IW611_PB

2.4/5 GHz Dual-band 1x1 Wi-Fi 6 and Bluetooth 5.2 Solution

Rev. 1 — 16 May 2023 Product brief

1 Product overview

The IW611 is a highly integrated 2.4/5 GHz dual-band 1x1 Wi-Fi 6 and Bluetooth/Bluetooth Low Energy 5.2 single-chip solution optimized for a broad array of IoT and Industrial applications in smart home, smart devices and accessories, smart appliances, smart energy, industrial automation, gateways and many more. This high degree of integration contributes to very low system costs and a minimum external BOM while achieving efficient co-existence between all internal radios as well as external radios.

IW611 includes a full-feature Wi-Fi subsystem powered by NXP's 802.11ax (Wi-Fi 6) technology bringing higher throughput, better network efficiency, lower latency and improved range over previous generation Wi-Fi standards. The Wi-Fi subsystem integrates a Wi-Fi MAC, baseband, and direct-conversion radio with integrated PA, LNA, and transmit/receive switch removing the need for an RF front end module (FEMs), saving cost ,and reducing system complexity.

In addition to a Wi-Fi 6 radio, the IW611 integrates an independent Bluetooth 5.2 subsystem that supports Bluetooth and Bluetooth Low Energy (LE). The device features Bluetooth Profiles such as hands free (HFP), advanced audio distribution profile (A2DP) for audio streaming as well as additional profiles like dual wide band speech (WBS). For Bluetooth Low Energy, the IW611 enables 2 Mbit/s high speed data rate, long range, and extended advertising. Finally, LE Audio is supported utilizing Isochronous channels for a better overall audio experience.

The IW611 supports two front-end antenna configurations: single-antenna (Figure 1) and dual antenna (Figure 2).

The IW611 integrates dedicated CPUs and memories for both the Wi-Fi and Bluetooth subsystems which enable real time, independent protocol processing. Interfaces for connecting the IW611 to external host processors include SDIO 3.0 for Wi-Fi and UART for Bluetooth.

Figure 1 shows the application diagram for the single-antenna configuration.

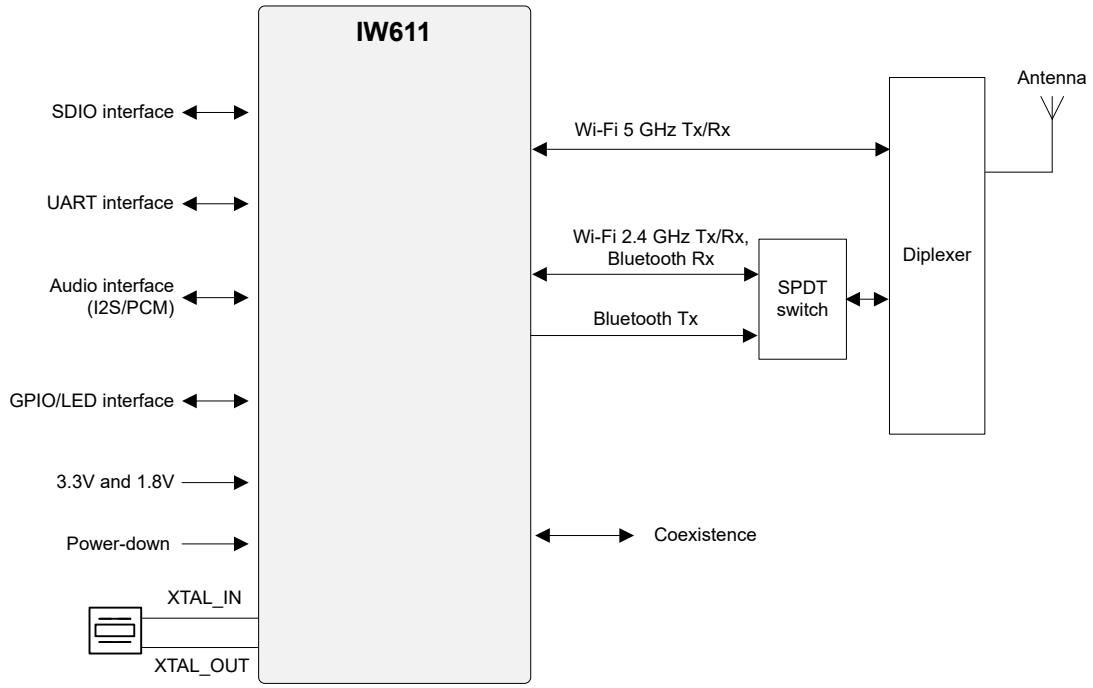

Figure 1. Application diagram - Single antenna configuration

Figure 2 shows the application diagram for the dual-antenna configuration.

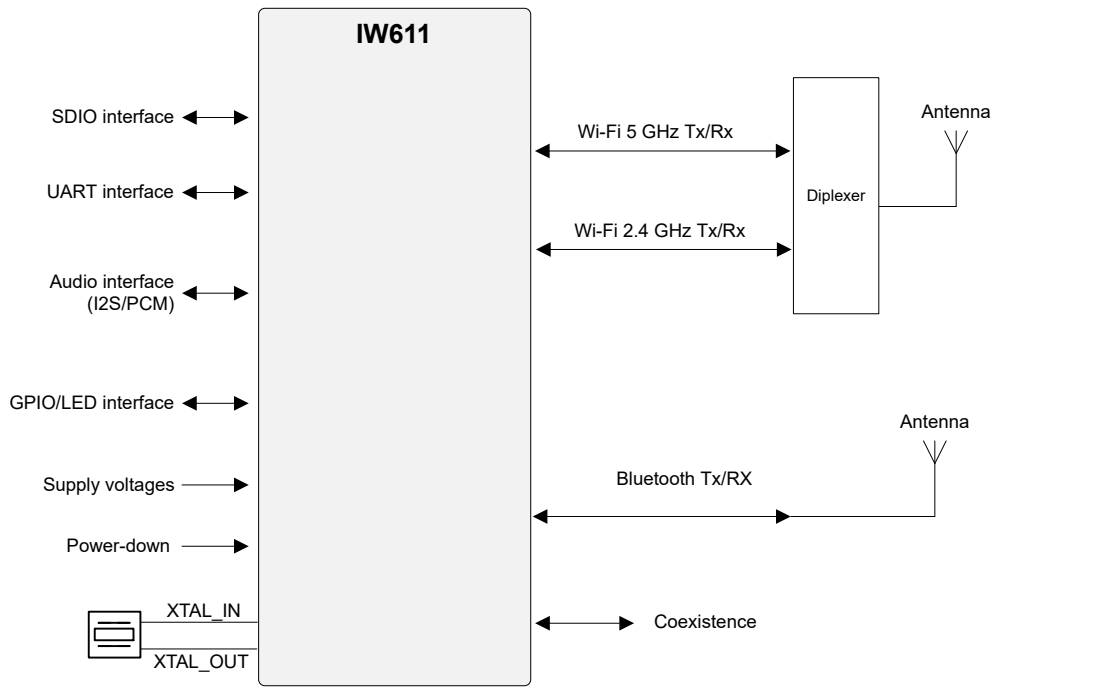

Figure 2. Application diagram - Dual-antenna configuration

1.1 Applications

- Smart entertainment — Smart speaker, sound bar, audio receiver, smart display, streaming/OTT device, smart television, tablet
- Gateways/hubs/bridges — Voice assistant front-end, audio controller, and other radios to Wi-Fi/IP network
- Smart home — Control panel, security system, thermostat, sprinkler controller, security camera, garage door controller, smart outlet, light switch, smart doorbell, smoke alarm/CO detector
- Industrial — Building automation, smart lighting, Wi-Fi to other radio bridge, point of sale (POS) terminal
- Smart appliances — Refrigerator, washer, dryer, oven range, microwave, dishwasher, water heater, air conditioner, coffee pot, rice cooker, vacuum cleaner, air purifier

1.2 Product family devices

- AW611: Automotive AECQ-100 grade 2 and grade 3, Wi-Fi 6 and Bluetooth/Bluetooth Low Energy (LE)
- IW611: Wi-Fi 6 and Bluetooth/Bluetooth Low Energy (LE)
- IW612: Wi-Fi 6, Bluetooth/Bluetooth Low Energy (LE), and 802.15.4 Tri-radio

2 Wi-Fi subsystem

2.1 IEEE 802.11 standards

- 802.11ax 1x1 SU and MU-MIMO/OFDMA
- 802.11ac Wave 1/2 backward compatible
- 802.11n/a/g/b backward compatible
- 802.11d operation in additional regulatory domains
- 802.11az accurate ranging
- 802.11e quality of service
- 802.11h transmit power control
- 802.11h DFS radar pulse detection
- 802.11k radio resource measurement
- 802.11mc precise indoor location positioning
- 802.11r fast hand-off for AP roaming
- 802.11v BTM frame transmission/reception
- 802.11w protected management frames
- 802.11y ECSA
- 802.11z tunneled direct link setup
- Fully supports clients (stations) implementing IEEE Power Save mode

2.2 Wi-Fi MAC

- 802.11ax 1x1 MU-MIMO MAC
- Trigger Frame Formats
  - Basic trigger frame
  - MU-BAR, MU-RTS, Beamforming Report Poll (BFRP), BSR Poll (BSRP) trigger variant
  - Trigger frame MAC padding
- HE Variants of HT Control
  - Basic format
  - UL Power Headroom
  - Receive Operation Mode control subfield
- HE MU Frame Exchange Sequences
- MU Acknowledgment (ACK)
- M-BA and C-BA Variants in BA Frames
- MU-RTS/CTS Procedures
- Target Wait Time Scheduling
- HE Dual-NAV
- UL Carrier Sensing
- Buffer Status Reports in response to BSRP trigger frames
- Operating Mode Indication (OMI)
- A-MPDU Rx (de-aggregation) and Tx (aggregation) (supports single-MPDU A-MPDU)
- Reduced Inter-Frame Spacing (RIFS) receive
- Management information base counters
- Radio resource measurement counters
- Quality of service queues
- Block acknowledgment extension
- Dynamic frequency selection
- Multiple-BSS/Station
- Long and short preamble generation on a frame-by-frame basis for 802.11b frames
- Transmit rate adaptation
- Transmit power control
- Mobile hotspot

2.3 Wi-Fi baseband

- 802.11ax 1x1 MU-MIMO baseband, backward compatible with 802.11ac/n/a/g/b technology
- Bandwidth support
  - 20 MHz
  - 40 MHz
  - 80 MHz
- Modulation and Coding Schemes (MCS)
  - 802.11ax—MCS0~11
  - 802.11ac—MCS0~9
  - 802.11n—MCS0~7
  - Dual Sub-Carrier Modulation (DCM)
    - MCS0
  - BCC and LDPC coding
- Frame Formats
  - 802.11ax HE_SU (Tx/Rx)
  - 802.11ax HE_MU (Rx)
  - 802.11ax HE_ER_SU (Tx/Rx)
  - 802.11ax HE_TB (Tx)
  - 802.11ac VHT
  - 802.11n HT
  - 802.11a (including dup/quad modes)
  - 802.11g (including dup mode)
  - 802.11b
- Uplink MU-MIMO Tx as STA
- Downlink MU-MIMO Rx as STA
- Aggressive Packet Extension
- Range Extension
- Receiver Beam Change
- Guard Interval Modes
  - 1x HE-LTF with 0.8 us GI
  - 1x HE-LTF with 1.6 us GI (for UL TB PPDU)
  - 2x HE-LTF with 0.8 us GI
  - 2x HE-LTF with 1.6 us GI
  - 4x HE-LTF with 3.2 us GI
  - 4x HE-LTF with 0.8 us GI
- Dynamic Frequency Selection (DFS) (radar detection)
- Optional 802.11ac and 802.11n MIMO features:
  - 20/40/80 MHz coexistence with middle-packet detection (GI detection) for enhanced CCA
  - LDPC transmission and reception for both 802.11ac and 802.11n
  - Short guard interval (0.4 us)
  - RIFS on receive path for 802.11n packets
  - VHT MU-PPDU (receive)
- Spectral intelligence
  - Spectrum monitoring
  - DFS assist to reduce false detections
  - Interference identification/classification

- Power save features

2.4 Wi-Fi radio

- 5 GHz and 2.4 GHz Wi-Fi band operation
- 802.11ax 1x1 MU-MIMO on-chip RF radio
- Integrated PA, LNA

2.5 RF channels

Table 1 shows the list of supported channels for 2.4 GHz and 5 GHz.

Table 1. List of supported Wi-Fi channels

Channel number	Frequency	Channel number	Frequency	Channel number	Frequency
2.4 GHz channel					
1	2412 MHz	2	2417 MHz	3	2422 MHz
4	2427 MHz	5	2432 MHz	6	2437 MHz
7	2442 MHz	8	2447 MHz	9	2452 MHz
10	2457 MHz	11	2462 MHz	12	2467 MHz
13	2472 MHz	—	—	—	—
5 GHz channel					
36	5180 MHz	40	5200 MHz	44	5220 MHz
48	5240 MHz	52	5260 MHz	56	5280 MHz
60	5300 MHz	64	5320 MHz	100	5500 MHz
104	5520 MHz	108	5540 MHz	112	5560 MHz
116	5580 MHz	120	5600 MHz	124	5620 MHz
128	5640 MHz	132	5660 MHz	136	5680 MHz
140	5700 MHz	144	5720 MHz	149	5745 MHz
153	5765 MHz	157	5785 MHz	161	5805 MHz
165	5825 MHz	169	5845 MHz	173	5865 MHz
177	5885 MHz	—	—	—	—
184	4920	187	4935	188	4940
192	4960	196	4980	—	—
8	5040	11	5055	12	5060
16	5080	—	—	—	—

2.6 Wi-Fi encryption

- Supports WPA2 and WPA3 personal and enterprise
- Data Frame Encryption/Decryption
  - Advanced Encryption Standard (AES) / Counter-Mode/CBC-MAC Protocol (CCMP)
  - Advanced Encryption Standard (AES) / Galois/Counter Mode Protocol (GCMP)
  - WLAN Authentication and Privacy Infrastructure (WAPI)
- Management Frame Encryption/Decryption for broadcast/multicast packets
  - Advanced Encryption Standard (AES) / Cipher-based Message Authentication Code (CMAC)
  - BIP-GMAC
- Management Frame Encryption/Decryption for unicast packets
  - AES/CCMP
  - AES/GCMP

2.7 Beamforming

- 802.11ax/ac/n Explicit Beamformee
  - Supports sounding feedback for up to 4x4 Beamformer

2.8 Wi-Fi host interface

- SDIO 3.0 (4-bit SDIO and 1-bit SDIO) with transfer rates up to SDR104 (208 MHz)

3 Bluetooth subsystem

3.1 Bluetooth features

- Bluetooth 5.2 features
- Bluetooth Class 2
- Bluetooth Class 1
- Single-ended, shared Tx/Rx path for Bluetooth
- I2S/PCM interface for voice applications
- Baseband/radio BDR/EDR packet types—1 Mbps (GFSK), 2 Mbps (π/4-DQPSK), 3 Mbps (8DPSK)
- Fully functional Bluetooth baseband—AFH, forward error correction, header error control, access code correlation, CRC, encryption bit stream generation, and whitening
- Interlaced scan for faster connection setup
- Simultaneous active ACL connection support
- Automatic ACL packet type selection
- Full central[1] and peripheral[1] piconet support
- Scatternet support
- Standard UART HCI transport layer
- HCI layer to integrate with profile stack
- SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement
- All standard SCO/eSCO voice coding
- A2DP support
- All standard pairing, authentication, link key, and encryption operations
- Standard Bluetooth power-saving mechanisms (hold, sniff modes, and sniff subrating)
- Enhanced Power Control (EPC)
- Channel Quality Driven Data Rate (CQDDR)
- Wideband Speech (WBS) support (2 WBS links)
- Encryption (AES) support

1 The master/slave replacement in this document follows the recommendation of Bluetooth SIG.

3.2 Bluetooth Low Energy (LE) features

- Bluetooth LE 5.3
- Supports up to 16 simultaneous central[2]/peripheral[2] connections
- Wi-Fi/Bluetooth coexistence protocol support
- Shared RF with BDR/EDR
- Encryption (AES) support
- Intelligent Adaptive Frequency Hopping (AFH)
- Bluetooth LE Privacy 1.3
- Bluetooth LE Secure Connection
- Bluetooth LE Data Length Extension
- Bluetooth LE Advertising Extension
- Bluetooth LE Long Range
- Bluetooth LE 2 Mbps
- Bluetooth LE power control
- Bluetooth LE isochronous channels[3]

3.3 Bluetooth host interface

- High-Speed UART with support up to 3 Mbps baud rate

2 The master/slave replacement in this document follows the recommendation of Bluetooth SIG.

3 Bluetooth LE audio supported with external host running Low Complexity Communication codec (LC3) through HCI interface

3.4 Digital audio interfaces

3.4.1 I2S interface

- Central[4] or peripheral[4] mode
- I2S (Inter-IC Sound) interface for audio data connection to Analog-to-Digital Converters (ADC) and Digital-to-Analog Converters (DAC)
- 3-state I2S interface capability
- I2S pins shared with PCM pins
- Supports clock speeds of 4.096 MHz, 2.048 MHz, and 2 MHz

3.4.1.1 I2S interface protocol

Figure 3 shows I2S interface protocol.

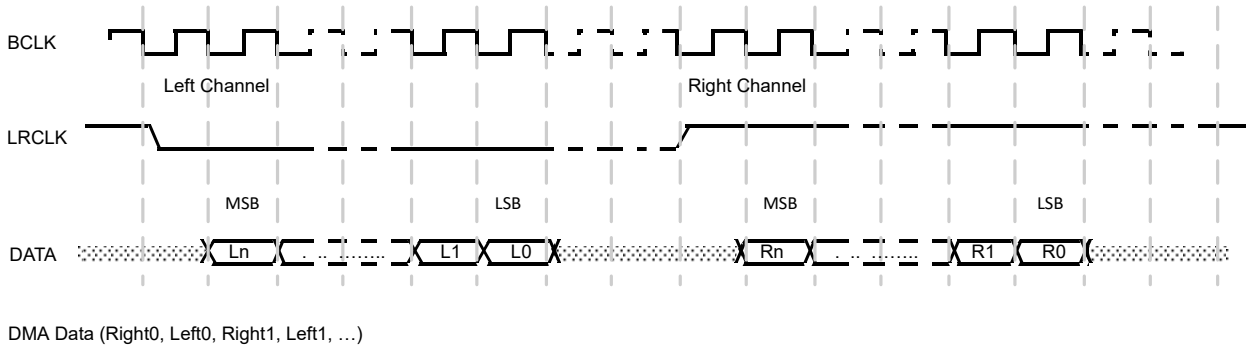

Figure 3. I2S interface protocol

4 The master/slave replacement in this document follows the recommendation of Bluetooth SIG.

IW611 supports mono and dual channel modes.

In mono-channel mode, by default the left channel is used for data.

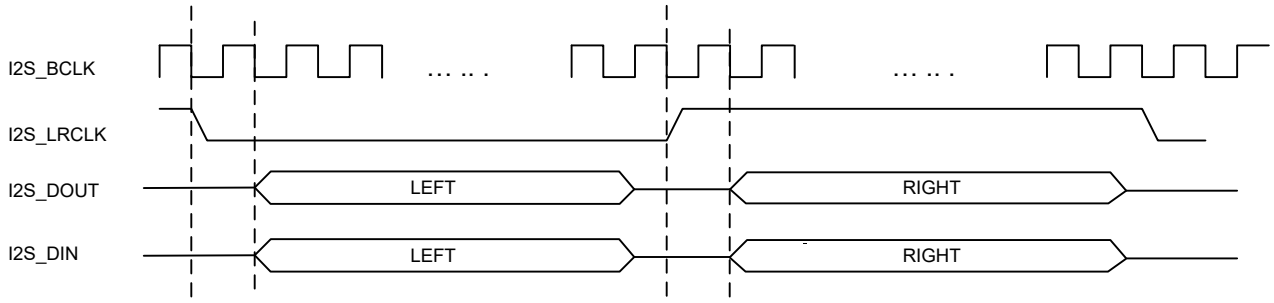

Figure 4. I2S timing specification diagram—Mono channel mode

In dual-channel mode, the two channels are supported on two time slots.

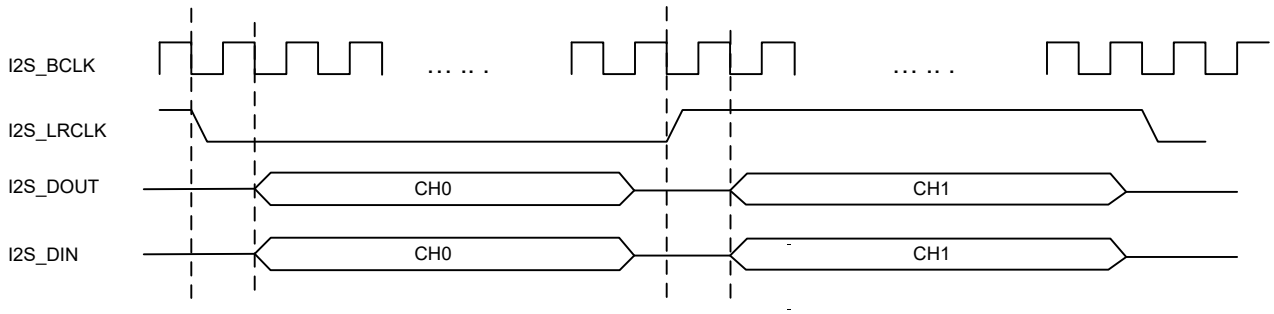

Figure 5. I2S timing specification diagram—Dual channel mode - Single Bluetooth

With dual Bluetooth, the channel pair CH0 + CH2 is for one Bluetooth, and the channel pair CH1 + CH3 is for the second Bluetooth.

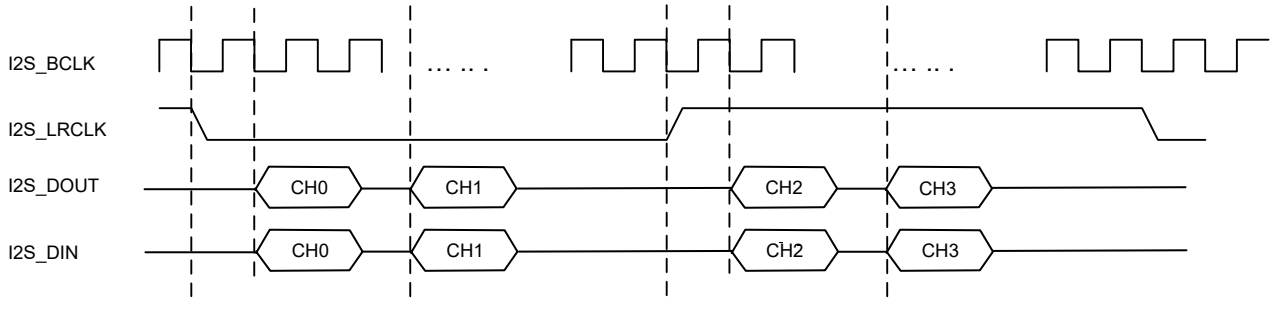

Figure 6. I2S timing specification diagram—Dual channel mode - Dual Bluetooth

3.4.1.2 Clock frequency and audio data resolutions

Audio data may arrive with different input data formats with different sampling rates.

In central[5] mode, the I2S interface uses an audio input clock of 4.096 MHz or 2.048 MHz to provide the appropriate M clock (MCLK) and bit clock (I2S_BCLK) frequency to match the sampling rates of each audio data format. The sampling rates can be 8 kHz to 16 kHz.

In peripheral[5] mode, the I2S interface does not provide the bit clock (I2S_BCLK) but it can provide the M clock (MCLK).

5 The master/slave replacement in this document follows the recommendation of Bluetooth SIG.

3.4.2 PCM interface

- Central[6] or peripheral[6] mode
- PCM bit width size of 8 bits or 16 bits
- Up to four slots with configurable bit width and start positions
- 3-state PCM interface capability
- PCM short frame and long frame[7] synchronization
- PCM pins shared with I2S pins
- Supports clock speeds of 4.096 MHz, 2.048 MHz, and 2 MHz

3.4.2.1 PCM protocol

The PCM interface supports long and short frame sync. Figure 7 and Figure 8 show an example of a PCM interface with four signals.

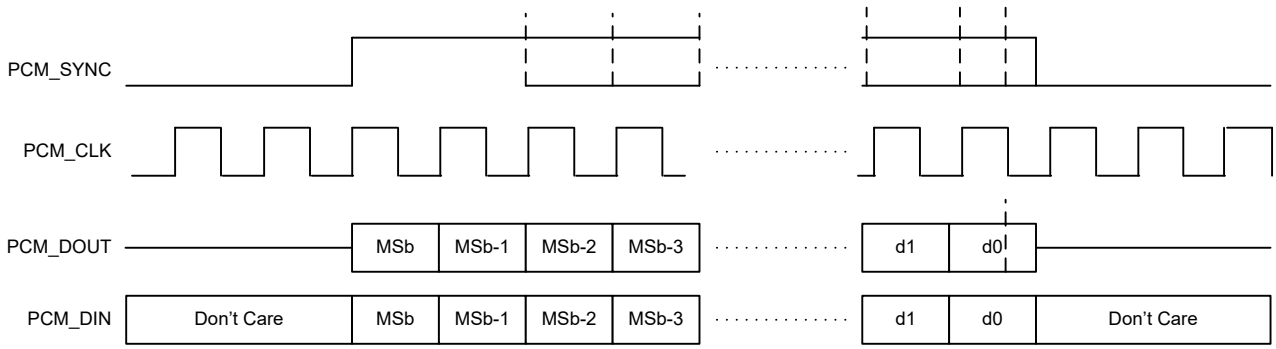

Figure 7. PCM long frame sync

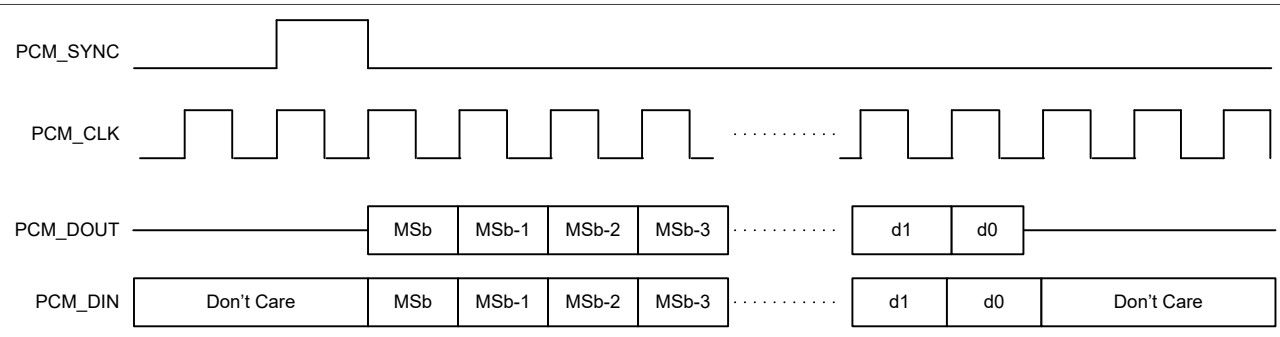

Figure 8. PCM short frame sync

6 The master/slave replacement in this document follows the recommendation of Bluetooth SIG.

7 In PCM central mode, PCM long frame synchronization is 1 clock wide. In PCM peripheral mode, PCM central long frame synchronization pattern is supported.

IW611 supports mono and dual channel modes.

Note: *Figure 9 and Figure 10 illustrate PCM mono and dual channel modes in short frame sync. The same applies to long frame sync.*

In mono-channel mode, by default the left channel is used for data.

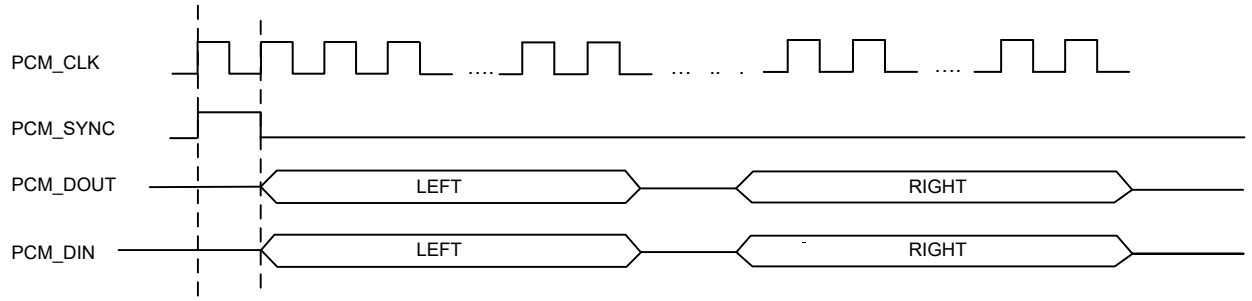

Figure 9. PCM mono channel mode (short frame sync)

In dual-channel mode, the two channels are supported on two time slots.

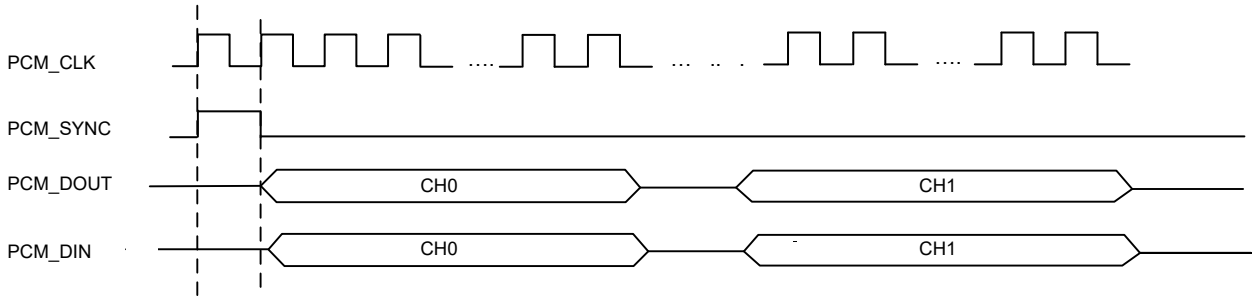

Figure 10. PCM dual channel mode (short frame sync)

3.4.2.2 PCM modes of operation

The PCM interface supports two modes of operation:

- PCM central[8]
- PCM peripheral[8]

When in PCM central[8] mode, the interface generates a 2 MHz or a 2.048 MHz PCM_CLK and 8 kHz PCM_SYNC signal. An alternative PCM central[8] mode is available that uses an externally generated PCM_CLK, but still generates the 8 kHz PCM_SYNC. The external PCM_CLK must have a frequency that is an integer multiple of 8 kHz. Supported frequencies are in the 512 kHz to 4 MHz range.

When in PCM peripheral[8] mode, the interface has both PCM_CLK and PCM_SYNC as inputs, thereby letting another unit on the PCM bus generate the signals.

The PCM interface consists of up to four PCM slots (time divided) preceded by a PCM sync signal. Each PCM slot can be either 8 or 16 bits wide. The slots can be separated in time, but are not required to follow immediately after one other. The timing is relative to PCM_CLK. Figure 12 shows an example of a PCM burst with two slots.

The burst starts with a PCM_SYNC and then follows the PCM burst. In this example, the PCM burst consists of two PCM slots (the first slot is 8 bits wide, the second slot is 16 bits wide) separated with two PCM_CLK clock cycles. The PCM slots can be configured to start at an arbitrary point in time, and the start value is given relative to the start of the PCM_SYNC. The timing of the four PCM slots must be such that slot 0 is always located before slot 1, slot 1 before slot 2, etc. It is possible to only use for example slot 1 and not slot 0.

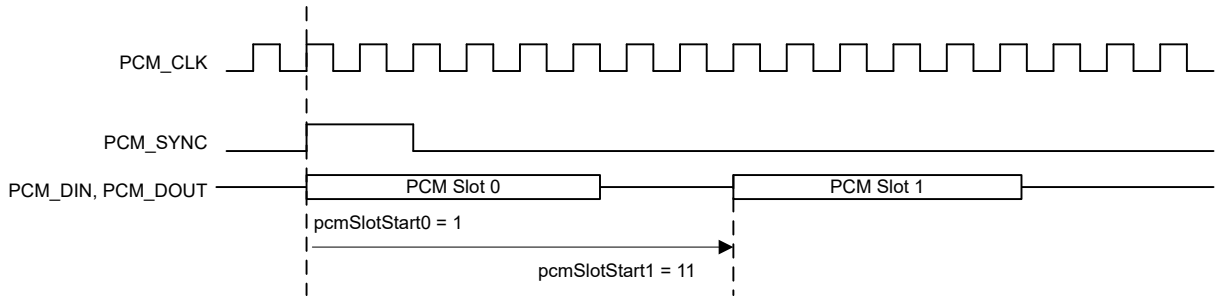

Figure 11. PCM burst with two PCM slots - PCM long frame sync

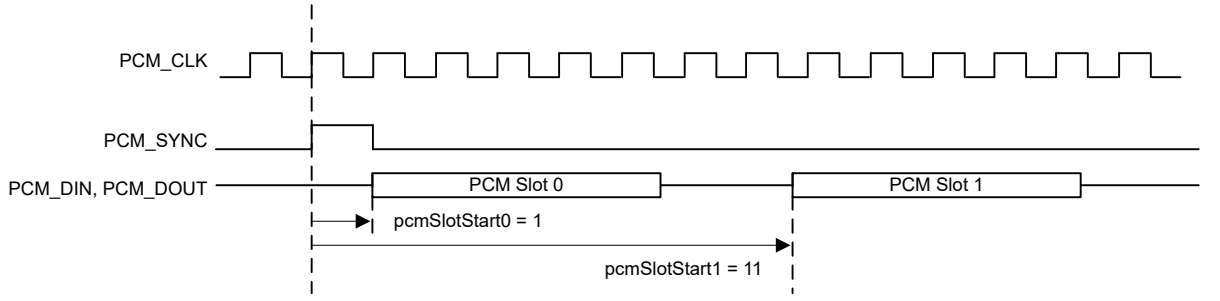

Figure 12. PCM burst with two PCM slots - PCM short frame sync

8 The central/peripheral replacement in this document follows the recommendation of Bluetooth SIG.

4 Revision history

Table 2. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW611 v.1.0	20230516	Product brief	-	-

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