

Being Smart Isn't Enough for Thermostats Today

Johnsy Varghese



Given how the word “smart” is bandied about when discussing IoT technology, you may wonder exactly what it means – if it has any meaning at all. If you asked me to define a smart thermostat, here’s what I’d say:

- A device that can remember a user’s preferences is nice, but that’s what the older programmable thermostats do today. A smart thermostat should be able to learn the user’s behavior as they enter or leave the home or room.
- It has to be able to display temperature and local weather information on its liquid crystal display (LCD) or on a smartphone or tablet.
- The thermostat should have the ability to sense a variety of sensors like temperature, humidity, pressure, ambient light, air quality and proximity sensors.
- It must be able to defend itself from security threats.
- If battery operated, the smart thermostat should consume as little power as possible to allow it to run for extended periods of time without the user needing to change or recharge the batteries.
- It must have remote configurability and control when the user isn’t home.

This may sound like a lot to ask of a single device, but it’s well within the reach of thermostat products using SimpleLink™ Wi-Fi® microcontrollers (MCUs) such as the [CC3220](#), a dual-core wireless MCU with a dedicated Arm® Cortex® M4 application processor and a certified Wi-Fi network processor. A diagram of the CC3220 IC can be seen below.

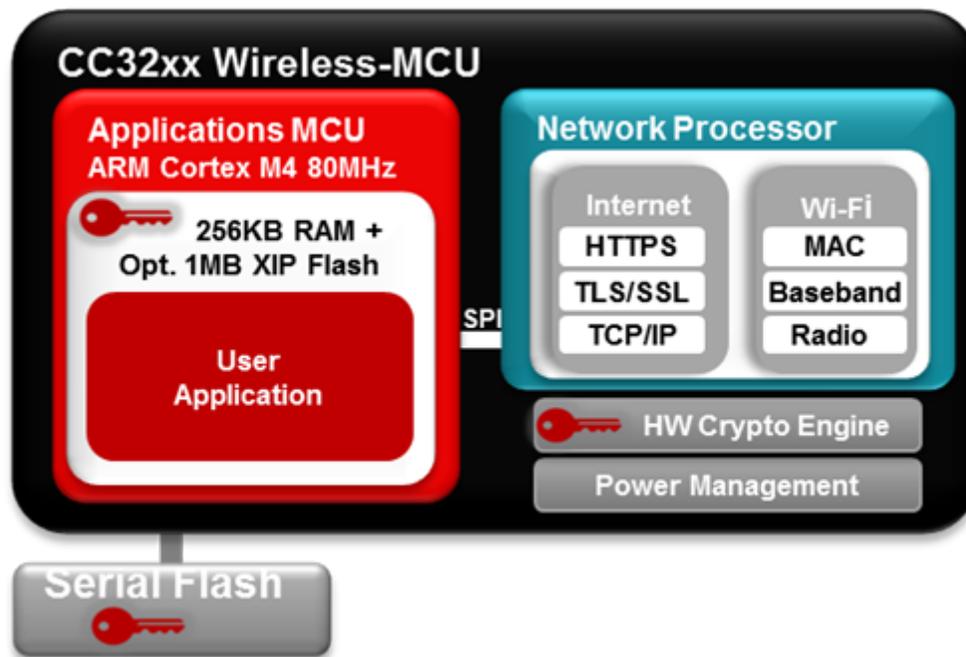


Figure 1. CC3220 Dual Core Wireless MCU

Once a smart thermostat has learned a user’s occupancy patterns based on proximity detection, the next logical step is to anticipate them. That’s where features like geofencing comes in. Users can control and remotely monitor a SimpleLink MCU-connected thermostat because of its integrated Wi-Fi connectivity. In addition, the thermostat can use the location feature of the smartphone to adjust to the user’s personal comfort settings when they’re within a certain geographic distance to the home.

Since many thermostats are battery or line-powered, and geofencing requires that the thermostat to periodically interact with the internet and/or a cloud-based service, low power consumption will be essential, especially for battery-operated thermostats. SimpleLink wireless MCUs have power consumption rates that are 30% better than even previous generations. Configurable power modes include a 135uA deep-sleep mode and a 200ms secure connection from wakeup.

Another power saver is the unique SimpleLink network learning algorithm (NLA). Because the power consumption of a connected device, such as a smart thermostat, is greatly affected by the way the local Wi-Fi access point behaves, NLA learns the behavior of the access point in always-connected mode – in real time – to optimize power consumption. In addition to NLA, a SimpleLink wireless MCU supports three connectivity modes with different power-consumption profiles. The device can be “always connected,” where two AA batteries will last a year or more, “intermittently connected” with a battery life of three years and can be configured depending on the system requirements.

Save Integration Costs without Losing Reliability

The integrated networking processor core of SimpleLink wireless MCUs offloads the burden of Wi-Fi and internet communications processing from the application processor core, freeing up resources for differentiating features in the application. The network processor’s Wi-Fi connectivity is already fully certified by the Wi-Fi Alliance and that certification is transferrable, saving you from going through the often time-consuming and costly ordeal of Wi-Fi certification.

Some smart thermostats need to communicate through cloud-based services like Amazon Web Services (AWS), Apple HomeKit, Microsoft Azure, IBM Watson and others. Starter software examples and plug-ins are readily available for SimpleLink MCUs to help get to market quickly.

Additionally, the interoperability of Wi-Fi connectivity is very important for worldwide deployments. TI has been exhaustively testing this against more than 210 access points to date, ensuring reliable and robust performance when compared to other solutions.

Self Defense

Connectivity raises the issue of security. SimpleLink MCUs provide protection from application storage to run-time operation, including over-the-air communications transfers. Most resources, such as intellectual property (IP) code, data, user identities, the file system and security keys are safeguarded. Both processor cores have extensive security enhancements to protect against hacking, malicious theft, hostile takeovers and other threats. Features like hardware-based cryptographic engines reduce the need for external security chips that only add cost and complexity and enable vulnerabilities when compared to a single-chip offering.

Sensible Sensors

You can build a smart thermostat based on a SimpleLink wireless MCU with a variety of environmental sensors wired directly to the device or connected wirelessly as remote sensors in remote rooms. An on-chip four-channel analog-to-digital converter (ADC) can interface analog sensors to the processing cores, or one of the peripheral interfaces (such as I²C) can link to digital sensors. For example, a microphone might connect to the ADC to implement voice recognition of simple commands. Or a digital temperature sensor might use the I²C port. Air quality, humidity, pressure, ambient light, proximity or occupancy sensors can also enhance the intelligence of the thermostat while saving energy.

Listen up

There is an increasing push to further simplify the control of smart devices and smart thermostats by integrating voice activation. TI offers two different options for voice activation. One uses the CC3220 with a simple single microphone approach; the second is a more sophisticated four-microphone option that uses TI's latest C55xx digital signal processing (DSP) integrated circuits (ICs) to enable voice activation. These options, paired with cloud connectivity offerings like Amazon Web Services (AWS), Apple HomeKit, Microsoft Azure or IBM Watson, can help solidify an even smarter thermostat.

A Bright Future

Based on user feedback and other research, most products are enhanced and expanded over time with additional connectivity features which can be complicated. This process is greatly simplified with SimpleLink MCUs. A cohesive [SimpleLink SDK](#) platform approach includes related technologies, like sensors and other wireless communication protocols and interfaces, along with development tools like software plug-ins, low-level drivers, code examples and hardware design kits.

If, for example, you wanted to add other wireless communication options besides Wi-Fi to the second or third generation of a smart thermostat, you could add *Bluetooth*[®] low energy as a direct interface to smartphones, or have a Sub-1 GHz radio connect wirelessly to sensors throughout the building. You might use this wireless sensor connectivity to implement a zone temperature sensing and control application. The smart thermostat could link wirelessly to an occupancy or motion sensor and a temperature sensor in a room some distance away. The motion sensor could signal the thermostat when someone enters the room so that the electronically controlled dampers on the ventilation vents could open. The room's temperature, sensed by the temperature sensor, would adjust to match the settings stored in the smart thermostat.

This brings me back to my original question about what a smart thermostat really is. SimpleLink wireless MCUs and SimpleLink MCU platform support make it easy for you to make your thermostats as smart as you want them to be – today and in the future.

Watch this video on smart thermostats with our TI Design:

[Smart Thermostat TI Design with SimpleLink Wi-Fi](#)

Additional Resources

- For more information on SimpleLink wireless MCUs and the SimpleLink platform approach, see:
 - Visit the [SimpleLink Wi-Fi Thermostat Applications](#) tab.
 - Check out the one-pager, “[Enabling Smarter Thermostats with SimpleLink™ Wi-Fi® Wireless MCUs.](#)”
 - Learn how to “[Design Thermostats With CC3220 SimpleLink Single-Chip Wi-Fi MCU SoC](#)” in this Application note.
 - Discover the “[SimpleLink™ CC3120, CC3220 Wi-Fi® IoC™ Solution Built-In Security Features](#)” Application note.
 - Take a look at our reference design for “[Voice Triggering and Processing with Cloud Connection to IBM Watson](#)”

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated