feedback
14. Fbk tm   -   feedback telemetry
15. CE   -   control electronics
16. PVC   -   Poly vinyl chloride
17. CAT-6   -   Category 6
18. PREV   -   preview
19. CV   -   Constant voltage
20. CC   -   Constant current
21. PROT   -   protection
22. OCP   -   over current protection
23. OVP   -   over voltage protection
24. OTP   -   over temperature protection
25. CMRR   -   common mode rejection ratio
26. NGC   -   Navigation guidance control
27. INST   -   Instrumentation
28. Ry Ch   -   Relay channel

Part 1
<u>Technical Aspects</u>

1. Introduction

LPSC is responsible for developing the PS1 Integrated Control Electronics (PICE) package for the SITVC System. In order to evaluate the performance of the package a dedicated PXI/PXIe based automated checkout system is envisaged. The checkout system should provide facility to carry out all tests as per the test plan document. The PICE is a modular package with the following modules.

Power module	- 1 No.
TVCE modules	- 2 Nos
RCE module	- 1 No.
Interface module	- 1 No.
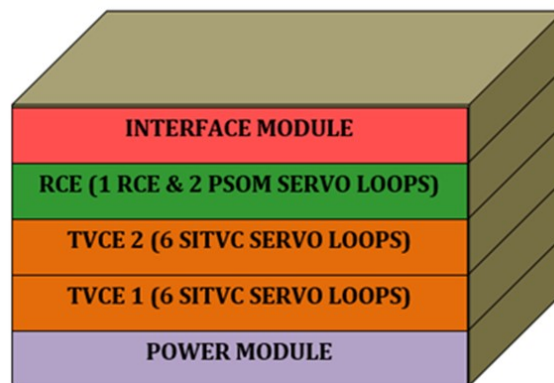
Each TVCE module consists of 6 servo loops identified as loop A to loop F. RCE module consists of 3 servo loops identified as RCT, SOV(+) & SOV(-).The Interface module is for resolving the command input to RCE module and the Power module meets the total power requirement of all the modules. The evaluation tests to be carried out on the PICE Package in both open and closed loop conditions.
Following are the major requirements of the system.
   a) Generation of input commands to the package.
   b) Acquisition of direct outputs and telemetry (T/M) parameters in analog as well as in digital domain.
   c) Real time monitoring of Power supply voltage and current.
   d) Online display, data processing, analysis and storage of acquired data.

This RFP document provides the scope of supply, hardware and software requirements, specification of deliverables, terms and conditions etc, needed for commissioning of PICE checkout system at LPSC (V)

2. Scope

2.1   Procurement and Supply of Equipments / Materials

Refer Table 1in section9 (Equipments / Materials which are under the scope of supply of the Vendor) for the list of items to be supplied by the vendor and its specification. Vendor should supply the items as per the detailed specification given in annexure 2.

2.2 Installation & Wiring of the Checkout Systems

Necessary routing diagrams for command generation and acquisition of data for execution of work are provided in this RFP. Details of installation & wiring work to be done by the vendor and corresponding figures & routing diagrams are given in the section 7. Vendor should prepare and submit the detailed engineering drawing to LPSC for concurrence. For the integration of total system at LPSC(V),vendor should carry out the wiring of a) checkout system rack ie. Power supplies and instruments b) Laying of shielded cables, connector harness, Installation of Racks etc. are also to be done by the vendor.

2.3 Development of software

Vendor shall do the development and installation of - checkout software and other system software /drivers for basic functionality. Requirements of software configuration are mentioned in section 5.2.

2.4 Evaluation, Checking & Commissioning Activities

Vendor should carry out necessary functional checks like continuity and integrity check of end to end wiring, voltage simulation tests and calibration of measurements and command channels etc. as part of the commissioning of the entire system. Vendor should generate and submit the necessary test report of the above tests to LPSC. Test plan will be given by LPSC to the vendor after PO placement.

a. Demonstration of checkout system with PICE package.
b. Training of personnel at LPSC

2.5 Documentation

Vendor should provide the following documents
1. Hardware requirement specification (HRS)
2. Software requirement specification (SRS)
3. Software design document (SDD)
4. User manual
5. Source code for the checkout software

2.6 General

1. Warranty of the system for minimum 1 year from the date of commissioning.
2. Vendor should have previous experience in similar work.
3. AMC (non comprehensive) rates should be quoted separately.

3. Responsibilities of Vendor

1. Submission of detailed engineering drawing.
2. Supply of equipments/ materials mentioned in section 9(Table1).
3. Providing warranty for the equipments supplied by the vendor.
4. Installation and commissioning activities in stipulated time.
5. Development of Checkout software.
6. Test & evaluation of the total Checkout system and submit the report to LPSC.
7. Work site safety of the workers of the vendor.

8. Tools required for the installation activities.
9. Safe handling of the items and equipment without any damage during the installation and commissioning phase of instrumentation systems.

4. Responsibilities of LPSC

1. Make the work site ready for the installation activities.
2. Supply of PICE packages, Valve, Actuator and engine. Details mentioned in section 11.
3. Arranging pre-bid meeting with the vendor at LPSC.
4. Acceptance of detailed engineering drawing.
5. Inspection of the equipment / materials supplied by the vendor.
6. Providing test & evaluation plan to the vendor.
7. Supervision & evaluation of the work done by the vendor.

5. Scope of Work

The scope of work includes the configuration of checkout hardware and instrumentation.

5.1   Checkout system instrumentation

The Checkout will be installed in an air-conditioned room. The 19-inch instrumentation racks will be placed in this room. The rack houses PXI/ PXIe system for data acquisition, power supplies, monitor, measurement instruments to communicate with PXI system, connector plates etc. The hardware elements of the checkout system need to be positioned in the rack with proper routing of cable.

Rack of checkout includes the following components
1. Power supplies
2. LEM current sensors
3. Digital Multimeters
4. High resistance meter
5. PXI/ PXIe chassis and associated cards
   a. PXI/PXIe Controllers
   b. Relay module cards (high current switching and signal switching)
   c. Data acquisition cards (Analog input and output, DMM add on modules)
   d. Frequency response analyzer card & RS 485 interface card
6. Monitor, Printer, Connectors &terminal blocks
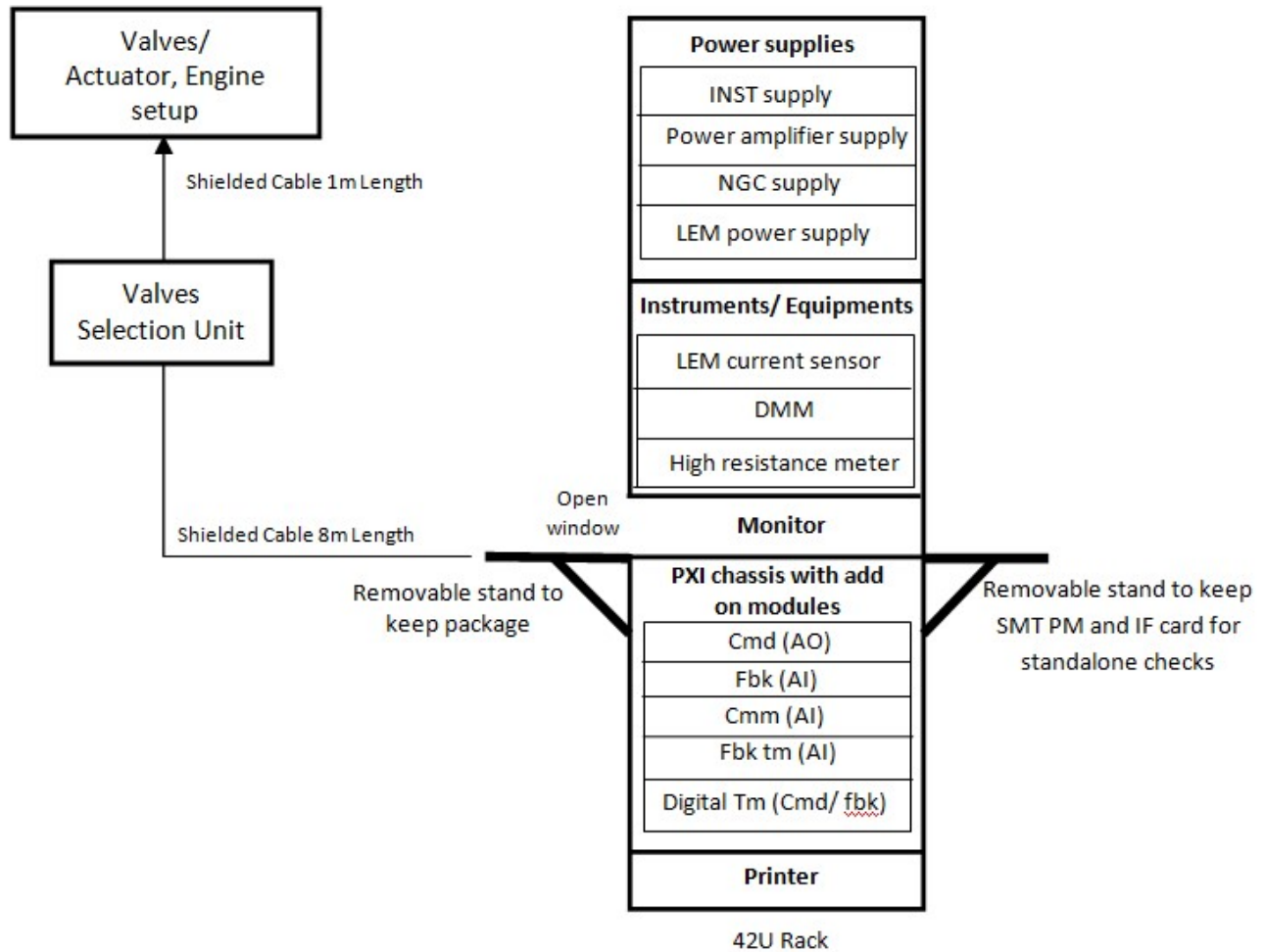
Figure 1- checkout system configuration

Checkout configuration for PICE package testing is shown in figure 1.The checkout system along with all add on modules and instruments, power supplies will be sitting on checkout rack.

The above mentioned equipments and devices are used to provide powering and control commands to PICE package, valve, Actuator and engine setup and monitor various parameters such as command, feedback, analog and digital telemetries etc. The data acquisition and command generation system is through PXI /PXIe based system. Instruments control is through LAN.

All Power Supplies, Network Switches and data acquisition cards with its accessories monitor with keyboard, measuring instruments, and sensors shall be mounted in 19-inch instrumentation racks. Power supplies are to be routed through relays for ON/OFF control and the relay drivers should be part of the PXI/ PXIe system. Wiring shall be done neatly and tied with cable ties. Racks shall be labelled with respective names. All the instruments mounted in the rack shall be labelled with printed stickers. All the termination of cables shall be labelled at both ends. Proper termination shall be used with proper tools. The length of harness between package and valve/ actuator and engine setup is 9m.

5.1.1 Valve Selection Unit

During the closed loop test, only one loop will be active at a time which shall be connected to the reference valve and the remaining loops to test valves. A Valve selection unit is required to switch the servo loop outputs with either the reference valve or to the test valves without manual intervention. There are 12 PS1 SITVC loops from TVCE1 & TVCE2 modules which require 12 test valves & 1 reference valve. In RCE module 2 PS0 SITVC loops are there, which require 2 test valves & 1 reference valve. For the RCT loop, the output should be able to switch between Actuator and Actuator + Engine configuration. Fig. 2a shows the switching diagram of the valve selection unit.

Valve Selection Unit
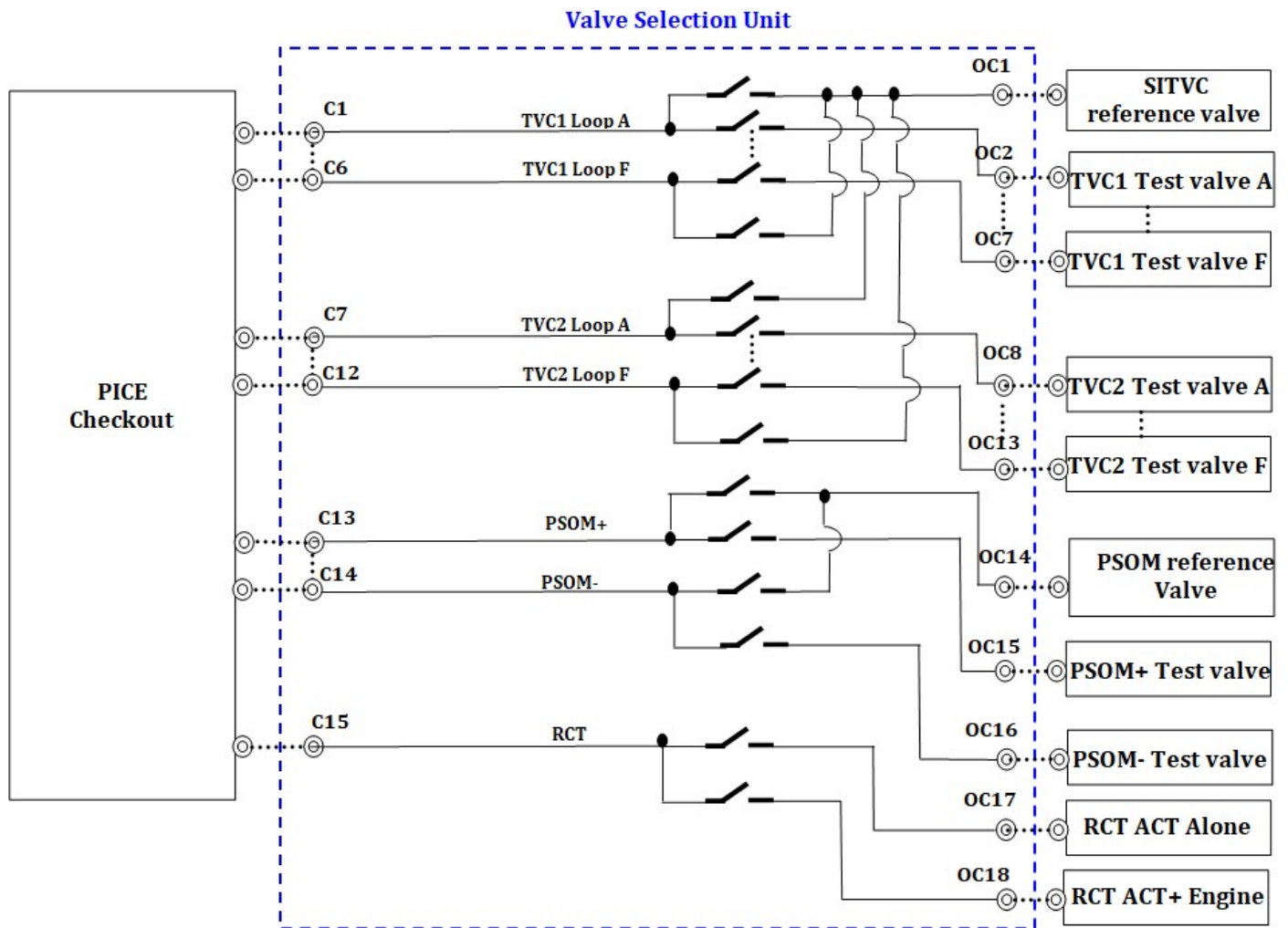
Note: C1- C15 and OC1 – OC18 are 12 pin connectors (4pins routed through high current (20AWG) and 6 pins routed through low current (26 AWG) relays, 2 unused pins)

Figure 2 a- Valve Selection unit switching diagram
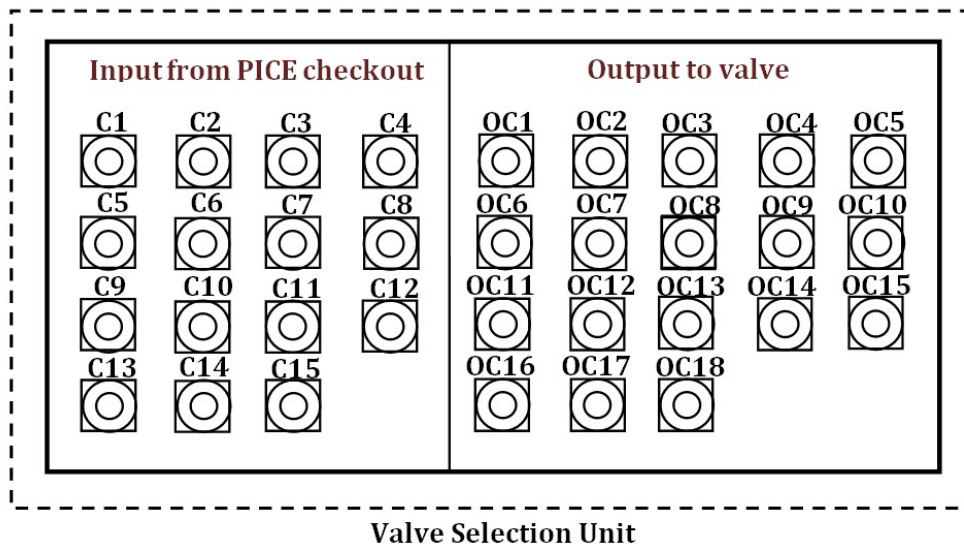
Valve Selection Unit
Figure 2 b- Valve Selection Console

The connectors C1 to C15 shall be same as the valve/Actuator connector as given in annexure3.

15 connectors are needed as input to valve selection unit from PICE checkout (TVC1- 6 loops, TVC2 - 6 loops & RCT – 3 loops (PSOM-2 , RCT-1)). At output side apart from actual 15 valve connectors 3 additional reference valve connectors (TVC 1 & TVC 2 -1no, 2 PSOM -1 no and RCT – 1 no) are needed.

5.2   Software Configuration

The test software should contain proper GUI for carrying out the testing in Manual and auto mode and for displaying all parameters during testing in graphical and numeric formats using engineering unit. The operator should be able to select any window of interest for doing a particular test. The application software should provide easy access to the test and storage of test results and raw data. After completion of the test, report generation software should provide a consolidated test report and provision to take print out of the report. Checkout System software is to be developed, delivered and installed with the following functional modules.

a) **Command generation module**
   The function of this module is to generate the commands for the PICE package required for its function.
b) **Data acquisition module**
   The function of this module is to continuously acquire all the analog and digital telemetries, direct outputs and power supply currents during operation. It also saves the raw data during operation.
c) **Report generation module**
   This module is required for consolidating the test results and for generating the test report in the prescribed format provided by LPSC and for printing the test results.
d) **Data processing module**
   1. To process the acquired data and calculate the performance parameters.
   2. Check whether the results are within spec and indicates pass or fail status.
   3. Plot or tabulate the data real time along with performance parameters.

e) Graphical user interface (GUI)

The software should have a user friendly GUI for operation. It should have provision to
1. Enter the package details, test condition, power supply limits etc
2. Select the manual mode or automated mode of operation.
3. Selection of test module in stand-alone mode or integrated condition.
4. Selection of power supply voltages.
5. Refer section 10.5

6. Channel requirement for package testing:

Sl no	Channel type	Total channels (Nos)	Spare channels
1	Analog input (isolated)	18	2
2	Analog output	2	2
3	Supply current relay channels	18	2
4	Signal switching relay channels	160	32
5	Frequency response analyzer card Analog Input Analog output	2 1	1

7. Proposed checkout system routing diagrams for testing PICE package

7.1 Power supply current monitoring continuous (18 nos)
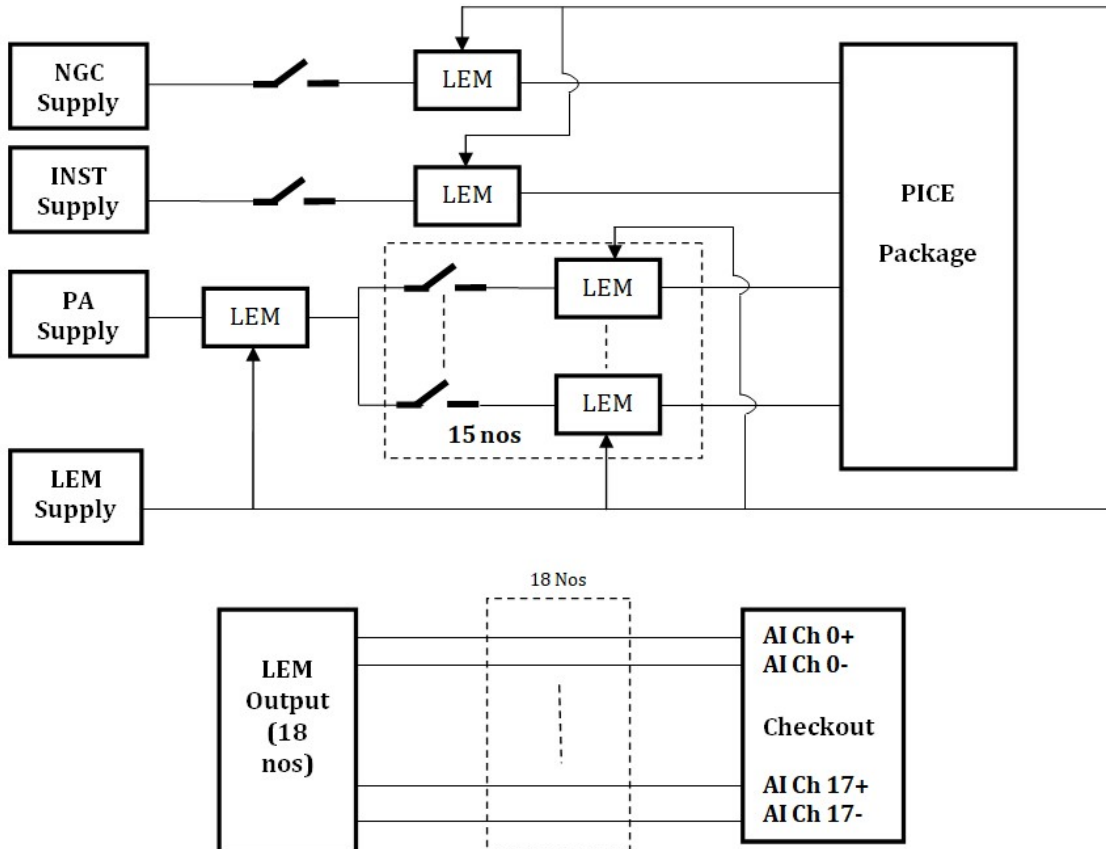
7.2 Power module stand alone test

Load connection

```
┌──────────────┐         ┌──────────┐        ┌──────────────┐
│   Power      │         │          │        │  Minimum     │
│   module     │         │  Matrix  │────────│  Load        │
│   Outputs    │─────────│  Relay   │        └──────────────┘
│   16 nos     │         │  16 x 3  │        ┌──────────────┐
│              │         │          │────────│  Typical     │
│              │         │          │        │  Load        │
└──────────────┘         └──────────┘        └──────────────┘
                                     ────────┌──────────────┐
                                             │  Maximum     │
                                             │  Load        │
                                             └──────────────┘
```

Output monitoring

17 Nos LIVE

3 Nos RET

```
┌──────────────┐
│   Power      │
│   Module     │
│   17nos      │
│  (16 direct, │
│  1 Telemetry)│
└──────────────┘
```

┌──────────────┐
│ +   │
│   Checkout   │
│ (DMM card) │
│   │
│ -   │
└──────────────┘
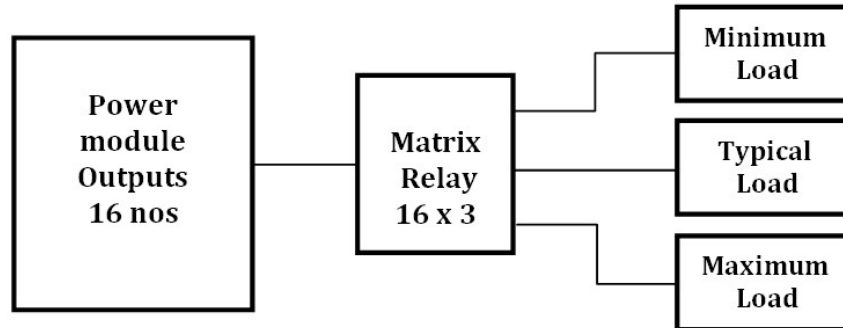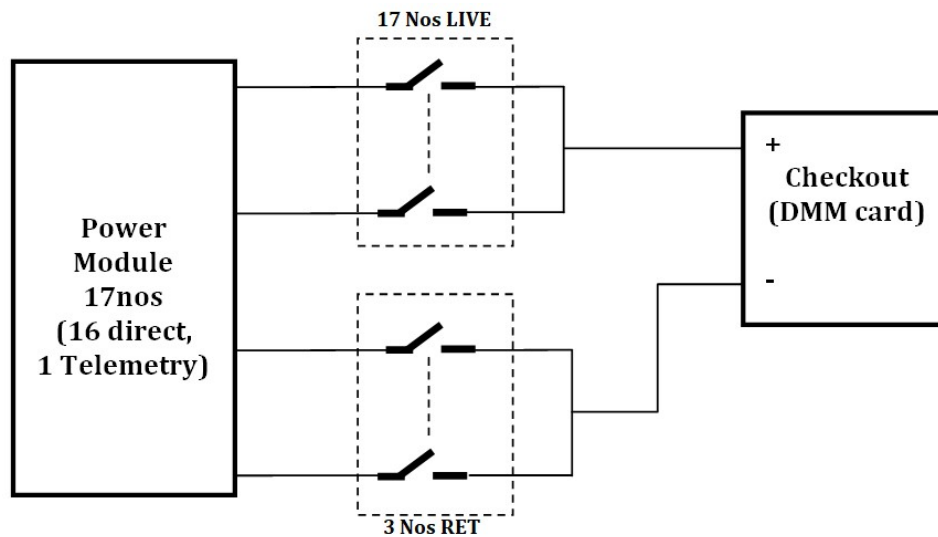
7.3 Converter outputs Spike and Ripple Waveform capture

16 Nos LIVE

3 Nos RET

```
┌──────────────┐
│   Power      │
│   Module     │
│  (16 nos     │
│  converter   │
│  outputs)    │
└──────────────┘
```

┌──────────────┐
│ +   │
│   SCOPE   │
│   │
│ -   │
└──────────────┘
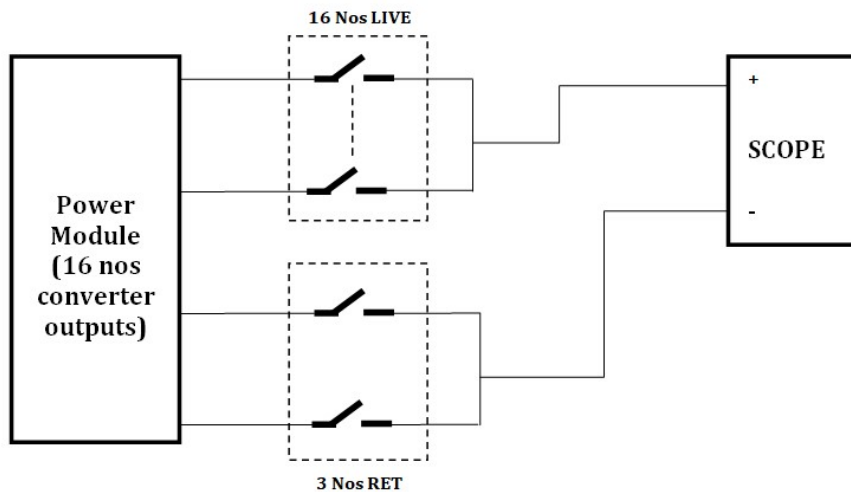
7.4 Feedback telemetry spike and Ripple Measurement
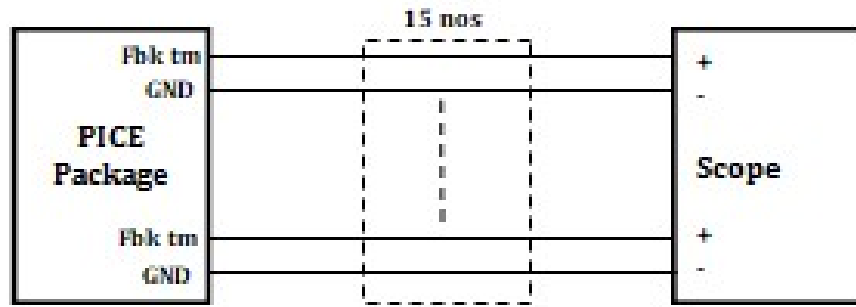
7.5 Transient Monitoring
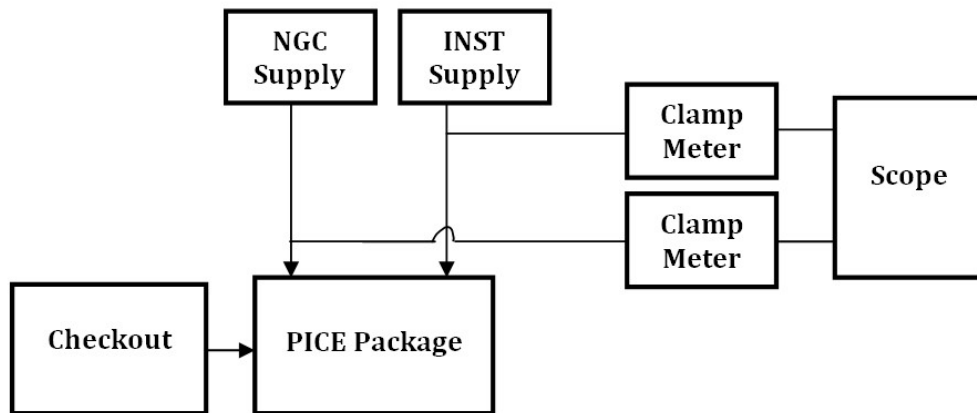
7.6 IF card stand alone test
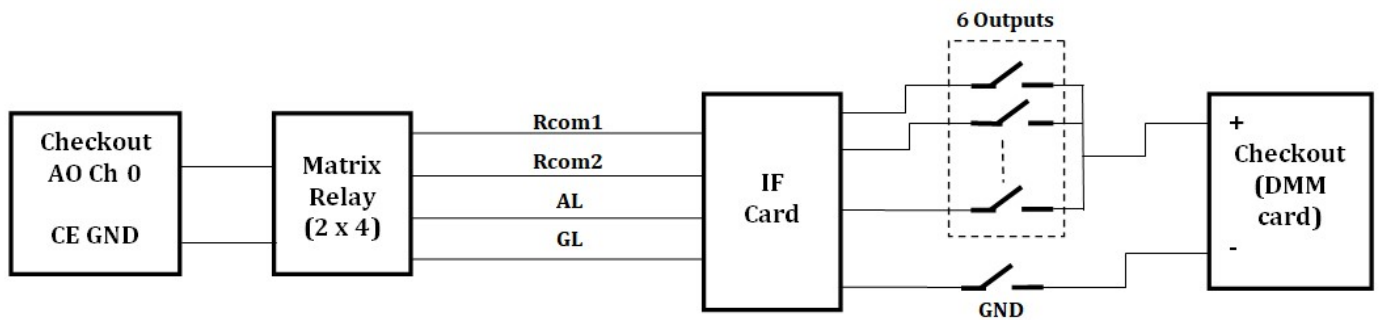
7.7 Command generation for feedback telemetry Linearity
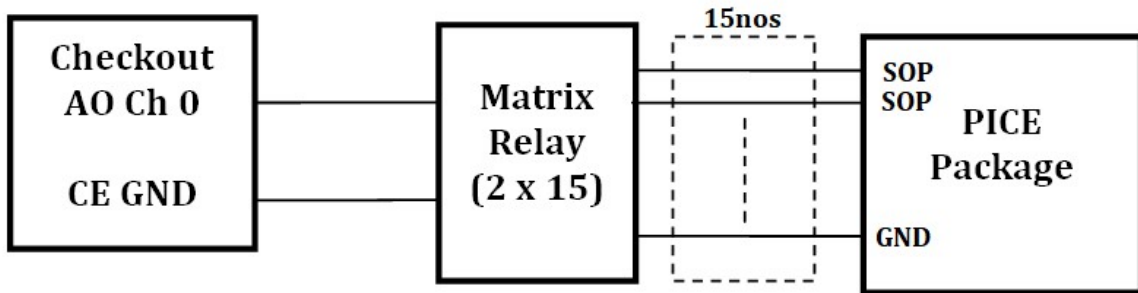
7.8 Command generation
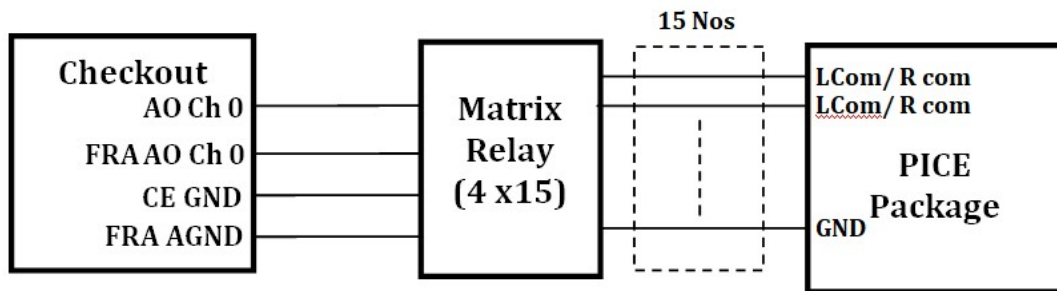
7.9 Command Monitoring

7.10 Feedback Telemetry monitoring
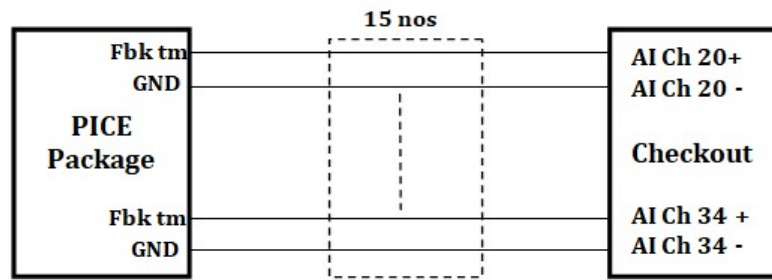
7.11 Sensor Excitation Checks
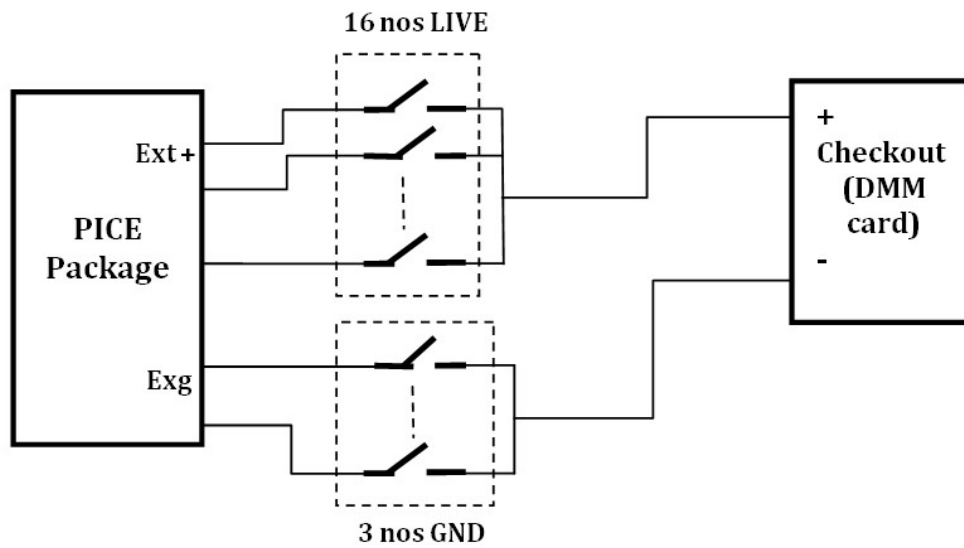
7.12 Forward Path gain
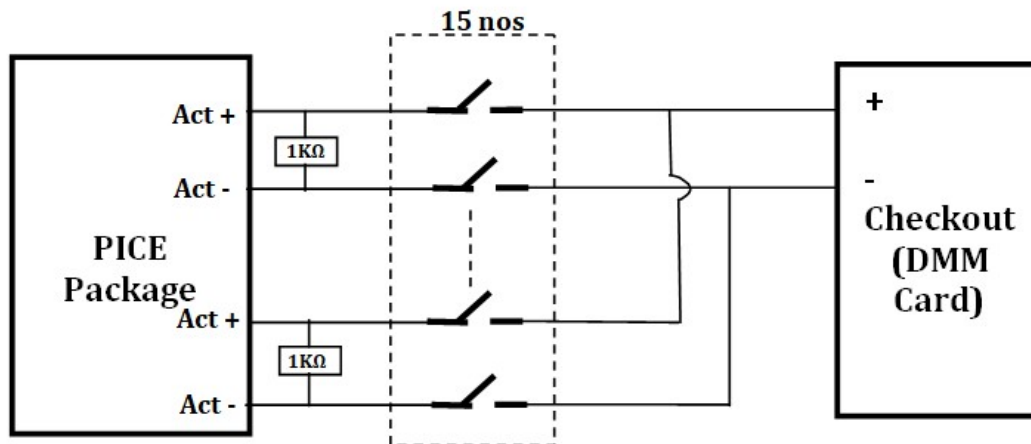
7.13 Resistive to valve / Actuator Load Switching
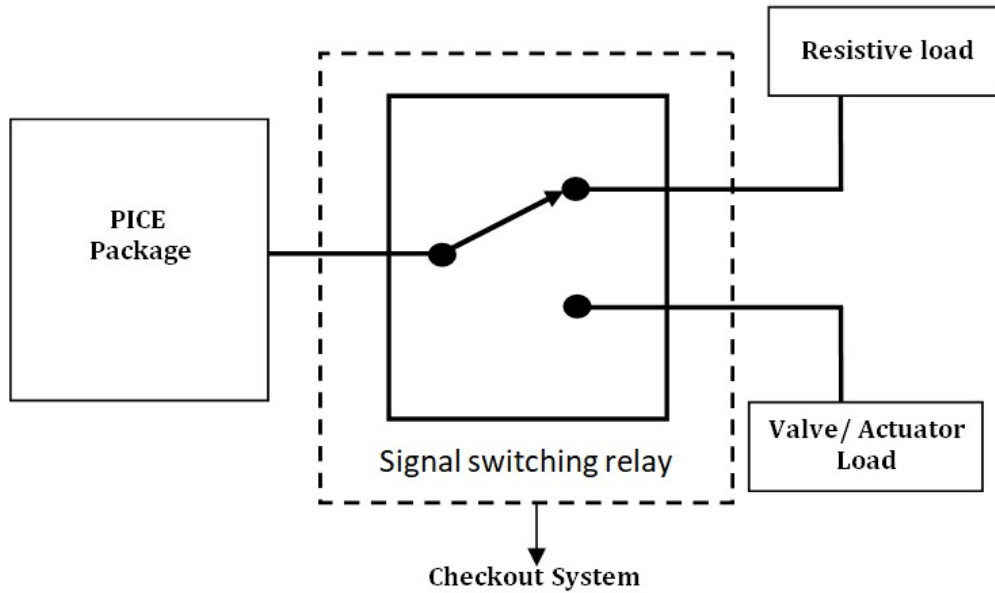
Note: signal switching relay switches ACT+,ACT-,EXT+,EXT-,EXTGND &
SOP Lines from PICE package either to Resistive load or to valve /Actuator load.
For TVC1, TVC2 and PSOM modules there is no EXT- line.

7.14 FDI check – Load connection
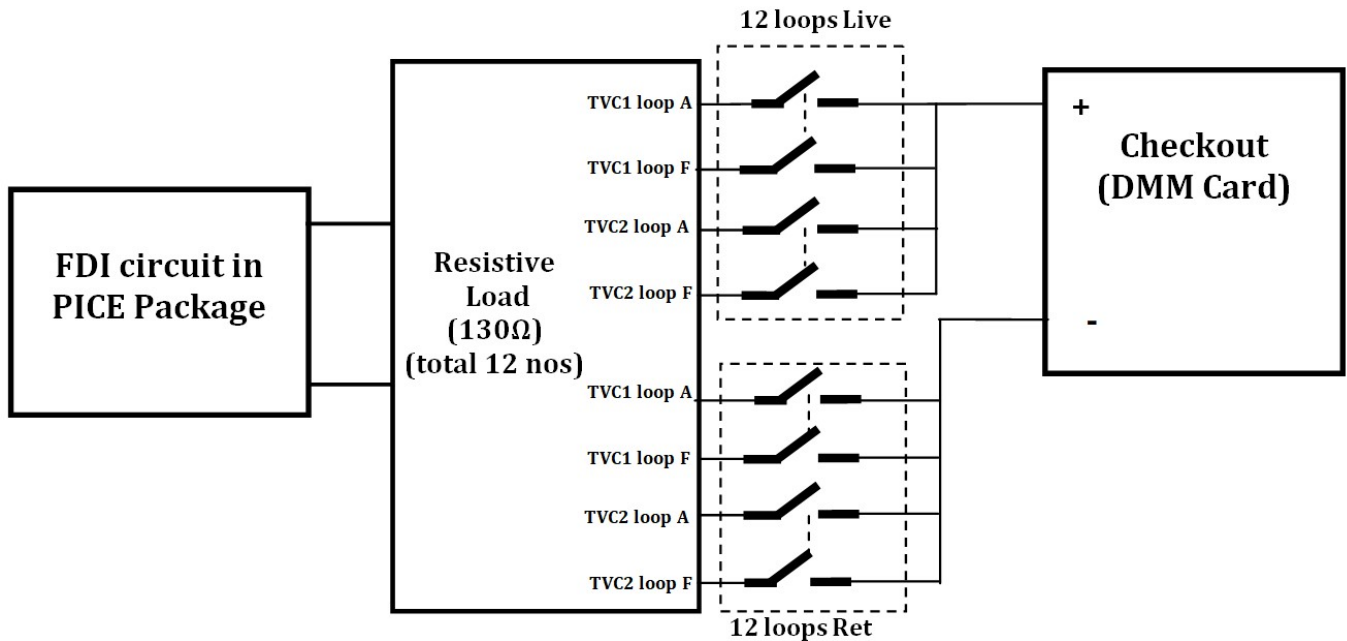
7.16 Null capture test for RCT
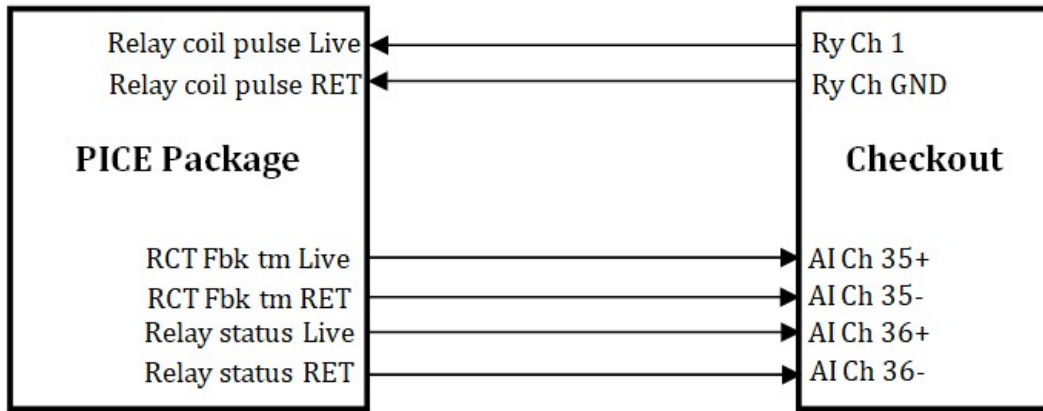
8. Block Diagrams for Different Tests

8.1 Power supply and converter output checks
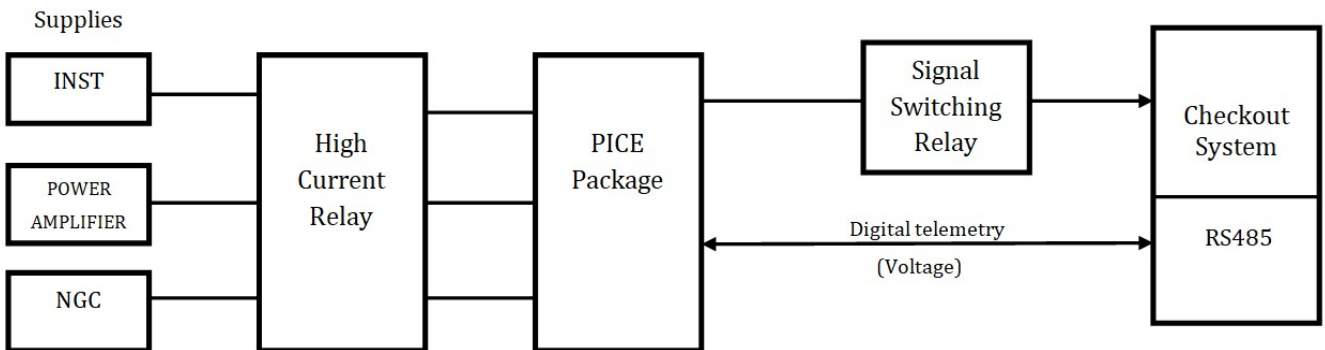
8.2 Sensor excitation Check with valve Load
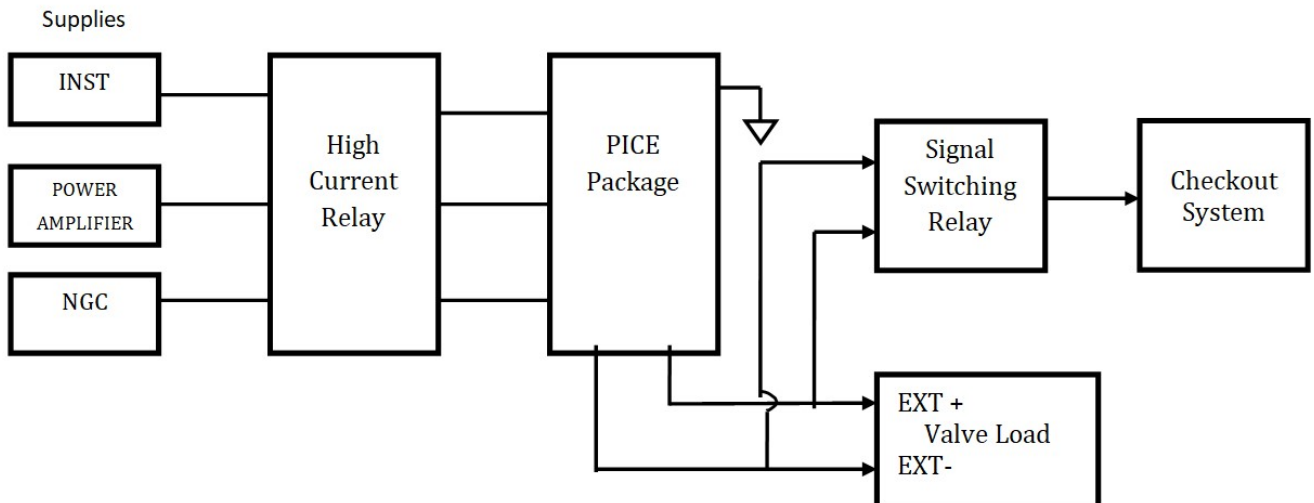
8.3 Feedback telemetry linearity checks (Digital and Analog)

Supplies

INST — High Current Relay — PICE Package

Command generation → Signal Switching Relay ← Command Monitoring — Checkout System

Feedback telemetry analog →

NGC — High Current Relay

Digital telemetry (Command/feedback) ← RS485
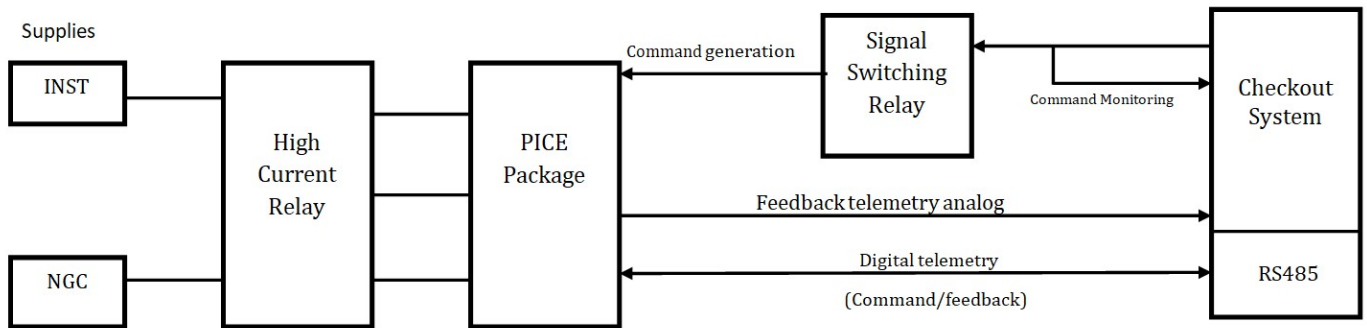
8.4 Command telemetry Linearity check

Supplies

INST — High Current Relay — PICE Package

Command generation ← Signal Switching Relay ← Checkout System

NGC

Digital telemetry (Command) → RS485

8.5 Forward path linearity and gain Check

Supplies

INST — High Current Relay — PICE Package

Command generation ← Signal Switching Relay ← Checkout System

Command Monitoring

Voltage across Actuator

Resistive Load
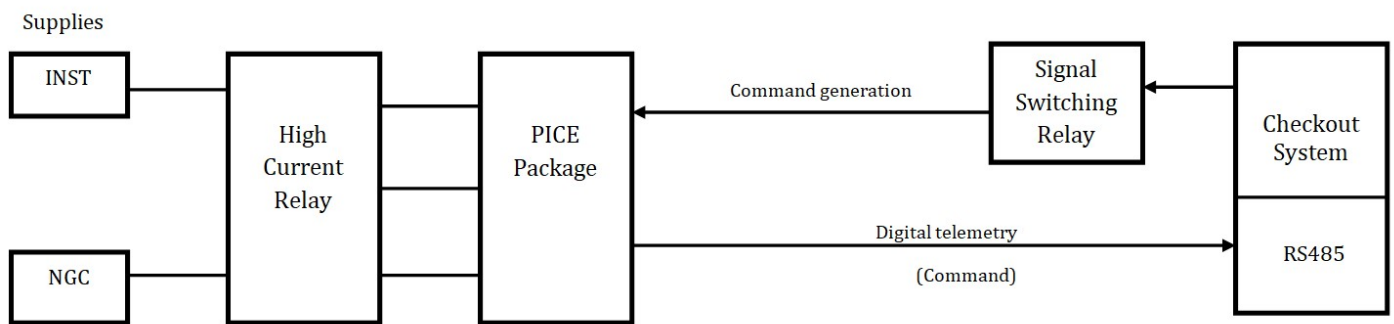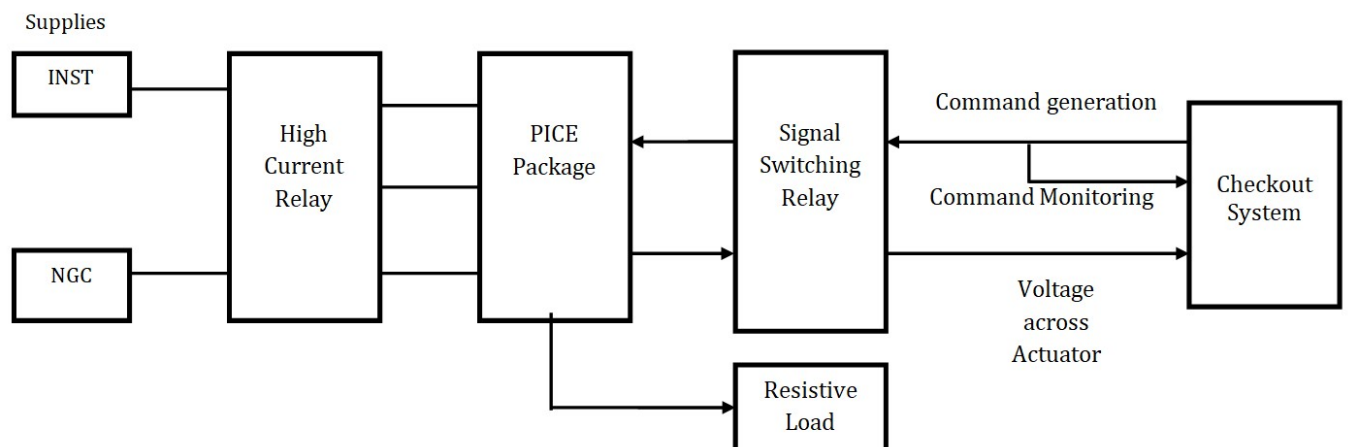
8.6 FDI logic check
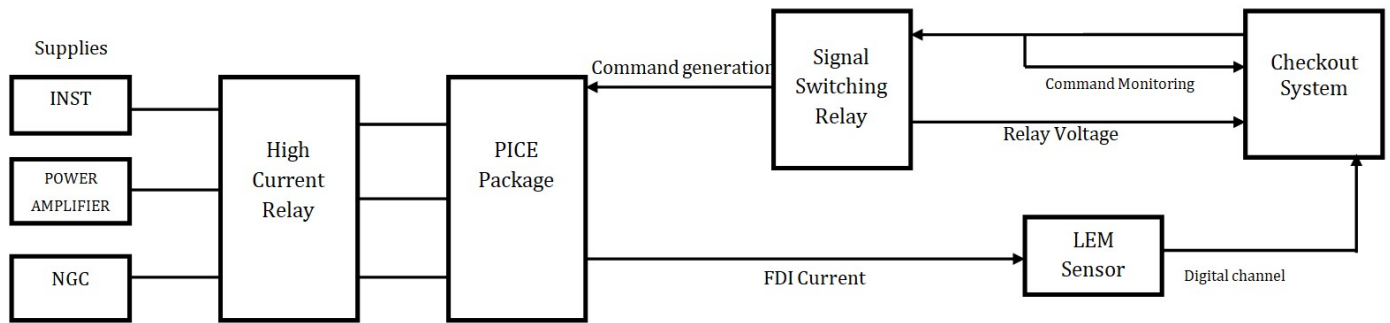
8.7 Steady State error Test (Analog and Digital)
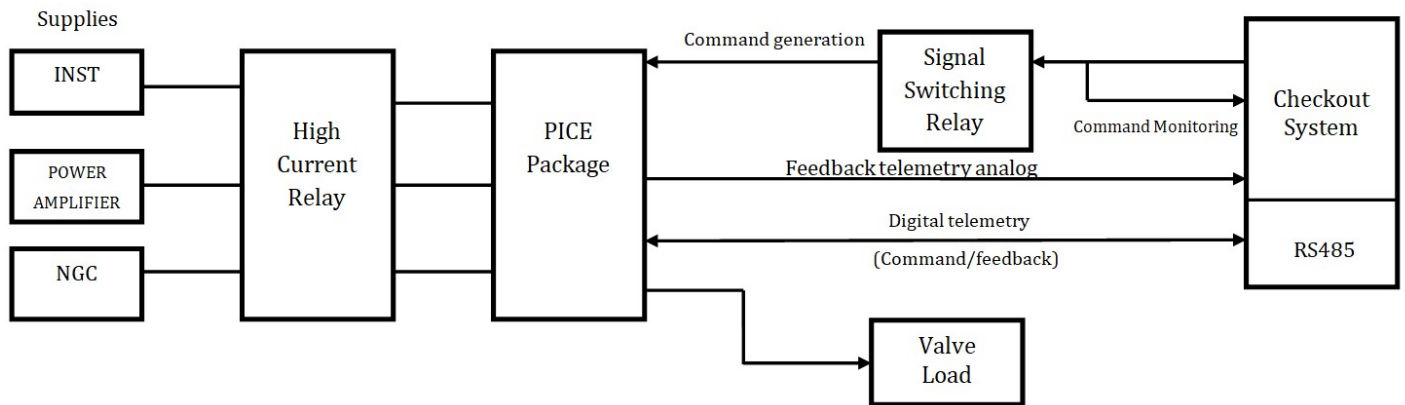
8.8 Combined Steady State error Test (Analog and Digital)

8.9 Step response

Supplies

```
┌──────────┐
│   INST   │──────┐
└──────────┘      │
                  │      ┌──────────┐      ┌──────────┐
┌──────────┐      ├──────│   High   │──────│   PICE   │
│  POWER   │──────┤      │ Current  │──────│ Package  │
│AMPLIFIER │      │      │  Relay   │──────│          │
└──────────┘      │      └──────────┘      └──────────┘
                  │
┌──────────┐      │
│   NGC    │──────┘
└──────────┘
```

Command generation → Signal Switching Relay ← Command Monitoring → Checkout System

Feedback telemetry analog →

Valve Load

8.10 Frequency Response Test

Supplies

```
┌──────────┐
│   INST   │──────┐
└──────────┘      │
                  │      ┌──────────┐      ┌──────────┐
┌──────────┐      ├──────│   High   │──────│   PICE   │
│  POWER   │──────┤      │ Current  │──────│ Package  │
│AMPLIFIER │      │      │  Relay   │──────│          │
└──────────┘      │      └──────────┘      └──────────┘
                  │
┌──────────┐      │
│   NGC    │──────┘
└──────────┘
```

Command generation → Signal Switching Relay ← Command Monitoring → Checkout System

Feedback telemetry analog →

Valve Load

8.11 Actuator current Telemetry

Resistive load

Supplies

```
┌──────────┐
│   INST   │──────┐
└──────────┘      │
                  │      ┌──────────┐      ┌──────────┐
┌──────────┐      ├──────│   High   │──────│   PICE   │
│  POWER   │──────┤      │ Current  │──────│ Package  │
│AMPLIFIER │      │      │  Relay   │──────│          │
└──────────┘      │      └──────────┘      └──────────┘
                  │
┌──────────┐      │
│   NGC    │──────┘
└──────────┘
```

Signal Switching Relay → LEM sensor → Checkout System

Command generation

Command Monitoring

Digital channel →

Actuator current telemetry

RS485

8.12 Pintle travel measurement

Supplies

```
INST ──────┐
           ├──→ High Current Relay ──→ PICE Package ──Command generation──→ Signal Switching Relay ←──Command Monitoring──← Checkout System
POWER      │
AMPLIFIER ─┤
           │
NGC ───────┘
```

Feedback telemetry analog

Valve Load

8.13 Angle measurement

Supplies

```
INST ──────┐
           ├──→ High Current Relay ──→ PICE Package ──Command generation──→ Signal Switching Relay ──Command Monitoring──→ Checkout System
POWER      │
AMPLIFIER ─┤
           │
NGC ───────┘
```

Feedback telemetry analog

Actuator Load (RCT, RCT+ Engine)

8.14 Digital Telemetry verification

Supplies

```
INST ──────┐
           ├──→ High Current Relay ──→ PICE Package          Checkout System
POWER      │
AMPLIFIER ─┤                                                 RS485
           │
NGC ───────┘
```

Digital telemetry

(Command/feedback)

8.15 Verification of feedback telemetry output impedance
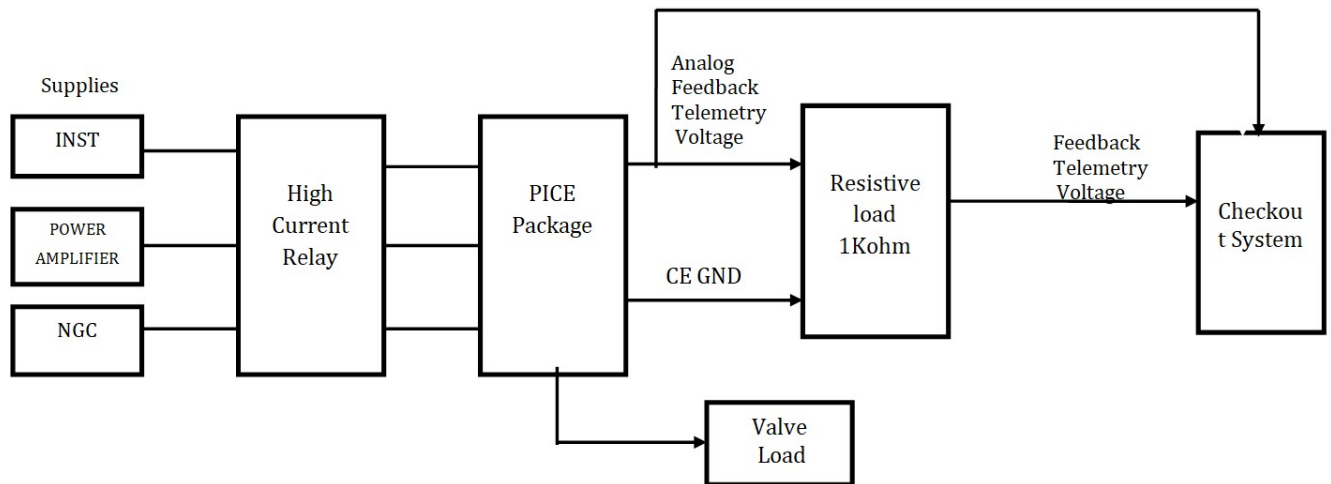
8.16 Power amplifier null current and null voltage measurement
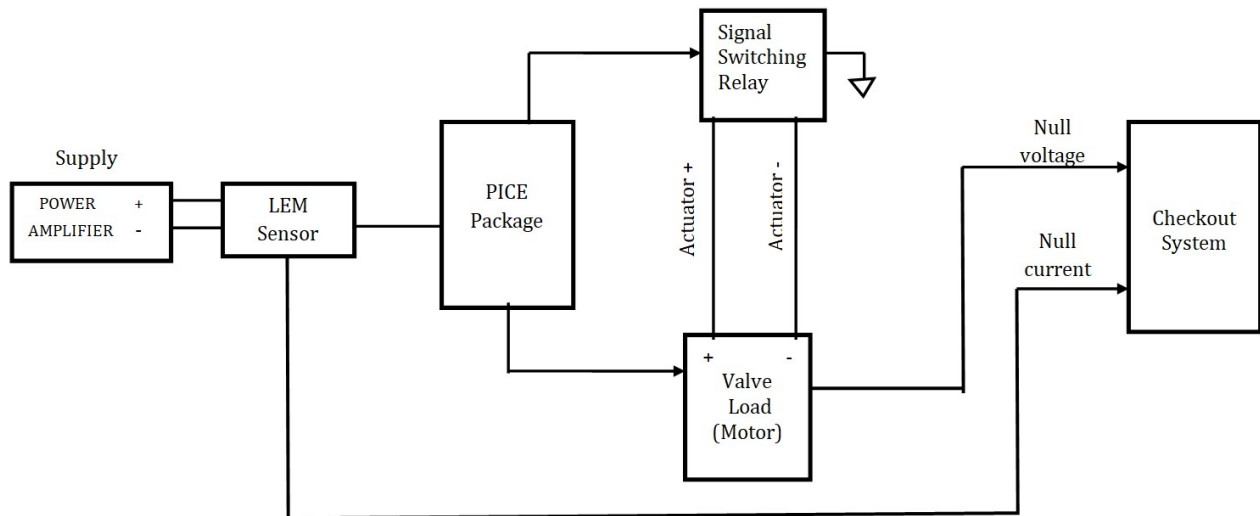
8.17 PICE package total null current (NGC, INST , PA supplies)
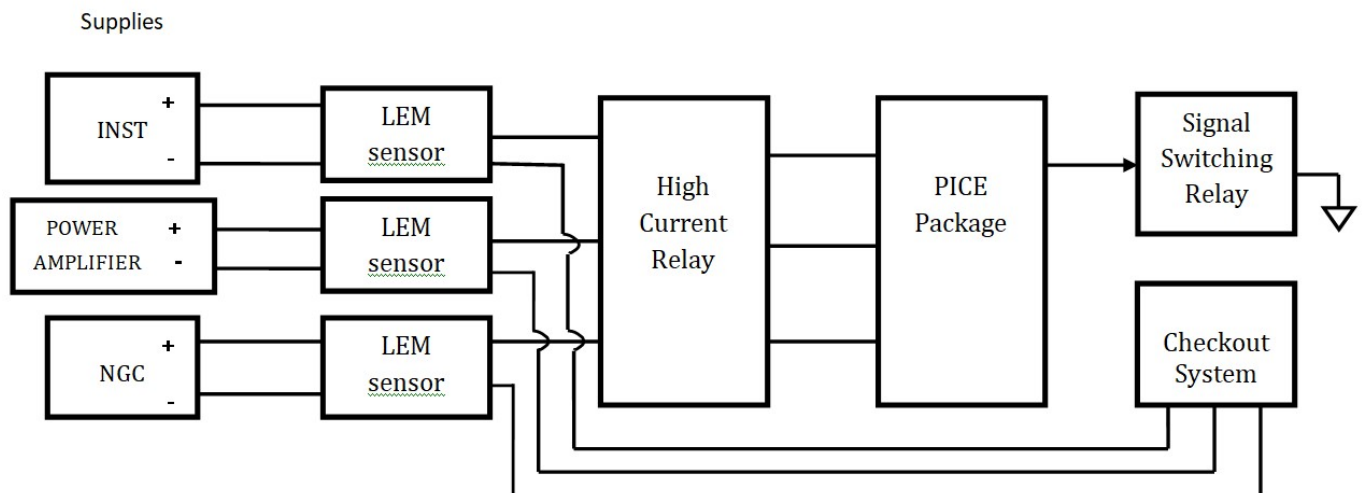
8.18 Null capture test for RCT
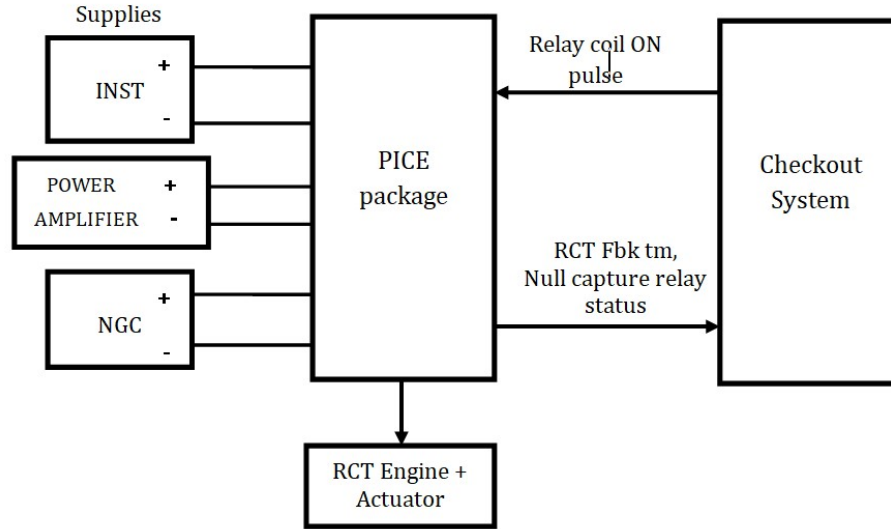
9. Equipments / Materials which are under the scope of supply of the Vendor

Table 1: List of major hardware

Sl. No.	Item Description	Quantity (Nos)	Spare quantity	Total Qty
1	42U Height Rack &its accessories	1		
2	19" Rack mount monitor with keyboard	1		
3	printer	1		
4	Remote monitor PC	1		
5	Programmable DC power supply type 1	1		
6	Programmable DC power supply type 2	2		
7	PXI chassis and rack mount kit	1		
8	PXI Controller	1		
9	Analog input module	2		
10	Analog output module	1		
11	High current relay module	2		
12	Signal Switching relay module	3		
13	FRA (Frequency response analyzer) module	1		
14	DMM add on module	1		
15	Relay driver add on module	1		
16	Scope coder	1		

Sl. No.	Item Description	Quantity (Nos)	Spare quantity	Total Qty
17	Clamp meter	1		
18	Rs485 interface card	1		
19	Digital multimeter - $6\frac{1}{2}$ digit DMM	1		
20	High resistance meter	1		
21	Micro meter (Depth gauge)	1		
22	LEM current sensor	18		
23	Power supply for LEM	1		
24	Relay 1 (low current)	25		
25	Relay 2 (High current)	30		
26	Network switches	1		
27	RJ-45 male connector	4		
28	Ethernet cable	1		
29	Shielded wires and harness	1 Lot		
30	connectors	127		
31	Integration, wiring and testing of hardware (including licensed application software)			
32	Documentation			
Total				

All the above mentioned items detailed in annexure 2

9.1 Unforeseen Items
Any other items which are essential for the successful commissioning of the facility and which are not specified in this RFP shall be suggested by the vendor at the time of pre- bid meeting and supplied at additional cost, with the approval of LPSC.

10. Software requirements specifications

10.1 General Requirements
Following are the general requirements of the checkout software
1. Facility to conduct all tests as listed in test matrix. Detailed test plan will be provided once PO is placed.
2. Communication with power supplies and measuring instruments for its configuration, parameter setting and ON/OFF control. Power supply setting is provided in annexure 6
3. Interface with AI/AO modules for generation of commands and acquisition of TM parameters.
4. Continuous acquisition of power supply parameters (voltage & current), analog/digital telemetries and logging of data.

5. Automatic abort on observing anomaly in the power supply parameters or telemetry parameters.
6. Provision to ground the command input before powering.
7. Provision to connect either resistive or valve load across excitation and Actuator lines and automatic switching according to the test condition, whether Open loop or closed loop. Details of resistive load are given in annexure 7.
8. Interface with digital communication protocols for acquisition of digital parameters
9. Archival of raw data with time stamp in .txt format
10. Report generation for each test.
11. Data analysis and processing to find out the performance parameters
12. Display of real time logged data as waveform/ table along with calculated parameters
13. Provision of data plotting software with User friendly GUI.
14. Option to switch from resistive to valve loads.
15. Separate software for standalone testing and integrated testing.
   Note: software to be developed preferably labview/ labwindows/ c#.

10.2 The major precautions to be taken are
1. Confirm the power supply setting before the start of test.
2. Ensure all command inputs are grounded before powering the package.
3. Ensure that Load (Resistive / Valve load) is connected at the excitation and Actuator lines before powering.
4. Avoid simultaneous commanding from multiple sources to the same package.
5. **Power ON sequence of power supplies**
   i. Instrumentation power supply
   ii. NGC power supply
   iii. Power amplifier supply
6. NGC Power supply cannot be switched on until Instrumentation supply is switched ON and voltage & current measurements are within specification
7. Power amplifier supply cannot be switched on until Instrumentation and NGC supply is switched ON and voltage & current measurements are within specification
8. **Power OFF sequence**
   i. Power amplifier supply
   ii. NGC power supply
   iii. Instrumentation power supply
9. Test should start only when all power supply voltage, current and the telemetry monitoring are within specification.
10. If a test needs to be aborted due to some anomaly, power supplies need to be switched off in the power off sequence.

10.3 Data acquisition requirements
   During functional test power supply surveillance and data acquisition should run concurrently.
Following are the major data acquisition requirements.
1. Ensure data acquisition and RS485 digital interface readiness - check prior to each test.
2. Continuous monitoring of the power supply voltages and current through LEM sensor and verification for its limits.

3. If the data exceeds the limit software should call for automatic abort.
4. Continuous monitoring of command and telemetry data in both analog and digital domain.
5. Status monitoring of the relays must be incorporated, Real time processing of data for performance parameter evaluation.
6. Comparison of the test results with the specifications and giving ok/ Not ok status.
7. Data input to the software must be based on .txt files, which include different configuration files, command input, command duration, frequency of operation (as in frequency response test)etc.

10.4 Data logging & Report generation

Data logging and report generation will be done by following steps

1. Test data along with result need to be logged in proper format along with Package ID, valve/ Actuator reference number, test name, test condition and date for each test.
2. Storage of raw data in .txt format w.r.t time stamp in separate directory for each test and package.
3. Provision for Offline data analysis and plotting of data.
4. Provide sufficient tool for plotting and graphical analysis.
5. Consolidation of module wise test data in proper format.
6. Generation of test report as per LPSC prescribed formats.

10.5 GUI (Graphical user interface) Requirements:

1. GUI should be user friendly.
2. Menu based GUI is required for selecting different tests according to the test matrix.
3. As per the test requirements, checkout must provide the provision for selecting
   a) Standalone mode / integration mode.
   b) Power supply Voltage selection (26 V, 28.5 V & 32 V)
   c) Module selection (TVC1 Module, TVC2 Module, RCE Module, IF module & Power module)
   d) Loop selection in each module (TVC 1 – 6loops, TVC2 – 6loops, RCE – 3 loops)
   e) For RCT loop, selection is required whether test is with Actuator alone or with Actuator + Engine configuration
   f) Type of test & command selection
   g) Provision to enter the package details (Package ID, scale factor, offset, valve/ Actuator Reference number etc) and test condition.
   h) Provision to select test configuration (Open loop/closed loop)
4. Interlocks must be provided for power supply sequencing and to enable the start button only after selecting all the required parameters. (Module, loop, command, test voltage etc).
5. Provision for online graphical and Tabular display of Acquired as well as calculated parameters.
6. Provision for printing the test report after each test.
7. Provision for selecting the text files through GUI in viewable format for offline analysis.

11. Equipments/ Materials which are under the scope of supply of LPSC

LPSC will supply the following items required for the checkout system work. These items will be handed over to the vendor at the time of installation work.

SL No	Item	Qty(Nos)
1	PICE package	1
2	Valve/ Actuator + Engine setup	1

Annexure 1

1. Test Matrix for TVCE Module (TVC1 and TVC2)

1. Power Supply Check
2. Feedback TM linearity and offset check
3. Command TM linearity and offset check
4. Forward path linearity and gain check
5. FDI logic check
6. Actuator current test
7. Sensor Excitation Check with valve Load
8. Steady State Error test for analog and digital telemetry
9. Step Response Test
10. Frequency Response Test
11. Pintle Travel measurement
12. RS-485 Link Test
13. Digital Telemetry verification
14. Feedback telemetry output impedance measurement
15. Power Amplifier null current and null voltage measurement with valve
16. PICE package total null current
17. ENOB test

*Each TVC module consists of 6 loops identified as Loop A to Loop F

TVC Modules test loops and signal notations
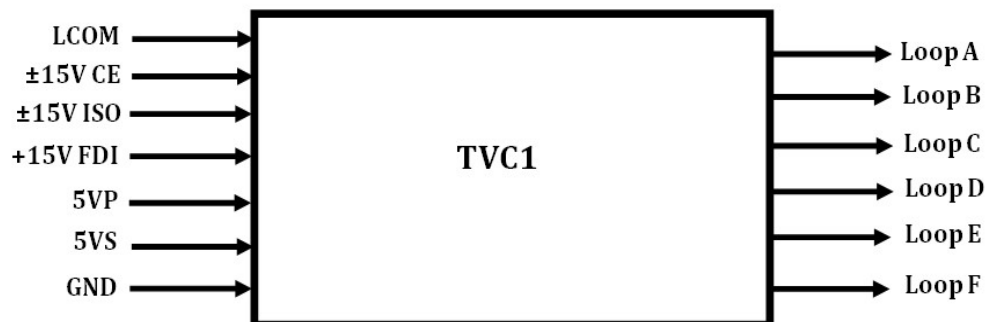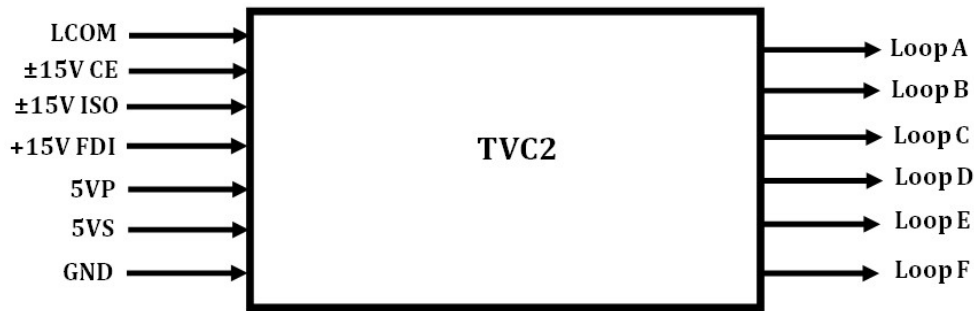
2. Test Matrix for RCE Module

1. Power Supply Check
2. Feedback TM linearity and offset check
3. Command TM linearity and offset check
4. Forward path linearity and gain check
5. Actuator Current TM Test
6. Sensor Excitation Check with valve Load
7. Null capture test
8. Steady State Error Test for Analog and Digital telemetry
9. Step Response Test
10. Frequency Response Test
11. Pintle Travel Measurement
12. Angle Measurement of Actuator
13. RS-485 Link Test
14. Digital Telemetry verification
15. Feedback telemetry output impedance measurement
16. Power Amplifier null current and null voltage measurement with valve
17. PICE package total null current
18. ENOB test

*RCE module consists of 3 loops identified as RCT, SOV (+), SOV (-), RCT loop testing consists of (i) Actuator and (ii) Actuator + Engine

RCT Module test loops and signal notations
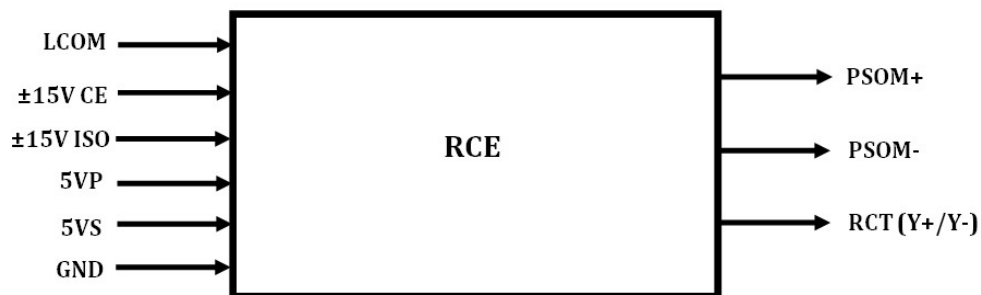
3. Test Matrix for Interface (IF) Module

1. Power supply check
2. Interface card functional output verification RCOM1
3. Interface card functional output verification RCOM2
4. Verification of SOV 4 ON and SOV 5 ON control output

Interface Module Test Parameters and Signal Notation
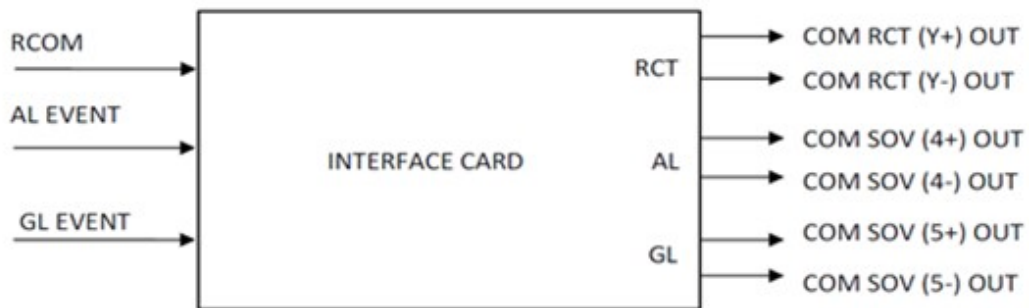
4 . Test Matrix for Power Module

1. Line and load regulation tests
2. Efficiency computation @28.5 for maximum load
3. Spike and ripple measurements with resistive load @28.5V
4. Cross regulation test @28.5V for ±15V CE and ±15V ISO converters
5. Power module test with CE Load @26,28.5 and 32V
6. Spike and ripple measurements with CE load @28.5V with PA ON
7. Input voltage ripple with CE load @ 28.5V
8. Inrush current measurement of power module with CE load and Max resistive load condition @28.5V

PM Module test parameters and signal notations
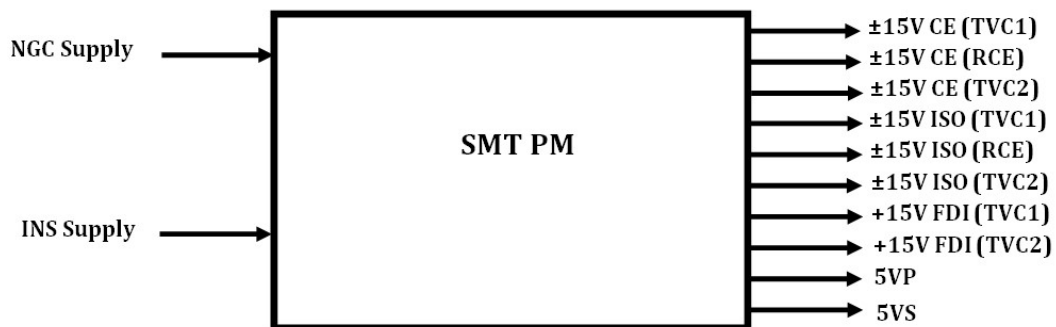
5. SMT Power module Outputs load specification details

SL. No.	Legend	Internal Bleeder	Min load	Typ Load	Max Load
1	+15 CE TVC1	Nil	50mA (300Ω)	310mA (48.38Ω)	372mA (40.32Ω)
2	-15 CE TVC1	Nil	50mA (300Ω)	220mA (68.18Ω)	264mA (56.81Ω)
3	+15 ISO TVC1	Nil	50mA (300Ω)	330mA (45.45Ω)	396mA (37.87Ω)
4	-15 ISO TVC1	50mA	Nil	160mA (93.75Ω)	192mA (78.125Ω)
5	+15V FDI TVC1	100mA	Nil	300mA (40Ω)	500mA (20Ω)
6	+15 CE TVC2	Nil	50mA (300Ω)	310mA (48.38Ω)	372mA (40.32Ω)
7	-15 CE TVC2	Nil	50mA (300Ω)	220mA (68.18Ω)	264mA (56.81Ω)
8	+15 ISO TVC2	Nil	50mA (300Ω)	330mA (45.45Ω)	396mA (37.87Ω)
9	-15 ISO TVC2	50mA	Nil	160mA (93.75Ω)	192mA (78.12Ω)
10	+15V FDI TVC2	100mA	Nil	300mA (40Ω)	500mA (20Ω)
11	+15 CE RCT IF	50mA	Nil	160mA (93.75Ω)	192mA (78.12Ω)
12	-15 CE RCT IF	50mA	Nil	100mA (150Ω)	120mA (125Ω)
13	+15 ISO RCT	50mA	Nil	160mA (93.75Ω)	192mA (78.12Ω)
14	-15 ISO RCT	50mA	Nil	80mA (187.5Ω)	96mA (156.25Ω)
15	5VP	100mA	100mA 50Ω	395mA (12.65Ω)	474mA (10.54Ω)
16	5VS	100mA	100mA 50Ω	395mA (12.65Ω)	474mA (10.54Ω)

Annexure 2

I. Specification of the hardware modules

Note : Wires and connectors :

1. Power supplies routed through 20AWG & signals through 24AWG shielded twisted pair cables.
2. Wiring for power amplifier supply: Max current will be 10A and wiring has to be done to sustain the same for a continuous testing duration of 1 hr.

1. 42U Height Rack &its accessories

S.L No	Parameter	Specification	Compliance by vendor
1	No of Rack	1 No	
2	Size(approx)	42U X 600 mm X 800 mm (H X W X D)	
3	Colour	Color of all the elements of the rack shall be RAL 7035 (Light Grey)	
4	Painting type	Powder coating	
5	Construction material	light duty stainless steel should be used.	
6	Heavy duty Nylon castor wheels with foot operated brakes	Required	
7	Front doors	Lockable Toughened Glass Door, Steel Single, Steel Dual	
8	Rear door	light duty stainless Steel. Door lock and door handle on rear side also	
9	Cooling system	Fan cooling	
10	Standards for rack	DIN 41494 and current industry practices	
11	Mounting angle	19" Mounting angles made of formed steel	
12	Mounting angle	19" Mounting angles made of formed steel	
13	Stand capacity	Must bear 20Kg weight maximum	
Scope of supply per each Rack			
Sl. No.	Description	Qty.(Nos.)	Compliance by vendor
1	Profile, vertical	4	
2	End frame assembly top	1	

3	End frame assembly bottom	1	
4	Cover side	2	
5	Cover top	1	
6	Cover bottom	1	
7	Horizontal support channel	5	
8	Front door	1	
9	Rear door	1	
10	Cooling fans suitable for mounting in 19" fan tray	4	
11	2 inch Heavy Duty Nylon Castor wheels with foot operated brakes	4	
12	Power distribution box of (15 x 5A, 2 x 15A) with spike suppressor	1	
13	Copper Earthing bar and accessories	1	
14	All fasteners such as mounting bolts, mounting screws, metallic washers, nuts and cage nuts required for mounting above items.	1 set	

2. 19 " Rack mount monitor with keyboard

SL. No.	Parameter	Specification	Compliance by vendor
1	Mounting	Foldable 1U rack mount	
2	Monitor	commercial type, 19 inch wide LCD monitor	
3	Interface	PS-2/USB /VGA	
4	External support	USB connectors for keyboard , mouse and printer, LAN ports	
5	Video quality	supports resolutions of up to 1280 x 1024	
6	Keyboard	Keyboard Language support: English	
7	Maximum Input voltage	230V AC, 50Hz	

3. Printer

SL. No.	Parameter	Specification	Compliance by vendor
1	Mounting	19 inch rack mount	
2	Type	Laser jet	

3	Power supply required	230V ,50Hz	
4	Duplex Print Options	automatic	
5	Resolution	600 x 600 dpi for both colour, black & white	
6	Paper handling capacity	Input: 100-sheet input tray Output: 50-sheet output bin	
7	Operating system compatibility	Windows 10/11(32/64 bit)	
8	Connectivity	USB port	

4. Remote monitor PC

SL. No.	Parameter	Specification	Compliance by vendor
1	Interface	USB 2.0, 9-pin D-Sub, LAN port	
2	Hard disk	10TB	
3	Operating system	Windows 10 professional 64 bit or better	
4	Processor criteria	Intel 10th generation Core i9/i7 processor with H420E chipset	
5	PCI LAN card	1 no of PCI LAN card with dual port addition to the onboard Ethernet port	
6	RAM	8 GB Dual channel DDR4 2133MHz	
7	Key board	USB keyboard	
8	mouse	USB optical mouse	
9	Monitor	27 inch commercial monitor, VGA interface, black colour body, aspect ratio 5:4 with accesorries	

5. Programmable DC power supply Type 1

SL. No.	Parameter	Specification	Compliance by vendor
1	Rated output voltage	0-60 minimum	
2	Rated Output current	0-15 A minimum	
3	Constant voltage mode		
	Max. line regulation	0.01% of Vout or better	
	Max load regulation		

	Constant current mode		
4	Max. line regulation	0.01% of Iout or better	
	Max. load regulation		
5	Ripple and Noise	≤ 50mV pk-pk or better	
6	Display	4 digits separate voltage and Current	
7	Status indication	Indication of Output On, V/I Limits, CV, CI	
8	Interface	LAN compatible mandatory, USB/GPIB optional	
9	Front panel description indication	Preview setting, output ON/OFF,CV/CC	
10	Weight of the supply	≤ 10 Kg	
Digital programming and read back (programming accuracy)			
11	Voltage	0.02% of full scale	
12	Current	0.02% of full scale	
13	Protective functions	OCP (constant current), OCP fold back, OVP, OTP	

6. Programmable DC power supply Type 2

SL. No.	Parameter	Specification	Compliance by vendor
1	Rated output voltage	0-36V minimum	
2	Rated Output current	0-5 A minimum	
	Constant voltage mode		
3	Load Regulation	0.01% of Vout or better	
	Line Regulation		
	Constant current mode		
4	Load Regulation	0.01% of Iout or better	
	Line Regulation		
5	Ripple and Noise	≤ 50mV pk-pk or better	
6	Display	4 digitsseparate voltage and Current	
7	Front panel buttons/Knobs	Coarse and fine controls for both Voltage and current	
8	Interface	LAN compatible mandatory, USB/GPIB optional	

9	indication	FINE, MENU , PREV, PROT, OUTPUT, CV , CC	
10	Weight of the supply	≤ 7 Kg	
Digital programming and read back (programming accuracy)			
11	Voltage	0.02% of full scale	
12	Current	0.02% of full scale	
13	Protective functions	OCP (constant current), OCP fold back, OVP, OTP	

7. PXI chassis and rack mount kit :

SL. No.	Parameter	Specification	Compliance by vendor
1	Slots	Min 16 Slots (including Controller & DAQ Modules), Should support PXI and PXIe cards (Hybrid slots)	
2	Chassis type	3U	
3	System bandwidth	Minimum 20 GB/s or better	
4	Cooling	Fan cooling for power supply and for module	
5	External support	USB connectors, LAN ports, GPIB interface port along with its cable/bus of 2m	
6	Operating Input voltage/ frequency	230V, 50Hz	
7	Synchronization between all slots	Yes	
8	All standard Accessories	Power cord & Rack mounting kit to be included	

8. PXI Controller

SL. No.	Parameter	Specification	Compliance by vendor
1	Hard disk	500 GB SSD or better	
2	Processor	Processor 8core(2 GHz min CPU frequency) or better	
3	RAM	16 GB or better	
4	Ethernet	10M/100M/1000M/2.5G Base-T, 2 ports	
5	Operating System	Windows 10/11, 64 bit	

6	Form factor	PXI /PXIe compatible with the chassis	
7	GPIB Controller	1	
8	USB 2.0	Min. 2	
9	USB 3.0	Min. 2	
10	Display Interface	Compatible to PS2/USB/ VGA	
11	Bandwidth	8GB/s or better	
12	Synchronization with other modules	Yes	
13	PXI/PXIe Trigger Bus Input/output	Yes	
14	Bus interface	PXI/ PXIe	

9. Analog Input module

SL. No.	Parameter	Specification	Compliance by vendor
1	No. of channels	Minimum 8 nos	
2	Channel type	Isolated channels	
3	Maximum working Current	5mA or better	
4	Resolution	16 bits or better	
5	Sampling rate	Minimum 5kS/s per channel	
6	Input coupling	DC	
7	Input signal range	±10 V or better	
8	Input range settings	±1 V, ±2 V, ±5 V, ±10 V	
9	Maximum working Voltage	± 10V or better	
10	Form factor	PXI /PXIe compatible with the chassis	
11	Input mode	Differential	
12	Trigger Modes	Analog and digital triggers	
13	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	

10. Analog output module

SL. No.	Parameter	Specification	Compliance by vendor
1	No. of channels	Minimum 4 Analog output channels	
2	Resolution	16 bits or better	
3	Maximum working current	± 5 mA or better	
4	Sampling rate	Minimum 10kS/s/ch	
5	output coupling	DC	
6	working voltage for analog inputs	Atleast ± 10V	
7	Trigger Modes	External digital triggers	
8	Form factor	PXI /PXIe compatible with the chassis	
9	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	

11. High current relay module

SL. No.	Parameter	Specification	Compliance by vendor
1	Type	Electro Mechanical	
2	Relay configuration	Atleast 10 channels or better	
3	Switching Voltage	36V or better	
4	Maximum switching Current (per Channel)	10A or better	
5	Maximum switching power	320W or better	
6	Relay operate time	<20ms	
7	Expected relay life	Minimum 1×10^7 cycles	
8	Form factor	PXI /PXIe compatible with the chassis	
9	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	

12. Signal Switching relay module

SL. No.	Parameter	Specification	Compliance by vendor
1	Relay configuration	2 wire matrix type minimum 64 channels or better	
2	Switching Voltage	20V DC or better	
3	Switching/carry Current (per Channel)	Minimum 500mA	
4	Minimum switch load	100Ω or better	
5	Scan rate	100cycles/s	
6	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	
7	Relay operate time	3 ms or better	
8	Form factor	PXI /PXIe compatible with the chassis	

13. FRA (Frequency Response Analyzer) module

SL. No.	Parameter	Specification	Compliance by vendor
1	No. of channels	2 Analog input and 2 analog output channels	
2	Sampling rate	Minimum 100KS/s per channel	
3	Type of sampling	Simultaneous sampling	
4	Input mode	Differential	
5	Resolution	16 bits or better	
6	Input coupling	AC or DC	
7	Input signal range	±10V min	
8	Trigger functions	Start Trigger, Reference Trigger	
9	Trigger Modes	Analog and digital triggers	
10	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	
11	Form factor	PXI /PXIe compatible with the chassis	

14. DMM add on module

SL. No.	Parameter	Specification	Compliance by vendor
1	Resolution	6 ½ digit or better	
2	Input impedance	10 MΩ min	
3	Input coupling	AC or DC coupled	
4	CMRR	>70dB	
5	Maximum DC voltage component	400 V	
6	Frequency measurement range	15 Hz to 500 kHz	
7	Voltage ranges	± 100mV to ± 1000V	
8	Current range	±1 µA to ± 3 A	
9	Sample rate ranges	10 S/s to1.8 MS/s	
10	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	
11	Form factor	PXI /PXIe compatible with the chassis	

15. Relay driver add on module

SL. No.	Parameter	Specification	Compliance by vendor
1	No of channels	15 or better	
2	Coil contact voltage	24/ 28 V	
3	Per channel drive current	Minimum 500mA	
4	Form factor	PXI /PXIe compatible with the chassis	
5	Cable	2m length shielded cable to interface with DAQ card. It is to be terminated on a D-sub connector at checkout back panel.	

16. Scope coder

SL. No.	Parameter	Specification	Compliance by vendor
1	Input Section	Plug in mode	
2	No of slots	8	
3	Max recording length	250Mpts/ Ch	
5	Time scale settings	Min 1us/Div Max 10hr/Div	
4	Time axis accuracy	±0.005% or better	
5	Amplitude settings(at least)	Min 50mV/ div Max 150V/ Div	
6	Trigger mode	auto, auto level, normal, single, single (N), ON start	
7	Trigger level setting range	0 centered ±10 div	
8	Display	LCD / LED monitor	
9	Sampling rate	Maximum 1 MS/s (1 CH used)	
10	Screen image data output	Built-in printer (preferred) External printer (Outputs the screen image to an external printer via Ethernet or USB), File output data format (PNG/ JPEG/ BMP)	
11	Storage	SD card slot ,USB memory , External HDD, Built-in HDD	
12	Rated power supply voltage/frequency	230V/50Hz	
13	Withstand voltage	1500 V AC between power supply and earth for 1 minute	
14	Insulation resistance	10 MΩ or higher at 500 V DC between power supply and earth	
15	interface	USB, Ethernet	
16	functions	Recording Start/Stop, Monitoring, Setup control, Data filing on a PC	

17. Clamp Meter

SL. No.	Parameter	Specification	Compliance by vendor
1	Measure range	+/- 30A	
2	Output sensitivity	100mV / A	
3	Resistance range	Upto 40 KΩ	
4	Resolution	0.01 A	
5	Frequency range	DC to 100KHz	
6	Battery operation	low battery indication	
7	Weight	less than 500gm	
8	cable	Provide 2m cable terminated with a BNC connector (50ohm) and safety adaptor for each equipment	

18. RS485 interface card

SL. No.	Parameter	Specification	Compliance by vendor
1	No. of connectors (I/O)	4 (preferably 68 pin female high density VHDCI type)	
2	No. of channels per connector	32	
3	Maximum frequency	≥ 50 MHz	
4	Input signal range (Max)	3.5V or better	
5	Input impedance	50 kΩ	
6	Maximum DC output	≥ 4 mA per channel	
7	Maximum voltage range	-5 to +11VDC(RS485 port to COM)	
8	External supply voltage	Minimum 5 V	
9	Input mode	Serial bits communication	
10	Baud rate	Minimum 2Mbps	
11	Cable	2m length shielded cable to interface with DAQ card. It isto be terminated on a D-sub connector at checkout back panel.	
12	Form factor	PXI /PXIe compatible with the chassis	

19. Digital multimeter – 6 ½ digit DMM

SL. No.	Parameter	Specification	Compliance by vendor
1	resolution	6-1/2 digit	
2	Maximum Input	1000 V on any range	
3	Common Mode Rejection	140 dB at 50 or 60 Hz}0.1 % (1kΩ unbalance)	
4	Normal Mode Rejection	60 dB for NPLC of 1 or greater with analog filter off and power line frequency }0.1 %100 dB for NPLC of 1 or greater with analog filter on and power line frequency }0.1 %	
5	Measurement Method	Multi-ramp A/D	
6	resistance measurements	2 and 4-wire resistance measurements	
7	Resistance range	Upto 100MΩ	
8	Frequency measurements	300 kHz	
9	current capability	10 A	
10	display	Vacuum Fluorescent Display, dot matrix	
11	Volatile Memory	SDRAM-128 MB, SRAM-4 MB	

20. High resistance Meter- Specifications

SL. No.	Parameter	Specification	Compliance by vendor
1	No of channels	1	
2	Ranging	Auto & hold	
3	Measurement parameters	Resistance & Current	
4	Resistance Range	$1\Omega\text{-}10^{16}\Omega$	
5	Accuracy	Better than 10%	
6	Current Range1	1nA to 10mA max	
7	Test Voltage	10Vto 100V(programmable)	
8	Test voltage resolution	10V min	
9	Test voltage accuracy	Better than 1V	
10	Display type	LCD	

11	Display resolution	Better than 5 Digit	
12	Input voltage	230V,50Hz	
13	Interface	GPIB/RS485/LAN	
14	Measurement time	<1 Sec	

21. Micro meter (Depth gauge)

SL. No.	Parameter	Specification	Compliance by vendor
1	Accuracy	Atleast 3µm	
2	rod length	≥25mm increments	
3	Resolution	0.001mm	
4	Flatness of reference face	1.3µm for 60mm width base or better	
5	Flatness of measuring rod face	Minimum 0.3µm	
6	Measuring rod diameter	Minimum 4mm	
7	Display	LCD	
8	Supply type	Battery	
9	Function of Digital Model	Preset, Zero-setting, Data hold, Automatic power ON/OFF, Data output, Preset inch/mm conversion (inch/mm models) Alarm: Low voltage, Counting value composition error	

22. LEM Current sensor

SL. No.	Parameter	Specification	Compliance by vendor
1	Primary current	10A	
2	Power supply	±15V	
3	Output	±4V	
4	Bandwidth	50KHz @ -3dB	

23. Power Supply for LEM Current sensor

SL. No.	Parameter	Specification	Compliance by vendor
1	Type	Fixed power supply	

2	Output Voltage	± 15 V with common GND	
3	Output Current	≥ ± 0.5 A	
4	Output Voltage accuracy	± 2 % or better	
5	Adjustability	±10 % of rated voltage	
6	Load Regulation	1 % or better	
7	Line Regulation	0.5 % or better	
8	Ripple and Noise (pk-pk)	≤150mv	
9	Over current protection	required	
10	Humidity	50% to 70% RH	
11	stability	0.3% or better	

24. Relay 1 (Low current)

SL. No.	Parameter	Specification	Compliance by vendor
1	Type	Electro mechanical	
2	Relay configuration	4P-DPDT (Double pole double through)	
3	Switching Voltage	11V	
4	Maximum Switching Current	1 A	
5	Relay operate time	20ms	
6	DC coil voltage	24V	

25. Relay 2 (High current)

SL. No.	Parameter	Specification	Compliance by vendor
1	Type	Electro mechanical	
2	Relay configuration	DPDT (Double pole double through)	
3	Switching Voltage	40V or better	
4	Maximum Switching Current	10 A	
5	Relay operate time	20ms	
6	DC coil voltage	24V	

26. Network Switch

SL. No.	Parameter	Specification	Compliance by vendor
1	Quantity	2nos	
2	Form factor	19 inch rack mountable , 1U size	
3	No of ports	16 or better	
4	Transfer rates	10/ 100/1000 Mbps	
5	Unidirectional link detection	required	
6	Indication	Link, active connection	
7	Basic layer -3 protocol	IPv4	
8	Power supply	12/24V DC, 230V AC, 50Hz	
9	Standards	IEEE 802.3 10 BASE-T Ethernet IEEE 802.3ab 1000 BASE-T Gigabit Ethernet IEEE 802.3u 100 BASE-TX fast Ethernet ANSI/ IEEE 802.3 N way auto negotiation IEEE 802.3x Flow control	
10	compatibility	LXI/ USB	
11	Forwarding types	Store and forward	
12	USB ports	1 or more	

27. RJ-45 Male connectors

SL. No.	Parameter	Specification	Compliance by vendor
1	Performance category	CAT -6	
2	Housing material	Polycarbonate	
3	contacts	Gold plated contacts	

28. Ethernet cable (Length : 300m)

SL. No.	Parameter	Specification	Compliance by vendor
1	Performance category	CAT -6	
2	Type	Unshielded twisted pair	
3	Insulation jacket	PVC	

Annexure 3

Connector details

SL No	Connector type	Connector pin type	Qty
Mating connectors of Package			
1	D-Type- rectangular (example part number for reference: : AM24308/24-35F (MALE)- 50pin male)	9 PIN MALE	3
2		15 PIN MALE	5
3		15 PIN FEMALE	3
4		25 PIN MALE	5
5		25 PIN FEMALE	2
6		50 PIN FEMALE	7
7		50 PIN MALE	4
		total	29
Circular connectors on checkout back end			
8	circular (example part number for reference: :D38999)	Circular connectors 6nos must be required to interfere with all the 29 connectors of the package and checkout power supplies and pxi chassis interface. circular connectors types can be decided by work centre people	5
		Total 334 lines from checkout backend. Example configuration of connectors selected 1. 32 pin -1 no 2. 66 pin -3 nos 3. 12 pin -1 no	
Circular connectors on checkout back end- mating			
9	circular (example part number for reference: :D38999)	The mating connectors required for mating the checkout back end connection	5
		Total 334 lines going from checkout backend. Example configuration of connectors selected 1. 32 pin -1 no 2. 66 pin -3 nos 3. 12 pin -1 no	
Intermediate connectors			
10	circular (example part number for reference:	19 pin -1 no 32 pin -1 no	2

	:D38999	24/26 AWG	
Intermediate connectors- mating
11	circular (example part number for reference: :D38999	19 pin -1 no 32 pin -1 no 24/26 AWG	2
Connector details for valve selection unit
12	Valve selection unit - input connectors (C1 – C15 in fig.2b)	(12 pin circular male connector Eg: D3899920FD97PN)	15
13	Valve selection unit - input mating connectors	(12 pin circular female conector)	15
14	Valve selection unit - output connectors (OC1 – OC18 in fig. 2b)	(12 pin circular female connector)	18
15	Valve selection unit - output mating connectors	(12 pin circular male connector)	18
16	Inj. Valve - mating connectors	(12 pin circular female connector)	18
	**TOTAL**	**127**

Note:
1. This is the reference for making of connectors interfacing with valve and Checkout harness. Apart from this any additional connectors harness can be provided from checkout (Optional) as per redundancy purpose.
2. The number and type of circular connectors can be selected by the vendor as per their configuration

Annexure 4

Multi Core Cables

1. 2 Core 20 AWG Un armoured cable (length: 500 m)

SL. No.	Specification	Description
1	Conductor size	Multi strand, 20 AWG, 19 strands(19 X 0.20mm, 0.60mm²) Silver plated Copper Conductor
2	No. of cores	2
3	No. of pairs	1 twisted pair
4	Insulation	PTFE insulation on individual bunched conductor, two core twisted to form pair
5	Thickness of Insulation (Nominal)	0.25±0.05mm
6	Conductor resistance at 20ºC	≤35Ω/km
7	Insulation Resistance at 500VDC	1500MΩ/km
8	Core Colour	Cores of Red + Black
9	Inner sheath	PTFE
10	Overall screening	Braided with silver plated copper conductor of 0.12mm dia strand. Coverage are of screening ≥ 90%
11	outer sheath	PTFE. Thickness 0.35± 0.05mm
12	Outer sheath	Light grey
13	Overall diameter	4 ± 1 mm approx.
14	Packing length	250 m continuous
15	Voltage Grade	600V
16	Temp range	Up to 200 ºC
17	Test standards to be followed	JSS 51034

2. 2 Core 24 AWG Un Armoured cable (length: 1500 m)

SL. No.	Specification	Description
1	Conductor size	Multi strand, 24 AWG, 7 strands (7 X 0.20mm, 0.20mm²) Silver plated Copper Conductor
2	No. of cores	2
3	No. of pairs	1 twisted pair

4	Insulation	PTFE insulation on individual bunched conductor
5	Thickness of Insulation (Nominal)	0.25±0.05mm
6	Conductor resistance at 20°C	≤90Ω/km
7	Insulation Resistance at 500VDC	1500MΩ/km
8	Core Colour	Red, Black
9	Temp range	Up to 200 °C
10	Voltage Grade	600V
11	Test standards to be followed	JSS 51034

3. 6 Core 20 AWG Un Armoured cable(length: 500 m)

SL. No.	Specification	Description
1	Conductor size	Multi strand, 24 AWG, 7 strands(7 X 0.20mm, 0.22mm^2) Silver plated Copper Conductor
2	No. of cores	6
3	No. of pairs	3 twisted pair
4	Insulation	PTFE insulation on individual bunched conductor, two core twisted to form pair
5	Thickness of Insulation (Nominal)	0.25±0.05mm approx.
6	Conductor resistance at 20°C	≤90Ω/km
7	Insulation Resistance at 500VDC	1500MΩ/km
8	Core Colour	Core of Red+ Black, blue + white & green + orange pairs
9	Inner sheath	PTFE
10	Overall screening	Braided with silver plated copper conductor of 0.12mm dia strand. Coverage are of screening ≥ 90%
11	outer sheath	PTFE. Thickness 0.35± 0.05mm
12	Outer sheath	Light blue
13	Overall diameter	6 ± 1 mm approx.
14	Voltage Grade	600V
15	Temp range	Up to 200 °C
16	Packing length	250m continuous
17	Test standards to be followed	JSS 51034

Annexure 5

Cost Details

Sl. No.	Item Description	Part No	Qty	Unit cost	Total cost
1	42U Height Rack &its accessories		1		
2	19 " Rack mount monitor with keyboard		1		
3	printer		1		
4	Remote monitor PC		1		
5	Programmable DC power supply type 1		1		
6	Programmable DC power supply type 2		2		
7	PXI chassis and rack mount kit		1		
8	PXI Controller		1		
9	Analog input module		2		
10	Analog output module		1		
11	High current relay module		2		
12	Signal Switching relay module		3		
13	FRA (Frequency response analyzer) module		1		
14	DMM add on module		1		
15	Relay Driver add on module		1		
16	Scope coder		1		
17	Clamp meter		1		
18	Rs485 interface card		1		
19	Digital multimeter - 6 $\frac{1}{2}$ digit DMM		1		
20	High resistance meter		1		
21	Micro meter (Depth gauge)		1		
22	LEM current sensor		18		
23	Power supply for LEM		1		
24	Relay 1 (Low current)		25		
25	Relay 2 (High current)		30		
26	Network switches		1		
27	RJ-45 male connector		4		

Sl. No.	Item Description	Part No	Qty	Unit cost	Total cost
28	Ethernet cable		1		
29	Shielded wires and harness		1 Lot		
30	connectors		127		
31	Integration, wiring and testing of hardware (including licensed application software)				
32	Documentation				
Total					

Annexure 6

Power supply settings

Supply	Voltage (V)	Current limit (A)	OVP (V)	Abort limit for current (A)
Instrumentation (INST) supply	26 – 36	2	36	1
NGC(Navigation & Guidance Control) supply	26 – 36	4	36	3.5
Power amplifier(PA) supply	26 – 32	20	40	10

Annexure 7

Resistive load specification during open loop testing

Module	Actuator load	Excitation load	FDI load	No. of loops
TVCE	1K, 2W	Valve	130 ohm, 6W	12
RCT	1K, 2W	Valve	NA	1
PSOM	1K, 2W	Valve	NA	2

Part 2

<u>Commercial Aspects</u>

1. **Important Instructions for Tenderers**
   a) All the tenderers are expected to go through the complete tender document carefully prior to submitting the offer.
   b) The tenderers must carefully assess their capabilities with respect to managing a large and technically involved project on a fixed time and fixed price basis. They are expected to be extremely strong in system engineering and capable of sourcing high quality technical expertise for all requirements of this project.
   c) The contractor shall only bid for the system if the contractor has supplied a checkout system to any aerospace industry and necessary proof for the same is to be submitted along with tender quotation and also it shall be presented during the pre-bid discussion going to be conducted in 15 days' time after floating the tender. If the contractor fails to provide the necessary proof regarding the supply of the system to any aerospace industry, LPSC reserves the right to disqualify the contractor without prior notice.
   d) Contractor must have certified software engineers for any support requirement and the copy of certificates of the concerned engineers must be submitted along with the technical bid .
   e) Contractor should produce a letter from the parties where they have established automated test setups stating the review of the contractor's service during and after installation.
   f) The offer for the project should be made in two parts i.e., technical and commercial part (without price bids) and price part (with price bid) separately.

   A pre-bid meeting with the vendors will be arranged to clarify the project requirements and scope of supplies within 2 weeks from the date of publishing tender enquiry.

   1. Also the vendors can present details on the quoted systems, fabrication / integration methodology, schedule, GANTT charts etc. Clarification sought for during the pre-bid meetings shall be given within the stipulated time.
   2. The offer for the contract should be complete in all respects and should compulsorily cover confirmation of specifications with respect to subsystems and integrated system, plan of execution of the contract as per specifications. It must also include all aspects of commercial part. Any matter mentioned vaguely by the tenderer shall be treated as non-compliance to the tender requirements.
   3. The offer must indicate the proposed design approaches and description of total system as well as individual subsystem.
   4. Tenderer shall clearly specify non-compliance with specification, if any giving merits with supporting documents.
   5. Tenderer shall clearly identify the detailed plan of procurement of various equipment including their sources of supply.
   6. Tenderer shall clearly identify their associates and collaborators under consortium mode of project execution. The extent of partnership and their involvement shall be clearly spelt out for each associate and collaborator.
   7. LPSC reserves the right to reject any or all the offers without assigning any reasons thereof and will not accept any responsibility regarding non receipt of delay in receipt of the offers sent by tenderers.

2. **Service and maintenance requirement**

   a) All Breakdown maintenance call inclusive of software update and bug correction shall be attended within 72 hours of time.
   b) Contractor should quote separately for AMC (non comprehensive) of the system for initial 5 years (1 AMC/ year) after the warranty period. Also Contractor has to suggest the list of spares and equipment with its price for AMC till the validity period.
   c) Half yearly preventive maintenance (once in 6 months) and two breakdown calls visit per year at no extra cost.
   d) Attend breakdown calls within 72 hrs. Apart from this , any additional visit if required shall be quoted separately.
   e) Party has to provide the required upgradations for the software as and when required

3. **Delivery, Supply &Installation**

Delivery and installation shall be performed by the vendor, in already existing building at Liquid Propulsion Systems Centre (LPSC), Valiamala within 15 months (preferred date) from the date of acceptance of P.O. But before the final installation following are the milestones to be completed:
   1. Design documents have to be submitted to LPSC within stipulate time (30days after releasing the purchase order) which will be mentioned by LPSC during technical evaluation phase and party should get approval for the same from LPSC.
   2. Party has to deliver the items at LPSC within 8 months of date of acceptance of P.O.
   3. Party has to install the total system in the premises of LPSC within 10 months of date of acceptance of P.O.
   4. Software has to be developed by Contractor at LPSC within 12 months of date of acceptance of P.O.
   5. System has to be qualified and installed at LPSC within 15 months time period from the date of acceptance of P.O.
System has to undergo final acceptance test after installation.

4. **Mode of Quoting**

The offers shall be submitted on a two-part basis: Technical and commercial bid (other than price) & Price bid. Also the validity of quotation shall be 6 months minimum from the date of quoting. The contractor chosen on the basis of suitability of techno-commercial merits will have to sign a contract with ISRO. The scope of contract will cover the turnkey execution of the total system as per the technical and commercial terms mentioned in this document
   a. **Technical Bid:**
      1. Confirmation of each specification as outlined in Part 1.
      2. Conformance on all clauses of this RFP.
      3. List and details of non-compliance of specification by the tenderer, if any.
      4. Confirmation of scope of work by tenderer as outlined in point 2 of Part 2 of this document.
      5. List of exclusion from scope of work by tenderer, if any
      6. Overall plan of project execution with details of facilities/capabilities available for timely completion of the project in all respect.
      7. Overall time schedule in the form of bar chart.

8. Monthly progress report showing the milestones/activities covered should be submitted.
9. Activity wise time schedule in the form of CPM/PERT network diagram.
10. Procurement plan including monitoring and control methods adopted by the contractor for selection of equipment/subsystem.
11. Procurement plan for imported items including list of items & probable suppliers.
12. Reliability and quality management plan proposed to be adopted during project execution.
13. Base design of each sub-system to meet overall specification of the system and explanation for their merits, demerits, alternatives and suggestion Etc.
14. All equipment specification and their source of supply and part number.
15. List of Indian associates or partners, foreign collaborators, consultants, subcontractors, major equipment suppliers, proposal to be involved in this project, the past experience, competence and extent of the involvement.
16. Major subsystem interface and the details
17. Details of utilities to be provided by LPSC/ISRO and time stages at which these are required by the contractor
18. Total electrical power required and its details and time stage at which these are required by the contractor.
19. List of items/ equipment/ to be provided by LPSC/ISRO and time stage at which these are required by the contractor
20. List of clarifications required from LPSC/ISRO.
21. Profile of the company clearly bringing out the areas of strength and weakness enclosing following information:
    a) Average financial turnover during last five financial years
    b) Copy of the latest income-tax clearance certificate
    c) Details of financial capacity of the firm viz., details of audited balance sheet including profit & loss account for the last five years.
    d) Self-assessment of technical and organizational competence to supply the system of this nature and magnitude.
22. Commercial Terms such as delivery date, taxes, duties payable, place of delivery, payment term, validity, guarantee etc. and scope of supply shall be covered in this part. Please enclose a copy of the details indicated in price quotation (WITHOUT PRICES OR BY MASKING THE PRICE) mainly to know the items/ specifications for which you have indicated prices in price bid. This part should not contain prices.

b. Price Bid:
The price bid shall contain the following prices.
1. This part shall contain PRICE details only.
2. Total system cost including design (comprehensive packed).
3. The price for the item should be indicated item wise in this part. All the items/specifications mentioned in the Technical Part should come here and prices indicates against each. The break –up for each item of supply or service should be indicated.
4. Breakup of each subsystem cost into various elements like design changes, direct material, direct labor, overheads, profit, transportation charges, taxes & duties applicable.
5. Whenever operation is quoted, the same should also be indicated with quantity and unit rate separately. The price is to be mentioned both in figures and in words.

6. Installation& Commissioning charges.
7. Start-up trials and acceptance testing charges inclusive of all consumables. Tenderer shall clearly specify list of consumable included.
8. Acceptance to furnish performance guarantee for a minimum period of 14 months from the date of acceptance of the total system by LPSC/ISRO form a nationalized Bank
9. If more than one design options are proposed by the contractor for any subsystem or total system, break up of costs for different options is to be specified.

5. **Price**

The prices are FIRM and FIXED. On receipt of order, Contractor has to prepare detailed work break-up and schedule chart (in consultation with LPSC) and submit to LPSC for our acceptance.

6. **Payment terms**

100% of Payment within 30 days of receipt, installation & acceptance of items.

7. **Warranty**

Warranty for all the components should be minimum 1year from the date of final commissioning.

8. **Insurance**

No insurance is required at our cost. You should take adequate precautions to ensure safe delivery of the consignment.

9. **Liquidated Damages**

If the Contractor fails to deliver and Install the items within the time specified or any extension thereof, Liquidated Damage at the rate of 0.5% (zero point five percent only) of the order value or part thereof of the undelivered components for each calendar weeks of delay shall be recovered from the bill. However, total Liquidated Damage shall not exceed 10 % (ten percent only) of the order value.

10. **Force Majeure**

If at any time during the continuance of the order the performance in whole or in part by either Contractor of any obligation under this order shall be prevented or delayed by reasons of any war, hostility, acts of public enemy, civil commotion, sabotage, fire, floods, epidemic, quarantine restrictions, strikes, go-slow, lockout or acts of God, notice of which is given either Contractor to the other within 21 days from the date of occurrence thereof, neither Contractor shall be reasons of such eventuality be entitled to terminate this order nor shall either Contractor have any claim for damages against the other in respect of such non-performance or delay in performance.

11. **Secrecy**

The drawings and documents sent along with this tender form part of vital documents and same should be kept on top secret. Under any situations, contractor should not part with or transfer the technology/contents of drawings and documents whatsoever to any 3rd party/agency without our prior consent. If at any time, it is brought to our notice that the secrecy has been transferred by you intentionally or otherwise to any third party /agency, contractor shall be liable to indemnify the loss/ damage to Government of India.

12. Arbitration

In the event of any question, dispute or difference arising out of any terms and conditions of the order, the parties shall strive to find mutually acceptable solution, failing which, all questions, disputes or difference arising under or in connection with the order shall be settled through arbitration, (under conciliation and Arbitration Act of India 1996) through a person, not below the rank of Joint Secretary, nominated by the Secretary, Department of Space. The award of the Arbitrator so appointed shall be final and binding on both the parties to this order.

13. Applicable Law and Infringement thereof

This Contract shall be governed by and interpreted and construed in accordance with the law of India. The Department shall not be responsible if the Contractor infringes the laws or statutes in force during the currency of the Contract.

14. Performance Bank Guarantee

You shall submit Performance Bank Guarantee worth 3% of contract value in the form of Bank Guarantee in Rs.200/- non – judicial stamp paper obtained from Nationalized/ Scheduled Bank. This is towards the performance of the system. This PBG shall be returned after successful completion of the warranty period.

15. Security Deposit

An interest free amount equivalent to 3% of the total contract value shall submit towards Security Deposit in the form of DD or Bank Guarantee. This interest free security deposit shall be returned to you on successful completion of the contractual obligations or shall be adjusted/forfeited against non – fulfillment of any of the contractual obligations.

16. Indemnity

Contractor shall warrant and be deemed to have warranted that all the items supplied against this tender are free and clean of any infringement of any patent, copy right or trademark and shall at all times indemnify LPSC against all claims which may be made in respect of the items for infringement of any right protected by patent registration of design or trade mark and shall take all risk of accidents or damage which may cause a failure of the supply from whatsoever cause arising and the entire responsibility for the sufficiency of all the means used for executing the Purchase Order.

17. Format for technical & commercial Compliance Matrix

Sl no	Descriptions/Specifications (Technical &commercial Terms & conditions)	Compliance (Yes/ No)	If 'No' specify deviations explicitly	Remarks
1	Vendor should have previous experience of having successfully completed similar systems for Measurements, data acquisition and control of checkout system , in any establishments of Govt. / PSU or any other major private industries during last			

	8 years, ending on last day of month previous to the one in which applications are invited for this tender. The previous work experience should satisfy **either one** of the following criteria. i. One similar completed work costing not less than 180 lakhs. ii. Two similar completed works costing not less than 100 lakhs each. iii. Three similar completed works costing not less than 80 lakhs each iv. Details regarding the proof of experience of the vendor (copy of purchase order and installation & commissioning certificate from end user) shall be provided along with the quotations.			
2	Vendor should supply all the equipments / materials which are under the scope of supply of the vendor with the specification mentioned in Annexure 2. A specification compliance matrix with make, model and datasheet of the equipments shall be provided along with the quote for all standard electronic items and cables. In this compliance matrix , numerical values of specifications shall be provided in addition to yes/no.			
3	Minimum1-year warranty shall be there for the total system (except for the items supplied by LPSC)from the date of commissioning and acceptance by LPSC.			
4	Vendor should provide detailed engineering drawing of the wiring scheme, mounting of equipments after finalizing the equipments and items.			
5	Vendor shall deploy a person competent enough to address any technical issues during the operation of the facility at LPSC, for 3 months after commissioning of the facility.			
6	Support shall be provided for modifying application software for a period of 1 year after the commissioning of the system without any extra cost.			
7	In addition to the details of checkout work mentioned in technical aspects, vendor shall execute minor works and supply additional equipments/ materials required for the completion of the work, if needed, with prior approval from LPSC. Payment shall be done for actual work/ material supplied against the submission of the bill			
8	Vendor shall have to carryout necessary functional check like continuity, isolation and integrity check of end to end wiring, voltage simulation tests,			

	calibration of channels etc. as part of the commissioning of the entire system. Vendor shall have to provide necessary validation certificate/ report for each channel.			
9	The technicians who are doing the wiring and installation work should have atleast ITI qualification in the relevant field with minimum 1 year of experience and the engineers must have software experience (min 1 year) with proficiency certificate.			
10	Vendor shall bring tools like multimeters, crimping tools, screw drivers, spanners, label printers, Checkout rack fixing tools etc. for the completion of the work.			
11	The staff of the vendor shall take all safety precautions as per the safety standards while doing the wiring, installation and commissioning activities.			
12	Vendor will be responsible for the damage (if happened)of the items and equipment during the installation and commissioning phase of instrumentation systems.			

18. Format for Price bid

Vendor shall have to submit the unit price / cost and total price / cost of each to be Material supplied and Instrumentation Work. Quoted price/ cost shall be all inclusive of taxes, levies, duties etc. Cost format of Checkout Work to be done by the vendor refer **Annexure 5.**

19. Instruction to the Bidder / Vendor

This is a two-part public tender. The bidder / vendor shall submit their bid on 2-part basis.
  Part-1: Technical and Commercial Aspects
  Part-2: Price Details
The price quotation submitted by those parties who satisfy the technical & commercial requirement only shall be opened subsequently and selected. The vendor will be disqualified if they reveal the price in technical & commercial aspects (Part-1).
The vendor shall submit the technical & commercial quotation / compliance statement as per section 17.
Bidders have to submit quotation through EGPS only, other modes cannot be accepted.