L&T SEMICONDUCTOR TECHNOLOGIES LIMITED

# LTSCT Module Design

## Performance Driven Hardware for Smart Modules

*A Global Market Whitepaper*

**December 2025**


*Authored By:*

**Pavithra R**
*Team Lead*
*Digital & Power*

**Amit P Hegde**
*Sr RF Engineer*


***Future. Made Together.***


# Contents


# Executive Summary

This white paper provides an insight into the ever-increasing demand for high quality hardware design that drives the System on Module performance. It focuses on the module hardware differentiators such as excellent RF performance across cellular, Wi-Fi/BT, and GNSS, together with power-efficient design forming the backbone of next-generation Infotainment, Connectivity, Automotive Telematics, and POS applications. It emphasizes hardware-focused enhancements in smart modules that deliver exceptional RF performance for dependable, high-quality connectivity at optimized low-power operation that extends battery life through reduced energy consumption.

The LTSCT SAC20 and related modules combine superior RF performance with optimized power design to meet this goal. These aspects help next-generation modules deliver resilient connectivity and sustainable energy operation which are key enablers for scalable telematics deployments, improved vehicle reliability, and the expansion of advanced connected-vehicle services worldwide.

# Global Telematics & Connectivity Market Trends

The Global Telematics and Connectivity business segment is experiencing rapid modernization, with telematics emerging as a key driver. Telematics offers major benefits like improved safety, cost savings, and smarter vehicle management for both individuals and businesses.

A few of the key advantages of Telematics are:

**Automatic Emergency Response**:

In case of a crash, telematics can alert emergency services instantly.

**Vehicle Diagnostics**:

Real-time alerts about engine issues or maintenance needs help prevent breakdowns.

**Driver Behaviour Monitoring**:

Tracks habits like speeding or harsh braking, encouraging safer driving.

**Usage-Based Insurance (UBI)**:
Insurance companies use telematics to offer personalized premiums based on driving behaviour.

**Fleet Optimization**:
Real-time tracking of vehicle location, speed, and routes improves logistics and delivery efficiency.

**Fuel Cost Reduction**:
Monitoring idle time and route efficiency helps cut fuel expenses.

**Improved Safety and Compliance**:
Ensures drivers follow regulations and safety protocols.

**Maintenance Scheduling**:
Predictive maintenance based on vehicle data reduces downtime and repair costs.

**Productivity Boost**:
Smarter routing and performance tracking lead to better time management and service delivery.

> LTSCT supports the evolution of the telematics industry by delivering tailored smart connectivity solutions built on high-quality hardware, transforming traditional systems into intelligent, networked platforms ready for the modern commercial environment.

# Importance of RF Performance in Telematics

Cellular RF (Radio frequency) technology is the backbone of modern telematics systems that enable seamless wireless communication between vehicles, infrastructure, and cloud services. Without robust RF performance, telematics modules cannot deliver reliable connectivity performance, safety, or user experience.

**Telematics systems integrate multiple wireless technologies namely:**

- Cellular connectivity (4G/5G) for data transmission
- Wi-Fi and Bluetooth for infotainment and device pairing
- Navigation and positioning via GNSS (GPS, GLONASS, etc.)
- Over-the-air (OTA) updates for firmware and software upgrade

**Each of these functions depends on high-performance RF subsystems to ensure:**

- Reliable signal reception even within poor signal reception range.
- High quality signal transmission
- Low latency and high data throughput
- Resilience to interference and multipath fading
- Compliance with global regulatory standards

# LTSCT SAC20 Module RF Performance

LTSCT's SAC20 module is designed for reliable and efficient cellular 4G LTE connectivity across a wide range of frequency bands covering a wide gamut of telecom spectrums in India, Europe and rest of the world.


The Cellular RF front end of the module incorporates a high-linear power amplifier, whose gain stability and distortion control play a crucial role in maintaining consistent modulation quality and reliable output power across all operating bands. The amplification characteristics are carefully optimized to minimize both amplitude and phase distortion, enabling support for high-order modulation.

## 01

### RF Transmitter Performance:

Transmit path in the cellular RF frontend includes a feedback chain which allows a small portion of the signal from near the antenna to be fed back to the transceiver to monitor and calibrate the signal for better signal quality.
This is made possible by a low insertion loss RF coupler integrated within the Antenna switch module in the transmit path.

This feature enables the transceiver to perform real-time power monitoring, apply closed-loop corrections, support digital predistortion convergence, and keep spectral regrowth tightly controlled, thereby ensuring uniform transmit performance across diverse LTE bandwidths and channel conditions.

Spectral integrity is further reinforced through band-specific duplexers and TDD/FDD filters, which are engineered to manage out-of-band components without compromising transmit efficiency. Their sharp rejection characteristics help maintain compliance with spectral emission requirements and ensure that modulation quality remains unaffected during dynamic uplink operation. System-level coexistence is also strengthened through the physical separation of LTE and Wi-Fi/BT subsystems on the PCB, with independent routing zones and dedicated compartment level shielding that prevent cross-coupling between the cellular transmit path and nearby WLAN/BT circuitry. This isolation reduces broadband noise interaction and ensures that high-power LTE transmissions do not desensitize Wi-Fi or GNSS receiver and degrade performance.

By combining these performance contributors, namely, the linear behavior of the power amplifier, the transmit path monitoring and correction accuracy enabled by the Antenna Switch module (ASM ), optimized RF routing and the selective attenuation provided by the duplexers/filters, the SAC20 module achieves consistently strong conducted and radiated transmit power in real-world environments. Through coordinated linearity control, spectral stability, and continuous correction mechanisms, the SAC20 meets 3GPP cellular specification requirements for transmit power, Adjacent channel rejection (ACLR), spectral emission mask (SEM) requirement, and modulation quality, ensuring reliable and robust cellular transmission across all supported LTE bands.

# 02

## Cellular Receiver Performance:

The SAC20 module delivers strong cellular receiver performance through a combination of low-noise amplification, optimized gain behavior, and band-selective filtering that collectively enhance sensitivity and resilience under weak-signal conditions. The diversity reception path along with the primary reception path allows better quality reception. The primary receive path (PRX) is tuned to achieve a low effective noise figure while maintaining high linearity, enabling the device to preserve downlink signal integrity even in the presence of strong neighboring channels. The diversity receiver (DRX) provides an additional spatial signal path that improves fading margin, stabilizes throughput, and enhances downlink reliability under mobility and challenging coverage scenarios.

Duplexers and band-selective filters in the receiver path reinforce overall receiver robustness by attenuating out-of-band components and minimizing de-sense from coexisting transmitters, both within the device and from external sources. Carefully managed RF routing ensures that PRX and DRX lines maintain controlled impedance and minimal insertion loss, preventing unintended coupling and preserving signal purity throughout the receive chain. Sensitive receiver paths are also routed with isolation from other high-speed traces in mind, avoiding proximity to high-power Tx traces and digital noise sources not allowing noise to couple into the receiver path to maintain optimal receiver sensitivity.

This balanced receiver performance allows the SAC20 to maintain stable demodulation quality, strong reference sensitivity, and reliable signal acquisition. Additionally, system-level layout separations such as isolation and shielding the LTE section from the Wi-Fi subsystem—further reduce cross-domain interference and prevent de-sense under simultaneous operation.

This ensures consistent downlink performance even under weak, fluctuating, or interference-heavy scenarios.

It may be noted that SAC20 supports 2G GSM fallback to allow 2G connectivity in regions where 4G LTE is weak or absent.

# 03

## Cellular Data Throughput:

The SAC20 RF architecture is optimized to support high modem-level throughput by minimizing losses, distortion, and detuning across the full signal chain. The PA, switch networks, and antenna interface are designed to maintain high linearity and wide dynamic range, enabling the modem to sustain higher-order modulation schemes and preserve low Block Error rate (BLER). On the receive side, the low-noise front end and diversity architecture improve received signal quality (RSRP/RSRQ/SINR), enabling stable downlink and uplink throughput even in dense RF environments or under mobility.

Throughput scalability is further enhanced through optimized RF routing that minimizes insertion loss, ensuring the modem maintains sufficient Signal to Noise Ratio (SINR). Additionally, the physical separation and dedicated shielding between LTE and Wi-Fi segments of the board reduce cross-system interference, preventing desensitization and preserves modem performance during concurrent connectivity. The combination of efficient uplink power delivery, strong receiver sensitivity, and well-tuned antenna performance ensures consistent, reliable cellular data rates in accordance with 3GPP capabilities, without degradation from the RF subsystem.

# 04

## Wi-Fi/ Bluetooth Performance:

The SAC20 platform supports dual-band Wi-Fi (IEEE 802.11ac) and multi-mode Bluetooth (BLE 5.0) operation through a front-end architecture that maintains high isolation, controlled selectivity, and low-loss RF behavior across both the 2.4 GHz and 5 GHz bands. The signal paths are engineered to suppress spurious energy in the 2.4 GHz region while preventing mutual interference between the 2.4 GHz and 5 GHz domains, allowing both WLAN bands to maintain clean spectral characteristics and remain compliant with regulatory Error Vector Magnitude (EVM), spectral mask, and out-of-band emission requirements. The Bluetooth subsystem leverages the 2.4 GHz chain through a coexistence-oriented RF topology that preserves modulation fidelity across classic BR/EDR modes as well as Bluetooth Low Energy (LE) operations.

Carefully optimized RF routing minimizes parasitic coupling and insertion loss, helping preserve sensitivity, Packet Error Rate (PER) performance, and modulation accuracy under dense RF conditions. Additionally, the Wi-Fi/Bluetooth domain is physically separated from the cellular

LTE RF section on the PCB and enclosed with dedicated shielding, significantly reducing cross-system interference, preventing desensitization and stabilizing performance during concurrent operation. These design considerations ensure that both dual-band Wi-Fi and Bluetooth maintain high throughput, robust sensitivity, and interference-resilient operation without degradation when operating simultaneously with cellular transmit and receive activity.

# 05

## GNSS Performance:

The SAC20 module incorporates a single band L1 GNSS receive architecture designed to deliver high sensitivity, strong interference resilience, and precise satellite acquisition. The incoming signal from the GNSS antenna passes through a filter that provides initial out-of-band rejection and improves immunity to nearby cellular and Wi-Fi transmissions. This filtered L1 signal is supported by a dedicated low-noise, high-linearity amplification stage engineered to maintain an exceptionally low effective noise figure, enabling the receiver to preserve satellite signals even under weak-signal. Additional band-specific filtering provides strong rejection of adjacent-band and out-of-band interferers, preventing de-sense and maintaining clean correlation waveforms at the transceiver.

The architecture is optimized for fast and stable GNSS acquisition, with low-level signal processing tuned to improve initial satellite detection and maintain strong correlation peaks even in low-SNR environments. This contributes to reduced cold-start, warm-start, and hot-start, Time-To-First-Fix (TTFF), enabling the system to establish a reliable position solution quickly after power-up or after brief signal interruptions. Re-acquisition performance is likewise enhanced through stable gain behavior and fast recovery from interference or blockage, allowing rapid re-lock to previously tracked satellites.

During steady-state operation, the L1 chain support high tracking sensitivity and enabling consistent position precision across GPS, GLONASS, and Galileo constellations.

By combining low-noise amplification, tightly controlled filtering, and well-managed routing of the GNSS traces, the SAC20 maintains stable sensitivity and reliable fix performance across dynamic conditions, ensuring consistent satellite acquisition, re-acquisition, and long-term tracking stability.

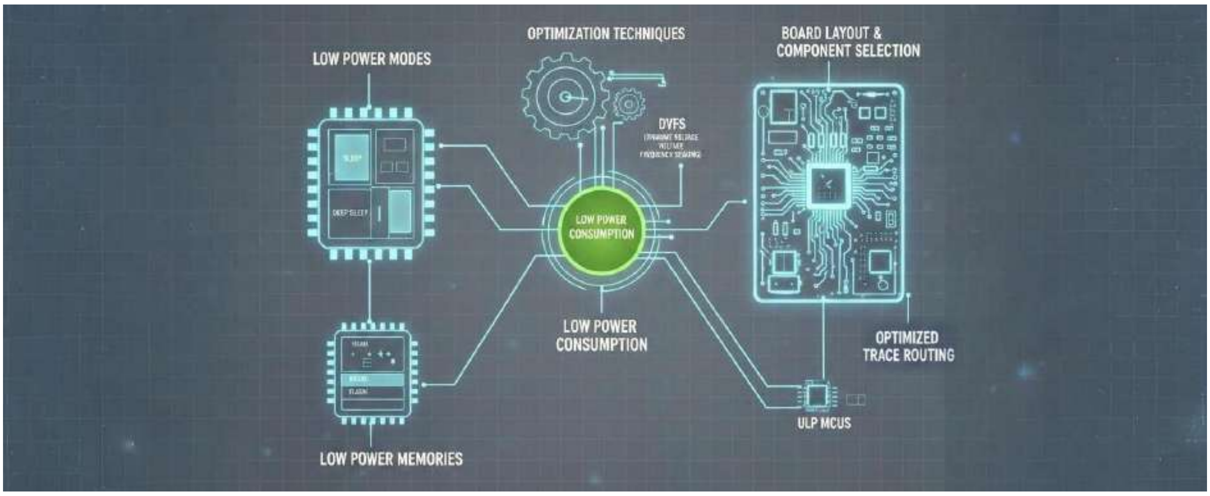
# 06

## Summary

LTSCT SAC20 module's sterling RF performance ensures:

- **Excellent Cellular Receiver sensitivity –** Superior receiver sensitivity that allows the weakest signal to be latched when vehicle is passing through remote terrains or valleys and regions where signal reception is poor. Diversity antenna in the receiver path allows best receiver performance.
- **High Cellular Data throughput –** Downlink data rates and uplink data rates are high enough and very close to the upper limits of CAT 4 specification for reliable data transmission.
- **Superior Wi-Fi/BT Performance –** Wide range WLAN and BT coverage allows better connectivity. Excellent co-existence between Wi-Fi/BT and LTE prevent de-sensitization of Wi-Fi receiver and allows excellent Wi-Fi receiver sensitivity.
- **GNSS Support –** Receiver architecture has a lower Noise Figure LNA and filters which allow a very high receiver sensitivity to locate an object with respect to a satellite constellation

# SIGNIFICANCE OF LOWER POWER CONSUMPTION IN TELEMATICS




Low power consumption is a key requirement for contemporary telematics platforms, directly affecting system reliability, vehicle battery longevity, thermal performance, and operational availability. These systems often operate continuously in low-power monitoring states while maintaining cellular connectivity, GNSS tracking, and remote wake-up functions. Inefficient power management unnecessarily increases parasitic battery drain, particularly during extended parking periods or transport storage. Optimized energy usage prevents vehicle battery depletion and supports compliance with OEM sleep-current specifications. In both combustion-engine vehicles and EVs, lower electrical load improves overall efficiency while reducing heat generation, which simplifies thermal management and allows more compact hardware integration.

These benefits translate into longer component life, reduced cooling requirements, and relaxed enclosure constraints within clustered cabin electronics. Effective power optimization reduces stress on legacy 12-V batteries and extends usable driving range in EV platforms, where continuous display, connectivity, and computation can produce measurable energy demand. Furthermore, stringent regulatory requirements and sustainability targets encourage manufacturers to deploy energy-efficient electronic designs aligned with ISO 26262 safety expectations and European eco-design standards.

## LTSCT's SAC20 Low Power Design:

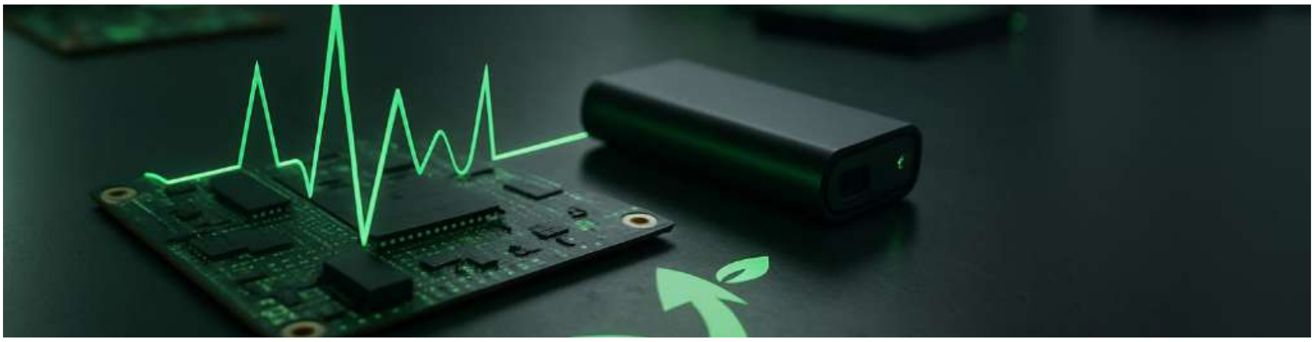
LTSCT's SAC20 is designed for the lowest power consumption in normal and low power modes. This allows enhanced battery life and optimal thermal performance. The module supports low power modes like PSM, DRX, eDRX and suspend to RAM mode to conserve power in idle mode. The underlying hardware responsible for powering various blocks of the module is based on a very efficient power delivery system. Right from IOT modem SOC selection based on low power ARM architecture to low power memory and power efficient regulators as well as power tracking feature for critically power hungry RF power amplifier, every component is selected keeping power saving in mind.

## Power-Optimized SAC20 Hardware Design:

Power Delivery design in SAC20 plays a major role in reducing power consumption. Selection of DC–DC regulators is based on real operating behavior rather than isolated peak-efficiency metrics. Regulators are selected based on high efficiency across the full load spectrum—especially at light loads where telematics systems operate for most of their duty cycle. Adaptive switching modes (PWM/PFM or burst operation) help balance efficiency between active and idle states. Additional evaluation criteria include optimized switching frequency management, synchronous conversion efficiency, minimal output noise, shutdown leakage control, reverse current protection, strong transient response capability, low DCR passives, robust thermal behavior, and integrated sequencing or telemetry features. Automotive-qualified parts certified to AEC-Q standards ensure consistent power performance in harsh environmental conditions.

# SAC20

## Circuit & Board - Level Power Optimization Techniques



- **Power gating** is widely used in SAC20 to eliminate idle consumption by selectively disconnecting unused subsystems. Using MOSFET or SOC-controlled supply rails, components such as sensors or radios remain powered only when actively required.

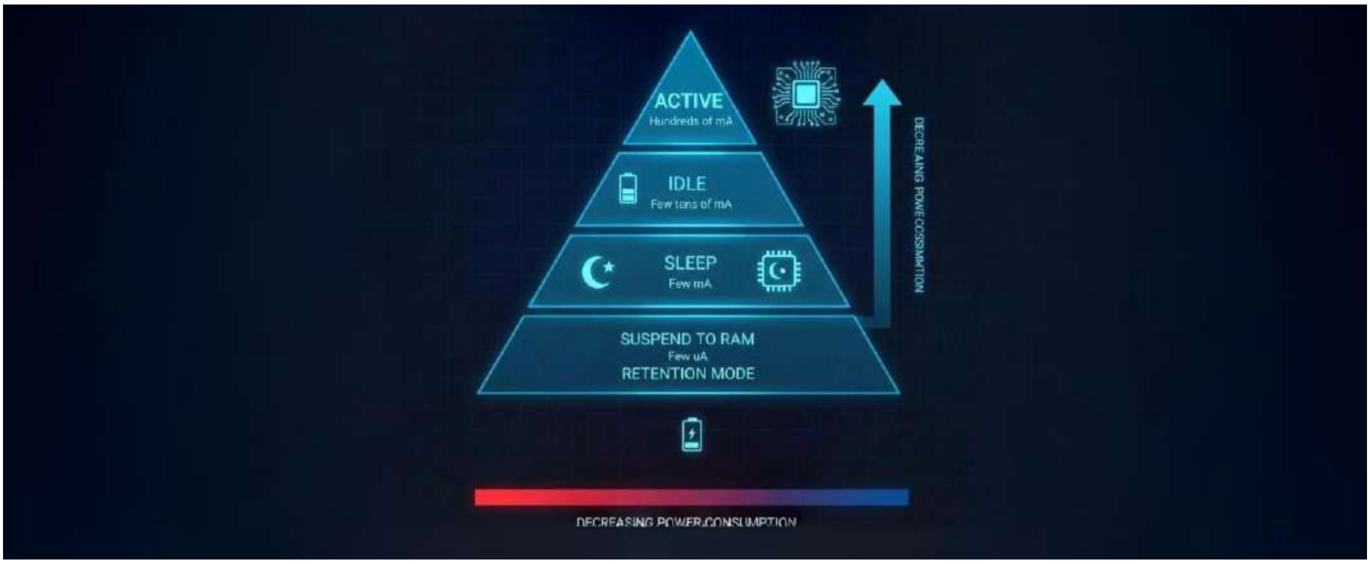
- **Clock gating** in SAC20 reduces unnecessary toggling by disabling clock input to idle processing blocks while allowing other portions of the system to remain operational.

- **Dynamic Voltage and Frequency Scaling (DVFS) in SAC20**: It further optimizes energy usage by reducing supply voltage and clock rate based on workload demands, enabling dynamic balancing between power consumption and performance.

- **Board design of SAC20:** Board design significantly affects power stability and efficiency. Power routing in SAC20 is with wider shapes and parallel power shapes in multiple layers are added to ensure IR losses in the power transmission path are lower. Having adequate via count and optimized via placement on the power planes to manage via current density effectively without compromising on the integrity of power planes is the one which is followed in SAC20 design.

  SAC20 uses low power LPDDR4x memory for lower power consumption. While in low power mode, it operates in self-refresh mode to save power. In low power mode particularly suspend to RAM mode, the RAM remains powered ON but consuming low power and wakes up with very low latency upon exit from this mode.

  IOT modem SoC and other components of SAC20 are chosen not only for computational capability but also for advanced sleep-mode support. The SoC chosen in SAC20 supports a **Low Power Subsystem** – It is a self-contained ultra-low-power subsystem that maintains system awareness and wake capability while allowing the rest of the SoC to be fully powered down. It is a critical enabler for PSM, eDRX, long-park endurance, battery preservation, and regulatory sleep-current compliance in LTE and 5G telematics platforms. LTSCT's System on module offer multiple low-power states enabling progressive shutdown of internal blocks while retaining wake capability.




**Active mode**:
All peripherals active and peak operating load, High power consumption (Hundreds of mA).

**Idle mode:**
Network Registered and peripherals active, Waiting for data or commands, medium power draw (Few tens of mA).

**Sleep mode:**
Network Registered and peripherals inactive, Low traffic operation, Low power draw, minimal power draw (Few mA).

**Suspend to RAM:**
Cellular modem core ON, Application processor context is retained in RAM, Peripherals OFF (Few mA).

**Retention mode:**
Memory preserved at ultra-low energy levels.

## Power Saving in RF Section of SAC20:

**Power Saving in RF Section of SAC20:** The Cellular RF Power Amplifier (PA) is one of the biggest power consumers in a handset. Envelope power tracking feature in SAC20 improves power-added efficiency (PAE), extending device battery life. Envelope tracking (ET) is a PA supply modulation technique that dynamically adjusts the PA's supply voltage to follow the instantaneous amplitude (envelope) of the transmit signal, keeping the PA near its peak efficiency across time-varying power levels

# SAC20 MODULE OVERVIEW

The SAC20 is optimized for Android /Yocto Linux POS, vending, payment kiosks, and IoT gateways. Key features include LTE Cat 4, dual-band Wi-Fi, GNSS, secure boot, and rich interfaces for camera, LCM, USB, UART, and GPIO.


## Key Features

- ARM Cortex-A53 64-bit Processor (Quad-core)
- Dual ISPs and up to 25MP camera @ 30fps
- Bluetooth 5.0 (BR/EDR + BLE)
- Max. 150 Mbps (DL) Max. 50 Mbps (UL)
- 4G CAT 4
- Qualcomm® Adreno™ 702 GPU
- LCC + LGA Package
- GPS/BDS/GLONASS/ Galileo/L1 Band
- Wi-Fi - IEEE 802.11 a/b/g/n/ac
- 2G Fallback
- Android OS 14, up to 15
- Integrated LCD Touchscreen interface

## Typical Applications


POS Machines


Self Checkout


Industrial Handhelds


Vending Machines


Surveillance Displays

# Value Proposition

LTSCT smart modules form the foundation of modern Infotainment & Connectivity telematics ecosystems. With global market for telematics accelerating, SAC20 and related LTSCT modules provide optimal connectivity through highest RF performance and lowest power consumption  required for next-generation systems

The **SAC20** is a high-performance LTE CAT 4 Smart module equipped with Wi-Fi, Bluetooth and Multimedia capabilities. Powered by a Qualcomm® ARM Cortex-A53 64-bit Quad-core processor and an integrated Adreno 702 GPU, designed to meet the demands of both industrial and consumer applications, offering high data rates, multimedia support, and extended lifespan.


# LTSCT At A Glance

Largest Indian Semiconductor Product Company

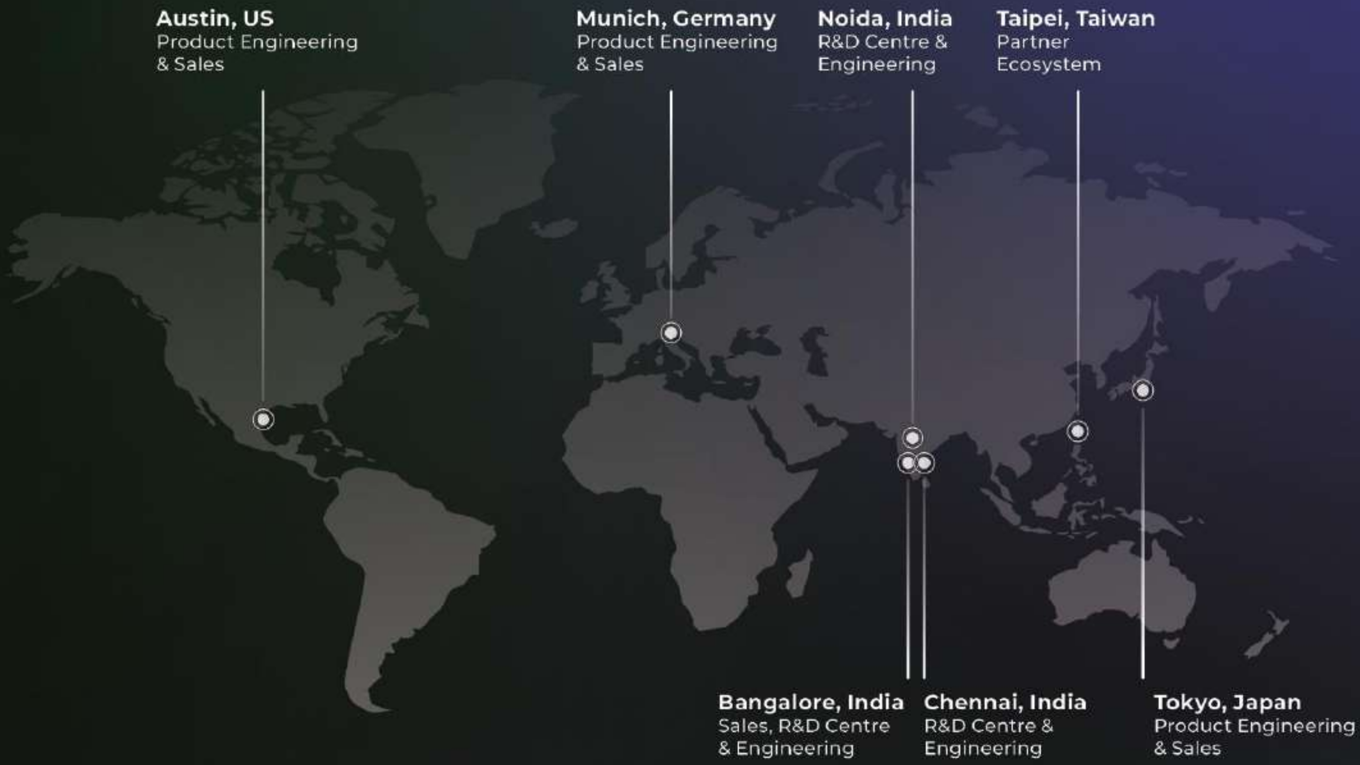
**60+**
Patents

**400+**
Employees Globally

**5**
Geographies

# Our global footprint

LTSCT operates on a global scale with strategic locations in Asia, Europe, and North America. This footprint allows us to stay close to our customers, enabling rapid support, localized production, and seamless logistics.




## INDIA

S2 Building, 10th Floor,
L&T Tech Park, Bellary Road,
Next to Raintree Boulevard, Park
View Layout, Byatarayanapura,
Bengaluru 560092

TC 3 Building, Tower B, 2nd Floor,
A Wing, Mount Poonamallee Road
Manapakkam, Chennai 600089

TOWER-EXPRESS TRADE,
Plot 15&16, Film City,
Sector 16A, Noida 201301

## UNITED STATES

8701 Bee Caves Road,
Suite 230, Austin, TX 78746

## EUROPE

3rd Floor, Hopfenstraße 6,
80335 München, Germany

## JAPAN

7F, Shinagawa East One Tower,
2-16-1 Konan, Minato-ku,
Tokyo 108-0075

## Contact us today!

Ready to shape the future together?
Reach out via our website: **www.ltsct.com**
to start a partnership that accelerates innovation.
Contact: Asha.Kulkarni@ltsct.com / JRN@ltsct.com

Find us on:

www.ltsct.com

Linkedin