PiEST Systems
PIEST SYSTEMS (OPC) PRIVATE LIMITED

HIL Testing Engineer Training Syllabus

6-Month – Expert HIL Testing & Automation with AI Course

Module 1: V Control Systems

- ECU architecture overview
- Powertrain, Body, ADAS & EV ECUs
- Sensor → ECU → Actuator signal flow
- Closed-loop control systems
- Real-time ECU behavior
- Common ECU failure reasons
- Safety-critical automotive systems

Module 2: Automotive V-Model

- Development lifecycle: Requirements → Design → Testing
- Verification vs Validation
- SIL, MIL & HIL concepts
- Why OEMs depend on HIL testing

Module 3: Control & Plant Modeling

- Plant modeling fundamentals
- Sensor physics modeling
- Actuator behavior models
- Sampling time & delays
- Stability concepts

Module 4: Vehicle Network Architecture

- CAN, LIN, FlexRay, Ethernet
- Domain controllers
- Gateways & network segmentation

Module 5: Automotive Protocols (End-to-End)

- CAN, CAN-FD, CAN-XL
- ISO-TP
- UDS (Diagnostics)
- LIN protocol

- FlexRay
- Automotive Ethernet
- TCP / UDP basics
- DoIP
- XCP / QCP

Module 6: AUTOSAR & ISO-26262

- AUTOSAR Classic vs Adaptive
- Application, RTE, BSW & MCAL layers
- Signal-to-CAN mapping
- ISO-26262 functional safety
- ASIL A–D
- Fail-safe & limp-home strategies

Module 7: V-Style HIL System

- HIL bench architecture
- Real-time target system
- I/O racks
- Signal conditioning
- Load simulation
- Fault injection techniques

Module 8: V & NI HIL Hardware

- V I/O cards
- NI PXI real-time systems
- Wiring best practices
- Scaling & calibration
- Protection mechanisms

Module 9: Sensor Simulation

- Speed sensors
- Temperature sensors
- Pressure sensors
- Pedals

- Voltage & resistance simulation
- PWM signals
- Noise injection

Module 10: Actuator & Load Simulation

- Motors
- Relays
- Lamps
- Short-to-GND
- Short-to-BATT
- Open-circuit faults

Module 11: HIL Operation

- Power-up sequence
- Model loading
- Run & stop control
- Emergency handling
- Recovery procedures

Module 12: TESAF Test Execution

- Signal control
- Logging & monitoring
- Fault execution
- Graph analysis
- Pass/Fail criteria
- OEM-style test reports

Module 13: C, Python

- C programming for ECU logic
- Python for CAN & UDS automation
- Python scripting (TESAF testing)

Module 14: AI for Automotive Validation

- AI-based test case generation
- AI log analysis

- AI-driven CAN & UDS scripting
- Regression test optimization

Project 1: ECU Communication & Diagnostics

- CAN & CAN-FD communication
- UDS diagnostics
- DID reading
- ECU flashing
- DoIP (if supported)

Project 2: HIL-Based Functional Validation

- Sensor simulation
- Actuator simulation
- Fault injection
- Safety response validation
- ASIL compliance checks

Project 3: Full ECU System Validation

Student selects one ECU:

- Blind Spot Monitoring
- Body Control Module (BCM)
- Instrument Cluster
- EV Controller
- Battery Management System (BMS)
- ADAS ECU

Activities:

- Connect real ECU
- Run HIL tests
- Automate test cases
- Inject faults
- Validate safety behavior
- Generate OEM-style validation report

3-Month – Professional HIL Testing Course

Module 1 – Automotive Control Systems

- Vehicle control architecture
- What an ECU actually does
- Sensor → ECU → Actuator loop
- Closed-loop control
- Engine, Body, EV & ADAS ECUs
- Why ECUs fail
- Software vs hardware failures
- Safety-critical behavior
- Automotive real-time systems
- Recalls caused by software bugs

Module 2 – Automotive V-Model & HIL Role

- What is V-model
- Requirement → Test traceability
- Why 60% of cost is testing
- SIL, MIL, HIL difference
- Why OEMs don't test on real cars
- Where V HIL fits
- Validation vs Verification
- Regression testing
- Software release cycles
- Sign-off flow

Module 3 – V-Style HIL System

- What is a HIL bench
- V NI LabVIEW / TESAF
- Real-time target
- I/O rack
- ECU harness
- Signal conditioning

- Safety relays
- Fault injection
- Load simulation
- Why V is used by OEMs

Module 4 – Control & Plant Modeling

- What is a plant model
- What ECU expects
- Real-time simulation
- Sampling rate
- Sensor physics
- Actuator behavior
- Continuous vs discrete
- Stability
- Time delay
- Why modeling matters
-

Module 5 – V HIL I/O Cards

(Theory mapped to real OEM systems)

- Analog input cards
- Analog output cards
- Digital I/O
- PWM cards
- Frequency I/O
- Relay cards
- Fault insertion cards
- Load cards
- Power cards
- Safety cards

Module 6 – NI HIL Hardware

- NI PXI system
- Real-time controller
- I/O modules
- Signal wiring
- Grounding
- Scaling
- Calibration
- Protection
- Hardware diagnostics
- LabVIEW hardware interface

Module 7 – Sensor Simulation

(Using NI LabVIEW & TESAF)

- Speed sensor
- Temperature
- Pressure
- Pedal
- Switches
- Voltage simulation
- Resistance simulation
- PWM generation
- Noise injection
- Real sensor emulation

Module 8 – Actuator & Load Simulation

- Motor loads
- Lamp loads
- Solenoids
- Relays
- Short to ground
- Short to battery

- Open circuit
- Over-current
- Feedback
- Protection

Module 9 – HIL Operation

- Starting NI HIL
- Loading plant models
- Connecting ECU
- Power-up
- Safety checks
- Real-time run
- Stop
- Emergency
- Reset
- Bench recovery

Module 10 – TESAF Test Execution

- Signal visualization
- Sensor control
- Actuator monitoring
- Data logging
- Fault triggering
- Test sequencing
- Result display
- Graphs
- Pass/Fail
- Export reports

Module 11 – Fault Injection & Safety Validation

- Sensor failure
- Actuator failure
- Power failure
- Stuck signal
- Out-of-range
- Timing failure
- Recovery
- Limp-home
- Safety response
- OEM validation

Module 12 – Data Analysis

- Logs
- Waveforms
- Expected vs actual
- Timing
- Delays
- Spikes
- Root cause
- Bug identification
- Evidence collection
- Test reports

Final OEM-Style Project

Students will:

- Use **NI LabVIEW HIL**
- Simulate **5 sensors**
- Run **ECU on HIL**
- Use **TESAF to monitor & inject faults**
- Validate safety behavior
- Produce OEM-style report

1-Month – Foundation HIL Testing Course

Module 1 – Automotive Systems & ECUs (Basics)

- Introduction to automotive embedded systems
- Vehicle domains & ECU overview
- ECU components & communication networks
- Signal flow between ECUs & sensors
- Vehicle architecture: Domain vs Zonal

Module 2 – Automotive Communication Protocols (Overview)

- CAN, LIN, FlexRay, Ethernet basics
- CAN frame structure
- Capturing/analyzing CAN signals (PCAN/TESAF)
- Basics of UDS & diagnostics

Module 3 – Fundamentals of HIL Testing

- What is HIL testing & why it's used
- Difference between MIL, SIL, HIL
- Components of a HIL system
- Real-time simulation basics
- ECU-to-HIL connectivity

Module 4 – Practical Hands-on & Mini Project

- Connect ECU → CAN analyzer & observe signals
- Configure a basic HIL loop (TESAF/PCAN)
- Create signal simulation & record test data
- **Mini Project:** Vehicle speed sensor simulation

Module 5 – Career Preparation (Intro)

- Roles in Automotive Testing
- Tools used by OEM/Tier-1
- HIL testing job opportunities
- Resume tips for freshers