

IW416

Dual-band 1x1 Wi-Fi 4 and Bluetooth 5.2 Combo SoC

Rev. 7 — 5 September 2024

Product data sheet

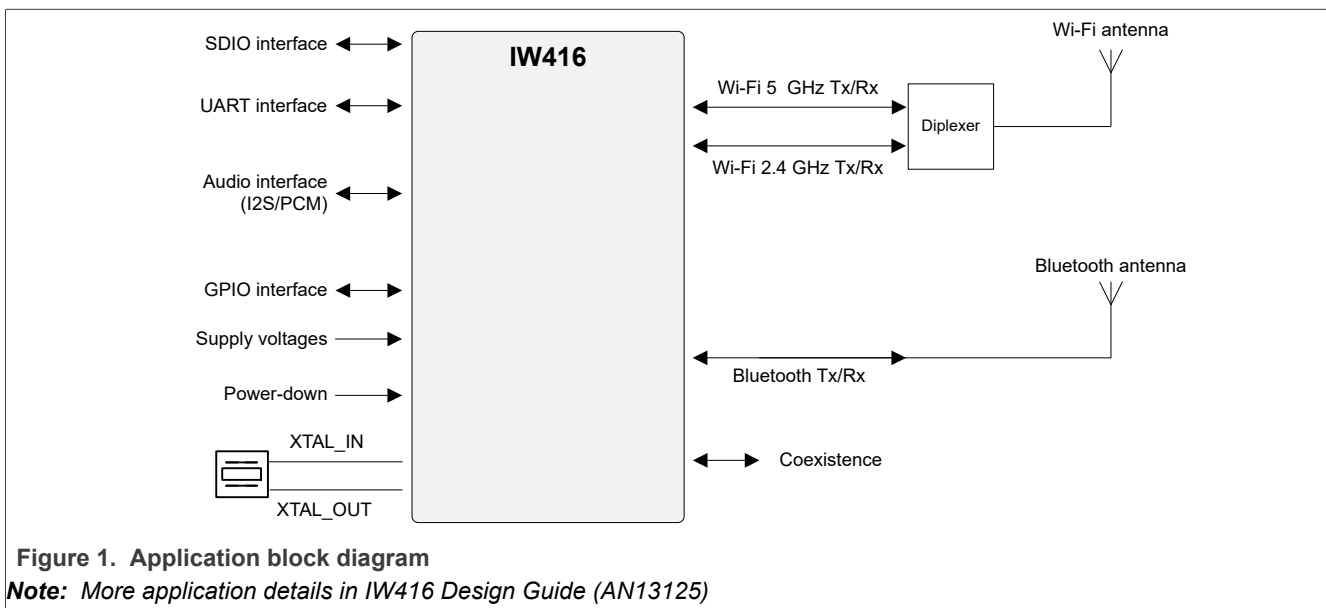
1 Product overview

The IW416 is a highly integrated Wi-Fi 4 and Bluetooth 5.2 System-on-Chip (SoC) enabling a low-cost connectivity solution. Supporting a 1x1 SISO Wi-Fi operation in the 2.4 GHz and the 5 GHz band, the SoC provides a full-feature Wi-Fi subsystem with a peak PHY data rate of 150 Mbit/s. In addition to classic Bluetooth features, the IW416 enables Bluetooth 5.2 capabilities including Low Energy (LE), LE long range, LE 2 Mbps, and Periodic Advertising Sync Transfer (PAST).

With integrated transmit (Tx) PAs, receive (Rx) LNAs and Tx/Rx switches for the Wi-Fi and Bluetooth radios, the IW416 simplifies design allowing quick integration of either dual or single-antenna operation. The dual-antenna configuration enables simultaneous Wi-Fi and Bluetooth operation. With the single-antenna configuration, simultaneous 5 GHz Wi-Fi and Bluetooth is supported. In the 2.4 GHz band, the single-antenna configuration allows arbitrated transmit and receive operation of Wi-Fi and Bluetooth.

Promoting synergistic operation, the IW416 implements advanced Wi-Fi and Bluetooth co-existence hardware in conjunction with algorithms to optimize collaborative performance. In addition, support for external radio co-existence is provided through an external interface.

Available in both HVQFN68 and WLCSP76 packages with two operating temperature ranges of 0 to 70°C and -40 to 85°C, the IW416 supports a SDIO host interface for the Wi-Fi radio and a UART host interface for Bluetooth radio.



1.1 Applications

- Smart home: Voice assist device, smart printer, smart speaker, home automation gateway, and IP camera
- Industrial and building automation
- Asset management
- Retail/POS
- Healthcare and medical devices
- Smart city

1.2 Wi-Fi key features

- Support 802.11 a/b/g/n
- Dual band: 2.4 GHz and 5 GHz
- Single stream 802.11n with 20 MHz and 40 MHz channels
- Up to MCS7 data rates (150 Mbit/s)
- Dynamic Rapid Channel Switching (DRCS) for simultaneous operation in 2.4 GHz and 5 GHz bands
- Packet Traffic Arbiter (PTA) interface to coexist with an external radios. The external radio can be 802.15.4 or other radios.
- Security: WPA3, WPA2, WPA2-WPA mixed mode

1.3 Bluetooth key features

- Supports Bluetooth 5.1 (Class 1/Class 2) and Bluetooth Low Energy features
- Bluetooth 5.2 certified
- Long range - 4x coverage
- 2 Mbit/s data rate - 2x faster
- Improved advertisement capability - enables more IoT services
- I2S and PCM audio interfaces
- AES security¹

1.4 Host interfaces

Wi-Fi and Bluetooth host interface options

Wi-Fi	Bluetooth
SDIO 3.0	UART

¹ Refer to IW416 errata sheet (ES_IW416)

1.5 Operating characteristics

- Supply voltages: 1.05V, 1.8V, and 2.2V
- Operating temperature ranges:
 - Commercial: 0 to 70°C
 - Industrial: -40 to 85°C

1.6 General features

- Package options
 - HVQFN68 (68 pins, 0.4 mm pitch, 8 mm x 8 mm x 0.85 mm body)
 - WLCSP76 (76 terminals, 0.35 mm pitch, 3.95 mm x 3.565 mm x 0.495 mm body)
- Simultaneous Wi-Fi and Bluetooth operation supported with dual antenna configuration
 - Shared Wi-Fi and Bluetooth operation with single antenna is possible
- Power saving features
 - Efficient power management system
 - Sleep and standby modes
 - Deep-sleep mode
- Independent ARM-based Wi-Fi and Bluetooth CPUs
 - Wi-Fi CPU: 160 MHz clock speed
 - Bluetooth CPU: 128 MHz clock speed
- Memory:
 - Internal SRAM
 - Boot ROM
 - OTP memory to store the MAC address and calibration data
- Peripheral Interface
 - General-Purpose I/O (GPIO) interface

1.7 Internal block diagram

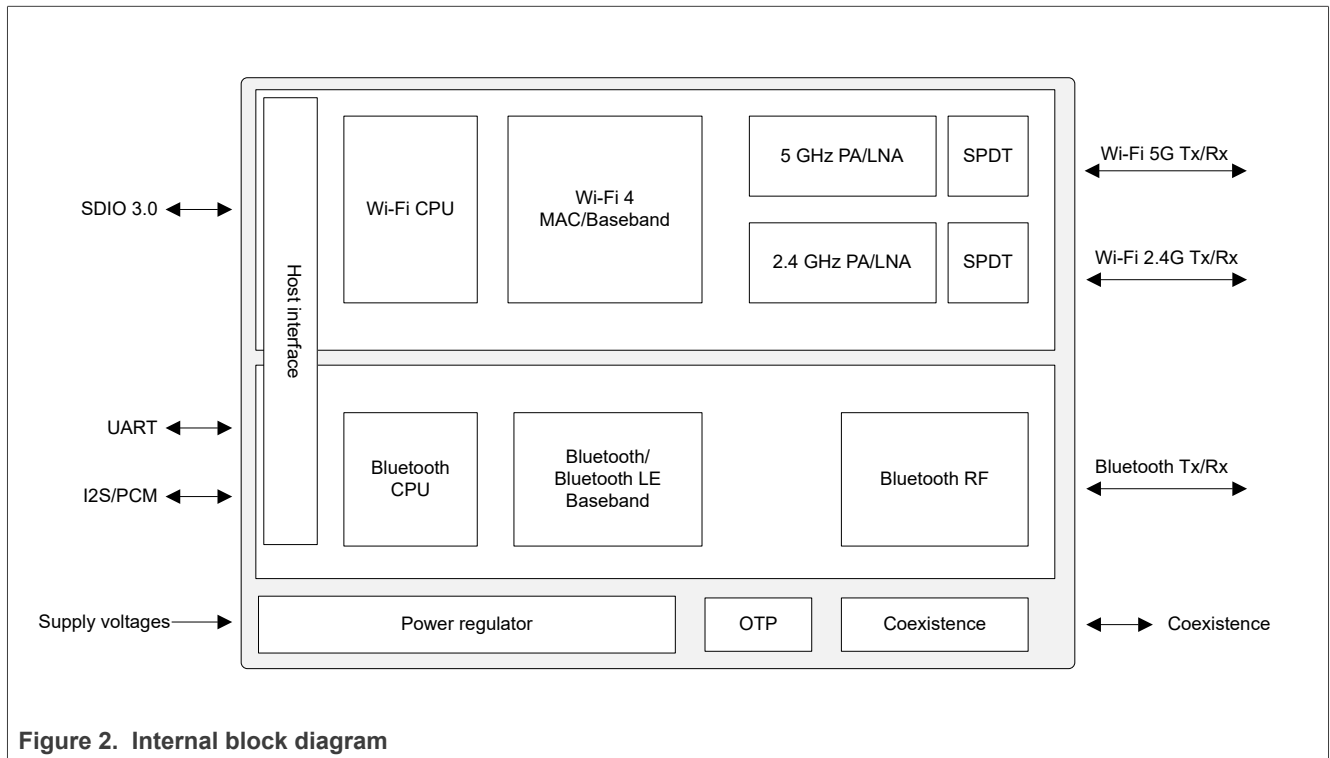


Figure 2. Internal block diagram

2 Ordering information

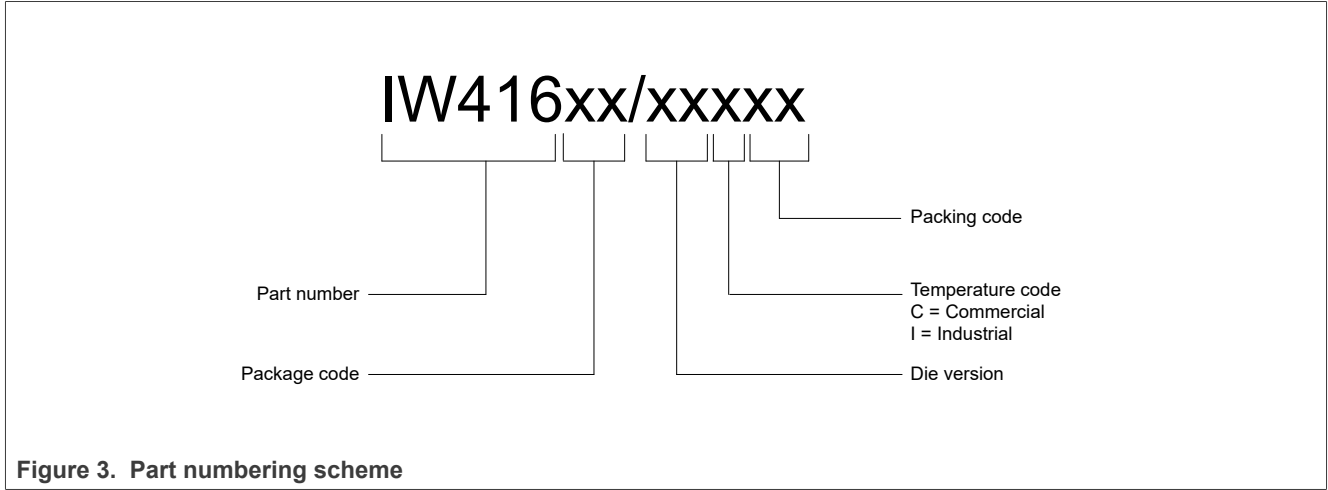


Figure 3. Part numbering scheme

Table 1. Part order codes

Part order code	Package type	Operating temperature range	Packing
IW416HN/A1CK	HVQFN68 - 8 x 8 x 0.85 mm, with 0.4 mm pitch	Commercial	Tray
IW416HN/A1CMP	HVQFN68 - 8 x 8 x 0.85 mm, with 0.4 mm pitch	Commercial	Tape and Reel
IW416HN/A1IK	HVQFN68 - 8 x 8 x 0.85 mm, with 0.4 mm pitch	Industrial	Tray
IW416HN/A1IMP	HVQFN68 - 8 x 8 x 0.85 mm, with 0.4 mm pitch	Industrial	Tape and Reel
IW416UK/A1CZ	WLCSP76 - 3.95 x 3.565 x 0.495 mm, with 0.35 mm pitch	Commercial	Tape and Reel
IW416UK/A1IZ	WLCSP76 - 3.95 x 3.565 x 0.495 mm, with 0.35 mm pitch	Industrial	Tape and Reel

3 Wi-Fi subsystem

3.1 IEEE 802.11 standards

- 802.11n maximum data rates up to 72 Mbit/s (20 MHz channel bandwidth), 150 Mbit/s (40 MHz channel bandwidth)
- 802.11a/g/b backward compatibility
- 802.11d international roaming
- 802.11e quality of service
- 802.11h transmit power control
- 802.11h DFS radar pulse detection
- 802.11i enhanced security
- 802.11k radio resource measurement²
- 802.11n block acknowledgment extension
- 802.11r fast hand-off for AP roaming²
- 802.11u Hotspot 2.0 (STA mode only)
- 802.11v TIM frame transmission/reception²
- 802.11w protected management frames
- Fully supports clients (stations) implementing IEEE Power Save mode

3.2 Wi-Fi MAC

The Wi-Fi MAC has the following features:

- Simultaneous peer-to-peer and infrastructure modes
- RTS/CTS for operation under DCF
- Duplicate frame detection
- On-chip Tx and Rx FIFO for maximum throughput
- Open System and Shared Key Authentication services
- A-MPDU Rx (de-aggregation) and Tx (aggregation)
- 20/40 MHz coexistence
- Reduced Inter-Frame Spacing (RIFS) receive
- Management information base counters
- Radio resource measurement counters
- Quality of service queues
- Block acknowledgment extension
- Dynamic frequency selection
- TIM frame transmission/reception
- Transmit rate adaptation
- Transmit power control
- Long and short preamble generation on a frame-by-frame basis for 802.11b frames

² Available through Host Supplicant

3.3 Wi-Fi baseband

The Wi-Fi baseband has the following features:

- 802.11n 1x1 SISO
- Bandwidth supported:
 - 20 MHz
 - 20 in 40 MHz (upper and lower)
 - 40 MHz
 - 20 MHz duplicate
- 802.11n modulation coding scheme (MCS) 0-7 and MCS 32 (HT duplicate mode)
- 802.11n 400 ns and 800 ns guard interval
- Dynamic frequency selection (radar detection)
 - Enhanced radar detection for long and short pulse radar
 - Enhanced AGC scheme for DFS channel
- Radio resource measurement
- Optional 802.11n SISO features:
 - 20/40 MHz coexistence
 - 1 spatial stream STBC reception
 - Short guard interval
 - RIFS on receive path for 802.11n packets
 - 802.11n greenfield Tx/Rx
- Power save features

3.4 Wi-Fi radio

The Wi-Fi radio has the following features:

- Integrated direct-conversion radio
- 20 MHz and 40 MHz channel bandwidths

Wi-Fi Rx path

- On-chip LNA with optimized noise figure and power consumption
- High dynamic range AGC function in receive mode

Wi-Fi Tx path

- Internal PA with power control
- Optimized Tx gain distribution for linearity and noise performance

Radio channel frequencies

The Wi-Fi RF radio integrates all the necessary functions for transmit and receive operation.

The channel frequencies are controlled through an internal bus and software programmable.

[Table 2](#) lists the supported channels (20 MHz).

Table 2. Supported channels (20 MHz)

Channel	Frequency (GHz)
1	2.412
2	2.417
3	2.422
4	2.427
5	2.432
6	2.437
7	2.442
8	2.447
9	2.452
10	2.457
11	2.462
12	2.467
13	2.472
--	--
36	5.180
40	5.200
44	5.220
48	5.240
52	5.260
56	5.280
60	5.300
64	5.320
100	5.500
104	5.520
108	5.540
112	5.560
116	5.580
120	5.600
124	5.620
128	5.640
132	5.660

Table 2. Supported channels (20 MHz)...continued

Channel	Frequency (GHz)
136	5.680
140	5.700
144	5.720
149	5.745
153	5.765
157	5.785
161	5.805
165	5.825

[Table 3](#) lists the supported channels (40 MHz).

Table 3. Supported channels (40 MHz)

Channel	Frequency (GHz)
1–5	2.422
2–6	2.427
3–7	2.432
4–8	2.437
5–9	2.442
6–10	2.447
7–11	2.452
9–13	2.462
—	—
36–40	5.190
44–48	5.230
52–56	5.270
60–64	5.310
100–104	5.510
108–112	5.550
116–120	5.590
124–128	5.630
132–136	5.670
149–153	5.755
157–161	5.795

3.5 Wi-Fi encryption

- AES/CCMP as part of the 802.11i security standard (WPA3, WPA2, WPA2-WPA mixed mode)
- AES/CMAC as part of the 802.11w security standard

3.6 Wi-Fi host interfaces

- SDIO 3.0 device interface

4 Bluetooth subsystem

4.1 Bluetooth 2.4 GHz Tx/Rx

- Bluetooth 5.1 features
- Bluetooth Class 2 and Bluetooth Class 1
- Single-ended, shared TX/RX path for Bluetooth
- PCM interface for voice applications
- Baseband and radio basic data rate (BDR)/enhanced data rate (EDR) packet types—1 Mbit/s (GFSK), 2 Mbit/s ($\pi/4$ -DQPSK), and 3 Mbit/s (8DPSK)
- Fully functional Bluetooth baseband—adaptive frequency hopping (AFH), forward error correction, header error control, access code correlation, Cyclic Redundancy Check (CRC), encryption bit stream generation, and whitening
- Adaptive Frequency Hopping (AFH) using packet error rate (PER)
- Interlaced scan for faster connection setup
- Simultaneous active Asynchronous Connection-Less (ACL) connection support
- Automatic ACL packet type selection
- Full central and peripheral 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
- All standard pairing, authentication, link key, and encryption operations
- Standard Bluetooth power-saving mechanisms (hold, sniff modes, and sniff sub-rating)
- Enhanced Power Control (EPC)
- Channel Quality Driven data rate (CQDDR)
- Wide-band Speech (WBS) support (2 WBS link)
- Encryption (AES) support³

³ Refer to IW416 errata sheet (ES_IW416).

4.2 Bluetooth Low Energy (LE)

- Broadcaster, observer, central, and peripheral roles
- Supports link layer topology to be central and peripheral (connects up to 16 links)
- Wi-Fi/Bluetooth coexistence protocol support
- Shared RF with BDR/EDR
- Encryption (AES) support⁴
- Intelligent Adaptive Frequency Hopping (AFH)
- LE Privacy 1.2
- LE Secure Connection⁴
- LE Data Length Extension
- LE Advertising Extension
- LE 2 Mbps
- LE Long Range
- Periodic Advertising Sync Transfer(PAST)
- Advertising Channel Index

4.3 Bluetooth host interfaces

- High-Speed UART interface up to 3 Mbit/s

4.4 Audio interfaces

4.4.1 I2S interface

- I2S (Inter-IC Sound) interface for audio data connection to analog-to-digital converter (ADC)
- Central and peripheral modes for I2S, MSB, and LSB audio interfaces
- 3-state I2S interface compatibility
- I2S pins shared with PCM pins

4.4.2 PCM interface

The PCM interface is used to exchange audio data between the host and the Bluetooth functional block.

- Central or peripheral mode
- PCM bit width size of 8 bits or 16 bits
- Up to 4 slots with configurable bit width and start positions
- PCM short frame and long frame synchronization⁵
- 3-state PCM interface capability
- PCM pins shared with I2S pins

⁴ Refer to IW416 errata sheet (ES_IW416).

⁵ In PCM central mode, PCM long frame synchronization is 1 clock wide. In PCM peripheral mode, PCM central long frame synchronization pattern is supported.

4.4.2.1 Protocol description

The PCM interface supports short frame sync. [Figure 4](#) shows an example of a PCM interface with 4 signals.

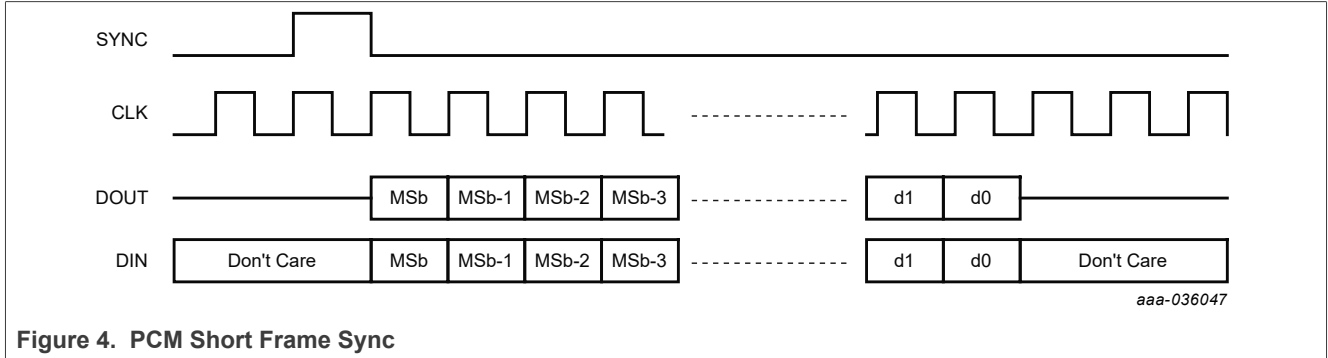


Figure 4. PCM Short Frame Sync

5 Coexistence

5.1 Antenna configurations

The IW416 supports two antenna configurations: single-antenna and dual-antenna configurations.

5.1.1 Dual-antenna configuration

The two separate antennas allow simultaneous independent operation of the Wi-Fi and Bluetooth radios.

5.1.2 Single-antenna configuration

With the single-antenna configuration, simultaneous 5 GHz Wi-Fi and Bluetooth is supported. In the 2.4 GHz band, the single-antenna configuration allows arbitrated transmit and receive operation of Wi-Fi and Bluetooth.

[Table 4](#) shows the supported TX and/or RX operations with the IW416 single-antenna configuration.

Table 4. Wi-Fi and Bluetooth/Bluetooth LE supported TX and or RX operations - Single-antenna configuration

Row #	Bluetooth/ Bluetooth LE	Wi-Fi 2.4 GHz	Wi-Fi 5 GHz
1	TX	—	TX/RX
2	—	TX	—
3	RX	—	—
4	—	RX	—
5	RX	—	TX/RX

In single-antenna configuration:

- Wi-Fi 2.4 GHz TX and Bluetooth TX operations are arbitrated (rows 1 and 2)
- Wi-Fi 2.4 GHz RX and Bluetooth RX operations are arbitrated (rows 3 and 4)
- Wi-Fi 5 GHz TX/RX and Bluetooth RX or TX operations are simultaneous (rows 1 and 5)

5.2 Central hardware packet traffic arbiter

The central hardware packet traffic arbiter arbitrates the transmit and/or receive operations between the on-chip Wi-Fi and Bluetooth radios as per the supported hardware configuration. See [Section 5.1](#).

In addition to the on-chip radios, the central hardware packet traffic arbiter arbitrates one external radio. Refer to [Section 5.3](#).

5.3 Coexistence with an external radio

WCI-2 and PTA external coexistence interfaces are used for the coexistence with an external radio.

WCI-2 external coexistence interface

WCI-2 is the two-wire wireless coexistence interface 2 protocol defined in the Bluetooth Core Specification (Vol 7 Part C).

Figure 5 illustrates the hardware coexistence interface between the central hardware packet traffic arbiter and the external radio. In the figure, Wireless SoC is IW416.

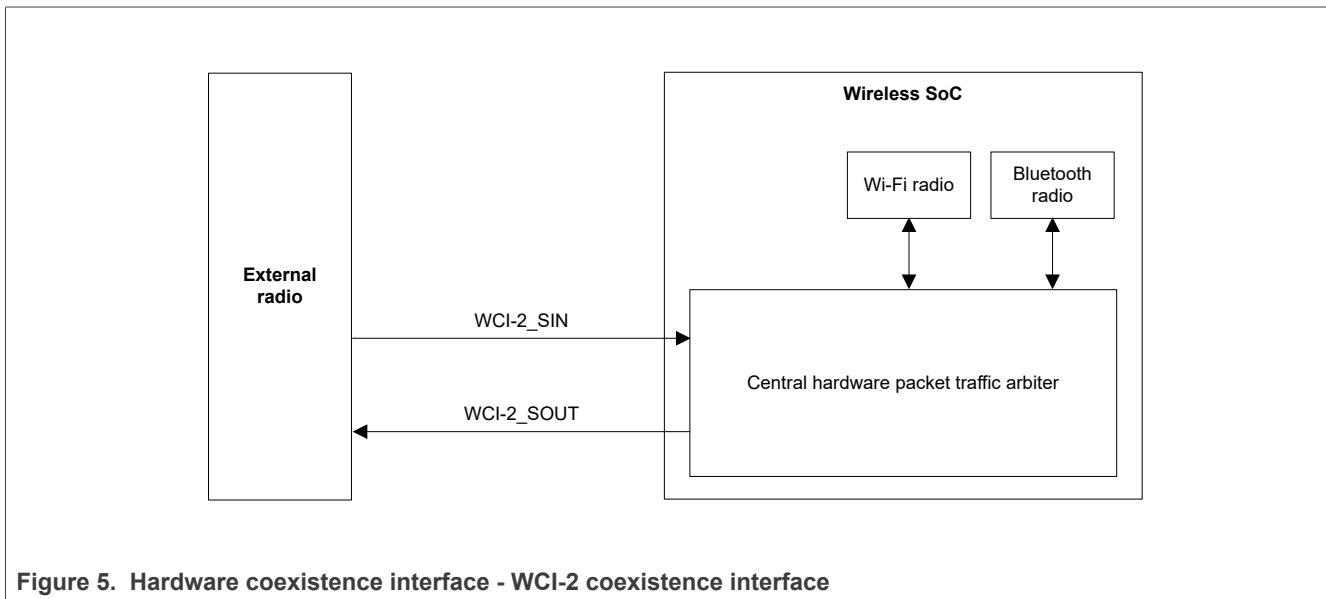


Figure 5. Hardware coexistence interface - WCI-2 coexistence interface

Note: Refer to [Section 6.5.9](#) for the description of WCI-2 coexistence interface signals.

PTA external coexistence interface

Figure 6 illustrates the hardware coexistence interface between the central hardware packet traffic arbiter and the external radio. In the figure, Wireless SoC is IW416.

Note: The PCM interface and the PTA external coexistence interface share the same multi-function pins (MFP). Refer to Section 6.5.2 "General purpose I/O (GPIO) (MFP)" for more details. As such, when PCM interface is used, WCI-2 is the only interface available for coexistence with an external radio.

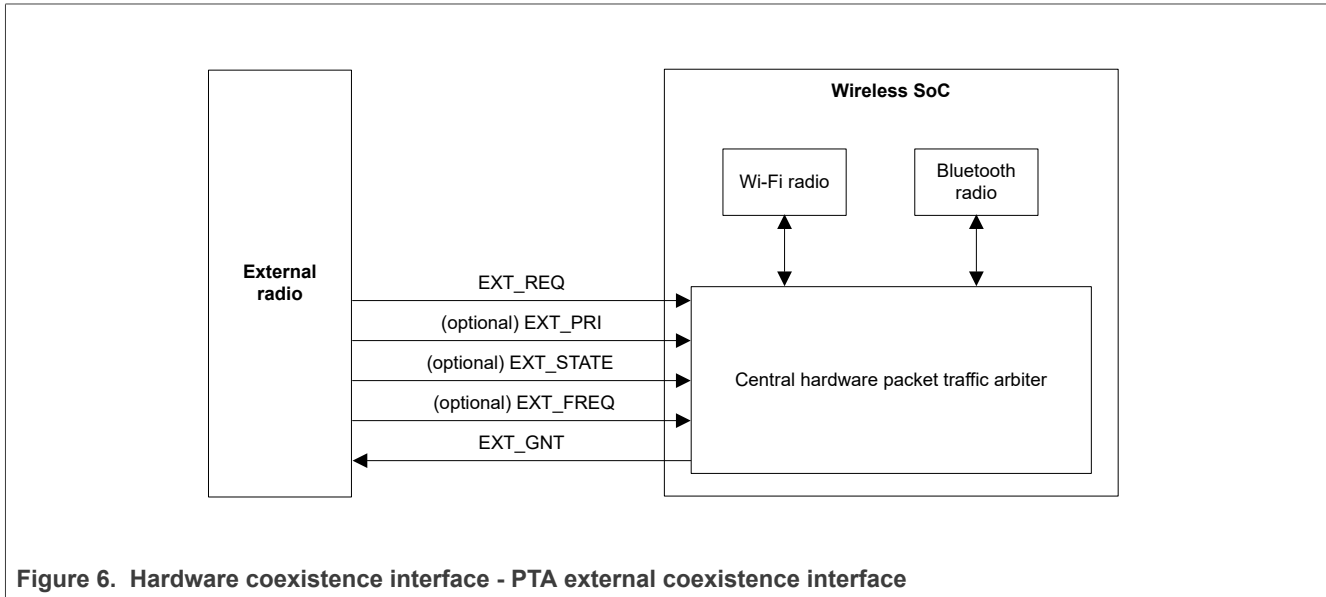


Figure 6. Hardware coexistence interface - PTA external coexistence interface

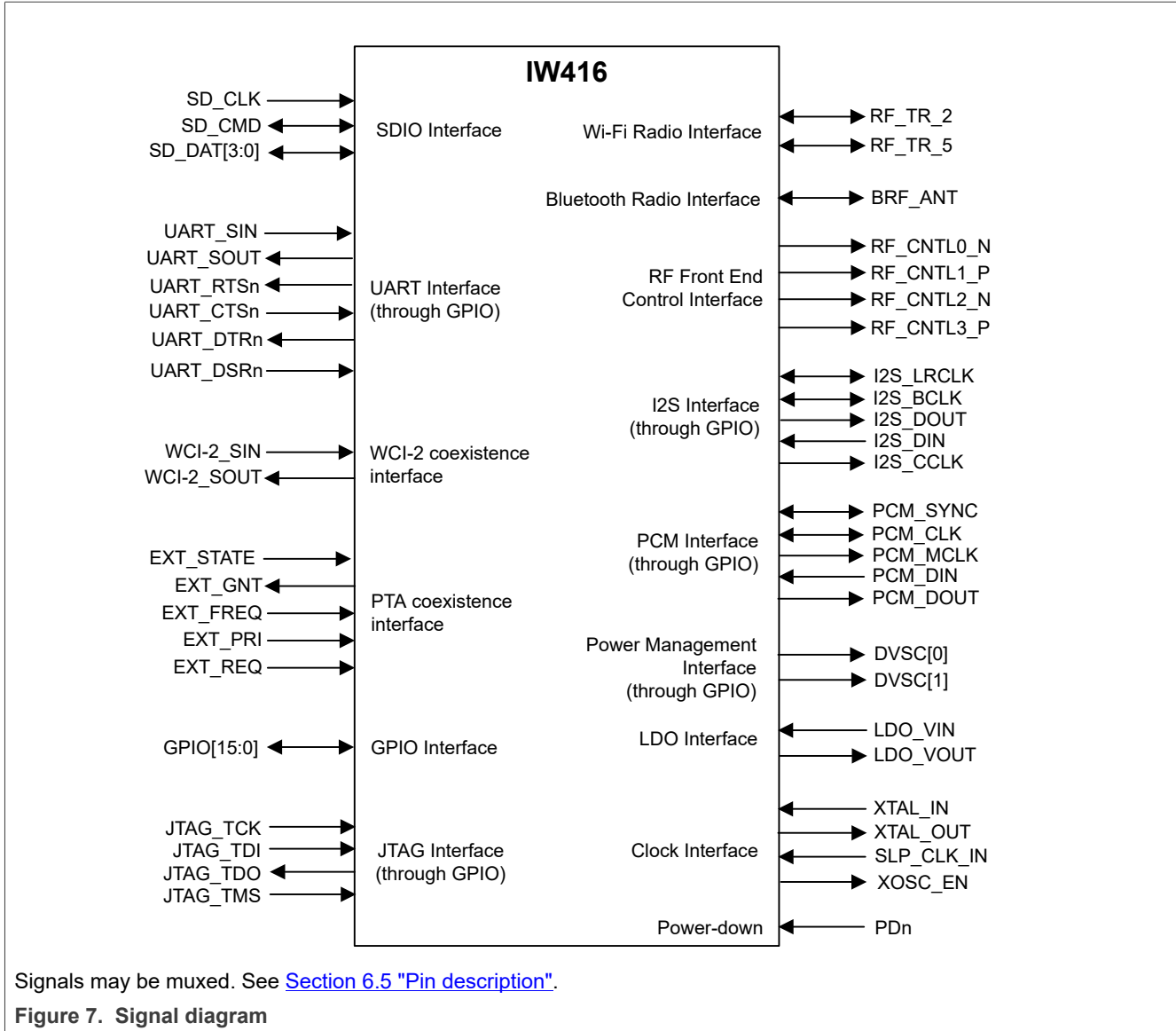
Note: Refer to:

- Section 6.5.8 for the description of PTA external coexistence interface signals
- The application note Coexistence Overview for IW416 (AN13372) for more information on the coexistence feature

6 Pin information

6.1 Signal diagram

Figure 7 shows the signals for the device. Some signals are muxed through GPIO.



6.2 Pin assignment - HVQFN68 package

Note that some pins have muxed signals. See [Section 6.5 "Pin description"](#).

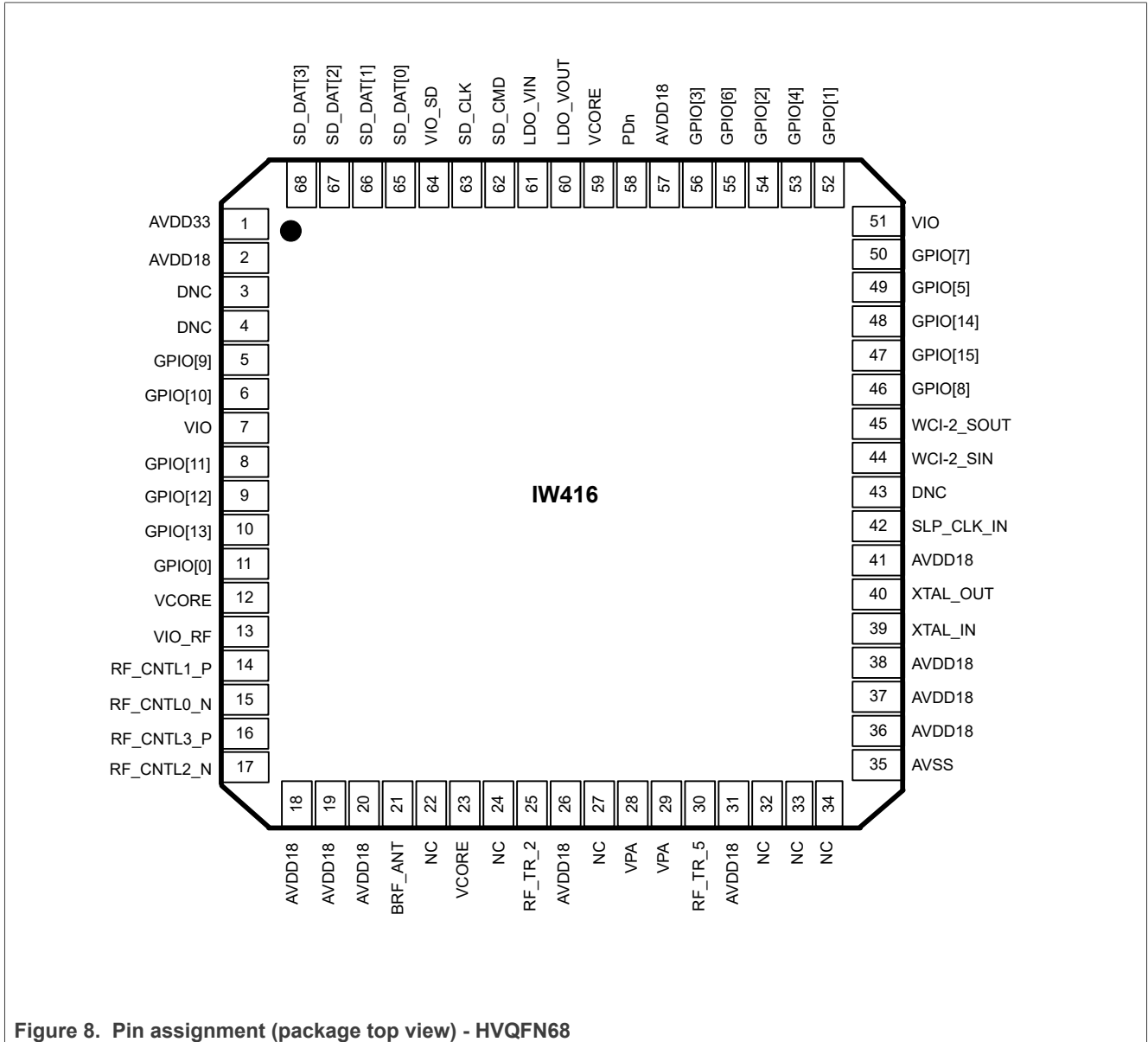


Figure 8. Pin assignment (package top view) - HVQFN68

Note: See [Section 10.10 "Reference clock specifications"](#) for electrical specifications. See [Section 11.3 "Package marking"](#) for more information on package marking and pin 1 location.

6.2.1 Pin list by number - HVQFN68 package

The following table shows the pin list sorted by pin number.

Table 5. Pin list by number - HVQFN68 package

Pin number	Pin name	Power	Type
1	AVDD33	—	Power
2	AVDD18	—	Power
3	DNC	—	DNC
4	DNC	—	DNC
5	GPIO[9]	VIO	I/O
6	GPIO[10]	VIO	I/O
7	VIO	—	Power
8	GPIO[11]	VIO	I/O
9	GPIO[12]	VIO	I/O
10	GPIO[13]	VIO	I/O
11	GPIO[0]	VIO	I/O
12	VCORE	—	Power
13	VIO_RF	—	Power
14	RF_CNTL1_P	VIO_RF	O
15	RF_CNTL0_N	VIO_RF	O
16	RF_CNTL3_P	VIO_RF	O
17	RF_CNTL2_N	VIO_RF	O
18	AVDD18	—	Power
19	AVDD18	—	Power
20	AVDD18	—	Power
21	BRF_ANT	AVDD18	A, I/O
22	NC	—	NC
23	VCORE	—	Power
24	NC	—	NC
25	RF_TR_2	AVDD18	A, I/O
26	AVDD18	—	Power
27	NC	—	NC
28	VPA	—	Power
29	VPA	—	Power
30	RF_TR_5	AVDD18	A, I/O
31	AVDD18	—	Power
32	NC	—	NC
33	NC	—	NC
34	NC	—	NC

Table 5. Pin list by number - HVQFN68 package...continued

Pin number	Pin name	Power	Type
35	AVSS	—	Ground
36	AVDD18	—	Power
37	AVDD18	—	Power
38	AVDD18	—	Power
39	XTAL_IN	AVDD18	A, I/O
40	XTAL_OUT	AVDD18	A, I/O
41	AVDD18	—	Power
42	SLP_CLK_IN	AVDD18	I
43	DNC	--	DNC
44	WCI-2_SIN	AVDD18	I
45	WCI-2_SOUT	AVDD18	O
46	GPIO[8]	VIO	I/O
47	GPIO[15]	VIO	I/O
48	GPIO[14]	VIO	I/O
49	GPIO[5]	VIO	I/O
50	GPIO[7]	VIO	I/O
51	VIO	—	Power
52	GPIO[1]	VIO	I/O
53	GPIO[4]	VIO	I/O
54	GPIO[2]	VIO	I/O
55	GPIO[6]	VIO	I/O
56	GPIO[3]	VIO	I/O
57	AVDD18	—	Power
58	PDn	AVDD18	I
59	VCORE	—	Power
60	LDO_VOUT	—	Power
61	LDO_VIN	—	Power
62	SD_CMD	VIO_SD	I/O
63	SD_CLK	VIO_SD	I
64	VIO_SD	—	Power
65	SD_DAT[0]	VIO_SD	I/O
66	SD_DAT[1]	VIO_SD	I/O
67	SD_DAT[2]	VIO_SD	I/O
68	SD_DAT[3]	VIO_SD	I/O

6.2.1 Pin list by name - HVQFN68 package

The following table shows the pin list sorted by pin name.

Table 6. Pin by name - HVQFN68 package

Pin name	Pin number	Power	Type
AVDD18	2	—	Power
AVDD18	18	—	Power
AVDD18	19	—	Power
AVDD18	20	—	Power
AVDD18	26	—	Power
AVDD18	31	—	Power
AVDD18	36	—	Power
AVDD18	37	—	Power
AVDD18	38	—	Power
AVDD18	41	—	Power
AVDD18	57	—	Power
AVDD33	1	—	Power
AVSS	35	—	Ground
BRF_ANT	21	AVDD18	A, I/O
DNC	3	—	DNC
DNC	4	—	DNC
DNC	43	—	DNC
GPIO[0]	11	VIO	I/O
GPIO[1]	52	VIO	I/O
GPIO[10]	6	VIO	I/O
GPIO[11]	8	VIO	I/O
GPIO[12]	9	VIO	I/O
GPIO[13]	10	VIO	I/O
GPIO[14]	48	VIO	I/O
GPIO[15]	47	VIO	I/O
GPIO[2]	54	VIO	I/O
GPIO[3]	56	VIO	I/O
GPIO[4]	53	VIO	I/O
GPIO[5]	49	VIO	I/O
GPIO[6]	55	VIO	I/O
GPIO[7]	50	VIO	I/O
GPIO[8]	46	VIO	I/O
GPIO[9]	5	VIO	I/O
LDO_VIN	61	—	Power

Table 6. Pin by name - HVQFN68 package...continued

Pin name	Pin number	Power	Type
LDO_VOUT	60	—	Power
NC	22	—	NC
NC	24	—	NC
NC	27	—	NC
NC	32	—	NC
NC	33	—	NC
NC	34	—	NC
PDn	58	AVDD18	I
RF_CNTL0_N	15	VIO_RF	O
RF_CNTL1_P	14	VIO_RF	O
RF_CNTL2_N	17	VIO_RF	O
RF_CNTL3_P	16	VIO_RF	O
RF_TR_2	25	AVDD18	A, I/O
RF_TR_5	30	AVDD18	A, I/O
SD_CLK	63	VIO_SD	I
SD_CMD	62	VIO_SD	I/O
SD_DAT[0]	65	VIO_SD	I/O
SD_DAT[1]	66	VIO_SD	I/O
SD_DAT[2]	67	VIO_SD	I/O
SD_DAT[3]	68	VIO_SD	I/O
SLP_CLK_IN	42	AVDD18	I
VCORE	12	—	Power
VCORE	23	—	Power
VCORE	59	—	Power
VIO	7	—	Power
VIO	51	—	Power
VIO_RF	13	—	Power
VIO_SD	64	—	Power
VPA	28	—	Power
VPA	29	—	Power
WCI-2_SIN	44	AVDD18	I
WCI-2_SOUT	45	AVDD18	O
XTAL_IN	39	AVDD18	A, I/O
XTAL_OUT	40	AVDD18	A, I/O

6.3 Bump locations - WLCSP76 package



Figure 9. Bump locations - WLCSP76 (non-bump side view, bumps down)

6.3.1 Bump positions relative to die center - WLCSP76

Table 7. Bump names and locations on WLCSP76 top view

Alpha-numeric designation	Signal name	Bump location relative to die center (non-bump side view)	
		X (μm)	Y (μm)
A2	SD_DAT[1]	-1080.696	1562.352
A3	SD_DAT[3]	-730.696	1562.352
A5	VIO	-380.696	1562.352
A7	VIO_RF	81.805	1562.352
A8	RF_CNTL1_P	431.805	1562.352
A9	AVDD18	781.805	1562.352
A10	AVDD18	1131.805	1562.352
B11	VSS	1506.805	1377.352
C1	LDO_VIN	-1430.696	1124.852
C2	VIO_SD	-1080.696	1212.352
C3	SD_DAT[2]	-730.696	1212.352
C5	VCORE	-380.696	1212.352
C7	GPIO[0]	81.805	1212.352
C8	VSS	431.805	1212.352
C9	VSS	781.805	1212.352
C10	VSS	1131.805	1212.352
D1	LDO_VOUT	-1430.696	774.852
D2	SD_CLK	-1080.696	862.352
D3	SD_DAT[0]	-730.696	862.352
D5	GPIO[10]	-380.696	862.352
D7	GPIO[13]	81.805	862.352
D8	RF_CNTL0_N	431.805	862.352
D9	RF_CNTL3_P	781.805	774.852
D10	VSS	1156.805	774.852
D11	BRF_ANT	1506.805	724.852
E1	VCORE	-1430.696	424.852
E2	SD_CMD	-1080.696	512.352
E3	VSS	-730.696	512.352
E5	GPIO[9]	-380.696	512.352
E7	GPIO[11]	81.805	512.352
E8	GPIO[12]	431.805	512.352
E9	RF_CNTL2_N	781.805	424.852
E10	VSS	1131.805	424.852

Table 7. Bump names and locations on WLCSP76 top view...continued

Alpha-numeric designation	Signal name	Bump location relative to die center (non-bump side view)	
		X (μm)	Y (μm)
E11	AVDD18	1506.805	374.852
F1	VSS	-1430.696	74.852
F2	GPIO[3]	-1080.696	74.852
F3	GPIO[7]	-618.196	74.852
F5	VSS	-268.196	74.852
F7	WCI-2_SOUT	81.805	74.852
F8	WCI-2_SIN	431.805	74.852
F10	VSS	1131.805	74.852
G1	GPIO[6]	-1430.696	-275.148
G2	GPIO[4]	-1080.696	-275.148
G3	GPIO[5]	-618.196	-275.148
G5	GPIO[14]	-268.196	-275.148
G7	SLP_CLK_IN	81.805	-275.148
G8	DNC	431.805	-275.148
G10	AVDD18	1116.805	-275.148
G11	RF_TR_2	1481.805	-275.148
H1	PDn	-1430.696	-625.148
H2	GPIO[1]	-1080.696	-625.148
H3	GPIO[8]	-618.196	-625.148
H5	VSS	-268.196	-625.148
H9	VCORE	781.805	-625.148
H10	VSS	1131.805	-625.148
J1	AVDD18	-1430.696	-975.148
J2	VSS	-1080.696	-975.148
J3	AVDD18	-618.196	-975.148
J5	VSS	-268.196	-975.148
J7	VSS	81.805	-975.148
J8	VSS	431.805	-975.148
J9	VSS	781.805	-975.148
J10	VPA	1131.805	-975.148
J11	RF_TR_5	1481.805	-975.148
K1	GPIO[2]	-1430.696	-1325.148
K2	VIO	-1080.696	-1325.148
K4	XTAL_OUT	-518.196	-1325.148
K6	VSS	-168.196	-1325.148

Table 7. Bump names and locations on WLCSP76 top view...continued

Alpha-numeric designation	Signal name	Bump location relative to die center (non-bump side view)	
		X (um)	Y (um)
K7	AVDD18	181.805	-1325.148
K9	VSS	781.805	-1325.148
K10	VSS	1131.805	-1325.148
L2	GPIO[15]	-1080.696	-1675.148
L4	XTAL_IN	-493.196	-1675.148
L6	AVDD18	-143.195	-1675.148
L9	AVDD18	781.805	-1675.148
L10	VSS	1131.805	-1675.148

6.4 Pin types

Table 8. Pin types

Pin type	Description
I/O	Digital input/output
I	Digital input
O	Digital output
A, I	Analog input
A,O	Analog output
A, I/O	Analog input/output
NC	No connect
DNC	Do not connect
Power	Power
Ground	Ground

6.5 Pin description

6.5.1 Pin states

The pin states information provided in the tables includes:

- **No Pad Power State** indicates the state when there is no power
- **PwrDwn State** denotes the power-down state in default configuration. Many pads have programmable power-down values, which can be set by firmware.
- **Reset State** is the state after the power-on-reset state and before the hardware state (HW State)
- **HW State** (hardware state) is the state after boot code finishes and before firmware download begins (firmware may change the pin state). HW State may differ based on the pin muxing/strap setting. For example, for UART_RTSn and UART_SOUT, the boot code will enable the UART interface when the device is in SDIO-UART mode, making the HW states output high and output low, respectively.
- **PwrDwn Prog** indicates if the power-down state can be programmed
- **Internal PU/PD** columns indicates the following:
 - Type of PU/PD (weak vs nominal)
 - The polarity (PU vs. PD)

The internal pull-up or pull-down applies when the pin is in input mode

- **PU** denotes whether the pull-up can be programmed or not
- **PD** denotes whether the pull-down can be programmed or not
- Pull-up and pull-down are only effective when the pad is in input mode
- After firmware is downloaded, the pads (GPIO, RF control, and so on) are programmed in functional mode per the functionality of the pins

6.5.2 General purpose I/O (GPIO) (MFP)

Table 9. GPIO^[1] (MFP)

Pins may be Multi-Functional Pins (MFP).

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/PD	PU	PD
GPIO[15]	VIO	3-state	input	input	drive high	yes	nominal PU	yes	yes
GPIO mode: GPIO[15] (input/output) JTAG mode: JTAG_TMS - JTAG test mode select (input). See Section 6.5.13 "JTAG interface" . Reset recovery mode: Independent software reset for Bluetooth subsystem (input)									
GPIO[14]	VIO	3-state	input	input	3-state	yes	nominal PU	yes	yes
GPIO mode: GPIO[14] (input/output) JTAG mode: JTAG_TCK - JTAG test clock (input). See Section 6.5.13 "JTAG interface" . Reset recovery mode: Independent software reset for Wi-Fi subsystem (input)									
GPIO[13]	VIO	3-state	input	input	drive high	yes	nominal PU	yes	yes
GPIO mode: GPIO[13] (input/output) UART mode: UART_DTRn - UART data-terminal-ready (output). See Section 6.5.6 "UART host interface" . Out-of-band wake-up mode: Host to IW416 Wi-Fi wake-up (input)									
GPIO[12]	VIO	3-state	input	input	3-state	yes	nominal PU	yes	yes
GPIO mode: GPIO[12] (input/output) UART mode: UART_DSRn - UART data-set-ready (input) (active low). See Section 6.5.6 "UART host interface" . Out-of-band wake-up mode: Host to IW416 Bluetooth wake-up (input)									
GPIO[11]	VIO	3-state	output	input	drive high	yes	weak PU	yes	yes
GPIO mode: GPIO[11] (input/output) This pin is used as a configuration pin: CON[8] (input) See Section 6.6 "Configuration pins" . UART mode: UART_RTSn - UART request-to-send (output) (active low). See Section 6.5.6 "UART host interface" .									
GPIO[10]	VIO	3-state	input	input	3-state	yes	nominal PU	yes	yes
GPIO mode: GPIO[10] (input/output) UART mode: UART_SOUT - UART serial (output). See Section 6.5.6 "UART host interface" .									
GPIO[9]	VIO	3-state	output	input	3-state	yes	nominal PU	yes	yes
GPIO mode: GPIO[9] (input/output) UART mode: UART_SIN - UART serial (input). See Section 6.5.6 "UART host interface" .									
GPIO[8]	VIO	3-state	input	input	drive low	yes	weak PU	yes	yes
GPIO mode: GPIO[8] (input/output) This pin is used as a configuration pin: CON[7] (input) See Section 6.6 "Configuration pins" . UART mode: UART_CTSn - UART clear-to-send input signal (input, active low). See Section 6.5.6 "UART host interface" .									
GPIO[7]	VIO	3-state	input	input	3-state	yes	nominal PU	yes	yes
GPIO mode: GPIO[7] (input/output) PCM mode: PCM_SYNC - PCM frame sync (input if peripheral, output if central). See Section 6.5.7 "Audio interface" . I2S mode: I2S_LRCLK - I2S left-right clock (input if peripheral, output if central). See Section 6.5.7 "Audio interface" . PTA coexistence mode: EXT_REQ - Request from the external radio (input). See Section 6.5.8 "PTA coexistence interface" .									

Table 9. GPIO^[1] (MFP)...continued

Pins may be Multi-Functional Pins (MFP).

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/PD	PU	PD
GPIO[6]	VIO	3-state	input	input	3-state	yes	nominal PU	yes	yes
<p>GPIO mode: GPIO[6] (input/output)</p> <p>PCM mode: PCM_CLK - PCM data clock (input if peripheral, output if central). See Section 6.5.7 "Audio interface".</p> <p>I2S mode: I2S_BCLK - I2S bit clock (input if peripheral, output if central). See Section 6.5.7 "Audio interface".</p> <p>PTA coexistence mode: EXT_PRI - External radio priority signal (input). See Section 6.5.8 "PTA coexistence interface".</p>									
GPIO[5]	VIO	3-state	input	input	3-state	yes	weak PU	yes	yes
<p>GPIO mode: GPIO[5] (input/output)</p> <p>PCM mode: PCM_DIN^[2] - PCM receive signal (input). See Section 6.5.7 "Audio interface".</p> <p>I2S mode: I2S_DOUT/I2S_DIN - I2S transmit/receive signal (output/input) (depending on the configuration). See Section 6.5.7 "Audio interface".</p> <p>PTA coexistence mode: EXT_GNT - External radio grant signal (output). See Section 6.5.8 "PTA coexistence interface".</p>									
GPIO[4]	VIO	3-state	output	input	3-state	yes	nominal PU	yes	yes
<p>GPIO mode: GPIO[4] (input/output)</p> <p>PCM mode: PCM_DOUT^[3] - PCM transmit signal (output). See Section 6.5.7 "Audio interface".</p> <p>I2S mode: I2S_DOUT/I2S_DIN (depending on the configuration. If GPIO[5] is configured as I2S_DIN, then GPIO[4] is set as I2S_DOUT, and vice-versa). See Section 6.5.7 "Audio interface".</p> <p>PTA coexistence mode: EXT_FREQ - External radio frequency signal (input). See Section 6.5.8 "PTA coexistence interface".</p> <p>Out-of-band wake-up mode: IW416 Bluetooth to host wake-up signal (output)^[4]</p>									
GPIO[3]	VIO	3-state	input	input	3-state	yes	weak PU	yes	yes
<p>GPIO mode: GPIO[3] (input/I/O output)</p> <p>Power management mode: DVSC[1], Digital voltage scaling control (output)</p> <p>JTAG mode: JTAG_TDO, JTAG test data (output). See Section 6.5.13 "JTAG interface".</p> <p>PCM mode: PCM_MCLK (output) - PCM clock signal (output, optional). See Section 6.5.7 "Audio interface".</p> <p>I2S mode: I2S_CCLK - I2S clock (output, optional). See Section 6.5.7 "Audio interface".</p>									
GPIO[2]	VIO	3-state	input	input	3-state	yes	weak PU	yes	yes
<p>GPIO mode: GPIO[2] (input/output)</p> <p>Power management mode: DVSC[0], Digital voltage scaling control (output)</p> <p>JTAG mode: JTAG_TDI, JTAG test data (input). See Section 6.5.13 "JTAG interface".</p>									
GPIO[1]	VIO	3-state	input	input	3-state	yes	weak PU	yes	yes
<p>GPIO mode: GPIO[1] (input/output)</p> <p>This pin is used as a configuration pin: CON[9] (input). See Section 6.6 "Configuration pins".</p> <p>PTA coexistence mode: EXT_STATE - External radio state signal (input). See Section 6.5.8 "PTA coexistence interface".</p> <p>Out-of-band wake-up mode: IW416 Wi-Fi to host wake-up signal (output)</p>									
GPIO[0]	VIO	3-state	output	output	drive low	yes	nominal PU	yes	yes
<p>GPIO mode: GPIO[0] (input/output)</p> <p>Oscillator enable mode: XOSC_EN (output) (active high). See Section 6.5.10 "Clock interface".</p>									

[1] Not all GPIO pins can be used for Host-to-SoC wake-up signals.

[2] The function can be swapped with GPIO[4] using a software command without affecting the hardware connection.

[3] The function can be swapped with GPIO[5] using a software command without affecting the hardware connection.

[4] If PCM and UART interfaces are used in application, use GPIO[0] as alternative for this wake-up signal.

6.5.3 Wi-Fi/Bluetooth radio interface

Table 10. Wi-Fi/Bluetooth radio interface

Pin Name	Type	Supply	Description
RF_TR_2	A, I/O	AVDD18	Wi-Fi Transmit/Receive (2.4 GHz)
RF_TR_5	A, I/O	AVDD18	Wi-Fi Transmit/Receive (5 GHz)
BRF_ANT	A, I/O	AVDD18	Bluetooth Transmit/Receive

6.5.4 Wi-Fi RF front-end control interface

Table 11. Wi-Fi RF front-end control interface

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/PD	PU	PD
RF_CNTL0_N	VIO_RF	tristate	input	output	drive low	yes	weak PU	no	no
RF Control 0—RF Control Output Low (output) This pin is used as a configuration pin: CON[0] (input) See Section 6.6 "Configuration pins" .									
RF_CNTL1_P	VIO_RF	tristate	input	output	drive high	yes	weak PU	no	no
RF Control 1—RF Control Output High (output) This pin is used as a configuration pin: CON[6] (input)									
RF_CNTL2_N	VIO_RF	tristate	input	output	drive low	yes	weak PU	no	no
RF Control 2—RF Control Output Low (output) This pin is used as a configuration pin: CON[1] (input) See Section 6.6 "Configuration pins" .									
RF_CNTL3_P	VIO_RF	tristate	input	output	drive high	yes	weak PU	no	no
RF Control 3—RF Control Output High (output) This pin is used as a configuration pin: CON[5] (input) See Section 6.6 "Configuration pins" .									

6.5.5 SDIO host interface (MFP)

Table 12. SDIO host i (MFP)

Pins may be Multi-Functional Pins (MFP). See pin descriptions for functional modes.

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/PD	PU	PD
SD_CLK	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Clock input SDIO 1-bit mode: Clock input									
SD_CMD	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Command/response (input/output) SDIO 1-bit mode: Command line (input/output)									
SD_DAT[3]	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Data line Bit[3] SDIO 1-bit mode: Reserved									
SD_DAT[2]	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Data line Bit[2] or read wait (optional) SDIO 1-bit mode: Read wait (optional)									
SD_DAT[1]	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Data line Bit[1] SDIO 1-bit mode: Interrupt									
SD_DAT[0]	VIO_SD	tristate	input	input	tristate	no	nominal PU	yes	yes
SDIO 4-bit mode: Data line Bit[0] SDIO 1-bit mode: Data line									

6.5.6 UART host interface

Table 13. UART host interface (MFP)

Pins may be Multi-Functional Pins (MFP).

Pin Name	Type	Supply	Description
UART_SIN	I	VIO	UART serial input signal - muxed with GPIO[9]
UART_SOUT	O	VIO	UART serial output signal - muxed with GPIO[10]
UART_RTSn	O	VIO	UART request-to-send output signal (active low) - muxed with GPIO[11]
UART_CTSn	I	VIO	UART clear-to-send input signal (active low) - muxed with GPIO[8]
UART_DTRn	O	VIO	UART data-terminal-ready output signal (active low) - muxed with GPIO[13]
UART_DSRn	I	VIO	UART data-set-ready input signal (active low) - muxed with GPIO[12]

6.5.7 Audio interface

Table 14. Audio interface pins (MFP)

Pins may be Multi-Functional Pins (MFP). See pin descriptions for functional modes.

Pin Name	Type	Supply	Description
PCM_DIN	I	VIO	PCM audio codec output data (for recording) - muxed with GPIO[4]/GPIO[5]
PCM_DOUT	O	VIO	PCM audio codec input data (for playback) - muxed with GPIO[4]/GPIO[5]
PCM_SYNC	I/O	VIO	PCM sync pulse signal - muxed with GPIO[7] . Central mode: output . Peripheral mode: input
PCM_CLK	I/O	VIO	PCM clock signal - muxed with GPIO[6] . Central mode: output . Peripheral mode: input
PCM_MCLK	O	VIO	PCM codec main clock signal (optional) - muxed with GPIO[3] Optional clock used for some codecs. Derived from PCM_CLK.
I2S_DIN	I	VIO	I2S audio codec output data (for recording) - muxed with GPIO[4]/GPIO[5], depending on the configuration.
I2S_DOUT	O	VIO	I2S audio codec input data (for playback) - muxed with GPIO[4]/GPIO[5], depending on the configuration.
I2S_LRCLK	I/O	VIO	I2S audio left/right clock - muxed with GPIO[7] . Central mode: output . Peripheral mode: input
I2S_BCLK	I/O	VIO	I2S audio bit clock - muxed with GPIO[6] . Central mode: output . Peripheral mode: input
I2S_CCLK	O	VIO	I2S codec main clock (optional) - muxed with GPIO[3] Optional clock used for some codecs. Derived from I2S_BCLK.

6.5.8 PTA coexistence interface

Table 15. PTA coexistence interface (MFP)

Pins may be Multi-Functional Pins (MFP). See pin descriptions for functional modes.

Pin Name	Type	Supply	Description
EXT_STATE	I	VIO	External radio state input signal - muxed with GPIO[1] External radio traffic direction (Tx/Rx): <ul style="list-style-type: none"> • 1: Tx • 0: rx
EXT_GNT	O	VIO	External radio grant output signal - muxed with GPIO[5]
EXT_FREQ	I	VIO	External radio frequency input signal - muxed with GPIO[4] Frequency overlap between external radio and Wi-Fi: <ul style="list-style-type: none"> • 1: overlap • 0: non-overlap This signal is useful when the external radio is a frequency hopping device.
EXT_PRI	I	VIO	External radio input priority signal - muxed with GPIO[6] Priority of the request from the external radio. Can support 1 bit priority (sample once) and 2 bit priority (sample twice). Can also have Tx/Rx info following the priority info if EXT_STATE is not used.
EXT_REQ	I	VIO	Request from the external radio - muxed with GPIO[7]

6.5.9 WCI-2 coexistence interface

Table 16. WCI-2 coexistence interface

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/PD	PU	PD
WCI-2_SIN	AVDD18	tristate	input	input	tristate	no	weak PU	yes	yes
WCI-2_SIN (input)									
WCI-2_SOUT	AVDD18	tristate	output	output	tristate	no	weak PU	yes	yes
WCI-2_SOUT (output)									

6.5.10 Clock interface

Table 17. Clock interface

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/ PD	PU	PD
XTAL_IN	AVDD18	--	--	--	--	--	--	--	--
Reference clock input Reference clock signal frequency must be 26 MHz or 40 MHz from an external crystal or external crystal oscillator. Power consumption in sleep mode is lower with an external crystal compared to an external crystal oscillator when an external sleep clock is not used. See Section 10.10 "Reference clock specifications" .									
XTAL_OUT	AVDD18	--	--	--	--	--	--	--	--
Connect this pin to an external crystal when an external crystal is used. When an external crystal oscillator is used, connect this pin to ground with resistance less than 100 Ω.									
SLP_CLK_IN	AVDD18	tristate	input	input	tristate	no	nominal PU	yes	yes
Sleep clock input (optional) Used for lower power operation in sleep mode. <ul style="list-style-type: none"> An external sleep clock of 32.768 kHz can be used to reduce the current consumption in sleep mode. If no external sleep clock is used, leave this pin floating (DNC). 									
XOSC_EN	VIO	--	--	--	--	--	--	--	--
Oscillator enable (output) (active high) XOSC_EN signal can be used ONLY when an external sleep clock is used. Used to enable an external oscillator. 0 = disable external oscillator 1 = enable external oscillator Note: Muxed with GPIO[0].									

6.5.11 Power down (PDn) pin

Table 18. Power down (PDn) pin

Pin Name	Supply	No Pad Power State	Reset State	HW State	PwrDwn State	PwrDwn Prog	Internal PU/ PD	PU	PD
PDn	AVDD18	--	--	--	--	--	--	--	--
Full power-down (input) (active low) 0 = full power-down mode 1 = normal mode <ul style="list-style-type: none"> PDn can accept an input of 1.8V to 4.5V PDn may be driven by the host PDn must be high for normal operation No internal pull-up on this pin.									

6.5.12 Power supply and ground

Table 19. Power and ground pins

Pin Name	Type	Description
VCORE	Power	1.05V core power supply
VIO	Power	1.8V/3.3V digital I/O power supply
VIO_SD	Power	1.8V/3.3V digital I/O SDIO power supply Note: 1. For SDIO 2.0, VIO_SD must be 3.3 V 2. For SDIO 3.0, VIO_SD must be 1.8 V
VIO_RF	Power	1.8V/3.3V analog I/O RF power supply
AVDD33	Power	3.3V analog power supply
AVDD18	Power	1.8V analog power supply
VPA	Power	2.2V analog power supply
LDO_VIN	Power	LDO voltage input (1.8V)
LDO_VOUT	Power	LDO voltage output
AVSS	Ground	Ground
NC	NC	No Connect
DNC	DNC	Do Not Connect Do not connect these pins. Leave these pins floating.

6.5.13 JTAG interface

Table 20. JTAG interface pins (MFP)

Pins may be Multi-Functional Pins (MFP).

Pin Name	Type	Supply	Description
JTAG_TDO	O	VIO	JTAG test data output signal - muxed with GPIO[3]
JTAG_TDI	I	VIO	JTAG test data input signal - muxed with GPIO[2]
JTAG_TMS	I	VIO	JTAG test mode select input signal - muxed with GPIO[15]
JTAG_TCK	I	VIO	JTAG test clock input signal - muxed with GPIO[14]

6.6 Configuration pins

The table below shows the pins used as configuration inputs to set parameters following a reset. The definition of these pins changes immediately after reset to their usual function.

To set a configuration bit to 0, attach a 50 kΩ–100 kΩ resistor from the pin to ground. No external circuitry is required to set a configuration bit to 1.

Table 21. Configuration pins

Configuration bits	Pin name	Configuration function
CON[9]	GPIO[1]	Reserved Set to 111.
CON[8]	GPIO[11]	
CON[7]	GPIO[8]	
CON[6]	RF_CNTL1_P	Reserved Set to 1.
CON[5]	RF_CNTL3_P	Reference clock frequency select 1 = 26 MHz (default) 0 = 40 MHz
CON[1]	RF_CNTL2_N	Host configuration options (see Table 22). No hardware impact. Software reads and boots accordingly. See the table below. Note: <i>The boot code needs to use the strap value to set the correct boot sequence.</i>
CON[0]	RF_CNTL0_N	

[Table 22](#) shows the host configuration options.

Table 22. Host configuration options

RF_CNTL2_N/ CON[1]	RF_CNTL0_N/ CON[0]	Wi-Fi	Bluetooth/ Bluetooth LE	Number of SDIO functions
1	0	SDIO	UART	1 (Wi-Fi)
Others	Others	Reserved	Reserved	—

7 Power information

The table in [Section 6.5.12 "Power supply and ground"](#) shows the required voltage levels for each rail and PDn input signal.

7.1 Power modes

The IW416 power modes reflect the combination of the respective state of Wi-Fi and Bluetooth subsystems.

[Table 23](#) shows the device power modes, Wi-Fi and Bluetooth states, and associated Wi-Fi and Bluetooth CPU status.

Refer to [Section 10.6 "Current consumption"](#) for the power consumption values of Wi-Fi and Bluetooth subsystems.

Table 23. Device power modes

Device mode	Wi-Fi state	Bluetooth state	Wi-Fi CPU status	Bluetooth CPU status
Wi-Fi and Bluetooth active	Active	Active	Active	Active
Standby/idle	Standby/idle	Standby/idle	Active	Active
Wi-Fi active	Active	Sleep	Active	WFI ^[1]
Bluetooth active	Sleep	Active	WFI	Active
Sleep	Sleep	Sleep	WFI	WFI
Deep-sleep ^[2]	Deep-sleep	Deep-sleep	--	--

[1] Wait for Interrupt: the ARM-based CPU is in low-power standby state.

[2] Memory placed in low-power retention mode.

7.2 Power-up sequence

The IW416 VCORE is supplied through an external PMIC. The PDn pin of the IW416 is tied to 1.8V. The ramp-up is controlled by the Host using PMIC_EN, the input enable pin of the power regulator.

The power configuration is detailed in [Section 7.2.1 "Configuration—VCORE from PMIC"](#) and [Section 7.2.2 "Power-up sequence timing"](#) shows the power-up timing.

7.2.1 Configuration—VCORE from PMIC

- VCORE from PMIC
- PMIC_EN ramps up from Host 3.3V or Host GPIO pin
- PDn supplied from AVDD18 (follow AVDD18; PDn is connected 1.8V supply)
- External VPA/AVDD18 from PMIC
- External VIO/VIO_RF from Host (1.8V/3.3V)

Table 24. Configuration—VCORE from PMIC [1]

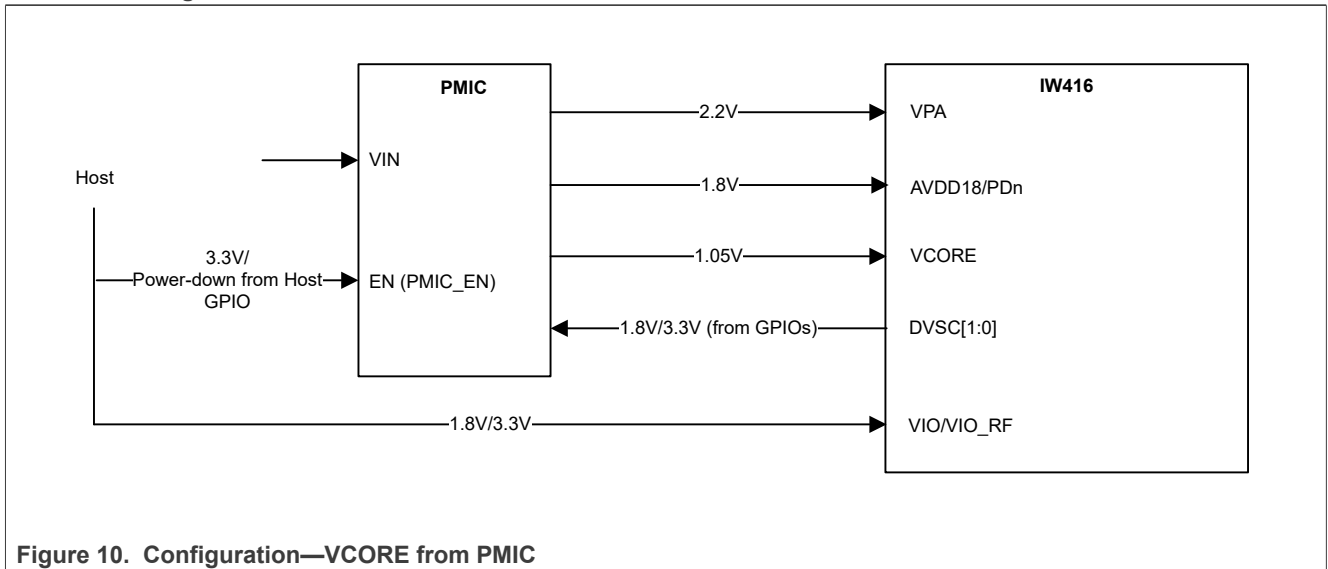


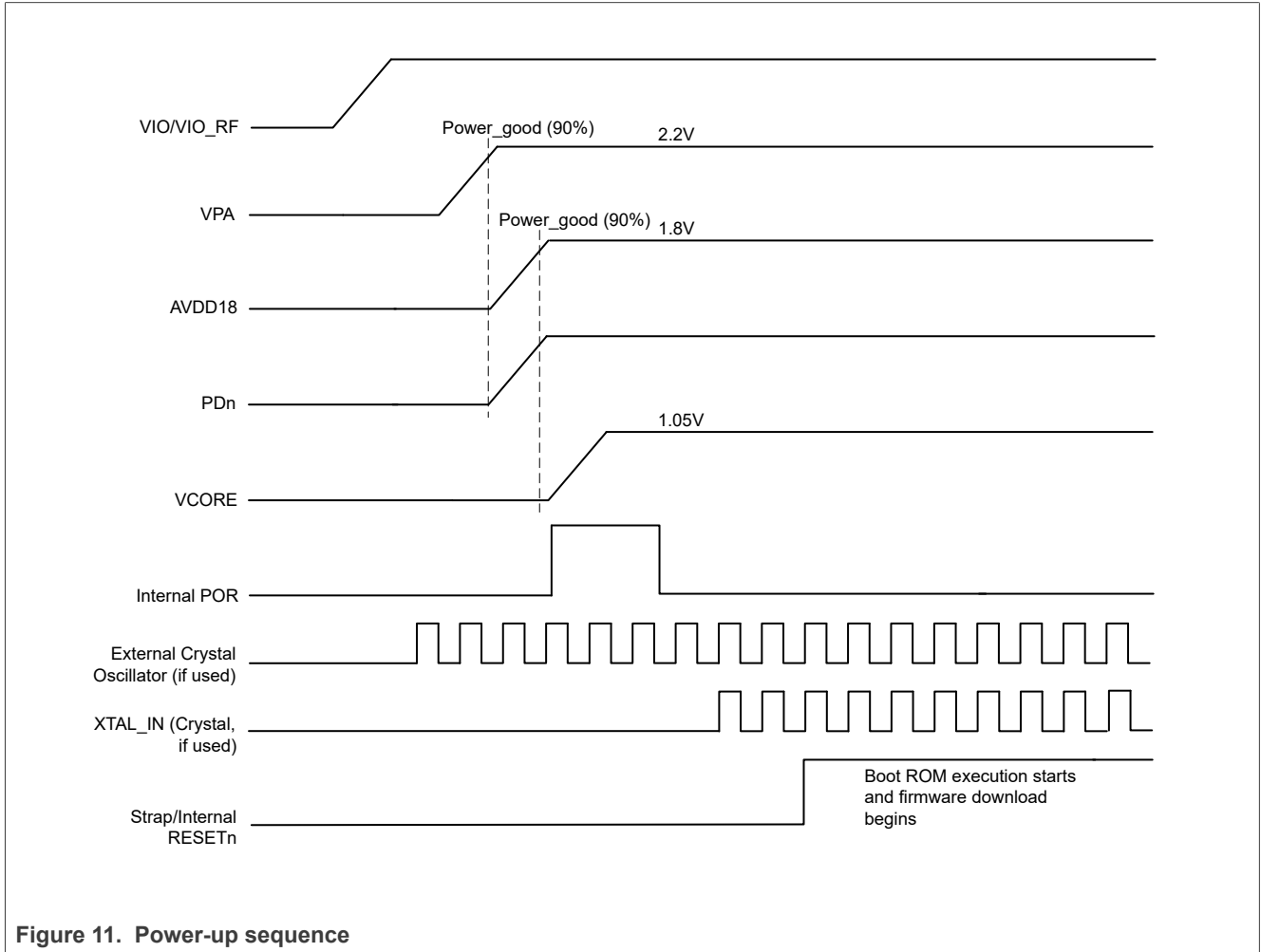
Figure 10. Configuration—VCORE from PMIC

[1] A minimum time of 100 ms is required after PMIC_EN is deasserted (=0) and before it is asserted (=1).

7.2.2 Power-up sequence timing

- VPA must be good (90%) before AVDD18 starts ramping up.
- AVDD18 must be good (90%) before VCORE starts ramping up.

Figure 11 shows the power-up sequence.

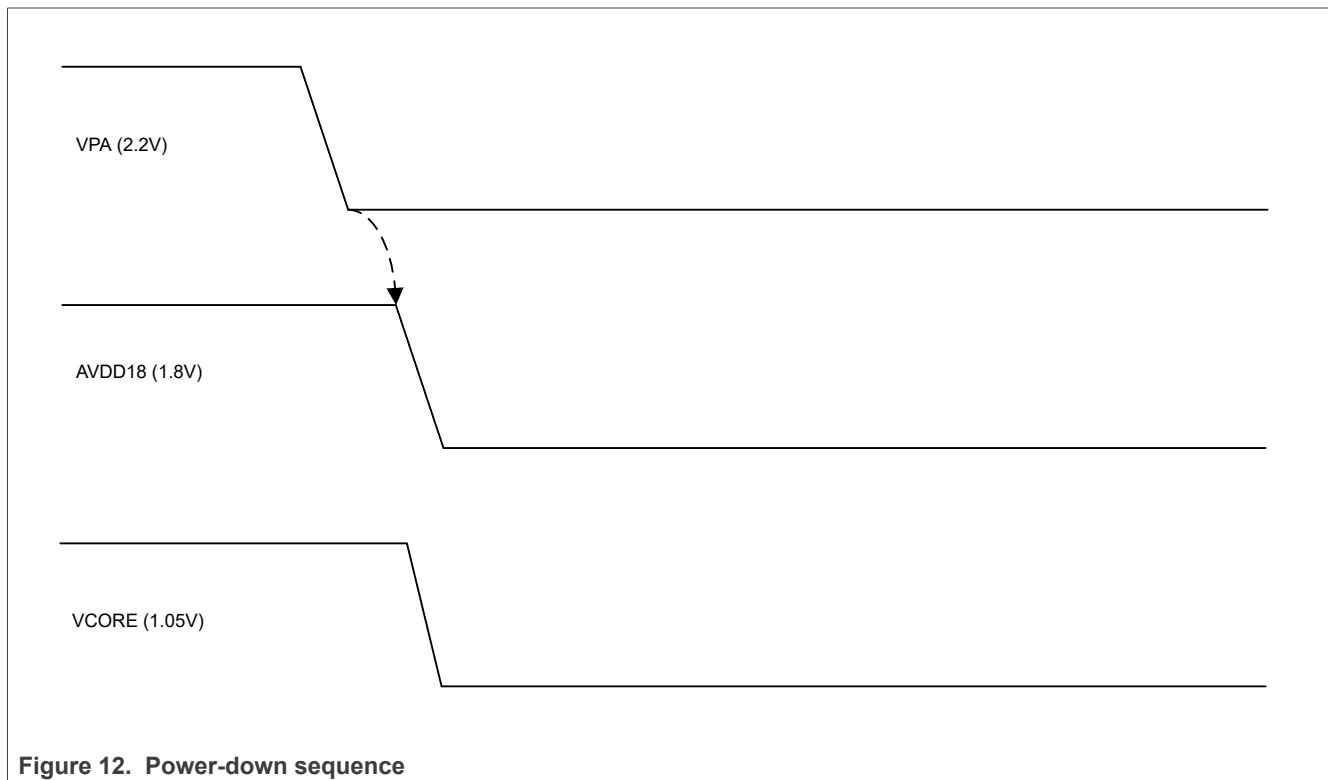


7.3 Power-down sequence

7.3.1 Power-down sequence

During the power-down sequence, VPA ramps down before AVDD18 in order for the RF PA to turn the logic off (depends on the control logic generated from AVDD18). Also, when the PMIC VBAT is removed, the PMIC cannot guarantee a ramp-down requirement.

[Figure 12](#) shows the recommended power-down sequence.



7.3.2 Host power-down pin (PMIC_EN) usage

The maximum ramp-down time for V_{CORE} from PMIC_EN assertion is 10 ms. PMIC_EN must be asserted a minimum of 100 ms to guarantee that V_{CORE} and AVDD18 are discharged to less than 0.2V for the POR to generate properly after PMIC_EN is deasserted.

Figure 13 shows the sequence.

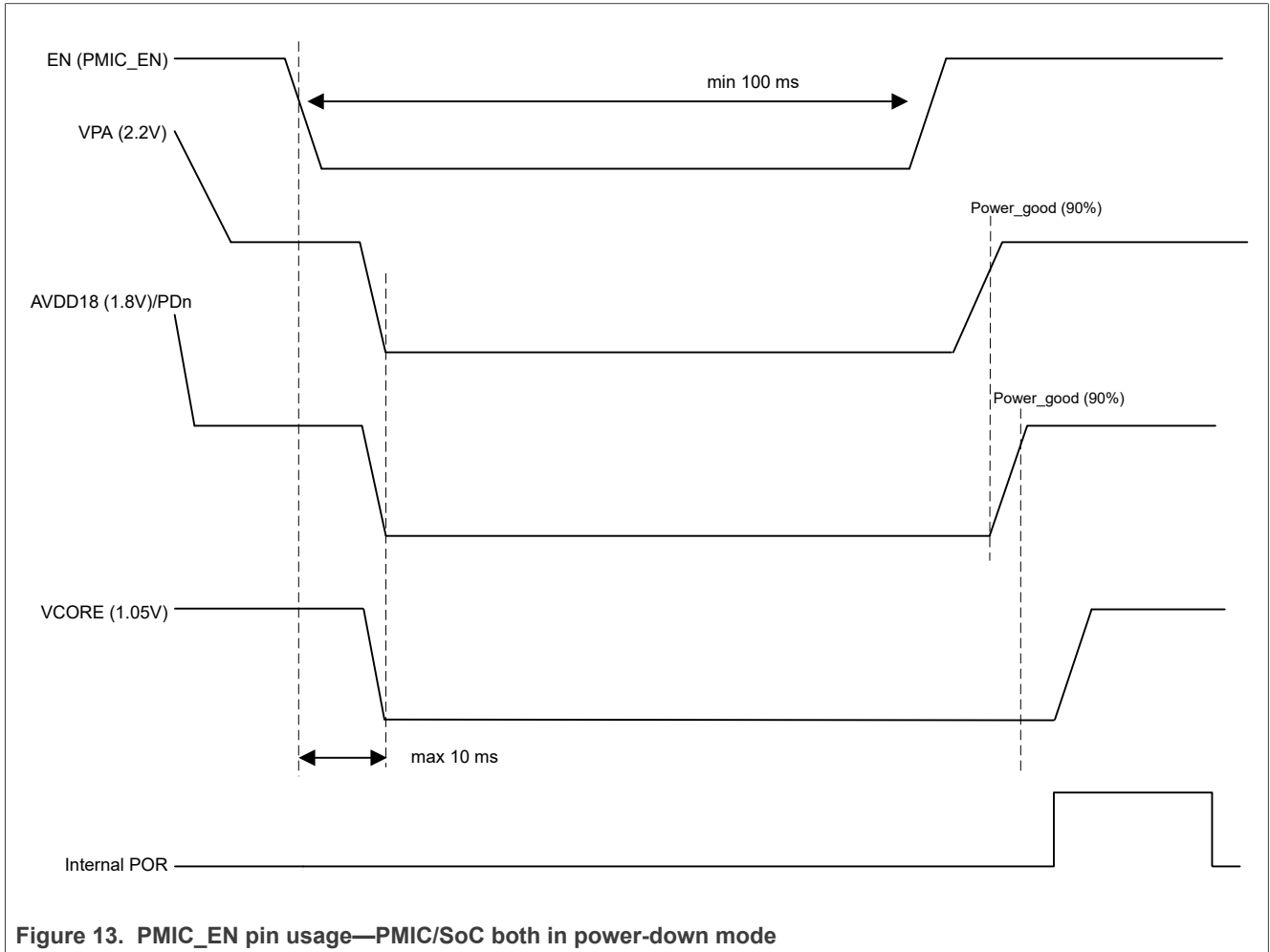


Figure 13. PMIC_EN pin usage—PMIC/SoC both in power-down mode

7.4 Leakage optimization

For applications not using Wi-Fi and Bluetooth, the device can be put into a low-leakage mode of operation. Two methods are available to set the device to low-leakage mode:

- Using PDn pin
The power-down state provides the lowest leakage mode of operation. Assert PDn low to enter power-down. If firmware is not downloaded, the device must be kept in power-down mode to reduce the leakage.
- Powering off all the rails
Alternatively, all the power rails can be powered off. In this case, the state of the PDn pin is irrelevant.

7.5 Deep sleep

When a programmable power regulator is used to supply V_{CORE}, the IW416 may use the power management interface to reduce V_{CORE} to approximately 0.8V to reduce power consumption in deep sleep mode.

7.6 Reset

The IW416 is reset to its default operating state under any of the following conditions:

- Internal Power-On Reset (POR): POR is triggered when the device receives power and V_{CORE} and AVDD18 supplies are good. See [Section 7.2 "Power-up sequence"](#).
- Software/firmware reset: software/firmware issues a reset.
- External PDn pin assertion: the device is reset when the PDn input pin is <0.5 V and transitions from low to high.

See [Section 10.11 "Power down \(PDn\) pin specifications"](#) for the electrical specifications.

8 Absolute maximum ratings

CAUTION: The absolute maximum ratings table defines the limitations for electrical and thermal stresses. These limits prevent permanent damage to the device. Exposure to conditions at or beyond these ratings is not guaranteed and can damage the device.

Table 25. Absolute maximum ratings

Symbol	Parameter	Min	Max	Unit
VCORE	Core power supply	-	1.15	V
VIO	1.8 V/3.3 V digital I/O power supply	-	2.2	V
		-	4.0	V
VIO_SD	1.8 V/3.3 V digital I/O power supply	-	2.2	V
		-	4.0	V
VIO_RF	1.8 V/3.3 V digital I/O power supply	-	2.2	V
		-	4.0	V
AVDD18	1.8 V analog power supply	-	1.98	V
VPA	2.2 V analog power supply	-	2.3	V
AVDD33	3.3 V analog power supply	-	3.96	V
LDO_VIN	LDO input voltage supply	-	2.0	V
T _{STORAGE}	Storage temperature	-55	+125	°C

Table 26. Limiting values

Symbol	Parameter	Condition	Min	Max	Unit
V _{ESD}	Electrostatic discharge	human body model (HBM) ^[1]	-2	+2	kV
		charged device model (CDM) ^[2]	-500	+500	V

[1] According to ANSI/ESDA/JEDEC JS-001.

[2] According to ANSI/ESDA/JEDEC JS-002

9 Recommended operating conditions

Note: Operation beyond the recommended operating conditions is neither recommended nor guaranteed.

Table 27. Recommended operating conditions

Symbol	Parameter	Condition	Min	Typ	Max	Unit
VCORE	1.05V core power supply	Active mode	1.018	1.05	1.10	V
VIO	1.8V/3.3V digital I/O power supply	—	1.62	1.8	1.98	V
		—	2.97	3.3	3.47	V
VIO_SD	1.8V/3.3V digital I/O SDIO power supply	—	1.62	1.8	1.98	V
		—	2.97	3.3	3.47	V
VIO_RF	1.8V/3.3V I/O power supply	—	1.62	1.8	1.98	V
		—	2.97	3.3	3.47	V
AVDD18	1.8V analog power supply	—	1.71	1.8	1.89	V
VPA	2.2V analog power supply	—	2.09	2.2	2.26	V
AVDD33	3.3V analog power supply	—	3.14	3.3	3.46	V
LDO_VIN	LDO input voltage supply	—	1.71	1.8	1.89	V
T _A	Ambient operating temperature	Commercial	0	—	70	°C
T _A	Ambient operating temperature	Industrial	-40	-	85	°C
T _J	Junction temperature	—	—	—	125	°C

10 Electrical specifications

10.1 GPIO/LED interface specifications

The GPIO pins are powered by VIO voltage supply.

10.1.1 VIO DC characteristics

10.1.1.1 1.8V operation

Table 28. DC electrical characteristics—1.8V operation (VIO)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO	--	VIO+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.1.1.2 3.3V operation

Table 29. DC electrical characteristics—3.3V operation (VIO)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO	--	VIO+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.2 RF front-end control interface specifications

10.2.1 VIO_RF DC characteristics

10.2.1.1 1.8V operation

Table 30. DC electrical characteristics—1.8V operation (VIO_RF)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO_RF	--	VIO_RF+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO_RF	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO_RF-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.2.1.2 3.3V operation

Table 31. DC electrical characteristics—3.3V operation (VIO_RF)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO_RF	--	VIO_RF+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO_RF	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO_RF-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.3 Wi-Fi radio specifications

The Wi-Fi radio interface pins are powered by AVDD18.

10.3.1 Wi-Fi radio performance measurement

The Wi-Fi transmit/receive performance is measured either at the antenna port or at the chip port.

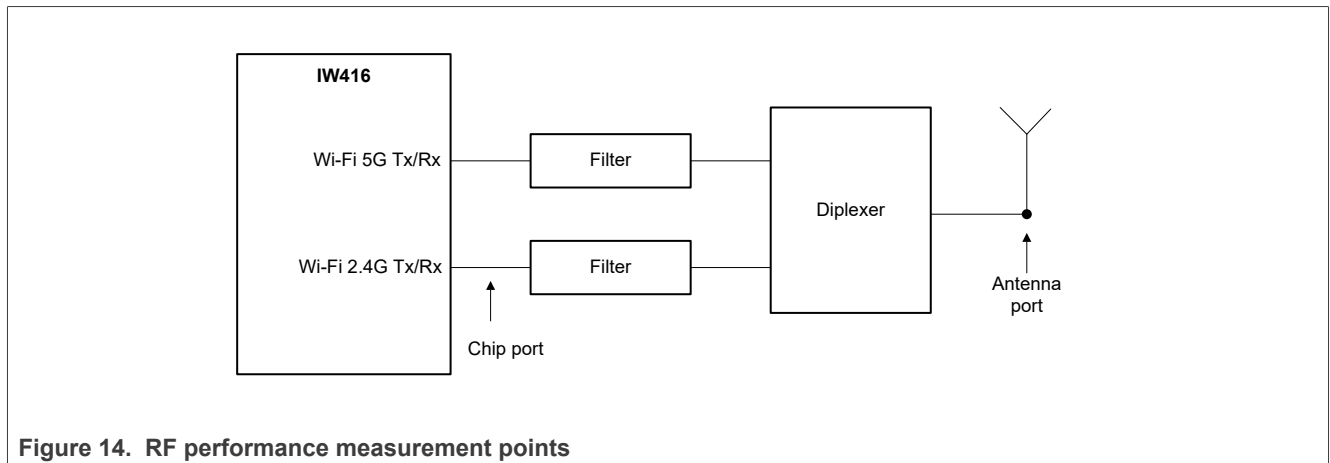


Figure 14. RF performance measurement points

10.3.2 2.4 GHz Wi-Fi receive performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and at the chip port.

Table 32. 2.4 GHz Wi-Fi receive performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	2.4 GHz—IEEE 802.11n/g/b	2400	—	2484	MHz
Maximum Rx input level	Maximum Rx input level without device damage	—	—	2	dBm
Receiver sensitivity 802.11b	1 Mbit/s	—	-99	—	dBm
	2 Mbit/s	—	-95	—	dBm
	5.5 Mbit/s	—	-94	—	dBm
	11 Mbit/s	—	-91	—	dBm
Receiver sensitivity 802.11g	6 Mbit/s	—	-92	—	dBm
	9 Mbit/s	—	-92	—	dBm
	12 Mbit/s	—	-91	—	dBm
	18 Mbit/s	—	-89	—	dBm
	24 Mbit/s	—	-86	—	dBm
	36 Mbit/s	—	-83	—	dBm
	48 Mbit/s	—	-78	—	dBm
Receiver sensitivity 802.11n HT20 ^[1]	MCS0	—	-92	—	dBm
	MCS1	—	-90	—	dBm
	MCS2	—	-87	—	dBm
	MCS3	—	-84	—	dBm
	MCS4	—	-81	—	dBm
	MCS5	—	-76	—	dBm
	MCS6	—	-75	—	dBm
	MCS7	—	-73 ^[2]	—	dBm
Receiver sensitivity 802.11n HT40 ^[1]	MCS0	—	-89	—	dBm
	MCS1	—	-87	—	dBm
	MCS2	—	-84	—	dBm
	MCS3	—	-82	—	dBm
	MCS4	—	-78	—	dBm
	MCS5	—	-74	—	dBm
	MCS6	—	-72	—	dBm
	MCS7	—	-71	—	dBm

Table 32. 2.4 GHz Wi-Fi receive performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
Receiver maximum input level 802.11	802.11b	—	5	—	dBm
	802.11g	—	-4	—	dBm
	MCS0-4	—	-2	—	dBm
	MCS5	—	-4	—	dBm
	MCS6	—	-5	—	dBm
	MCS7	—	-8	—	dBm
Receiver adjacent channel interference rejection (ACI) 802.11b	1Mbit/s	—	41	—	dB
	2Mbit/s	—	39	—	dB
	5.5Mbit/s	—	38	—	dB
	11Mbit/s	—	37	—	dB
Receiver adjacent channel interference rejection (ACI) 802.11g	6Mbit/s	—	31	—	dB
	9Mbit/s	—	30	—	dB
	12Mbit/s	—	28	—	dB
	18Mbit/s	—	29	—	dB
	24Mbit/s	—	26	—	dB
	36Mbit/s	—	23	—	dB
	48Mbit/s	—	19	—	dB
	54Mbit/s	—	21	—	dB
Receiver adjacent channel interference rejection (ACI) 802.11n HT20	MCS0	—	31	—	dB
	MCS1	—	28	—	dB
	MCS2	—	31	—	dB
	MCS3	—	30	—	dB
	MCS4	—	27	—	dB
	MCS5	—	25	—	dB
	MCS6	—	24	—	dB
	MCS7	—	23	—	dB
Receiver adjacent channel interference rejection (ACI) 802.11n HT40	MCS0	—	28	—	dB
	MCS1	—	27	—	dB
	MCS2	—	24	—	dB
	MCS3	—	23	—	dB
	MCS4	—	19	—	dB
	MCS5	—	16	—	dB
	MCS6	—	14	—	dB
	MCS7	—	12	—	dB

[1] With BCC waveform
 [2] De-sense of ~1 dB at 2417 MHz

10.3.3 5 GHz Wi-Fi receive performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, averaged over one channel per sub-band, and at the chip port.

Table 33. 5 GHz Wi-Fi receive performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	5 GHz—IEEE 802.11n/a	5150	—	5850	MHz
Maximum receiver input level	Maximum receive input level without device damage	—	—	2	dBm
Receiver sensitivity 802.11a	6 Mbit/s	—	-90	—	dBm
	9 Mbit/s	—	-90	—	dBm
	12 Mbit/s	—	-89	—	dBm
	18 Mbit/s	—	-87	—	dBm
	14 Mbit/s	—	-85	—	dBm
	36 Mbit/s	—	-81	—	dBm
	48 Mbit/s	—	-77	—	dBm
	54 Mbit/s	—	-75	—	dBm
Receiver sensitivity 802.11n HT20 ^[1]	MCS0	—	-90	—	dBm
	MCS1	—	-87	—	dBm
	MCS2	—	-85	—	dBm
	MCS3	—	-82	—	dBm
	MCS4	—	-79	—	dBm
	MCS5	—	-75	—	dBm
	MCS6	—	-73	—	dBm
	MCS7	—	-71	—	dBm
Receiver sensitivity 802.11n HT40 ^[1]	MCS0	—	-86	—	dBm
	MCS1	—	-85	—	dBm
	MCS2	—	-82	—	dBm
	MCS3	—	-79	—	dBm
	MCS4	—	-76	—	dBm
	MCS5	—	-72	—	dBm
	MCS6	—	-70	—	dBm
	MCS7	—	-69	—	dBm
Receiver maximum input level 802.11	802.11a 6-36 Mbit/s	—	0	—	dBm
	802.11a 48-54 Mbit/s	—	-5	—	dBm
	MCS0-4	—	-1	—	dBm
	MCS5	—	-5	—	dBm
	MCS6	—	-6	—	dBm
	MCS7	—	-9	—	dBm

Table 33. 5 GHz Wi-Fi receive performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
Receiver adjacent channel interference rejection (ACI) 802.11a	6 Mbit/s	—	30	—	dB
	9 Mbit/s	—	28	—	dB
	12 Mbit/s	—	28	—	dB
	18 Mbit/s	—	26	—	dB
	24 Mbit/s	—	23	—	dB
	36 Mbit/s	—	19	—	dB
	48 Mbit/s	—	16	—	dB
	54 Mbit/s	—	15	—	dB
Receiver adjacent channel interference rejection (ACI) 802.11n HT20	MCS0	—	28	—	dB
	MCS1	—	25	—	dB
	MCS2	—	22	—	dB
	MCS3	—	22	—	dB
	MCS4	—	17	—	dB
	MCS5	—	14	—	dB
	MCS6	—	12	—	dB
	MCS7	—	10	—	dB
Receiver adjacent channel interference rejection (ACI) 802.11n HT40	MCS0	—	29	—	dB
	MCS1	—	27	—	dB
	MCS2	—	24	—	dB
	MCS3	—	24	—	dB
	MCS4	—	19	—	dB
	MCS5	—	17	—	dB
	MCS6	—	14	—	dB
	MCS7	—	12	—	dB

[1] With BCC waveform

10.3.4 2.4 GHz Wi-Fi transmit performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and at the chip port.

Table 34. 2.4 GHz Wi-Fi transmit performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	2.4 GHz—IEEE 802.11n/g/b	2400	—	2484	MHz
Transmit I/Q suppression with IQ calibration	I/Q suppression at chip output	—	-45	—	dBc
Transmit power (EVM and mask compliant) 20 MHz	802.11b	—	21	—	dBm
	OFDM BPSK	—	19	—	dBm
	OFDM QPSK	—	19	—	dBm
	OFDM 16-QAM	—	19	—	dBm
	OFDM 64-QAM	—	19	—	dBm
Transmit power (EVM and mask compliant) 40 MHz	OFDM BPSK	—	19	—	dBm
	OFDM QPSK	—	19	—	dBm
	OFDM 16-QAM	—	18	—	dBm
	OFDM 64-QAM	—	18	—	dBm
Transmit output power level control range	—	—	21 ^[1]	—	dB
Transmit output power control step	—	—	1	—	dB
Transmit output power accuracy	—	—	1.5	—	dB
Transmit carrier suppression	802.11n MCS7 HT40, at 17 dBm	—	46	—	dB

[1] 0-21 dBm. For 802.11b data rates, TX power range is 8-21 dBm

10.3.5 5 GHz Wi-Fi transmit performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and at the chip port.

Table 35. 5 GHz Wi-Fi transmit performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	5 GHz—IEEE 802.11n/a	5150	--	5850	MHz
Transmit I/Q suppression with IQ calibration	I/Q suppression at chip output	--	-45	--	dBc
Transmit power (EVM and mask compliant) 20 MHz	OFDM BPSK	--	20	--	dBm
	OFDM QPSK	--	20	--	dBm
	OFDM 16-QAM	--	20	--	dBm
	OFDM 64-QAM	--	19	--	dBm
Transmit power (EVM and mask compliant) 40 MHz	OFDM BPSK	--	19	--	dBm
	OFDM QPSK	--	19	--	dBm
	OFDM 16-QAM	--	19	--	dBm
	OFDM 64-QAM	--	18	--	dBm
Transmit output power level control range	--	--	20 ^[1]	--	dB
Transmit output power control step	--	--	1	--	dB
Transmit output power accuracy	--	--	1.5	--	dB
Transmit carrier suppression	802.11n MCS7 HT40, at 16 dBm	--	51	--	dB

[1] 0-20 dBm

10.3.6 Local oscillator

Table 36. Local oscillator

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Phase noise	Measured at 2.438 GHz at 100 kHz offset	--	-103	--	dBc/Hz
	Measured at 5.501 GHz at 100 kHz offset	--	-100	--	dBc/Hz
Integrated RMS phase noise at RF output (from 10 kHz–10 MHz)	Reference clock frequency = 26 MHz (2.4 GHz)	--	0.35	--	degrees
	Reference clock frequency = 26 MHz (5 GHz)	--	0.65	--	degrees
Frequency resolution	--	0.02	--	--	kHz

10.4 Bluetooth radio specifications

The Bluetooth radio interface pin is powered by AVDD18 voltage supply.

10.4.1 Bluetooth/Bluetooth LE receive performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and at BRF_ANT pin.

Table 37. Bluetooth/Bluetooth LE receive performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	—	2400	—	2483.5	MHz
Input IP3 (@ maximum gain of 72 dB)	—	—	-19	—	dBm
Out-of-band blocking	30–2000 MHz	—	-12.5	—	dBm
	2–2.399 GHz	—	-12.4	—	dBm
	2.484–3 GHz	—	-18	—	dBm
	3–12.75 GHz	—	-2.6	—	dBm
RSSI Range	Resolution = 1 dB	—	-90	0	dBm
Sensitivity ^[1] (RCV/CA/01/C, RCV/CA/02/C, RCV/CA/07/C)	DH5	—	-97	—	dBm
	2DH5	—	-96	—	dBm
	3DH5	—	-89.5	—	dBm
Bluetooth LE sensitivity ^{[1] [2]} (RFPHY/RCV/BV-01-C, RFPHY/RCV/BV-08-C, RFPHY/RCV/BV-26-C, RFPHY/RCV/BV-27-C)	LE 1 Mbit/s	—	-98	—	dBm
	LE 2 Mbit/s	—	-96	—	dBm
	LE coded 500 kbit/s (S = 2)	—	-100	—	dBm
	LE coded 125 kbit/s (S = 8)	—	-106	—	dBm

Table 37. Bluetooth/Bluetooth LE receive performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
C/I performance (RCV/CA/03/C & RCV/CA/09/C) ^[3]	DH1- Co-Channel interference, C/I co-channel	—	10	—	dB
	DH1- Adjacent (1 MHz) interference, C/I 1 MHz	—	-9	—	dB
	DH1- Adjacent (2 MHz) interference, C/I 2 MHz	—	-45	—	dB
	DH1- Adjacent (2 MHz) interference, C/I >= 3 MHz	—	-52	—	dB
	DH1- Image frequency interference, C/I image channel	—	-29	—	dB
	DH1- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image ± 1 MHz	—	-44	—	dB
	2DHx- Co-channel interference, C/I co-channel	—	9	—	dB
	2DHx- Adjacent (1 MHz) interference, C/I 1 MHz	—	-11	—	dB
	2DHx- Adjacent (2 MHz) interference, C/I 2 MHz	—	-45	—	dB
	2DHx- Adjacent (2 MHz) interference, C/I >= 3 MHz	—	-50	—	dB
	2DHx- Image frequency interference, C/I image channel	—	-29	—	dB
	2DHx- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image ± 1 MHz	—	-45	—	dB
	3DHx- Co-channel interference, C/I co-channel	—	15	—	dB
	3DHx- Adjacent (1 MHz) interference, C/I 1 MHz	—	-7	—	dB
	3DHx- Adjacent (2 MHz) interference, C/I 2 MHz	—	-39	—	dB
	3DHx- Adjacent (2 MHz) interference, C/I >= 3 MHz	—	-44	—	dB
	3DHx- Image frequency interference, C/I image channel	—	-23	—	dB
	3DHx- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image ± 1 MHz	—	-38	—	dB

Table 37. Bluetooth/Bluetooth LE receive performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
C/I performance (RCV/BV/03/C, RCV/BV/09/C, RCV/BV/28/C and RDC/BV/29/C)	LE 1 Mbit/s - Co-channel interference, C/I co-channel	—	8.5	—	dB
	LE 1 Mbit/s- Adjacent (1 MHz) interference, C/I 1 MHz	—	-5	—	dB
	LE 1 Mbit/s- Adjacent (2 MHz) interference, C/I 2 MHz	—	-42	—	dB
	LE 1 Mbit/s- Adjacent (2 MHz) interference, C/I >= 3 MHz	—	-50	—	dB
	LE 1 Mbit/s- Image frequency interference, C/I image channel	—	-30.5	—	dB
	LE 1 Mbit/s- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image ± 1 MHz	—	-38.5	—	dB
	LE 2 Mbit/s- Co-channel interference, C/I co-channel	—	6	—	dB
	LE 2 Mbit/s- Adjacent (2 MHz) interference, C/I 2 MHz	—	-24.5	—	dB
	LE 2 Mbit/s- Adjacent (4 MHz) interference, C/I 4 MHz	—	-51	—	dB
	LE 2 Mbit/s- Adjacent (6 MHz) interference, C/I >= 6 MHz	—	-52.5	—	dB
	LE 2 Mbit/s- Image frequency Interference C/I image channel	—	-30	—	dB
	LE 2 Mbit/s- Adjacent (2 MHz) interference to in-band mirror frequency, C/I image ± 2 MHz	—	-37	—	dB
	LE coded 500 kbit/s (S = 2)- Co-channel interference, C/I co-channel	—	7.5	—	dB
	LE coded 500 kbit/s (S = 2)- Adjacent (1 MHz) interference, C/I 1 MHz	—	-8	—	dB
	LE coded 500 kbit/s (S = 2)- Adjacent (2 MHz) interference, C/I 2 MHz	—	-47.5	—	dB
	LE coded 500 kbit/s (S = 2)- Adjacent (2 MHz) interference, C/I >= 3 MHz	—	-55.5	—	dB
	LE coded 500 kbit/s (S = 2)- Image frequency interference, C/I image channel	—	-32	—	dB

Table 37. Bluetooth/Bluetooth LE receive performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
C/I performance (RCV/CA/09/C) (continued)	LE coded 500 kbit/s (S = 2)- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image \pm 1 MHz	—	-41	—	dB
	LE coded 125 kbit/s (S = 8)- Co-channel interference, C/I co channel	—	7	—	dB
	LE coded 125 kbit/s (S = 8)- Adjacent (1 MHz) interference, C/I 1 MHz	—	-9	—	dB
	LE coded 125 kbit/s (S = 8)- Adjacent (2 MHz) interference, C/I 2 MHz	—	-51	—	dB
	LE coded 125 kbit/s (S = 8)- Adjacent (3 MHz) interference, C/I \geq 3 MHz	—	-61	—	dB
	LE coded 125 kbit/s (S = 8)- Image frequency Interference, C/I image channel	—	-33	—	dB
	LE coded 125 kbit/s (S = 8)- Adjacent (1 MHz) interference to in-band mirror frequency, C/I image \pm 1 MHz	—	-42	—	dB

[1] De-rated at 2418 MHz, 2444 MHz and 2470 MHz. Compliant with BT SIG requirements.
 [2] Measured with packet length of 255 bytes and Tx impairments set to Dirty TX ON, following Bluetooth RF test specifications.
 [3] Primary/reference channels: 2405 MHz, 2441 MHz, and 2477 MHz. Average value across the three channels.

10.4.2 Bluetooth/Bluetooth LE transmit performance

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and at BRF_ANT pin.

Table 38. Bluetooth/Bluetooth LE transmit performance

Parameter	Conditions	Min	Typ	Max	Unit
RF frequency range	—	2400	—	2483.5	MHz
Output power	Class 1 without external PA—BDR	—	13	—	dBm
	Class 1 without external PA—EDR	—	10	—	dBm
Gain range	Class 1 without external PA	—	30	—	dB
Gain resolution	—	—	0.5	—	dB
Spurious emission (BDR) (in-band)	±500 kHz	—	-20	—	dBc
	±2 MHz	—	-33	—	dBm
	±3 MHz	—	-45	—	dBm
Spurious emission (EDR) (in-band)	±1 MHz	—	-26	—	dBc
	±2 MHz	—	-29	—	dBm
	±3 MHz	—	-40	—	dBm
Spurious emission (out-of-band)	30–88 MHz	—	-65	-41.25	dBm
	88–960 MHz	—	-65	-41.25	
	0.96–20 GHz All frequencies in this range < -41.25 dBm, except at 2x Bluetooth channel frequency. Measured at pin without external filter.	—	-23	-18	
	Restricted—2.38–2.39 GHz	—	-55	-41.25	
	Restricted—2.4835–2.6 GHz	—	-50	-41.25	
Out-of-band/ Cellular band noise	GSM850 (869–894 MHz)	—	-140	—	dBm/Hz
	GSM900 (925–960 MHz)	—	-140	—	
	GSM DCS (1805–1880 MHz)	—	-135	—	
	GSM PCS (1930–1990 MHz)	—	-135	—	
	GPS (1575.42 ±1.023 MHz)	—	-140	—	
	WCDMA Band I (2110–2170 MHz)	—	-130	—	
	WCDMA Band V (869–894 MHz)	—	-140	—	

Table 38. Bluetooth/Bluetooth LE transmit performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
Bluetooth classic					
Transmit output power (TRM/CA/01/C)	BDR	—	13	—	dBm
	EDR	—	10	—	dBm
Power control (TRM/CA/03/C) ^[1]	—	—	3 to 6.4	—	dB
Frequency range (TRM/CA/04/C)	Low range	—	2401	—	MHz
	High range	—	2481	—	MHz
-20 dB bandwidth (TRM/CA/05/C)	DH5 packets	—	957	—	kHz
Modulation characteristics (TRM/CA/07/C)	Delta F1 avg	—	166	—	kHz
	Delta F2 max threshold	—	100	—	%
	Delta F2/Delta F1	—	0.9	—	—
	Delta F2 avg	—	149	—	kHz
Initial carrier frequency tolerance (ICTF) test (TRM/CA/08/C)	DH1 packets	—	-11	—	kHz
Carrier frequency drift (TRM/CA/09/C)	Max Drift - DH1	—	-16	—	kHz
	Drift rate - DH1	—	$\pm 1.5^{[2]}$	—	kHz
	Max Drift - DH3	—	-17	—	kHz
	Drift rate - DH3	—	$-2^{[3]}$	—	kHz
	Max drift - DH5	—	-16	—	kHz
	Drift rate - DH5	—	$\pm 2^{[4]}$	—	kHz
EDR relative power (TRM/CA/10/C)	2DH5 (DPSK/GFSK)	—	-0.2	—	dB
	3DH5 (DPSK/GFSK)	—	-0.2	—	dB
EDR carrier frequency stability and modulation accuracy (TRM/CA/11/C)	2DH5 peak DEVM	—	0.14	—	%
	2DH5 RMS DEVM	—	0.05	—	%
	3DH5 Peak DEVM	—	0.16	—	%
	3DH5 RMS DEVM	—	0.06	—	%
Diff. phase encoding (TRM/CA/12/C)	2DH5	—	100	—	%
	3DH5	—	100	—	%

Table 38. Bluetooth/Bluetooth LE transmit performance...continued

Parameter	Conditions	Min	Typ	Max	Unit
Bluetooth LE					
Bluetooth LE output power (TRM/-LE/CA/01/C)	LE 1 Mbit/s	—	12	—	dBm
	LE 2 Mbit/s	—	12	—	dBm
	LE coded 500 kbit/s (S = 2)	—	12	—	dBm
	LE coded 125 kbit/s (S = 8)	—	12	—	dBm
Bluetooth LE modulation characteristics (TRM-LE/CA/05/C)	Delta F1 avg - LE 1 Mbit/s	—	253	—	kHz
	Delta F2/Delta F1- LE 1 Mbit/s	—	1	—	—
	Delta F2 avg- LE 1 Mbit/s	—	223	—	kHz
	Delta F1 avg - LE 2 Mbit/s	—	505	—	kHz
	Delta F2/Delta F1- LE 2 Mbit/s	—	1	—	—
	Delta F2 avg- LE 2 Mbit/s	—	460	—	kHz
Bluetooth LE carrier frequency drift (TRM-LE/CA/06/C)	Max drift - LE 1 Mbit/s	—	-9	—	kHz
	Drift rate - LE 1 Mbit/s	—	1	—	kHz
	Max drift - LE 2 Mbit/s	—	-12	—	kHz
	Drift rate - LE 2 Mbit/s	—	1	—	kHz
	Max drift - LE coded 500 kbit/s (S = 2)	—	-6	—	kHz
	Drift rate - LE coded 500 kbit/s (S = 2)	—	-5	—	kHz
	Max Drift - LE coded 125 kbit/s (S = 8)	—	-6	—	kHz
	Drift rate - LE coded 125 kbit/s (S = 8)	—	-5	—	kHz
Frequency accuracy (TRM-LE/CA/BV-06-C)	LE 1 Mbit/s	—	-15	—	kHz
	LE 2 Mbit/s	—	-15	—	kHz
	LE coded 500 kbit/s (S = 2)	—	-15	—	kHz
	LE coded 125 kbit/s (S = 8)	—	-15	—	kHz

[1] Specifies the minimum and maximum transmit power step size. As per Bluetooth SIG specification, min step size = 2 dB and max step size = 8 dB
 [2] As per Bluetooth SIG specification, the lower limit is -20 kHz and the upper limit is +20 kHz.
 [3] Calculated over 50 us - Bluetooth SIG specification.
 [4] As per Bluetooth SIG specification, the lower limit is -40 kHz and the upper limit is +40 kHz.

10.5 External coexistence interface specifications

10.5.1 WCI-2 coexistence interface specifications

10.5.1.1 WCI-2 interface

WCI-2 is a simplified 2-wire UART interface defined in Bluetooth Core Spec Vol 7 Part C.

[Figure 15](#) shows UART waveform.

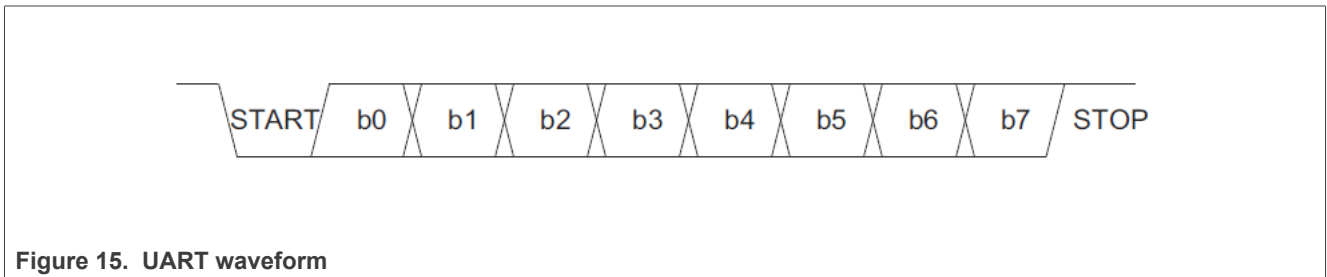


Figure 15. UART waveform

[Figure 16](#) illustrates WCI-2 hardware coexistence interface between IW416 and the external radio.

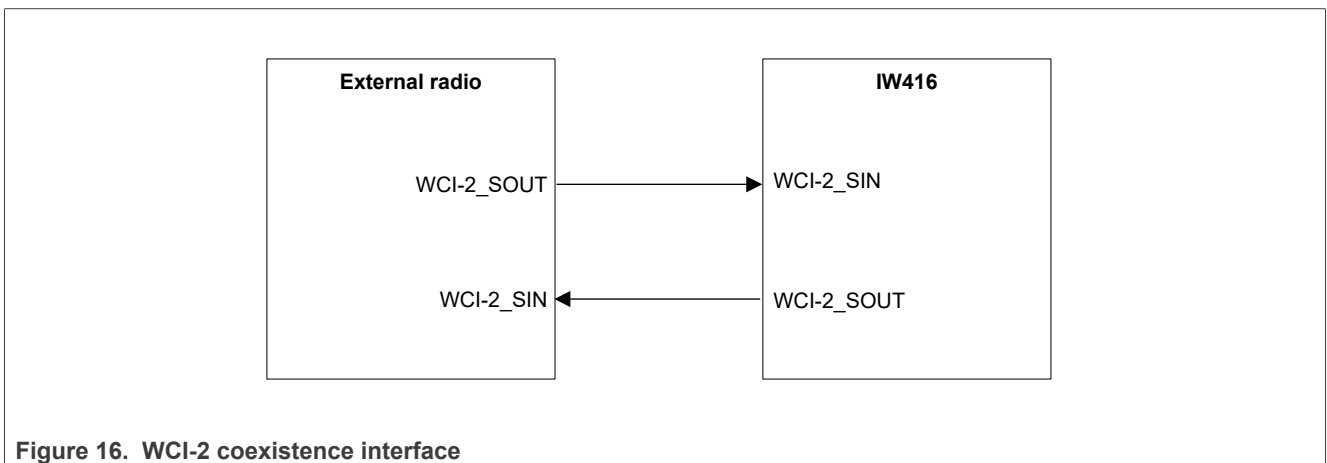


Figure 16. WCI-2 coexistence interface

10.5.1.2 WCI-2 messages

WCI-2 coexistence interface supports the messages defined in Bluetooth Core Specification Vol 7 Part C for request and grant, where:

- The real time message from the external radio to IW416 indicates the request to operate (Figure 17)
 - MWS_Rx=1 indicates an external radio request to Rx
 - MWS_Tx=1 indicates an external radio request to Tx

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
0	0	0	FRAME_SYNC	MWS_RX	MWS_TX	MWS_PATTERN[0]	MWS_PATTERN[1]

Figure 17. Type 0: Real time signaling message - external radio to IW416

- The external radio can send an optional second message following the real time message to indicate the traffic priority using the vendor specific message (Figure 18). Otherwise, the priority is set via a BCA register.

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
1	1	1	0	MWS_TX_PRI[0]	MWS_TX_PRI[1]	MWS_RX_PRI[0]	MWS_RX_PRI[1]

Figure 18. Type 7: Vendor specific message - external radio to IW416

- The real time message from IW416 to the external radio indicates the arbitration results (Figure 19):
 - BT_Rx_Pri = 1: the Bluetooth radio Rx wins the arbitration and is in operation
 - BT_Tx_On = 1: the Bluetooth radio Tx wins the arbitration and is in operation
 - 802_Rx_Pri = 1: Wi-Fi Rx wins the arbitration and is in operation
 - 802_Tx_On = 1: Wi-Fi Tx wins the arbitration and is in operation
 - Otherwise, the external radio is granted

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
0	0	0	BT_RX_PRI	BT_TX_ON	802_RX_PRI	802_TX_ON	RFU

Figure 19. Type 0: Real time signaling message - IW416 to external radio

WCI-2 coexistence interface supports the messages defined in Bluetooth Core Specification Vol 7 Part C for other purposes, such as:

- Transport control message from IW416 to the external radio to request real time message upon wake up ([Figure 20](#))

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
0	0	1	Resend_real_time	RFU	RFU	RFU	RFU

Figure 20. Type 1: Transport control message time signaling message - IW416 to external radio

- MWS inactivity duration message from the external radio to IW416 indicates the inactivity duration to IW416 before going to sleep ([Figure 21](#))

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
0	1	1	Duration[0]	Duration[1]	Duration[2]	Duration[3]	Duration[4]

Figure 21. MWS inactivity duration message

- MWS scan frequency message from the external radio to IW416 indicates the external radio scan frequency to IW416 ([Figure 22](#))

Type(0)	Type(1)	Type(2)	MSG(0)	MSG(1)	MSG(2)	MSG(3)	MSG(4)
1	0	0	Freq[0]	Freq[1]	Freq[2]	Freq[3]	Freq[4]

Figure 22. Type 5: MWS scan frequency message

10.5.1.3 WCI-2 signal waveform format

The messaging is based on a standard UART format.

Figure 23 shows the waveform for the transmit signal (UART_SOUT to UART_SIN).

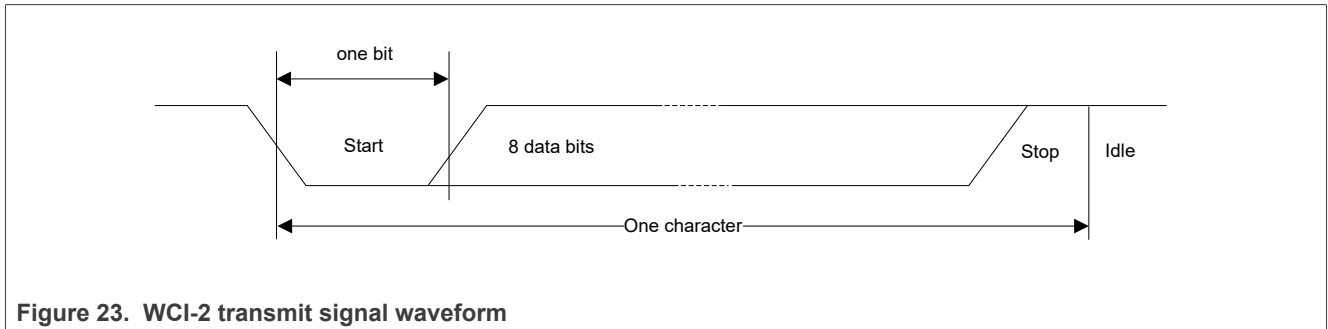


Figure 23. WCI-2 transmit signal waveform

Table 39. WCI-2 interface transport settings

Parameter	Range	Note
Baud rate	921600 ~ 4000000	Baud
Data bits	8	LSB first
Parity bits	0	No parity
Stop bit	1	One stop bit
Flow control	No	No flow control

10.5.2 PTA interface coexistence specifications

This section illustrates how the central hardware packet traffic arbiter samples the interface signals. The sampling is based on which interface signals are being used.

Figure 24 shows PTA coexistence interface signal timing diagram for the example where:

- Input: request, 1-bit priority
 - Priority ready at Request signal assertion
- Output: grant

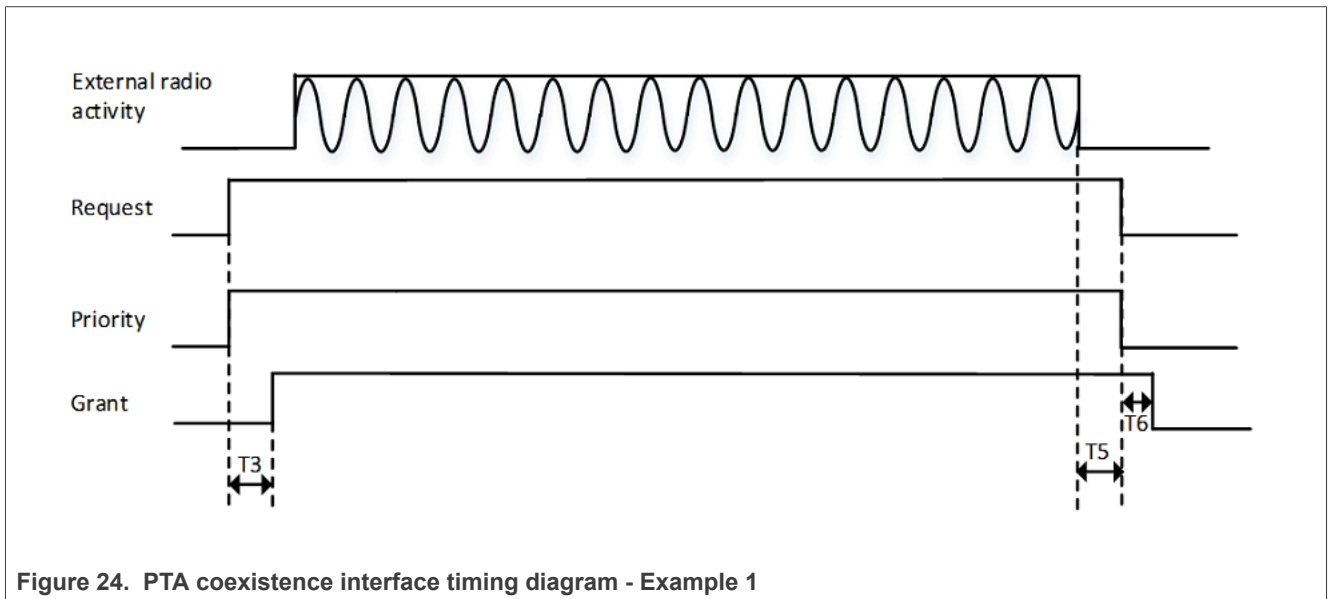


Figure 24. PTA coexistence interface timing diagram - Example 1

Figure 25 shows PTA coexistence interface timing diagram for the example where:

- Input: request, 1-bit priority, state
 - Priority signal and State signal are ready at Request signal assertion
- Output: grant

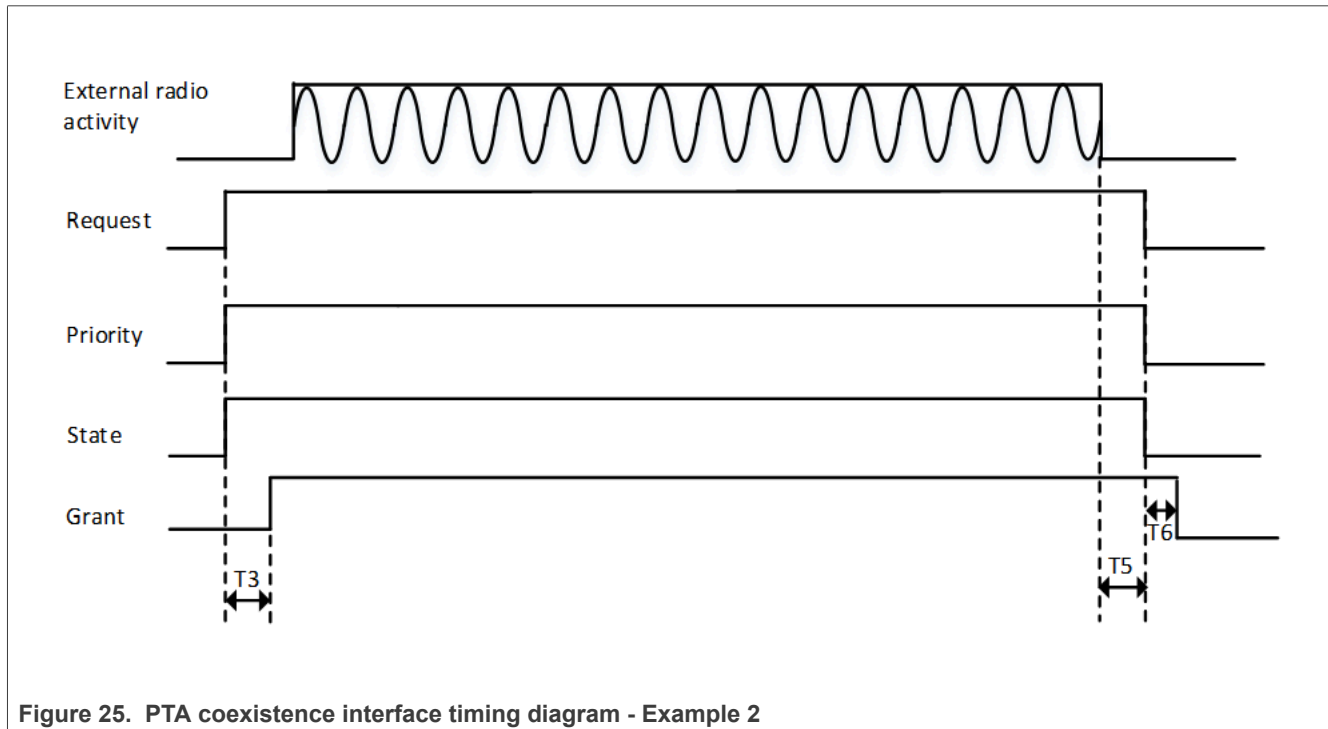


Figure 26 shows PTA coexistence interface timing diagram for the example where:

- Input: request, 1-bit priority, frequency, state
 - Priority, State, and Frequency ready at Request assertion
- Output: grant

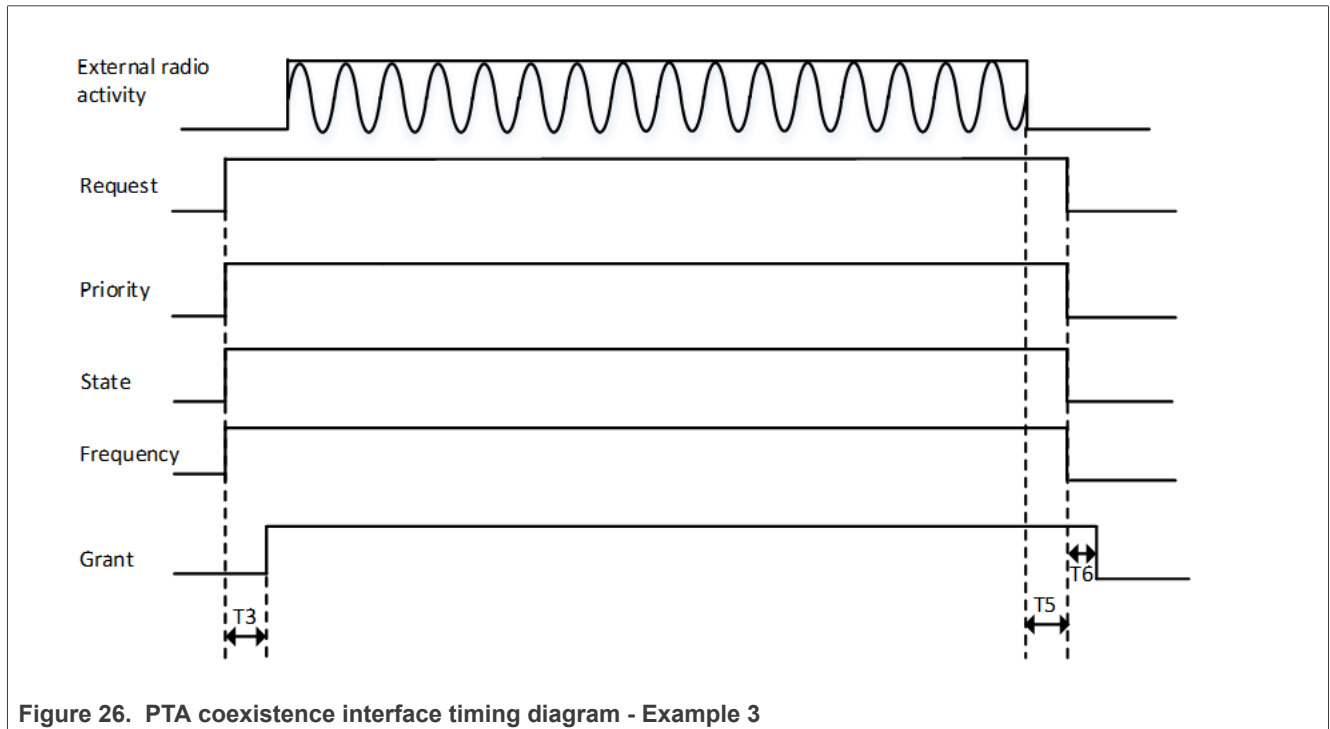


Figure 26. PTA coexistence interface timing diagram - Example 3

Figure 27 shows PTA coexistence interface timing diagram for the example where:

- Input: request, 1-bit priority
 - Priority signal is ready at Request signal assertion
- Output: grant
 - Grant signal is de-asserted before Request signal de-assertion due to a traffic abort caused by other traffic with higher priority

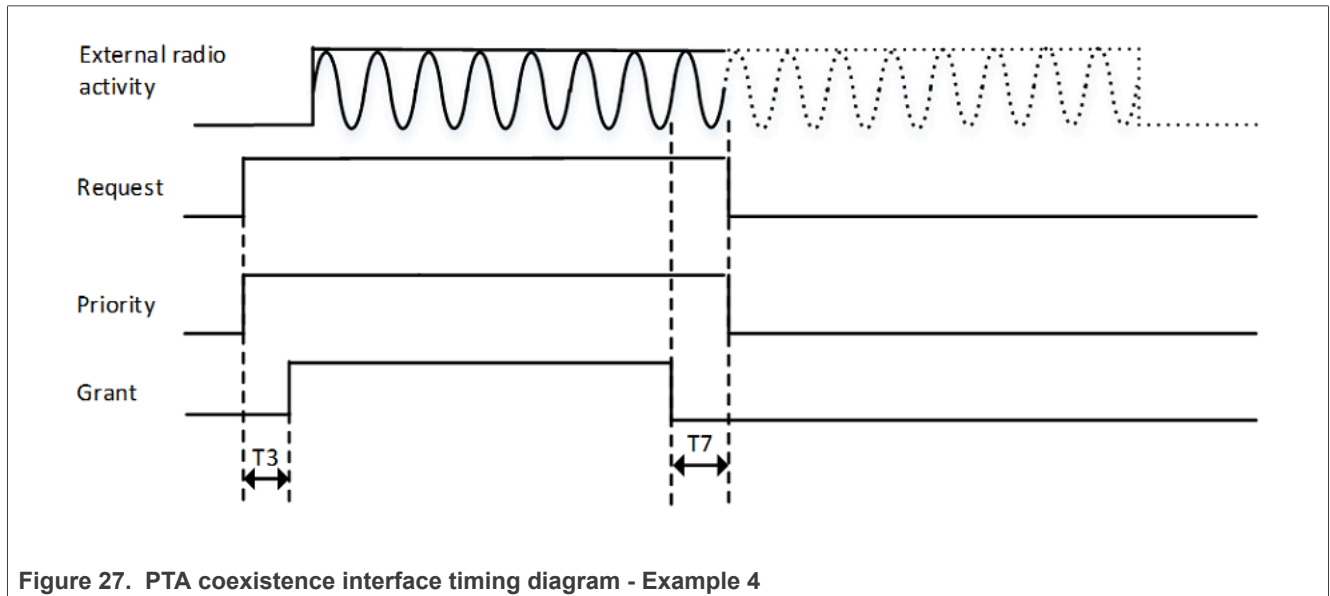


Figure 27. PTA coexistence interface timing diagram - Example 4

Figure 28 shows PTA coexistence interface timing diagram for the example where:

- Input: request and priority
 - Priority pin is sampled three times to obtain two priority bits and Tx/Rx info. No input from State pin.
- Output: grant

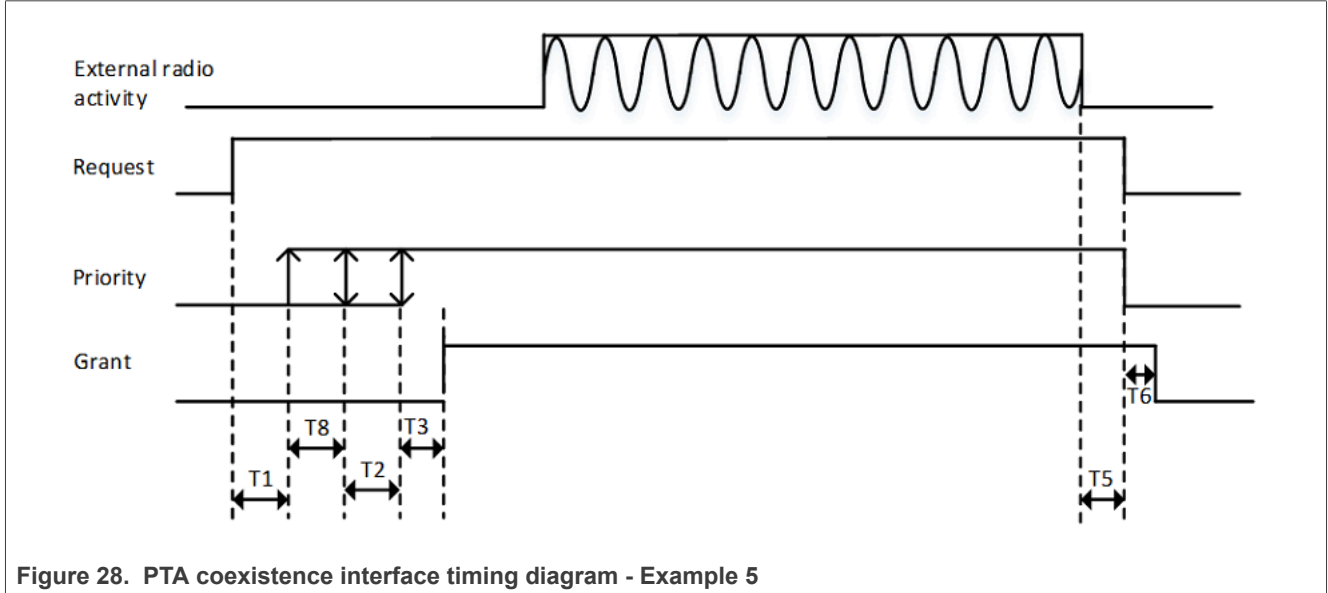


Figure 28. PTA coexistence interface timing diagram - Example 5

Table 40 provides the timing specifications for PTA coexistence interface signals.

Table 40. PTA coexistence interface signal timing data

Parameter	Conditions	Min	Typ.	Max	Unit
T1 ^[1]	Priority[0] is sampled on Priority pin at T1 from Request assertion.	0	—	100	µs
T8 ^[1]	Optional: priority[1], if present on Priority pin, is sampled at T1+T8 from Request assertion.	0.025	—	100	µs
T2 ^[1]	Optional: Tx/Rx Info, if present on Priority pin, is sampled at T1+T2 (one priority bit on Priority pin) or T1+T8+T2 (two priority bits on Priority pin) from Request assertion.	0.025	—	100	µs
T3 ^[2]	Time from all information available to BCA to grant decision ready	0.1	—	0.4	µs
T5 ^[2]	The Request signal de-asserts T5 after the last symbol is done	—	—	—	µs
T6 ^[2]	The Grant signal de-asserts T6 after the Request de-assertion	0.1	—	0.3	µs
T7 ^[2]	The Request signal de-asserts T7 after the grant de-assertion due to a traffic abort.	—	—	—	µs

[1] Valid for serially sampled Priority pin

[2] Valid for all implementations

10.6 Current consumption

Note: Unless otherwise stated, all specifications are at 25°C, nominal voltage, and typical value.

Table 41. Current consumption values

Mode	Conditions	VPA	AVDD18	VCORE	VIO (3.3 V)	Unit
Sleep mode						
Power down	—	0.003	0.04	0.4	0	mA
Wi-Fi and Bluetooth in deep-sleep mode	—	0.005	0.025	0.44	0.03	mA
Bluetooth LE ^[1]						
Bluetooth LE advertise	Interval = 1.28 s	0.005	0.06	0.28	0.03	mA
Bluetooth LE scan	Interval = 1.28 s, window = 11.25 ms	0.005	0.14	0.4	0.03	mA
Bluetooth LE link	Master mode, interval=1.28 s	0.005	0.145	0.49	0.03	mA
Bluetooth LE peak transmit	@ 0 dBm, 1 Mbit/s	0.005	27	19	0.24	mA
Bluetooth LE peak transmit	@ 4 dBm, 1 Mbit/s	0.005	31	19	0.24	mA
Bluetooth LE peak transmit	@ 7 dBm, 1 Mbit/s	0.005	50	19	0.24	mA
Bluetooth LE peak transmit	@ 10 dBm, 1 Mbit/s	0.005	66	19	0.24	mA
Bluetooth LE peak receive	1 Mbit/s	0.005	16	20	0.24	mA
Bluetooth ^[1]						
Bluetooth page scan	--	0.005	0.19	0.46	0.03	mA
Bluetooth page and inquiry scan	--	0.005	0.3	0.6	0.03	mA
Bluetooth ACL link	Master sniff mode interval=1.28s	0.005	0.12	0.4	0.03	mA
Bluetooth ACL link	Master sniff mode interval = 500 ms	0.005	0.24	0.64	0.03	mA
Bluetooth ACL	Data pump, DH1	0.005	11.8	13.1	0.24	mA
Bluetooth ACL	Data pump, 2-DH3	0.005	19.2	15.4	0.24	mA
Bluetooth ACL	Data pump, 3-DH5	0.005	21.6	16.1	0.24	mA
Bluetooth SCO HV3 peak transmit	@ 0 dBm	0.005	26	19	0.24	mA
Bluetooth SCO HV3 peak transmit	@ 4 dBm	0.005	31	19	0.24	mA
Bluetooth SCO HV3 peak transmit	@ 10 dBm	0.005	67	19	0.24	mA
Bluetooth SCO HV3 peak transmit	@ 13 dBm	0.005	88	19	0.24	mA
Bluetooth SCO HV3 peak receive	--	0.005	15.5	20	0.24	mA
Bluetooth peak transmit	@ 0 dBm, DH5	0.005	26	19	0.24	mA
Bluetooth peak transmit	@ 4 dBm, DH5	0.005	31	19	0.24	mA
Bluetooth peak transmit	@ 10 dBm, DH5	0.005	67	19	0.24	mA
Bluetooth peak transmit	@ 13 dBm, DH5	0.005	88	19	0.24	mA
Bluetooth peak receive	DH5	0.005	15.5	20	0.24	mA

Table 41. Current consumption values...continued

Mode	Conditions	VPA	AVDD18	VCORE	VIO (3.3 V)	Unit
IEEE power save^[2]						
IEEE-PS_2GHz-Legacy (DTIM-1)	Beacon interval : 100 msec 5G basic rate for beacon Tx: 6 Mbit/s 2G basic rate for beacon Tx: 1 Mbit/s	0.005	0.94	1.18	0.03	mA
IEEE-PS_2GHz-Legacy (DTIM-3)		0.005	0.33	0.7	0.03	mA
IEEE-PS_2GHz-Legacy (DTIM-5)		0.005	0.21	0.59	0.03	mA
IEEE-PS_2GHz-Legacy (DTIM-10)		0.005	0.17	0.55	0.03	mA
IEEE-PS_5GHz-Legacy (DTIM-1)		0.005	0.75	0.91	0.03	mA
IEEE-PS_5GHz-Legacy (DTIM-3)		0.005	0.26	0.62	0.03	mA
IEEE-PS_5GHz-Legacy (DTIM-5)		0.005	0.19	0.55	0.03	mA
IEEE-PS_5GHz-Legacy (DTIM-10)		0.005	0.12	0.52	0.03	mA
Wi-Fi 2.4 GHz receive idle mode^[2]						
802.11b, 11 Mbit/s	—	0.005	40	26	0.24	mA
802.11g, 54 Mbit/s	—	0.005	40	26	0.24	mA
802.11n, 20 MHz MCS7	—	0.005	40	26	0.24	mA
802.11n, 40 MHz MCS7	—	0.005	40	34	0.24	mA
Wi-Fi 5 GHz receive idle mode^[2]						
802.11a, 54 Mbit/s	—	0.005	60	27	0.24	mA
802.11n, 20 MHz	—	0.005	60	27	0.24	mA
802.11n, 40 MHz	—	0.005	72	35	0.24	mA
Wi-Fi 2.4 GHz receive mode^[2]						
802.11b, 11 Mbit/s	—	0.005	33	27	0.24	mA
802.11g, 54 Mbit/s	—	0.005	37	38	0.24	mA
802.11n, 20 MHz MCS7	—	0.005	35	47	0.24	mA
802.11n, 40 MHz MCS7	—	0.005	36	60	0.24	mA
Wi-Fi 5 GHz receive mode^[2]						
802.11a, 54 Mbit/s	—	0.005	50	39	0.24	mA
802.11n, 20 MHz MCS7	—	0.005	50	48	0.24	mA
802.11n, 40 MHz MCS7	—	0.005	60	60	0.24	mA
Wi-Fi 2.4 GHz transmit mode^[2] (Tx referred to pin)						
802.11b, 1 Mbit/s @ 20 dBm	—	313	95	88	0.24	mA
802.11b, 11 Mbit/s @ 20 dBm	—	323	95	90	0.24	mA
802.11g, 54 Mbit/s @ 20 dBm	—	311	96	95	0.24	mA
802.11n, 20 MHz MCS0 @ 20 dBm	—	311	96	98	0.24	mA
802.11n, 20 MHz MCS7 @ 20 dBm	—	311	96	98	0.24	mA
802.11n, 40 MHz MCS0 @ 20 dBm	—	325	97	105	0.24	mA
802.11n, 40 MHz MCS7 @ 20 dBm	—	325	97	105	0.24	mA

Table 41. Current consumption values...continued

Mode	Conditions	VPA	AVDD18	VCORE	VIO (3.3 V)	Unit
Wi-Fi 5 GHz transmit mode ^[2] (Tx referred to pin)						
802.11a, 6 Mbit/s @ 19 dBm	—	274	158	99	0.24	mA
802.11a, 54 Mbit/s @ 19 dBm	—	278	157	103	0.24	mA
802.11n, 20 MHz MCS0 @ 19 dBm	—	272	158	100	0.24	mA
802.11n, 20 MHz MCS7 @ 19 dBm	—	280	158	102	0.24	mA
802.11n, 40 MHz MCS0 @ 17 dBm	—	227	155	105	0.24	mA
802.11n, 40 MHz MCS7 @ 17 dBm	—	227	157	115	0.24	mA
Peak current						
Peak current during device initialization	--	862	224	141	0.24	mA

[1] Wi-Fi in deep-sleep mode
 [2] Bluetooth in deep-sleep mode

10.7 SDIO host interface specifications

The SDIO host interface pins are powered by VIO_SD voltage supply.

See [Section 10.7.1 "VIO_SD DC characteristics"](#) for specifications.

The SDIO electrical specifications are identical for 4-bit SDIO and 1-bit SDIO transfer modes.

10.7.1 VIO_SD DC characteristics

Table 42. VIO_SD requirements

SDIO version	Specifications	Maximum frequency	VIO_SD value
SDIO 2.0	Default speed	25 MHz	3.3 V
	High speed	50 MHz	3.3 V
SDIO 3.0	SDR12	25 MHz	1.8 V
	SDR25	50 MHz	1.8 V
	SDR50	100 MHz	1.8 V
	DDR50	50 MHz	1.8 V

10.7.1.1 1.8V operation

Table 43. DC electrical characteristics—1.8V operation (VIO_SD)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO_SD	--	VIO_SD+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO_SD	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO_SD-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.7.1.2 3.3V operation

Table 44. DC electrical characteristics—3.3V operation (VIO_SD)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	--	0.7*VIO_SD	--	VIO_SD+0.4	V
V _{IL}	Input low voltage	--	-0.4	--	0.3*VIO_SD	V
V _{HYS}	Input hysteresis	--	100	--	--	mV
V _{OH}	Output high voltage	--	VIO_SD-0.4	--	--	V
V _{OL}	Output low voltage	--	--	--	0.4	V

10.7.2 Default speed, high-speed modes

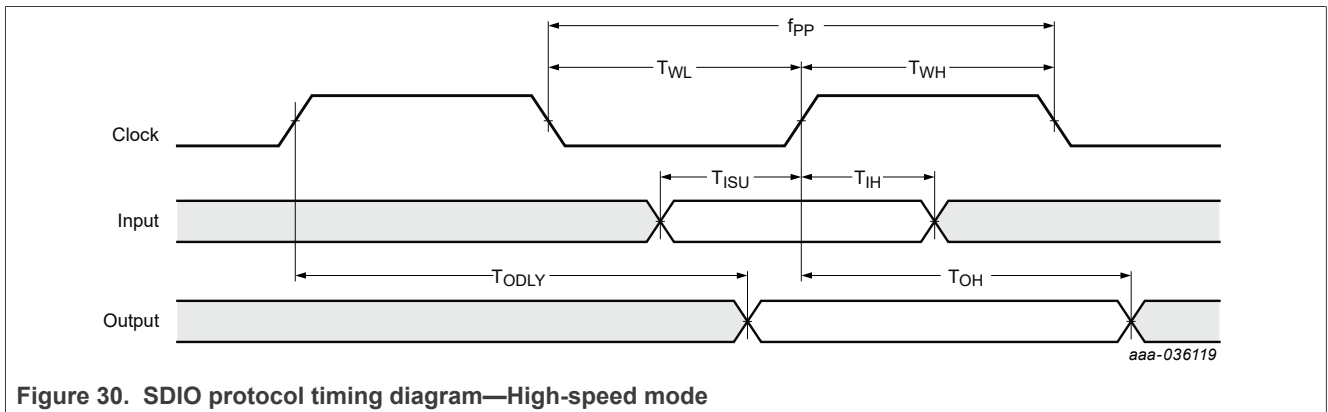
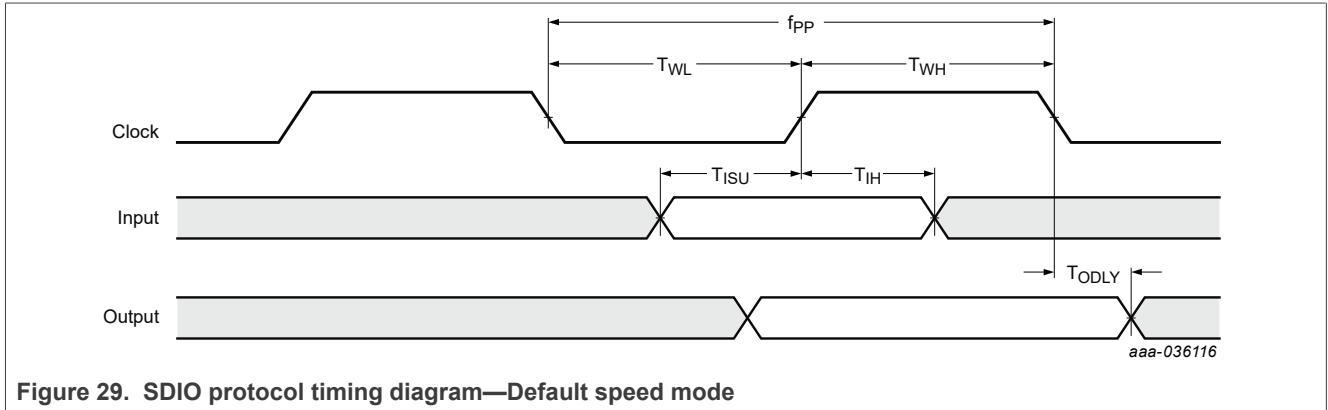


Table 45. SDIO timing data—Default speed, high-speed modes

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f _{PP}	Clock frequency	Normal	0	--	25	MHz
		High-speed	0	--	50	MHz
T _{WL}	Clock low time	Normal	10	--	--	ns
		High-speed	7	--	--	ns
T _{WH}	Clock high time	Normal	10	--	--	ns
		High-speed	7	--	--	ns
T _{ISU}	Input setup time	Normal	5	--	--	ns
		High-speed	6	--	--	ns
T _{IH}	Input hold time	Normal	5	--	--	ns
		High-speed	2	--	--	ns
T _{ODLY}	Output delay time	Normal	--	--	14	ns
	CL ≤ 40 pF (1 card)	High-speed	--	--	14	ns

Table 45. SDIO timing data—Default speed, high-speed modes...continued

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T _{OH}	Output hold time	High-speed	2.5	--	--	ns

10.7.3 SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

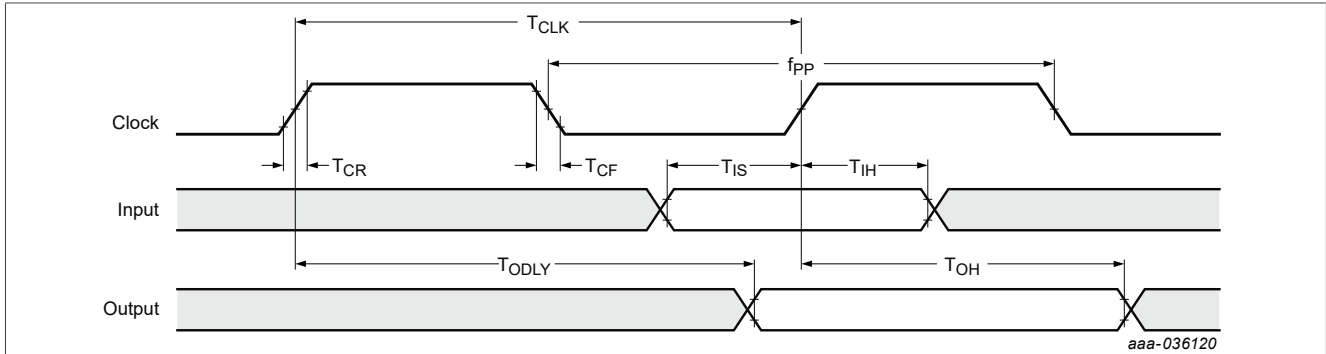


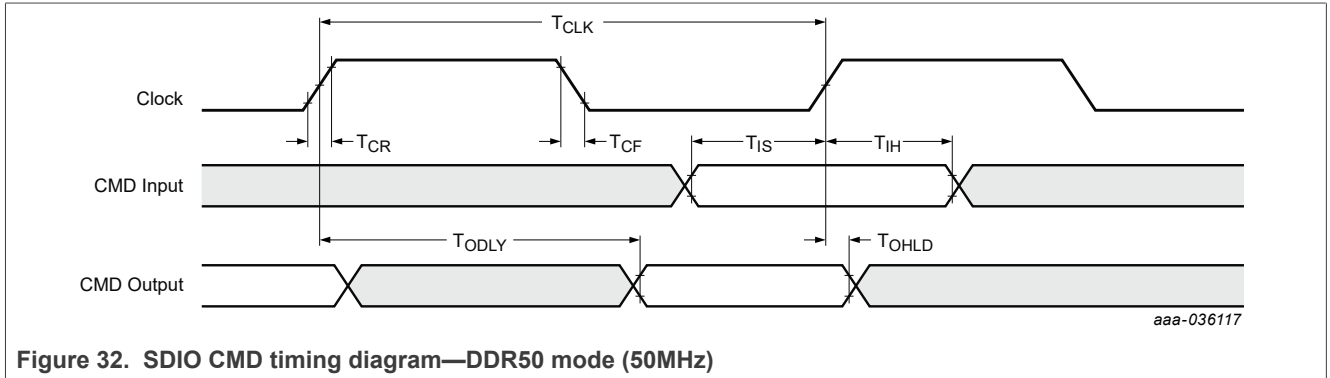
Figure 31. SDIO protocol timing diagram—SDR12, SDR25, SDR50 modes (up to 100MHz) (1.8V)

Table 46. SDIO timing data—SDR12, SDR25, SDR50 modes (up to 100MHz) (1.8V)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f _{PP}	Clock frequency	SDR12/25/50	25	--	100	MHz
T _{IS}	Input setup time	SDR12/25/50	3	--	--	ns
T _{IH}	Input hold time	SDR12/25/50	0.8	--	--	ns
T _{CLK}	Clock time	SDR12/25/50	10	--	40	ns
T _{CR} , T _{CF}	Rise time, fall time T _{CR} , T _{CF} < 2 ns (max) at 100 MHz C _{CARD} = 10 pF	SDR12/25/50	--	--	0.2*T _{CLK}	ns
T _{ODLY}	Output delay time C _L ≤ 30 pF	SDR12/25/50	--	--	7.5	ns
T _{OH}	Output hold time C _L = 15 pF	SDR12/25/50	1.5	--	--	ns

10.7.4 DDR50 mode (50MHz) (1.8V)



In DDR50 mode, DAT[3:0] lines are sampled on both edges of the clock (not applicable for CMD line).

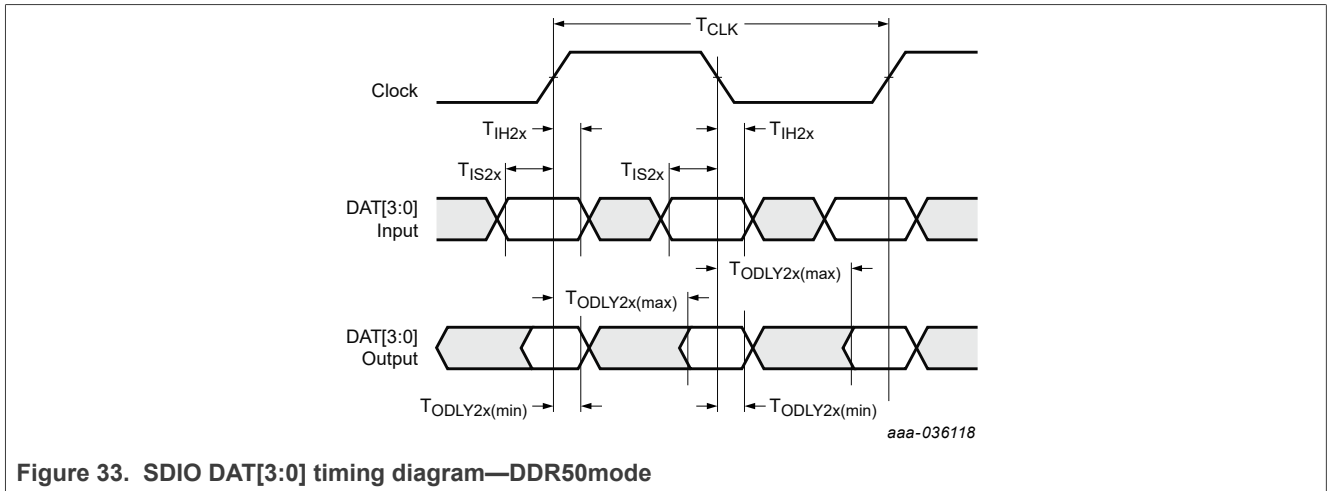


Table 47. SDIO timing data—DDR50 mode (50MHz)

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Clock						
T _{CLK}	Clock time 50 MHz (max) between rising edges	DDR50	20	--	--	ns
T _{CR} , T _{CF}	Rise time, fall time T _{CR} , T _{CF} < 4.00 ns (max) at 50 MHz C _{CARD} = 10 pF	DDR50	--	--	0.2*T _{CLK}	ns
Clock Duty	--	DDR50	45	--	55	%
CMD Input (referenced to clock rising edge)						
T _{IS}	Input setup time C _{CARD} ≤ 10 pF (1 card)	DDR50	6	--	--	ns
T _{IH}	Input hold time C _{CARD} ≤ 10 pF (1 card)	DDR50	0.8	--	--	ns
CMD Output (referenced to clock rising edge)						
T _{ODLY}	Output delay time during data transfer mode C _L ≤ 30 pF (1 card)	DDR50	--	--	13.7	ns
T _{OHLD}	Output hold time C _L ≥ 15 pF (1 card)	DDR50	1.5	--	--	ns
DAT[3:0] Input (referenced to clock rising and falling edges)						
T _{IS2x}	Input setup time C _{CARD} ≤ 10 pF (1 card)	DDR50	3	--	--	ns
T _{IH2x}	Input hold time C _{CARD} ≤ 10 pF (1 card)	DDR50	0.8	--	--	ns
DAT[3:0] Output (referenced to clock rising and falling edges)						
T _{ODLY2x (max)}	Output delay time during data transfer mode C _L ≤ 25 pF (1 card)	DDR50	--	--	7.0	ns
T _{ODLY2x (min)}	Output hold time C _L ≥ 15 pF (1 card)	DDR50	1.5	--	--	ns

10.7.5 SDIO internal pull-up/pull-down specifications

Table 48. SDIO internal pull-up/pull-down specifications

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Internal nominal pull-up/pull-down resistance	--	60	90	120	kΩ

10.8 High-speed UART specifications

The UART Tx and Rx pins are powered by VIO voltage supply.
See [Section 10.1.1 "VIO DC characteristics"](#) for DC specifications.

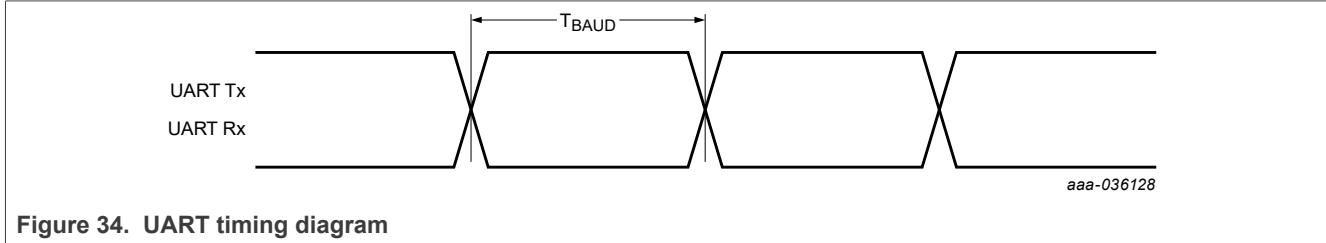


Figure 34. UART timing diagram

Table 49. UART timing data ^[1]

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Units
T _{BAUD}	Baud rate	26 MHz or 40 MHz reference clock	250	--	--	ns

[1] The acceptable deviation from the UART Rx target baud rate is ±3%.

10.9 Audio interface specifications

The device has two audio interfaces: I2S interface and PCM interface.

10.9.1 I2S interface specifications

The I2S pins are powered by VIO voltage supply. See [Section 10.1.1 "VIO DC characteristics"](#) for the specifications.

10.9.2 PCM interface specifications

The PCM pins are powered by VIO voltage supply. See [Section 10.1.1 "VIO DC characteristics"](#) for specifications.

Central mode

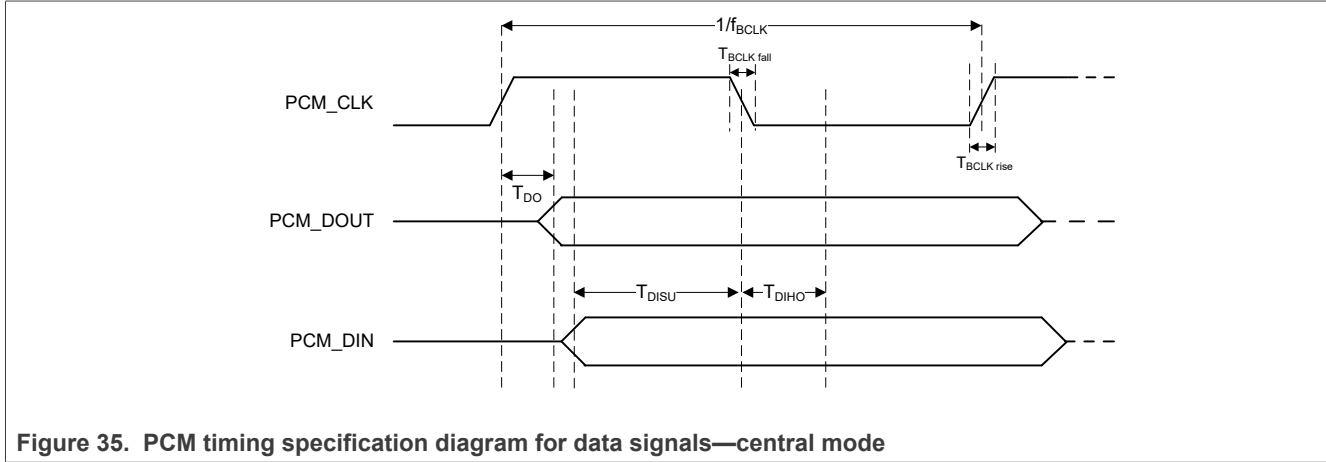


Figure 35. PCM timing specification diagram for data signals—central mode

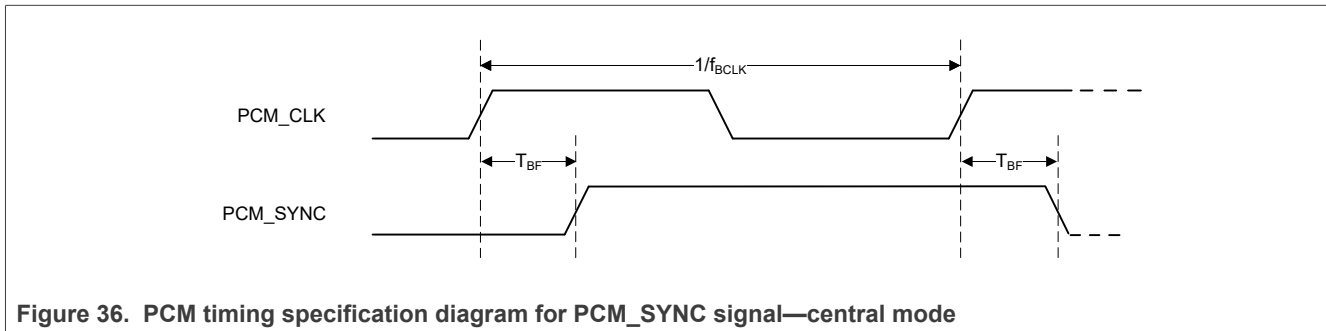


Figure 36. PCM timing specification diagram for PCM_SYNC signal—central mode

Table 50. PCM timing specification data—central mode

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{BCLK}	Bit clock frequency	--	2	2/2.048	2.048	MHz
Duty Cycle _{BCLK}	Bit clock duty cycle	--	0.4	0.5	0.6	--
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time	--	--	3	--	ns
T_{DO}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge	--	--	--	15	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge	--	20	--	--	ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge	--	15	--	--	ns
T_{BF}	Delay from PCM_CLK rising edge to PCM_SYNC rising edge	--	--	--	15	ns

Peripheral mode

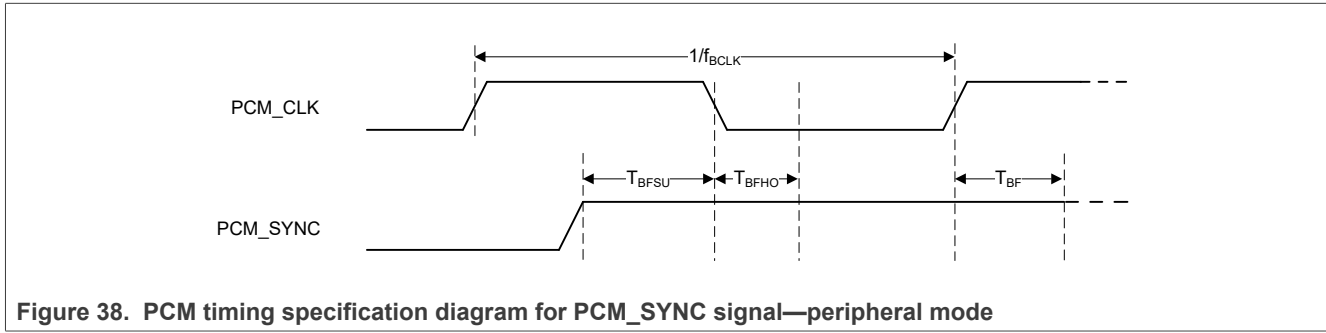
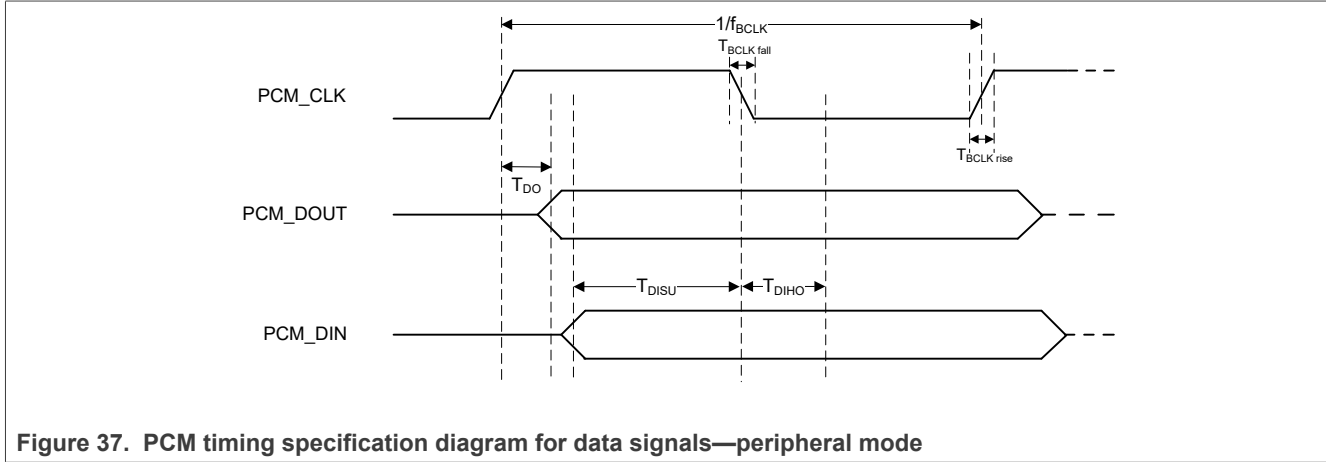


Table 51. PCM timing specification data—peripheral mode

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{BCLK}	Bit clock frequency	--	0.512	2/2.048	4	MHz
Duty Cycle _{BCLK}	Bit clock duty cycle	--	0.4	0.5	0.6	--
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time	--	--	3	--	ns
T_{D0}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge	--	--	--	30	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge	--	15	--	--	ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge	--	10	--	--	ns
T_{BFSU}	Setup time for PCM_SYNC before PCM_CLK falling edge	--	15	--	--	ns
T_{BFHO}	Hold time for PCM_SYNC after PCM_CLK falling edge	--	10	--	--	ns

10.10 Reference clock specifications

10.10.1 External crystal oscillator specifications

Note: The reference clock from the external crystal oscillator requires a CMOS input signal.

Table 52. Clock DC specifications ^[1]

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Single-ended high-level voltage	--	--	--	1.8	V
Single-ended low-level voltage	--	0	--	--	V
Clock amplitude (pk-pk)	--	0.5	--	1	V
Mid-point slope	--	125	--	--	MV/s

[1] AC-coupling capacitor is integrated into the SoC.

Table 53. 26 MHz clock timing

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
XO26 period	--	38.46 - 20 ppm	38.46	38.46 + 20 ppm	ns
XO26 rise time	--	--	--	5.00	ns
XO26 fall time	--	--	--	5.00	ns
XO26 duty cycle	--	48.05	50	51.95	%

Table 54. 40 MHz clock timing

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
XO40 period	--	25.00 - 20 ppm	25.00	25.00 + 20 ppm	ns
XO40 rise time	--	--	--	2.00	ns
XO40 fall time	--	--	--	2.00	ns
XO40 duty cycle	--	47	50	53	%

Table 55. Phase noise—2.4 GHz operation

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Fref = 26 MHz	Offset = 1 kHz	--	--	-126	dBc/Hz
	Offset = 10 kHz	--	--	-137	dBc/Hz
	Offset = 100 kHz	--	--	-145	dBc/Hz
	Offset > 1 MHz	--	--	-145	dBc/Hz
Fref = 40 MHz	Offset = 1 kHz	--	--	-126	dBc/Hz
	Offset = 10 kHz	--	--	-137	dBc/Hz
	Offset = 100 kHz	--	--	-145	dBc/Hz
	Offset > 1 MHz	--	--	-145	dBc/Hz

Table 56. Phase noise—5 GHz operation

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Test Conditions	Min	Typ	Max	Unit
Fref = 26 MHz	Offset = 1 kHz	--	--	-130	dBc/Hz
	Offset = 10 kHz	--	--	-150	dBc/Hz
	Offset = 100 kHz	--	--	-156	dBc/Hz
	Offset > 1 MHz	--	--	-156	dBc/Hz
Fref = 40 MHz	Offset = 1 kHz	--	--	-130	dBc/Hz
	Offset = 10 kHz	--	--	-150	dBc/Hz
	Offset = 100 kHz	--	--	-156	dBc/Hz
	Offset > 1 MHz	--	--	-156	dBc/Hz

10.10.2 External crystal specifications

Table 57. External crystal specifications

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Fundamental frequencies	—	—	26 (40)	—	MHz
Resonance mode	—	—	A1, Fundamental	—	—
Equivalent differential load capacitance	—	—	8	—	pF
Shunt capacitance	—	—	2	—	pF
Frequency tolerance	Over process at 25°C	—	±10	—	ppm
Frequency stability	Over operating temperature	—	±10	—	ppm
Aging	—	—	±2	—	ppm/5 years
Series resistance (ESR)	26 MHz	—	—	60	Ω
	40 MHz	—	—	60	Ω
Insulation resistance	at DC 100V	500	—	—	MΩ
Drive level	—	150	—	—	μW

10.10.3 External sleep clock specifications

Table 58. External sleep clock specifications ^[1]

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Min	Typ	Max	Unit
Clock frequency range/accuracy • CMOS input clock signal type • ±250 ppm (initial, aging, temperature)	--	32.768	--	kHz
Phase noise requirement (@ 100 kHz)	--	-125	--	dBc/Hz
Cycle jitter	--	1.5	--	ns (RMS)
Slew rate limit (10-90%)	--	--	100	ns
Duty cycle tolerance	20	--	80	%

[1] Voltage input level = 1.8V. See [Section 10.1.1 "VIO DC characteristics"](#).

10.11 Power down (PDn) pin specifications

10.11.1 PDn asserted low—All power supplies good

Figure 39 and Table 59 show the specifications for the PDn signal when it is asserted (low) while all power supplies to the device are good.

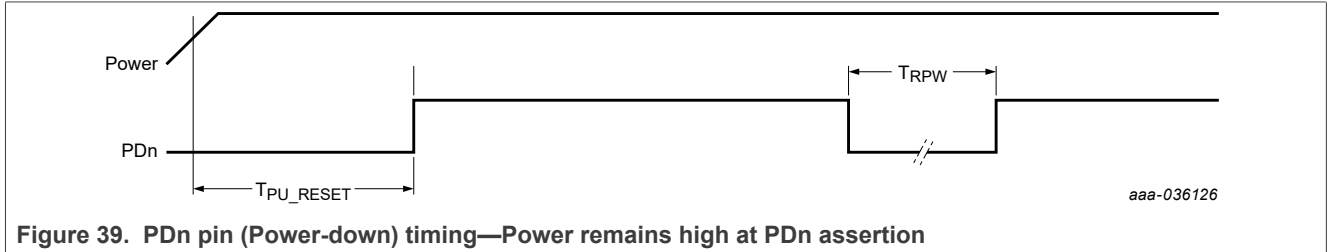


Figure 39. PDn pin (Power-down) timing—Power remains high at PDn assertion

Table 59. PDn pin (Power Down) specifications—Power remains high at PDn assertion

Unless otherwise specified, the values apply per Section 9 "Recommended operating conditions"

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{PU_RESET}	Valid power to PDn de-asserted	--	0	--	--	ms
T_{RPW}	PDn pulse width	--	50 ^[1]	--	--	μ s
V_{IH}	Input high voltage	--	1.4	--	4.5	V
V_{IL}	Input low voltage	--	-0.4	--	0.5	V

[1] Minimum value guaranteed for a valid reset. Smaller values may put the device in an undefined state.

10.11.2 PDn asserted low—One or more power supplies ramp down

Figure 40 and Table 60 show the specifications for the PDn signal when it is asserted (low) while 1 or more of the power supplies (including VCORE) ramps down. When the integrated LDO is used, VCORE will ramp down when PDn is asserted.

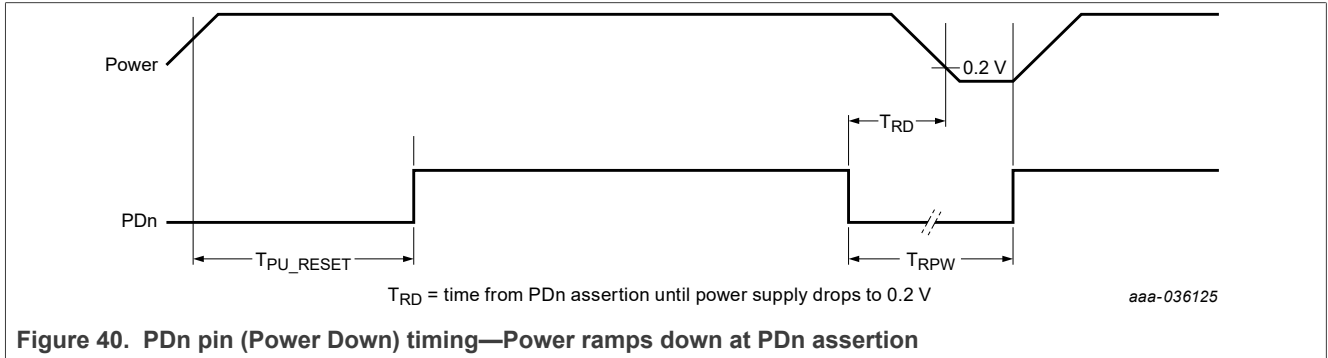


Figure 40. PDn pin (Power Down) timing—Power ramps down at PDn assertion

Table 60. PDn pin (Power Down) specifications—Power ramps down at PDn assertion

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{PU_RESET}	Valid power to PDn de-asserted	--	0	--	--	ms
T_{RPW}	PDn pulse width	--	$T_{RD}^{[1]}$	--	--	μs
V_{IH}	Input high voltage	--	1.4	--	4.5	V
V_{IL}	Input low voltage	--	-0.4	--	0.5	V

[1] Minimum value guaranteed for a valid reset. Smaller values may put the device in an undefined state.

10.12 Configuration pin specifications

For a list of configuration pins, see [Section 6.6 "Configuration pins"](#).

Table 61. Configuration pin specifications ^[1]

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Parameter	Condition	Min	Typ	Max	Unit
Internal weak pull-up resistance	Around 1 ms following any reset	--	800	--	kΩ
Internal nominal pull-up resistance	Around 1 ms following any reset	--	100	--	kΩ

[1] After approximately 1 ms, the configuration pins become functional pins.

10.13 JTAG interface specifications

JTAG interface pins are powered by VIO voltage supply.

See [Section 10.1.1 "VIO DC characteristics"](#) for specifications.

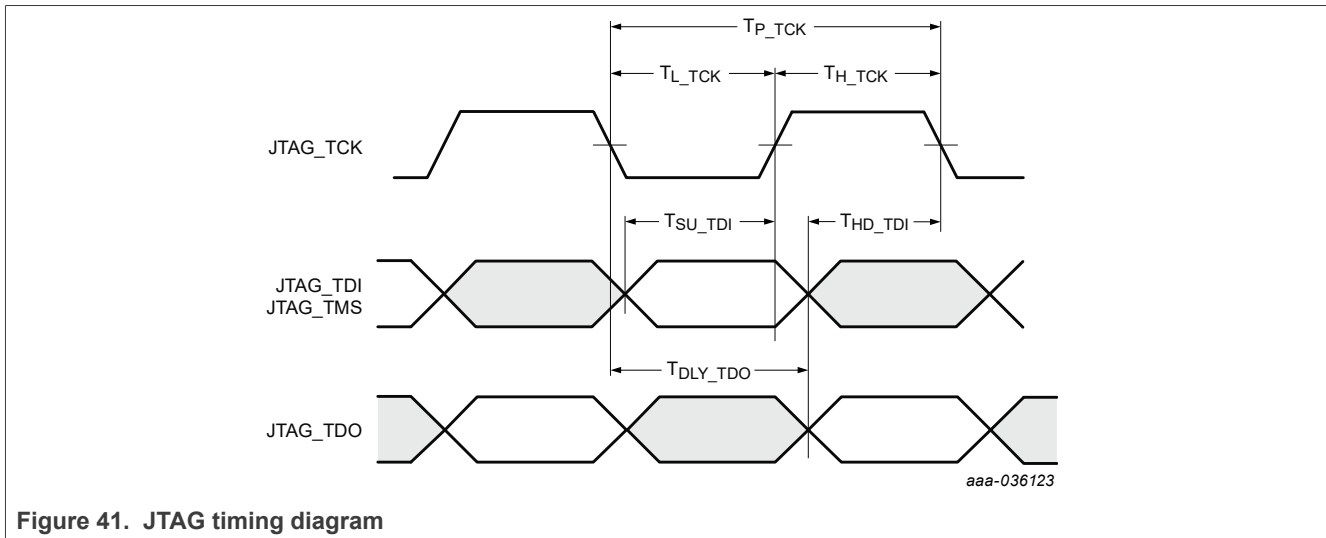


Figure 41. JTAG timing diagram

Table 62. JTAG timing data ^[1]

Unless otherwise specified, the values apply per [Section 9 "Recommended operating conditions"](#)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
T_{P_TCK}	TCK period	--	40	--	--	ns
T_{H_TCK}	TCK high	--	12	--	--	ns
T_{L_TCK}	TCK low	--	12	--	--	ns
T_{SU_TDI}	TDI, TMS to TCK setup time	--	10	--	--	ns
T_{HD_TDI}	TDI, TMS to TCK hold time	--	10	--	--	ns
T_{DLY_TDO}	TCK to TDO delay	--	0	--	15	ns

[1] Does not apply to JTAG enabled by the JTAG_TMS pin.

11 Package information

11.1 Package thermal conditions

11.1.1 HVQFN68 thermal conditions

Table 63. Package thermal conditions—HVQFN68

Symbol	Parameter	Condition	Typ	Units
θ_{JA}	Thermal resistance Junction to ambient of package. $\theta_{JA} = (T_J - T_A) / P$ P = total power dissipation	JEDEC 3 in. x 4.5 in. 4-layer PCB no air flow	28.4	°C/W
		JEDEC 3 in. x 4.5 in. 4-layer PCB 1 meter/sec air flow	27.6	°C/W
		JEDEC 3 in. x 4.5 in. 4-layer PCB 2 meter/sec air flow	26.1	°C/W
		JEDEC 3 in. x 4.5 in. 4-layer PCB 3 meter/sec air flow	25.3	°C/W
ψ_{JT}	Thermal characteristic parameter Junction to top-center of package. $\psi_{JT} = (T_J - T_{TOP}) / P$ T_{TOP} = temperature on top-center of package	JEDEC 3 in. x 4.5 in. 4-layer PCB no air flow	0.44	°C/W
ψ_{JB}	Thermal characteristic parameter Junction to bottom surface, center of PCB. $\psi_{JB} = (T_J - T_B) / P$ T_B = surface temperature of PCB	JEDEC 3 in. x 4.5 in. 4-layer PCB no air flow	15.4	°C/W
θ_{JC}	Thermal resistance Junction to case of the package. $\theta_{JC} = (T_J - T_C) / P_{TOP}$ T_C = temperature on top-center of package P_{TOP} = power dissipation from top of package	JEDEC 3 in. x 4.5 in. 4-layer PCB no air flow	13.0	°C/W
θ_{JB}	Thermal resistance Junction to board of package. $\theta_{JB} = (T_J - T_B) / P_{BOTTOM}$ P_{BOTTOM} = power dissipation from bottom of package to PCB surface	JEDEC 3 in. x 4.5 in. 4-layer PCB no air flow	15.6	°C/W

11.1.2 WLCSP76 thermal conditions

Table 64. Package thermal conditions—WLCSP76

Symbol	Rating	Board type ^[1]	Value	Unit
$R_{\theta JA}$	Junction to ambient thermal resistance ^[2]	JESD51-9, 2s2p	37.6	°C/W
$R_{\psi JT}$	Junction to top of package thermal characterization parameter ^[2]	JESD51-9, 2s2p	1.3	°C/W

[1] The thermal test board meets JEDEC specification for this package (JESD51-9).

[2] Determined in accordance to JEDEC JESD51-2A natural convection environment. Thermal resistance data in this report is solely for a thermal performance comparison of one package to another in a standardized specified environment. It is not meant to predict the performance of a package in an application-specific environment.

11.2 Package mechanical drawing

Table 65. Package information

Package name	Link to package information on NXP website
HVQFN68	SOT2107-1
WLCSP76	SOT2073-1

11.2.1 HVQFN68 mechanical drawing

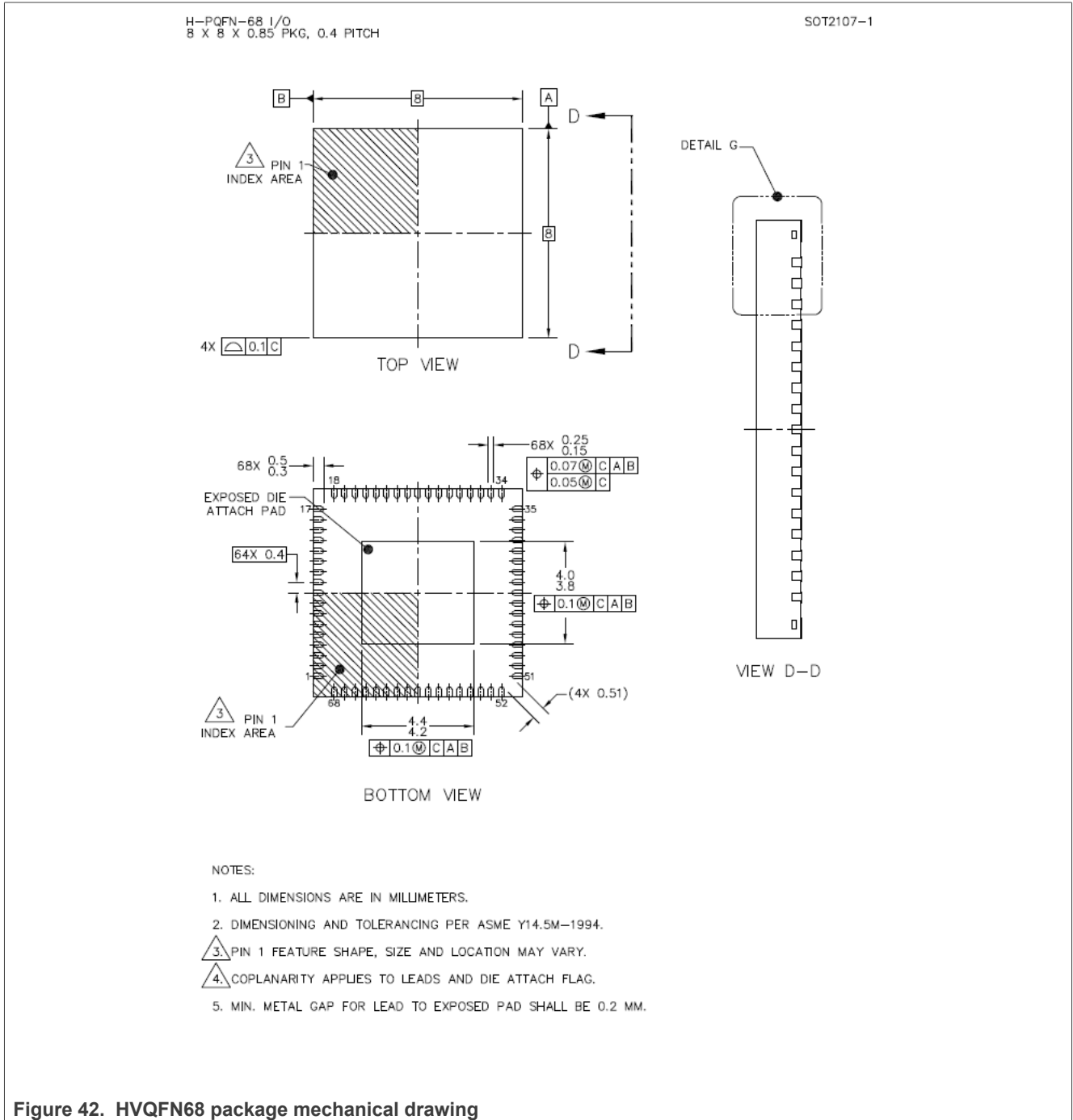


Figure 42. HVQFN68 package mechanical drawing

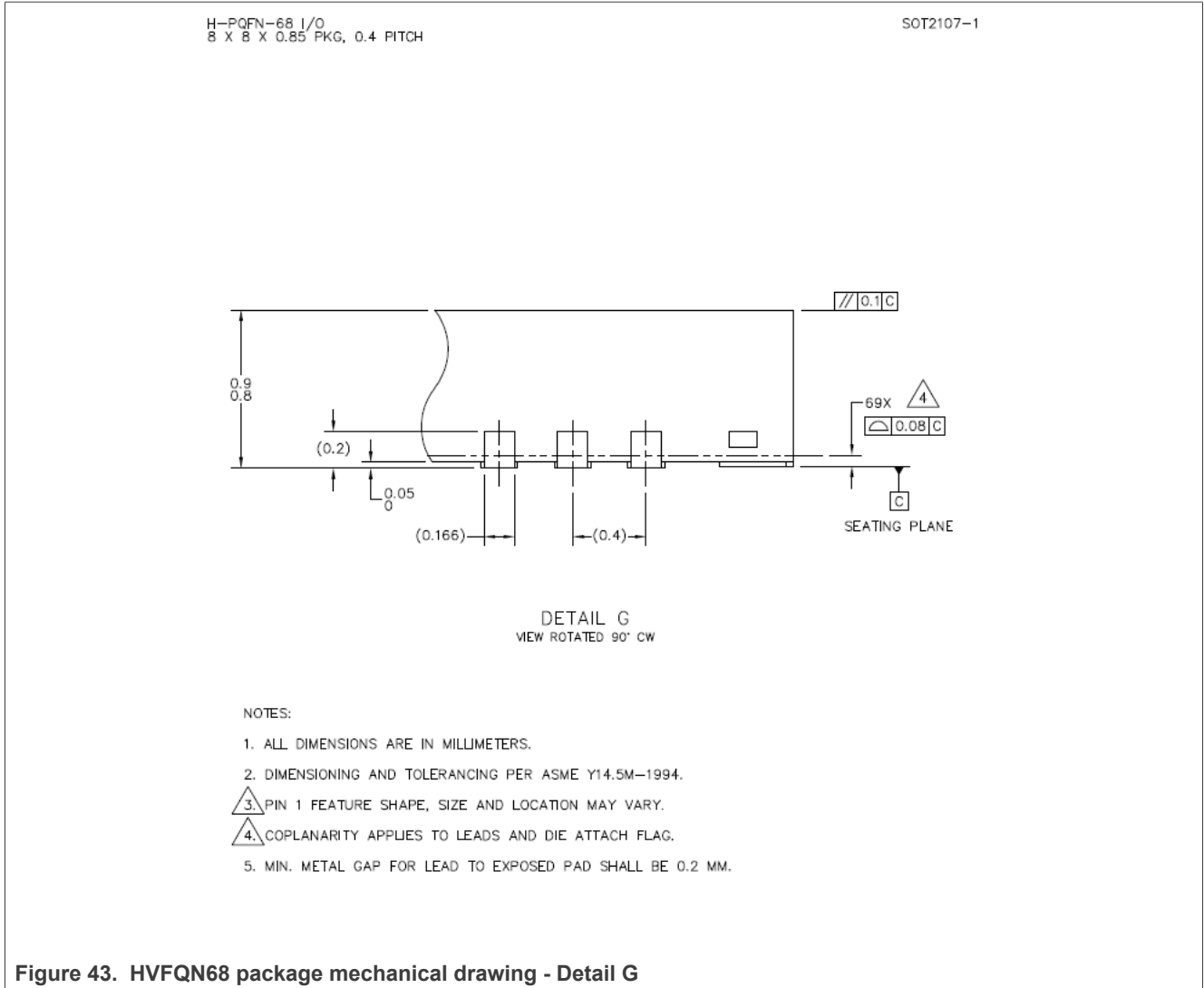
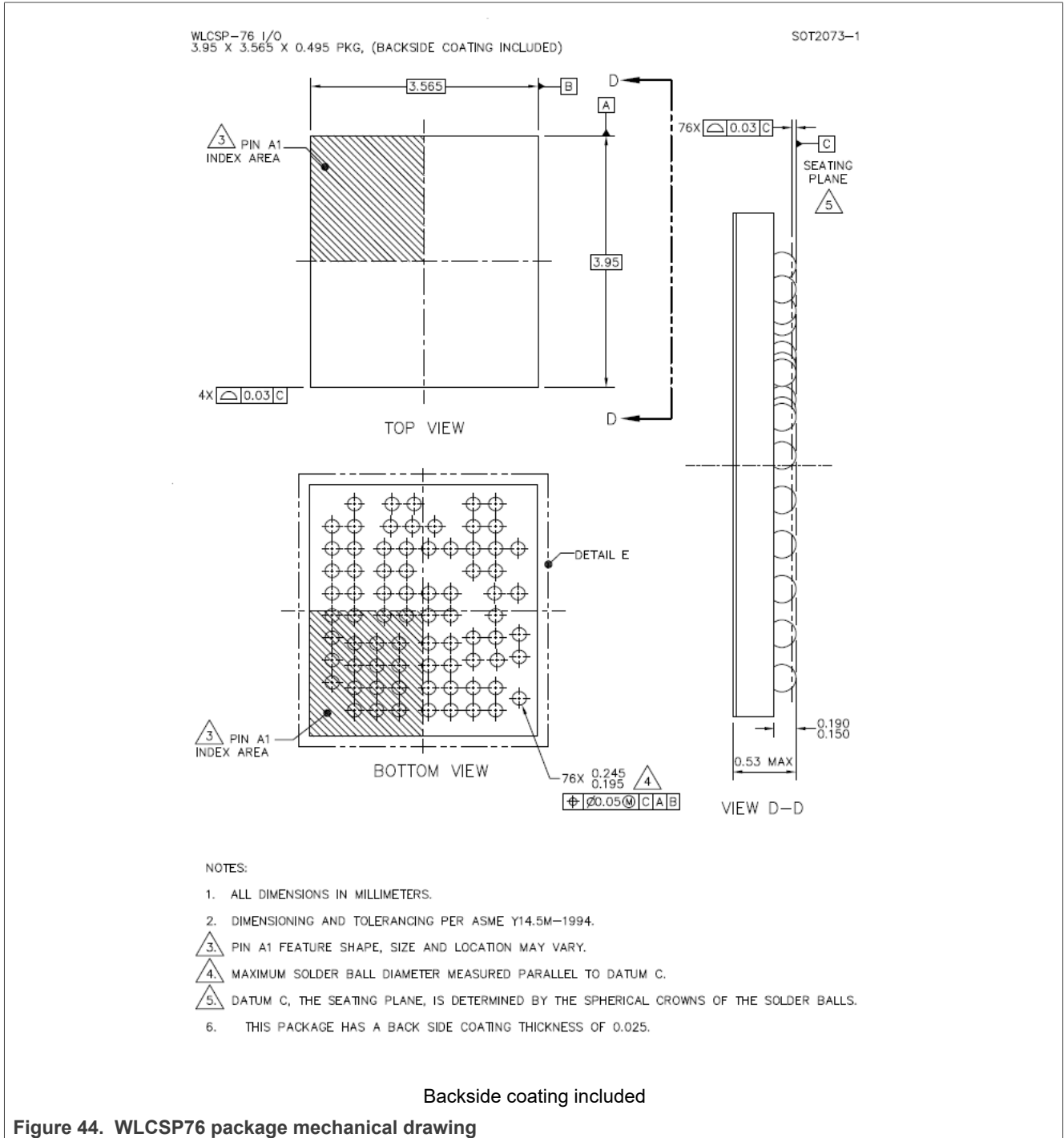
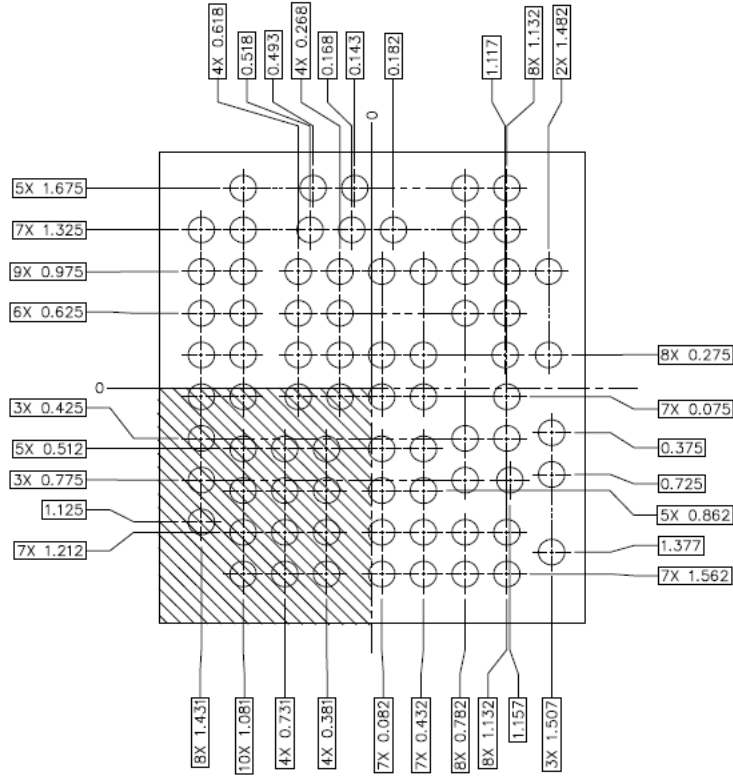


Figure 43. HVFQFN68 package mechanical drawing - Detail G

11.2.2 WLCSP76 mechanical drawing





DETAIL E

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. PIN A1 FEATURE SHAPE, SIZE AND LOCATION MAY VARY.
4. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM C.
5. DATUM C, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
6. THIS PACKAGE HAS A BACK SIDE COATING THICKNESS OF 0.025.

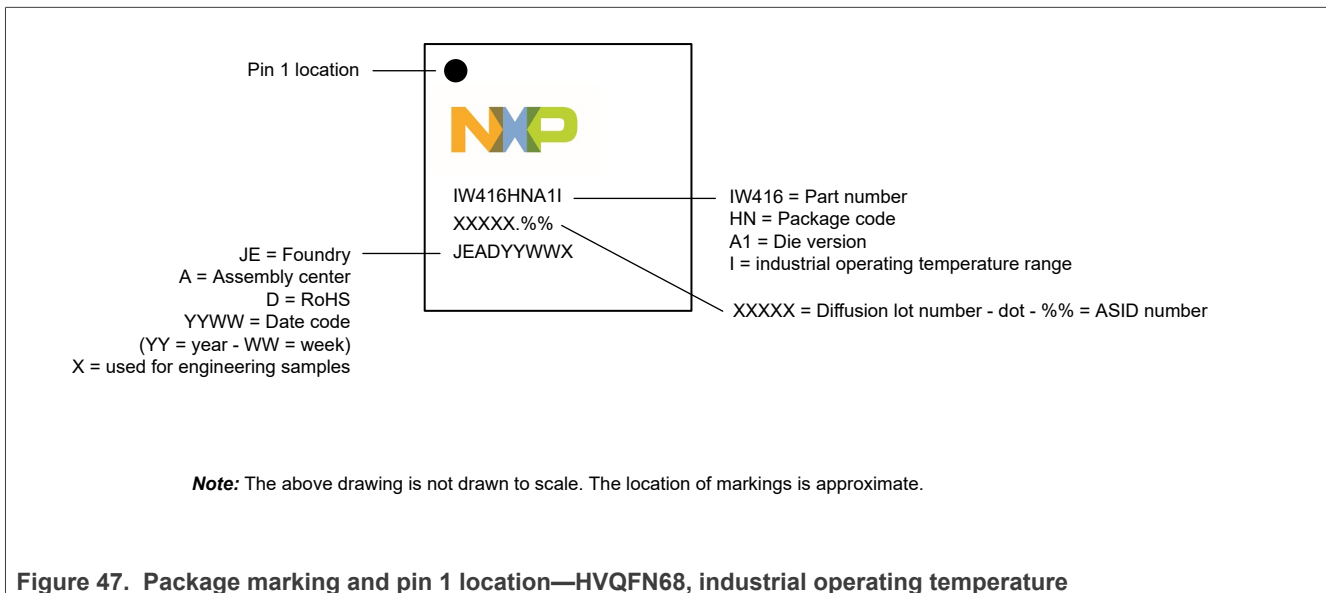
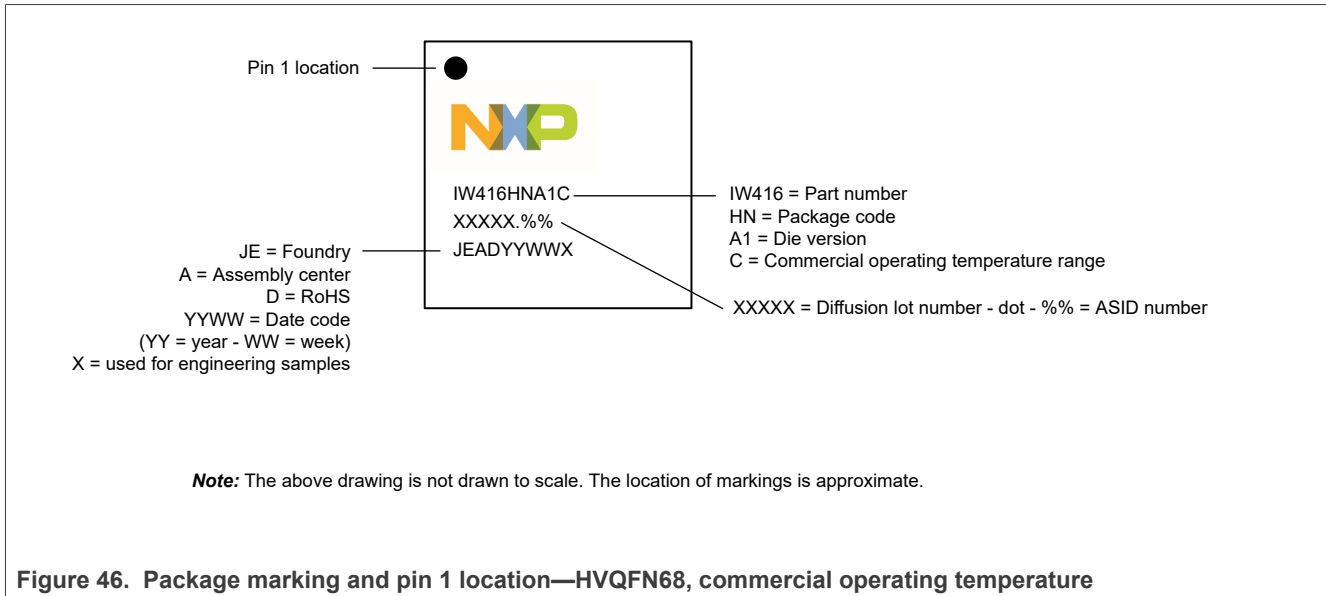
Backside coating included

Figure 45. WLCSP76 package mechanical drawing - Detail E

11.3 Package marking

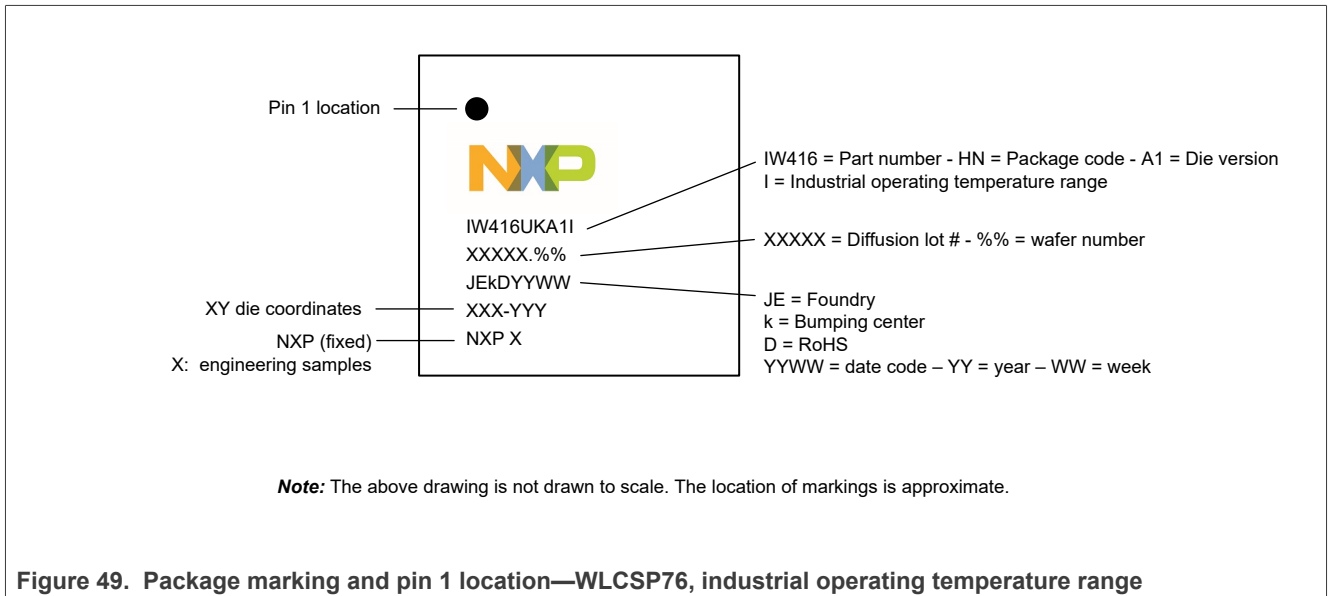
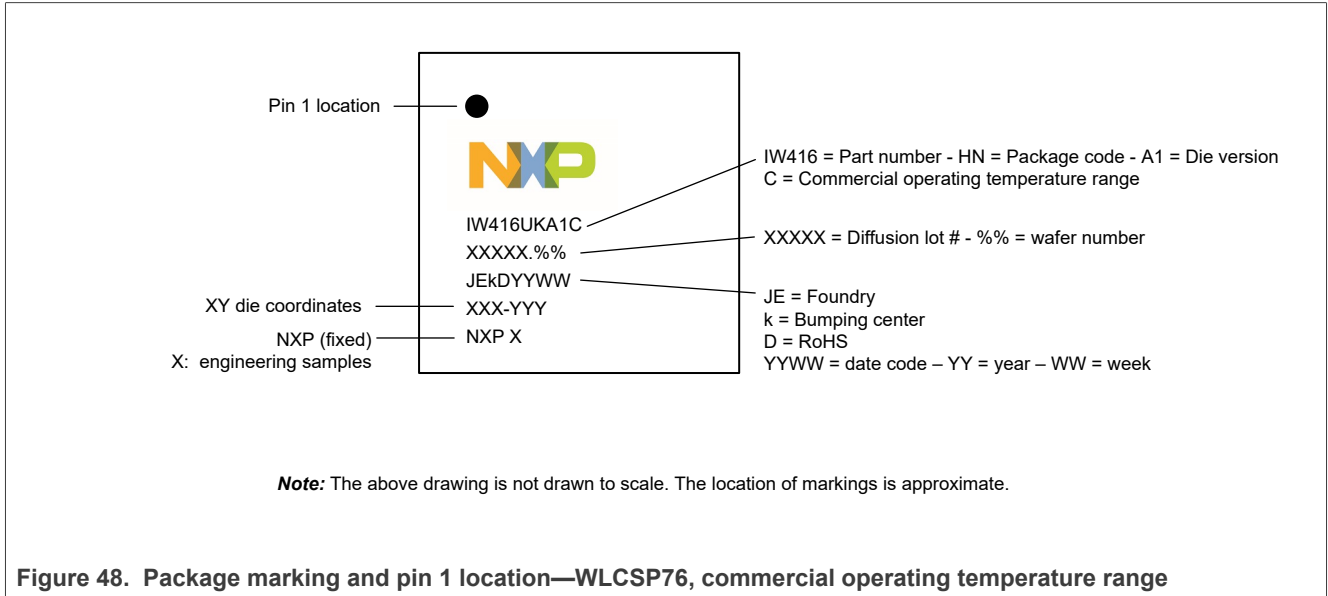
11.3.1 HVFQN68 marking

Figure 46 and Figure 47 show the location of pin 1 and describe each line of the package marking on HVQFN68.



11.3.2 WLCSP76 marking

Figure 48 and Figure 49 show the location of pin 1 and describes each line of the package marking on the WLCSP76.



12 Acronyms and abbreviations

Table 66. Acronyms and abbreviations

Acronym	Definition
A2DP	Advanced audio distribution profiles
ABR	Automatic baud rate
ACK	Acknowledgment
ADAS	Advanced driver assistance systems
ADC	Analog-to-digital converter
AES	Advanced encryption standard
AFC	Automatic frequency correction
AFH	Adaptive frequency hopping
AGC	Automatic gain control
AHB	Advanced high-performance bus
AIFS	Arbitration inter-frame space
AoA	Angle of arrival
AoD	Angle of departure
AP	Access point
APB	Advanced peripheral bus
API	Application program interface
ARM	Advanced RISC machine
ATIM	Announcement traffic indication message
BAMR	Base address mask register
BAR	Base address register
BBU	Baseband processor unit
BCB	Benzocyclobutene (flip chip bump process)
BDR	Basic data rate
BER	Bit error rate
BOM	Bill of materials
BR	Baud rate
BRF	Bluetooth RF unit
BSS	Basic service set
BSSID	Basic service set identifier
BTM	BSS transition management
BTU	Bluetooth baseband unit
BWQ	Bandwidth queue
CBC	Cipher block chaining
CBP	Contention-based period

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
CCA	Clear channel assessment
CCK	Complementary code keying
CCMP	Counter mode CBC-MAC protocol
CDE	Close descriptor enable
CFP	Contention-free period
CFQ	Contention-free queue
CID	Connection identifier
CIS	Card information structure
CIU	CPU interface unit
CMD	Command
CMQ	Control management queue
CRC	Cyclic redundancy check
CS	Card select
CSL	Coordinated sampled listening
CSMA/CA	Carrier sense multiple access / collision avoidance
CSMA/CD	Carrier sense multiple access / collision detection
CSU	Clocked serial unit
CTS	Clear to send
DAC	Digital-to-analog converter
DBPSK	Differential binary phase shift keying
DCD	Device controller driver
DCE	Data communication equipment
DCF	Distributed coordination function
DCLA	Direct current level adjustment
DCLB	Digital contactless bridge
DCU	DMA controller unit
DFS	Dynamic frequency selection
DIFS	Distributed inter frame space
DMA	Direct memory access
DPD	Digital pre distortion
dQH	Device queue head
DQPSK	Differential quadrature phase shift keying
DSM	Distribution system medium
DSP	Digital signal processor
DSRC	Dedicated short range communications
dTD	Linked list transfer descriptors

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
DTIM	Delivery traffic indication message
DUP	Duplicated packet
DVSC	Digital voltage scaling control
EAP	Extensible authentication protocol
EBRAM	Extended block random access memory
ECDSA	Elliptic curve digital signature algorithm
ED	Energy detect
EDCA	Enhanced distributed channel access
EEPROM	Electrically erasable programmable read only memory
EIFS	Extended inter frame Space
ELS	Embedded Edgelock [®] secure subsystem
EMC	Electromagnetic compatibility
eMLSR	Enhanced multi link single-radio
ER	Extended range
ERP-OFDM	Extended rate PHY-orthogonal frequency division multiplexing
ETSI	European telecommunications standards institute
eWLP	Embedded wafer level package
FCC	Federal communications commission
FIFO	First in first out
FIPS	Federal information processing standards
FIQ	Fast interrupt request
FPU	Floating point unit
FW	Firmware
GATT	Generic attribute profile
GCMP	Galois/counter mode protocol
GI	Guard interval
GPIO	General purpose input/output
GPL	General Public License
GPT	General purpose timer
GPU	General purpose input/output unit
HID	Human interface device
HIU	Host interface unit
HOGP	HID over GATT profile
HSP	Hands-free profile
HT	High throughput
HVQFN	Thermal enhanced very thin quad flat package

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
HW	Hardware
I/F	Interface
I/Q	In-phase/quadrature
IB	In band
ICE	In-circuit emulator (or emulation)
ICR	Interrupt cause register
ICU	Interrupt controller unit
ICV	Integrity check value
IE	Information element
IEEE	Institute of electrical and electronics engineers
IEMR	Interrupt event mask register
IFS	inter frame space
IMR	Interrupt mask register
IPG	Inter-packet gap
IPsec	Internet protocol security
IR	Infrared
IRQ	Interrupt request
ISA	Instruction set architecture
ISDN	Integrated services digital network
ISM	Industrial, scientific, and medical
ISMR	Interrupt status mask register
ISR	Interrupt status register
JEDEC	Joint electronic device engineering council
JTAG	Joint test action group
LC3	Low complexity communication codec
LDPC	Low density parity check
LE	Low energy
LED	Light emitting diode
LME	Layer management entity
LNA	Low noise amplifier
LPM	Low power management
LSb	Least significant bit
LSB	Least significant byte
LSP	Low-speed peripheral
LTE	Long term evolution
MAC	Media/medium access controller

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
MC	Memory controller
MCI	Microcontroller subsystem
MCS	Modulation and coding scheme
MCU	MAC Control unit
MDI	Modem data interface
MFP	Multi functional pin
MIB	Management information base
MIC	Message integrity code
MII	Media independent interface
MIMO	Multiple input multiple output
MIPS	Million instructions per second
MLME	MAC sublayer management entity
MLMR	Multi link multi radio
MLO	Multi link operation
MMI	Modem management interface
MMPDU	MAC management protocol data unit
MMU	Memory management unit
MPDU	MAC protocol data unit
MPU	Memory protection unit
MSb	Most significant bit
MSB	Most significant byte
MSDU	MAC service data unit
MU-MIMO	Multi user MIMO
MU-PPDU	Multi user PPDU
MWS	Mobile wireless system Multimedia wireless system
NAV	Network allocation vector
NBS	Narrow band speech
NDP	Null data packet
NL	No load
NPTR	Next descriptor pointer
Nsts	Number of space time streams
NVIC	Nested vector interrupt controller
OCB	Outside the context of a BSS
OFDM	Orthogonal frequency division multiplexing
OFDMA	Orthogonal frequency division multiple access

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
OID	Object identifier
OOB	Out of band
OTP	One time programmable
OTT	Over-the-top (device)
P2P	Peer-to-peer
PA	Power amplifier
PAD	Packet assembler/disassembler
PBU	Peripheral bus unit
PC	Point coordinator
PCB	Printed circuit board
PCF	Point coordination function
PCI	Peripheral component interconnect
PCIe	PCI express
PCM	Pulse code modulation
PDn	Power down
PDU	Protocol data unit
PEAP	Protected EAP
PHY	Physical layer
PIFS	Priority inter frame space
PLL	Phase-locked loop
PLME	Physical layer management entity
PMU	Power management unit
POS	Point of sale
POST	Power-on self test
PPDU	PHY protocol data unit
PPK	Per-packet key
PPM	Pulse position modulation
PSK	Pre shared keys
PTA	Packet traffic arbitration
PUF	Physically unclonable function
PWK	Pairwise key
QAM	Quadrature amplitude modulation
QFN	Quad flat non-leaded package
QoS	Quality of service
RA	Receiver address
RBDS	Radio broadcast data system

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
RDS	Radio data system
RF	Radio frequency
RFID	Radio frequency identification
RIFS	Reduced inter frame space
RISC	Reduced instruction set computer
ROM	Read only memory
RSSI	Receiver signal strength indication
RTC	Real time clock
RTS	Request to send
RTU	General purpose timer unit
RU	Resource unit
SA	Source address
SAP	Service access point
SCLK	Serial interface clock
SDA	Serial interface data
SDK	Software development kit
SE	Secure element
SFD	Start of frame delimiter
SHA	Secure hash algorithm
SIFS	Short inter frame space
SISO	Single input single output
SIU	Serial interface unit (UART)
SJU	System/software JTAG controller unit
SM	Switch module
SMI	Serial management interface
SNR	Signal-to-noise ratio
SO	Serial out
SoC	System-on-chip
SPDT	Single pole double throw
SPI	Serial peripheral interface
SQU	Internal SRAM unit
SRWB	Serial interface read write
SS	Service set
SSID	Service set identifier
STA	Station
STBC	Space-time block code

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
STR	Simultaneous transmit and receive
SWD	Serial wire debug
SWP	Single wire protocol
SysTick	System tick timer
TA	Transmitter address
TBG	Time base generator
TBTT	Target beacon transmission time
TCM	Tightly coupled memory
TCP/IP	Transmission control protocol/internet protocol
TCQ	Traffic category queue
TEE	Trusted execution environment
TIM	Traffic indication map
TKIP	Temporal key integrity protocol
TPC	Transmit power control
TQFP	Thin quad flat pack
TRPC	Transmit rate-based power control
TSF	Timing synchronization function
TWT	Target wait time
UART	Universal asynchronous receiver/transmitter
UBM	Under bump metal
UDP	User datagram protocol
UNII	Unlicensed national information infrastructure
USART	Universal synchronous/asynchronous receiver/transmitter
VCO	Voltage controlled oscillator
VHT	Very high throughput
VIF	Voice interface
WAP	Wireless application protocol
WAVE	Wireless access in vehicular environments
WBS	Wide band speech
WCI-2	Wireless coexistence interface 2
WEP	Wired equivalent privacy
WFI	Wait for interrupt
WI	Wired interface
Wi-Fi	Hardware implementation of IEEE 802.11 for wireless connectivity
WLAN	Wireless local area network
WLCSP	Wafer level chip scale package

Table 66. Acronyms and abbreviations...continued

Acronym	Definition
WMM	Wi-Fi multimedia
WPA	Wi-Fi protected access
WPA2	Wi-Fi protected access 2
WPA2-PSK	Wi-Fi protected access 2 - pre shared key
WPA3	Wi-Fi protected access 3
WPA-PSK	Wi-Fi protected access - pre shared key
XIP	Execute in place
XOSC	Crystal oscillator
ZIF	Zero intermediate frequency

13 Revision history

Table 67. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW416 v.7.0	20240905	Product data sheet	—	IW416 v.6.0
Modifications	<p>Pin information</p> <ul style="list-style-type: none"> Table 5 "Pin list by number - HVQFN68 package": removed the double entry for pin 5 (DNC). <p>Electrical specifications</p> <ul style="list-style-type: none"> Section 10.10.2 "External crystal specifications": changed the typical value of "Equivalent differential load capacitance". 			
IW416 v.6.0	20230303	Product data sheet	-	IW416 v.5.0
Modifications	<p>Product overview</p> <ul style="list-style-type: none"> Section 1.2 "Wi-Fi key features": updated the description of PTA external coexistence interface Section 1.3 "Bluetooth key features": <ul style="list-style-type: none"> Updated the first item about Bluetooth version Added a note to <i>AES security</i> <p>Bluetooth subsystem</p> <ul style="list-style-type: none"> Section 4.1 "Bluetooth 2.4 GHz Tx/Rx": replaced <i>Bluetooth 5.2</i> with <i>Bluetooth 5.1 features</i> Section 4.1 "Bluetooth 2.4 GHz Tx/Rx": added a note to <i>Encryption (AES) support</i> Section 4.1 "Bluetooth 2.4 GHz Tx/Rx": added a note to <i>Encryption (AES) support</i> and <i>LE Secure Connection</i> <p>Coexistence</p> <ul style="list-style-type: none"> Section 5 "Coexistence": updated <p>Electrical specifications</p> <ul style="list-style-type: none"> Section 10.5 "External coexistence interface specifications": added Section 10.5.1 "WCI-2 coexistence interface specifications": added Replaced the section <i>PTA coexistence interface specifications</i> with Section 10.5.2 "PTA interface coexistence specifications" Section 10.4.1 "Bluetooth/Bluetooth LE receive performance": added the note [2] and updated the description of Bluetooth LE Rx sensitivity parameter 			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW416 v.5.0	20211215	Product data sheet	-	IW416 v.4.0
Modifications	<p>Overall document</p> <ul style="list-style-type: none"> Updated Bluetooth 5.1 to Bluetooth 5.2 Renamed PTA interface and WCI-2 interface as PTA coexistence interface and WCI-2 coexistence interface. Updated sections: <ul style="list-style-type: none"> Section 5 "Coexistence " Section 6.1 "Signal diagram" Section 6.5.8 "PTA coexistence interface" Section 6.5.9 "WCI-2 coexistence interface" <i>PTA coexistence interface specifications</i> <p>Product overview</p> <ul style="list-style-type: none"> Section 1 "Product overview": <ul style="list-style-type: none"> . First paragraph: replaced [In addition to classic Bluetooth features, the IW416 enables Bluetooth 5.1 capabilities including Low Energy (LE), LE long range and LE data up to 2 Mbit/s.] with [In addition to classic Bluetooth features, the IW416 enables Bluetooth 5.2 capabilities including Low Energy (LE), LE long range, LE 2 Mbps, and Periodic Advertising Sync Transfer(PAST).] . Second paragraph: replaced [With the single-antenna configuration, simultaneous 5 GHz Wi-Fi and Bluetooth is supported and in the 2.4 GHz band, the single-antenna configuration allows arbitrated transmit and receive operation of Wi-Fi and Bluetooth.] with [With the single-antenna configuration, simultaneous 5 GHz Wi-Fi and Bluetooth is supported. In the 2.4 GHz band, the single-antenna configuration allows arbitrated transmit and receive operation of Wi-Fi and Bluetooth.] . Third paragraph: replaced [In addition, support for external radio co-existence (e.g. cellular) is provided through an external interface.] with [In addition, support for external radio co-existence is provided through an external interface.] Section 1.2 "Wi-Fi key features": <ul style="list-style-type: none"> . Removed WEP and TKIP as these encryption methods are no longer supported. . Replaced [Interface to coexist with 802.15.4, LTE, or other radios] with [IEEE 802.15.2 PTA coexistence interface to coexist with 802.15.4, and other external radios] . Replaced [Security: WPA3, WPA2, WPA2 and WPA mixed mode] with [Security: WPA3, WPA2, WPA2-WPA mixed mode] Section 1.5 "Operating characteristics": <ul style="list-style-type: none"> . Replaced [Supply voltage] with [Supply voltages] . Replaced [Operating temperature] with [Operating temperature ranges] Section 1.6 "General features": replaced [WLCSP76 (76 terminals, 3.95 mm x 3.565 mm x 0.495 mm body)] with [WLCSP76 (76 terminals, 0.35 mm pitch, 3.95 mm x 3.565 mm x 0.495 mm body)] <p>Ordering information</p> <ul style="list-style-type: none"> Table 1 "Part order codes": added [, with 0.35 mm pitch] to WLCSP76 package type (2 entries) <p><i>Continues --></i></p>			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
Modifications	<p>IW416 v5.0 ... continued</p> <p>Wi-Fi subsystem</p> <ul style="list-style-type: none"> • Section 3.1 "IEEE 802.11 standards": added the note [(available through Host Supplicant)] to 802.11k, 802.11v, and 802.11r features • Section 3.2 "Wi-Fi MAC": <ul style="list-style-type: none"> . Replaced [Hardware filtering of 32 multicast addresses and duplicate frame detection for up to 32 unicast addresses] with [Duplicate frame detection] . Removed [Packet drop scheme] . Removed [Multiple BSS/Station] . Removed [NXP mobile hotspot] • Section 3.4 "Wi-Fi radio": <ul style="list-style-type: none"> . In Wi-Fi Rx path subsection: <ul style="list-style-type: none"> - Removed [Direct conversion architecture: no need for an external SAW filter] - Replaced [On-chip gain selectable LNA with optimized noise figure and power consumption] with [On-chip LNA with optimized noise figure and power consumption] . In Radio channel frequencies: <ul style="list-style-type: none"> - Renamed the caption of the first table as [Supported channels (20 MHz)] - Removed the duplicated rows (channel 128 to 165) - Added one row for channel 144 - 5845 MHz - Renamed the caption of the second table as [Supported channels (40 MHz)] - Added one row for channel pair 9-13 - 2462 MHz • Section 3.5 "Wi-Fi encryption": <ul style="list-style-type: none"> . Removed WEP and TKIP as these encryption methods are no longer supported. . Replaced [AES/CCMP as part of the 802.11i security standard (WPA2 and WPA mixed mode)] with [AES/CCMP as part of the 802.11i security standard (WPA3, WPA2, WPA2-WPA mixed mode)] <p>Bluetooth subsystem</p> <ul style="list-style-type: none"> • Section 4.1 "Bluetooth 2.4 GHz Tx/Rx": <ul style="list-style-type: none"> . Removed [Bluetooth-based indoor location with up to 16 antenna support] . Removed [Low Latency Reconnection (LLR) (future BT standard)] • Section 4.2 "Bluetooth Low Energy (LE)": <ul style="list-style-type: none"> . Replaced [2 Mbit/s LE] with [LE 2 Mbps] . Added [LE Long Range] , [Periodic Advertising Sync Transfer(PAST)], and [Advertising Channel Index] • Section 4.3 "Bluetooth host interfaces": <ul style="list-style-type: none"> . Replaced [High-Speed UART interface up to 4 Mbit/s] with [High-Speed UART interface up to 3 Mbit/s] • Section 4.4.2 "PCM interface": <ul style="list-style-type: none"> . Replaced [The PCM interface is used to exchange audio data between the host and the Bluetooth/ LE functional block.] with [The PCM interface is used to exchange audio data between the host and the Bluetooth functional block.] • Section <i>Coexistence</i>: <ul style="list-style-type: none"> . Replaced [Coexistence between internal Wi-Fi and Bluetooth radios and an external radio such as 802.15.4, LTE or 5G.] with [Coexistence between internal Wi-Fi and Bluetooth radios and an external radio such as 802.15.4.] <p><i>Continues --></i></p>			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
Modifications	IW416 v5.0 ... continued Pin information <ul style="list-style-type: none"> • Section 6.5.2 "General purpose I/O (GPIO) (MFP)": rename [Host wake-up mode] as [Out-of-band mode] for GPIO[12] • Section 6.5.5 "SDIO host interface (MFP)": updated SD_CMD 1-bit mode definition • Section 6.5.7 "Audio interface": updated PCM and I2S signal descriptions Power information <ul style="list-style-type: none"> • Table 23 "Device power modes ": replaced [standby] with [standby/idle] • Section 7.6 "Reset": changed the value for PDn input pin to 0.5 V in the third bullet point Absolute maximum ratings <ul style="list-style-type: none"> • Table 26 "Limiting values": replaced [Limiting values (HVQFN68 package)] with [Limiting values] Electrical specifications <ul style="list-style-type: none"> • Section 10.3.2 "2.4 GHz Wi-Fi receive performance": updated RF frequency range maximum value to 2484 MHz • Section 10.3.4 "2.4 GHz Wi-Fi transmit performance": updated RF frequency range min and max values to 2400 MHz and 2484 MHz respectively • Section 10.3.5 "5 GHz Wi-Fi transmit performance": updated RF frequency range min and max values to 5150 MHz and 5850 MHz respectively • Section 10.4.1 "Bluetooth/Bluetooth LE receive performance": updated RF frequency range min and max values to 2400 MHz and 2483.5 MHz respectively • Section 10.4.2 "Bluetooth/Bluetooth LE transmit performance": <ul style="list-style-type: none"> . Updated RF frequency range min and max values to 2400 MHz and 2483.5 MHz respectively . Updated transmit output power (TRM/CA/01/C) typical value to 13 dBm (BDR), and 10 dBm (EDR) • Section 10.7.1 "VIO_SD DC characteristics": replaced [SDR50] with [DDR50] in the last table row • Section 10.6 "Current consumption" <ul style="list-style-type: none"> . Added the parameters and values for Wi-Fi 2.4 GHz receive idle mode . Added the parameters and values for Wi-Fi 5 GHz receive idle mode • : changed T_{BAUD} condition to [26 MHz or 40 MHz reference clock] • Section 10.9.2 "PCM interface specifications": <ul style="list-style-type: none"> – Figure 35 and Figure 37 : renamed T_{BCLK} as 1/F_{BCLK} , added T_{BCLK} rise and T_{BCLK} fall – Table 50 and Table 51: added F_{BCLK} min and max values • Table 59 "PDn pin (Power Down) specifications—Power remains high at PDn assertion ": changed PDn pulse width minimum value to 50 us • Table 60 "PDn pin (Power Down) specifications—Power ramps down at PDn assertion ": changed V_{IL} maximum value to 0.5 V 			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW416 v.4.0	20210625	Product data sheet	-	IW416 v.3.0
Modifications	<p>Product overview</p> <ul style="list-style-type: none"> • Figure 1 "Application block diagram": Added a reference to IW416 design guide • Section 1.5 "Operating characteristics": Removed "3.3 V (optional)" <p>Pin information</p> <ul style="list-style-type: none"> • Section 6.5.12 "Power supply and ground": Added a note to AVDD33 description <p>Electrical specifications</p> <ul style="list-style-type: none"> • Section 10.6 "Current consumption": added the values for VIO (3.3 V) • Table 42 "VIO_SD requirements": added <p>Package information</p> <ul style="list-style-type: none"> • Table 65 "Package information" : added 			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW416 v.3.0	20210312	Preliminary data sheet	-	IW416 v.2.0
Modifications	<p>Product overview</p> <ul style="list-style-type: none"> • Section 1 "Product overview": updated • Section 1.2 "Wi-Fi key features": updated • Section 1.3 "Bluetooth key features": updated • Section 1.4 "Host interfaces": updated <p>Ordering information</p> <ul style="list-style-type: none"> • Figure 3 "Part numbering scheme": updated • Table 1 "Part order codes": updated <p>Wi-Fi subsystem</p> <ul style="list-style-type: none"> • Section 3.1 "IEEE 802.11 standards": updated • Section 3.3 "Wi-Fi baseband": updated • Section 3.6 "Wi-Fi host interfaces": updated <p>Bluetooth subsystem</p> <ul style="list-style-type: none"> • Section 4.3 "Bluetooth host interfaces": updated • Section 5 "Coexistence": updated <p>Pin information</p> <ul style="list-style-type: none"> • Section 6.4 "Pin types": added A I/O • Section 6.5.1 "Pin states": updated • Section 6.5.2 "General purpose I/O (GPIO) (MFP)": updated GPIO[15], GPIO[14], GPIO[13], GPIO[12], GPIO[5], GPIO[4], and GPIO[1] description • Section 6.5.10 "Clock interface": updated XTAL_IN and SLP_CLK_IN descriptions • Section 6.5.12 "Power supply and ground": updated VIO_SD description • Section 6.5.13 "JTAG interface": added • Section 6.6 "Configuration pins": updated the second table <i>Host configuration options</i> <p>Power information</p> <ul style="list-style-type: none"> • Section 7.1 "Power modes": added a table footnote for deep-sleep mode • Section 7.2 "Power-up sequence": updated the introduction • Section 7.3 "Power-down sequence": updated VCORE value in the figure • Section 7.3.2 "Host power-down pin (PMIC_EN) usage": updated VCORE value in the figure <p>Absolute maximum ratings</p> <ul style="list-style-type: none"> • Table 25 "Absolute maximum ratings": updated the parameter definitions and removed the column with typical values. No change for the min. and max. values. <p>Electrical specifications</p> <ul style="list-style-type: none"> • Section 10.10.2 "External crystal specifications": updated the series resistance (ESR) maximum value • Section 10.3.1 "Wi-Fi radio performance measurement": added • Section 10.3.2 "2.4 GHz Wi-Fi receive performance": updated • Section 10.3.3 "5 GHz Wi-Fi receive performance": updated • Section 10.3.4 "2.4 GHz Wi-Fi transmit performance": updated • Section 10.3.4 "2.4 GHz Wi-Fi transmit performance": updated • Section 10.4.1 "Bluetooth/Bluetooth LE receive performance": updated • Section 10.4.2 "Bluetooth/Bluetooth LE transmit performance": updated • Section 10.6 "Current consumption": updated <p>Package information</p> <ul style="list-style-type: none"> • Section 11.1.2 "WLCSP76 thermal conditions": added • Section 11.3.1 "HVFQN68 marking": updated • Section 11.3.2 "WLCSP76 marking": added 			

Table 67. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
IW416 v.2.0	20200731	Preliminary data sheet	-	88W8978 v.1.0
Modifications	<p>Overall document</p> <ul style="list-style-type: none"> Changed the document title Renamed WLAN as Wi-Fi <p>Product overview</p> <ul style="list-style-type: none"> Updated the introduction Replaced the overall block diagram with the application block diagram and the internal block diagram Section 1.6 "General features": added WLCSP76 package option <p>Wi-Fi subsystem</p> <ul style="list-style-type: none"> Moved the content related to Wi-Fi in former Main Features section into this section <p>Bluetooth subsystem</p> <ul style="list-style-type: none"> Moved the content related to Bluetooth in former Main Features section into this section <p>Pin information</p> <ul style="list-style-type: none"> Updated Section 6.1 "Signal diagram" Corrected pins 39 and 40 in Section 6.2 "Pin assignment - HVQFN68 package" and rotated the diagram to reflect the position of pin 1 on the top left side Added Section 6.2.1 "Pin list by number - HVQFN68 package" Added Section 6.5 "Pin description" Added Section 6.3 "Bump locations - WLCSP76 package" <p>Absolute maximum ratings</p> <ul style="list-style-type: none"> Section 8 "Absolute maximum ratings": added the table with limiting values <p>Recommended operating conditions</p> <ul style="list-style-type: none"> Updated V_{CORE} minimum value <p>Electrical specifications</p> <ul style="list-style-type: none"> Section 10.10.1 "External crystal oscillator specifications": added 40 MHz reference clock Section 10.10.2 "External crystal specifications": updated fundamental frequencies typical value <p>Package information</p> <ul style="list-style-type: none"> Updated Section 11.2.1 "HVQFN68 mechanical drawing" Added Section 11.2.2 "WLCSP76 mechanical drawing" Added Section 11.1.2 "WLCSP76 thermal conditions" Updated Section 11.3.1 "HVFQN68 marking" Added Section 11.3.2 "WLCSP76 marking" <p>Ordering information</p> <ul style="list-style-type: none"> Added the part numbering scheme and updated the part order codes 			
88W8978 v.1.0	20200110	Objective data sheet	-	-

Legal information

Data sheet status

Document status ^{[1][2]}	Product status ^[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <https://www.nxp.com>.

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Short data sheet — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

Product specification — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <https://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this document expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

HTML publications — An HTML version, if available, of this document is provided as a courtesy. Definitive information is contained in the applicable document in PDF format. If there is a discrepancy between the HTML document and the PDF document, the PDF document has priority.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

NXP B.V. — NXP B.V. is not an operating company and it does not distribute or sell products.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

Bluetooth — the Bluetooth wordmark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by NXP Semiconductors is under license.

Tables

Tab. 1.	Part order codes	5	Tab. 37.	Bluetooth/Bluetooth LE receive performance	54
Tab. 2.	Supported channels (20 MHz)	8	Tab. 38.	Bluetooth/Bluetooth LE transmit performance	58
Tab. 3.	Supported channels (40 MHz)	9	Tab. 39.	WCI-2 interface transport settings	64
Tab. 4.	Wi-Fi and Bluetooth/Bluetooth LE supported TX and or RX operations - Single-antenna configuration	14	Tab. 40.	PTA coexistence interface signal timing data	70
Tab. 5.	Pin list by number - HVQFN68 package	19	Tab. 41.	Current consumption values	71
Tab. 6.	Pin by name - HVQFN68 package	21	Tab. 42.	VIO_SD requirements	74
Tab. 7.	Bump names and locations on WLCSP76 top view	24	Tab. 43.	DC electrical characteristics—1.8V operation (VIO_SD)	74
Tab. 8.	Pin types	27	Tab. 44.	DC electrical characteristics—3.3V operation (VIO_SD)	74
Tab. 9.	GPIO (MFP)	28	Tab. 45.	SDIO timing data—Default speed, high-speed modes	75
Tab. 10.	Wi-Fi/Bluetooth radio interface	30	Tab. 46.	SDIO timing data—SDR12, SDR25, SDR50 modes (up to 100MHz) (1.8V)	76
Tab. 11.	Wi-Fi RF front-end control interface	30	Tab. 47.	SDIO timing data—DDR50 mode (50MHz)	78
Tab. 12.	SDIO host i (MFP)	31	Tab. 48.	SDIO internal pull-up/pull-down specifications	78
Tab. 13.	UART host interface (MFP)	32	Tab. 49.	UART timing data	79
Tab. 14.	Audio interface pins (MFP)	32	Tab. 50.	PCM timing specification data—central mode	80
Tab. 15.	PTA coexistence interface (MFP)	33	Tab. 51.	PCM timing specification data—peripheral mode	81
Tab. 16.	WCI-2 coexistence interface	33	Tab. 52.	Clock DC specifications	82
Tab. 17.	Clock interface	34	Tab. 53.	26 MHz clock timing	82
Tab. 18.	Power down (PDn) pin	34	Tab. 54.	40 MHz clock timing	82
Tab. 19.	Power and ground pins	35	Tab. 55.	Phase noise—2.4 GHz operation	83
Tab. 20.	JTAG interface pins (MFP)	35	Tab. 56.	Phase noise—5 GHz operation	83
Tab. 21.	Configuration pins	36	Tab. 57.	External crystal specifications	84
Tab. 22.	Host configuration options	36	Tab. 58.	External sleep clock specifications	84
Tab. 23.	Device power modes	37	Tab. 59.	PDn pin (Power Down) specifications—Power remains high at PDn assertion	85
Tab. 24.	Configuration—VCORE from PMIC	38	Tab. 60.	PDn pin (Power Down) specifications—Power ramps down at PDn assertion	86
Tab. 25.	Absolute maximum ratings	43	Tab. 61.	Configuration pin specifications	87
Tab. 26.	Limiting values	43	Tab. 62.	JTAG timing data	87
Tab. 27.	Recommended operating conditions	44	Tab. 63.	Package thermal conditions—HVQFN68	88
Tab. 28.	DC electrical characteristics—1.8V operation (VIO)	45	Tab. 64.	Package thermal conditions—WLCSP76	89
Tab. 29.	DC electrical characteristics—3.3V operation (VIO)	45	Tab. 65.	Package information	90
Tab. 30.	DC electrical characteristics—1.8V operation (VIO_RF)	46	Tab. 66.	Acronyms and abbreviations	97
Tab. 31.	DC electrical characteristics—3.3V operation (VIO_RF)	46	Tab. 67.	Revision history	106
Tab. 32.	2.4 GHz Wi-Fi receive performance	48			
Tab. 33.	5 GHz Wi-Fi receive performance	50			
Tab. 34.	2.4 GHz Wi-Fi transmit performance	52			
Tab. 35.	5 GHz Wi-Fi transmit performance	53			
Tab. 36.	Local oscillator	53			

Figures

Fig. 1.	Application block diagram	1	Fig. 8.	Pin assignment (package top view) - HVQFN68	18
Fig. 2.	Internal block diagram	4	Fig. 9.	Bump locations - WLCSP76 (non-bump side view, bumps down)	23
Fig. 3.	Part numbering scheme	5	Fig. 10.	Configuration—VCORE from PMIC	38
Fig. 4.	PCM Short Frame Sync	13	Fig. 11.	Power-up sequence	39
Fig. 5.	Hardware coexistence interface - WCI-2 coexistence interface	15	Fig. 12.	Power-down sequence	40
Fig. 6.	Hardware coexistence interface - PTA external coexistence interface	16	Fig. 13.	PMIC_EN pin usage—PMIC/SoC both in power-down mode	41
Fig. 7.	Signal diagram	17			

Fig. 14.	RF performance measurement points	47	Fig. 33.	SDIO DAT[3:0] timing diagram—DDR50 mode	77
Fig. 15.	UART waveform	61	Fig. 34.	UART timing diagram	79
Fig. 16.	WCI-2 coexistence interface	61	Fig. 35.	PCM timing specification diagram for data signals—central mode	80
Fig. 17.	Type 0: Real time signaling message - external radio to IW416	62	Fig. 36.	PCM timing specification diagram for PCM_SYNC signal—central mode	80
Fig. 18.	Type 7: Vendor specific message - external radio to IW416	62	Fig. 37.	PCM timing specification diagram for data signals—peripheral mode	81
Fig. 19.	Type 0: Real time signaling message - IW416 to external radio	62	Fig. 38.	PCM timing specification diagram for PCM_SYNC signal—peripheral mode	81
Fig. 20.	Type 1: Transport control message time signaling message - IW416 to external radio	63	Fig. 39.	PDn pin (Power-down) timing—Power remains high at PDn assertion	85
Fig. 21.	MWS inactivity duration message	63	Fig. 40.	PDn pin (Power Down) timing—Power ramps down at PDn assertion	86
Fig. 22.	Type 5: MWS scan frequency message	63	Fig. 41.	JTAG timing diagram	87
Fig. 23.	WCI-2 transmit signal waveform	64	Fig. 42.	HVQFN68 package mechanical drawing	91
Fig. 24.	PTA coexistence interface timing diagram - Example 1	65	Fig. 43.	HVFQN68 package mechanical drawing - Detail G	92
Fig. 25.	PTA coexistence interface timing diagram - Example 2	66	Fig. 44.	WLCSP76 package mechanical drawing	93
Fig. 26.	PTA coexistence interface timing diagram - Example 3	67	Fig. 45.	WLCSP76 package mechanical drawing - Detail E	94
Fig. 27.	PTA coexistence interface timing diagram - Example 4	68	Fig. 46.	Package marking and pin 1 location —HVQFN68, commercial operating temperature	95
Fig. 28.	PTA coexistence interface timing diagram - Example 5	69	Fig. 47.	Package marking and pin 1 location—HVQFN68, industrial operating temperature ...	95
Fig. 29.	SDIO protocol timing diagram—Default speed mode	75	Fig. 48.	Package marking and pin 1 location —WLCSP76, commercial operating temperature range	96
Fig. 30.	SDIO protocol timing diagram—High-speed mode	75	Fig. 49.	Package marking and pin 1 location—WLCSP76, industrial operating temperature range	96
Fig. 31.	SDIO protocol timing diagram—SDR12, SDR25, SDR50 modes (up to 100MHz) (1.8V)	76			
Fig. 32.	SDIO CMD timing diagram—DDR50 mode (50MHz)	77			

Contents

1	Product overview	1	7.2	Power-up sequence	38
1.1	Applications	2	7.2.1	Configuration—VCORE from PMIC	38
1.2	Wi-Fi key features	2	7.2.2	Power-up sequence timing	39
1.3	Bluetooth key features	2	7.3	Power-down sequence	40
1.4	Host interfaces	2	7.3.1	Power-down sequence	40
1.5	Operating characteristics	3	7.3.2	Host power-down pin (PMIC_EN) usage	41
1.6	General features	3	7.4	Leakage optimization	42
1.7	Internal block diagram	4	7.5	Deep sleep	42
2	Ordering information	5	7.6	Reset	42
3	Wi-Fi subsystem	6	8	Absolute maximum ratings	43
3.1	IEEE 802.11 standards	6	9	Recommended operating conditions	44
3.2	Wi-Fi MAC	6	10	Electrical specifications	45
3.3	Wi-Fi baseband	7	10.1	GPIO/LED interface specifications	45
3.4	Wi-Fi radio	7	10.1.1	VIO DC characteristics	45
3.5	Wi-Fi encryption	10	10.1.1.1	1.8V operation	45
3.6	Wi-Fi host interfaces	10	10.1.1.2	3.3V operation	45
4	Bluetooth subsystem	11	10.2	RF front-end control interface specifications	46
4.1	Bluetooth 2.4 GHz Tx/Rx	11	10.2.1	VIO_RF DC characteristics	46
4.2	Bluetooth Low Energy (LE)	12	10.2.1.1	1.8V operation	46
4.3	Bluetooth host interfaces	12	10.2.1.2	3.3V operation	46
4.4	Audio interfaces	12	10.3	Wi-Fi radio specifications	47
4.4.1	I2S interface	12	10.3.1	Wi-Fi radio performance measurement	47
4.4.2	PCM interface	12	10.3.2	2.4 GHz Wi-Fi receive performance	48
4.4.2.1	Protocol description	13	10.3.3	5 GHz Wi-Fi receive performance	50
5	Coexistence	14	10.3.4	2.4 GHz Wi-Fi transmit performance	52
5.1	Antenna configurations	14	10.3.5	5 GHz Wi-Fi transmit performance	53
5.1.1	Dual-antenna configuration	14	10.3.6	Local oscillator	53
5.1.2	Single-antenna configuration	14	10.4	Bluetooth radio specifications	54
5.2	Central hardware packet traffic arbiter	14	10.4.1	Bluetooth/Bluetooth LE receive performance	54
5.3	Coexistence with an external radio	15	10.4.2	Bluetooth/Bluetooth LE transmit performance	58
6	Pin information	17	10.5	External coexistence interface specifications	61
6.1	Signal diagram	17	10.5.1	WCI-2 coexistence interface specifications	61
6.2	Pin assignment - HVQFN68 package	18	10.5.1.1	WCI-2 interface	61
6.2.1	Pin list by number - HVQFN68 package	19	10.5.1.2	WCI-2 messages	62
6.2.1	Pin list by name - HVQFN68 package	21	10.5.1.3	WCI-2 signal waveform format	64
6.3	Bump locations - WLCSP76 package	23	10.5.2	PTA interface coexistence specifications	65
6.3.1	Bump positions relative to die center - WLCSP76	24	10.6	Current consumption	71
6.4	Pin types	27	10.7	SDIO host interface specifications	74
6.5	Pin description	27	10.7.1	VIO_SD DC characteristics	74
6.5.1	Pin states	27	10.7.1.1	1.8V operation	74
6.5.2	General purpose I/O (GPIO) (MFP)	28	10.7.1.2	3.3V operation	74
6.5.3	Wi-Fi/Bluetooth radio interface	30	10.7.2	Default speed, high-speed modes	75
6.5.4	Wi-Fi RF front-end control interface	30	10.7.3	SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)	76
6.5.5	SDIO host interface (MFP)	31	10.7.4	DDR50 mode (50MHz) (1.8V)	77
6.5.6	UART host interface	32	10.7.5	SDIO internal pull-up/pull-down specifications	78
6.5.7	Audio interface	32	10.8	High-speed UART specifications	79
6.5.8	PTA coexistence interface	33	10.9	Audio interface specifications	79
6.5.9	WCI-2 coexistence interface	33	10.9.1	I2S interface specifications	79
6.5.10	Clock interface	34	10.9.2	PCM interface specifications	79
6.5.11	Power down (PDn) pin	34	10.10	Reference clock specifications	82
6.5.12	Power supply and ground	35	10.10.1	External crystal oscillator specifications	82
6.5.13	JTAG interface	35			
6.6	Configuration pins	36			
7	Power information	37			
7.1	Power modes	37			

10.10.2	External crystal specifications	84
10.10.3	External sleep clock specifications	84
10.11	Power down (PDn) pin specifications	85
10.11.1	PDn asserted low—All power supplies good ...	85
10.11.2	PDn asserted low—One or more power supplies ramp down	86
10.12	Configuration pin specifications	87
10.13	JTAG interface specifications	87
11	Package information	88
11.1	Package thermal conditions	88
11.1.1	HVQFN68 thermal conditions	88
11.1.2	WLCSP76 thermal conditions	89
11.2	Package mechanical drawing	90
11.2.1	HVQFN68 mechanical drawing	91
11.2.2	WLCSP76 mechanical drawing	93
11.3	Package marking	95
11.3.1	HVFN68 marking	95
11.3.2	WLCSP76 marking	96
12	Acronyms and abbreviations	97
13	Revision history	106
	Legal information	113

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.
