



# ENABLING THE AGE OF **INTELLIGENT MACHINES**



# Scalable, Securely Connected, AI-enabled Microcontrollers and Fusion Processors to Power the Smart Devices of Tomorrow

*The Internet of Things revolution has arrived. Today, we are surrounded by smart, connected devices that help us perform daily tasks, provide useful automation, control and monitor our environment, keep track of where things are located, and more. Smart devices are most useful when they seamlessly integrate into your daily life and routines while performing tasks quickly, correctly, non-intrusively, and maintain a strong level of security to prevent your information, or the device itself from being compromised.*

## **Alif Semiconductor™ is closing the gap**

*In the past, developers of these smart IoT devices had to source fundamental technology blocks by piecemeal procurement, of varied effectiveness, and spend excessive time and effort integrating them to create their desired solutions. Alif Semiconductor was founded in 2019 to address this problem and close the gap between what is required by developers versus what is available in the market.*



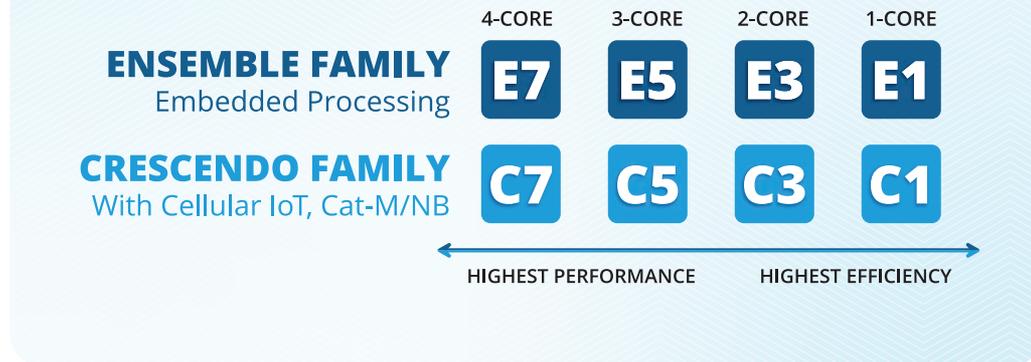
## A modern, revolutionary platform

Alif Semiconductor has developed an innovative technology platform with the range and functional completeness that enables developers to design entire IoT systems using a single chip. This platform at its core is built around a scalability concept that allows movement up and down a wide performance continuum as needed, without requiring architectural changes that force costly software rewrites and migration exercises along the way.

Alif's platform brings scalable, genuinely power-efficient embedded controllers integrated with Artificial Intelligence/Machine Learning (AI/ML) acceleration, multi-layered security, cellular IoT connectivity, global positioning, all the required interfaces, and plenty of integrated memory to enable the design of smart IoT devices where processing can be done locally or in the cloud. Alif has created two product families from the platform.

### Highly scalable families of embedded controllers

The Ensemble™ family is built on the latest generation embedded processing technology that scales from single Arm® Cortex®-M55 microcontrollers (MCUs) to a new class of multi-core devices — fusion processors — that blend up to two Cortex-M55 MCU cores, up to two Cortex-A32 microprocessors (MPU) cores capable of running high-level operating systems, and up to two Arm Ethos™-U55 microNPUs for AI/ML acceleration. Ensemble family devices contain an advanced secure enclave that provides multiple layers of security, such as device integrity protection, secure identity and strong root-of-trust, secure lifecycle management, and more. Together with large on-chip SRAM and non-volatile memory, accelerated graphics, imaging, and class-leading power characteristics, the



Ensemble family is ideal for smart home products, appliances, point-of-sale, robotics applications, and much more.

The Crescendo™ family offers the same functionality as the Ensemble family, and adds LTE Cat-M1 and NB-IoT cellular connectivity, optional integrated SIM (iSIM) for simplified subscriber management, integrated radio, radio frequency (RF) power amplifiers, and a concurrent Global Navigation Satellite System (GNSS) receiver for positioning, thus delivering the key capabilities required for next-generation smart city, connected infrastructure, asset tracking, healthcare devices, wearables and more, in a single chip.

## aiPM™ technology to extend battery life

Many deployed IoT devices are battery powered, and battery life is critically challenged when there is a high requirement for local processing, AI/ML, and wireless communication.

To address this, Alif Semiconductor is introducing its exclusive aiPM™ technology that essentially  powers on only sections of the chip that are needed, when they are needed, and off when they're not based on the immediate processing load per use case. This makes even the complex quad-core devices behave like small purpose-built low-power MCUs when they need to, enabling smart IoT devices to run longer on smaller batteries.

## Ensemble™ and Crescendo™ family features and benefits\*

### Fusion processors, a new category of embedded controllers

- Fusion processors blend MCU cores, MPU cores, and AI/ML acceleration into a single device
- Operating system diversity, get the best of both. For example, Linux can run on MPUs for networking and graphics, RTOS can run on MCUs for real time control, while AI/ML inferencing is accelerated in hardware – all simultaneously

- Alif takes this a step further because device resources (memory, peripherals, interrupts, events, etc.) are assigned and safely shared among these masters based on the developer's choice, not fixed assignments, as products in market have today
- Devices use a common “fabric” of bus structure, peripherals, firewalls, power management, interrupt handling, etc. that make it easier for Alif to create derivative devices, but more importantly it makes it easier for developers to re-use software from one project to the next

## THE SCALABLE PERFORMANCE OF THE ENSEMBLE™ & CRESCENDO™ FAMILIES

	Quad-Core Fusion Processor 		Triple-Core Fusion Processor 		Dual-Core MCU 		Single-Core MCU 
Real-Time MCU Core	Cortex-M55 160 MHz	Cortex-M55 400 MHz	Cortex-M55 160 MHz	Cortex-M55 400 MHz	Cortex-M55 160 MHz	Cortex-M55 400 MHz	Cortex-M55 160 MHz
MicroNPU AI/ML Accelerator	Ethos-U55 128 MAC/c	Ethos-U55 256 MAC/c	Ethos-U55 128 MAC/c	Ethos-U55 256 MAC/c	Ethos-U55 128 MAC/c	Ethos-U55 256 MAC/c	Ethos-U55 128 MAC/c
Application MPU Core	Cortex-A32 800 MHz	Cortex-A32 800 MHz	Cortex-A32 800 MHz				

### Smart power management through Alif's aiPM™ technology

- aiPM™ technology is a blend of the use of:
  - Several independent smart power domains that can decide to shut down autonomously when there is no activity
  - Internal power conditioning, sequencing, and regulation, eliminating the need to use an external PMIC (Power Management IC) device
  - Close connection to the interconnection bus fabric
  - Software configuration
- The sum of this essentially powers on only sections of the chip that are needed, when they are needed, and off when they're not depending on immediate processing load per use case

## Measured AI/ML Performance

Image Classification, for 1 inference, M-55 + U-55 is:

**800x faster** than previous gen Cortex-M  
**78x faster** than M-55 alone (8 vs 624 msec)  
**76x less energy** than M-55 alone (3 vs 228 mJ)

MobileNet V2 1.0 Model

### Beyond aiPM™ technology, more intelligent methods that reduce power consumption

- Multi-core devices are architected in such a way to dedicate the high-efficiency pair of Cortex-M55 MCU/Ethos-U55 NPU to operate at very low power levels while sensing the surroundings (vibration, sound, image, etc.). The high-efficiency Cortex-M55 MCU will then wake up other portions of the device (high-performance Cortex-M55/Ethos-U55, Cortex-A32's, graphics, USB, etc.) in an escalated way as needed to execute the workload based on the immediate use case. aiPM™ technology will take care of shutting them off when no longer needed

- Power consumption, measured at the device pin while operating at 3.3V
  - STOP mode, less than 1.0 uA, with Real-Time Clock running, wake sources active
  - RUN mode, 18 uA/MHz, with Cortex-M55 CPU running code from SRAM

## Multi-layer security

- Provides multiple layers of defense that protect and restrict access from rogue software attacks, protects secure credentials and provides an additional level of security beyond TrustZone 
- A separate isolated security subsystem, like a Secure Element with its own CPU core and memory, plus immutable secure key storage, and secure cryptographic hardware acceleration
- Secure boot with signature-based code images
- Extensive bus fabric firewalls provide low level hardware protection against illegal bus transactions and allows users to restrict access to various chip resources to a given core
- Device-wide hypervisor functions to manage security policies, secure software updates and coordinates device power management
- The sum of these security features enable secure life cycle management of an end-product from manufacture through deployment, maintenance, and retirement
- Developers can choose to use a subset of these security features, but once the features are enabled, they remain in effect through entire life cycle of an end-product

## Key available peripherals, interfaces, and memory

- High speed connectivity: USB-HS, Ethernet 10/100, SDIO
- Memory expansion: OctalSPI, SD/MMC
- Display and Graphics: MIPI-DSI, Parallel RGB, 2D Graphic Acceleration
- Image: MIPI-CSI, Parallel Camera Interface
- Serial: I3C, I2C, CAN, SPI, UART
- Audio: PDM, I2S
- Analog: ADC, DAC, Comparator
- Memory: Kbytes to Mbytes of on-chip SRAM and Non-Volatile Memory

## Packages

- Very small Wafer Level Chip Scale Packages (WLCSP)
- Dual-Row Quad-Flat No-Leads (DR-QFN) packages for easy circuit board layout, Ensemble family only

## Flexible, intuitive software development

- Common chip fabric allows reuse of software engineering resources across multiple end-products
- Alif's device configuration tool simplifies the start of a new design and reduces coding errors from the beginning
- Major 3rd party tool chains, debuggers, and software development environments support Alif device families, including support to easily translate and compile popular machine learning frameworks
- Alif DevKits (development kits) provide a hardware platform for fast prototyping and evaluation

## Additional features of the Crescendo™ family

### On-chip wireless LTE cellular IoT

- Alif's own cellular IoT technology for Cat-M and NB-IoT
- Includes cellular modem, protocol stack, RF transceiver, RF power amplifiers (PA)
- Modem operates independently, does not consume processor or memory resources needed by the user application
- Cellular radio will address global bands and includes two RF PA's for low and high band ranges, and the PA's are integrated monolithically on the die. This eliminates the need to use external PA components, reducing the bill of materials
- Very few components are required outside Alif's device to complete the RF design all the way to the antenna, because Alif devices include ample on-chip memory and complete power management, there is no need to use external memory devices in most cases, nor any need for a PMIC. This means RF modules become smaller and simplified

### On-chip integrated SIM (iSIM)

- Eliminates need for plastic SIM cards, or external embedded SIM (eSIM) devices to establish connection to mobile operator networks, overcoming barriers to designing for deployed intelligent IoT edge nodes
- Alif devices do support the external interface for SIM and eSIM if needed

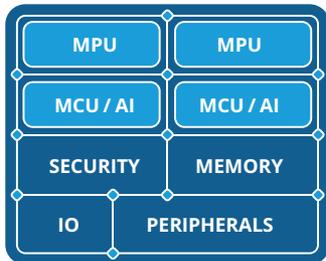
### Global Positioning

- A GNSS RF receiver is included on the die which enables reception of precision positioning data using constellations of global satellites serving GPS, Galileo, GLONASS, BeiDou, QZSS, and other positioning systems
- The GNSS receiver operates concurrently with the modem, no need to timeshare the functionality, and it does not consume processing or memory resources needed by the user application

*The highly integrated design of Alif's devices help **shrink and simplify RF modules.***

# Ensemble™: High-performance embedded controllers with diverse abilities.

Quad-Core  
Fusion Processor



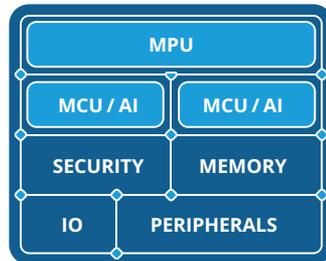
**E7**

Linux-capable dual application cores, and dual real-time cores with security, AI/ML, graphics, imaging, and more.

**APPLICATIONS INCLUDE:**

- **Building Automation**
- **EV Recharging Station**
- **Point-of-Sale Systems**

Triple-Core  
Fusion Processor



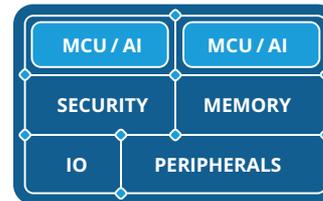
**E5**

Linux-capable single application core, and dual real-time cores with security, AI/ML, imaging, and more.

**APPLICATIONS INCLUDE:**

- **Robotics**
- **Appliances**
- **Graphical Control Panels**

Dual-Core  
Microcontroller



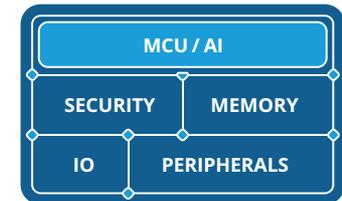
**E3**

Dual real-time cores with security, AI/ML, imaging and more.

**APPLICATIONS INCLUDE:**

- **Barcode Scanners**
- **Failure Prediction**
- **Portable Healthcare**

Single-Core  
Microcontroller



**E1**

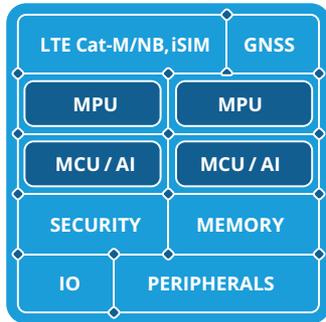
Single real-time core with security, AI/ML, imaging, and more.

**APPLICATIONS INCLUDE:**

- **Lighting Control**
- **Smart Homes**
- **Industrial Sense/Control**

# Crescendo™: Power-efficient, cellular-connected controllers at the edge.

Quad-Core Fusion Processor Cellular



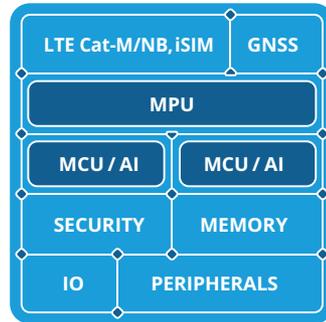
**C7**

Linux-capable dual application cores, and dual real-time cores with cellular IoT modem, iSIM, positioning, security, AI/ML, graphics, imaging, and more.

**APPLICATIONS INCLUDE:**

- *Vending machines*
- *Biometric access control*
- *Mobile point-of-sale*

Triple-Core Fusion Processor Cellular



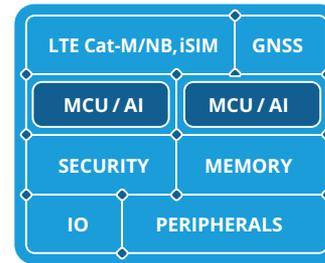
**C5**

Linux-capable single application core, and dual real-time cores with cellular IoT modem, iSIM, positioning, security, AI/ML, graphics, imaging, and more.

**APPLICATIONS INCLUDE:**

- *Wearables*
- *Telehealth*
- *Smart Speakers*

Dual-Core Microcontroller Cellular



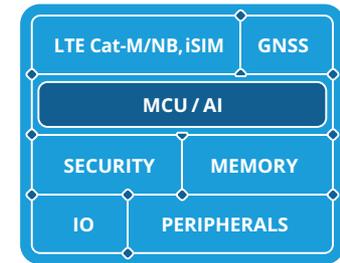
**C3**

Dual real-time cores with cellular IoT modem, iSIM, positioning, security, AI/ML, imaging, and more.

**APPLICATIONS INCLUDE:**

- *Fitness Wearables*
- *AI Camera*
- *Smart City Infrastructure*

Single-Core Microcontroller Cellular



**C1**

Single real-time core with cellular IoT modem, iSIM, positioning, security, AI/ML, imaging, and more.

**APPLICATIONS INCLUDE:**

- *Cargo Trackers*
- *Utility Meters*
- *Fleet Management*

## Leading-edge, scalable capabilities for development

Success in developing and deploying tomorrow's IoT devices depends on access to the most effective and efficient processing technology. Alif Semiconductor's device families deliver this technology today, enabling developers to create smart IoT devices across a wide application spectrum.



MOBILE POS



INDUSTRIAL



BIOMETRIC ID



SMART SPEAKER



PARKING FINDER



PORTABLE MEDICAL



RECHARGE STATION



VENDING MACHINE



WEARABLE



SMART LIGHTING



PROCESS CONTROL



DRONE



SMART APPLIANCE



SMART METER



ASSET TRACKER



TRAFFIC FLOW



SMART HOME



AI CAMERA



SCANNER



FLEET MANAGEMENT



## **ALIF SEMICONDUCTOR**

*fills the gap that exists in the current semiconductor market by providing the highly scalable Ensemble™ and Crescendo™ families. For the age of intelligent machines, these device families enable developers to create intelligent IoT applications **without limitations.***

For more information about the Alif MCUs and fusion processors, **visit [www.alifsemi.com](http://www.alifsemi.com).**



**Alif Semiconductor** was founded in 2019 with the vision to address the rapidly growing market need for broad, scalable and connected AI-enabled embedded computing solutions that are genuinely power efficient. Alif Semiconductor created a new class of embedded controllers – fusion processors – that enable seamless integration of technology for everyday life by unlocking innovative low-power techniques, unparalleled functional integration, accelerated AI and ML edge processing, high security, ubiquitous wireless connectivity and operating system diversity. For more information, visit **[www.alifsemi.com](http://www.alifsemi.com)**.