Faculty Mission: Enable 49 ML & AI Solutions

That 1.4 Billion People Are Waiting For

Where Intelligent Software Meets Designed-and-Built-in-India Hardware

Appendix F: India Hardware Ecosystem & Policy

Honest Assessment · Real Opportunities · Clear Path Forward

F-1 Gaps · F-2 Semiconductor Mission · F-3 PCB Fab · F-4 PCBA · F-5 Enclosure · F-6 Schemes · F-7 R&D Labs · F-8 RF/Sensor Ecosystem · F-9 Policy

For: All Faculty · Students Building Indian Hardware Products · Anyone Who Wants to Understand Why India Imports Every Component

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How to Use This Appendix

> This appendix does two things simultaneously:
>
> 1. It tells the truth about where India is today.
> No fab. No RF components. Counterfeit crisis.
> Import dependency across every layer of the hardware stack.
> These are facts — not criticisms.
> Engineers who know the gap can close it. Engineers who don't know it cannot.
>
> 2. It maps the path from where India is to where India must go.
> India Semiconductor Mission — ₹76,000 crore committed.
> PLI schemes — ₹2 lakh crore across 14 sectors.
> Government schemes — TIDE 2.0, DST NIDHI, SAMRIDH.
> R&D labs — SAMEER, C-DAC, CDOT, ERTL, NPL.
> PCB fabricators — who can do 4-layer impedance-controlled today.
> Enclosure makers — who can do IP67 injection moulding today.
>
> The gap is real. The path is visible.
> The engineers to walk it are in your classrooms.

Section	Content
F-1	India's Structural Hardware Gaps — Honest Assessment
F-2	India Semiconductor Mission — What It Means for Students Today
F-3	PCB Fabrication in India — Who Can Do Impedance-Controlled 4-Layer
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F-8	India's RF & Sensor Component Ecosystem
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F-1: India's Structural Hardware Gaps — The Honest Assessment

The Gap Map — Layer by Layer

LAYER	INDIA TODAY	GLOBAL BENCHMARK
SEMICONDUCTOR FAB	ZERO below 28nm ISM announced — Tata 28nm planned	TSMC 3nm, Samsung 4nm Intel 20A, GlobalFoundries 12nm standard production
RF COMPONENTS (SAW, BAW, LNA, RFIC, PA)	100% imported Lead time 16–52 weeks No Indian equivalent	Murata, TDK, Skyworks, Qorvo — Japan, USA dominate globally
SENSORS (precision, MEMS, calibrated)	< 5% local production Most imported from Japan, Germany, USA	Sensirion (CH), Honeywell (US), TE Connectivity, Bosch Sensortec — no Indian equivalent
PASSIVE COMPONENTS (capacitors, resistors, inductors, crystals)	~30% local (low-grade) Precision parts imported No Indian SMD crystal	Murata, TDK, Yageo, Vishay — Japan, Taiwan dominate
PCB FABRICATION	Multi-layer available 4-layer impedance-controlled — few vendors	IPC Class 3 widely available in China, Europe, USA India: few can do reliably
PCBA (Assembly)	Good for > 500 units > ₹1L for < 100 units Prototype assembly poor	China < 10 unit runs at low cost — India expensive for small volumes
ENCLOSURE (IP-rated, DFM-ready)	Injection moulding available but DFM expertise limited	DFM-ready toolrooms widely available globally India: CMTI, CIPET improving
TEST EQUIPMENT (VNA, spectrum analyser, EMC)	Imported — expensive NABL labs limited SAMEER: improving	Keysight, R&S — widely available globally

Gap 1: No Semiconductor Fabrication

> India has zero advanced chip fabrication below 28nm.
> Every MCU, MPU, RF chip, sensor IC is imported.
>
> Impact on IoT:
> - Every STM32, ESP32, nRF5340, Qualcomm chip — foreign
> - Import duty + shipping adds 20–35% to component cost
> - Geopolitical risk — chip shortages (2021–2023) disrupted global IoT
> - India has no leverage in supply chain disruptions
>
> What is changing:
> - Tata Electronics — 28nm fab planned in Gujarat (Dholera)

> CG Power — OSAT facility — Sanand, Gujarat
> Micron Technology — ATMP facility — Sanand (packaging)
> India Semiconductor Mission — ₹76,000 crore committed
> Timeline: first Indian fab production 2027–2028 (28nm)
>
> What students must do now:
> Learn chip design — VLSI, RTL, verification
> Contribute to open-source hardware (RISC-V, OpenROAD)
> India's fabless chip design ecosystem is strong — leverage it

Gap 2: No RF Component Ecosystem

> Every RF component in every Indian IoT product is imported:
> SAW filters — Murata, TDK (Japan)
> BAW filters — Broadcom, Qorvo (USA)
> RF switches — Skyworks, pSemi (USA)
> LNAs — Maxim, Mini-Circuits (USA)
> Power amplifiers — Qorvo, Skyworks (USA)
>
> Impact: Lead times 16–52 weeks. No Indian substitute. 100% import dependency.
>
> What students can do:
> Learn RF IC design — a high-value, rare skill in India
> SAMEER works on some RF components — engage with them
> Long-term: India needs RF fabless design companies

Gap 3: No Precision Sensor Ecosystem

Sensor Type	Indian Option?	Import Source
MEMS pressure	No	Sensata, Honeywell, TE Connectivity
MEMS accelerometer	No	STMicro, Bosch, TDK
Soil NPK (calibrated)	No	Decagon/METER (USA)
Water quality (precision)	No	YSI, Hach, Atlas Scientific
Electrochemical gas	No	Alphasense, SGX Sensortech (UK)
MEMS microphone	No	Knowles, TDK InvenSense
Temperature RTD (NABL)	Limited	Heraeus, Honeywell
NIR spectrometer	No	Ocean Insight, Hamamatsu

> What India has: Some basic capacitive sensors (local manufacture), some thermocouple assemblies.
> CSIR-CEERI (Pilani) — sensor research — not commercial.

> The opportunity: Building precision sensors for India-specific use cases
> (Indian soil types, Indian grain varieties, Indian water chemistry)
> is a genuine research + commercialisation opportunity.
> No global vendor will do this for India.

Gap 4: Counterfeit Component Crisis

> *The counterfeit component problem is systemic in India.*
>
> *Where counterfeits enter:*
> *IndiaMART — unregulated marketplace*
> *Local electronics markets — Lajpat Nagar (Delhi), SP Road (Bengaluru), Lamington Road (Mumbai), Richie Street (Chennai)*
> *Amazon India — third-party sellers*
> *AliExpress direct imports — zero QC*
>
> *Most commonly counterfeited:*
> *STM32F103 (Blue Pill) — fake die, wrong markings*
> *ESP32 modules — non-Espressif die, wrong RF performance*
> *Crystal oscillators — wrong frequency, poor stability*
> *AMS1117 LDO — fails under load, wrong dropout voltage*
> *Sensors — ₹50 'DHT22' with no calibration, random IC inside*
>
> *The solution: Mouser, Digi-Key, element14, Arrow — authorised only.*
> *A ₹200 counterfeit component in a ₹50,000 device can cause a ₹5,00,000 field failure.*

Gap 5: Limited EMC Test Infrastructure

Facility	Count	Location	Wait Time
ERTL (government)	5	Metro cities only	4–8 weeks
NABL accredited private labs	~50	Major cities	2–4 weeks
Anechoic chambers (full)	< 20	Mostly metro	4–8 weeks
SAR testing facilities	< 10	Very limited	6–10 weeks

> What India needs: 200+ NABL accredited EMC labs across India.
> Regional EMC testing centres in Tier 2 cities.
> Automated pre-compliance test equipment (< ₹5 lakh) in every engineering college.
>
> What students can do: Build college pre-compliance labs (Appendix C-19).
> Partner with SAMEER for advanced testing. Use ERTL government labs.

F-2: India Semiconductor Mission — What It Means for Students Today

> Announced: December 2021
> Budget: ₹76,000 crore (₹760 billion)
> Goal: Establish India as a global semiconductor hub by 2030
>
> Three pillars:
> 1. Semiconductor fabrication — wafer fabs
> 2. Display fabrication — display fabs
> 3. Compound semiconductors + ATMP — packaging + assembly

The Approved Projects — as of 2024

Company	Project	Location	Technology	Investment	Status
Tata Electronics	Semiconductor fab	Dholera, Gujarat	28nm CMOS	₹91,000 cr	Under construction
CG Power + Renesas + Stars Microelectronics	OSAT facility	Sanand, Gujarat	Chip packaging + test	₹7,600 cr	Under construction
Micron Technology	ATMP facility	Sanand, Gujarat	Memory packaging	₹22,500 cr	Under construction
Kaynes Semicon	OSAT facility	Sanand, Gujarat	Chip packaging	₹3,300 cr	Approved
Tata Electronics	OSAT facility	Assam	Chip packaging	₹27,000 cr	Approved

What This Means for Students Graduating 2025–2030

```
2025: Students graduating NOW
  → India has no fab, no packaging in volume
  → All chips still imported
  → BUT: chip design skills are in high demand for fab-ready IP

2026-2027: First ATMP facilities operational (Micron, CG Power)
  → Memory and logic packaging starts in India
  → Testing infrastructure growing
  → Jobs: process engineers, yield engineers, test engineers

2027-2028: Tata 28nm fab operational (early production)
  → First India-made silicon possible
  → VLSI design, process integration skills critical
  → Jobs: fab engineers, process control, equipment maintenance

2028-2030: Scale-up + ecosystem
  → India fabless design companies designing for Tata fab
  → India MEMS sensors possible (28nm process supports MEMS)
  → Jobs: hundreds of thousands across the value chain
```

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THE STUDENTS IN YOUR CLASSROOM TODAY
WILL BE THE ENGINEERS WHO RUN INDIA'S FIRST FAB.
TEACH THEM ACCORDINGLY.
```

What to Teach Now — Aligned with India Semiconductor Mission

Skill Area	Why Needed	Course Integration
VLSI Design (RTL + synthesis)	Chip design for India fab	Add VLSI design to CSE curriculum
Embedded systems + firmware	Chip bring-up + validation	Strengthen embedded in ECE
Semiconductor physics	Process understanding	Physics + device course — ECE Year 2
PCB design for chipsets	Carrier board design — SOM	Add KiCad to ECE curriculum
Python + ML for yield analysis	Fab data analytics	CSE + ECE joint course
Quality & reliability engineering	OSAT quality	Include in final year project reviews
Supply chain + logistics	Semiconductor supply chain	Management elective

India's Chip Design Ecosystem — Already Strong

> India's secret strength: India is already a global chip design hub.
> 200+ semiconductor companies have design centres in India.
> 80,000+ chip design engineers in India today.
> Need 300,000+ by 2030 for ISM goals. The gap = your students.

Company	India Design Centre	What They Design
Intel	Bengaluru	Core, Xeon, chipsets
Qualcomm	Hyderabad	Snapdragon SoC
Texas Instruments	Bengaluru	Analog + embedded processors
NXP	Bengaluru, Noida	Automotive, IoT SoCs
STMicroelectronics	Noida	STM32, analog
MediaTek	Bengaluru	Mobile SoC
Marvell	Bengaluru	Data infrastructure
Analog Devices	Bengaluru	Analog + mixed-signal
Broadcom	Bengaluru	Network, storage
AMD	Bengaluru, Hyderabad	CPU, GPU

F-3: PCB Fabrication in India — Who Can Do 4-Layer Impedance-Controlled Today

> Most Indian PCB manufacturers can do:
> 2-layer FR4 — widely available
> 4-layer FR4 — available from ~50 vendors
> Basic specifications — track/space 100/100µm
>
> What IoT RF products need — fewer vendors can do:
> 4-layer with impedance control (50Ω microstrip)
> IPC Class 3 quality standard
> Track/space 75/75µm or finer
> Controlled dielectric constant prepreg
> High-frequency materials (Rogers, Taconic — for RF above 5 GHz)

India PCB Vendor Reference Table

Vendor	Location	4-Layer?	Impedance Control?	IPC Class 3?	Quick Turn?	Website
AT&S India	Nanjangud, Karnataka	Yes	Yes	Yes	No	ats.net
Shogini Technoarts	Pune	Yes	Yes	Yes	Yes	shogini.com
Utthunga	Bengaluru	Yes	Yes	Partial	Yes	utthunga.com
Epitome Components	Bengaluru	Yes	Limited	No	Yes	epitomecomponents.com
Circuit Systems India	Delhi	Yes	Limited	No	Yes	circuitsystems.in
ASTER Electronics	Chennai	Yes	Yes	Yes	Partial	asterelectronics.in
Dynamic PCB	Pune	Yes	Limited	No	Yes	dynamicpcb.co.in

When to Use Indian vs Overseas PCB Fabrication

Scenario	Recommendation	Reason
Student prototype — non-RF	JLCPCB or PCBWay (China)	Lowest cost, fast, good quality for basic designs
Student prototype — RF	JLCPCB with impedance control specified	JLCPCB can do impedance control — specify stack-up
Product prototype — RF	Shogini or AT&S India	India vendor for IP protection + local support
Production — volume	AT&S India or overseas for high-mix	India for < 1000 units if IP sensitive

Scenario	Recommendation	Reason
High-frequency RF (> 5 GHz)	PCBWay with Rogers material	India vendors limited for Rogers/Taconic
Medical device — IPC Class 3	AT&S India or overseas certified vendor	IPC Class 3 certification required for CDSCO

PCB Specification Checklist — For Ordering 4-Layer RF Board

- ☐ Layers: 4
- ☐ Stack-up: L1 signal / L2 ground / L3 power / L4 signal
- ☐ Total thickness: 1.6 mm (standard)
- ☐ Core 1 (L1–L2): 0.2 mm
- ☐ Core 2 (L2–L3): 1.0 mm
- ☐ Core 3 (L3–L4): 0.2 mm
- ☐ Copper weight: 1 oz (35µm) all layers
- ☐ Controlled impedance: YES — 50Ω microstrip on L1
- ☐ Trace width for 50Ω: [calculate with Saturn PCB, confirm with manufacturer]
- ☐ Surface finish: ENIG (Electroless Nickel Immersion Gold) — not HASL for fine pitch
- ☐ Solder mask: both sides
- ☐ Silkscreen: both sides
- ☐ IPC Class: 2 (standard) or 3 (high reliability — specify if required)
- ☐ Test: 100% electrical test — flying probe or bed of nails

Overseas PCB Vendors for Students

Vendor	Location	4-Layer Price	Impedance Control?	Delivery to India	Link
JLCPCB	China	₹500–₹2,000 for 5 pcs	Yes (specify)	7–15 days	jlcpcb.com
PCBWay	China	₹800–₹3,000 for 5 pcs	Yes (specify)	7–15 days	pcbway.com
OSHPark	USA	₹3,000–₹8,000 for 3 pcs	Limited	14–21 days	oshpark.com
Eurocircuits	Europe	₹5,000–₹15,000	Yes — excellent	14–21 days	eurocircuits.com

F-4: PCBA in India — From Prototype to Production

> India's PCBA landscape:
>
> Large volume (> 10,000 units):
> Strong capability — Foxconn, Flextronics, Jabil, Dixon Technologies
> All have India manufacturing — for mobile phones + electronics
>
> Medium volume (500–10,000 units):
> Available — many EMS providers. Quality varies — IPC-A-610 not always verified.
>
> Small volume (< 100 units — prototype):
> Expensive and unreliable in India.
> Most students use JLCPCB or PCBWay assembly service (China).
> Better quality, lower cost, faster for prototype volumes.

India EMS Vendor Reference

Vendor	Scale	Capability	Location	Website
Dixon Technologies	Large	SMT, THT, box build	Noida, Dehradun	dixoninfo.com
Kaynes Technology	Medium-Large	SMT, THT, RF	Mysuru, Manesar	kaynes.in
Centum Electronics	Medium	Defence, aerospace, industrial	Bengaluru	centumelectronics.com
SFO Technologies	Medium	Medical, defence, telecom	Kochi	sfotechnologies.com
VVDN Technologies	Medium-Large	Telecom, IoT, networking	Manesar	vvdntech.com
Tonbo Imaging	Small-Medium	Defence-grade, precision	Bengaluru	tonboimaging.com

Prototype Assembly Strategy

```
FOR STUDENT PROTOTYPES (1-10 units):

Option A: JLCPCB Assembly Service (China)
├── Order PCB + assembly together
├── Upload Gerbers + BOM + centroid file
├── Cost: PCB ₹1,000 + assembly ₹2,000-₹5,000 per board
├── Quality: IPC Class 2 — good for prototype
├── Timeline: 10-18 days door to India
└── Best for: standard components in their library

Option B: PCBWay Assembly
├── Similar to JLCPCB — slightly higher cost, better for custom parts
├── Cost: PCB ₹1,500 + assembly ₹3,000-₹8,000 per board
└── Best for: non-standard components, Rogers PCB + assembly

Option C: Manual assembly in college lab
├── Requires: soldering station, solder paste, hot air gun or reflow oven
├── Equipment cost: ₹15,000-₹50,000 one-time
└── Best for: learning DFM + assembly process firsthand

RECOMMENDATION:
Use JLCPCB for first prototype — verify design works
Then manual assembly for iterations — learn the process
Then Indian EMS for production — build relationship early
```

F-5: Injection Moulding & Enclosure — CMTI, CIPET, Tool Room Network

> Most college IoT projects have no enclosure.
> Most commercial IoT products in India use off-the-shelf enclosures.
> Custom injection-moulded IP67 enclosures for IoT — rare in India.
>
> Why this matters:
> Off-the-shelf enclosures don't fit custom PCBs perfectly
> Antenna window placement not designed for RF performance
> Thermal management not designed for India climate
> IP rating not verified for specific product and environment

The Enclosure Development Path

```
STEP 1: 3D MODELLING (SolidWorks / Fusion 360 / FreeCAD)
├── Design enclosure around PCB — not PCB around enclosure
├── Include: cable entry, antenna window, mounting boss, PCB standoffs
├── Check: component height clearance, thermal venting if needed
└── Free tools: FreeCAD (open source), Fusion 360 (student free)

STEP 2: 3D PRINTING — PROTOTYPE FIT CHECK
├── Print in ABS or PETG — not PLA (too brittle, low temperature)
├── Verify PCB fits — all connectors accessible
├── Verify antenna window position — test VSWR in printed enclosure
└── Tools: FDM printers in college lab or Fablab

STEP 3: SOFT TOOLING — LOW VOLUME INJECTION MOULDING
├── Aluminium tool — 500–5,000 units
├── Cost: ₹1,00,000–₹5,00,000 for simple enclosure
├── Timeline: 6–10 weeks
└── Vendors: CMTI, CIPET, local tool rooms

STEP 4: HARD TOOLING — PRODUCTION INJECTION MOULDING
├── Steel tool — 50,000–5,00,000 units
├── Cost: ₹5,00,000–₹30,00,000
└── Timeline: 10–16 weeks
```

Government Tool Room Network — India

Institution	Location	Capability	For Students?	Website
CMTI (Central Manufacturing Technology Institute)	Bengaluru	Precision tooling, CNC, injection moulding	Yes — training + prototyping	cmti-india.net
CIPET (Central Institute of Petrochemicals Engineering & Technology)	Chennai + 37 locations	Plastics processing, injection moulding, testing	Yes — courses + prototyping	cipet.gov.in
NTTF (Nettur Technical Training Foundation)	Bengaluru + others	Precision machining, tooling	Yes — training	nttf.co.in
IGTR (Indo-German Tool Room)	Aurangabad	Precision tools, moulds, dies	Yes — prototyping	igtr-aurangabad.com
SIDBI Tool Rooms	Pan India	Various — depends on location	SME support	sidbi.in

IP Rating Testing in India

> After enclosure manufacture — IP rating must be verified by testing.
>
> IP rating tests:
> IP5X (dust protection): Air jet test — 8 hours in dust chamber
> IP6X (dust tight): Vacuum test — no dust ingress
> IPX4 (splash): Water spray 10 minutes from any direction
> IPX5 (water jet): 12.5 L/min nozzle — 1m distance — 3 minutes
> IPX6 (powerful jet): 100 L/min nozzle — 1m distance — 3 minutes
> IPX7 (immersion 1m): 30 minutes immersion at 1m depth
> IPX8 (immersion spec): Manufacturer-specified depth + duration
>
> IP test labs in India: NABL accredited labs (see Appendix C-20), ERTL government labs, TUV SUD India, SGS India
>
> Cost: ₹15,000–₹50,000 per enclosure design per IP rating
> Timeline: 1–2 weeks

F-6: Government Schemes — India Has Allocated the Money. Now Apply for It.

Student & Startup Schemes

Scheme	Organiser	What It Funds	Amount	Link
TIDE 2.0	MeitY	Tech startup incubation — IoT, AI, ML, cybersecurity	Up to ₹75 lakh	tide20.in
DST NIDHI PRAYAS	DST	Prototype development — idea to POC	Up to ₹10 lakh	nidhi.dst.gov.in
DST NIDHI SEED SUPPORT	DST	Early stage startup — product development	Up to ₹50 lakh	nidhi.dst.gov.in
Startup India Seed Fund	DPIIT	Early stage startup funding	Up to ₹20 lakh	startupindia.gov.in
AIM ARISE	NITI Aayog AIM	AI + IoT student innovation	Grant + mentoring	aim.gov.in
iCreate	Government of Gujarat	Hardware startup incubation	Up to ₹2 crore	icreate.in
BIRAC BIG	BIRAC	Biotech + health IoT innovation	Up to ₹50 lakh	birac.nic.in
PM Vishwakarma	Ministry of MSME	Traditional + tech skill development	Up to ₹3 lakh + training	pmvishwakarma.gov.in

Faculty & Institution Schemes

Scheme	Organiser	What It Funds	Amount	Link
SERB CRG	DST SERB	Core research grant — faculty led	₹20–50 lakh	serb.gov.in
SERB TARE	DST SERB	Teachers associateship for research at IIT/IISc	₹10–30 lakh	serb.gov.in
DST FIST	DST	Lab equipment upgrade	₹25–1,00,000	dst.gov.in
AICTE RPS	AICTE	Research promotion scheme	₹10–30 lakh	aicte-india.org
AICTE MODROB	AICTE	Modernisation of lab equipment	₹5–20 lakh	aicte-india.org
MeitY SAMRIDH	MeitY	Hardware startup acceleration	Up to ₹40 lakh	samridh.meity.gov.in

Hardware-Specific Schemes

Scheme	Organiser	What It Funds	Amount	Link
India Semiconductor Mission	MeitY ISM	Chip design, fab, ATMP	Thousands of crores	semiconductors.india.gov.in

Scheme	Organiser	What It Funds	Amount	Link
PLI Electronics	MeitY	Electronic manufacturing	₹13,000 cr total	meity.gov.in
SPECS	MeitY	Electronic component manufacturing	25% capex subsidy	meity.gov.in
RDSS	MoPNG	Smart metering deployment	₹3.03 lakh crore	rdss.gov.in
FAME II	Heavy Industries	EV charging hardware	₹10,000 cr	fame2.heavyindustries.gov.in
PM-KUSUM	MNRE	Solar agriculture hardware	₹34,422 cr	mnre.gov.in/pm-kusum
Namami Gange	Jal Shakti	River monitoring hardware	₹20,000 cr	nmcg.nic.in

The Scheme Application Guide — Three Practical Steps

Stage	Recommended Scheme
Idea — no prototype	DST NIDHI PRAYAS (₹10 lakh)
Prototype done — no product	TIDE 2.0 or NIDHI SEED (₹50 lakh)
Product — need scale	Startup India Seed Fund + iCreate
Faculty research	SERB CRG or AICTE RPS
Lab equipment	DST FIST or AICTE MODROB

> Step 1: Identify the right scheme for your stage (table above)
> Step 2: Register on the right portal
> Startup India: startupindia.gov.in — register startup first
> DST NIDHI: nidhi.dst.gov.in — incubator linkage needed
> SERB: serb.gov.in — faculty registration
> Step 3: Write a strong application
> Problem statement: specific Indian problem with scale data
> Solution: hardware + software — both specified
> Market: India market size + addressable segment
> Team: ECE + CSE — both represented
> Impact: lives affected, economic saving, government scheme linkage

F-7: Government R&D Labs Students Can Partner With

Lab	Full Name	Location	Specialisation	Student Partnership	Website
SAMEER	Society for Applied Microwave Electronics Engineering & Research	Mumbai, Chennai, Kolkata	RF + microwave, EMC testing, antenna, wireless systems	Yes — internships, joint projects, testing	sameer.gov.in
C-DAC	Centre for Development of Advanced Computing	Pune, Bengaluru, Hyderabad, Chennai	HPC, embedded systems, AI, semiconductor design tools	Yes — internships, ACTS courses, joint projects	cdac.in
CDOT	Centre for Development of Telematics	New Delhi, Bengaluru	Telecom equipment, 5G, optical, rural broadband	Limited — project partnerships	cdot.in
ERTL	Electronics Regional Test Laboratories	Chennai, Mumbai, Delhi, Bengaluru, Kolkata	Testing + certification, BIS, EMC	Yes — testing services, student projects	ertlindia.gov.in
CSIR-CEERI	Central Electronics Engineering Research Institute	Pilani, Rajasthan	Sensors, MEMS, displays, microwave	Yes — research projects, internships	ceeri.res.in
CSIR-NPL	National Physical Laboratory	New Delhi	Measurement standards, calibration, metrology	Yes — calibration services, research	nplindia.org
NIOT	National Institute of Ocean Technology	Chennai	Ocean sensors, coastal monitoring, buoys	Yes — research projects	niot.res.in
INCOIS	Indian National Centre for Ocean Information Services	Hyderabad	Ocean data, tsunami warning, coastal	Yes — data access, academic projects	incois.gov.in

How to Partner with Government Labs — Practical Guide

> For Students — Internship Route:
> SAMEER: Apply directly at sameer.gov.in/careers — summer internship programme
> C-DAC: ACTS (Advanced Computing Training School) courses + research internships
> CSIR labs: CSIR-SRF/JRF fellowships for postgraduate students
>
> For Faculty — Project Collaboration Route:
> Faculty writes a collaborative project proposal
> Lab agrees to provide: equipment, expertise, testing access
> College provides: students, computational resources, publication rights
> Formalised through MOU between college and lab

> Testing Services Route (most accessible):
> Any college can use ERTL for BIS testing — no MOU needed
> NABL labs for sensor calibration — available for fee
> SAMEER for EMC pre-testing — available for fee
> NPL for metrology traceable calibration

SAMEER — The Most Relevant Lab for IoT

> SAMEER (Society for Applied Microwave Electronics Engineering & Research) is India's primary government RF + EMC laboratory.
>
> What SAMEER offers IoT students and faculty:

Service	Relevance	Contact
EMC pre-compliance testing	Test before expensive commercial lab	sameer.gov.in
Antenna characterisation	Measure gain + pattern in anechoic chamber	Mumbai centre
RF product development support	Design review + testing for RF products	Chennai centre
LoRa / IoT propagation studies	India-specific coverage studies	Kolkata centre
Student training programs	RF + microwave short courses	All three centres
Joint research projects	Faculty-led collaborative projects	Any centre

> SAMEER locations:
> Mumbai: IIT Bombay campus — sameer.gov.in
> Chennai: Taramani — near IIT Madras
> Kolkata: Sector V, Salt Lake

F-8: India's RF & Sensor Component Ecosystem

Component Category	Indian Manufacturer?	Import Alternative	Opportunity
SAW filters	No	Murata, TDK (Japan)	Fabless design possible for Tata fab
BAW filters	No	Broadcom, Qorvo (USA)	Requires BAW process — future ISM
RF switches	No	Skyworks, pSemi (USA)	Fabless design for Tata 28nm
LNA (Low Noise Amp)	No	Mini-Circuits, Maxim (USA)	Fabless design opportunity
LoRa transceivers	No	Semtech (USA)	—
BLE SoC	No	Nordic, TI, STM (Europe/USA)	—
GPS/NavIC receiver	Limited (ISRO research)	Quectel (China), u-blox (Switzerland)	ISRO NavIC chipset commercialisation
Soil sensors (calibrated)	No commercial	Decagon/METER (USA)	Startup opportunity — CSIR-CEERI research base
Water quality probes	No	YSI, Hach (USA), Atlas (UK)	Startup opportunity
Gas sensors (EC)	No	Alphasense (UK), SGX (UK)	Startup opportunity
MEMS accelerometer	No	STM, Bosch, TDK	—
MEMS pressure	No	Honeywell, TE Connectivity	—
Industrial temp (RTD)	Limited	Heraeus, Honeywell	Some thermocouple assemblies local
PCB antennas	Limited design	Taoglas, Molex (Ireland/USA)	Startup opportunity
Crystal oscillators	No	Abracon, TXC, Epson	—
Passive (resistors/caps)	Basic grades only	Murata, TDK, Yageo	Low-precision local — precision imported

The Three Sensor Startup Opportunities for India

> ① Soil sensor ecosystem for Indian agriculture
> Problem: Global sensors not calibrated for Indian soil types
> Market: 140 million farming households
> What's needed: Soil NPK + moisture + pH — calibrated for Indian soils
> Technical path: ISFET pH + AC impedance moisture + ion-selective NPK
> Reference: CSIR-CEERI has research prototypes — commercialisation gap
>
> ② Grain quality sensor for Indian varieties
> Problem: NIR models trained on Western grain — wrong for jowar/ragi/bajra
> Market: 7,000 APMCs + 150,000 FCI depots

What's needed: NIR spectrometer + ML model trained on Indian grain
Technical path: AS7265x NIR + Edge Impulse on RPi or Jetson
Reference: IIT Kharagpur has grain sensor research

③ Water quality buoy for Indian rivers
Problem: No Indian commercial multi-parameter river buoy with anti-fouling
Market: 400+ polluted river stretches needing CPCB WQMS
What's needed: DO + pH + turbidity + conductivity + auto-wiper in buoy
Technical path: Atlas Scientific probes + STM32H7 + anti-fouling wiper
Reference: NIOT (Chennai) has ocean buoy experience — river adaptation needed

F-9: Make in India Electronics Policy Framework

The Policy Landscape — Simplified

```
NATIONAL ELECTRONICS POLICY 2019
        │
        ├── PLI Scheme (Production Linked Incentive)
        │   14 sectors — ₹1.97 lakh crore total
        │   Electronics: ₹13,000 crore
        │
        ├── SPECS (Semiconductor + Display Fabs)
        │   25% capex subsidy for component manufacturing
        │
        ├── EMC2 (Electronics Manufacturing Clusters)
        │   Infrastructure for electronics parks
        │
        ├── MeitY IoT initiatives
        │   TIDE 2.0, SAMRIDH, Centre of Excellence for IoT
        │
        └── BIS + WPC + TEC regulatory framework
            Mandatory certification for electronics
```

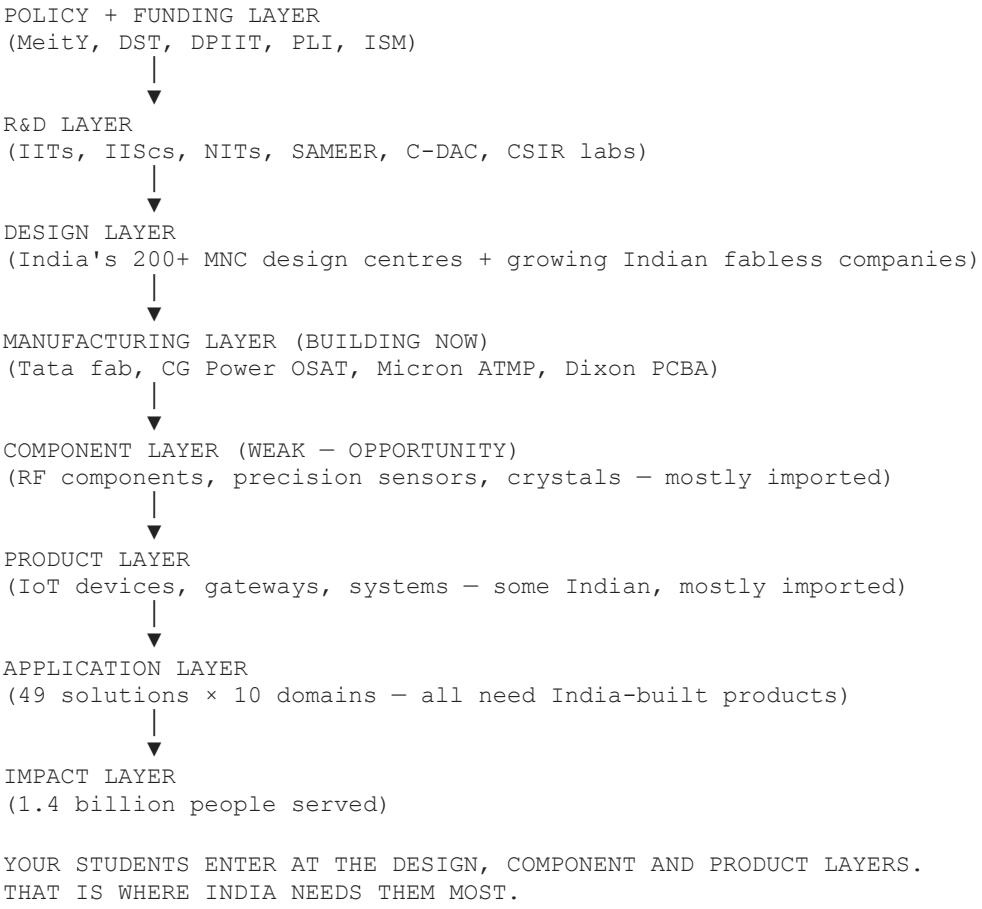
The PLI Scheme — What It Means for IoT Engineers

PLI Sector	PLI Outlay	IoT Relevance
IT Hardware	₹7,325 cr	Laptops, servers, IoT hardware
Telecom + Networking	₹12,195 cr	LoRa gateways, NB-IoT devices
Advanced Chemistry Cell Battery	₹18,100 cr	IoT device batteries — LiFePO4
Drones	₹120 cr	Agricultural + infrastructure drones
Medical Devices	₹3,420 cr	Health IoT devices
Solar PV	₹4,500 cr	Solar IoT node power systems

> For IoT startups: if your product is in a PLI category — manufacturing in India qualifies for PLI cash incentive on incremental sales over a base year.
> A ₹100 cr revenue IoT manufacturer may get ₹4–6 cr/year PLI.

T

he India Electronics Ecosystem Map



The Centre of Excellence for IoT — MeitY

CoE	Location	Focus	Partnership
CoE IoT — NASSCOM	Bengaluru	IoT product development	Industry
CoE Smart Agriculture	IIT Hyderabad	AgriTech IoT	Academic
CoE Wearables	IIT Jodhpur	Health + wearable IoT	Academic
CoE Water	IIT Patna	Water quality IoT	Academic
STPI AI CoE	Pan India	AI + IoT startup support	Startup

> How to connect:
> Faculty can apply for collaborative research with CoE
> Students can apply for internships
> Startups can apply for incubation + funding
>
> Reference: meity.gov.in/content/centres-excellence-internet-things-iot

Cross-References

For	Go to
PCB design rules — stack-up, ground plane, impedance for RF products	Appendix C: Engineering Integrity | C-11 PCB Stack-up
BIS CRS, WPC ETA, TEC TA — certification pathways for India electronics	Appendix E: Certification & Compliance | E-2, E-3, E-4
Component sourcing — authorised distributors, counterfeit warning	Appendix B: Hardware Stack Reference | B-13
Sensor integrity — NABL calibration, anti-fouling, material science	Appendix C: Engineering Integrity | C-4, C-5, C-6
SAMEER EMC lab for pre-compliance and antenna testing	Appendix C: Engineering Integrity | C-20 EMC Test Labs
Government scheme applications — DST NIDHI, TIDE 2.0, SERB CRG	Appendix H: Learning Ecosystem | 'Government Funding Guide'
All 52 solutions — which domains need India-built sensors first	Appendix A6: Master Solutions Index | 'Open Innovation Gaps'