

# Power Shuttle Transmission Test Rig



## About us:

Neometrix Defence Celebrating 20 Years of Excellence! For the past two decades, Neometrix Defence has maintained its position as a premier provider of advanced test benches and rigs.

Our accreditation by the Directorate General of Aeronautical Quality Assurance, India (DGAQA) and Defence Research & Development Organization, India (DRDO) underscores our commitment to upholding the highest international defence industry standards.

Counting the Indian Air Force/Army/Navy, Ministry of Defence, Hindustan Aeronautical Limited, and DRDO among our esteemed clientele, we are recognized for delivering state-of-the-art solutions and unwavering performance reliability.

## Strengths & Capabilities:

Neometrix Defence is a powerhouse of engineering brilliance, proudly serving every Indian Air Force station and partnering with the Indian Army, Navy, Railways, BARC, NPCIL, and ISRO. With a team of over 100 elite engineers and visionary founders from IIT Kanpur and IIT Delhi, we harness cutting-edge technology to set the gold standard in mechanical engineering.

## We Don't Just Meet Industry Demands – We Define Them!



- We have established our presence in all Air Force stations across India. With the Indian Air Force as our leading customer, we are dedicated to upholding the highest standards of excellence in the aerospace industry.
- Our extensive clientele extends beyond the defence industry, including projects with the Indian Army, Navy, Railways, BARC, NPCIL, ISRO, and more. In essence, we excel in all aspects of mechanical engineering!
- Our team comprises over 100 graduate engineers, supported by a cutting-edge manufacturing site equipped with state-of-the-art machinery, enabling us to meet the highest Engineering standards.
- The founders of our company are distinguished graduates from IIT Kanpur and IIT Delhi, bringing extensive expertise and a wealth of engineering knowledge to Neometrix Defence.

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## Introduction:

The ARJUN NOVO Power Shuttle Transmission Test Rig represents the pinnacle of automated hydraulic testing technology, purpose-built to validate every facet of Power Shuttle Clutch (PST) performance under conditions that mirror real-world tractor operation. At its core, the system leverages a closed-loop hydraulic circuit—powered by a precision 3.7 kW variable-frequency drive (VFD) and a 22.5 cc/rev gear pump—to reproduce the complete gamut of field stresses. From sub-ambient “cold start” scenarios (simulating pre-dawn startup at 5 °C) to sustained high-pressure cycling (up to 100 bar under hot-loop conditions), every forward, neutral, and reverse shift is executed with microsecond-level timing accuracy.

With advanced sub-millisecond response tracking, the rig not only monitors clutch engagement speed but also characterizes spool modulation curves down to 0.1 Hz resolution. This granularity uncovers even the smallest seal wear, spool misalignment, or internal leakage before they propagate into costly in-service failures. The inclusion of temperature-controlled hydraulic circuits further allows OEMs to assess performance at both 5 °C and 60 °C, ensuring reliable operation across the full agricultural operating range.

Designed for versatility, ARJUN NOVO’s modular fixture plate accommodates PST housings ranging from 50 mm to 200 mm bore, with quick-release hydraulic and electrical couplings enabling tool-less changeover in under five minutes. An intuitive touchscreen HMI guides technicians through automated setup wizards, calibration routines, and multi-step test sequences—minimizing training time and operator variability.

Despite its robust capabilities, the rig’s compact 2 m × 1.5 m footprint and 500 kg skid-mount design allow seamless integration into crowded production floors, specialized service workshops, or R&D laboratories. Comprehensive safety interlocks — including dual-channel emergency stops, over-temperature shutdowns, and pneumatic interlocks — ensure compliance with ISO 13849-1 Cat. 3 and IEC 60204-1, safeguarding personnel and equipment alike. By detecting latent defects early, streamlining test workflows, and standardizing quality metrics, ARJUN NOVO elevates end-of-line validation to a strategic advantage for agricultural OEMs and service providers.



## Purpose & Applications:

### 2.1 Production Validation

In high-volume manufacturing environments, consistency is paramount. The ARJUN NOVO rig integrates seamlessly into OEM assembly lines to deliver fully automated, barcode-driven pass/fail testing of every PST unit. As each clutch assembly arrives, its unique serial code is scanned and linked to a bespoke test recipe stored in the SQL database. The rig then executes a precisely controlled sequence of forward, neutral, and reverse shifts—applying the exact flow-rate, pressure ramp, and dwell-time parameters specified by the OEM. Real-time statistical process control (SPC) charts are overlaid on the HMI, allowing engineers to monitor key metrics (e.g., peak shift pressure, response latency, and internal leakage rates) across batches. Should any parameter drift beyond predefined control limits, the system flags the batch, generates a corrective-action alert, and automatically tags suspect units for rework—ensuring that only conforming PSTs proceed to assembly.

### 2.2 After-Sales Diagnostics

Beyond the factory floor, ARJUN NOVO becomes an indispensable asset for service centers and field workshops. When a PTO clutch is returned for rebuild or repair, the technician mounts the unit on the same hydraulic fixture used in production. The rig runs a diagnostic protocol that mirrors the OEM's original validation routine, comparing the remanufactured clutch's modulation curves and spool-position response times against the golden reference profile. Any deviations—such as slowed spool recovery, increased hysteresis, or micro-leakage—are logged in the service report. This data-driven approach eliminates guesswork, providing clear, quantifiable evidence of repair quality, reducing repeat returns, and strengthening end-user confidence in workshop workmanship.

### 2.3 R&D Prototyping & Testing

For design and development teams, ARJUN NOVO offers a high-fidelity testbed for next-generation PST innovations. Engineers can program extended endurance cycles—tens of thousands of shifts at varying pressures—to generate life-cycle durability curves. Embedded thermal control loops allow rapid temperature transitions between 5 °C and 60 °C, revealing potential cold-start binding or hot-loop fading in prototypes. By adjusting spool geometry parameters, spring preloads, and valve orifice sizes within the test recipe, teams can conduct Design of Experiments (DoE) studies directly on the rig. The instant feedback on fatigue cracking, seal wear, and hysteresis drift accelerates iterative improvement, slashing development timelines and material costs associated with physical “build-and-break” trial runs.

## Key Features:

### Micro-Step VFD Control

- 3.7 kW VFD with 0.1 Hz resolution for ultra-fine flow regulation and capture of hysteresis/dead-zone behavior.

### Triple-Channel Monitoring

- Independent turbine flow meters and  $\pm 0.5$  % FS pressure transducers for clutch actuation, lubrication, and main-circuit analysis.

### Automated Sequencing & Fault Injection

- Preloaded and customizable recipes: dwell-time control, pressure-ramp profiles, back-pressure compensation, and programmable fault scenarios.

### Integrated Data Suite

- Barcode part tracking, encrypted SQL database, and multi-format report export (PDF certificates, CSV logs, XML for ERP/MES).

### Comprehensive Safety Architecture

- Dual-channel emergency stops, hydraulic and thermal interlocks, compliant with ISO 13849-1 Cat. 3 and IEC 60204-1.

### Modular Fixture Plate

- Quick-release clamping for PST housings from 50 mm to 200 mm bore—tool-less changeover in under five minutes.

### Temperature-Controlled Circuit

- Integrated heat exchanger allows testing at 5 °C and 60 °C to simulate cold-start and high-temperature operating conditions.

### Remote Monitoring & Alerts

- OPC UA interface for SCADA integration, with real-time dashboards and configurable e-mail/SMS alarms for out-of-tolerance events.

### User-Role Management

- Three access levels (Operator, Engineer, Administrator) with password-protected profiles and audit-trail logging.

## Technical Specifications:

| Component            | Specification   |
|----------------------|---|
| Hydraulic Power Unit | <ul style="list-style-type: none"> <li>• Gear pump: 22.5 cc/rev, up to 30 L/min, 100 bar max</li> <li>• Drive motor: 3.7 kW, 3-phase induction, 415 VAC, 50 Hz</li> </ul>   |
| Control Electronics  | <ul style="list-style-type: none"> <li>• PLC: 16 ms scan time, 24 VDC safety I/O</li> <li>• VFD: torque-control mode, OPC UA communications</li> </ul>  |
| Instrumentation      | <ul style="list-style-type: none"> <li>• Flow meters: <math>\pm 1</math> % FS</li> <li>• Pressure transducers: <math>\pm 0.5</math> % FS</li> <li>• Temperature probes: <math>-20</math> °C to <math>+80</math> °C</li> </ul> |
| Software             | <ul style="list-style-type: none"> <li>• HMI: Windows 10/11, .NET 5 framework</li> <li>• Database: SQL Server 2019</li> <li>• Integration: OPC UA server, API for SCADA/MES</li> </ul>  |
| Physical & Utilities | <ul style="list-style-type: none"> <li>• Footprint: 2 m <math>\times</math> 1.5 m <math>\times</math> 2.5 m; weight ~500 kg</li> <li>• Power draw: 5 kW peak; optional pneumatic: 6 bar @ 50 LPM</li> </ul>                   |



## System Components & Architecture:

### Hydraulic Skid:

- 3.7 kW motor and 22.5 cc/rev gear pump deliver up to 30 L/min at 100 bar; integrated 100 L reservoir with duplex 10  $\mu\text{m}$ →6  $\mu\text{m}$  filtration, pilot-operated relief valves, and ISO-A quick-disconnects for rapid hose changes.

### Directional Valve Module:

- Proportional four-way valve with 0–10 V control and 0.01 mm LVDT feedback; pressure-compensated orifice ensures constant flow under varying supply pressures.

### Data Acquisition Unit:

- Four-channel, 16-bit A/D sampling at 1 kHz; onboard microcontroller for noise filtering, timestamping, and EtherCAT communication to the PLC.

### Control Cabinet:

- Industrial PLC with hot-swap I/O and safety PLC; AC VFD with torque-limit, current-vector control, and EMC filter; 15" IP65 touchscreen HMI for recipe management, live diagnostics, and manual override.

### Safety & Interlocks:

- Hardwired E-stops at front, rear, and control panel; pneumatic pressure-sensing locks; over-temperature shutdown at 70 °C; safety PLC executes a full safe-halt in under 100 ms.

### Modular Fixture Plate:

- Tool-less, quick-release clamps accommodate PST housings from 50 mm–200 mm bore, reducing changeover time to under five minutes.

### Communications & Integration:

- OPC UA server and Ethernet port for SCADA/MES integration; USB and WLAN options for data export and remote firmware updates.

### Maintenance Access:

- Front-panel doors provide easy access to filters, relief cartridges, and electrical terminals; color-coded hoses and connectors simplify routine checks.

## Installation & Maintenance

### Site Requirements:

- Electrical: 415 VAC  $\pm$  10 %, 50 Hz; 20 A RCD-protected circuit
- Pneumatics (optional): 6 bar dry, filtered air @ 50 LPM
- Environment: 10–40 °C; 20–80 % RH; indoor, dust-free
- Foundation: Level concrete pad  $\geq$  600 kg, with anchor-bolt template

### Maintenance Schedule:

- Daily: Inspect hoses, fittings, filter indicators; verify oil level
- Monthly: Lubricate pump bearings; test emergency stops; review alarm logs
- Quarterly: Update PLC/VFD firmware; run closed-loop control diagnostics
- Annual: Flush and replace hydraulic oil and filters; full leak test; recalibrate all sensors

## Operational Workflow

### Setup & Calibration

- Connect utilities, level rig, perform zero-offset calibration via HMI wizard

### Recipe Load

- Scan part barcode, select or upload custom test profile (shift sequences, dwell times, temperature set-points)

### Automated Test Execution

- PLC orchestrates forward, neutral, reverse cycles; live graphs displayed on HMI

### Data Capture & Analysis

- High-resolution logging, instant comparison to “golden” reference curves, deviation alerts

### Reporting

- Auto-generate PDF certificate, CSV raw data, and XML export for ERP/MES ingestion

### Reset & Purge

- Hydraulic fluid purge, valve neutralization, system ready-state for next cycle

## Safety, Compliance & Quality:

- ISO 13849-1 Cat. 3: Dual-channel architecture, validated MTTFd
- IEC 60204-1: Industrial control panel design with protective earth and UL-certified components
- CE & EMC Directive: Emissions-tested; noise < 75 dBA at 1 m
- Traceability: Serialized parts, QA/QC logs with digital signatures, radiographically inspected welds
- Warranty & Support: 12-month standard warranty; optional AMC up to 5 years with next-business-day on-site support in Asia & UK

