



# Welcome to the IoT universe



## More than just advanced technology solutions

Acal BFi are not a distributor. We are a group of technical specialists who use leading-edge technology to create custom solutions for your designs and applications, supporting hundreds of customers across Europe.

Our engineers are subject-matter specialists who combine their technology expertise with sector experience to find the right solution for your situation and application.

Whether you take this brochure for inspiration, are evaluating our offer or only just discovering us for the first time, this is just a sample of how we can help you succeed in the IoT universe.

The most important thing for us is to find or create the right solution for your requirements. So, when you are ready, simply contact any of our offices across Europe, and we will be happy to help you with your next challenge.

## Design and consultancy

We find the right solution for your exact requirements, providing impartial advice and technical support. Put simply, we make the impossible possible and help you bring better solutions to market faster.



## Technical support

Our engineers are trained by our partner suppliers and combine years of experience to act as expert extensions of your in-house teams, supporting you from concept to post-production.

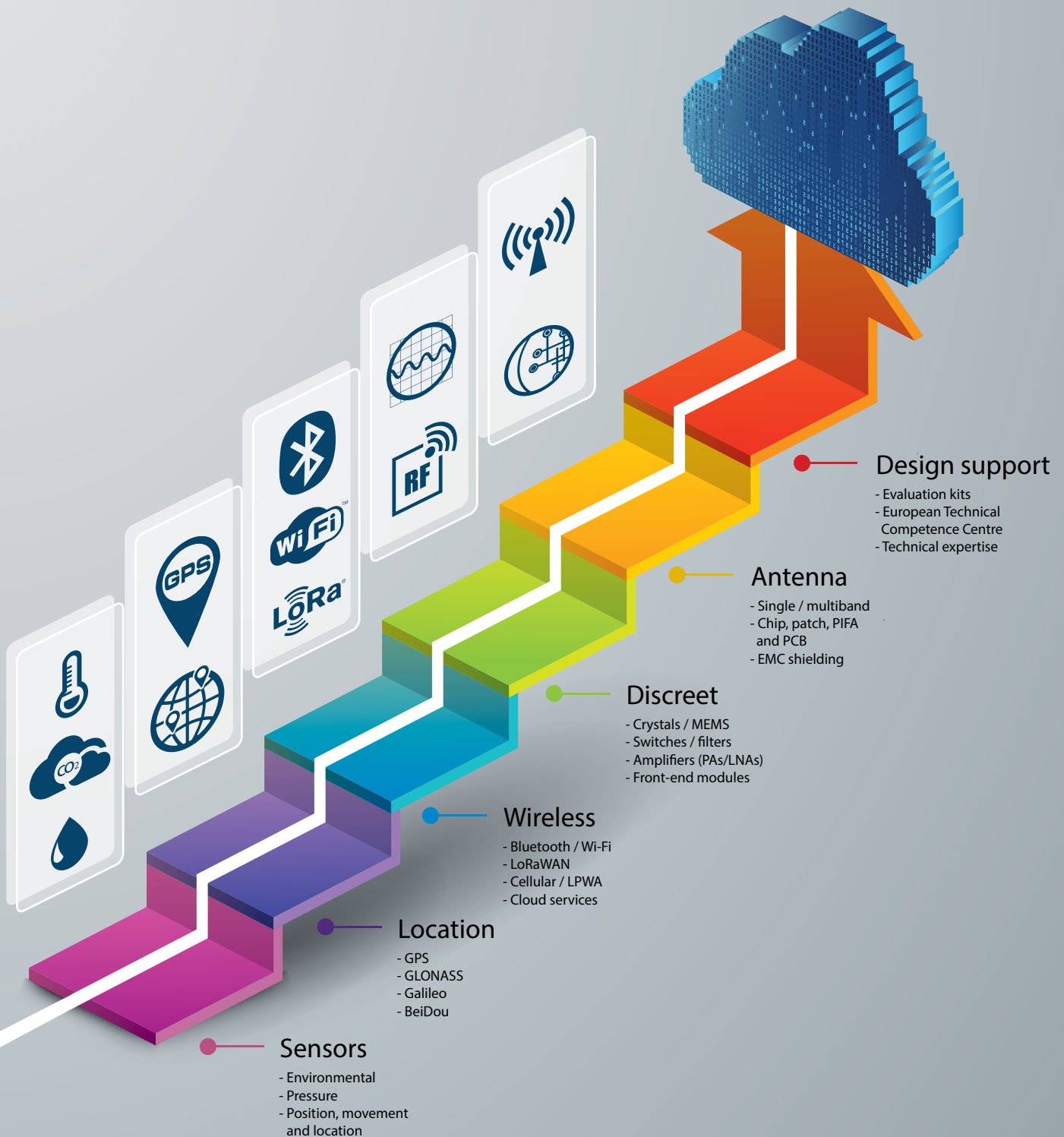


## Products and solutions

We have partnered with global technology leaders to provide you with unprecedented access to a solutions portfolio like no other, offering multiple component options for every aspect of an IoT device.



# From sensors to the cloud



# Technical support for your sector

By 2023 more than 51bn devices are expected to be connected to the Internet of Things (IoT), with a market value of more than \$700bn. One thing is certain – the IoT universe will keep expanding, with or without you.

Acal BFi are here to ensure you are at the forefront of this growth by keeping your solutions ahead of the curve with market-leading designs and technologies.

Within our portfolio we offer solutions perfectly suited to all applications.

## Industrial



- Robust
- Extended-temperature range
- Dependable
- Cellular solutions
- Common form factors

## Medical



- Certified
- Mission critical
- Multiple technologies
- Low power
- Secure

## Transport



- Rugged
- Wide temperature range
- Certified
- Reliable
- High-power switches

Intelligent safety



Digital metering



Medical device deployment



Patient motion control



People tracking



Asset tracking



Waste management



Digital signage



We have supported every sector with innovative technology for decades. Our experienced Field Application Engineers ensure you have the best solution for your requirements.

We also understand that although many IoT designs are based on the same principle of gathering, sharing and analysing data and information, each application has its own, very specific requirements – whether this is cost, reliability, ruggedness, power consumption, weight or size.

### Smart home



- Compact
- Best-in-class FEMs
- Low power
- Highly efficient
- Wide range of technologies

### Wearables



- Ultra compact
- Combination technologies
- MEMS and crystals
- Wide range of FEMs
- Best-in-class SiPs and SoCs

### Smart energy



- Global standards
- Long-range wireless
- Certified
- Air-time services
- Easy integration

#### Smart city infrastructure



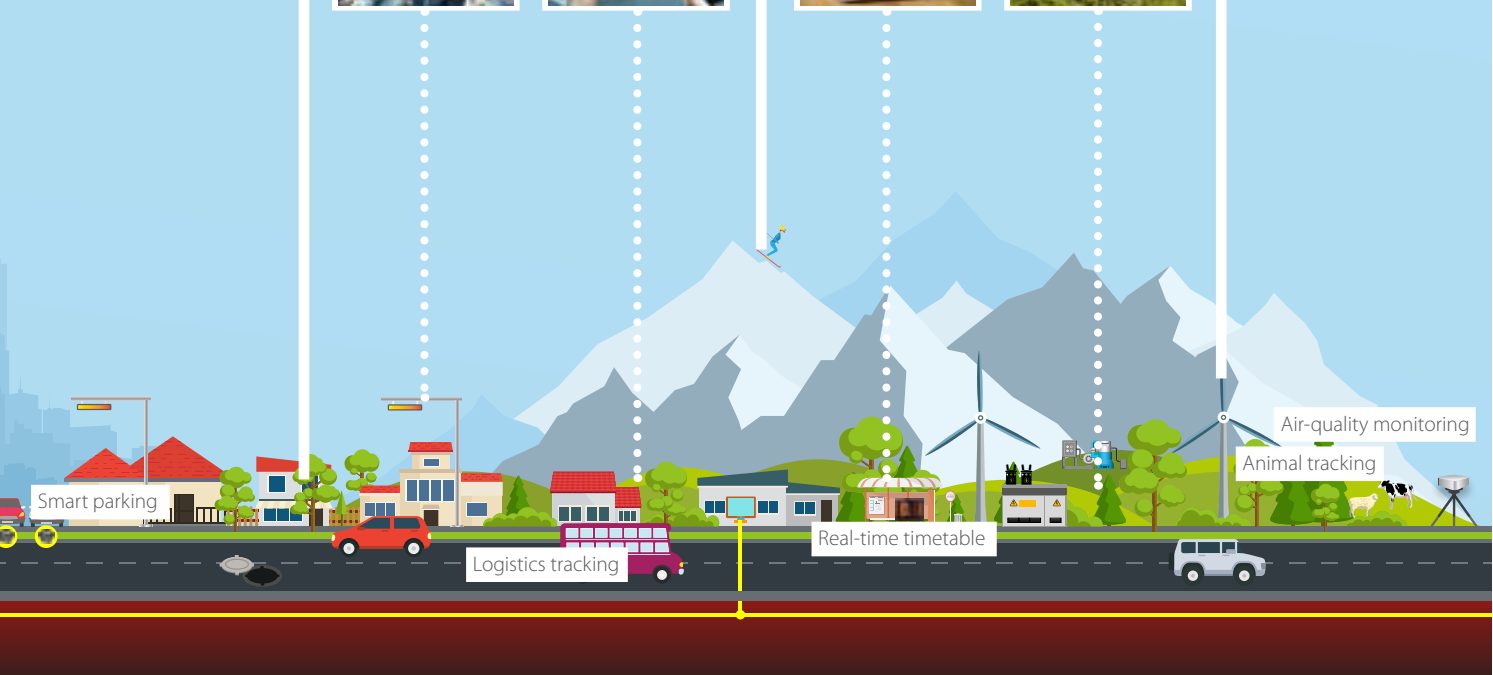
#### Smart HVAC systems



#### Wireless meter reading



#### Remote crop irrigation





# Sensors

## Bringing the physical world into a digital universe

For any data journey, the data must first be generated and collated, so let's start our IoT journey with our comprehensive sensor range.

With our miniature, low-power sensors you can measure almost any physical parameter from almost anywhere in the world. And you can be sure the data is as accurate and reliable as if you had measured it yourself with our high-quality, robust solutions.

### Environmental

#### Gas

- VoC, CO, CO<sub>2</sub> and air-quality monitoring
- Wall-mounted, duct-mounted, handheld and PCB-mount versions for domestic and industrial applications
- No calibration required
- High-accuracy, wide measurement range

#### Dust, smoke and particle

- PM1.0, PM2.5 and PM10.0 sensors

#### Temperature

- Thermistor elements and sensors
- Clip sensors, platinum sensors and thermocouples
- Overmoulded temperature probes, waterproof to IP68

#### Humidity

- Small size and low weight – leaded and SMD variants
- Analogue and digital output variants
- Low-power variants

#### Combination

- Relative humidity (RH) and temperature
- Dust, CO<sub>2</sub>, VOC, RH and temperature



### Custom solutions

From simple sensor combinations to complete, custom products, we can design and build a complete solution to your specific application needs. We can also combine multiple sensors with wireless connectivity, display/controllers and enclosures.

#### Wireless options

- Bluetooth®
- Wi-Fi
- LoRa®
- Cellular

#### Interface options

- HMI
- Display
- Packaging



From highly precise measurements in demanding, harsh environments to combination sensors for smart home products, we can provide the knowledge, expertise and solutions required to start your IoT journey.

## Pressure

- Board-mount through to heavy-duty industrial solutions
- Amplified and unamplified, analogue and digital output
- Absolute, differential and gauge pressure
- Wide range of port and termination styles



## Position, movement and location

### Accelerometers

- Low-power, digital-output, miniature LGA packages
- MEMS-based, three-axis, measuring tilt, motion and shock

### Gyro / angular rate

- High-performance MEMS inertial sensors
- Best-in-class bias stability and angular random walk
- Packaged, multi-axis inertial solutions

### Position

- Linear and rotary position sensors
- Cable-extension transducers
- Non-contacting, Hall-Effect, rotary position sensors

### Vibration, tilt and acceleration

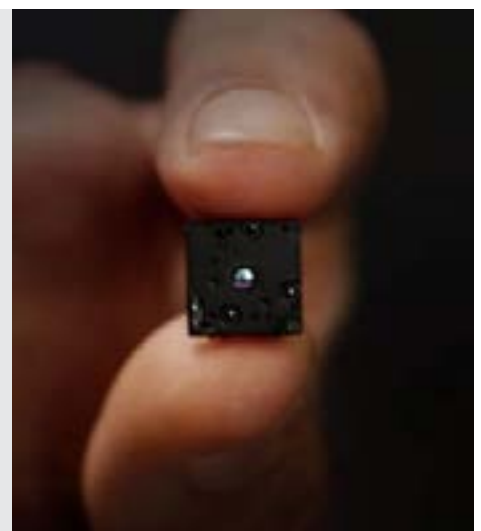
- High-performance MEMS capacitive accelerometers
- Long-term stability in harsh environments
- Wide temperature range from -40 to 175°C
- Lowest noise and non-linearity
- High stability under shock and vibration



## Gain greater situation intelligence with one tiny thermal-imaging solution

When operating over a large area, such as in a public space, conference hall, industrial facility or outdoor location, designs can often benefit from observing, monitoring and gathering multiple data points. The FLIR Lepton range of tiny, cost-effective thermal cores can be integrated into your design to give you intelligence beyond the visible spectrum.

This lightweight, low-power solution can be used with even the strictest requirements, from drones to mobile phones. With this enhanced intelligence, your actions can be more effective, whether this is responding to a potential intruder or improving the efficiency of the home.



# Location

## Pinpoint accuracy on a global scale

The IoT universe is a sprawling network of devices creating and sharing data. Location can be a critical part of this, whether it is to provide a location reference or to keep track of your device.

We have a range of multi-GNSS solutions, including modules and System-on-Chip (SoC) solutions to meet your exact requirements, from adding a beneficial feature to being an essential part of your design.

### Key features

- GPS, GLONASS, Galileo and BeiDou
- Integral and external antenna versions
- Very small, surface-mount form factors
- Rapid time to first fix (TTFF), as low as 1s from hot start
- Excellent accuracy, within 1-2m
- Multiple power-management options

### Modules

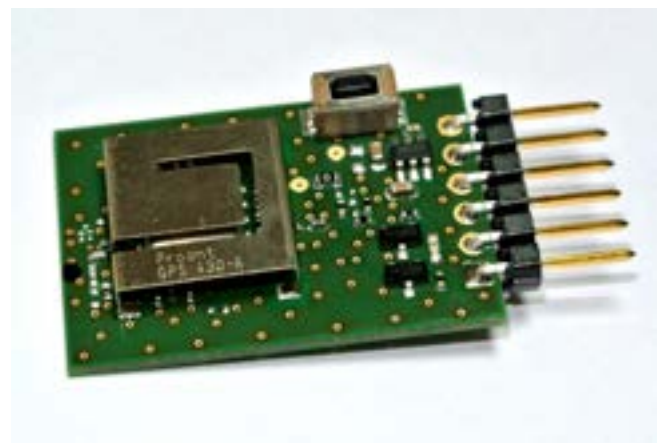
Our module range is easy to integrate from both hardware and software perspectives. It includes the smallest, fully integrated solutions on the market for both navigation and timing, suitable for a wide range of end markets from tracking to wearables, and from drones to smart cities. The OriginGPS Spider module series provides unmatched sensitivity and uncompromised performance in compact packages for exceptional design flexibility, with the Hornet series also featuring an integrated antenna.



### Get to market faster with our open-source approved reference designs

Whilst layout considerations are relatively straightforward, many engineers are not familiar with on-board RF antenna requirements. Our European Technical Competence Centre supports customers with open-source reference designs with Proant antennas.

Our layouts are fully approved by suppliers and can easily be adapted for other modules or antennas. The designs can be used as a plug-in board to easily add GNSS functionality, or as a reference PCB layout that can be used as part of a cut-and-paste approach, saving time in the design process.





Whether you are using location services as a reference for the data you are gathering, or to keep track of your asset in the field, we have a range of solutions for your needs.

## Introducing OriginIoT™ systems – develop your IoT device in just six weeks

These cellular IoT systems expedite the device development programme with minimal required expertise in electrical engineering, RF and embedded programming. The combination of high-quality GNSS, GSM/LTE communications with a wide variety of interfaces provides you with a strong hardware platform to develop low-power, high-performance IoT products.

Augment your creations by quickly integrating technologies, including power management, measurement sensors, Wi-Fi and Bluetooth® modules and encryption components.

- Low-power consumption
- No additional embedded code required
- Full cellular technology range
- Saves development resources
- Interfacable to 100+ sensors and devices
- Superior GNSS/cellular matching



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### System-on-Chip

For high-volume applications, you could benefit from integrating an SoC solution. We can provide you with unique access to the portfolio of chip-based location intelligence solutions from Airoha (a MediaTek company), with the technical expertise to integrate this innovative technology into both new and existing designs.

#### The MT333(x) series from Airoha

Airoha are an industry leader providing location intelligence to millions of devices in almost every sector and category – including mobile, automotive, timing, personal tracker and industrial applications. Their MT333(x) GNSS chipset family delivers positioning accuracy of up to 2.5m, GPS time reference accuracy of  $\pm 10$ ns, and rapid TTFF and power efficiency as low as 3mW – all key requirements in today's IoT applications.

#### Key features

- GPS, GLONASS, BeiDou and Galileo receivers
- SBAS, QZSS, DGPS (RTCM) and AGPS support
- -165dBm tracking sensitivity
- 5~19mA continuous-tracking power consumption
- AlwaysLocate™ technology for reduced power consumption
- Includes CMOS RF, digital baseband, ARM7 CPU and embedded NOR Flash

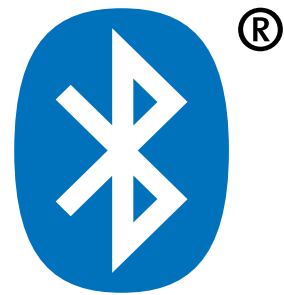


### Get the most from your design with the right antenna

The antenna is a critical part of your design and can literally make or break your final product. Discover our range of internal, external, custom, single and multiband antennas on page 26.



Thanks to its lightweight stack and user familiarity, Bluetooth® technology is widely used in multiple sectors, with a huge number of Bluetooth-enabled products in the marketplace. Bluetooth low energy (4.1, 4.2 and 5.0) enables very low-power applications to use this popular wireless standard.



### Modules

For quick enablement, our range of Bluetooth modules cannot be beaten. Through a serial port – UART, or SPI – pre-configured modules from Sierra Wireless can be added to your design to quickly provide wireless communication with other local devices.

These compact, hostless modules feature dual-mode Bluetooth – both classic and Bluetooth low energy – with integrated antenna and regulatory certifications for easy integration. The range features embedded protocol stacks with simple UART and GPIO interfaces for command and control, and supports multiple connections to external (audio) codecs with I2S, PCM and SPDIF interfaces.



### System-in-Package

For applications requiring a higher degree of flexibility and customisation with low-power consumption, we offer a range of Bluetooth System-in-Package (SiP) solutions ideal for mid- to high-volume applications.

Fully compliant with Bluetooth classic and low-energy standards, SiP solutions from USI and Airoha pack built-in antennas and stand-alone baseband processors with integrated transceivers into a compact form factor.



### System-on-Chip

Engineers and designers can also benefit from ultra-compact solutions from Airoha. Their range of wireless data and audio SoCs empower millions of devices around the world, including headsets, speakers, keyboards, remote controls, 3D glasses and voice controlled virtual assistants.

These advanced chips are available as a single-mode solution, with Bluetooth low energy, and as a dual-mode solution to include Bluetooth classic with low-energy profiles.

These tightly integrated chips integrate baseband and radio for intensive audio applications with built-in noise reduction and echo cancellation functions to further enhance the voice quality. High audio quality is combined with low latency, enabling entirely new categories of products and markets.



# Combined technologies

Reduce board space and power consumption while improving time to market

Combining technologies can bring a host of cost, design and capability benefits. We offer a range of combined technology modules, SiPs and SoCs to meet design requirements, offering a mix of two or more technologies in one compact solution.

## Wi-Fi and Bluetooth

As two of the most prolific wireless technologies in the world, it is often common for designers to integrate both Bluetooth and Wi-Fi into their design. We offer a huge range of solutions for you to integrate multiple Wi-Fi and Bluetooth standards into your design.

Modules offer the quickest and easiest solution of adding these complementary wireless technologies to your design, while volume applications could benefit from a SiP solution from USI or a SoC solution from Airoha. SiPs and SoCs are the most compact, cost-effective methods of adding both Wi-Fi and Bluetooth to higher-volume applications.



## Bluetooth and location

Many mobile, wearable and peripheral devices use Bluetooth to communicate over a short distance. More designers are now opting to collect data and information, such as location, speed and bio-data, over a period of time to share this with a parent device when in range of Bluetooth.

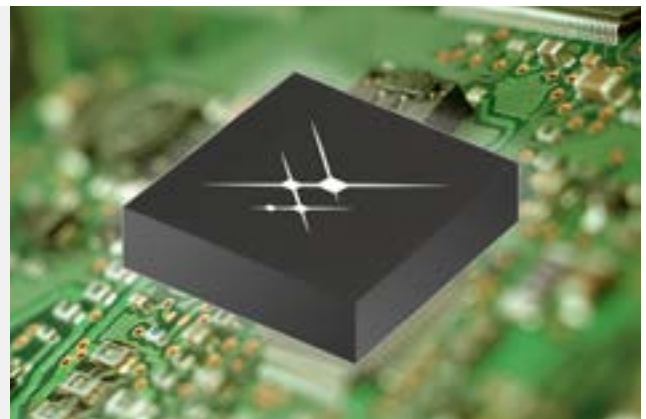
Airoha also offer a range of highly integrated SiPs that contain a microcontroller unit, low-power GNSS chip, dual-mode Bluetooth and a power management unit (PMU) for such requirements. The multi-GNSS RF SoC inside supports multiple location and navigation applications with the advantages of Bluetooth low energy and Bluetooth classic (dual-mode) connectivity.



## Enhancing the performance of your design

Front-end modules (FEMs) do more than increase the wireless range of SoC solutions – they can also lower the power consumption of your design and increase the battery life. Greater range and more powerful wireless signals can also improve reliability, providing your customer with a premium product without the associated costs.

Turn to page 25 to find out more about FEMs.



# Wi-Fi / embedded Ethernet

A fast, reliable and efficient way of transferring large amounts of data

As more devices use this technology to communicate with other devices, services and even users, the requirements for Ethernet and Wi-Fi solutions have become more demanding.

We offer a range of solutions for all levels of integration, from industrial and professional grade Wi-Fi modules that are quick and easy to integrate with on-board software stacks and device servers, to some of the most compact and advanced solutions in the world – including cutting-edge SiP and SoC solutions from industry leaders USI and Airoha.

## Key features

- Complete device server application with full IP stack and webserver
- Production ready, easy to configure, with zero host load
- 802.11 a/b/g/n/ac support
- Single and dual band, 2.4GHz and 5GHz
- Secure – IEEE 802.11i WPA-personal, WPA2-personal, 256-bit AES
- Modular RF certification – FCC Class B, UL and EN EMC certification, CE RED
- Industrial temperature range (-40 to 85°C)
- Integrated and external antenna versions, with or without antenna diversity



## Modules and embedded solutions

Modules and embedded solutions make it easy to add Wi-Fi connectivity to your design, by providing an AT-like command set over a serial interface that easily connects to any host via an SPI, USB (device) or serial interface. Put simply, we have a quick-to-integrate solution for almost any application within our vast portfolio.

Our experienced Field Application Engineers can recommend the most appropriate solution based on your specific requirements, preferred form factor and price/performance balance. SparkLAN, for example, offer a range of solutions ideal for industrial and professional applications, and could even benefit top-end, premium consumer products where failure is not an option, from thermostats to wireless projectors.

## Industrial and professional grades

Our wide range of Wi-Fi cards include rugged, industrial-grade solutions from world-leading manufacturers in the most commonly used form factors. Our professional-grade solutions offer all the advantages of our industrial range in a more cost-effective package for less extreme environments.

Our modules are simple to integrate, allowing you to add Wi-Fi capabilities without any prior knowledge of wireless technologies. Configuration of modules is via a built-in webserver, which is very easy to use. Many include dual-band Wi-Fi and can be combined with other technologies such as Bluetooth (see page 11).

Our partner relationships with chip manufacturers can help you gain certification for any global location and can provide you with access to dedicated software teams who can develop special drivers and support open source drivers.





Wi-Fi is one of the most popular wireless technologies on the market, with more developers using it to make an increasingly diverse range of products smart, expanding and broadening the Internet of Things.

## System-in-Package

For medium- and high-volume projects, we offer SiP solutions from USI, which provide excellent power-management performance to deliver low-power consumption and extended battery life.

- IEEE 802.11b/g and 802.11n 1x1 single-band 2.4GHz and dual band, with or without Bluetooth
- Advanced security with WEP 64/128, WPA and TKIP, AES, CCX
- WAPI support
- Wi-Fi direct and software AP function
- Simple APIs to access Wi-Fi and network functions
- Serial interface to host – SPI, UART and USB
- RF certification – FCC, CE – with metal-lid shielding

## System-on-Chip

Medium- and high-volume applications can also benefit from tightly integrated SoC solutions. Airoha increase opportunities for developers to build connected home software and innovative devices through their range of power-efficient Wi-Fi products.

With advanced security and rich peripheral interface, their chips support everything from smart plugs to industrial robotics.

- Highly integrated, compact solutions with RF, MCU and memory
- Low-power mode with RTC
- Multiple Wi-Fi standards available, including dual-band Wi-Fi for faster transmission speeds
- Integrated 4Kbit eFuse to store device-specific information and RF calibration data
- Available with advanced Wi-Fi/Bluetooth combinations
- Multiple peripherals, including UART, I2C, SPI, I2S, PWM, IrDA and auxiliary ADC available
- Can also include embedded SRAM/ROM



## Wi-Fi module for industrial and commercial applications

For mission-critical applications, we offer solutions that provide 5G Wi-Fi (802.11ac) connectivity. Available with a production-ready software stack, enterprise-class security and modular RF certification, these solutions reduce development and deployment risks and accelerate the availability of robust WLAN connected IoT products.

- Dual-band 2.4 and 5GHz Wi-Fi
- IEEE 802.11b/g/n and IEEE802.11ac support
- Extensive security
- Certified including FCC and CEM





LoRaWAN™ is designed to enable very low-power devices, such as battery-powered sensor modules, to easily communicate at regional, national and even global levels. Using a star-of-stars network topology, LoRaWAN provides secure, bi-directional, multicast communication between end devices and gateways connected to the network server via standard IP connections.

End devices and gateways communicate across different frequency channels and data rates, allowing you to find the right balance of data rate, distance and power consumption within your design. To maximise both the battery life of the end devices and the overall network capacity, the LoRaWAN network server manages each end device individually by means of an adaptive data rate (ADR) scheme.

We support all levels of integration for you to bring LoRaWAN-enabled devices to market quickly and effectively.



### Create your LoRaWAN network

At the heart of every LoRaWAN network are gateways which manage high volumes of LoRaWAN-enabled end devices and transfer information from your LoRaWAN network to the Cloud via other wired or wireless interfaces.

These multi-service, upgradable platforms provide a cost-effective solution capable of managing thousands of bi-directional messages between multiple end devices over vast distances of up to 15km in rural environments.

Our range of gateways offer network connectivity via a number of wired and wireless interfaces, including but not limited to Ethernet, cellular, Wi-Fi and Zigbee. Our range also includes Power over Ethernet (PoE) and GPS functionality.

Gateways are available with IP67-rated enclosures for outdoor usage and can be preloaded with firmware to your requirements/configurations or with the most well-known LoRaWAN network provider's configuration.



### Try LoRaWAN with the Embit evaluation kit

Develop your LoRaWAN application and manage compatible LoRaWAN eco-systems with our comprehensive evaluation kits from Embit. Thanks to their many interfaces and multiple evaluation boards, these kits enable a fast development-deploy-debugging cycle.

We offer a comprehensive range of evaluation kits, to help reduce the time, energy and effort of testing and evaluating both the technology and your design concept, and without the need to create a custom mounting.

See a sample of our evaluation kits on pages 28 and 29.



LoRaWAN enables battery-operated 'things' to connect and share data wirelessly at regional, national and global levels through public and private networks.

## LoRaWAN for end devices

Most end devices in LoRaWAN networks are located remotely, with only a battery source for power. Their situation often requires data to be transferred over a long distance for extended periods of time – sometimes years or even decades.

Our range of compact, low-power solutions include modules, for quick and easy deployment and SiPs, to give designers an even more compact, volume-cost-effective solution.

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### Modules

Our flexible and dynamic module range provides you a choice of ultra-long-range, ultra-low-power solutions, including the most compact solution available today, with a tiny 11 x 11mm form factor. Modules can include Class A, B and C protocols embedded into the module, enabling connection to any LoRaWAN-compliant network infrastructure, with high interference immunity.

Combined with a wide range of serial interfaces – including UART, I2C and SPI ports – and up to 19 digital and four analogue I/O ports, you can quickly and easily add LoRaWAN connectivity to your design with one of our modules.

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### System-in-Package

We also offer a range of stand-alone, compact SiPs for volume applications. Featuring leading chipsets, such as the Semtech SX1272 ultra-long-range wireless transceiver, our SiPs can be integrated through a variety of interfaces, such as LPUART, SPI and I2C. Up to 20 GPIOs enable designers to connect multiple sensors, switches and status LEDs to the SiP, reducing overall power consumption whilst enabling a range of wireless distances.



## LoRa and LoRaWAN – what is the difference?

LoRa and LoRaWAN are inexpensive, long-range methods of connecting IoT devices in rural and remote locations.

**LoRa** – (meaning Long Range) – represents the physical layer of the communication stack. The radio modulation scheme, developed by Semtech, is a good wireless network for IoT solutions, offering a better link budget than other comparable wireless technologies.

**LoRaWAN** – (meaning Long Range Wide Area Network) – is a networking protocol, which exploits LoRa modulation (physical layer). It is designed to connect battery-operated 'things' to the Internet via gateways in a local, regional, national or global network. It provides several key features for IoT applications, including bi-directional communication, end-to-end security, mobility and localisation services.



# Cellular – integrated solutions

## Connect directly to the Cloud

Few technologies offer the flexibility and coverage of cellular, and there are multiple ways of adding direct Cloud connectivity to your design, including modems, gateways and embedded modules.

We are uniquely positioned to support you with the three core elements required for cellular connectivity.

- **Hardware** – a huge range of solutions to meet your design, network and geographic requirements
- **Air-time services** – global air-time data services which can be deployed and managed anywhere with just one SIM
- **Cloud connectivity** – connect to your own Cloud-based server, preferred supplier or with one of our partner suppliers

## Integrate cellular connectivity into your design

One of the most cost-effective and user-friendly ways of adding global wireless connectivity to your design is through an embedded cellular module. As a leading technical design partner to Sierra Wireless, we offer their comprehensive range of 2G, 3G, 4G LTE modules with direct technical support to integrate the technology into your design.



### Sierra Wireless AirPrime® range

#### HL series

Scalable 2G, 3G and 4G modules



Provides a reliable connection in compact design with a long life cycle and the ability to support multiple product lines with a single platform.

- Scalability – 2G, 3G and 4G LTE cat 4, cat 1 and LPWA cat M1/NB1 (NB-IoT)
- Secure and Cloud ready, with FOTA upgrades
- Small and flexible – CF3™ form factor, 15 x 18 or 22 x 23mm, with solder-down or snap-in socket options

#### WP series

3G and 4G smart modules (Linux OS)



Simplifies overall system design with secure device-to-Cloud architecture. Runs a full, embedded Linux OS with the Legato® application framework.

- Cortex A application processor and integrated Flash
- Comprehensive set of interfaces including USB, UART, HSIC, SDIO, I2C, SPI, GPIO, ADC
- 150Mbps DL, 50Mbps UL from LPWA cat M1/NB1 to LTE cat 4

#### MC and EM series

High-speed, standards-based modules



Designed for mobile broadband applications and offering unprecedented LTE speeds on PCI Express Mini Card and M.2 form factors.

- LTE-A cat 12 for download data rates of up to 600Mbit/s
- Global coverage on LTE-advanced networks, only two module variants
- Linux SDK is available to extend control over the module using APIs instead of AT commands

## Start designing today with the mangOH™ Red

Designed specifically for cellular-enabled IoT applications, mangOH™ Red is a sensor-to-Cloud platform which delivers 90% of an IoT prototype out of the box. It features a CF3™ socket for WP and HL modules, Raspberry Pi shield connector and built-in Wi-Fi and Bluetooth. See page 28 for more details.



# Cellular – external and network solutions

## Modems, routers and gateways – the simplest form of cellular connection

Modems routers and gateways are the quickest, most convenient way of enabling wireless capabilities with your device, providing remote configuration, deployment, monitoring and management.

Modems use an existing serial or USB port to connect to your design and provide direct access to the Cloud in minutes. For products with an Ethernet port or Wi-Fi connectivity, gateways provide the same easy access with even greater design flexibility.

Turn to page 12 to see more details on our Wi-Fi solutions.



### GL series

Can immediately connect to any IoT system via a serial or USB high-speed interface to provide essential global 3G and 4G LTE connectivity with integrated fallback options. The industrial-grade, compact design features low-power modes as little as 0.8mA in sleep mode. As a pre-certified product, it is easy to integrate with your products – simply connect this standalone solution to begin sending and receiving data remotely, with enterprise-class quality and reliability.



### FX30

The industry's smallest, rugged 3G/4G LTE cellular gateway integrates the Legato® Open Source Linux Platform and supports Sierra Wireless' flexible *IoT Connector* hardware expansion approach, enabling swift, scalable and global deployments of IoT applications for any connected machine or infrastructure. Based on the WP series modules, running Linux with the Legato application framework, the FX30 can be used as a basis for initial deployments or market trials prior to developing your own device.

## One smart SIM provides global access to more networks than any single mobile network operator

With just one smart SIM, your product benefits from multi-operator, global coverage that is resilient to outages and provides superior data-service quality.

### Key features

- Global multi-operator connectivity with central management
- Resilient to outages with smart network selection
- Integrated data security
- Flexible and scalable

See our range of Cloud services on page 19





# Cellular for low-power applications

## A brand new category of wireless technology for remote device deployment

To implement remote management and collect data from more locations, solutions must overcome the challenges of device cost, power consumption, coverage and capacity. These can be particularly difficult barriers for low-cost or battery-operated devices.

A new type of low-power cellular solution, known as Low Power Wide Area (LPWA), is currently being deployed that overcomes these issues to bring all the benefits of cellular with long battery life (up to 10 years) to more applications than ever before.

### Designed for remote device deployment

**Cost** – more than 50% reduction compared with broadband LTE (close to 2G)

**Current** – more than 100 times lower power than broadband LTE, 10+ year battery life

**Coverage** – more than 20dB increased coverage, compared to broadband LTE

**Capacity** – increasing the number of connected devices in a condensed area (1 million users per square km)

# LPWA

Low Power Wide Area

### Cellular LPWA

'Narrowband IoT' is sometimes used to describe both CAT-NB1 and CAT-M1 technologies. Officially recognised as LPWA technology, CAT-NB1 (or NB-IoT) and CAT-M1 (or LTE-M) provides devices with wireless data connectivity, ranging between 27 and 375kbps.

#### CAT-NB1

Ideal for simpler static sensor applications, it uses both 4G and 2G spectrums to offer data rates ranging from 27kbps DL to 65kbps UL.

#### CAT-M1

CAT-M1 delivers the highest speed of any LPWA technology, supporting voice and roaming on 4G spectrum. With data rates ranging from 300kbps DL to 375kbps UL, it covers a wider LPWA application base.



### LPWA modules from Sierra Wireless

Delivering up to 300Kbps download speed and 375Kbps upload speed, these modules are ideal for simple static-sensor applications, or real-time fixed or mobile applications such as asset tracking and monitoring, industrial equipment, consumer wearables, smart city, healthcare and agricultural monitoring devices.

The HL7800/02 and WP7700/02 modules come in the CF3® form factor and scale, providing connectivity to 3G or 4G networks around the world. The 'xx02' variants of each module also provide further connectivity assurance with 2G fallback for any cellular network in the world.

### Dual-mode modules

#### AirPrime WP7700/02

The WP7700 module for CAT-M1/NB1 worldwide networks is fully compliant with the 3GPP release-13 standard, providing a new low-cost, low-power technology for low-bandwidth IoT applications with extended reach beyond traditional cellular.



#### AirPrime HL7800/02

The HL7800/02 module is the world's smallest multi-mode LPWA module, offering best-in-class power performance for global LTE-M, NB-IoT and GNSS networks. Fully compliant with the 3GPP release-13 standard, it is release-14 ready to support NB2 features in the future.





# Cloud services

## Air-time and Cloud-connectivity services

Regardless of technology, your data needs to be securely stored and analysed. Cloud-based services are a popular choice, providing the benefit of anywhere, anytime access.

We are proud to offer two Cloud-based services – AirVantage® from Sierra Wireless and MACH10™ from Lantronix.

These purpose-built, high-performance platforms provide you with the tools and development community to get your service to market faster, enabling you to focus on your customer experience without worrying about your IoT infrastructure.



### Lantronix MACH10™

The Lantronix MACH10 IoT development and deployment platform provides OEMs and system integrators with an industrial-grade, scalable device-management platform for Lantronix gateways and existing connected devices.

LANTRONIX®

MACH10➤

MACH10 simplifies the process of delivering web-scale applications. It features production-ready features, including extendible, ready-to-use applications which deliver fully functional, robust management tools for immediate deployment. Customers can create multiple, custom interfaces – including look, feel, branding and custom URLs – to meet the needs of multiple users at a global level.

### Software building blocks

Using APIs built on industry-standard protocols, MACH10's suite of essential microservices features pre-tested software building blocks for OEMs to develop new web-scale applications faster, and allows them to focus on their core business logic without needing to build applications from scratch.

### Sierra Wireless AirVantage®

AirVantage powers some of the largest wireless IoT deployments in the industry and is trusted by thousands of organisations to securely connect their remote machines and accelerate the rollout of their connected products and services.

SIERRA  
WIRELESS®

AirVantage  
IoT Platform

### Smart SIM fleet management

Sierra Wireless' smart SIMs enable you to use multiple networks on a global basis. AirVantage offers everything you need for tracking your global SIM inventory, monitoring usage and managing the lifecycles of your Sierra Wireless and legacy SIMs.

Thanks to Sierra Wireless' strong partnerships with global operators, AirVantage is also able to manage SIM cards from most of the other operators you may work with.

# Frequency control

Discover our leading range of quartz- and MEMS-based timing-device solutions

IoT applications often require highly reliable, low-power, cost-effective frequency solutions in small form factors. We offer a leading range of timing device solutions from global leading suppliers – including ACT, SiTime, Taitien and TaiSaw – with the engineering expertise to find and integrate the most suitable solution for your application.

Our range covers:

- 32.768kHz crystals and oscillators
- MHz crystals
- Clock oscillators
- VCXOs / TCXOs / OCXOs
- Real-time clocks
- SAW filters and resonators
- VCO / PLL
- MEMS-based oscillators

## Wide operating temperature, from -40 to 125°C

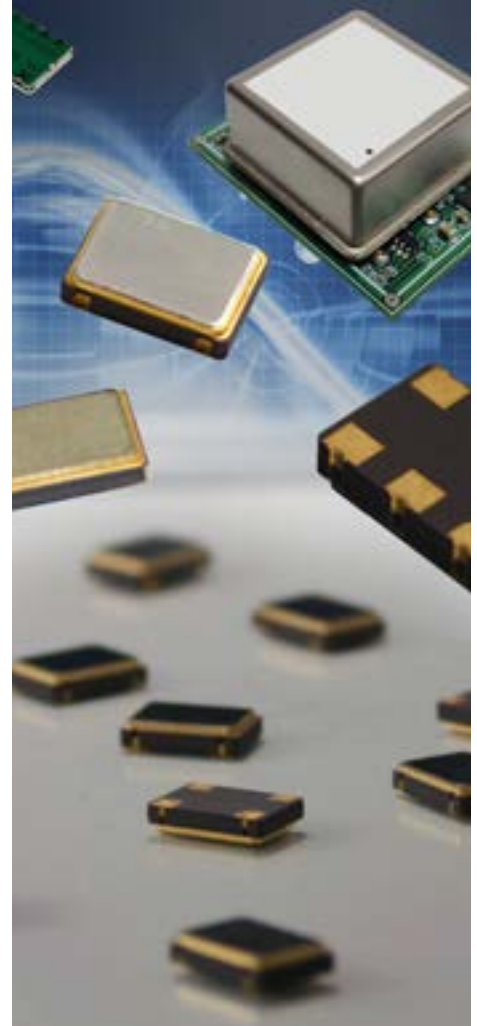
Our portfolio includes leading-edge solutions from TaiSaw, which operate across an extended temperature range from -40 to 125°C. Ideal for demanding applications, these ultra-small, ultra-low-power, surface-mount crystal oscillators can be optimised for industrial applications and the special requirements of the automotive industry (AEC-Q200).

## MEMS-based timing devices

MEMS oscillators combine Micro-Electro-Mechanical-Systems technology with analogue CMOS circuit design to produce a unique, silicon-based timing solution.

These programmable solutions from SiTime boast excellent vibration and mechanical shock resistance with outstanding stability, aging performance and activity levels. In many cases, we can supply a direct, drop-in replacement to your existing solution to avoid design and board changes.

In some cases, MEMS oscillators can offer precise time/clock accuracy with a package that is 85% smaller than the equivalent quartz-based solution. It can also offer significant power savings of up to 30%, with an ultra-low power consumption of just 900nA.



## Advanced support from the experts

ACT – formerly Advanced Crystal Technology – are a leading design partner for high-performance, frequency-control products with more than 30 years' experience. The in-house ACT engineering team can help you choose the right frequency product, provide technical assistance on crystal optimisation with MCU and provide quick sample support to meet your project deadlines.

As part of discoverIE Group plc, ACT can support your frequency-control requirements on a global basis.



## Highly efficient, compact power supplies – perfect for small IoT applications

Critical to an IoT device is power, and RSG, part of the discoverIE group, offer a broad range of lightweight, low-power, compact DC/DC converters from just 0.25W. These are ideally suited for IoT and remote-device designs, even those with the most stringent needs, such as handheld, mobile and wearable devices or peak-load demanding applications such as GSM/UMTS transceivers.

The R-series portfolio includes all packaging options, including SMT, and provides a cost-competitive DC/DC converter and Point-of-Load (PoL) solution at the lowest range of power outputs. These compact components offer very low losses and are therefore highly efficient, conserving power within your design.

Thanks to their efficiency, these converters generate almost no heat, enabling you to further condense the overall size of your design and create sealed products for harsh or remote environment deployment.

### Key features

- Broad power rating – from as low as 0.25 to 60W
- All footprints – SIL3 to SIL12, DIL8 to DIL24, 1x1 to 2x1 inches, THT and SMT
- Various outputs – single, dual, dual-separate, dual-split and triple
- Various load regulations – regulated, semi-regulated and unregulated
- Broad isolation voltages – from 1,000 to 6,000VDC
- Non-isolated, step-down regulators for PoL applications
- CE, UL and other approvals



## Solving conflicting design requirements – low power and long range

Thinnovation's remote asset monitoring solution – *Remon* – required data from sensors to travel up to 10km wirelessly to the Cloud. Installed on vessels in a marina, the design had to operate for at least one year on battery power alone.

### Overcoming impossible requirements with innovative design

Thinnovation contacted us for advice on which wireless technology to use. Analysing the requirements, the resulting solution split the data journey into smaller stages, enabling them to use the most efficient technology at each stage.

Thanks to our wide technical expertise, we were able to suggest the most appropriate wireless technology solutions with total design support, enabling Thinnovation to create a market-leading solution with additional features and increased functionality.



# RF components

## In-house support to help find the right solution for your design

We offer a comprehensive portfolio of RF components with a complete range of solutions from world-leading suppliers. From high-performance switches, custom filters, powerful amplifiers and innovative FEMs, we will help you find the right solution from our complete portfolio, ensuring you get the very best from your wireless design.

On these pages we bring you a selection of discreet RF components, including switches, filters and amplifiers. On the following page, discover how one FEM component could replace three or more key devices from your BOM, improving both performance and efficiency at the same time.

To transmit your signals, we provide a total range of antenna solutions, including single and multiband, internal and external, standard and custom solutions, on page 26.

Finally, we can help you protect your design from other unwanted interference, or stop your solution impacting its surrounding environment with our shielding solutions on page 27.

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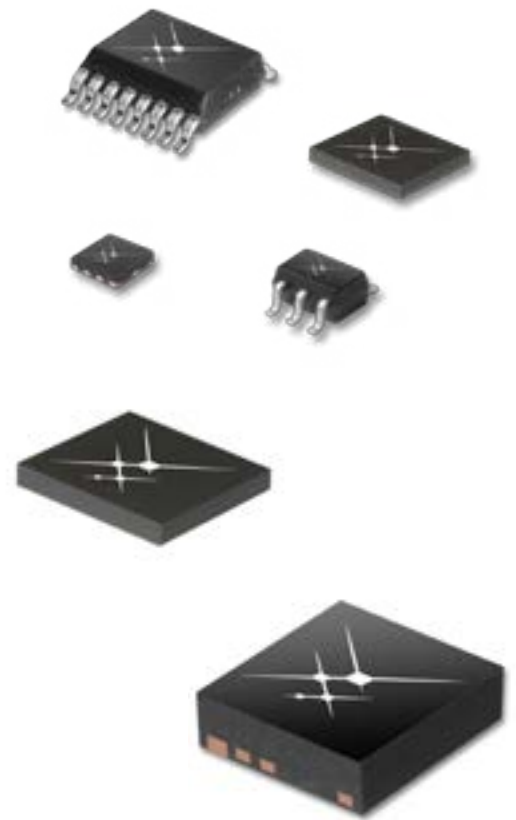
### Switches

We offer a broad portfolio of switches for IoT designs, with every option delivering the must-have attributes of any component in a demanding application – value, reliability and performance – three areas at which our switch solutions really excel.

Our comprehensive range includes every type of switch you may need, from simple SPST to multi-port SP16T. Standard options are readily available to sample or ship from stock with rapid delivery.

- Standard and custom designs
- SPDT, SP2T, SP3T, SP4T, DPDT and up to SP16T
- Low insertions loss
- High isolation
- High linearity and low distortion
- Broad frequency range – 20MHz to 8GHz
- Low bias and control-logic voltage
- Low-current operation

All SOI (Silicon on Insulator), GaAs (Gallium Arsenide), pHEMT (pseudomorphic high-electron mobility transistor) and PIN diode-based switches are broadband by design and can be used throughout IoT applications.



### Our chosen partner supplier – Skyworks

Skyworks Solutions Inc are one of the largest semiconductor manufacturers in the world. Over the last two decades their solutions have empowered entirely new market segments, enabling designers and manufacturers to bring breakthrough products to market. Their solutions are found on a global scale in thousands of volume products, including smart-home, automotive, wearable and industrial devices.



A comprehensive range of discreet components – including switches, filters, amplifiers, FEMs, antennas and shielding – from the world's leading suppliers.

## Filters

We offer a huge range of filters from the world's leading manufacturers – including TaiSaw, Johanson Technology and Sangshin Elecom – ensuring your signals are clean and precise, and noise is reduced to a minimum.

Our range includes band pass, high pass, low pass, SAW filters and duplexers for all types of IoT applications. These compact solutions are developed with easy RF design integration in mind to provide low-insertion and high-attenuation levels without compromising performance or cost.

### High performance at extreme temperatures

Our thermally compensated SAW filters are proven to be highly effective and reliable over extended operating temperature ranges, an indispensable requirement for automotive and industrial applications. Exceptional performance is achieved through drastically reducing temperature sensitivity and improving insertion loss, providing total support for demanding applications – including LTE, GNSS and digital radio.



### Excellent performance across an extensive range

Our range includes more than 700 designs for narrow and ultra-wide bandwidths, covering a frequency range from 500MHz to more than 6GHz. Our solutions are available with extremely short sample and production lead times, are competitively priced and can be fully customised to meet your exact RF product requirements. AEC-Q200 automotive qualification is also available across many of our solutions.



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## Power and low-noise amplifiers

We offer a wide selection of amplifiers, including power amplifiers (PAs) and low-noise amplifiers (LNAs), from our market-leading supplier Skyworks.

Leveraging their extensive design knowledge, technical leadership, superior quality and manufacturing expertise, we have an amplifier solution ready to meet your exact needs.

Demanding applications in multiple sectors – including automotive, smart home, industrial, mobile, M2M, medical and smart energy – have all been realised and gained superior performance from our design support and Skyworks' amplifiers. The range includes low-noise, power, linear, driver and variable-gain amplifiers.

All amplifiers benefit from a low-cost, small-footprint package, and are supported by comprehensive application notes and design-in expertise from Acal BFi, enabling you to achieve superior performance from a cost-effective, small-form-factor design.





# Front-end modules

## Increasing the performance of every wireless standard

We support all of the common wireless standards – including Wi-Fi, Bluetooth, LoRaWAN and other ISM frequencies – from major chip manufacturers with a range of integrated FEMs to help you get the most from your design.

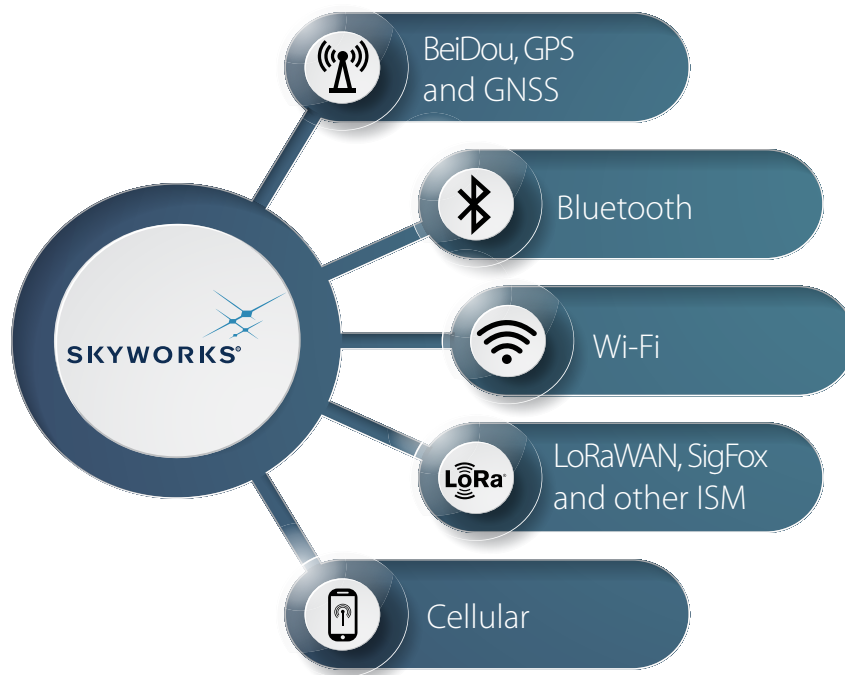
A single FEM can efficiently increase the total performance of your wireless design, enabling you to reduce the power consumption, increase the efficiency or further the range of your design from an easy-to-integrate, cost-effective, compact solution.

### Supporting SoCs from all major manufacturers

We offer Skyworks' leading range of FEMs, with a solution offered for most SoCs produced today, whether it is one from our leading portfolio of wireless solutions or sourced from another manufacturer or supplier.

### Enhancing wireless standards with a single, cost-effective component

Regardless of the wireless standard you are using, Skyworks support almost every wireless standard with a dedicated FEM solution – available for every category and standard.



#### Key features

- Multiband / multi-mode power amplifiers
- High-linearity TX/RX switches
- Single, multi-chip module design
- Reduced design time
- Ease of manufacturing
- Consistency / reliability

FEMs boost the performance of your chosen SoC and can deliver stronger wireless signals, greater range, more efficiency, lower power consumption and a better user experience. There are no downsides.

Many engineers understand that FEMs can increase the range of a wireless SoC solution, but they can also bring a host of other benefits to your entire design.

- **Lower power consumption**  
By adding an FEM to your design, the SoC can operate more efficiently within nominal tasks or deliver more performance with the power provided.
- **Increased battery life**  
Increased efficiency means less power is consumed. For battery-powered devices, this means your solution can operate for longer periods on a single charge and will use fewer batteries over its life cycle.
- **Cost saving and simpler designs**  
FEMs are multi-chip modules and can be used in place of multiple components, reducing your overall BOM and simplifying your design.
- **Faster time to market**  
FEMs include multiple discrete components, therefore do not require external matching components, further accelerating your time to market.

### Enhancing the performance of your design

The performance benefits of an FEM mean you may also be able to use a more cost-effective SoC in your design. Post-production, the cost savings continue, with a more reliable, efficient design reducing the amount of power consumed.

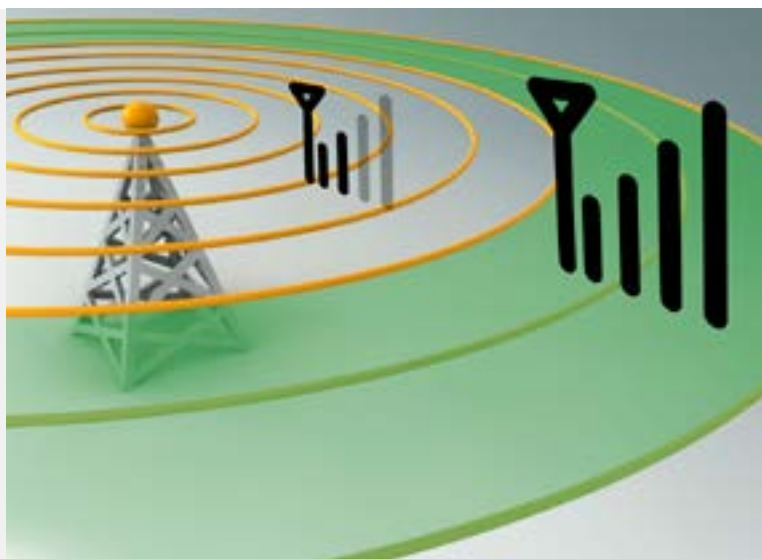
- Increased Tx efficiency
- Increased Rx sensitivity
- Improved efficiency
- Longer battery life
- Stronger signals
- Greater range
- One-for-three component replacement
- Technology agnostic – FEMs are available for all wireless standards

Skyworks work with all major chipset manufacturers and suppliers. Check with your local Acal BFi team to discover the latest IoT FEM solutions.

### What is an FEM?

Skyworks' FEMs combine the company's industry-leading PAs, LNAs and switch functions into a single, low-cost, laminate-based, multi-chip module.

Manufactured using their proprietary heterojunction bipolar transistor (HBT) power amplifier process and low-loss pseudomorphic high-electron mobility transistor (pHEMT) switch technologies, their FEMs deliver superior performance to multiple applications, including automotive, smart home, industrial, M2M, medical, smart energy and wearables.



# Antennas

## Having the right antenna can make or break your design

Working with our carefully selected antenna partners, Proant and Johanson Technology, we provide you with the most appropriate antenna solution for your application and frequency, ensuring you get the best range with the lowest power consumption.

Our Field Application Engineers offer complete support, finding the right options for your application, advising which is best for your design and working with you to match the RF input/output. Our range includes:

- Single and multiband antennas
- External connectorised antennas
- Internal chip, patch, PIFA and PCB antennas
- Customised antennas

### Antennas for all technologies

Reducing RF inference has enabled multiple wireless technologies to co-exist within a few millimetres of one another, therefore antenna efficiency, RF isolation and antenna selectivity are all critical considerations. We offer a wide range of antennas specifically developed for every wireless technology standard.

- Cellular (2G, 3G, 4G LTE)
- Wi-Fi, Bluetooth
- ISM bands including LoRaWAN™, SIGFOX and Zigbee
- GNSS (including BeiDou, Galileo, GLONASS and GPS)
- NB-IoT – Band 8 (880 to 960MHz) and Band 20 (791 to 862MHz)
- Custom designs for non-standard frequencies

We can also support you with your design. Through Proant, your RF design can be tested and refined in their anechoic chamber to get the best possible results from your solution, whether it features a standard, modified or fully customised solution.



### Intelligent antenna design can overcome the challenges of embedded and miniaturised antennas

In many data-gathering and wearable IoT applications, compact designs mandate the use of an on-board antenna. These antennas can be chip, patch or PIFA antennas, or embedded into the PCB itself.

Many factors affect the performance of these types of antenna including ground planes, position of other components, orientation of the unit, materials used in the outer casing, and proximity to the outer casing. A poorly optimised or tuned antenna will have an adverse effect on the wireless range and power consumption.

With Acal BFi, you have access to the latest RF antenna modelling tools, to help you determine the optimum antenna for your system.



# Protection and shielding

## Enhance the performance of your design with EMC shielding

Wireless solutions use radio frequencies to communicate and transfer data, however these frequencies can interfere and impede the performance of other components within your design. Similarly, other components can generate heat or unwanted frequencies, impacting the overall effectiveness.

No matter how big or small your design, managing radiation, heat and other radio magnetic frequencies is essential to the overall performance of your final product.

### Protection against high-frequency electromagnetic interference and thermal influences

MTC (Micro Tech Components GmbH) are a leading manufacturer of high-quality products for electromagnetic shielding and heat dissipation. Part of the discoverIE Group, MTC provide customers with individual services and support, including consulting on projects, an extensive range of standard components, and the development and production of individual solutions.

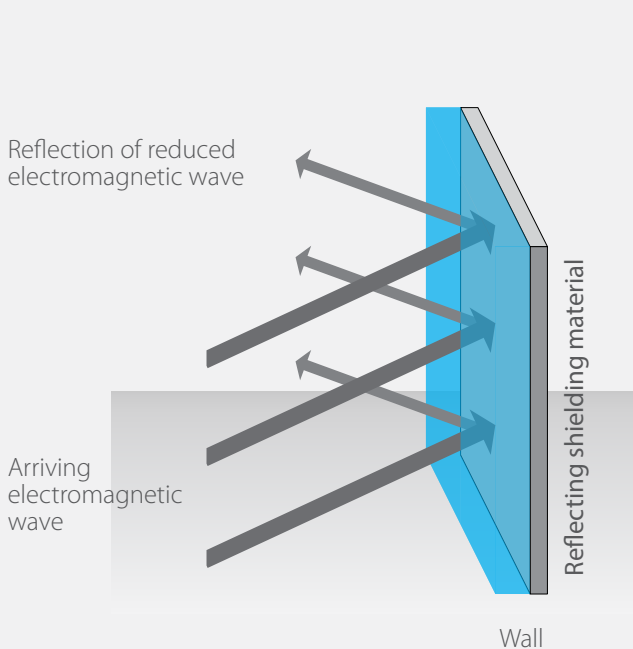


Whether you are looking to manage heat within your design at the initial concept stage, or need to stop unwanted frequencies entering your design before entering production, MTC can offer solutions for any size or scale of project.

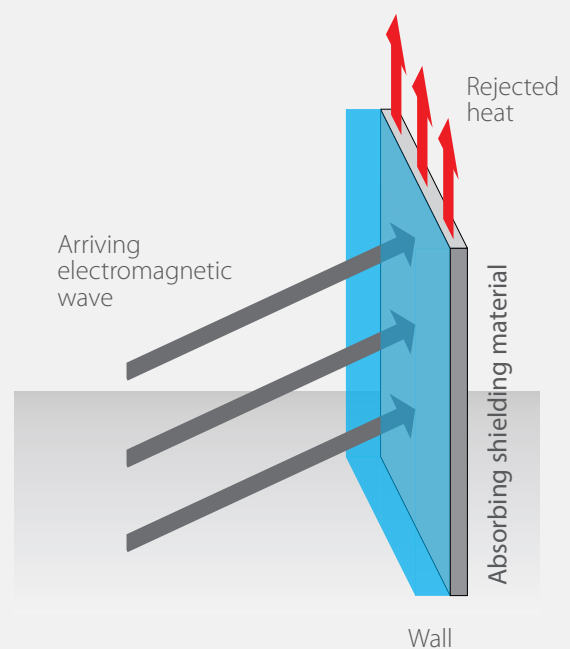
#### Protection for your design

- Fabric-over-foam gaskets
- Conductive foams, elastomers and tapes
- Metal contact strips for chassis shielding
- Board-level shields
- SMD contacts
- Shielding clips
- Thermal conduction solutions
- Custom solutions

#### Electromagnetic shielding using reflection



#### Electromagnetic shielding using heat dissipation



# Evaluation kits

Our solutions are supported by a range of development kits to kick start your design

Not all solutions can be used out of the box. These solutions provide you with cost advantages at mid- to high-volumes; however, every design starts with an initial concept, and developing a custom PCB at this stage is costly and time consuming.

Our evaluation kits reduce the time, energy and effort of testing and evaluating both the technology and your design concept, without needing to create a custom mounting. Most operate over a standard port, such as USB, or can be programmed wirelessly with a smartphone.

## mangOH™ Red

A complete, flexible IoT development platform



Build low-power IoT applications that can run for 10 years on a battery with the newest and smallest mangOH platform. Its credit card size form factor ideal for rapidly building proof of concepts and sending your IoT data to the Cloud.

### Key features

- Built-in Wi-Fi b/g/n and Bluetooth 4.2 with a Cortex M4 to provide real-time access to I/O
- Integrated smart SIM (slot) with up to 100MB free data (depending on region), and can also be used with any commercially available SIM
- Built-in accelerometer/gyroscope, pressure and light sensors along with a 26-pin Raspberry-Pi-compatible connector and MicroSD slot
- Snap-in socket to add any CF3™-compatible modules, including wireless modules (2G to 4G and LTE-M/NB-IoT)
- IoT expansion card slot to plug in any technology
- Integrated with the AirVantage IoT platform to create, deploy and manage solutions in the Cloud

## BX310x development kit

Add Bluetooth and Wi-Fi to your design



A small form factor evaluation board, powered by USB, that exposes all the BX3100 and BX3105 modules' pin interfaces via headers. It has a UART-to-USB converter at 1Mb/s for direct connection of the UART to a PC.

### Key features

- Ideal for evaluation and prototyping, it works out of the box and allows AT commands to be sent directly to the BX310x module UART using a simple terminal
- Simple Wi-Fi, Bluetooth-classic and Bluetooth-low-energy connectivity
- Schematics of development kit available – use as a reference design for your final product form factor
- Built-in temperature sensor and accelerometer connected via I2C to enable read/write and transfer of the information to the Cloud for demos and testing
- Integrated with the AirVantage IoT platform to create and manage solutions in the Cloud
- Comes with the BX310x module included and an FTDI UART-to-USB on board to connect to your PC



Evaluation kits enable you to instantly test and integrate the latest technology with your design. Some of our development kits can be used as design and product platforms, enabling faster time to market.

### xPico 240 evaluation kit

Connect and control via Wi-Fi



LANTRONIX®

The xPico 240 evaluation kit includes the evaluation board, two u.fl to RP-SMA adapter cables and antennas, power adapters with regional blades, and firmware. With the kit, you can quickly connect to the xPico 240 module to share data via the module's dual-band Wi-Fi (802.11 a/b/g/n) and Ethernet connection.

The board includes a 10/100 Ethernet RJ45 port, USB port for host/device, peripheral I/O header, 3.3V header and a DB9 RS232 serial port, to support multiple designs and interfaces.

You can connect to and configure the xPico 240 module wirelessly via the built-in wireless client interface.

### USI BM-22 EVB

Fast integration for Wi-Fi and Bluetooth SiPs



USI®

The BM-22 development kit enables you to quickly integrate and evaluate USI's compact WM-BN-BM-22 Bluetooth/Wi-Fi combination SiP. The board includes USB-to-UART connectors, with a port for an external antenna output. It also features an optional connector for Jlink/STlink connectivity with a module-programming interface setting. Once connected to power via USB, designers can develop with the BM-22 EVB using their smartphone or computer.

### ORG1510-MK04-UAR

Get a flying start with the Hornet family



OriginGPS  
mini+mighty

The ORG1510-MK04-UAR evaluation kit provides engineers and designers easy access to the OriginGPS Hornet family of GNSS receiver modules. The Hornet range is the industry's smallest, fully integrated, highly-sensitive of GPS and GNSS, modules with integrated antennas or on-board RF connectors.

The evaluation kit includes demo board, USB-to-UART cable, CD with GPS simulator software for PC, and supporting documentation. The demo board consists of a main board incorporating 3.3V LDO regulator, UART connector, push-button, and various test points. The ORG1510-MK-04 GNSS antenna module is soldered on to the main board through the interface adaptor.

### LinkIt 2523 HDK

SoC support with compact Bluetooth solutions



AIROHA

The LinkIt 2523 HDK by SAC is a fully functional demonstration board for IoT and wearables applications powered by Airoha's MT2523G and an ARM Cortex-M4 core-based MCU. It enables rich connectivity features, communication with Cloud services, and real-time control. The HDK supports development on Keil IDE and provides additional libraries to integrate a variety of peripherals and enable a new class of highly connected applications.

# European Technical Competence Centre

Our expert technical team will help you get the most from your design

Our European Technical Competence Centre (ETCC) team provide IoT designers and engineers with consultancy, turnkey design and low-volume manufacturing services to support the successful realisation of wireless solutions.

## Complete support for every stage of the development journey

Established in 2010, the ETCC is home to our multi-discipline design team, including RF, hardware (analogue and digital) and software engineers. The team act as a natural extension to your in-house resource. Their expertise enables you to focus on your core competencies, providing you with direct end-to-end project support, complete system design, prototype realisation and development, and production management via third-party contract manufacturers.

Our specialist design team works with the latest innovations in wireless technology on a daily basis, giving you the advantage of broad technology experience from a single partner. We will always ensure we understand your exact needs before providing you with the most effective solution for your market and customers.

### Principal capabilities and technologies offered

- RF hardware/module development
- Hardware development at chip level
- Software development on both proprietary and standard protocols
- Consultation
- System design
- Turnkey design to working prototype or first production batch
- High-level FAE support for customers designs
- RF design review service
- Management of production batches through third-party, sub-contract manufacturers
- Technologies include propriety ISM solutions, Wi-Fi, Bluetooth, cellular, NB-IoT, LoRaWAN, GPS, GNSS, Zigbee and other RF bands



# Your technical design specialist

## From sensors to the cloud

### The complete IoT offer

We deliver total support for your products, designs and solutions, from concept to post-production. Our leading-edge technology portfolio, technical expertise and custom-design capabilities provide you with a service like no other, for any application in any sector.

### A natural extension of your engineering teams

We have dedicated teams of technical specialists to bring design expertise to your existing engineering teams. Many of our engineers are supplier trained and work hand in hand with you to get the most from your design and the technology within. With Acal BFi, you can concentrate on your core technologies whilst integrating the latest technology to bring a more advanced solution to market.

### Hand-picked solutions from carefully selected technology partners

We offer advanced solutions across 12 specialist technology areas from the world's leading suppliers and manufacturers. Our close partner relationships enable us to offer solutions beyond the standard product range, and tailor these to your exact specifications and requirements. We are vendor and technology neutral so you will always get the right solution for your needs.

### Custom design to your requirements

From our close supplier relationships and in-house expertise, we can develop and deliver custom designs to your exact requirements. Whether your solution uses fully or semi-custom components, modified standard or a mix of standard solutions, we make sure you get the right solution in terms of performance, cost and specification.

### Total support from the experts

Regardless of sector and application, we work with you to find the right balance of innovative design and leading-edge technologies. Support can start at any stage and lasts for as long as you need it.

#### Design phase support

- Advice on the best technology for your needs
- Full technical support from initial start to refined tuning
- Detailed responses to technical queries
- Direct access to manufacturer's technical support team
- PCB and schematic review to advise on optimum layout
- Evaluation boards

#### Pre-production phase support

- Access to our ETCC to solve complex design issues
- Advice on regulatory compliance issues
- Access to our UK-based EMC chamber for pre-compliance testing
- Design support on impedance matching for optimum antenna performance

#### Production phase support

- Continued technical support for unforeseen production issues

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