Application Notes for CC2564C Bluetooth® 4.1 and 4.2

1 Introduction

The CC2564C device is the successor of the CC2564B device as a dual-mode Bluetooth® Classic and Bluetooth low energy chip. The CC2564C adds new and significant capabilities to the CC2564B.

New Capabilities:

- LE Secure connections – Bluetooth 4.2 security algorithm Elliptic Curve Diffie Hellman (ECDH) for key generation and new pairing procedure for key exchange. The ECDH allows a higher security level for Bluetooth low energy authentication during connection to enable secure connections and protect the communication from passive eavesdropping and man-in-the-middle (MITM) attacks. Additional information can be retrieved from the Bluetooth specifications.

  This feature is required and requested by customers due to new regulatory requirements (for example, the new Europay, MasterCard, and Visa (EMV) standard and PCI DSS requirement).
- Link Layer topology – Bluetooth 4.1 feature that enables the device to act as a peripheral and central device at the same time. It adds Bluetooth and Bluetooth low energy scatternet capabilities and connection management in a dual-mode topology. See further details in Section 3.
- Enhanced audio time synchronization supporting multispeaker functionality
  - Speaker-to-speaker drift compensation
  - Speaker-to-speaker latency compensation
- 16/8 support – Ease PCM host integration when using both WBS (16 Khz) and NBS (8 Khz). This feature enables the customer to send both NBS and WBS streams without the need to reconfigure the codec settings, simplifying the process.
- PCM Clock Extension – The option to start or stop the PCM clock as master on the PCM BUS, even when voice call is not active. This feature is usually used to allow other peripherals on the host side that would like to use the clock generated by the controller regardless if a voice call is active or not.
- LE Ping – Bluetooth 4.1 security feature. This feature ensures a secure connection between two devices within a set time-out.

  If no data is sent during this time-out, then an encrypted ping message is sent to confirm the link is still secure. Check the Bluetooth 4.1 specifications for more details.
- LE Slave Initiate – Bluetooth 4.1 feature. This feature enables the slave to initiate transactions, which until now could only be initiated by the master. For example, feature request, name request, and so on. Check the Bluetooth 4.1 specifications for more details.
- LE Connectable advertise during low duty cycle – Bluetooth 4.1. This feature enables the device to perform a direct advertise for a specific device using a low duty cycle, which is repetitive advertising that was not supported. Until now the user had to reinitiate the direct advertise command repeatedly. Check the Bluetooth 4.1 specifications for more details.
- LE Connection Parameters request – Bluetooth 4.1 feature. This feature lets the slave in a Bluetooth connection offer suggestions concerning the parameters of the connection. Until Bluetooth 4.1, the master dictated the connection parameters, while the slave had no input on these parameters. This feature enables a negotiation process between the master and slave that can be slave-initiated, to optimize the connection settings for a better fit for the slave. The master can decide whether to accept these suggestions or decline them. Check the Bluetooth 4.1 specifications for more details.

- Adaptive frequency hopping (AFH) detection mechanism – This improved algorithm enhances the CC2564B AFH algorithm to ensure the channels used for frequency hopping are the least noisy, thereby reducing the collisions and retries whenever sending or receiving data.
- L2CAP dedicated channel – Bluetooth 4.1 IPV6 infrastructure, allows customers to develop IoT applications requiring Internet connection and advanced cloud services. Check the Bluetooth 4.1 specifications for more details.
- WBS specification compliance support – In earlier versions of the CC256x, WBS was supported through vendor-specific commands. The CC2564C aligns with the specifications and uses the enhanced voice HFP 1.6 (CSA2 specification commands), which uses standard Bluetooth HCI commands.

The CC2564C embeds all bug fixes that were added to the CC2564B.

2 LE Secure Connections

This feature introduces a new security model. To ensure the communication is secure, Bluetooth 4.2 introduces major enhancements to the features involved in the communication process. These enhancements follow:

- Pairing

  Bluetooth 4.2 adds the numeric comparison method to the three already existing in Bluetooth 4.0 and Bluetooth 4.1 (Just Works, Passkey Entry, and OOB), and adds the use of an ECDH algorithm for the key exchange procedure.
- Key Generation

  Key generation is performed by the host. In the past, key generation was done on the controller side. This enables upgrading of the key generation algorithms without the need to change the controller. The public/private key is generated in the host and the secure connection key is generated by combining inputs from each device in the pairing process.
- Encryption

  The encryption algorithm uses a AES-CCM 128-bit key and 128-bit plain text data, compliant with FIPS-1971. These feature enhancements raise the bar and help solve MITM issues and other passive eavesdropping mechanisms. This feature was introduced to enhance the security level of Bluetooth low energy and it is a mandatory feature for mPOS applications and applications that require a higher level of security.

Check the Bluetooth 4.1 specifications for more details.

3 Dual-Mode Topology

By supporting the dual-mode topology feature, the CC2564C device can be a central Bluetooth low energy device and a peripheral at the same time. Dual-mode topology allows the device to become a gateway between end equipment devices, sensors and smart devices.

For Example:

The CC2564C can be implemented within a smart watch acting as a central Bluetooth low energy device that collects data from Bluetooth low energy sensors (such as heart rate monitors, proximity sensors, cadence sensors, and so on), while simultaneously acting as a peripheral device for a mobile phone serving as a gateway between all sensor devices and the mobile phone.

Using this topology, a smart watch can present the data collected from the sensors, and send the data to the phone to save it to the cloud.

Besides supporting dual-mode topology, the CC2564C is a dual-mode device (supporting both Bluetooth low energy and Bluetooth Classic). The device, therefore, can be connected simultaneously to different networks of Bluetooth Classic and Bluetooth low energy. The CC2564C has an embedded advanced prioritization mechanism implemented, optimizing all network constraints and throughput use.

Check the Bluetooth 4.1 specifications for more details.

4 Audio and Voice Enhancement

The CC2564C device adds several features and mechanisms to the features supported by the CC2564B (assisted A2DP and WBS).

- Audio: multispeaker system support

  This feature synchronizes the time between up to four speakers so that all four speakers begin playing an audio stream with a latency of ~ 30 µs of each other, thereby creating a fully synchronized multispeaker user experience.

- Voice: 16/8 support

  This feature eases the PCM host integration when using both WBS (16 kHz) and NBS (8 kHz). In prior versions the host could only set the PCM to receive either WBS or NBS. By implementing this feature the PCM is set to WBS (16 kHz) and can double the NBS (8 Khz) signal to act as a 16 kHz signal, which enables the host to receive 16 kHz and 8 kHz using a single configuration.

- PCM Clock Extension

  This feature lets the system start or stop the PCM clock (as master on the PCM bus) even when a voice call is not active. The PCM clock extension can also set a timer to extend the clock after voice or audio is removed. This feature enables use of the PCM even when there is no active audio connection (for example, making a beep sound when receiving an incoming call).

5 Tested Environment and Recommendations

Dual-Mode Topology

The dual-mode topology feature enables the device to be both central and peripheral Bluetooth low energy simultaneously.

Theoretically the CC2564C can simultaneously support up to 10 devices (any combination of central and peripherals LE connections). However, when considering real-life scenarios and the Bluetooth specification bandwidth restrictions TI recommends the following conditions for the CC2564C device:

- Acting as a central device for up to three peripherals
- Serving as a peripheral to one central device

Each of these connections must have an interval that can coexist with the other connections. Optimally, all connections should have the same interval which must be large enough so the system can accommodate these connections while never colliding with the other connections. If it is not possible to set the intervals in this manner, note that the shorter the intervals are, the more collisions and connection prioritization may occur.

Audio

The new enhanced audio features can overcome drift and latency between devices (speakers). This feature was tested with a topology of up to four devices.

6 Known Issues and Limitations

A3DP and Bluetooth low energy cannot work concurrently.

SPPDMMultiDemo: the sample application gets stuck due to memory leak. When running in a loop of connect, send data, and disconnect, the application becomes slower with time until completely stuck.

SPPDMMultiDemo: the sample application gets stuck after using the SetBluetoothPower command bug for the NoOS version.

LinuxIBeacon cannot enter a negative TX power.

Wrong GATT error response when trying to read BR/EDR service over LE.

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