

TI-RSLK **MAX**

Texas Instruments Robotics System Learning Kit



Module 19

Introduction: Bluetooth Low Energy



Introduction: Bluetooth Low Energy

Educational Objectives:

UNDERSTAND Basic concepts of Bluetooth Low Energy

INTERFACE The CC2650 to the MSP432 using UART communication

CREATE A BLE service with multiple characteristics

DESIGN A robot system that can be controlled by a smart device using BLE

Prerequisites (Module 18)

- Interrupting UART interface (Module 18)

Recommended reading materials for students:

- Chapter 19, **Embedded Systems: Introduction to Robotics**, Jonathan W. Valvano, ISBN: 9781074544300, copyright © 2019

Bluetooth is wireless medium and a data protocol that connects devices together over a short distance. Examples of Bluetooth connectivity include headset to phone, speaker to computer, and fitness device to phone/computer. Bluetooth is an important component of billions of products on the market today. Bluetooth operates from 1 to 100 meters, depending on the strength of the radio. Most Bluetooth devices operate up to a maximum of 10 meters. However, in order to improve battery life, many devices reduce the strength of the radio, and therefore save power by operating across distances shorter than 10 meters. If the computer or phone provides a bridge to the internet, a Bluetooth-connected device becomes part of the Internet of Things (IoT).

Bluetooth is classified as a **personal area network** (PAN) because it implements communication within the range of an individual person. Alternatively, devices within a Bluetooth network are usually owned or controlled by one person. When two devices on the network are connected, we often say the devices are **paired**.

At the highest level, we see Bluetooth devices implement profiles. A **profile** is a suite of functionalities that support a certain type of communication. For example, the Advanced Audio Distribution Profile (A2DP) can be used to stream data. The Health Device Profile (HDP) is a standard profile for medical devices. There are profiles for remote controls, images, printers, cordless telephones, health devices, hands free devices, and intercoms. The profile we will use in this chapter is the **generic attribute protocol** (GATT). Within the GATT there can be once or more services.

Within a **service** there may be one or more characteristics. A **characteristic** is user or application data that is transmitted from one device to another across the

network. One of the attributes of a characteristic is whether it is readable, writeable, or both. We will use the notify indication to stream data from the embedded object to the smart phone. Characteristics have a **universally unique identifier** (UUID), which is a 128-bit (16-byte) number that is unique. BLE can use either 16-bit or 32-bit UUIDs. A specific UUID is used within the network to identify a specific characteristic. Often a characteristic has one or more descriptors. Descriptors may be information like its name and its units. We will also see **handles**, which are a mechanism to identify characteristics within the device. A handle is a pointer to an internal data structure within the GATT that contains all the information about that characteristic. Handles are not passed across the Bluetooth network; rather, handles are used by the host and controller to keep track of characteristics. UUIDs are passed across the network.

Simple Network Processor (SNP) is TI's name for the application that runs on the CC2650 when using the CC2650 with another microcontroller such as the MSP432. In this configuration the controller and host are implemented together on the CC2650, while the profiles and application are implemented on an external MCU. The application and profiles communicate with the CC2650 via the Application Programming Interface (API) that simplifies the management of the BLE network processor. The SNP API communicates with the BLE device using the Network Protocol Interface (NPI) over a serial (SPI or UART) connection. In this module, we will use a UART interface. This configuration is useful for applications that wish to add Bluetooth functionality to an existing device. In this paradigm, the application runs on the existing microcontroller, and BLE runs on the CC2650.

ti.com/rslk

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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, 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 (www.ti.com/legal/termsofsale.html) or other applicable terms available either on 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated