



**PALLADIUM  
DYNAMICS**

# PLC & SCADA INTEGRATION GUIDE

for Indian Manufacturers

## ABOUT PALLADIUM DYNAMICS

Palladium Dynamics is a trusted provider of industrial automation and safety solutions serving manufacturing industries across India. We deliver end-to-end PLC, SCADA, DCS, and IIoT integration services with a commitment to reliability, safety, and operational excellence.

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Senior Automation Consultant · 30+ Years · DCS · PLC · SCADA · IIoT · Automotive · Pharma · Steel · FMCG

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**FOREWORD**

# From the Desk of a Veteran Automation Engineer

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I started my career in 1993, wiring relay panels at a textile mill in Coimbatore. The plant manager handed me a dog-eared Siemens S5 manual and said, 'Figure it out.' I did. Over the next three decades I commissioned automation systems across automotive assembly lines in Pune, pharmaceutical clean-rooms in Hyderabad, steel melt shops in Bhilai, and FMCG packaging halls in Manesar. I have seen every brand promise made - and often broken - by vendors. I have crawled inside cable trays at midnight troubleshooting ground faults, argued with MNCs over P&ID; deviations, and trained fresh engineers who had never touched a real PLC before.

This whitepaper is what I wish someone had handed me at the start. It is not written to sell you a product. It is written to save you time, money, and the kind of 3 AM phone calls that age a man prematurely. Every recommendation here is grounded in field experience, not datasheet fantasy.

Indian manufacturing is at an inflection point. The PLI scheme, 'China+1' supply-chain shifts, and the government's push for smart manufacturing have created both opportunity and pressure. Plants that automate intelligently will win. Plants that automate recklessly - buying the wrong platform, skipping documentation, ignoring cybersecurity - will pay for those decisions for fifteen years.

Read this guide critically. Argue with it. The best engineers I have worked with never accepted anything at face value, including advice from veterans like me.

*"Automation is not about replacing people. It is about amplifying what people can do."*

## CHAPTER 01

# The Indian Manufacturing Landscape & Automation Imperatives

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## 1.1 Where Indian Plants Stand Today

Walk into a hundred Indian manufacturing plants and you will find a remarkable spectrum: a world-class automated line installed in 2022 sitting fifty metres from a manual operation unchanged since 1987. This coexistence is not laziness - it is the reality of phased investment, complex ownership structures, and the genuine challenge of justifying automation ROI when labour costs remain relatively low in certain segments.

Despite this, the automation gap is closing fast. According to data from the International Federation of Robotics, India's robot density in manufacturing crossed 50 units per 10,000 employees in 2023, up from just 4 in 2012. The automotive sector leads with density comparable to mid-tier European nations. Pharmaceuticals, food processing, and electronics are catching up rapidly.

What I consistently observe is that most Indian plants are not under-automated at the equipment level - they are under-integrated at the system level. PLCs exist. HMIs exist. Even historians exist in some cases. But they do not talk to each other coherently, the data collected is rarely analysed, and the alarm systems are so poorly configured that operators silence them reflexively.

## 1.2 PLI Scheme, Make in India & Export Competitiveness

The Production Linked Incentive (PLI) scheme has injected significant capital into specialty chemicals, semiconductors, pharmaceuticals, and advanced manufacturing. This capital is flowing into automation and digitalisation. Plants competing for export markets - particularly those supplying European and American OEMs - face increasingly strict quality, traceability, and regulatory requirements that manual processes simply cannot meet.

Global customers now routinely audit not just product quality but manufacturing process capability. They want to see OEE data, SPC charts, batch records, and deviation management systems. The market is no longer asking whether to automate; it is asking how fast and how intelligently.

## 1.3 Common Pitfalls Seen on the Shop Floor

- **Vendor lock-in without leverage:** Buying a proprietary SCADA and then discovering the vendor's local support team consists of two people, neither of whom understands your process.
- **Skipping the functional specification:** Going straight from concept to purchase order without a proper FDS/FRS. The scope creep costs three times the spec effort that was avoided.
- **Commissioning as a sprint, not a process:** Rushing SAT to meet a production deadline, then spending six months firefighting issues that a proper protocol would have caught.
- **No version control for PLC programs:** I have visited plants where the running PLC program does not match any document. Nobody knows what changed, or when, or why.
- **Ignoring cybersecurity until after an incident:** OT networks connected to corporate IT with no segmentation, running Windows XP SCADA servers.
- **Training as an afterthought:** Buying a sophisticated DCS and leaving operators with a two-day familiarisation course. The system gets used at 30% of its capability.

CHAPTER 02

# PLC Fundamentals & Programming Best Practices

## 2.1 Choosing the Right PLC Architecture

The first question is not which brand - it is what architecture. A standalone PLC, a modular rack system, a distributed I/O setup, or a fully distributed control system each has its place. Getting this wrong sets up a decade of pain.

For small machines and standalone cells (under 500 I/O points), a compact PLC with integrated I/O is typically most economical. Allen-Bradley's CompactLogix and Siemens' S7-1200/1500 compact models are mature choices. For large plant-wide systems, distributed I/O with a central processor provides better maintainability and fault isolation. The cardinal rule: size for tomorrow, not today.

## 2.2 IEC 61131-3 Programming Languages – When to Use What

Language	Best Used For	Indian Industry Applicability
Ladder Diagram (LD)	Discrete logic, motor control, interlock sequences	Universal - electricians and instrument engineers read it. Ideal for maintenance-first environments.
Structured Text (ST)	Complex calculations, PID algorithms, data processing, string handling	Growing acceptance. Essential for recipe management and advanced control.
Function Block Diagram (FBD)	Analog control loops, process control, signal conditioning	Common in process industries (pharma, chemicals). Intuitive for instrument engineers.
Sequential Function Chart (SFC)	Batch processes, multi-step sequences, machine cycles	Underused in India but powerful for FMCG/pharma batch sequences. Self-documenting.

## 2.3 Structured Programming, Modularity & Version Control

Every PLC program not structured from day one eventually becomes what engineers call 'spaghetti code' - an unmaintainable mess of cross-references, undocumented rungs, and logic nobody dares touch. Use Program Organisation Units (POUs). Create function blocks for every repeating element: motors, valves, pumps, PID loops. A well-written motor FB handles start/stop, fault, running feedback, local/remote mode, and simulation mode. Write it once, test it thoroughly, and instantiate it wherever needed.

**Best Practice**

Adopt a naming convention on day one and enforce it ruthlessly. Tag names should be self-describing: 'MTR\_FD\_001\_RUN' is better than 'Motor1'. Version control every PLC program. Every change should have a timestamp, an engineer's name, and a reason.

## 2.4 Safety Integrity Levels (SIL) & Functional Safety

IEC 61508 and IEC 61511 govern functional safety in process industries. SIL-rated Safety Instrumented Systems (SIS) must be separate from Basic Process Control Systems (BPCS) - this is not a recommendation, it is a fundamental architectural requirement. I have visited chemical plants where the same PLC performing regulatory control was also implementing safety shutdowns. In many cases this is a regulatory violation under PESO and OISD guidelines.

For Indian plants, the minimum expectations are: conduct a HAZOP/LOPA study to determine required SIL levels, specify SIL-certified SIS hardware (Siemens S7-300F/1500F, Allen-Bradley GuardLogix, Hima, or Triconex), and ensure independent proof testing schedules. Plants in petroleum, petrochemical, and bulk chemical sectors must

align with OISD-GDN-189.

## CHAPTER 03

# SCADA Architecture for Modern Plants

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## 3.1 Centralised vs Distributed SCADA

For single-site plants up to moderate size, centralised SCADA with redundant servers remains the most cost-effective and maintainable architecture. For multi-site operations or very large plants with unreliable WAN links, distributed SCADA with local site servers reporting to a central system makes more sense. What has changed dramatically in the last decade is the shift toward server virtualisation - running SCADA servers as virtual machines on enterprise-grade hypervisors offers snapshot-based backup and recovery that physical servers cannot match.

## 3.2 Redundancy, High-Availability & Disaster Recovery

Redundancy is not the same as high availability. Many plants buy redundant SCADA servers and then discover that failover takes six minutes because nobody tested it. True high availability requires hot standby with sub-second failover, redundant network paths, redundant communication interfaces to field devices, and regular tested failover drills.

Minimum redundancy architecture: dual SCADA servers in hot-standby, dual network switches with redundant topology, dual fibre paths between control room and field junction boxes, and UPS with minimum 30 minutes autonomy. Diesel generator backup with auto-start is mandatory for continuous process plants.

## 3.3 Industrial Communication Protocols

- **PROFIBUS DP:** Still dominant in Siemens-based discrete manufacturing. Robust, well-understood, but legacy. New installations should consider PROFINET.
- **PROFINET:** Siemens' Ethernet-based successor. Deterministic, supports IRT for motion control. Specify for all new Siemens-based systems.
  - **EtherNet/IP:** Allen-Bradley's industrial Ethernet standard. CIP-based, excellent ecosystem, strong in automotive and material handling.
- **Modbus TCP:** Old, everywhere, not going away. Useful for interfacing legacy instruments and third-party devices.
- **OPC UA:** The future of plant-to-enterprise integration. Vendor-neutral, secure, supports complex data models. Specify OPC UA servers on all new SCADA installations.
- **HART over 4-20mA:** Still the workaround for instrument diagnostics. Use a HART multiplexer to pull diagnostics without replacing wiring.

## 3.4 Historian & Data Management

A process historian is arguably the most valuable asset an automated plant has, yet it is routinely under-specified and under-utilised. AVEVA PI dominates in Indian refining, petrochemical, and power sectors. Wonderware Historian and Ignition's historian are strong alternatives. Whatever you choose: tag everything meaningful, set appropriate compression settings (do not compress away transients), and build a data governance process.

## CHAPTER 04

# HMI Design – The Human Factor

## 4.1 ISA-101 HMI Design Philosophy

Most HMIs in Indian plants were designed by engineers who thought good HMI design meant colourful mimics with animated pumps, flashing lights, and gradient-filled tanks. This is wrong. Cognitive science research - formalised in the ISA-101 standard - shows that cluttered, high-colour HMIs impair operator situational awareness and slow response times during abnormal situations.

ISA-101 uses a grey background palette with colour used exclusively to communicate state. Normal operation should be visually quiet. Deviations and alarms should be immediately visually prominent. Use high-chroma colours (red, yellow) for alarms only - never for branding or decoration. Structure your HMI in levels: Level 1 plant overview, Level 2 process area views, Level 3 equipment detail, Level 4 trends and diagnostics.

**■ Design Principle**

If your HMI looks boring during normal operation, you have probably designed it correctly. Minimal cognitive load during normal running; maximum visual attention drawn immediately when something goes wrong.

## 4.2 Alarm Management (ISA-18.2)

Bad alarm management kills. The Texas City refinery disaster, the Deepwater Horizon incident, and numerous smaller industrial accidents have alarm flooding as a contributing factor. ISA-18.2 is the baseline for every Indian plant's alarm philosophy. A well-designed system should present no more than one alarm per ten minutes during normal operation, and no more than ten alarms in the first ten minutes of any abnormal situation. Most Indian plants I have audited run at five to twenty times these rates.

- **Alarm rationalisation:** Every alarm must have a defined cause, consequence, and corrective action.
- **Priority assignment:** Use a three-tier system maximum (Critical, High, Low). Five or more priority levels are treated identically by operators.
- **Nuisance alarm elimination:** Any alarm activating more than once per day without operator action required is a nuisance alarm. Fix or eliminate it.
- **Suppression management:** Shelved alarms must be tracked and time-limited. An alarm shelved indefinitely is a defect.

## 4.3 Mobile & Remote HMI Considerations

Modern SCADA platforms support HTML5-based thin clients that work on tablets and smartphones. This is useful for supervisory visibility but must be implemented with appropriate security controls.

**■ Security Warning**

Never expose SCADA interfaces directly to the internet, even behind a password. Use VPN with multi-factor authentication, or a properly configured DMZ with a jump server. I have seen Indian plants with SCADA servers directly port-forwarded on public IP addresses. This is an invitation to ransomware.

CHAPTER 05

# Siemens vs Allen-Bradley: A Candid Comparison

## 5.1 Platform Overview & Indian Market Reality

I have programmed both platforms extensively across three decades and have strong opinions - including why the answer is almost always 'it depends.' Siemens has historically dominated the Indian market outside of automotive. Their installed base in pharmaceuticals, textiles, cement, steel, food & beverage, and infrastructure is enormous. Allen-Bradley leads in automotive assembly, particularly in plants with North American multinational parentage. Both are excellent platforms. Neither is categorically superior.

## 5.2 Technical Deep-Dive Comparison

Parameter	Siemens S7-1500 / TIA Portal	Allen-Bradley ControlLogix / Studio 5000
Programming Environment	TIA Portal V18 - unified engineering framework. Steep learning curve, powerful once mastered.	Studio 5000 - mature, intuitive. FactoryTalk suite for SCADA/HMI. Separate tools per product.
Scan Time	S7-1516 achieves <1ms cycle times. OB structure gives fine control.	ControlLogix L8x achieves sub-millisecond for motion. Task-based multitasking.
Motion Control	SIMOTION/S120 integration. Strong for coordinated multi-axis applications.	Kinetix servo family with CIP Motion. Strong North American automotive preference.
Network	PROFINET native. Strong PROFIBUS legacy. OPC UA server integrated.	EtherNet/IP native. Strong CIP ecosystem. DeviceNet legacy support.
Safety (SIL 3)	S7-1500F / ET 200SP F modules. PROFIsafe protocol. Integrated in TIA Portal.	GuardLogix platform. CIP Safety protocol. Excellent Studio 5000 integration.
India Support	Excellent. Wide distributor network, local repair centres, training academies.	Good in metros and automotive hubs. Tier-2 city coverage still improving.
Total Cost	Hardware 10–20% lower than equivalent AB. TIA Portal license significant.	Premium priced. FactoryTalk licensing adds up. Studio 5000 productivity offsets some cost.

## 5.3 Total Cost of Ownership for Indian Plants

Hardware cost is the number every procurement team focuses on. It is also the least important cost over a ten-year plant life. Training, spares holding, migration costs, and productivity losses during downtime dwarf the initial hardware differential. When I help clients with platform decisions, I build a 10-year TCO model that includes: initial hardware and software, engineering time, training, annual spares inventory, expected failure rates and MTTR, upgrade costs at year five, and vendor support contracts.

## 5.4 Decision Framework & Recommendation Matrix

Scenario	Recommended Platform	Rationale
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Pharma / Chemicals / Cement	Siemens S7-1500	Dominant installed base. Easier to find trained engineers and spares in these sectors.
Automotive (MNC Parent)	Follow parent standard	Global spares, support alignment, and cross-site standardisation outweigh local preference.
Discrete Mfg / SME	Siemens S7-1200/1500	Lower cost, wide integrator ecosystem in India, strong training availability.
High-Speed Packaging	Evaluate motion requirements	Both platforms excellent. Decision turns on OEM machine platform and servo ecosystem.
Greenfield + IIoT Focus	Siemens TIA + MindSphere or AB + FactoryTalk	Both have mature cloud connectivity. Evaluate ecosystem fit and internal IT platform.

## CHAPTER 06

# Cybersecurity in OT Environments

## 6.1 The Threat Landscape Indian Plants Face

OT cybersecurity is the topic that makes plant managers uncomfortable because they know they have neglected it. The threat is real and growing. India has seen high-profile OT security incidents in utilities and critical infrastructure. Manufacturing plants are increasingly targeted - not because attackers want to understand your process, but because they want to encrypt your systems and hold your production line for ransom.

**■ Critical Risk**

Legacy SCADA systems running Windows XP or Windows 7 are a clear and present danger. 'We can't patch because the vendor says so' is not an acceptable risk position for a plant handling hazardous materials. Demand an upgrade path or implement compensating controls: strict network isolation and application whitelisting.

## 6.2 IEC 62443 Implementation Roadmap

- 1. Asset inventory (Month 1–2):** Document every device on your OT network - PLCs, HMIs, historians, switches, servers, engineering workstations.
- 2. Network segmentation (Month 2–4):** Separate OT and IT networks. Implement a DMZ with a data diode or historian-only connection between zones.
- 3. Access control (Month 3–5):** Role-based access control for all SCADA and engineering software. No shared accounts. All remote access through VPN with MFA.
- 4. Patch management (Ongoing):** Establish a tested, vendor-approved patching schedule. Test patches in a lab before production deployment.
- 5. Incident response plan (Month 4–6):** A written, rehearsed plan for when (not if) you have an OT security incident.
- 6. Periodic assessment (Annual):** Engage an independent OT security assessor annually.

## 6.3 Network Segmentation & DMZ Architecture

The Purdue Model (ISA-95/ISA-99) remains the most widely referenced reference architecture for OT network segmentation. At minimum, implement three zones: the field/control zone (PLCs, field devices), the operations zone (SCADA, historian, HMI servers), and the enterprise zone (ERP, business systems). Between each zone, a firewall with strict rule sets and default-deny policies. The historian sits in the DMZ - pulling data from the operations zone and pushing to the enterprise zone, never bidirectional.

**CHAPTER 07**

# IloT, Industry 4.0 & the Path Forward

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## 7.1 Brownfield Integration Strategies

Most Indian manufacturing is brownfield - existing plants with legacy equipment, mixed vendors, and incremental automation investments. The pragmatic brownfield path: start by extracting data that already exists but is not being used. Your PLCs are already generating process data; you just need a pathway to collect and analyse it. Protocol converters and edge gateways (Moxa, Advantech, Red Lion, HMS Networks) can connect legacy Modbus, PROFIBUS, and proprietary protocols to modern Ethernet/OPC UA infrastructures without replacing the underlying control system.

**■ Practical Tip**

Before any IloT project, audit your existing data quality. Sensors with drift errors, transmitters without calibration records, and PLC clocks years out of sync will poison any analytics initiative. Fix your data foundation before building analytics on top of it.

## 7.2 Edge Computing & MQTT / Sparkplug B

Edge computing - processing data at or near the machine - is essential for Indian plants where WAN bandwidth is a constraint and cloud latency is unacceptable for real-time decisions. Edge devices running lightweight analytics can detect equipment anomalies, calculate OEE, and aggregate data before forwarding summaries to enterprise systems. MQTT with the Sparkplug B payload specification has emerged as the dominant IloT protocol for plant-to-cloud and plant-to-enterprise data transport.

## 7.3 OPC UA – Backbone of Smart Manufacturing

OPC UA (Unified Architecture) is the most important protocol development in industrial automation in twenty years. It provides: vendor-neutral data exchange, built-in security (authentication, encryption, signing), rich information modelling, and publish-subscribe in addition to traditional client-server. Every major PLC vendor now offers OPC UA servers integrated into their hardware. Specify OPC UA connectivity in every new project. This is your architecture for the next decade.

## CHAPTER 08

# Project Execution, Commissioning & Training

## 8.1 FAT / SAT Protocols

Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) are where automation projects succeed or fail. A well-conducted FAT catches design errors before they become field problems. A poorly conducted FAT - rushed, with open items 'to be resolved on site' - simply defers problems to commissioning where they cost three to ten times more to fix.

FAT requirements: complete I/O checkout with simulated field signals, every control narrative sequence tested end-to-end, alarm and interlock verification against the Cause and Effect matrix, HMI functionality test, historian tag verification, and network communication verification. SAT adds: actual field device loop checks, control loop tuning with real process dynamics, and signed documentation from both vendor and plant operations team.

## 8.2 Documentation That Saves You at 2 AM

- **Functional Design Specification (FDS):** What the system does, in plain language and logic diagrams. The master reference for all design decisions.
- **Cause & Effect Matrix:** For every process input condition, what control system response is triggered.
- **I/O List:** Every hardware I/O point, tagged, described, scaled, and cross-referenced to the P&ID.;
- **Network Architecture Diagram:** Physical and logical network topology, IP addressing, VLAN assignments.
- **PLC Program Documentation:** Not just the program file - the narrative explanation of each program section with revision history.
- **Loop Tuning Records:** Commissioned PID parameters for every control loop, with justification.
- **Alarm Rationalisation Database:** Every alarm with cause, consequence, corrective action, and priority.
- **Spares List:** Recommended critical spares with part numbers, suppliers, and reorder quantities.

## 8.3 Building In-House Competence

The most common complaint five years after commissioning: 'We are completely dependent on the vendor for any change.' From day one, designate plant engineers who shadow the commissioning team. Require the vendor to conduct structured knowledge transfer sessions. Insist on programming access - you must have the ability to open, read, and modify your own PLC programs without a vendor's presence.

### ■ Investment Mindset

Treat automation training as infrastructure investment, not operational expense. Plants that invest INR 5–10 lakhs annually in training their automation teams recover that cost many times over in reduced downtime, faster troubleshooting, and the ability to implement improvements internally.

**CLOSING**

## Lessons From 30 Years on the Floor

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Automation is fundamentally about people. The best technical system in the world fails if the operators do not trust it, the maintenance team does not understand it, and management does not support it. Every technology decision should be filtered through: 'Will the people who operate and maintain this system for the next twenty years be able to understand and use it effectively?'

Simplicity is a discipline. The instinct of every engineer is to make things more sophisticated. Resist it. The most reliable plants run on clear, simple control philosophies executed with discipline. Complexity is where failures hide.

Documentation is a gift to your future self. Every undocumented decision, every change made without a record - you will pay for all of it at 2 AM during a production crisis, when the engineer who made the change has left the company.

The automation industry in India is genuinely exciting right now. The scale of manufacturing investment, the hunger for technology, and the quality of young engineers coming into the field give me real optimism. Automate with intent. Commission with patience. Document everything. Train your people. And always know your process before you try to automate it.

*"The plant will always be smarter than the engineer who thinks he has automated it completely."*

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*Palladium Dynamics · Trusted Provider of Industrial Automation & Safety Solutions · India · 2026*

*Standards referenced: IEC 61131-3, IEC 61508, IEC 61511, IEC 62443, ISA-18.2, ISA-101, ISA-95. Recommendations should be validated against current standards and site-specific requirements before implementation.*



# THANK YOU

for reading the **PLC & SCADA Integration Guide**

We hope this guide empowers your team to make smarter automation decisions, avoid costly mistakes, and build plants that will serve your business for decades.

Palladium Dynamics is here to support you at every step - from platform selection and engineering design to commissioning, training, and ongoing operational support.

## GET IN TOUCH

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