From Sensors to Interfaces – Wireless Communication Has a Lot to Offer

The world of wireless communication has exploded in the last few years, making its way to the common man but becoming a genuine challenge for the designers. Let us discuss some new components and technologies that are now available for designing safe and secure communication devices

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Wireless communication is growing rapidly to touch every aspect of our lives. Besides communication, it now allows technologies like Machine to Machine (M2M) and the Internet of Things (IoT) to evolve, for instance.

While there are modules that transmit the data from our body to the cloud, there are also modules that send that data to our mobile phones or laptops for us to analyse. Then there are modules that can be embedded in our shoes so we can know, for instance, how much we have walked or run, for how long, and how many calories we have burnt in the process. For all this, we need to use power-efficient wireless systems with small form factor, high reliability, small size and low cost. The systems should also have less interference. Obviously, the responsibility of design engineers is increasing.

Communication interfaces

The integral part of a device that enables communication is an interface. No communication is possible without it. But the important thing to understand is that, the interface should allow minimum power consumption during data transfer and be efficient at the same time. With wired communication, the efficiency has not been much of a concern, though power has always been. Now, with the advent of wireless communication, the wired interfaces are getting replaced with wireless interfaces like interface modules and smart sensors. Even microcontrollers (MCUs)
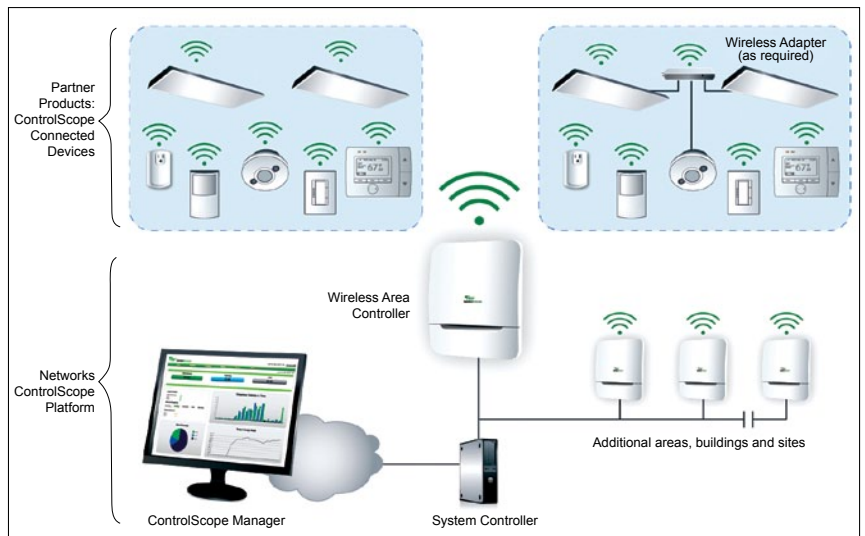

Fig. 1: Wireless communication

are getting integrated with the transmitters to provide better interfaces. Such interfaces can help reduce wires and overcome the obstacles that make hard wiring impossible or impractical.

Complex communication interface. It is an interface, generally for an 8-bit MCU, that allows integration of a transceiver (sub-GHz) with an ultra-low-power 8051 core to allow a data transmit rate of up to 256kbps and a maximum output power of about 20 decibel-milliwatts (dBm). It is called complex interface because the MCU is integrated with the transceiver on the same module. It is suitable for applications related to IoT, wireless connectivity and low-power processing.

Interface with frequency hopping spread spectrum technology. It is an interface that allows rapid signal transmission over multiple frequency channels. It operates in a frequency band of

900MHz to communicate between the operator interface and individual, or groups of smart sensors. The 900MHz band is Federal Communication Commission (FCC) licence-free, has lower signal loss than other available frequency bands, offers greater signal transmissions through obstructions and avails greater transmission distances. A designer can use this interface to replace the RS-485 wiring that is used between the smart sensor and the personal computer or human-machine interface (HMI). One can also use it to design devices that can work on multiple frequency channels.

Interface for medical equipment. Some medical equipment like electroencephalograph (EEG)/polysomnography (PSG) holter monitor or a blood glucose monitor (BGM) need wireless interfaces to allow the patients mobility and provide continuous data

for tracking. These interfaces have multiple MCUs replaced with a single MCU on a module, so as to reduce the component count and to provide a continuous reading even if the transceiver fails. It also applies to such wearable devices as a wristband to warn against possibility of a heart attack.

Wireless interface module. This module, based on Bluetooth wireless technology, supports display serial interface (DSI) protocol. This decreases the requirement of an external power source, thus further decreasing the number of components on the module. Such modules receive power from software drives, allowing the engineers to design a compact hardware without any requirement to search for an appropriate external power source.

Wireless transceiver with serial data interface. It supports 2×3 multiple input and multiple output (MIMO) configurations for a better array gain and a significant increase in data throughput. This allows the designing of a module without additional frequency requirement and increased transmit power.

Avinash Babu, senior project manager, Mistral Solutions, says, "There has been considerable traction on low-power wireless interfaces like Bluetooth low energy (BTLE or BLE), ZigBee and low-power radio frequency (RF) in the last couple of years. Many of today's low-power wireless solutions are aimed at enabling the Internet of Things."

Wireless microcontrollers

According to Babu, "There are several standard off-the-shelf wireless MCUs available currently, which the designer can use to quickly implement wireless solutions." The recently introduced wireless MCUs based on BLE technology are suitable for systems that have ultra-low-power consumption requirements. These MCUs support different data transfer rates like 250kbps, 500kbps, 1Mbps and 2Mbps, and have good blocking performance and a receiver sensitivity of about -94dBm at 1Mbps. Such MCUs enable long-range applications without any external front-end. These have hardware debug sup-
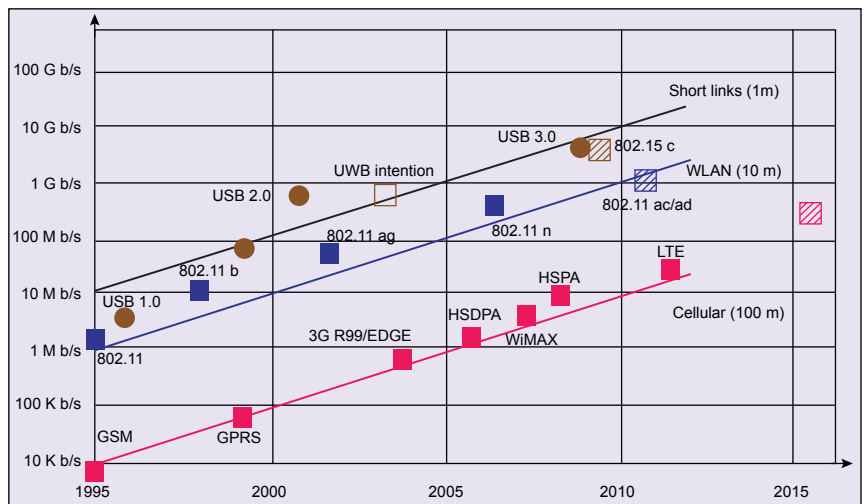
Fig. 2: Trend in wireless communication (Source: Google Search)

port and provide retention to all the relevant registers in all the power modes.

Then there are wireless MCUs suitable for applications related to IoT. This family of MCUs has built-in support for security protocols. Mrinmoy Purkayastha, vice president-Marketing, Calsoft Labs, says, "Security is a very important element in IoT and M2M communications. Devices with embedded hardware accelerators that support different security standards are valuable to build products that are reliable and power-efficient." This family of MCUs is well suited for such applications as heating, ventilation and air-conditioning (HVAC), power-line communication, refrigerators and smart e-meters.

Praveen Ganapathy, director-Processor & Connectivity Applications, TI (India) says, "Design engineers can now design using a single-chip MCU with built-in Wi-Fi connectivity. TI has created a wireless MCU for the Internet of Things, that integrates a high-performance ARM Cortex-M4 MCU, allowing customers to develop an entire application with a single IC. With on-chip Wi-Fi, Internet and robust security protocols, no prior Wi-Fi experience is required. The Wi-Fi network subsystem includes an 802.11 b/g/n radio, baseband and MAC with a powerful crypto engine for fast, secure Internet connections and 256-bit encryption. The Wi-Fi Internet-on-a-chip includes
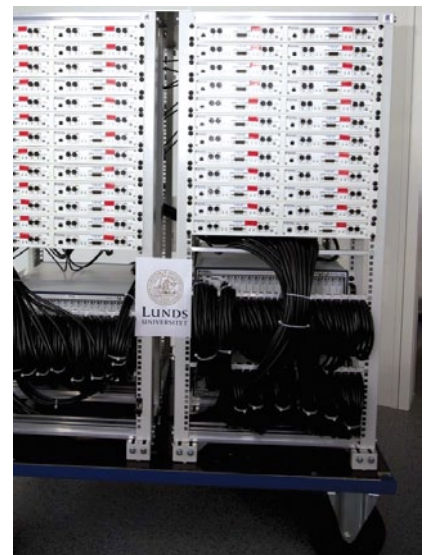
Fig. 3: The massive MIMO testbed at Lund University in Sweden is based on USRP RIO (Source: National Instruments)

embedded transmission control protocol (TCP)/Internet protocol (IP) and transport layer security (TLS)/secure sockets layer (SSL) stacks, hypertext transfer protocol (HTTP) server and multiple Internet protocols."

Smart sensors

The smart and intelligent sensors help reduce the installation and system costs. These increase system flexibility, simplify system deployment and address a new set of applications that was previously impossible with a wired approach. The sensors allow the engineers to design a system with ben-

TABLE I
Components and Chips

Manufacturer	Device Family	Part Number of family	Benefits Summary	Applications	Technologies	Key Parameters
Silicon Labs	Wireless Microcontroller	Si106x/ Si108x	Combines high-performance wireless connectivity and ultra-low power microcontroller processing into a small 5mm x 6mm form factor	Home automation Home health care Building HVAC control Telemetry	Compliant with the 802.15.4g smart metering standard	-On-chip debug -Ultra-low power 8051MCU core -2 μs wake-up time
NXP	Wireless Microcontroller	JN5148	Offers fully compliant 2.4GHz IEEE802.15.4 transceiver, 128kB of ROM and 128kB of RAM to support both the networking protocol stacks	JenNet, JenNet-IP and ZigBee PRO applications	Based on the IEEE802.15.4 standard	-Operating current consumption of 18mA when receiving, and 15mA when transmitting @ +3dBm -Ultra low power consumption -Highly efficient memory architecture -32-bit RISC CPU – 32MIPs
Texas Instruments	Wireless Microcontroller	CC2541-Q1	Enables the building of robust nework nodes with low total bill-of-material costs	Both low-energy and proprietary 2.4GHz applications	Bluetooth Low Energy	-2.4GHz low energy compliant -Supports data rates of 250kbps, 500kbps, 1Mbps, and 2Mbps -Excellent link budget, Enabling long-range
Atmel	Wireless AVR Microcontoller	Atmega-a256RFR2	Combines AVR microcontroller and best-in-class 2.4GHz RF transceiver and offers highest RF performance for single-chip devices.	-ZigBee/IEEE 802.15.4 – full and reduced function device -General purpose 2.4GHz ISM band transceiver with microcontroller -RF4CE, SP100, wirelessHART, ISM applications and IPv6 / 6LoWPAN	ZigBee/IEEE 802.15.4	-Ultra low power consumption (1.8 to 3.6V) for AVR & Rx/Tx: 10.1mA/18.6mA -38 programmable I/O lines -Speed grade: 0 – 16 MHz @ 1.8 – 3.6V range with integrated voltage regulators
Hope RF	Wireless Transceiver Module	RFM12B-S2	Module is implemented with a unique PLL (phase locked loop) and operates in the 915MHz band	Applications compliant with FCC and ETSI regulations		-Wakeup timer -Differential antenna input -Programmable TX frequency deviation (from 15 to 240kHz) -Programmable receiver bandwidth (from 67 to 400kHz)
Silicon Labs	Wireless Transceiver	Si4438 RF	High-performance, low-current, ISM band transceiver covering the 425 to 525MHz frequency band	-Smart metering and automated meter reading -Robust in home communications to home appliances -Long-range backhaul communications to the collector		-Frequency range: 425–525MHz band -Receive sensitivity: –124dBm -Power supply: 1.8V to 3.6V -> 84dB blocking for > 8MHz offset
Texas Instruments	System on Chip	TMS320T-CI6636	Multicore SoC architecture designed for high-performance wireless infrastructure applications		CDMA/HSPA/ HSPA+, TD-SCDMA, GSM, TDD-LTE, FDD-LTE, LTE-A and WiMAX	-Eight TMS320C66x DSP core subsystems per core @ 1.2GHz -ARM Cortex A15 quad core cluster @ 1.2GHz per core with 4MB L2 cache coherent memory
Allen-Bradley	Wireless Interface Module	Bulletin 22-WIM	Provides a wireless communications interface between computers equipped with Bluetooth wireless technology	All products that support the DSI protocol	Bluetooth wireless technology	-Full-duplex point-to-point protocol -Compatible with all powerflex compact-class drives and peripherals

Changing standards and technologies

Today, if we talk about the standards and the technologies associated with wireless communication, we will notice that there are fewer standards than technologies. Of course, there is a continuous research and innovation in baseband technologies to make them transmit/receive data faster and securely in noisy environments. Of all the standards in wireless communication, IEEE has become the most popular over the years (apart from 3GPP) due to its broad coverage of wireless technologies for different applications. IEEE standards like Wi-Fi and WiMAX provide high data transfer rates (11Mbps to 150Mbps), depending on the availability of the network. At the other end of the spectrum, a whole range of technologies under the 802.15 umbrella cover specialised applications such as wireless personal area networks, body area networks and industrial wireless communications.

Purkayastha says, "There is a considerable amount of research going on in RF side to develop software-defined radios with tunable RF support for better long-range wireless communication (4G/5G), personal area network and sensor area networks (802.15 umbrella). Then there is research going on to increase the interference cancellation techniques associated with the technologies." Most of the wireless communication technologies developed in the past are meant for use in applications that required clients to download data from the network most of the time. However, new applications like SmartGrid and SmartCities require sensors to upload data back to the grid all the time. Therefore wireless interfaces need to be designed to be more uplink efficient.

Wireless Gigabit (WiGig). WiGig is based on the more advanced 802.11ad standard and was named so by Wi-Fi Alliance. It allows a super-fast video streaming with a data transfer speed of up to 7Gbps. WiGig is based on the triband frequencies (2.4GHz, 5GHz and 60GHz) and has a network operating range of more or less nine metres only, so the triband chipsets can be considered to be advantageous as one can seamlessly switch between the 802.11n, 802.11ac and 802.11ad (WiGig) wireless standards.

Bluetooth Smart. Although it is the same old Bluetooth technology without much change, Bluetooth Smart uses less power as it does not send out signal all the time. This technology is better known as BLE and is widely used in almost every application, from home automation to medical devices and from mobile payments to retail geo-fencing. Companies like Apple and PayPal are working to build applications based on this technology to push phone upgrade messages and to implement a voice recognition technology.

5G. Although there are improvements going on in the existing technologies, companies like National Instruments (NI) are working on new ITU standards like 5G. 5G is in its early development stage and is anticipated to offer a significant measure of profit over the other existing technologies. It not only requires a software support but also requires a good hardware support for faster communication. New ways have been found to research, develop and test radios designed using 5G. The LabView Communication System Design Suite by NI makes this task possible in three steps: algorithm development by researchers; radio mapping using non-design tools by the designers for generating design standards; and radio implementation through code generation by the team.

"In order to support all these new technologies, the industry is working closely with product designers to help them write software to exploit new features, and working together on issues like power management to increase the efficiency of wireless communication devices without any compromise in the functionality," says Mrinmoy Purkayashta.

efits without any compromise in the system's reliability and measurement quality. Wireless sensors make the end product excitingly useful for the users.

The low-power ZigBee standards are basically optimised to the needs of the wireless sensor networks and thus offer self-healing mesh networking option along with robust self organising, low cost and complexity, the large extent of scalability and an excellent battery life. The smart sensors are also supporting wireless communication in smart meter and advanced meter infrastructures (AMI), opening up a wide scope of designing options for the engineers.

Integrated transceivers

There are certain transceivers that not only offer a complete but also a high-performance mixed-signal system and RF on a single chip. In this category, there are some input/output RF based transceivers compatible with ZigBee standards that incorporate different layers of elements into another layer, facilitating a fast deployment feature.

This family of transceivers is

equipped with the smart wake-up feature that enables it to wake only at defined intervals and scan the channels to receive a valid packet. It allows the designers to incorporate timing-critical elements so as to facilitate shorter deployment cycles. Such transceivers are designed for high-performance cost-effective wireless systems operating at very low-power and low-voltage conditions. These have integrated filters and so do not require any of the costly external filters.

Operational amplifiers (op-amps)

Op-amp is another important component that helps in wireless communication. It captures the sensor information, amplifies it and then passes it on.

The latest range of op-amps offer very low input offset voltage and almost zero drift. Thus, being high-precision op-amps, these allow the engineers to design a product that would process the data without much wait. This family of op-amps is virtually unaffected by any temperature change and can tolerate extreme temperatures in the range of -40°C to +125°C.

New-generation system on chip (SoC)

From BLE to the other standards, such as IEEE 802.15.4, RF4CE and ZigBee, the SoCs are compatible with many applications based on these standards. There are highly integrated SoC solutions with tightly coupled physical layer of the OSI model (PHY) and media access control (MAC) to minimise latency and to avoid complex software portioning across multiple devices. The best thing is the availability of better software suites to support the design of these SoCs.

Safe and secure communication parameters

The increasing use of wireless communication brings security into question. Then there are issues like noise, interference, energy efficiency, network coverage, reliability and latency. Purkayastha says, "Several integrated circuits with interference management

TABLE II **Design and Development Tools**		
Name	**Type**	**Manufacturer**
Code Composer Studio (CCS) Integrated Development Environment (IDE) for Multicore Processors	SW Development Tools, IDEs, Compilers	Texas Instruments
WLAN Measurement Suite	Test and Measurement tool Support for IEEE 802.11a/b/g/n/j/p/ac standards and up to 4x4 MIMO measurements	National Instruments
DriveExecutive software	Provides a simplified interface for programming, maintenance and troubleshooting of your PowerFlex AC and DC drives	Allen Bradley
Visual System Simulator	Enables engineers to design the right system architecture and formulate suitable specifications for each of the underlying components.	National Instruments
Advanced Design System	EDA software for RF, microwave, and high speed wireless communication with WiMAX, LTE, multi-gigabit per second data links, radar and satellite applications	Keysight Technologies
SimpleLink Bluetooth CC2564 Module Evaluation Board	Evaluation Modules and Boards	Texas Instruments

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and noise filtering capabilities are used in communication devices. Interference is a major issue in crowded areas, such as shopping malls, airports, busy industrial areas, etc, where MIMO with multiple antennae for transmission and reception are used for interference cancellation." Satish Mohanram, technical marketing manager, National Instruments, says, "High-end wireless technologies like 5G require high amount of bandwidth to transfer large amount of data without any latency. MIMO provides those devices a space diversity for a deterministic transfer for data over wireless medium."

Companies like National Instruments are working on the prototyping tools for Massive MIMO to help design high-end wireless technology based devices from the scratch. Massive MIMO enables MIMO diversity and transmission without any loss in signal, enables the use of low-cost and low-power components, simplifies the media access control (MAC) layer and also provides robustness to intentional jamming and interference.

Test initiatives and solutions

Cost-effective ways have come up recently to test wireless communication devices at a high speed using shorter and flexible measurement steps. The tools not only test the existing but also the new formats of radio, including WiMAX, Bluetooth, HSPA+ and LTE. Then there are test sets to reduce the capital investment required in order to optimise the architecture for the non-signalling test. These sets help plan the test and troubleshooting graphically, which simplifies the testing process and reduces long-term costs related to the advancements in test modes.

From latency to high-power usage, the new range of embedded components is helping the designers to overcome all the issues that would decrease the popularity of the wireless devices designed by them. It also opens up a lot of opportunities before the designers to choose the best components at a very low price, and the changing technologies are helping further. ●

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