# AirPrime WP75xx/WP8548

## Product Technical Specification

SIERRA

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Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

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## Revision History

| Revision number | Release date | Changes |
|---|---|---|
| 7 | February 2016 | Updated Table 3-9, WP8548 Current Consumption Values, on page 44 Updated Table 3-12, Conducted Tx Max Output Power Tolerances—GSM, on page 46 Updated Table 3-14, WP8548 Conducted Rx Sensitivity—GSM/EDGE Bands, on page 47 Updated Table 3-16, Conducted Tx Max Output Power Tolerances—WCDMA, on page 44 Updated Table 3-18, WP8548 Conducted Rx Sensitivity—WCDMA Bands, on page 49 Updated RF Circuit on page 94 Updated Important Compliance Information for North American Users on page 112 |

| Revision number | Release date | Changes |
|---|---|---|
| 8 | March 2016 | Updated GPS frequency range and added Galileo.<br>Updated I2C1_CLK references from 'O' to 'I/O'.<br>Removed DRX_IQ from Figure 2-3 on page 25.<br>Removed 'sku-dependent' notes from GNSS availability throughout document.<br>Updated Power Supply Ratings on page 35 description, Table 3-2 on page 36, Table 3-4 on page 36, and added Figure 3-1 on page 37.<br>Updated current consumption descriptions and values in Table 3-6 on page 39, Figure 3-3 on page 40, and Table 3-9 on page 44.<br>Added Active State to ULPM Transition on page 41.<br>Updated POWER_ON_N on page 67 (momentary switch recommendation) Table 4-3 on page 67), and Figure 4-1 on page 67 (POWER_ON_N and SAFE_PWR_REMOVE signals).<br>Exposed additional GPIOs —General Purpose Input/Output (GPIO) on page 72, Figure 10-1 on page 117, Table 10-1 on page 118).<br>Exposed additional ADCs —ADC on page 78, Figure 10-1 on page 117, Table 10-1 on page 118).<br>Removed pins (for GPIOs/ADCs) from Table 10-4 on page 124.<br>Removed auxiliary PCM timing content.<br>Added RF trace design requirement to Important Compliance Information for North American Users on page 112 |
| 9 | April 2016 | Updated Table 9-3 on page 114 (Column heading—EIRP values; marked unused cells as '—') |
| 10 | September 2016 | Merged in content from 4118045 rev3 WP75XX PTS<br>Added chapter: Testing on page 133.<br>Updated Coin cell voltage in Table 4-2 on page 66.<br>Updated idle/Airplane mode current consumption, and removed sleep mode current consumption in WP8548 Current Consumption Values on page 44.<br>Added note indicating UART1 (8-wire) software support will be in future f/w release.<br>Added notes indicating ADC2/ADC3 will be available as wakeup pins in future f/w release. |
| 11 | October 2016 | Added warning to Power Supply Ratings on page 35.<br>Added GPIO note to ULP M description (Table 3-6 on page 39).<br>Added warnings/notes and module-specific voltage values to Absolute Maximum Ratings on page 59.<br>Updated SAFE_PWR_REMOVE in Figure 4-1 on page 67.<br>Added ULPM note in General Purpose Input/Output (GPIO) on page 72 and updated Default State in Table 4-8 on page 73.<br>Corrected footnote (signal direction) for UART signals in Table 10-1 on page 118.<br>Marked ADC0-3 as supported.<br>Clarified ADC2-3 to be available (in future update) to wake-up from ULPM, not USB-SS mode.<br>Added Japan certification. |

| Revision number | Release date | Changes |
|---|---|---|
| 12 | December 2016 | Clarified USB-SS mode as supported only if ECH disabled or USB disconnected |
| | | Added Table 3-32, Digital I/O Characteristics (VDD_PX=1.20 V (nominal)), on page 60 |
| | | Updated list—Wakeup Interrupt (USB-SS Mode) on page 74 |
| | | Updated list—Wakeup Events (ULPM) on page 74 |
| | | Noted sensitivity decrease for snap-in sockets |
| | | Updated temperature recommendation in Module Testing Recommendations on page 102 |
| | | Updated GSM current consumption values—Table 3-7 on page 41, Table 3-9 on page 44 |
| | | Updated architecture (added GPIO28, GPIO29, GPIO30, GPIO31) |
| | | Updated Active State to ULPM Transition on page 41 |
| | | 8-wire UART1 now fully supported |
| | | Updated SPI supported clock speeds in SPI Bus on page 82 |
| | | Corrected HSIC I/O type—Table 4-25 on page 84 |
| | | Updated Figure 5-4 on page 98—ESD for UIM1_DET |
| | | Added chapter Reliability Specification on page 105 |
| 13 | May 2017 | Added triggers (GPIO39,ADC2,ADC3) to Figure 3-3, Power State Transitions, on page 40 |
| | | Updated Embedded Memory on page 64 and added write cycles detail |
| | | Added ULPM charging note in BAT_RTC on page 66 |
| | | Added details to I2C Interface on page 75 |
| | | Removed references to UART2_RTS and UART2_CTS (not supported) throughout document, marked pins as reserved |
| | | Removed reference to EXT_GPS_LNA_EN (pin 43) and marked as reserved |
| | | Clarified usage of !DAWSPARANGE in UMTS (WCDMA) RF Transmission Path Test on page 136 |

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# >> 1: Introduction

This document defines the high-level product features and illustrates the interfaces for the AirPrime WP75xx/AirPrime WP8548 Smart Embedded Modules. It covers the hardware aspects of the product series, including electrical and mechanical.

The AirPrime WP7502 is an LTE, HSPA, WCDMA, and dual-band GSM/GPRS/EDGE embedded wireless module.

The AirPrime WP7504 is an LTE, HSPA, WCDMA, and CDMA embedded wireless module.

The AirPrime WP8548 is an HSPA, WCDMA, and quad-band GSM/GPRS/EDGE embedded wireless module.

## 1.1 General Features

The AirPrime WP75xx/AirPrime WP8548 is an industrial-grade LGA 239-pad module. Its wireless modem provides voice and data connectivity on the following networks:
- WP7502—LTE, HSPA, WCDMA, EDGE/GPRS
- WP7504—LTE, HSPA, WCDMA, CDMA
- WP8548—HSPA, WCDMA, EDGE/GPRS

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*Note: VoLTE is not supported.*

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GNSS functionality is also available:
- WP75xx—Available as a SKU-configuration
- WP8548—Standard feature

In addition to modem features, the AirPrime WP75xx/AirPrime WP8548 also embeds several cores for maximum flexibility and security for embedded software execution, including:
- A Telecom Core that natively manages 2G (WP7502/WP8548)/3G/4G (WP75xx) modem features
- An Application Core dedicated to customer applications, natively provided with Legato Application framework.

The following tables detail the bands/connectivity supported by the AirPrime WP7502, AirPrime WP7504, and AirPrime WP8548.

### Table 1-1: WP7502 Supported Bands/Connectivity

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Notes |
|---|---|---|---|---|
| LTE | B1 | 1920–1980 | 2110–2170 | MIMO support |
| | B3 | 1710–1785 | 1805–1880 | |
| | B7 | 2500–2570 | 2620–2690 | |
| | B8 | 880–915 | 925–960 | |
| | B20 | 832–862 | 791–821 | |

**Table 1-1: WP7502 Supported Bands/Connectivity (Continued)**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Notes |
|---|---|---|---|---|
| UMTS | B1 | 1920–1980 | 2110–2170 | Diversity support |
| | B8 | 880–915 | 925–960 | |
| GSM/GPRS/EDGE | E-GSM 900 | 880–915 | 925–960 | |
| | DCS 1800 | 1710–1785 | 1805–1880 | |
| GNSS[a] | GPS | - | 1575.42 ± 1.023 | |
| | GLONASS | - | 1597.52–1605.92 | |
| | Galileo | - | 1575.42 ± 2.046 | |

    a.  GNSS support is SKU-dependent.

**Table 1-2: WP7504 Supported Bands/Connectivity**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Notes |
|---|---|---|---|---|
| LTE | B2 | 1850–1910 | 1930–1990 | MIMO support |
| | B4 | 1710–1755 | 2110–2155 | |
| | B5 | 824–849 | 869–894 | |
| | B12 | 699–716 | 729–746 | |
| | B17 | 704–716 | 734–746 | |
| | B25 | 1850–1915 | 1930–1995 | |
| | B26 | 814–849 | 859–894 | |
| UMTS | B2 | 1850–1910 | 1930–1990 | Diversity support |
| | B4 | 1710–1755 | 2110–2155 | |
| | B5 | 824–849 | 869–894 | |
| CDMA EVDO Release A | BC0 | 824–849 | 869–894 | Diversity support |
| | BC1 | 1850–1910 | 1930–1990 | |
| | BC10 | 816–824 | 861–869 | |
| GNSS[a] | GPS | - | 1575.42 ± 1.023 | |
| | GLONASS | - | 1597.52–1605.92 | |
| | Galileo | - | 1575.42 ± 2.046 | |

    a.  GNSS support is SKU-dependent.

**Table 1-3: WP8548 Supported Bands/Connectivity**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | |
|---|---|---|---|---|
| UMTS | B1 | 1920–1980 | 2110–2170 | |
| | B2 | 1850–1910 | 1930–1990 | |
| | B5 | 824–849 | 869–894 | |
| | B6 | 830–840 | 875–885 | |
| | B8 | 880–915 | 925–960 | |
| | B19 | 830–845 | 875–890 | |
| GSM/GPRS/ EDGE | GSM 850 | 824–849 | 869–894 | |
| | E-GSM 900 | 880–915 | 925–960 | |
| | DCS 1800 | 1710–1785 | 1805–1880 | |
| | PCS 1900 | 1850–1910 | 1930–1990 | |
| GNSS | GPS | - | 1575.42 ± 1.023 | |
| | GLONASS | - | 1597.52–1605.92 | |
| | Galileo | - | 1575.42 ± 2.046 | |

# 1.2 Interfaces

The AirPrime WP75xx/AirPrime WP8548 module provides the following interfaces and peripheral connectivity:

- Digital section running under 1.8V
- Dual UIM interfaces—See UIM interface on page 70.
- VBAT_RF/VBAT_BB power supply—See Power Supply Ratings on page 35.
- RF—See RF on page 45.
- GNSS[1] (RF_GNSS)—See GNSS on page 56.
- Real Time Clock battery backup—See BAT_RTC on page 66.
- ON/OFF control:
  - POWER_ON_N—See POWER_ON_N on page 67.
  - RESET_IN_N—See Reset Signal (RESET_IN_N) on page 77.
- USB 2.0—See USB on page 69.
- Two UART serial links—primary (8-line) and secondary (4-line)—See UART on page 69.
- GPIOs—See General Purpose Input/Output (GPIO) on page 72.
- SDIO—See Secure Digital IO (SDIO) interface on page 74.
- I$^2$C—See I2C Interface on page 75.
- 1.8V voltage reference—See VGPIO on page 76.
- Four ADCs—See ADC on page 78.
- Digital audio (PCM/I$^2$S)—See Digital Audio on page 79.
- HSIC bus—See HSIC Bus on page 84.
- Digital I/O

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1. (WP75xx) GNSS support is SKU-dependent; (WP8548) Supported

- Antenna control—See Antenna Control on page 88.
- Two System Clock outputs—See Clock on page 85.
- Test pins—See Test Pins on page 87.
- Tx Activity Indicator (TX_ON)—See Tx Activity Indicator (TX_ON) on page 89.

# 1.3 Common Flexible Form Factor (CF3)

The AirPrime WP75xx/AirPrime WP8548 belongs to the Common Flexible Form Factor (CF3) family of modules. This family consists of a series of WWAN modules that share the same mechanical dimensions (same width and length with varying thicknesses) and footprint. The CF3 form factor provides a unique solution to a series of problems faced commonly in the WWAN module space as it:
- Accommodates multiple radio technologies (from GSM to LTE advanced) and band groupings
- Supports bit-pipe (Essential Module Series) and value-add (Smart Module Series) solutions
- Offers electrical and functional compatibility

# 1.4 Physical Dimensions and Connection Interface

The AirPrime WP75xx/AirPrime WP8548 module is a compact, robust, fully shielded and labeled module with the dimensions noted in Table 1-4.

**Table 1-4: AirPrime WP75xx/AirPrime WP8548 Dimensions[a]**

| Parameter | Nominal | Tolerance | Units |
|-----------|---------|-----------|-------|
| Length | 23.00 | ±0.10 | mm |
| Width | 22.00 | ±0.10 | mm |
| Thickness | 4.352 | ±0.203 | mm |
| Weight (with label) | 4.2 | ±0.1 | g |

a. Dimensions are accurate as of the release date of this document.

The AirPrime WP75xx/AirPrime WP8548 module is an LGA form factor device. All electrical and mechanical connections are made through the 239 Land Grid Array (LGA) pads on the bottom side of the PCB. (See Figure 10-1 on page 117 for details.)
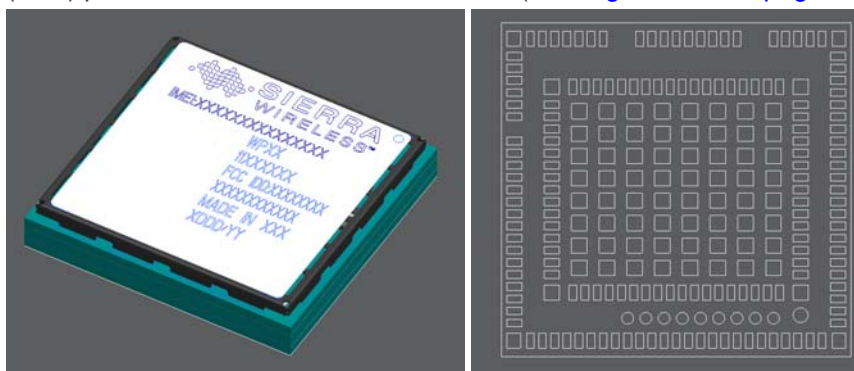


*Figure 1-1: AirPrime WP75xx/AirPrime WP8548 Mechanical Overview*

The 239 pads have the following distribution:
- 157 signal pads, 1.0x0.5 mm, 0.8 mm pitch
  - 66 inner signal pads
  - 91 outer signal pads
- 10 test points:
  - 1 polarity mark (Ground), 1.0 mm diameter
  - 9 test points, 0.8 mm diameter, 1.20 mm pitch
- 72 ground pads:
  - 64 inner ground pads, 1.0x1.0 mm, pitch 1.83 mm/1.48 mm
  - 4 inner corner ground pads, 1.0x1.0 mm
  - 4 outer corner ground pads, 1.0x0.9 mm

# 2: Functional Specifications

## 2.1 Architecture

The following figures present overviews of the AirPrime WP75xx/AirPrime WP8548 modules' internal architecture and external interfaces.
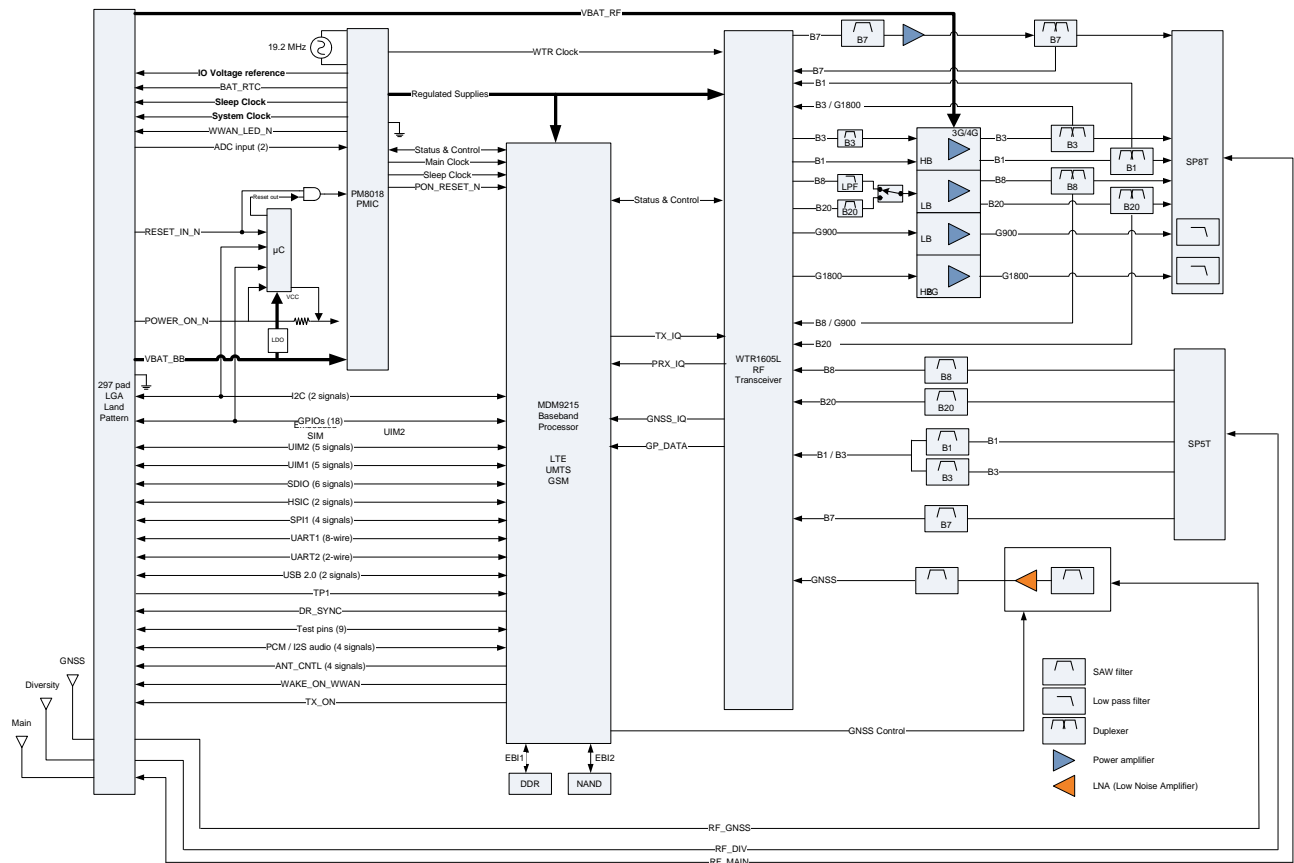


*Figure 2-1: AirPrime WP7502 Architecture Overview*
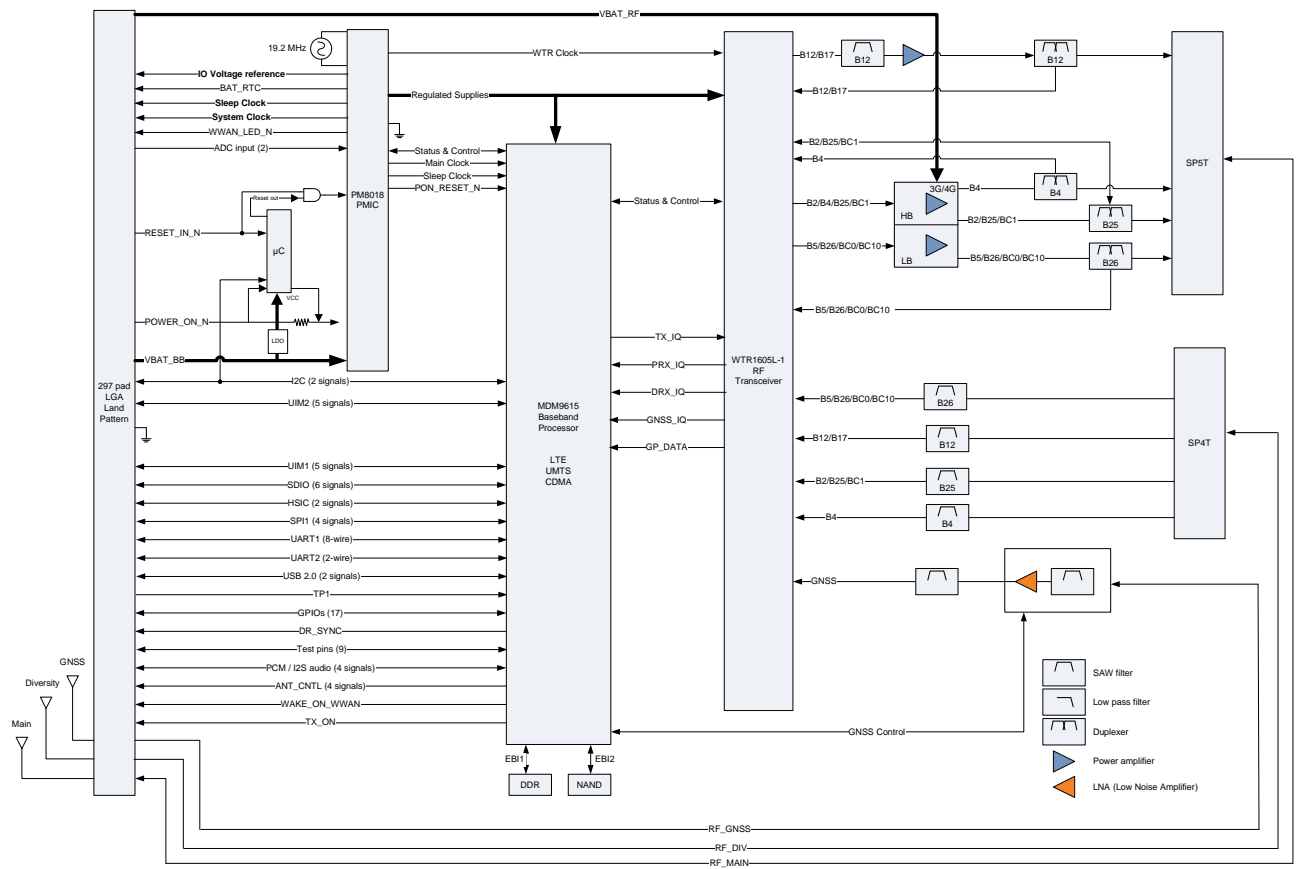
*Figure 2-2: AirPrime WP7504 Architecture Overview*

*Figure 2-3: AirPrime WP8548 Architecture Overview*
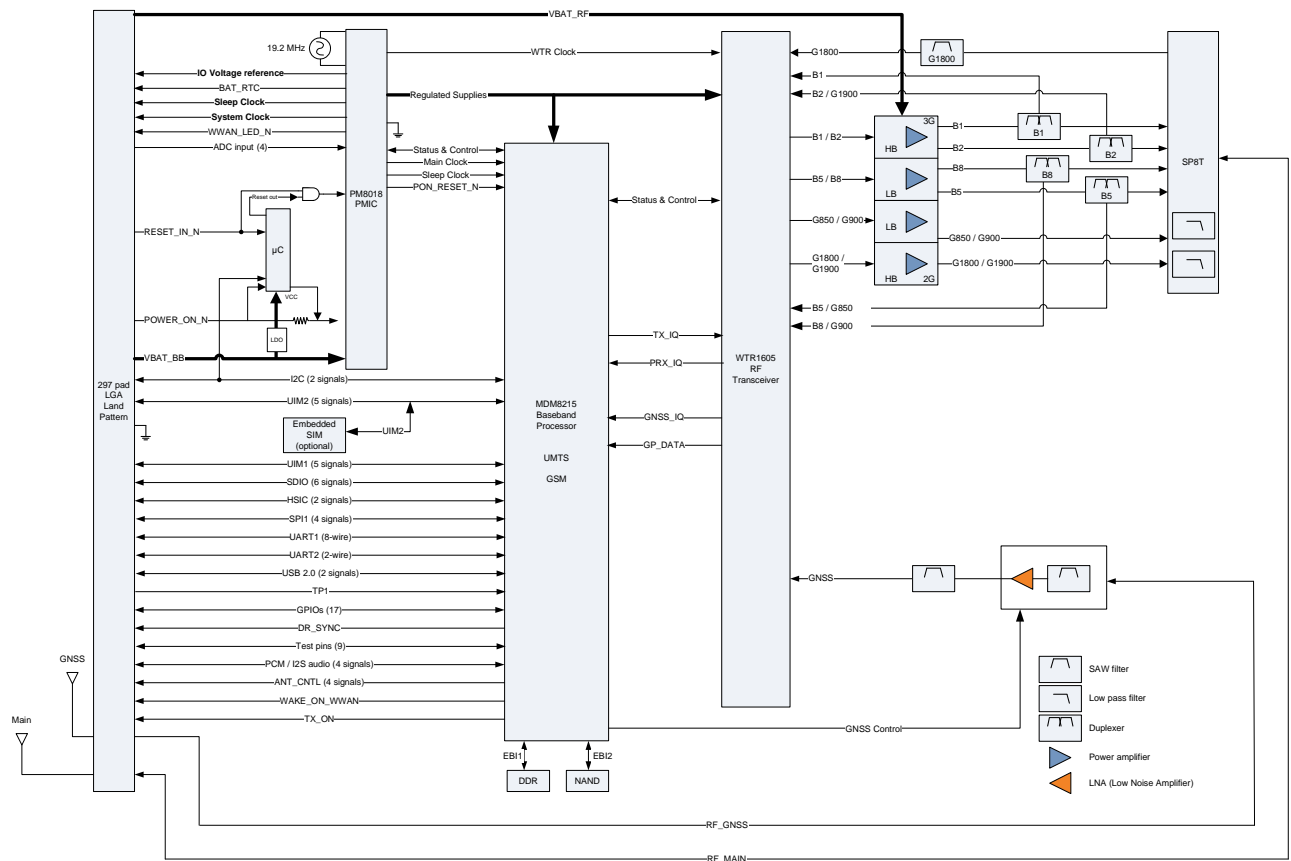
# 2.1.1 Chipsets

The AirPrime WP75xx/AirPrime WP8548 modules are based on the following QUALCOMM baseband processors:
•   MDM8215—AirPrime WP8548
•   MDM9215—AirPrime WP7502
•   MDM9615—AirPrime WP7504

## 2.2 Telecom Features

Table 2-1 summarizes the AirPrime WP75xx/AirPrime WP8548 module's capabilities offered through the Telecom core.

**Table 2-1: AirPrime WP75xx / AirPrime WP8548 Capabilities**

| Feature | Description |
|---|---|
| Electrical | 3.4–4.3V supply voltage (VBAT_BB, VBAT_RF):<br>• Single supply (recommended), VBAT_BB tied to VBAT_RF *or*<br>• Dual supplies, single supply each for VBAT_BB and VBAT_RF |
| Voice (Digital Audio) | • PCM/I$^2$S digital audio interface<br>• Supports Enhanced Full Rate (EFR), Full Rate (FR), Half Rate (HR), and both Narrow-Band and Wide-band Adaptive Multirate (AMR-NB and AMR-WB) vocoders<br>• MO and MT calling<br>• Echo cancellation and noise reduction<br>• Emergency calls (112, 110, 911, etc.)<br>• Incoming call notification<br>• DTMF generation<br>• Internal codec driver for WM8944 |
| SMS | • SMS MO and MT<br>• CS and PS support<br>• SMS saving to UIM card or ME storage<br>• SMS reading from UIM card or ME storage<br>• SMS sorting<br>• SMS concatenation<br>• SMS Status Report<br>• SMS replacement support<br>• SMS storing rules (support of AT+CNMI, AT+CNMA) |
| Supplementary services | • Call Barring<br>• Call Forwarding<br>• Call Hold<br>• Caller ID<br>• Call Waiting<br>• Multi-party service<br>• USSD<br>• Automatic answer |

**Table 2-2: WP7502 RF Bands / Connectivity**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Maximum output power |
|---|---|---|---|---|
| LTE | B1 | 1920–1980 | 2110–2170 | 23 dBm ± 1 dBm; Class 3bis |
| | B3 | 1710–1785 | 1805–1880 | 23 dBm ± 1 dBm; Class 3bis |
| | B7 | 2500–2570 | 2620–2690 | 22 dBm ± 1 dBm; Class 3bis |
| | B8 | 880–915 | 925–960 | 23 dBm ± 1 dBm; Class 3bis |
| | B20 | 832–862 | 791–821 | 23 dBm ± 1 dBm; Class 3bis |
| UMTS | B1 | 1920–1980 | 2110–2170 | 23 dBm ± 1 dBm; Class 3bis |
| | B8 | 880–915 | 925–960 | 23 dBm ± 1 dBm; Class 3bis |
| GSM/GPRS/ EDGE | E-GSM 900 | 880–915 | 925–960 | 2 Watts GSM/GPRS/EDGE |
| | DCS 1800 | 1710–1785 | 1805–1880 | 1 Watt GSM/GPRS/EDGE |
| GNSS[a] | GPS | - | 1575.42 ± 1.023 | - |
| | GLONASS | - | 1597.52–1605.92 | - |
| | Galileo | - | 1575.42 ± 2.046 | |

a. GNSS support is SKU-dependent.

**Table 2-3: WP7504 RF Bands / Connectivity**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Maximum output power |
|---|---|---|---|---|
| LTE | B2 | 1850–1910 | 1930–1990 | 23 dBm ± 1 dBm; Class 3bis |
| | B4 | 1710–1755 | 2110–2155 | 23 dBm ± 1 dBm; Class 3bis |
| | B5 | 824–849 | 869–894 | 23 dBm ± 1 dBm; Class 3bis |
| | B12 | 699–716 | 729–746 | 23 dBm ± 1 dBm; Class 3bis |
| | B17 | 704–716 | 734–746 | 23 dBm ± 1 dBm; Class 3bis |
| | B25 | 1850–1915 | 1930–1995 | 23 dBm ± 1 dBm; Class 3bis |
| | B26 | 814–849 | 859–894 | 23 dBm ± 1 dBm; Class 3bis |
| UMTS | B2 | 1850–1910 | 1930–1990 | 23 dBm ± 2 dBm; Class 3bis |
| | B4 | 1710–1755 | 2110–2155 | 23 dBm ± 1 dBm; Class 3bis |
| | B5 | 824–849 | 869–894 | 23 dBm ± 1 dBm; Class 3bis |
| CDMA | BC0 | 824–849 | 869–894 | 23 dBm ± 1 dBm; Class 3bis |
| | BC1 | 1850–1910 | 1930–1990 | 23 dBm ± 1 dBm; Class 3bis |
| | BC10 | 816–824 | 861–869 | 23 dBm ± 1 dBm; Class 3bis |

**Table 2-3: WP7504 RF Bands / Connectivity (Continued)**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Maximum output power |
|---|---|---|---|---|
| GNSS[a] | GPS | - | 1575.42 ± 1.023 | - |
| | GLONASS | - | 1597.52–1605.92 | - |
| | Galileo | - | 1575.42 ± 2.046 | |

a. GNSS support is SKU-dependent.

**Table 2-4: WP8548 RF Bands / Connectivity**

| Technology | RF band | Transmit band (Tx) (MHz) | Receive band (Rx) (MHz) | Maximum output power |
|---|---|---|---|---|
| UMTS | B1 | 1920–1980 | 2110–2170 | 23 dBm ± 1 dBm; Class 3bis |
| | B2 | 1850–1910 | 1930–1990 | 23 dBm ± 1 dBm; Class 3bis |
| | B5 | 824–849 | 869–894 | 23 dBm ± 1 dBm; Class 3bis |
| | B6 | 830–840 | 875–885 | 23 dBm ± 1 dBm; Class 3bis |
| | B8 | 880–915 | 925–960 | 23 dBm ± 1 dBm; Class 3bis |
| | B19 | 830–845 | 875–890 | 23 dBm ± 1 dBm; Class 3bis |
| GSM/GPRS/ EDGE | GSM 850 | 824–849 | 869–894 | 2 Watts GSM/GPRS/EDGE |
| | E-GSM 900 | 880–915 | 925–960 | 2 Watts GSM/GPRS/EDGE |
| | DCS 1800 | 1710–1785 | 1805–1880 | 1 Watt GSM/GPRS/EDGE |
| | PCS 1900 | 1850–1910 | 1930–1990 | 1 Watt GSM/GPRS/EDGE |
| GNSS | GPS | - | 1575.42 ± 1.023 | - |
| | GLONASS | - | 1597.52–1605.92 | - |
| | Galileo | - | 1575.42 ± 2.046 | - |

## 2.2.1 Network Technology Specifications

### 2.2.1.1 GSM/GPRS/EDGE Specifications

The following table describes GSM/GPRS/EDGE specifications for WP7502 and WP8548 modules.

**Table 2-5: Supported GSM/GPRS/EDGE Specifications[a]**

| Standard | Feature Description |
|---|---|
| GPRS | Packet-switched data:<br>• DTM (simple class A) operation<br>• GPRS Multislot class 10 (no backoff)—Four Rx slots (maximum), two Tx slots (maximum), five active slots total<br>• Coding schemes—CS1–CS4<br>• GEA1, GEA2, and GEA3 ciphering<br>• WCDMA/GERAN system selection |
| EDGE | • E2 power class for 8 PSK<br>• DTM (simple class A), multislot class 12<br>• EGPRS—Multislot class 12 (with backoff)—Four Rx slots (maximum), four Tx slots (maximum), five active slots total<br>• Coding schemes—MCS1–MCS9<br>• BEP reporting<br>• SRB loopback and test modes A and B<br>• 8-bit and 11-bit RACH<br>• PBCCH support<br>• One-phase/two-phase access procedures<br>• Link adaptation and IR<br>• NACC, extended UL TBF<br>• PFC/PFI (Packet Flow Context/Packet Flow Identifier) support - allows identity tagging of RLC blocks to identify separate QoS streams at the radio link layer<br>• GPRS/EDGE MSC12-EDA - permits allocation of more than two uplink timeslots for GPRS/EDGE<br>• Enh DL RLC/MAC Segmentation - permits reception of MAC control messages that exceed one radio block capacity in length<br>• Enhanced Ext UL TBF - dummy block transmission is punctured for current saving purposes<br>• 2G PS handover - packet-switched equivalent of CS handover to ensure faster cell change and improved throughput<br>• WCDMA/GERAN<br>    • Band Scan: Run-time Configurable RRC Band Scan Order<br>    • Power and Network Optimizations: Frame Early Termination for Power Optimization<br>    • Protocols: MRAB-Pack-1 Enhancements - reduces multi-RAB call drops |

a.  WP7502/WP8548 only

## 2.2.1.2 WCDMA Specifications

The following table describes WCDMA specifications for WP75xx/WP8548 modules.

**Table 2-6: Supported WCDMA Specifications**

| Standard | Feature Description |
|---|---|
| R99 | • All modes and data rates for WCDMA FDD, with the following restrictions:<br>　• The downlink supports the following specifications:<br>　　• Up to four physical channels, including the broadcast channel (BCH), if present<br>　　• Up to three dedicated physical channels (DPCHs)<br>　　• Spreading factor (SF) range support from 4 to 256<br>　• The uplink supports the following specifications:<br>　　• One physical channel, eight TrCH, and 16 TrBks starting at any frame boundary<br>　　• A maximum data rate of 384 kbps<br>　• Full SF range support from 4 to 256<br>• PS data rates of 384 kbps DL and 384 kbps UL |
| R5 HSDPA | • PS data speeds up to 42 Mbps (UE category 24) on the downlink<br>• HS-DSCH (HS-SCCH, HS-PDSCH, and HS-DPCCH)<br>• Maximum of 15 HS-PDSCH channels, both QPSK and 16 QAM modulation<br>• Support for 3GPP-defined features:<br>　• R99 transport channels<br>　• Maximum of four simultaneous HS-SCCH channels<br>　• CQI and ACK/NACK on HS-DPCCH channel<br>　• All incremental redundancy versions for HARQ<br>　• Configurable support for power classes 3 or 4, per TS 25.101<br>　• TFC selection limitation on UL factoring in transmissions on the HS-DPCCH, per TS 25.133<br>• Switching between HS-PDSCH and DPCH channel resources, as directed by the network<br>• Network activation of compressed mode by SF/2 or HLS on the DPCH for conducting inter-frequency or inter-radio access technology (RAT) measurements when the HS-DSCH is active<br>• STTD on both associated DPCH and HS-DSCH simultaneously<br>• CLTD mode 1 on the DPCH when the HS-PDSCH is active<br>• STTD on HS-SCCH when STTD or CLTD mode 1 are configured on the associated DPCH<br>• SCH-IC support<br>• HS-DSCH DRX support |

**Table 2-6: Supported WCDMA Specifications (Continued)**

| Standard | Feature Description |
|---|---|
| R6 HSUPA | <ul><li>E-DCH data rates of up to 5.76 Mbps for 2 ms TTI (UE category 6) uplink</li><li>Support for 3GPP-defined features:<ul><li>E-AGCH, E-RGCH, and E-HICH channels for downlink; E-RGCH and E-HICH supports serving and non-serving radio links, with up to four radio links in the E-DCH active set</li><li>All HARQ incremental redundancy versions and maximum number of HARQ retransmissions</li><li>Uplink E-DCH channel with support for up to four E-DPDCH channels</li><li>HSUPA channels run simultaneously with R99 and HSDPA channels</li></ul></li><li>STTD on all HSUPA downlink channels</li><li>CLTD mode 1 on HS-PDSCH and DPCH along with HSUPA channels</li><li>Switch between HSUPA channels and DPCH channel resources, as directed by the network</li><li>Handover using compressed mode with simultaneous E-DCH and HS-DSCH interactive, background, and streaming QoS classes</li><li>DPCCH DTX support</li></ul> |

## 2.2.1.3 LTE Specifications

The following table describes LTE specifications for WP75xx modules.

**Table 2-7: Supported LTE Specifications[a]**

| Standard | Feature Description |
|---|---|
| R9 Cat 3 FDD | • Release 9 mandatory LTE features<br>• FDD: up to 100 Mbps downlink, 50 Mbps uplink<br>• 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz RF bandwidth<br>• IPv6, QoS<br>• Inter-RAT capabilities with HSPA+, CDMA (WP7504 only), EDGE (WP7502 only) and applicable backward-compatible modes<br>• NAS & RRC standalone security<br>• Commercial Mobile Alert System (CMAS)<br>• ETWS (Earthquake Tsunami Warning System) notification<br>• Inter-frequency/bandwidth mobility<br>• DRX cycle while in:<br>  · Connected mode<br>  · Idle mode<br>• UE IRAT support for Self Organizing Networks and Automatic Neighbor Relation (SON AR)<br>• Mode reselections:<br>  · eHRPD to LTE in idle mode based on LTE neighbor cell measurements<br>  · LTE in idle mode to eHRPD idle<br>  · LTE <-> GERAN Idle mode mobility (cell reselection)<br>  · LTE <-> UMTS Idle mode mobility (cell reselection)<br>• Mode redirections:<br>  · LTE in connected mode to eHRPD idle<br>    · Blind redirection<br>    · Based on measurement gaps<br>  · UMTS to LTE redirections<br>    · Blind redirection<br>    · Based on measurements during WCDMA compressed mode gaps<br>  · GERAN to LTE redirections (blind; no measurements)<br>  · LTE to UMTS redirections (with measurements on UMTS)<br>• LTE to UMTS PS Handover<br>• LTE/GW Data Silent Redial for Inter-RAT<br>• Attach/detach PS during Voice Call or SMS |

**Table 2-7:  Supported LTE Specifications[a] (Continued)**

| Standard | Feature Description |
|---|---|
| System Determination | • Frequency Scan and System Selection within LTE<br>• LTE BPLMN support<br>• LTE Connected mode OOS<br>• System selection across RATs, Standalone Security, Dedicated EPS Bearer Management and Dormancy<br>• System selection across LTE, UMTS, GERAN<br>• 256 UPLMN and 256 OPLMN entries in UIM support<br>• Carrier Specific BSR Requirements<br>• Data Services: eHRPD/LTE - Data System Determination for Multiple Radio Systems<br>• Multimode system selection - facilitates system selection and avoids unnecessary attach requests in a 3GPP+3GPP2 multimode UE |
| Data | • Data call throttling<br>• Default IPv4 bearer activation at attach/IPv4 data call<br>• NW and UE initiated QoS<br>• Dual IP and IPv4/IPv6 continuity<br>• IPv4/IPv6 session continuity<br>• W/G IP session continuity<br>• Emergency services - LTE NAS Support for Control Plane LTE Positioning Protocol<br>• Data services - LTE-eHRPD Mobility Support of APN Class and APN Bearer in Application Profile over LTE |

a.  WP75xx only

## 2.2.1.4 CDMA Specifications

The following table describes CDMA specifications for WP7504 modules.

**Table 2-8:  Supported CDMA Specifications[a]**

| Standard | Feature Description |
|---|---|
| CDMA IS-2000 | • Up to 153 kbps, simultaneous forward and reverse channel |
| CDMA IS-856 (1xEV-DO Release A) | • Up to 3.1 Mbps forward channel<br>• Up to 1.8 Mbps reverse channel |

a.  WP7504 only

## 2.2.2 Modem Specifications

**Table 2-9: Supported Modem Specifications[a]**

| Standard | Feature Description |
|---|---|
| Data | • IPHC protocol as RFC 2509<br>• Stateless DHCPv4 protocol to get P-CSCF and DNS addresses<br>• IPv4/IPv6<br>• 4 PDNs Support over Multi-RmNet<br>• Dual IP on single RmNet<br>• IP only Mode/Raw IP Mode<br>• Multi-RmNet Data Call |

a. Preliminary

# 2.3 Multi-Core Processing Capabilities

The AirPrime WP75xx/AirPrime WP8548 is a powerful multiple-core system that includes:
• One QDSP6 core, embedding Telecom firmware with integrated cellular voice (future firmware release), data and wireless Internet connectivity
• One Cortex-A5 core entirely dedicated to customer application and natively provided with Linux operating system

# ≫ 3: Technical Specifications

## 3.1 Environmental

The environmental specifications for operation and storage of the AirPrime WP75xx/ AirPrime WP8548 are defined in Table 3-1.

**Table 3-1: Environmental Specifications**

| Parameter | Range | Operating Class |
|---|---|---|
| Ambient Operating Temperature | -30°C to +70°C | Class A |
| | -40°C to +85°C | Class B |
| Ambient Storage Temperature | -40°C to +85°C | - |
| Ambient Humidity | 95% or less | - |

Class A is defined as the operating temperature range within which the device:
• Shall exhibit normal function during and after environmental exposure.
• Shall meet the minimum requirements of 3GPP or appropriate wireless standards.

Class B is defined as the operating temperature range within which the device:
• Shall remain fully functional during and after environmental exposure
• Shall exhibit the ability to establish any of the device's supported call modes (SMS, Data, and emergency calls) at all times even when one or more environmental constraint exceeds the specified tolerance.
• Unless otherwise stated, full performance should return to normal after the excessive constraint(s) have been removed.

## 3.2 Power Supply Ratings

The AirPrime WP75xx/AirPrime WP8548 is powered via:
• (Recommended) A single regulated DC power supply (3.7V nominal)
• Two regulated DC power supplies (3.7V nominal), one each for VBAT_BB and VBAT_RF

The AirPrime WP75xx/AirPrime WP8548 does not support USB bus-operation. DC power is supplied via the VBAT_RF and VBAT_BB signals.

*Note: Operation above the maximum specified operating voltage (see Table 3-4 on page 36) is not recommended, and specified typical performance or functional operation of the device is neither implied nor guaranteed.*

**Table 3-2: Absolute Maximum Ratings**

| Parameter | Module | Min | Max | Units |
|---|---|---|---|---|
| Power supply voltage (VBAT_BB/VBAT_RF) | WP7502 | -0.3 | +4.6 | V |
| | WP7504 | -0.3 | +5.5 | V |
| | WP8548 | -0.3 | +6.0 | V |

**Table 3-3: Power Supply Pins**

| Pin | Name | Direction | Function | Notes |
|---|---|---|---|---|
| 63, 158 | VBAT_BB | Input | Baseband power supply | 63—Must be used<br>158—Optional |
| 61, 62, 157 | VBAT_RF | Input | RF power supply | 61/62—Must be used<br>157—Optional |

**Table 3-4: Operating Conditions**

| Parameter | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|
| Power supply voltage[a] | 3.4 | 3.7 | 4.3 | V | Must be within min/max values over all operating conditions (including voltage ripple, droop, and transient), especially (for the WP7502 and WP8548) during the GSM transmit burst. |
| Power supply ripple | - | - | 100 | mV$_{pp}$ | See Figure 3-1 on page 37. |
| Power supply voltage droop | - | - | 250 | mV | See Figure 3-1 on page 37 and Under-Voltage Lockout (UVLO) on page 37. |
| Power supply voltage transient (overshoot/undershoot) | - | - | 300 | mV | See Figure 3-1 on page 37. |
| Supply current | - | 1.0 | 3.0 | A | • Typical value varies and depends on output power, band, and operating voltage. See Current Consumption on page 41 for values measured under normal operating conditions.<br>• Max value measured over 100 µs period. |

a. Power supply voltage outside the required range may affect call quality (dropped calls, data transfer errors, etc.).

Customer should characterize the ripple, droop, and transient response (overshoot/undershoot) of the power supply delivery system at the module input under full GSM transmit power. To minimize voltage variation, add suitable capacitors to the supply line as close as possible to the module—depending on the power supply design, these capacitors may range from tens to several thousand µF.
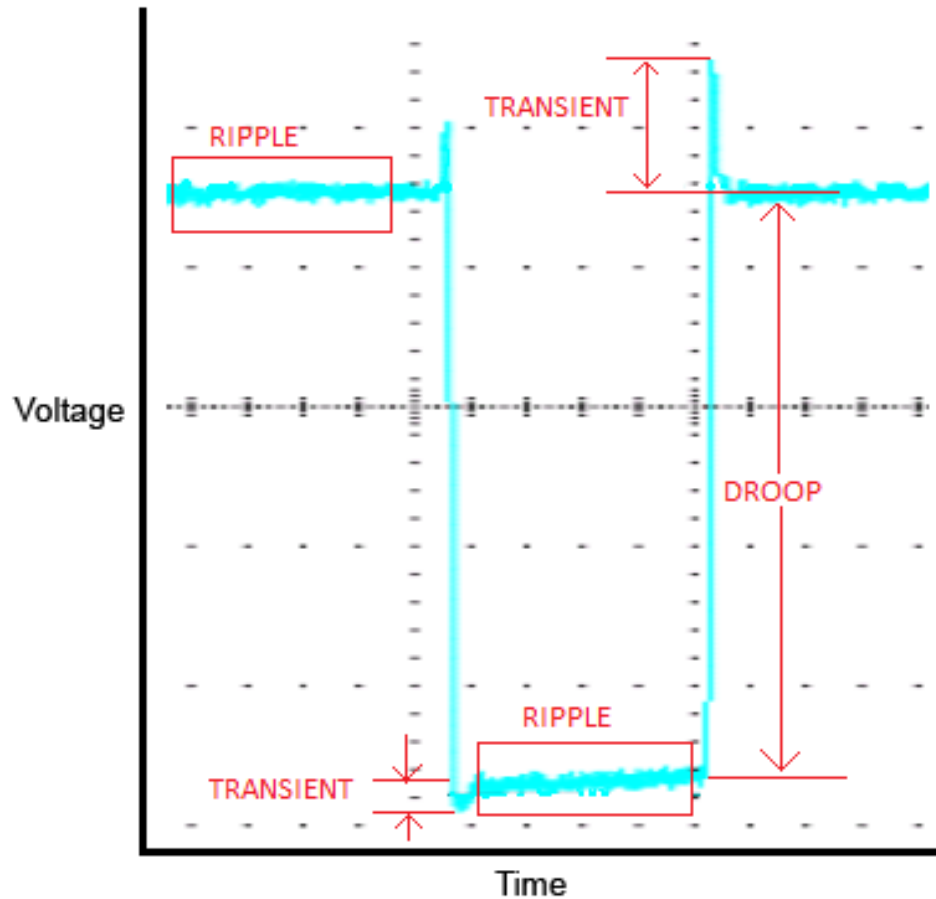


*Figure 3-1: Power Supply Characteristics (capture enlarged)*

## 3.2.1 Under-Voltage Lockout (UVLO)

The power management section of the AirPrime WP75xx/AirPrime WP8548 includes an under-voltage lockout circuit that monitors supply and shuts down when VBAT_BB/VBAT_RF falls below the threshold.
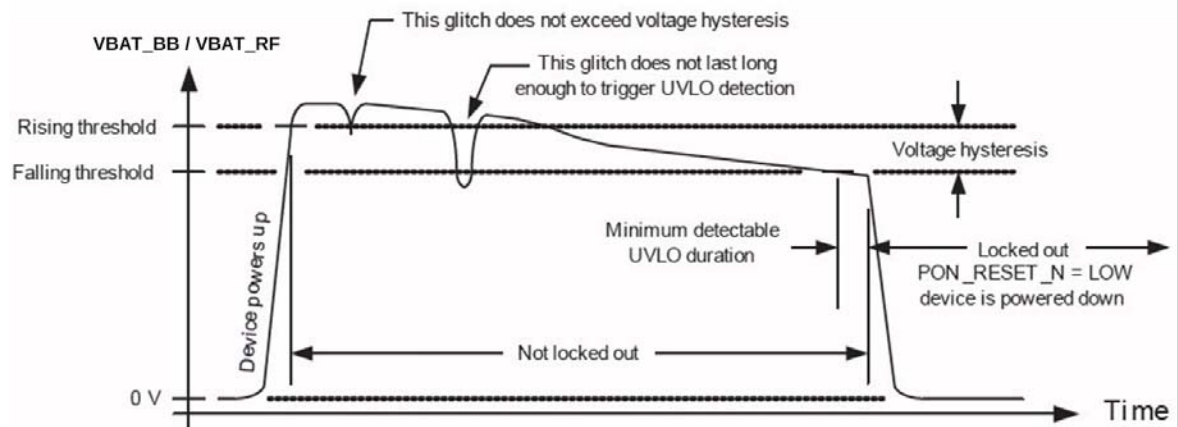
*Figure 3-2: Under-Voltage Lockout (UVLO) Diagram*

The AirPrime WP75xx/AirPrime WP8548 will power down and remain off until the level of VBAT_BB/VBAT_RF returns to the valid range and the ON/OFF signal is active.

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*Note: If the device experiences six consecutive UVLO events less than 45 seconds apart (approximately) and a host-initiated power down or reset has not occurred, the device enters a mode in which only the DM port enumerates on the USB.*

---

**Table 3-5: UVLO Specifications[a]**

| Parameter | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|
| Threshold voltage, falling | 1.500 | 2.550 | 3.050 | V | Programmable value |
| Threshold voltage, accuracy | -5 | - | +5 | % | |
| Hysteresis | 100 | 175 | 250 | mV | |
| UVLO detection interval | - | 1.0 | - | µs | |

    a.   All values are preliminary and subject to change.

## 3.2.2 Power Consumption States

The AirPrime WP75xx/AirPrime WP8548 has three basic power states (Active, Ultra Low Power Mode, and Off). As the module transitions between power states, the range of available device functionality adjusts appropriately, as described in and .

**Table 3-6:  Supported Power States**

| State | Description |
|---|---|
| Active | Module is fully powered and operating in one of the following modes:<br>• Full function (WWAN radio active; GNSS radio can be turned on/off)—Highest power consumption.<br>• Idle (Module registered on network, but no active connection; GNSS radio can be turned on/off)<br>• Airplane mode (WWAN radio off; GNSS radio can be active if allowed by PRI)<br>• USB-SS mode—Lowest power consumption while module is in Active state. When the module is in this mode, the processor monitors certain signals (triggers) that can 'wake' the module—see Wakeup Interrupt (USB-SS Mode) on page 74 for details.<br>Note: On Windows systems, due to limitations of the Windows ECM driver, USB-SS mode is only supported if ECM is disabled or USB is disconnected.<br><br>While in the Active state, the module actively reduces power consumption by disabling components that are not in use (for example, stepping down clock signals, putting the USB into 'selective suspend', etc.). If the device needs to be in use infrequently and greater current consumption savings are needed, the module can be configured to enter Ultra Low Power Mode. See Active State to ULPM Transition on page 41 for details. |
| Ultra Low Power Mode (ULPM) | Module is in its lowest power state monitoring configured triggers that will return the module to the Active state.<br>• For details on how ULPM is configured and entered, see Active State to ULPM Transition on page 41.<br>• The module remains in ULPM until any of the following occur:<br>  · A configured trigger occurs. (See Wakeup Interrupt (USB-SS Mode) on page 74 for details.)<br>  · POWER_ON_N is asserted (transitioned from OFF to ON)<br>  · RESET_IN_N is used to reset the module with POWER_ON_N on.<br>    (Note: If RESET_IN_N is used in ULPM when POWER_ON_N is off, all configured wakeup triggers are cleared, leaving only POWER_ON_N as a signal to exit ULPM mode.)<br>• ULPM current consumption varies depending on which triggers are configured. For example, the lowest consumption occurs when the processor is waiting only for a timer (approximately 6 µA), and the highest consumption occurs when all supported triggers are configured.<br><br>*Note:  All interfaces connected to the module's GPIOs (see Table 4-8 on page 73) must be tri-stated or off to prevent additional leakage current during ULPM and potentially damaging the unit by applying a voltage when the GPIOs are off.* |
| OFF | Module is OFF (no power to the system).<br>Apply power with POWER_ON_N asserted for the system to go to Active state. |

Figure 3-3 on page 40 illustrates the current consumption requirements of the different power states and the possible transitions between power states. For specific values, see Table 3-7 on page 41, Table 3-8 on page 43, and Table 3-9 on page 44.

Current Consumption

*Note: Approximate values; Illustration not to scale*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 6–50 µA | 850 µA | 1.4 mA | 36 mA | 3.5 mA | 40 mA | 835 mA | 780 mA | 550 mA |

WP7502   WP7504   WP8548

| OFF | POWER_ON_N off | POWER_ON_N on | Airplane: USB-SS | Airplane: USB active | Idle: USB-SS | Idle: USB active | On call |
|---|---|---|---|---|---|---|---|

Power States

| OFF | ULPM (Ultra Low Power Mode) | Active |
|---|---|---|

Power State Transitions

VCC On

Enable ULPM

OFF    ULPM (Ultra Low Power Mode)    Active

VCC Off

Triggers
GPIO36
GPIO38
GPIO39
ADC2
ADC3
Timer expire

RESET_IN_N

VCC Off

*Figure 3-3: Power State Transitions*

## 3.2.3 Active State to ULPM Transition

If the module will be used in situations where it needs to be active very infrequently (for example, in a remote monitoring station that must transmit data once a day), it can be placed in Ultra Low Power Mode (ULPM) via sysfs/Legato to achieve significantly lower power consumption than is possible in USB-SS mode (low power active state):

1.  Configure one or more supported wakeup triggers that the processor will monitor when the module is in ULPM. Supported triggers include:
    *   Interrupt-capable GPIOs (GPIO36, GPIO38, GPIO39)—Trigger on level (high/low) or edge (rising/falling/both)
    *   Timer — Trigger after a specified period. (1–4294967 seconds; 0=timer disabled)
    *   ADCs (ADC2, ADC3)—Trigger on threshold (above/below; e.g. wake on ADCx above 1.2V) or range (inside/outside; e.g. wake when value is inside a specified range, or outside a specified range)

2.  Initiate ULPM. If the configured wakeup conditions are still valid (they have not triggered yet), the module will enter ULPM, otherwise the request will fail and will need to be repeated.

*Note: These triggers are non-persistent — if the module enters ULPM and then returns to Active power state, the triggers are erased and will need to be reconfigured.*

## 3.2.4 Current Consumption

The following tables describe the WP7502, WP7504, and WP8548 modules' current consumption under various power states. Typical values are measured at nominal supply voltage, nominal ambient temperature, and with a conducted 50Ω load on the antenna port.

**Table 3-7: WP7502 Current Consumption Values[a]**

| Mode | Parameter | Min | Typ[b] | Max[c] | Units |
|---|---|---|---|---|---|
| Power state—Active | | | | | |
| On Call—GSM[d] | 900 MHz PCL5 +32 dBm | - | 379[e] | 929[f] | mA |
| | 1800 MHz PCL0 +29 dBm | - | 248[e] | 539[f] | mA |
| GSM Peak current[d] | 900 MHz PCL5 | - | - | 2.5[f] | A |
| | 1800 MHz PCL0 | - | - | 1.5[f] | A |
| HSDPA Data transfer[g] | Band 1 | - | 690 | 743 | mA |
| | Band 8 | - | 602 | 670 | mA |

**Table 3-7: WP7502 Current Consumption Values[a] (Continued)**

| Mode | Parameter | | Min | Typ[b] | Max[c] | Units |
|---|---|---|---|---|---|---|
| LTE Data transfer[h] | B1 | | - | 835 | 950 | mA |
| | B3 | | - | 754 | 924 | mA |
| | B7 | | - | 721 | 870 | mA |
| | B8 | | - | 758 | 850 | mA |
| | B20 | | - | 693 | 797 | mA |
| Idle—GSM | • Registered<br>• MFRMS=5 | USB active | 36 | 39 | 40 | mA |
| | | USB-SS[i] | 1.2 | 2.5 | 4.5 | mA |
| Idle—WCDMA | • Registered<br>• DRX=8 | USB active | 37 | 38 | 39 | mA |
| | | USB-SS[i] | 1.2 | 1.8 | 2.5 | mA |
| Idle—LTE | • Registered<br>• Paging cycle=256 | USB active | 36 | 39 | 41 | mA |
| | | USB-SS[i] | 2.7 | 2.9 | 3.7 | mA |
| Airplane mode | Radio off | USB active | 34 | 36 | 40 | mA |
| | | USB-SS[i] | 1.2 | 1.4 | 1.6 | mA |
| Power state—Ultra Low Power mode (ULPM) | | | | | | |
| See Table 3-10 on page 45 for details. | | | | | | |
| GNSS[j] | | | | | | |
| GNSS | Acquisition (Airplane mode, cold start) | | 30 | 40 | 50 | mA |
| | Tracking (Registered) | | 25 | 35 | 45 | mA |

a. All values are preliminary, subject to change.
b. Typical, measured at nominal temperature, nominal voltage.
c. Worst case, measured over extreme temperature and voltage.
d. At GSM conducted max Tx output power (see Table 3-12 on page 46)
e. Typical—values for one slot
f. Maximum—values for four slots with no backoff
g. At WCDMA conducted max Tx output power (see Table 3-15 on page 48)
h. At LTE conducted max Tx output power (see Table 3-21 on page 51)
i. On Windows systems, due to limitations of the Windows ECM driver, USB-SS mode is only supported if ECM is disabled or USB is disconnected.
j. GNSS current consumption values are for the GNSS radio only. For total consumption, add the GNSS value to the consumption for the mode being used.

**Table 3-8:  WP7504 Current Consumption Values[a]**

| Mode | Parameter | | Min | Typ[b] | Max[c] | Units |
|---|---|---|---|---|---|---|
| Power state—Active | | | | | | |
| On Call—CDMA[d] | BC0 | | - | 530 | 675 | mA |
| | BC1 | | - | 670 | 900 | |
| | BC10 | | - | 535 | 600 | mA |
| EV-DO[d] | BC0 | | - | 500 | 675 | mA |
| | BC1 | | - | 635 | 900 | |
| HSDPA data transfer[e] | Band 2 | | - | 675 | 825 | mA |
| | Band 4 | | - | 585 | 650 | |
| | Band 5 | | - | 535 | 625 | mA |
| LTE Data transfer[f] | B2 | | - | 780 | 975 | mA |
| | B4 | | - | 645 | 825 | mA |
| | B5 | | - | 595 | 800 | mA |
| | B12 | | - | 650 | 800 | mA |
| | B17 | | - | 665 | 800 | mA |
| | B25 | | - | 775 | 975 | mA |
| | B26 | | - | 610 | 800 | mA |
| Idle—CDMA | • Registered <br> • QPCH=5.12 s | USB active | 36 | 40 | 46 | mA |
| | | USB-SS[g] | 4 | 5 | 7.2 | mA |
| Idle—WCDMA | • Registered <br> • DRX=8 | USB active | 37 | 38 | 39 | mA |
| | | USB-SS[g] | 1.2 | 1.8 | 2.5 | mA |
| Idle—LTE | • Registered <br> • Paging cycle=256 | USB active | 36 | 39 | 41 | mA |
| | | USB-SS[g] | 2.7 | 2.9 | 3.7 | mA |
| Airplane mode | Radio off | USB active | 34 | 36 | 40 | mA |
| | | USB-SS[g] | 1.2 | 1.4 | 1.6 | mA |
| Power state—Ultra Low Power mode (ULPM) | | | | | | |
| See Table 3-10 on page 45 for details. | | | | | | |

**Table 3-8: WP7504 Current Consumption Values[a] (Continued)**

| Mode | Parameter | Min | Typ[b] | Max[c] | Units |
|---|---|---|---|---|---|
| GNSS[h] | | | | | |
| GNSS[i] | Acquisition (Airplane mode, cold start) | 30 | 40 | 50 | mA |
| | Tracking (Registered) | 25 | 35 | 45 | mA |

a. All values are preliminary, subject to change.
b. Typical, measured at nominal temperature, nominal voltage.
c. Worst case, measured over extreme temperature and voltage.
d. At CDMA conducted max Tx output power (see Table 3-19 on page 50)
e. At WCDMA conducted max Tx output power (see Table 3-17 on page 49)
f. At LTE conducted max Tx output power (see Table 3-22 on page 51)
g. On Windows systems, due to limitations of the Windows ECM driver, USB-SS mode is only supported if ECM is disabled or USB is disconnected.
h. GNSS current consumption values are for the GNSS radio only. For total consumption, add the GNSS value to the consumption for the mode being used.
i. GNSS support is SKU-dependent.

**Table 3-9: WP8548 Current Consumption Values[a]**

| Mode | Parameter | | Min | Typ | Max[b] | Units |
|---|---|---|---|---|---|---|
| Power state—Active | | | | | | |
| On Call—GSM[c] | 850/900 MHz PCL5 +32 dBm | | - | 336[d] | 816[e] | mA |
| | 1800/1900 MHz PCL0 +29 dBm | | - | 252[d] | 557[e] | mA |
| GSM Peak current[c] | 850/900 MHz PCL5 | | - | - | 2.5[e] | A |
| | 1800/1900 MHz PCL0 | | - | - | 1.5[e] | A |
| HSDPA Data transfer[f] | Band 1 | | 450 | 550 | 650 | mA |
| | Band 2 | | 450 | 550 | 650 | mA |
| | Band 5 | | 350 | 500 | 600 | mA |
| | Band 6 | | 330 | 500 | 550 | mA |
| | Band 8 | | 410 | 550 | 650 | mA |
| | Band 19 | | 330 | 500 | 550 | mA |
| Idle—GSM | • Registered<br>• MFRMS=5 | USB active | 36 | 39 | 40 | mA |
| | | USB-SS[g] | 1.2 | 2.5 | 4.5 | mA |
| Idle—WCDMA | • Registered<br>• DRX=8 | USB active | 37 | 38 | 39 | mA |
| | | USB-SS[g] | 1.2 | 1.8 | 2.5 | mA |
| Airplane mode | Radio off | USB active | 34 | 36 | 40 | mA |
| | | USB-SS[g] | 1.2 | 1.4 | 1.6 | mA |
| Power state—Ultra Low Power Mode (ULPM) | | | | | | |
| See Table 3-10 on page 45 for details. | | | | | | |

**Table 3-9:  WP8548 Current Consumption Values[a] (Continued)**

| Mode | Parameter | Min | Typ | Max[b] | Units |
|------|-----------|-----|-----|--------|-------|
| GNSS[h] | | | | | |
| GNSS | Acquisition (Airplane mode, cold start) | 30 | 40 | 50 | mA |
| | Tracking (Registered) | 25 | 35 | 45 | mA |

a.  All values are preliminary, subject to change.
b.  Worst case, measured over extreme temperature and voltage.
c.  At GSM conducted max Tx output power (see Table 3-12 on page 46)
d.  Typical—values for one slot
e.  Maximum—values for four slots with no backoff
f.  At WCDMA conducted max Tx output power (see Table 3-15 on page 48)
g.  On Windows systems, due to limitations of the Windows ECM driver, USB-SS mode is only supported if ECM is disabled or USB is disconnected.
h.  GNSS current consumption values are for the GNSS radio only. For total consumption, add the GNSS value to the consumption for the mode being used.

Table 3-10 describes parameters that contribute to total current consumption while the module is in ULPM.

**Table 3-10:  ULPM Current Consumption[a]**

| Parameter | | State | Value | Units |
|-----------|--|-------|-------|-------|
| POWER_ON_N | | Off | 6 | μA |
| | | On | 850 | μA |
| MCU monitoring triggers | Wakeup timer | - | Insignificant | |
| | GPIO36 GPIO38 GPIO39 ADC2[b] ADC3[b] | Configured as open (default) | Insignificant | |
| | | Other (Configured as closed and/or dependent on external circuitry design.) | $\leq 50$ | μA |

a.  All values are preliminary, subject to change.
b.  Current consumption is affected by the interval between successive ADC measurements—longer intervals result in lower current consumption.

# 3.3 RF

This section presents the module's WWAN RF interface, and defines the specifications for the LTE, HSPA, WCDMA, GSM, and CDMA interfaces for supporting modules.

*Note:  RF sensitivity values presented in this section are for soldered-down modules. Sensitivity values decrease for modules installed in snap-in sockets.*

AirPrime WP75xx/AirPrime WP8548 embedded modules are designed to be compliant with the standards in Table 3-11.

**Table 3-11:  Standards Compliance**

| Technology | Standards | WP7502 | WP7504 | WP8548 |
|---|---|---|---|---|
| LTE | • 3GPP Release 9 | Yes | Yes | |
| UMTS (WCDMA) | • 3GPP Release 8 | Yes | Yes | Yes |
| CDMA | • 3GPP2 C.S0011-D <br>• 3GPP2 C.S0033-C | | Yes | |
| GSM/GPRS/EDGE | • 3GPP Release 8 | Yes | | Yes |

## 3.3.1 GSM RF Interface

This section presents the GSM RF specification for AirPrime WP7502 and AirPrime WP8548 modules.

### 3.3.1.1 GSM Tx Output Power

The module's GSM maximum transmitter output power is specified in Table 3-12.

**Table 3-12:  Conducted Tx Max Output Power Tolerances — GSM[a]**

| RF band | Min | Typ | Max | Units | Notes | WP7502 | WP7504 | WP8548 |
|---|---|---|---|---|---|---|---|---|
| GSM 850 | 31 | 32 | 33 | dBm | GMSK mode (Power class 4; 2 W; 33 dBm) | | | Yes |
| E-GSM 900 | 31 | 32 | 33 | dBm | | Yes | | Yes |
| DCS 1800 | 28 | 29 | 30 | dBm | GMSK mode (Power class 1; 1 W, 30 dBm) | Yes | | Yes |
| PCS 1900 | 28 | 29 | 30 | dBm | | | | Yes |
| GSM 850 | 25.5 | 26.5 | 27.5 | dBm | 8PSK mode (Power class E2; 0.5 W; 27 dBm) | | | Yes |
| E-GSM 900 | 25.5 | 26.5 | 27.5 | dBm | | Yes | | Yes |
| DCS 1800 | 24.5 | 25.5 | 26.5 | dBm | 8PSK mode (Power class E2; 0.4 W, 26 dBm) | Yes | | Yes |
| PCS 1900 | 24.5 | 25.5 | 26.5 | dBm | | | | Yes |

a.  Stated power tolerances satisfy 3GPP TS 51.010-1 requirements for normal (25°C) conditions.

### 3.3.1.2 GSM Rx Sensitivity

The module's GSM receiver sensitivity is specified in Table 3-13 (WP7502) and Table 3-14 (WP8548).

**Table 3-13: WP7502 Conducted Rx Sensitivity — GSM/EDGE Bands[a,b]**

| GSM/EDGE Bands | | | Sensitivity @ +25°C (dBm)[c] | Sensitivity @ Class A (dBm)[d] | Standard Limit (dBm) |
|---|---|---|---|---|---|
| EGSM 900 | 2.44% BER CS | CS | -110.2 | -109.8 | -102 |
| | 10% BLER | GMSK CS1 | -114.0 | -113.2 | -102 |
| | 10% BLER | EDGE MCS5 | -105.5 | -104.5 | -98 |
| DCS 1800 | 2.44% BER CS | CS | -107.6 | -107.4 | -102 |
| | 10% BLER | GMSK CS1 | -111.2 | -110.1 | -102 |
| | 10% BLER | EDGE MCS5 | -102.9 | -101.5 | -98 |

a. All values are preliminary.
b. Stated sensitivity values satisfy 3GPP TS 51.010-1 requirements for normal (25°C) and Class A (extreme) conditions.
c. Typical value
d. Typical value, tested at Class A extreme condition

**Table 3-14: WP8548 Conducted Rx Sensitivity — GSM/EDGE Bands[a]**

| GSM/EDGE Bands | | | Sensitivity @ +25°C (dBm)[b] | Sensitivity @ Class A (dBm)[c] | Standard Limit (dBm) |
|---|---|---|---|---|---|
| GSM 850 | 2.44% BER CS | CS | -109 | -108 | -102 |
| | 10% BLER | GMSK CS1 | -113 | -112 | -102 |
| | 10% BLER | EDGE MCS5 | -105 | -104 | -98 |
| EGSM 900 | 2.44% BER CS | CS | -109 | -108 | -102 |
| | 10% BLER | GMSK CS1 | -113 | -112 | -102 |
| | 10% BLER | EDGE MCS5 | -105 | -104 | -98 |
| DCS 1800 | 2.44% BER CS | CS | -108 | -107 | -102 |
| | 10% BLER | GMSK CS1 | -112 | -111 | -102 |
| | 10% BLER | EDGE MCS5 | -104 | -103 | -98 |
| PCS 1900 | 2.44% BER CS | CS | -108 | -107 | -102 |
| | 10% BLER | GMSK CS1 | -112 | -111 | -102 |
| | 10% BLER | EDGE MCS5 | -104 | -103 | -98 |

a. Stated sensitivity values satisfy 3GPP TS 51.010-1 requirements for normal (25°C) and Class A (extreme) conditions.
b. Typical value
c. Typical value, tested at Class A extreme condition

## 3.3.2 WCDMA RF Interface

This section presents the WCDMA RF specification for AirPrime WP75xx and AirPrime WP8548 modules.

### 3.3.2.1 WCDMA Tx Output Power

The module's WCDMA maximum transmitter output power is specified in Table 3-15.

**Table 3-15: Conducted Tx Max Output Power Tolerances — WCDMA[a]**

| RF band | Min | Typ | Max | Units | Notes | WP7502 | WP7504 | WP8548 |
|---------|-----|-----|-----|-------|-------|--------|--------|--------|
| B1 | 22 | 23 | 24 | dBm | Power class 3 | Yes | | Yes |
| B2 | 22 | 23 | 24 | dBm | Power class 3 | | Yes | Yes |
| B4 | 22 | 23 | 24 | dBm | Power class 3 | | Yes | |
| B5 | 22 | 23 | 24 | dBm | Power class 3 | | Yes | Yes |
| B6 | 22 | 23 | 24 | dBm | Power class 3 | | | Yes |
| B8 | 22 | 23 | 24 | dBm | Power class 3 | Yes | | Yes |
| B19 | 22 | 23 | 24 | dBm | Power class 3 | | | Yes |

a. Stated power tolerances satisfy 3GPP TS 34.121-1 requirements for normal (25°C) conditions.

### 3.3.2.2 WCDMA Rx Sensitivity

The module's GSM receiver sensitivity is specified in Table 3-16 (WP7502), Table 3-17 (WP7504) and Table 3-14 (WP8548).

**Table 3-16: WP7502 Conducted Rx Sensitivity — WCDMA Bands[a,b]**

| Band | +25°C | | Class A | | Standard Limit (dBm) | Notes |
|------|-------|-----|---------|-----|------|-------|
| | Primary (dBm)[c] | Secondary (dBm)[c] | Primary (dBm)[d] | Secondary (dBm)[d] | | |
| B1 | -111.3 | -111.2 | -110.5 | -111.5 | -106 | CS 0.1% BER 12.2 kbps Reference Measurement Channel |
| B8 | -112.1 | -112.3 | -111.6 | -110.4 | -103 | |

a. All values are preliminary.
b. Stated sensitivity values satisfy 3GPP TS 34.121-1 V8.10.0 requirements for normal (25°C) and Class A (extreme) conditions.
c. Typical value
d. Typical value, tested at Class A extreme condition

**Table 3-17: WP7504 Conducted Rx Sensitivity — WCDMA Bands[a,b]**

| Band | +25°C | | Class A | | Standard Limit (dBm) | Notes |
|------|-------|------|---------|------|------|------|
| | Primary (dBm)[c] | Secondary (dBm)[c] | Primary (dBm)[d] | Secondary (dBm)[d] | | |
| B2 | -110.2 | -110.3 | -109.3 | -109.5 | -104 | CS 0.1% BER 12.2 kbps Reference Measurement Channel |
| B4 | -110.1 | -112.0 | -109.3 | -111.0 | -106 | |
| B5 | -111.9 | -111.8 | -110.8 | -110.8 | -104 | |

a. All values are preliminary.
b. Stated sensitivity values satisfy 3GPP TS 34.121-1 V8.10.0 requirements for normal (25°C) and Class A (extreme) conditions.
c. Typical value
d. Typical value, tested at Class A extreme condition

**Table 3-18: WP8548 Conducted Rx Sensitivity — WCDMA Bands[a]**

| Band | Sensitivity @ +25°C (dBm)[b] | Sensitivity @ Class A (dBm)[c] | Standard Limit (dBm) | Notes |
|------|------|------|------|------|
| B1 | -109 | -108 | -106 | CS 0.1% BER 12.2 kbps Reference Measurement Channel |
| B2 | -110 | -109 | -104 | |
| B5 | -111 | -110 | -104 | |
| B6 | -111 | -110 | -106 | |
| B8 | -111 | -110 | -103 | |
| B19 | -111 | -110 | -106 | |

a. Stated sensitivity values satisfy 3GPP TS 34.121-1 V8.10.0 requirements for normal (25°C) and Class A (extreme) conditions.
b. Typical value
c. Typical value, tested at Class A extreme condition

## 3.3.3 CDMA RF Interface

This section presents the CDMA RF specification for AirPrime WP7504 modules.

### 3.3.3.1 CDMA Tx Output Power

The module's CDMA maximum transmitter output power is specified in Table 3-19.

**Table 3-19: WP7504 Conducted Tx Max Output Power Tolerances—CDMA[a]**

| RF band | Operating condition | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|---|
| BC0 | Normal (25°C) | 22 | 23 | 24 | dBm | ERP_min: -7 dBW (0.2W) with antenna gain > 3 dBi |
| BC1 | Normal (25°C) | 22 | 23 | 24 | dBm | EIRP_min: -7 dBW (0.2W) with antenna gain > 1 dBi |
| BC10 | Normal (25°C) | 22 | 23 | 24 | dBm | ERP_min: -7 dBW (0.2W) with antenna gain > 3 dBi |

a. Stated power tolerances are compliant with 3GPP2 ERP/EIRP specifications.

### 3.3.3.2 CDMA Rx Sensitivity

The module's CDMA receiver sensitivity is specified in Table 3-20.

**Table 3-20: Conducted Rx Sensitivity—CDMA Bands [a,b,c]**

| | Band | +25°C Primary (dBm)[d] | +25°C Secondary (dBm)[d] | Class A Primary (dBm)[e] | Class A Secondary (dBm)[e] | Standard Limit (dBm) |
|---|---|---|---|---|---|---|
| BC0 | CDMA 1x[f] | -109.1 | -109.5 | -108.0 | -108.6 | -104.0 |
| | EVDO rev A[g] | -110.8 | n/a | -109.8 | n/a | -104.0 |
| BC1 | CDMA 1x[f] | -107.7 | -108.4 | -107.0 | -107.2 | -104.0 |
| | EVDO rev A[g] | -109.6 | n/a | -108.6 | n/a | -104.0 |
| BC10 | CDMA 1x[f] | -108.7 | -110.0 | -107.9 | -108.8 | -104.0 |

a. All values are preliminary.
b. Stated sensitivity values satisfy 3GPP2 specifications.
c. CS 0.1% BER 12.2 kbps Reference Measurement Channel
d. Typical value
e. Typical value, tested at Class A extreme condition
f. CDMA 1x 0.5% FER
g. EVDO rev A 0.5% PERS

# 3.3.4 LTE RF Interface

This section presents the LTE RF specification for AirPrime WP75xx modules.

## 3.3.4.1 LTE Tx Output Power

The module's LTE maximum transmitter output power is specified in Table 3-21 (WP7502) and Table 3-22 (WP7504).

**Table 3-21: WP7502 Conducted Tx Max Output Power Tolerances — LTE[a]**

| RF band | Operating condition | Min | Typ | Max | Units | Notes |
|---------|--------------------|-----|-----|-----|-------|-------|
| B1 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B3 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B7 | Normal (25°C) | 21 | 22 | 23 | dBm | Power class 3 |
| B8 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B20 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |

a. Stated power tolerances satisfy 3GPP TS 36.521-1 requirements for normal (25°C) and Class A (extreme) conditions.

**Table 3-22: WP7504 Conducted Tx Max Output Power Tolerances — LTE[a]**

| RF band | Operating condition | Min | Typ | Max | Units | Notes |
|---------|--------------------|-----|-----|-----|-------|-------|
| B2 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B4 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B5 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B12 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B17 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B25 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |
| B26 | Normal (25°C) | 22 | 23 | 24 | dBm | Power class 3 |

a. Stated power tolerances satisfy 3GPP TS 36.521-1 requirements for normal (25°C) and Class A (extreme) conditions.

## 3.3.4.2 LTE Rx Sensitivity

The module's LTE receiver sensitivity is specified in Table 3-23 (WP7502) and Table 3-24 (WP7504).

**Table 3-23: WP7502 Conducted Rx Sensitivity—LTE Bands**

| LTE bands | | +25°C (dBm) | | | Class A (dBm) | | | SIMO (Worst case)[a] |
|---|---|---|---|---|---|---|---|---|
| | | Primary (Typical) | Secondary (Typical) | SIMO (Typical) | Primary (Typical) | Secondary (Typical) | SIMO (Typical) | |
| B1 | Full RB BW: 10 MHz[b] | -98.7 | -98.9 | -101.8 | -98.1 | -97.9 | -100.9 | -96.3 |
| B3 | | -97.5 | -97.6 | -100.5 | -98.1 | -96.7 | -100.2 | -93.3 |
| B7 | | -96.9 | -97.0 | -99.6 | -96.3 | -96.0 | -98.9 | -94.3 |
| B8 | | -99.2 | -99.9 | -102.4 | -98.6 | -98.9 | .-101.7 | -93.3 |
| B20 | | -98.9 | -97.5 | -101.6 | -98.9 | -97.5 | .-100.9 | -93.3 |

a. Per 3GPP specification.
b. Sensitivity values scale with bandwidth:
   x_MHz_Sensitivity = 10_MHz_Sensitivyt - 10*log(10 MHz/x_MHz)
   Note: Bandwidth support is dependent on firmware version.

**Table 3-24: WP7504 Conducted Rx Sensitivity—LTE Bands**

| LTE bands | | +25°C (dBm) | | | Class A (dBm) | | | SIMO (Worst case)[a] |
|---|---|---|---|---|---|---|---|---|
| | | Primary (Typical) | Secondary (Typical) | SIMO (Typical) | Primary (Typical) | Secondary (Typical) | SIMO (Typical) | |
| B2 | Full RB BW: 10 MHz[b] | -97.4 | -98.1 | -100.8 | -96.5 | -97.0 | -99.9 | -94.3 |
| B4 | | -97.8 | -99.5 | -101.7 | -97.1 | -98.6 | -101.0 | -96.3 |
| B5 | | -99.1 | -99.5 | -102.5 | -97.9 | -98.6 | -101.2 | -94.3 |
| B12 | | -98.8 | -100.4 | -102.8 | -98.1 | -99.7 | -102.0 | -93.3 |
| B17 | | -98.4 | -100.3 | -102.6 | -98.1 | -100.0 | -101.9 | -93.3 |
| B25 | | -97.4 | -98.0 | -100.7 | -96.5 | -96.9 | -99.3 | -92.8 |
| B26 | | -98.9 | -99.5 | -102.3 | -97.9 | -98.6 | -101.3 | -93.8 |

a. Per 3GPP specification.
b. Sensitivity values scale with bandwidth:
   x_MHz_Sensitivity = 10_MHz_Sensitivyt - 10*log(10 MHz/x_MHz)
   Note: Bandwidth support is dependent on firmware version.

# 3.3.5 WWAN Antenna Interface

The following tables define the WWAN antenna interfaces of the AirPrime WP75xx and AirPrime WP8548.

**Table 3-25:  WP75xx WWAN Antenna Interface Pins**

| Pin # | Signal name | Direction | Function |
|---|---|---|---|
| 30 | GND | | Diversity Antenna Ground |
| 31 | RF_DIV | Input | Diversity Antenna Interface |
| 32 | GND | | Diversity Antenna Ground |
| 48 | GND | | Primary Antenna Ground |
| 49 | RF_MAIN | Input/Output | Primary Antenna Interface |
| 50 | GND | | Primary Antenna Ground |
| 111 | GND | | Diversity Antenna Ground |
| 113 | GND | | Diversity Antenna Ground |
| 136 | GND | | Primary Antenna Ground |
| 139 | GND | | Primary Antenna Ground |

**Table 3-26:  WP8548 WWAN Antenna Interface Pins**

| Pin # | Signal name | Direction | Function |
|---|---|---|---|
| 48 | GND | | Primary Antenna Ground |
| 49 | RF_MAIN | Input/Output | Primary Antenna Interface |
| 50 | GND | | Primary Antenna Ground |
| 136 | GND | | Primary Antenna Ground |
| 139 | GND | | Primary Antenna Ground |

## 3.3.5.1 WWAN Antenna Recommendations

Table 3-27 defines the key characteristics to consider for antenna selection.

**Table 3-27:  Antenna Recommendations[a,b]**

| Parameter | | Recommendations | Comments |
|---|---|---|---|
| Antenna system | | External multi-band antenna system | WP75xx—Dual WWAN antennas for diversity (Antenna 1/Antenna 2)[c]<br>• WP8548—Single WWAN antenna |
| **Important:** *Some specifications are not compatible with each other—the 3GPP specification for GSM/WCDMA/LTE max conducted power range, the 3GPP2 specification for CDMA/EVDO max radiated power range, and FCC radiated limits. As a result, the antennas that are used with WP8548 and WP7502 must meet different peak gains—gain > 3dBi for WP7504 in CDMA BC0/10, and gain < 3dBi for WP8548 in WCDMA/GSM 850/1900 MHz.* | | | |
| Operating bands | WP7502 (Antenna 1) | 791–960 MHz | Operating bands depend on the module's supported bands/modes. |
| | | 1710–1980 MHz | |
| | | 2110–2170 MHz | |
| | | 2500–2690 MHz | |
| | WP7502 (Antenna 2) | 791–960 MHz | Operating bands depend on the module's supported bands/modes. |
| | | 1805–1880 MHz | |
| | | 2110–2170 MHz | |
| | | 2620–2690 MHz | |
| | WP7504 (Antenna 1) | 699–894 MHz | Operating bands depend on the module's supported bands/modes. |
| | | 1710–1995 MHz | |
| | | 2110–2155 MHz | |
| | WP7504 (Antenna 2) | 729–894 MHz | Operating bands depend on the module's supported bands/modes. |
| | | 1930–1995 MHz | |
| | | 2110–2155 MHz | |
| | WP8548 | 824–960 MHz | Operating bands depend on the module's supported bands/modes. |
| | | 1710–1990 MHz | |
| | | 2110–2170 MHz | |
| VSWR | | < 2.5:1 (worst case) | • 1:1 (ideal)<br>• On all bands including band edges<br>• WP75xx—Applies to both antennas |

**Table 3-27: Antenna Recommendations[a,b] (Continued)**

| Parameter | | Recommendations | Comments |
|---|---|---|---|
| Total radiated efficiency | | > 50% on all bands | • Measured at the RF connector.<br>• WP75xx—Applies to both antennas<br>• Includes mismatch losses, losses in the matching circuit, and antenna losses, excluding cable loss.<br>• Sierra Wireless recommends using antenna efficiency as the primary parameter for evaluating the antenna system.<br>• Peak gain is not a good indication of antenna performance when integrated with a host device (the antenna does not provide omnidirectional gain patterns). Peak gain can be affected by antenna size, location, design type, etc.—the antenna gain pattern remains fixed unless one or more of these parameters change. |
| Radiation patterns | | Nominally omnidirectional radiation pattern in azimuth plane. | • WP75xx—Applies to both antennas |
| Envelope correlation coefficient between Antenna 1 and Antenna 2 | WP7502 | • < 0.4 on 791–821 MHz and 925–960 MHz bands<br>• < 0.2 on 1805–1880 MHz, 2110–2170 MHz, and 2620–2690 MHz bands | |
| | WP7504 | • < 0.4 on 729–746 MHz and 859–894 MHz bands<br>• < 0.2 on 1930–1995 MHz and 2110–2155 MHz bands | |
| Mean Effective Gain (MEG) | | ≥ -3 dBi | • WP75xx—Applies to both antennas (Antenna 1—MEG1, Antenna 2—MEG2) |
| Mean Effective Gain Imbalance— Antenna 1 and Antenna 2 (MEG1 / MEG2) | WP75xx | < 6 dB for diversity operation | |
| Maximum antenna gain | | Must not exceed antenna gains due to RF exposure and ERP/ EIRP limits, as listed in the module's FCC grant. | |
| Isolation between Antenna 1 and Antenna 2 (S21) | WP75xx | > 10 dB | • If antennas can be moved, test all positions for both antennas.<br>• Unless otherwise specified, this isolation requirement must be maintained for optimum operation.<br>• Make sure all other wireless devices (Bluetooth or WLAN antennas, etc.) are turned OFF to avoid interference. |

**Table 3-27: Antenna Recommendations[a,b] (Continued)**

| Parameter | Recommendations | Comments |
|---|---|---|
| Maximum voltage applied to antenna | 6.3 VDC | |
| Power handling | • > 2 W RF power on low bands<br>• > 1 W on high bands | • Measure power endurance over 4 hours (estimated talk time) using a 2 W CW signal—set the CW test signal frequency to the middle of the PCS Tx band (1880 MHz for PCS).<br>• Visually inspect device to ensure there is no damage to the antenna structure and matching components.<br>• VSWR/TIS/TRP measurements taken before and after this test must show similar results. |

a. These worst-case VSWR figures for the transmitter bands may not guarantee RSE levels to be within regulatory limits. The device alone meets all regulatory emissions limits when tested into a cabled (conducted) 50 ohm system. With antenna designs with up to 2.5:1 VSWR or worse, the radiated emissions could exceed limits. The antenna system may need to be tuned in order to meet the RSE limits as the complex match between the module and antenna can cause unwanted levels of emissions. Tuning may include antenna pattern changes, phase/delay adjustment, passive component matching. Examples of the application test limits would be included in FCC Part 22, Part 24 and Part 27, test case 4.2.16 for GSM (ETSI EN 301 511), and test case 4.2.2 for WCDMA (ETSI EN 301 908-1), where applicable.

b. All values are preliminary and subject to change.

c. Antenna 1—Primary (RF_MAIN), Antenna 2 (WP75xx only)—Secondary (RF_DIV) (Diversity)

# 3.4 GNSS

*Note: GNSS is supported on AirPrime WP8548 modules, and is a SKU-dependent feature on AirPrime WP75xx modules.*

The AirPrime WP75xx/AirPrime WP8548 includes Global Navigation Satellite System (GNSS) capabilities via the QUALCOMM IZat™ Gen8A Engine (formerly gpsOne), capable of operation in assisted and standalone GNSS modes (GPS/Galileo/GLONASS).

## 3.4.1 GNSS Characteristics

The GNSS implementation supports GPS L1, Galileo E1, and GLONASS L1 FDMA operation.

*Note: RF sensitivity values presented in this section are for soldered-down modules. Sensitivity values decrease for modules installed in snap-in sockets.*

**Table 3-28: GNSS Characteristics [a]**

| Parameter | | Value |
|---|---|---|
| Sensitivity | Standalone or MS-based tracking sensitivity | -161 dB |
| | Cold start sensitivity | -145 dB |
| | MS-assisted GNSS acquisition sensitivity | -158 dBm |
| Accuracy in open sky (1 Hz tracking) | | < 2 m CEP-50 |
| Satellite channels available[b] | Acquisition | 118 |
| | Simultaneous tracking | 40 |
| Support for predicted orbits | | Yes |
| Predicted orbit CEP-50 accuracy | | 5 m |
| Standalone Time To First Fix (TTFF) | Hot | 1 s |
| | Warm | 29 s |
| | Cold | 32 s |
| GNSS message protocols | | NMEA |

a.  WP7502/WP7504—All values are preliminary and subject to change.
b.  Resources are dynamically assigned and not constellation-specific.

*Note: Acquisition/tracking sensitivity performance figures assume open sky with active patch GNSS antenna and a 2.5 dB noise figure.*

# 3.4.2 GNSS Antenna Interface

The GNSS antenna interface is defined in Table 3-29.

**Table 3-29: GNSS Antenna Interface Pads**

| Pad | Name | Direction[a] | Function |
|---|---|---|---|
| 37 | GND | | GNSS Antenna Ground |
| 38 | RF_GNSS | Input | GNSS Antenna Interface |
| 39 | GND | | GNSS Antenna Ground |
| 125 | GND | | GNSS Antenna Ground |
| 128 | GND | | GNSS Antenna Ground |

a.  Signal direction with respect to the module.

*Note: On WP75xx modules, GNSS functionality is available on the dedicated GNSS antenna only; it is not available on the diversity antenna.*

## 3.4.2.1 GNSS Antenna Recommendations

Table 3-30 defines the key characteristics to consider for antenna selection.

**Table 3-30:  GNSS Standalone Antenna Recommendations[a]**

| Parameter | Recommendations | Notes |
|---|---|---|
| Frequency range | • Wide-band GPS, Galileo, and GLONASS: 1573–1606 MHz recommended<br>• Narrow-band GPS: 1575.42 MHz ± 2.046 MHz minimum | |
| Field of view (FOV) | • Omni-directional in azimuth<br>• -45° to +90° in elevation | |
| Polarization (average Gv/Gh) | > 0 dB | Vertical linear polarization is sufficient. |
| Free space average gain (Gv+Gh) over FOV | > -6 dBi (preferably > -3 dBi) | Gv and Gh are measured and averaged over -45° to +90° in elevation, and ±180° in azimuth. |
| Gain | • Maximum gain and uniform coverage in the high elevation angle and zenith.<br>• Gain in azimuth plane is not desired. | |
| Average 3D gain | > -5 dBi | |
| Isolation between GNSS and RF Antenna | > 10 dB in all uplink bands | |
| Typical VSWR | < 2.5:1 | |
| Polarization | Any other than LHCP (left-hand circular polarized) is acceptable. | Type of antenna and polarization (RHCP/ linear) to be implemented is a matter of consideration based on specific end application. |
| Maximum voltage applied to antenna | 6.3 VDC | |
| 700 MHz harmonic[b] | < -56 dBm (input jammer 787.76 MHz at -25 dBm and measure the harmonic tone at 1575.42 MHz) | This specification is for B13 coexistence. |
| IIP2[b] | > 45 dBm (Input jammers at 824.6 MHz with level -25 dBm and 2400 MHz with level -32 dBm and measure output IM2 at 1575.4 MHz) | Out of band |
| IIP3[b] | > 2 dBm (Input jammers at 1712.7 MHz with level -20 dBm and 1850 MHz with level -65 dBm and measure output IM3 at 1575.4 MHz) | Out of band |
| Input 1 dB power compression point[b] | > -10 dBm | |

**Table 3-30: GNSS Standalone Antenna Recommendations[a] (Continued)**

| Parameter | Recommendations | Notes |
|---|---|---|
| Out of band rejection for an active antenna | | |
| 777–798 MHz | > 50 dB | |
| 814–915 MHz | > 40 dB | 50 dB is preferred |
| 925–960 MHz | > 30 dB | 50 dB is preferred |
| 1427–1463 MHz | > 35 dB | |
| 1710–1785 MHz | > 35 dB | |
| 1850–1980 MHz | > 40 dB | |
| 2010–2025 MHz | > 40 dB | |
| 2305–2315 MHz | > 40 dB | |
| 2401–2483 MHz | > 40 dB | |
| 2500–2570 MHz | > 35 dB | |

a. All values are preliminary and subject to change.
b. For the LNA used by an active antenna

# 3.5 Electrical Specifications

This section provides details of the key electrical specifications of the AirPrime WP75xx/AirPrime WP8548 embedded module.

## 3.5.1 Absolute Maximum Ratings

This section defines the absolute maximum ratings of the AirPrime WP75xx/AirPrime WP8548.

**Warning:** *If these parameters are exceeded, even momentarily, damage may occur to the device. In addition, extended application of Absolute Maximum Rating conditions to the device may reduce device reliability.*

*Note: Operation above the maximum specified operating voltage (see Table 3-4 on page 36) is not recommended, and specified typical performance or functional operation of the device is neither implied nor guaranteed.*

**Table 3-31: Absolute Maximum Ratings [a]**

| Parameter | | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Power supply voltages | | | | | | |
| VBAT_BB/ VBAT_RF | Power Supply Input | WP7502 | -0.3 | - | 4.6 | V |
| | | WP7504 | -0.3 | - | 5.5 | V |
| | | WP8548 | -0.3 | - | 6.0 | V |
| VDD_Px (low-voltage operation) | Digital pad circuits | | - | - | 2.2 | V |
| VDD_Px (high-voltage operation) | Digital pad circuits | | - | - | 3.05 | V |
| USB signal pins | | | | | | |
| USB_D+ | High-speed USB data plus | | - | - | 5.25 | V |
| USB_D- | High-speed USB data minus | | - | - | 5.25 | V |
| USB_VBUS | High-speed USB bus voltage | | - | - | 5.25 | V |
| Thermal conditions | | | | | | |
| TS | Storage temperature | | -40 | | 85 | °C |
| TJ | Junction temperature | | - | - | 130 | °C |
| Maximum voltage applied to antenna interface pins | | | | | | |
| VANT | RF_MAIN | | - | | 6.3 | Vdc |
| | RF_DIV (WP75xx only) | | - | | 6.3 | Vdc |
| | RF_GNSS | | - | | 6.3 | Vdc |
| ESD ratings | | | | | | |
| See EMC and ESD Recommendations on page 97. | | | | | | |

a.   All values are preliminary and subject to change.

## 3.5.2 Digital I/O Characteristics

The I/O characteristics for supported digital interfaces are described in:
- Table 3-32—HSIC signals
- Table 3-33—GPIOs, UART, ANT_CNTL, TX_ON, and PCM/I²S signals
- Table 3-34—SDIO signals

**Table 3-32: Digital I/O Characteristics ($V_{DD\_PX}$ = 1.20 V (nominal)) [a]**

| Parameter | | Comments | Min | Max | Units |
|---|---|---|---|---|---|
| $V_{IH}$ | High level input voltage | CMOS | $0.65 * V_{DD\_PX}$ | - | V |
| $V_{IL}$ | Low level input voltage | CMOS | - | $0.35 * V_{DD\_PX}$ | V |

**Table 3-32: Digital I/O Characteristics (V$_{DD\_PX}$ = 1.20 V (nominal)) (Continued)[a]**

| | Parameter | Comments | Min | Max | Units |
|---|---|---|---|---|---|
| I$_{IH}$ | Input high leakage current[b] | No pull-down | - | 2 | μA |
| I$_{IL}$ | Input low leakage current[c] | No pull-up | -2 | - | μA |
| RPHS IC | HSIC pull up/down resistance | For HSIC_STRB and HSIC_DATA pins | 17 | 60 | kΩ |
| RKHS IC | HSIC keeper resistance | For HSIC_STRB and HSIC_DATA pins | 17 | 60 | kΩ |
| V$_{OH}$ | High level output voltage | CMOS, at pin-rated drive strength | 0.9 * V$_{DD\_PX}$ | - | V |
| V$_{OL}$ | Low level output voltage | CMOS, at pin-rated drive strength | - | 0.1 * V$_{DD\_PX}$ | V |
| I$_{OZH}$ | Tri-state leakage current[b] | Logic high output | - | 1 | μA |
| I$_{OZL}$ | Tri-state leakage current[b] | Logic low output | -1 | - | μA |
| C$_{IN}$ | Input capacitance[d] | | 1 | 2 | pF |
| C$_{I/O}$ | I/O capacitance[d] | I/O pins | 1.25 | 2.5 | pF |

a. All values are preliminary and subject to change.
b. Pin voltage = V$_{DD\_PX}$ max.
c. Pin voltage = GND and supply = V$_{DD\_PX}$ max.
d. Input capacitance and I/O capacitance values are guaranteed by design, but is not 100% tested.

**Table 3-33: Digital I/O Characteristics (V$_{DD\_PX}$ = 1.80 V (nominal)) [a]**

| | Parameter | Comments | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| V$_{IH}$ | High level input voltage | CMOS/Schmitt | 0.65 * V$_{DD\_PX}$ | - | V$_{DD\_PX}$ + 0.3 | V |
| V$_{IL}$ | Low level input voltage | CMOS/Schmitt | -0.3 | - | 0.35 * V$_{DD\_PX}$ | V |
| V$_{SHYS}$ | Schmitt hysteresis voltage | | 100 | - | - | mV |
| I$_{IH}$ | Input high leakage current[b] | No pull-down | - | | 1 | μA |
| I$_{IL}$ | Input low leakage current[c] | No pull-up | -1 | | - | μA |
| R$_P$ | Pull up/down resistance | | 55 | | 390 | kΩ |
| V$_{OH}$ | High level output voltage | CMOS, at pin-rated drive strength | V$_{DD\_PX}$ - 0.45 | - | V$_{DD\_PX}$ | V |
| V$_{OL}$ | Low level output voltage | CMOS, at pin-rated drive strength | 0 | - | 0.45 | V |
| I$_{OZH}$ | Tri-state leakage current[b] | Logic high output, no pull-down | - | | 1 | μA |
| I$_{OZL}$ | Tri-state leakage current[c] | Logic low output, no pull-up | -1 | | - | μA |

**Table 3-33: Digital I/O Characteristics (V$_{DD\_PX}$ = 1.80 V (nominal)) (Continued)[a]**

| Parameter | | Comments | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| R$_K$ | Keeper resistance | | 30 | | 150 | kΩ |
| I$_{ISL}$ | Sleep crystal input leakage | | -0.15 | - | 0.15 | μA |
| I$_{IHVKP}$ | High-V tolerant input leakage | With keeper | -1 | - | - | μA |
| C$_{IN}$ | Input capacitance[d] | | - | - | 5 | pF |
| I$_{PIN}$ | Current per pin | | - | - | 16 | mA |

a. All values are preliminary and subject to change.
b. Pin voltage = V$_{DD\_PX}$ max. For keeper pins, pin voltage = V$_{DD\_PX}$ max - 0.45 V.
c. Pin voltage = GND and supply = V$_{DD\_PX}$ max. For keeper pins, pin voltage = 0.45 V and supply = V$_{DD\_PX}$ max.
d. Input capacitance is guaranteed by design, but is not 100% tested.

**Table 3-34: Digital I/O Characteristics (V$_{DD\_PX}$ = 2.95 V (nominal) signals) [a]**

| Parameter | | Comments | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| V$_{IH}$ | High level input voltage | CMOS/Schmitt | 0.65 * V$_{DD\_PX}$ | - | V$_{DD\_PX}$ + 0.3 | V |
| V$_{IL}$ | Low level input voltage | CMOS/Schmitt | -0.3 | - | 0.25 * V$_{DD\_PX}$ | V |
| V$_{SHYS}$ | Schmitt hysteresis voltage | | 100 | - | - | mV |
| I$_{IH}$ | Input high leakage current[b] | No pull-down | - | | 10 | μA |
| I$_{IL}$ | Input low leakage current[c] | No pull-up | -10 | | - | μA |
| R$_{PSD}$ | High-V pad pull up/down resistance | For SDIO_CLK, SDIO_CMD, SDIO_DATA[0:3] | 10 | | 100 | kΩ |
| I$_{OZH}$ | Tri-state leakage current[b] | Logic high output, no pull-down | - | | 10 | μA |
| I$_{OZL}$ | Tri-state leakage current[c] | Logic low output, no pull-up | -10 | | - | μA |
| R$_{KSD}$ | High-V pad keeper resistance | For SDIO_CLK, SDIO_CMD, SDIO_DATA[0:3] | 10 | | 100 | kΩ |
| V$_{OH}$ | High-level output voltage | CMOS, at pin-rated drive strength | V$_{DD\_PX}$-0.45 | | V$_{DD\_PX}$ | V |
| V$_{OL}$ | Low-level output voltage | CMOS, at pin-rated drive strength | 0 | | 0.45 | V |
| C$_{IN}$ | Input capacitance[d] | | - | - | 5 | pF |
| I$_{PIN}$ | Current per pin | | - | - | 8 | mA |

a. All values are preliminary and subject to change.
b. Pin voltage = V$_{DD\_PX}$ max. For keeper pins, pin voltage = V$_{DD\_PX}$ max - 0.45 V.
c. Pin voltage = GND and supply = V$_{DD\_PX}$ max. for keeper pins, pin voltage = 0.45 V and supply = V$_{DD\_PX}$ max.
d. Input capacitance is guaranteed by design, but is not 100% tested.

## 3.5.3 Internal Device Frequencies

Table 3-35 summarizes the frequencies generated within the AirPrime WP75xx/ AirPrime WP8548. This table is provided for reference only to the device integrator.

**Table 3-35: Internal Device Frequencies [a]**

| Subsystem/Feature | Frequency | Units |
|---|---|---|
| Real Time Clock | 32.768 | kHz |
| PCM Audio Interface (PCM Master Mode) | • 128<br>• 2048 | kHz |
| $I^2C$ Interface | 400 | kHz |
| PMIC switching power supplies | 1.6 | MHz |
| Fundamental clock | 19.2 | MHz |
| PLL | • PLL0: 276.000<br>• PLL4: 393.216<br>• PLL5: 576.000<br>• PLL6: 460.800<br>• PLL7: 499.200<br>• PLL8: 384.000<br>• PLL9: 440.000 (v1) / 550.000 (v2+)<br>• PLL11: 400.000<br>• PLL14: 480.000 | MHz |
| USB | 480 | Mb/s |

a. All values are preliminary and subject to change.

# 3.6 Processing

## 3.6.1 Application Core

The Application Core is based on a Cortex A5 32-bit RISC architecture core. It has the following main characteristics:
• Up to 550 MHz operation
• Cache: Instruction (32kB) and Data (32kB)

The Application Core supports Legato™, an open source embedded platform built on Linux, which allows the simultaneous safe running of multiple applications.

Refer to Interfaces Specification on page 66 for the list of interfaces supported by this core.

## 3.6.2 Embedded Memory

The AirPrime WP75xx/AirPrime WP8548 module includes Flash and RAM embedded memory as detailed in Table 3-36.

**Table 3-36: Embedded Memory Details[a]**

| Memory | | WP75xx/WP8548 |
|---|---|---|
| Type | Details | |
| Flash | Total | 512 MB |
| | Reserved for Application processor | 256 MB |
| | Minimum number of write cycles | 50,000 |
| RAM | Total | 256 MB |
| | Reserved for Application processor | 128 MB |

a.  Preliminary values, subject to change.

The application processor memory is dedicated to the Legato platform, including:
•    Linux kernel
•    Root file system
•    Application framework
•    Customer applications

# 3.7 Mechanical Drawing

The AirPrime WP75xx/AirPrime WP8548 module's LGA footprint is a 239-pad array of copper pads (see Physical Dimensions and Connection Interface on page 21). The following drawing illustrates the device footprint and dimensions.

*Note: Dimensions in Figure 3-4 are preliminary and subject to change.*



*Figure 3-4: AirPrime WP75xx/AirPrime WP8548 Mechanical Drawings*

# ≫| 4: Interfaces Specification

## 4.1 Overview

This section describes the interfaces supported by the AirPrime WP75xx/AirPrime WP8548 embedded module and provides specific voltage, timing, and circuit recommendations for each interface.

## 4.2 BAT_RTC

The AirPrime WP75xx/AirPrime WP8548 module's internal RTC is powered from the VBAT_BB supply (when available).

The module also provides an interface (BAT_RTC) for using a coin cell to maintain the internal RTC when VBAT_BB is removed from the module. The coin cell can also be charged via BAT_RTC when VBAT_BB is available.

*Note: The coin cell will not charge when the device is in ULPM.*

**Table 4-1:  BAT_RTC Pin**

| Pin | Name | Direction | Function | If Unused |
|-----|------|-----------|----------|-----------|
| 21 | BAT_RTC | Input/Output | Voltage input/Charging output | Leave Open |

**Table 4-2:  BAT_RTC Charging Specifications [a]**

| Specification | | Comments | Min | Typ | Max | Units |
|---------------|---|----------|-----|-----|-----|-------|
| Target regulator voltage[b] | | $V_{IN}$ > 3.3 V, $I_{CHG}$ = 100 µA | 2.5 | - | 3.2 | V |
| Target series resistance[c] | | | 800 | - | 2100 | Ω |
| Coin cell voltage | | | 2.0 | - | 3.25 | V |
| Coin cell charger voltage error | | $I_{CHG}$ = 0 µA | -5 | - | +5 | % |
| Coin cell charger resistor error | | | -20 | - | +20 | % |
| Dropout voltage[d] | | $I_{CHG}$ = 2 mA | - | - | 200 | mV |
| Current draw | Charging | | - | 2.0 | - | mA |
| | Off | | - | 5.0 | 8.0 | µA |
| Ground current, charger enabled | VBAT=3.6V | IC = off; BAT_RTC = open, T=27°C | - | 4.5 | - | µA |
| | VBAT=3.4–4.3 V | | - | - | 8.0 | µA |
| Capacitance | | | - | - | 4.7 | µF |

a.  All values are preliminary and subject to change
b.  Programmable voltage: 2.5/3.0/3.1/3.2
c.  Valid series resistor settings are 800, 1200, 1700, and 2100 Ω
d.  Dropout is measured by reducing the supply voltage (VBAT) from 3.5 V until the charging voltage drops by 100 mV. Then calculate the dropout voltage: $V_{dropout}$ = VBAT - charger output voltage.

# 4.3 POWER_ON_N

The AirPrime WP75xx/AirPrime WP8548 module requires a low level signal (POWER_ON_N) that is used to switch the module ON.

The signal is connected internally to the permanent 1.8V supply regulator inside the module via a pull-up resistor. Once VBAT_BB is supplied to the module, this 1.8V supply regulator will be enabled and so the POWER_ON_N signal is by default at high level. Use a momentary switch to control this line to reduce leakage current in ULPM mode. Holding POWER_ON_N low in ULPM mode incurs a significant current draw—see Table 3-10 on page 45 for details.

Table 4-3 describes the POWER_ON_N signal's characteristics.

**Table 4-3:  POWER_ON_N Electrical Characteristics[a]**

| Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|
| Input Voltage—Low | | - | 0.63 | V |
| Input Voltage—High | 1.7 | - | 1.9 | V |
| POWER_ON_N assertion time[b] | 36.5 | | | ms |

    a.  All values are preliminary and subject to change.
    b.  Assertion time is the time between POWER_ON_N falling to VGPIO going high.

## 4.3.1 Power-up Sequence

### 4.3.1.1 Power On/Off Timing

Figure 4-1 describes the timing sequence for powering the module on and off.
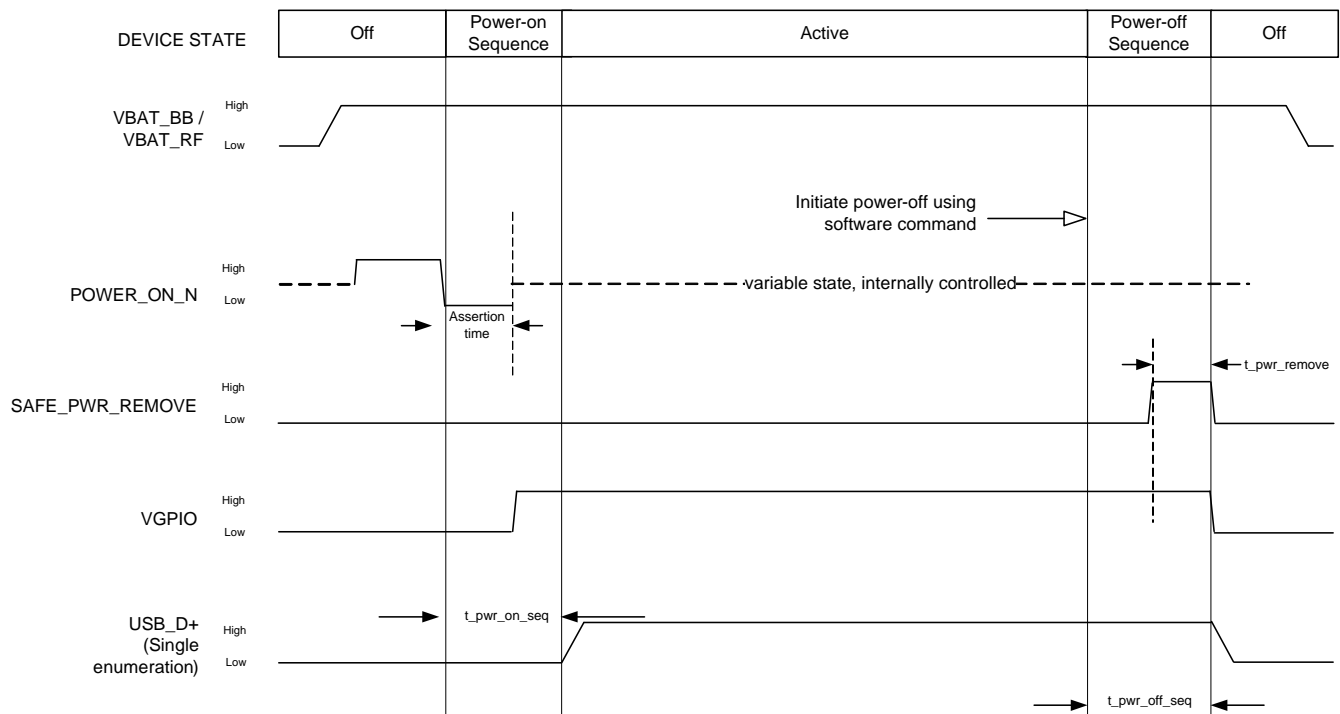


*Figure 4-1:  Signal timing (POWER_ON_N, and USB Enumeration)*

**Table 4-4:  POWER_ON_N Timing Parameters**

| Parameter | Typical | Maximum | Units |
|---|---|---|---|
| t_pwr_on_seq | 14.5 | 15.5 | s |
| t_pwr_off_seq | 0.4–5.5[a] | 6[a] | s |
| t_pwr_remove | 13 | - | ms |

    a.   Preliminary, subject to change

### 4.3.1.2 USB enumeration

The unit supports single USB enumeration with the host. Enumeration starts within (maximum) t_pwr_on_seq seconds of power-on.

## 4.3.2 Software-Initiated Power Down

To power down the module via software:

1. Initiate the power down process:
   **AT!POWERDOWN**

2. Monitor SAFE_PWR_REMOVE.

3. When SAFE_PWR_REMOVE transitions from low to high, remove power.

To power down the module via software:

1. Initiate the power down process:
   **AT!POWERDOWN**

2. Monitor VGPIO.

3. When VGPIO is low, remove power.

# 4.4 Emergency Power Off

The module can be switched off by controlling the RESET_IN_N pin. This must only be used in emergency situations if the system freezes (not responding to commands).

To perform an emergency power off:

1. De-assert POWER_ON_N.

2. While POWER_ON_N is de-asserted, assert RESET_IN_N (logic low) for at least 32 ms. This immediately powers down the module.

# 4.5 USB

The AirPrime WP75xx/AirPrime WP8548 implements one high-speed USB2.0 Interface, which conforms to the *Universal Serial Bus Specification, Revision 2.0*, except for USB_VBUS implementation (not connected internally).

See USB Interface on page 96 for a reference USB schematic.

**Table 4-5: USB Pin Descriptions**

| Pin | Signal name | Direction[a] | Function |
|---|---|---|---|
| 12 | USB_D- | Input/Output | Differential data interface negative |
| 13 | USB_D+ | Input/Output | Differential data interface positive |
| 16 | Reserved | Input | For compatibility with Sierra Wireless HL devices, connect as indicated in the reference USB schematic. |
| 16 | USB_VBUS[b] | Input | USB supply voltage |
| 91 | USB_ID | Input | Used for USB_OTG |

a. Signal direction with respect to the module. Example: USB_ID is an input to the module from the host.
b. Not currently connected internally, but customer solutions should provide this input for compatibility with future module revisions.

# 4.6 UART

The AirPrime WP75xx/AirPrime WP8548 provides two UART interfaces:
• UART1 (primary UART)—8-wire interface
• UART2 (secondary UART)—2-wire interface

The UART interfaces are used for data communication between the AirPrime WP75xx/AirPrime WP8548 module and a PC or host processor. These interfaces comply with the RS-232 interface.

Flow control is managed using the RTS/CTS signals, or using software XON/XOFF.

Table 4-6 on page 70 describes the signals used for UART1 and UART2.

*Note: UART signals are named with respect to the host device, and directions are listed with respect to the module. For example, UART1_RX is an output from the module to the host.*

**Table 4-6: UART Pins**

| Pin | Interface | Name[a] | Direction[b] | Function | If unused |
|---|---|---|---|---|---|
| 2 | UART1 | UART1_RI | Output | Ring Indicator<br>Signal incoming calls (voice and data), SMS, etc. | Leave open |
| 3 | | UART1_RTS | Input | Ready To Send, flow control | Leave open[c] |
| 4 | | UART1_CTS | Output | Clear To Send, flow control | Leave open |
| 5 | | UART1_TX | Input | Transmit Data | Leave open |
| 6 | | UART1_RX | Output | Receive Data | Leave open |
| 7 | | UART1_DTR | Input (active low) | Data terminal ready<br>Prevents the AirPrime WP75xx/ AirPrime WP8548 from entering USB-SS mode, switches between data mode and command mode, and wakes the module. | Leave open |
| 8 | | UART1_DCD | Output | Data Carrier Detect<br>Signal data connection in progress | Leave open |
| 9 | | UART1_DSR | Output | Data Set Ready<br>Signal UART interface is ON | Leave open |
| 96 | UART2 | UART2_TX | Input | Transmit data | Leave open |
| 97 | | UART2_RX | Output | Receive data | Leave open |

a. Signals are named with respect to the host device. For example, UART1_RX is the signal used by the host to receive data from the module.
b. Signal direction with respect to the module. For example, UART1_RX is an output from the module to the host.
c. If UART1 is implemented as a 2-wire interface, UART1_RTS should be pulled low to disable flow control.

# 4.7 UIM interface

The AirPrime WP75xx/AirPrime WP8548 has two physical UIM interfaces—UIM1 and UIM2, which support UIM for WCDMA and GSM.

Both UIM interfaces allow control of external 1.8V/3V UIMs and are fully compliant with GSM 11.11 recommendations concerning UIM functions.

describes the signals used for UIM1 and UIM2.

**Table 4-7: UIM Interface Pins**

| Pin | Interface | Name | Direction[a] | Function | If Unused |
|---|---|---|---|---|---|
| 26 | UIM1 | UIM1_VCC | Output | Supply output | Leave open |
| 27 | | UIM1_CLK | Output | Clock | Leave open |
| 28 | | UIM1_DATA | Input/Output | Data connection | Leave open |
| 29 | | UIM1_RESET_N | Output | Reset | Leave open |
| 64 | | UIM1_DET | Input | Detect UIM | Leave open |
| 55 | UIM2 | UIM2_VCC | Output | Supply output | Leave open |
| 56 | | UIM2_DATA | Input/Output | Data connection | Leave open |
| 57 | | UIM2_RESET_N | Output | Reset | Leave open |
| 58 | | UIM2_CLK | Output | Clock | Leave open |
| 65 | | UIM2_DET | Input | Detect UIM | Leave open |

a. Signal direction with respect to the module. Examples: UIM1_DET (pin 64) is an input to the module from the host; UIM1_RESET_N (pin 29) is an output from the module to the host.

Figure 4-2 illustrates the recommended implementation of a UIM holder. (For a more detailed UIM schematic, see Figure 5-4 on page 98.)
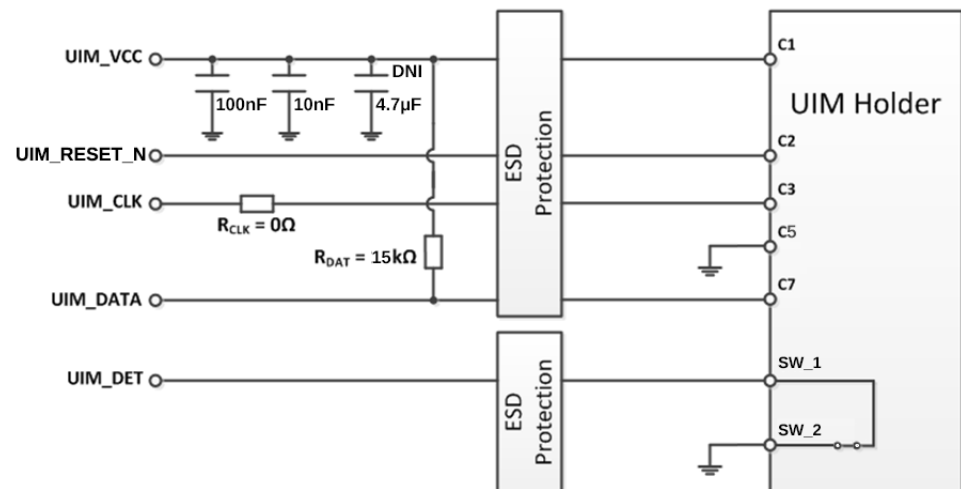


*Figure 4-2: Recommended UIM Holder Implementation*

The UIM Detect signals (UIM1_DET, UIM2_DET) are used to detect the physical presence of a UIM card in the UIM holder. Each UIM Detect signal has a pull-up internal to the AirPrime WP75xx/AirPrime WP8548. It should be set to GND when a UIM is not present. All signals near the UIM holder must be ESD-protected.

The UIM Detect signals transition:
• When a UIM is inserted—high (logic 0 to logic 1)
• When a UIM is removed—low (logic 1 to logic 0)

The capacitor and the two resistors, RCLK and RDAT, should be added as placeholders to compensate for potential layout issues. UIM_DAT trace should be routed away from the UIM_CLK trace. Keep the distance between the module and the UIM holder as short as possible.

An ESD device specifically designed for UIM cards is recommended for the UIM1 and UIM2 VCC, RESET_IN_N, CLK, and DAT signals (for example, STMicroelectronics DALC208SC6). For UIM1_DET/UIM2_DET a low leakage ESD suppressor should be selected.

# 4.8 General Purpose Input/Output (GPIO)

The AirPrime WP75xx/AirPrime WP8548 defines several GPIOs for customer use, as described in Table 4-8. For electrical specifications, see Table 3-33, Digital I/O Characteristics (VDD_PX=1.80 V (nominal)), on page 61.

*Note: In ULPM, all interfaces connected to GPIOs (see Table 4-8 on page 73) must be tri-stated or off to prevent additional leakage current during ULPM and potentially damaging the unit by applying a voltage when the GPIOs are off.*

**Table 4-8: GPIO Pin Description**

| Pin | Signal Name | Default state | Function | If Unused |
|-----|-------------|---------------|----------|-----------|
| 10 | GPIO2[a] | | | |
| 40 | GPIO7 | | | |
| 41 | GPIO8 | | | |
| 44 | GPIO13 | | | |
| 92 | GPIO38[a,b,c] | | | |
| 93 | GPIO39[a,b,c] | | | |
| 94 | GPIO40[c,d] | | | |
| 95 | GPIO41[c,d] | | | |
| 100 | GPIO34[c] | | | |
| 101 | GPIO35[c] | | | |
| 102 | GPIO36[a,b,c] | | | |
| 103 | GPIO37[c] | Input, no pull | General purpose I/O | Leave open |
| 104 | GPIO32 | | | |
| 105 | GPIO33 | | | |
| 109 | GPIO42[a] | | | |
| 147 | GPIO21[a] | | | |
| 148 | GPIO22 | | | |
| 149 | GPIO23 | | | |
| 150 | GPIO24 | | | |
| 153 | GPIO28[e] | | | |
| 154 | GPIO29[e] | | | |
| 155 | GPIO30[e] | | | |
| 156 | GPIO31[e] | | | |
| 159 | GPIO25 | | | |

a. Pin is 'wakeable'. Can be used to trigger the module to wake up from USB-SS mode (low power active state).See Wakeup Interrupt (USB-SS Mode) on page 74 for details.
b. Can be configured as a wakeup trigger for ULPM. See Wakeup Events (ULPM) on page 74 for details.
c. Accessible via sysfs/Legato only.
d. GPIO40 and GPIO41 may be unavailable in future WP products.
e. GPIOs 28–31 are available for use when configured using AT+WIOCFG.

## 4.9 Wakeup Interrupt (USB-SS Mode)

The following pins can be used to wake the device when it is in USB-SS mode (low-power active state):
* GPIO2
* GPIO21
* GPIO36
* GPIO38
* GPIO39
* GPIO42
* UIM1_DET
* UIM2_DET

If the device firmware is monitoring these pins while the device is in USB-SS mode, any transition on these pins will wake the device. (Note: The UIMx_DET pins transition high when a UIM is installed, and low when a UIM is removed.)

*Note:  These signals wake the device when it is in USB-SS mode (a low-power ACTIVE state where the module is fully powered). If the device is in ULPM (Ultra Low Power Mode), it is only woken by configured wakeup triggers—see Wakeup Events (ULPM) on page 74 for details.*

## 4.10 Wakeup Events (ULPM)

The following signals/sources can be used to wake the device from ULPM (Ultra Low Power Mode):
* Configurable:
  * Timer
  * GPIO36, GPIO38, GPIO39
  * ADC2, ADC3
* Always enabled:
  * POWER_ON_N

*Note:  These signals wake the device only when it is in ULPM. If the device is in regular USB-SS mode (a low-power ACTIVE state where the module is fully powered), it can be woken using the signals described in Wakeup Interrupt (USB-SS Mode) on page 74.*

For ULPM details, see Table 3-6, Supported Power States, on page 39.

## 4.11 Secure Digital IO (SDIO) interface

The AirPrime WP75xx/AirPrime WP8548 module defines a 3.0V SDIO interface (SD 2.0-compliant) for customer-defined use with SD cards, connection to a Wi-Fi module, etc.

*Note:  An external 3.0V supply is required to supply power to the SD card.*

Table 4-9 describes the signals used for SDIO.

**Table 4-9: SDIO Pin Descriptions**

| Pin | Signal Name | Direction[a] | Description | If unused | Voltage level |
|-----|-------------|-----------|-------------|-----------|---------------|
| 161 | SDIO_CMD | Output | SDIO command | Leave Open | 3.0V |
| 162 | SDIO_CLK | Output | SDIO clock | Leave Open | |
| 163 | SDIO_DATA_3 | Input/Output | SDIO data bit 3 | Leave Open | |
| 164 | SDIO_DATA_2 | Input/Output | SDIO data bit 2 | Leave Open | |
| 165 | SDIO_DATA_1 | Input/Output | SDIO data bit 1 | Leave Open | |
| 166 | SDIO_DATA_0 | Input/Output | SDIO data bit 0 | Leave Open | |

a. Signal direction with respect to the module. Example: SDIO_CMD (pin 161) is an output from the module to the host.

# 4.12 $I^2$C Interface

The AirPrime WP75xx/AirPrime WP8548 module provides one $I^2$C (Inter-Integrated Circuit) dedicated serial port (bus interface) based on [5] The I2C Bus Specification, Version 2.1, January 2000 (Phillips Semiconductor document number 9398 393 40011).

The interface uses the pins indicated in Table 4-10.

**Table 4-10: $I^2$C Interface Pins**

| Pin | Signal name | Direction | Function | If Unused |
|-----|-------------|-----------|----------|-----------|
| 1 | I2C1_CLK | Input/Output | $I^2$C Clock | Leave open |
| 66 | I2C1_DATA | Input/Output | $I^2$C Data | Leave open |

This implementation of the $I^2$C interface includes the following characteristics:
• Supported voltage—1.8 V
• Standard-mode interface—Data transfer rates up to 100 kbit/s
• Master mode operation only—WP75xx/WP8548 module always operates as the master
• $I^2$C signals are implemented internally as open drain outputs (per the $I^2$C specification) with 2.2 k$\Omega$ pull-up resistors to VGPIO (see Figure 4-3 on page 76).

For $I^2$C bus details, including I2C bus waveform and timing details, refer to the I2C Bus Specification.

## 4.12.1 Application
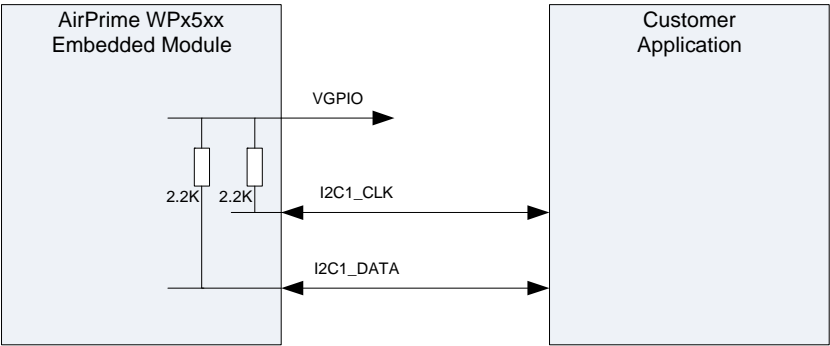


*Figure 4-3: Example of I²C Bus Application*

# 4.13 VGPIO

The AirPrime WP75xx/AirPrime WP8548 utilizes 1.8V logic, provided via the VGPIO (GPIO voltage output) pin.

**Table 4-11: VGPIO Reference Pin**

| Pin | Signal name | Direction[a] | Function | If Unused |
|-----|-------------|--------------|----------|-----------|
| 45 | VGPIO | Output | GPIO voltage output | Leave open |

    a. Signal direction with respect to the module—VGPIO (pin 45) is an output
       from the module to the host.

**Table 4-12: VGPIO Electrical Characteristics**

| Parameter | Min | Typ | Max | Unit | Remarks |
|-----------|-----|-----|-----|------|---------|
| Voltage level | 1.7 | 1.8 | 1.9 | V | Both active mode and USB-SS mode |
| Current capability | - | - | 50 | mA | Power Management support up to 50 mA output |

The VGPIO pin is available when the module is switched ON, and can be used to:
• Pull-up signals such as I/Os
• Supply external digital transistors driving LEDs
• Act as a voltage reference for the ADC interfaces—ADC0–ADC3

# 4.14 Reset Signal (RESET_IN_N)

The AirPrime WP75xx/AirPrime WP8548 provides the RESET_IN_N signal, which allows an external application to reset the module when it:
• has become unresponsive

    and
• does not have a mechanism to perform a power cycle

**Table 4-13: RESET_IN_N Pin**

| Pin | Signal name | Direction[a] | Function | If Unused |
|-----|-------------|--------------|----------|-----------|
| 11 | RESET_IN_N | Input | External Reset Input | Leave open |

a. Signal direction with respect to the module—RESET_IN_N (pin 11) is an input to the module from the host.

RESET_IN_N is internally pulled-up with a 40 kΩ resistor. An open collector transistor or equivalent should be used to ground the signal to reset the module.

The effect of asserting RESET_IN_N depends on the state of POWER_ON_N:
• POWER_ON_N low—Module reboots with CPU registers and RAM memory reset.

**Warning:** *RESET_IN_N must not be pulsed for more than max(Trlen), otherwise the module may repeatedly reboot. See Table 4-14 for timing details.*

**Table 4-14: Reset Timing [a]**

| Symbol | Parameter | Min | Typ | Max |
|--------|-----------|-----|-----|-----|
| Trdet | Duration of RESET_IN_N signal before firmware detects it (debounce timer) | - | 32 ms | - |
| Trlen | Duration reset asserted | 42 ms | - | 500 ms |
| Trdel | Delay between minimum Reset duration and internal reset generated | - | 500 ms | - |

a. All values are preliminary and subject to change
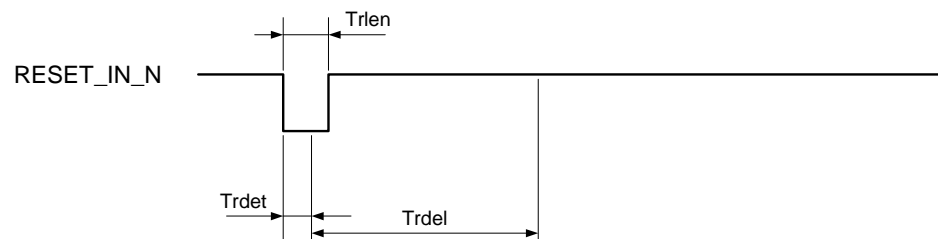


*Figure 4-4: Illustration of Reset Timing When RESET_IN_N < Trdel*

# 4.15 Reset Out (RESET_OUT_N)

The AirPrime WP75xx/AirPrime WP8548 provides a signal that will hold peripheral devices (such as a USB hub, I2C device, etc.) in reset until the power-up sequence is complete.

**Table 4-15: RESET_OUT_N Pin**

| Pin | Signal name | Direction[a] | Function | If Unused |
|-----|-------------|-----------|----------|-----------|
| 46 | RESET_OUT_N | Output | Module reset peripheral device control | Leave open |

a. Signal direction with respect to the module—RESET_OUT_N is an output from the module to the host.

When the module is in reset or powering up, the signal is held low to put peripheral devices in reset. Once the power-on sequence is complete, the RESET_OUT_N signal will be turned high to take the peripherals out of reset.

# 4.16 ADC

The AirPrime WP75xx/AirPrime WP8548 provides four general purpose ADC (Analog to Digital Converter) inputs, as described Table 4-16 and Table 4-17.

**Table 4-16: ADC Interface Pins**

| Pin | Signal name | Direction[a] | Function | If Unused |
|-----|-------------|-----------|----------|-----------|
| 24 | ADC1 | Input | Analog to Digital Converter | Leave open or Ground |
| 25 | ADC0 | Input | Analog to Digital Converter | Leave open or Ground |
| 107 | ADC2[b] | Input | Analog to Digital Converter | Leave open or Ground |
| 108 | ADC3[b] | Input | Analog to Digital Converter | Leave open or Ground |

a. Signal direction with respect to the module. Example: ADC1 (pin 24) is an input to the module from the host.
b. Pin is 'wakeable'. Can be used to trigger the module to wake up from ULPM. See Wakeup Events (ULPM) on page 74 for details.

**Table 4-17: ADC Interface Characteristics[a]**

|  | ADC0/ADC1 Value | ADC2/ADC3 Value | Units |
|--|-----------------|-----------------|-------|
| Full-scale voltage level | 0–1.8 | 0–1.8 | V |
| Resolution | 15 | 12 | bit |
| Sample rate | 1.15 | 20.000–818.330 | ksps |
| Voltage error | 8 (Typ) 16 (Max) | 2 (Typ) | mV |

a. All values are preliminary and subject to change

# 4.17 Digital Audio

The AirPrime WP75xx/AirPrime WP8548 provides a 4-wire digital audio interface that can be configured as either PCM (Pulse Code Modulation) or I$^2$S (Inter-IC Sound).

Table 4-18 on page 79 describes the audio interface signals.

*Note: Audio availability is firmware-dependent.*

**Table 4-18: PCM/I$^2$S Interface Signals**

| Pin | Signal name | Direction[a] | Function | If Unused |
|---|---|---|---|---|
| 33 | PCM_OUT | Output | PCM Data Out<br>The frame "data out" relies on the selected configuration mode. | Leave open |
|  | I2S_OUT | Output | I2S Data Out<br>The frame "data out" relies on the selected configuration mode. |  |
| 34 | PCM_IN | Input | PCM Data In<br>The frame "data in" relies on the selected configuration mode. | Leave open |
|  | I2S_IN | Input | I2S Data In<br>The frame "data in" relies on the selected configuration mode. |  |
| 35 | PCM_SYNC | Input/Output | PCM Sync<br>The frame synchronization signal delivers an 8 kHz frequency pulse that synchronizes the frame data in and the frame data out. | Leave open |
|  | I2S_WS | Output | I2S Word Select<br>The word select clock indicates which channel is currently being transmitted (low cycle indicates left audio channel, high cycle indicates right audio channel). |  |
| 36 | PCM_CLK | Input/Output | PCM Clock<br>The frame bit clock signal controls data transfer with the audio peripheral. | Leave open |
|  | I2S_CLK | Output | I2S Clock<br>The frame bit clock signal controls data transfer with the audio peripheral. |  |

a. Signal direction with respect to the module. Examples: PCM_IN (pin 34) is an input to the module from the host; PCM_OUT (pin 33) is an output from the module to the host.

## 4.17.1 PCM

Table 4-19 defines the PCM interface configuration.

**Table 4-19:  PCM Interface Configurations**

| Element | PCM |
|---|---|
| Slot configuration | Slot-based |
| Sync type | Short |
| Clock (in Master mode) | 2.048 MHz |
| Data formats | 16-bit linear, 8-bit A-law, 8-bit mu-law |
| Mode | Master or Slave |

## 4.17.1.1 PCM Data Format

The PCM data is 8 kHz and 16 bits with the following PDM (Pulse-density modulation) bit format:
• PCM_DIN—SDDD DDDD DDDD DDVV
• PCM_DOUT—SDDD DDDD DDDD DDVV

Where:
• S—Signed bit
• D—Data
• V—Volume padding

## 4.17.1.2 PCM Timing

The following table and drawings illustrate PCM signals timing when operating in PCM mode.

**Table 4-20:  PCM Mode Timing[a,b]**

| Parameter | Description | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| T(sync) | PCM_SYNC cycle time | - | 125 | - | μs |
| T(synch) | PCM_SYNC high time | - | 488 | - | ns |
| T(syncl) | PCM_SYNC low time | - | 124.5 | - | μs |
| T(clk) | PCM_CLK cycle time | - | 488 | - | ns |
| T(clkh) | PCM_CLK high time | - | 244 | - | ns |
| T(clkl) | PCM_CLK low time | - | 244 | - | ns |
| T(susync) | PCM_SYNC setup time high before falling edge of PCM_CLK | - | 122 | - | ns |
| T(sudin) | PCM_IN setup time before falling edge of PCM_CLK | 60 | - | - | ns |
| T(hdin) | PCM_IN hold time after falling edge of PCM_CLK | 60 | - | - | ns |

**Table 4-20: PCM Mode Timing[a,b] (Continued)**

| Parameter | Description | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| T(pdout) | Delay from PCM_CLK rising to PCM_OUT valid | - | - | 60 | ns |
| T(zdout) | Delay from PCM_CLK falling to PCM_OUT HIGH-Z | - | - | 60 | ns |

a. Maximum PCM clock rate is 2.048 MHz.
b. All values are preliminary and subject to change
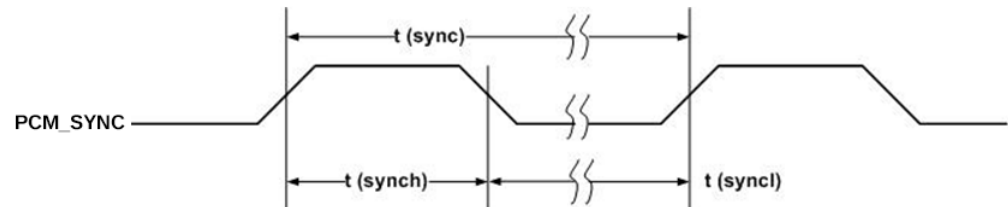


Figure 4-5: PCM_SYNC Timing Diagram (2048 kHz clock)
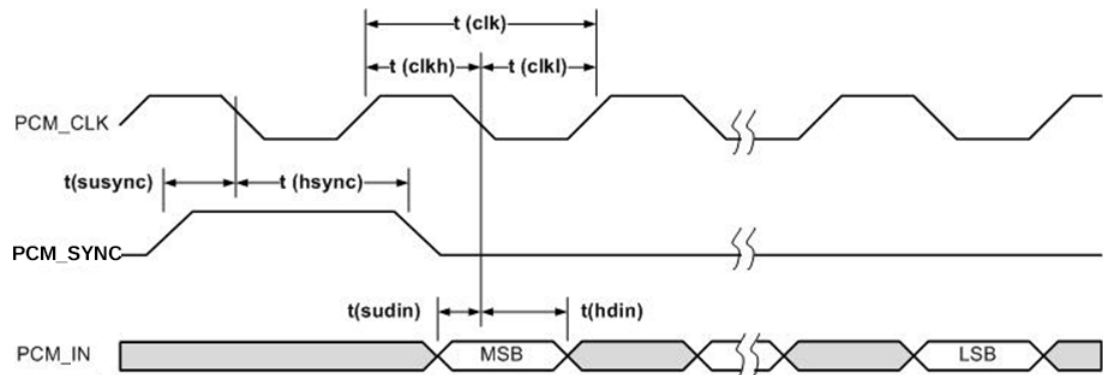


Figure 4-6: PCM Codec to Device Timing Diagram
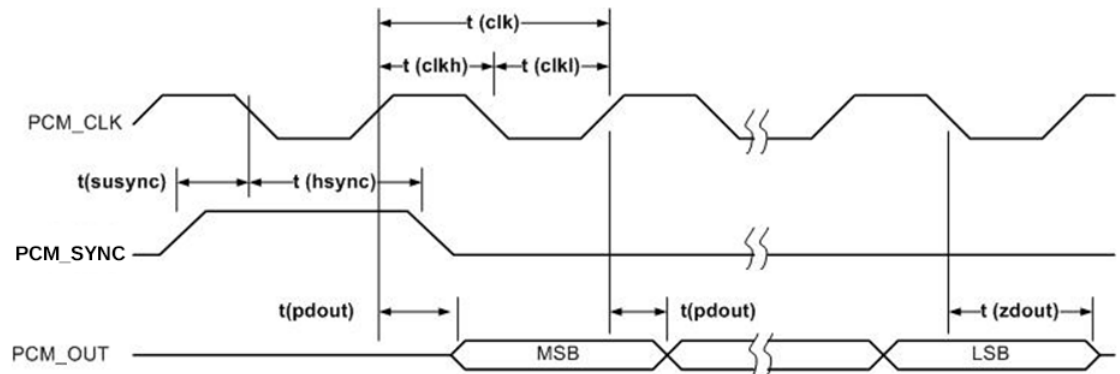


Figure 4-7: Device to PCM Codec Timing Diagram

## 4.17.2 I²S

The I²S interface can be used to transfer serial digital audio to or from an external stereo DAC/ADC and supports the following features:
- Mode: Master (Slave mode is not supported)
- Sampling rate: 48 kHz
- Bits per frame: 16
- Bit clock: 1536 kHz
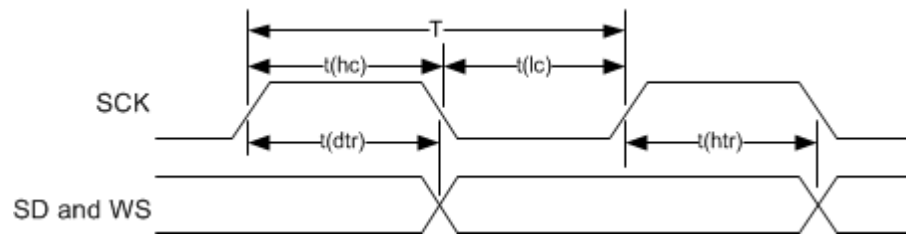


*Figure 4-8:  I²S Transmitter Timing*

**Table 4-21:  Master Transmitter With Data Rate = 3.072 MHz (±10%)[a]**

| Parameter | Description | Condition | Min | Typ | Max | Units |
|-----------|-------------|-----------|-----|-----|-----|-------|
| T | Clock period | I²S requirement: min T=293 | 293 | 326 | 359 | ns |
| t(hc) | Clock high | I²S requirement: min > 0.35T | 120 | - | - | ns |
| t(lc) | Clock low | I²S requirement: min > 0.35T | 120 | - | - | ns |
| t(dtr) | Delay | I²S requirement: max < 0.8T | - | - | 250 | ns |
| t(htr) | Hold time | I²S requirement: min > 0 | 100 | - | - | ns |

a.   Maximum sample rate = 48 kHz at 3.072 MHz (16 bits per sample)

# 4.18 SPI Bus

The AirPrime WP75xx/AirPrime WP8548 module provides one 4-wire serial peripheral interfaces (SPI1).

The following features are available on the SPI bus:
- Mode: Master (Slave mode is not supported)
- SPI speed from 960 kbps to 26 Mbps in master mode operation
- 4-wire interface
- 4 to 32 bits data length

Table 4-22 on page 83 describes the SPI interface pins.

**Table 4-22: SPI Pin Descriptions**

| Pin | Signal Name | Direction[a] | Description | Reset State | I/O Type |
|-----|-------------|-----------|-------------|-------------|----------|
| 51 | SPI1_MRDY | Output | SPI Master Ready | Z | 1V8 |
| 52 | SPI1_MISO | Input | SPI Master Input/Slave Output (output from slave) | Z | |
| 53 | SPI1_CLK | Output | SPI serial clock (output from Master) | Z | |
| 54 | SPI1_MOSI | Output | SPI Master Output/Slave Input (output from master) | Z | |

a. Signal direction with respect to module. Examples: SPI1_MISO (pin 52) is an input to the module from the host; SPI1_CLK (pin 53) is an output from the module to the host.

## 4.18.1 SPI Configuration

**Table 4-23: SPI Configuration**

| Operation | Max Speed | SPI-Mode | Duplex | 4-wire Type |
|-----------|-----------|----------|--------|-------------|
| Master | 26 Mb/s | 0,1,2,3 | Full | • SCLK (SPI1_CLK)<br>• MOSI (SPI1_MOSI)<br>• MISO (SPI1_MISO)<br>• SS (SPI1_MRDY) |

## 4.18.2 SPI Waveforms

The following figure shows waveforms for SPI transfer using a 4-wire configuration.
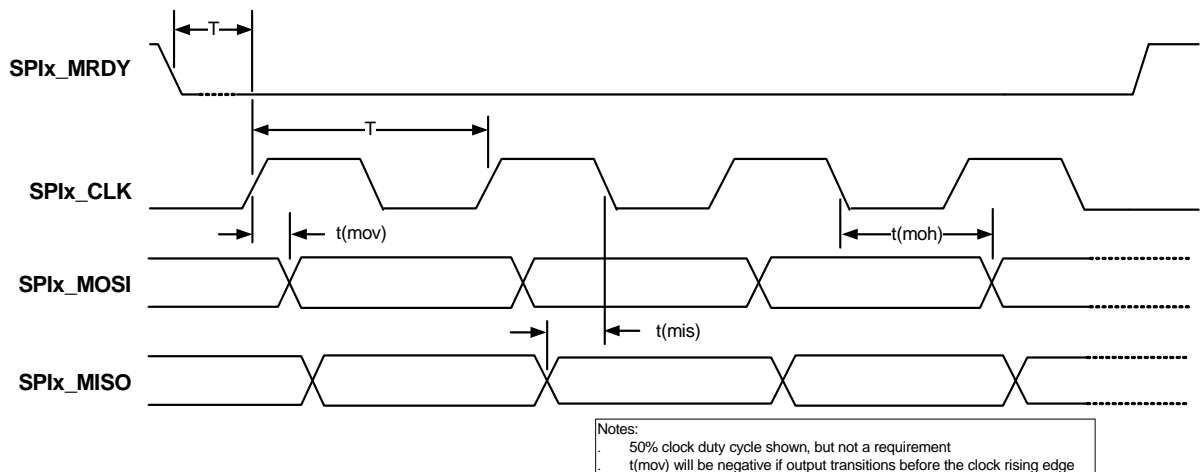


*Figure 4-9: 4-Wire Configuration SPI Transfer*

**Table 4-24: SPI Master Timing Characteristics**

| Parameter | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| SPI clock frequency | | 0.96 | - | 26 | MHz |
| T | SPI clock period | 38 | - | - | ns |
| t(ch) | Clock high | 17 | - | - | ns |
| t(cl) | Clock low | 17 | - | - | ns |
| t(mov) | Master output valid | -5 | - | 5 | ns |
| t(mis) | Master input setup | 3 | - | - | ns |
| t(moh) | Master output hold | 3 | - | - | ns |
| t(tse) | Tri-state enable | -5 | - | 5 | ns |
| t(tsd) | Tri-state disable | -5 | - | 5 | ns |

## 4.18.3 Application
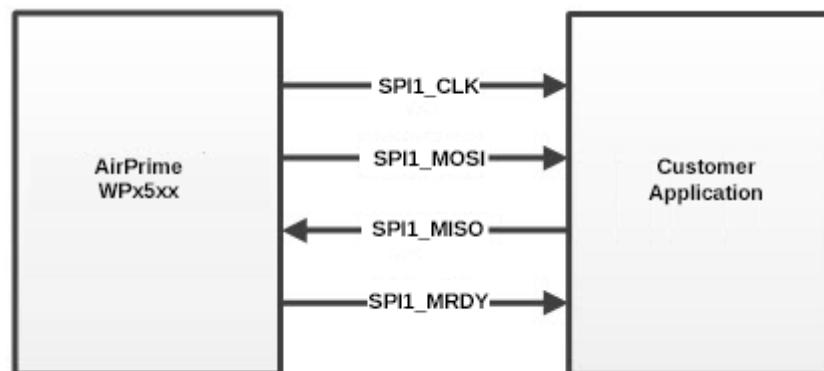


*Figure 4-10: Example of 4-wire SPI Bus Application*

# 4.19 HSIC Bus

The AirPrime WP75xx/AirPrime WP8548 module provides a 2-wire HSIC (High-Speed Inter-Chip) bus.

**Table 4-25: HSIC Pin Descriptions**

| Pin | Signal Name[a] | Direction[a] | Description | Reset State | I/O Type |
|---|---|---|---|---|---|
| 14 | HSIC_DATA | I/O | HSIC data | Z | 1V2 |
| 15 | HSIC_STRB | I/O | HSIC strobe signal | Z | |

a. From host view

## 4.19.1 HSIC Waveforms

Refer to [2] Inter-Chip USB Supplement to the USB 2.0 Specification Revision 1.0.

## 4.19.2 Application
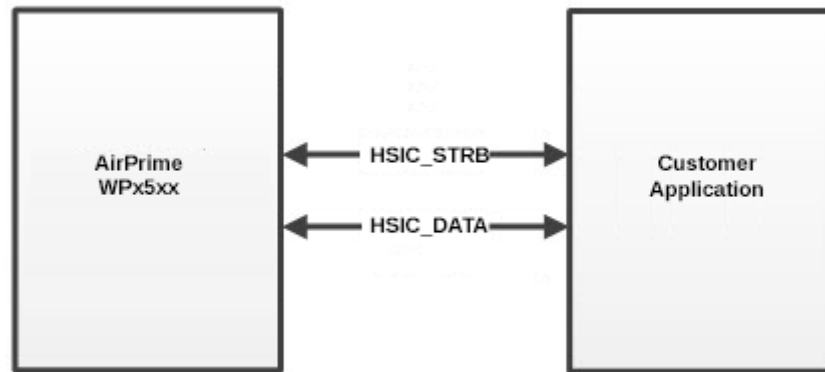


*Figure 4-11:  Example of 2-wire HSIC Bus Application*

Application notes:
*   Trace length < 10 cm
*   Skew between data and strobe signals < 15 ps
*   HSIC_DATA and HSIC_STRB should maintain a 50Ω impedance routing, and isolation between the lines should be maintained

# 4.20 Clock

The AirPrime WP75xx/AirPrime WP8548 module supports two digital clock interfaces that are connected directly from the PMIC.

Table 4-26 describes the clock interface pins.

**Table 4-26:  Clock Interface Pin Descriptions**

| Pin | Signal name | I/O | I/O type | Description | If Unused |
|-----|-------------|-----|----------|-------------|-----------|
| 22 | SYS_CLK | Output | 1.8V | 19.2 MHz digital clock output | Leave open |
| 23 | SLEEP_CLK | Output | 1.8V | 32.768 kHz digital clock output | Leave open |

# 4.21 TP1 (Boot Pin)

The TP1 pin (boot pin) can be used for two primary purposes:
*   The pin can be used to force the module to enter boot-loader mode on power-up—Connect the pin to a control mechanism (for example, a button, switch, or jumper) on the host platform, and use this mechanism to assert (drive low) the TP1 pin on power-up. The boot loader monitors the TP1 pin and when it detects a low signal, prevents normal power-up and prepares to download firmware via the DM port.

> When the module has restarted and entered boot-loader mode, make sure to de-assert the TP1 pin. When the firmware download finishes, the module reboots automatically and the de-asserted pin allows the module to boot normally.
>
> • If not connected to a control mechanism, at minimum the pin should be connected to a test point on the host platform, for use by Sierra Wireless in RMA debugging.

*Note: Firmware downloads also occur using software tools available on source.sierrawireless.com or over the air using an AirVantage server.*

**Table 4-27: TP1 Pin Description**

| Pin | Name | Direction | Function | If Unused |
|---|---|---|---|---|
| 47 | TP1 | Input | Device recovery (boot load) | Mandatory test point |

# 4.22 Temperature Monitoring

The AirPrime WP75xx/AirPrime WP8548 provides internal temperature monitoring of the module's baseband thermistor, as detailed below in Figure 4-12 and Table 4-28.

The temperature state can be queried directly, and unsolicited notifications of temperature state transitions can be received by using:
• AT!PATEMP—Display the current temperature state (normal, hi or low warning, hi or low critical).
• AT+WUSLMSK—Enable unsolicited notifications for !PATEMP, to be received over the AT port whenever the state changes.
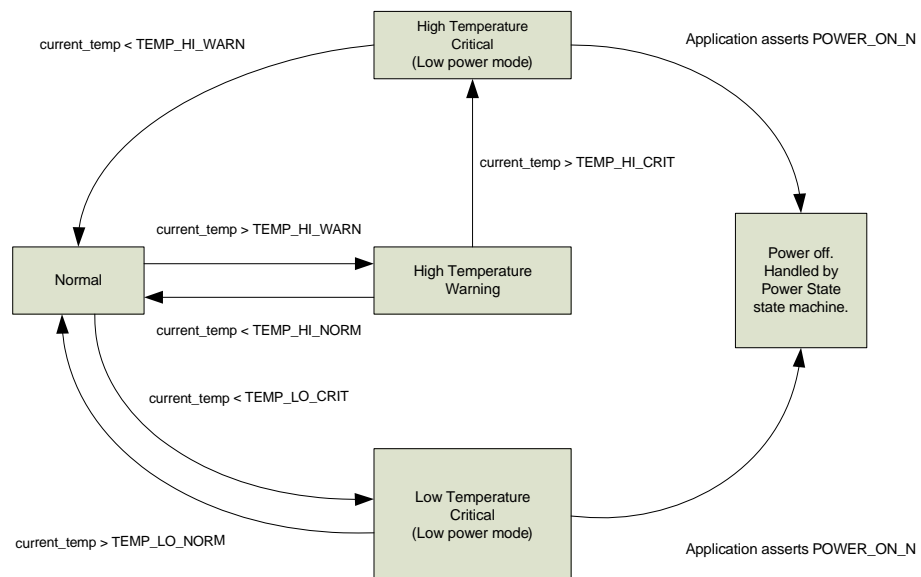


*Figure 4-12: Temperature Monitoring State Machine*

**Table 4-28:  Temperature Monitoring States** [a]

| State | Description | Threshold | Default Temp value (C)[b] | Functionality |
|---|---|---|---|---|
| Normal | Baseband thermistor is between | TEMP_HI_NORM | +100 | All |
| | | TEMP_LO_NORM | -40 | |
| High Temperature Warning | Baseband thermistor has exceeded | TEMP_HI_WARN | +110 | All |
| High Temperature Critical | Baseband thermistor has exceeded | TEMP_HI_CRIT | +120 | Low Power Mode |
| Low Temperature Critical | Baseband thermistor has descended past | TEMP_LO_CRIT | -45 | Low Power Mode |

a.  All values are preliminary and subject to change
b.  Junction temperature

To restore full operation, the baseband thermistor's temperature reading must be within the normal or high temperature warning state thresholds.

# 4.23 Test Pins

Sierra Wireless requires test points on the customer application for Sierra Wireless RMA and debug service.

**Table 4-29:  Test Pin Descriptions**

| Pin | Name | Function | If Unused |
|---|---|---|---|
| 236 | J1 | Test point | Mandatory test point |
| 237 | J2 | Test point | Mandatory test point |
| 238 | J3 | Test point | Mandatory test point |
| 239 | J4 | Test point | Mandatory test point |
| 240 | J5 | Test point | Mandatory test point |
| 241 | J6 | Test point | Mandatory test point |
| 242 | J7 | Test point | Mandatory test point |
| 243 | J8 | Test point | Mandatory test point |
| 244 | J9 | Test point | Mandatory test point |

# 4.24 Antenna Control

The AirPrime WP75xx/AirPrime WP8548 provides four output signals that can be used for host designs that incorporate tunable antennas.

*Note: It is the responsibility of developers of host designs to evaluate the performance of tunable antennas that use these signals for neighbor cell measurements, Inter-RAT handovers, etc. Sierra Wireless does not guarantee ANT_CNTLx signal timing.*

*Note: These pins can be configured for use as GPIOs using +WIOCFG.*

**Table 4-30: Antenna Control Signals**

| Pin | Name | Direction[a] | Function | If Unused |
|-----|------|-----------|----------|-----------|
| 153 | ANT_CNTL0 | Output | Customer-defined external switch control for tunable antennas | Leave open |
| 154 | ANT_CNTL1 | Output | | Leave open |
| 155 | ANT_CNTL2 | Output | | Leave open |
| 156 | ANT_CNTL3 | Output | | Leave open |

a. Signal direction with respect to module. Examples: ANT_CNTL0 (pin 153) is an output from the module to the host.

To tune the antenna:

1. Enable band selection, which is required to tune the antennas for specific bands:
   - **AT!CUSTOM="BANDSELEN",1**

   (Note: This setting is persistent unless disabled by issuing AT!CUSTOM="BANDSELEN",0.)

2. Drive the antenna control signals high or low, as required, for a specific band:
   - **AT!ANTSEL=<band>, <gpio1>, <gpio2>, <gpio3>[, <gpio4>]**

   See [1] AirPrime WPx5xx AT Command Reference for details.

   (Note: <gpio1>–<gpio4> correspond to ANT_CTRL0–ANTCTRL3.)

# 4.25 Indication Interfaces

The AirPrime WP75xx/AirPrime WP8548 module provides several indication interfaces that deliver notifications when specific events occur. These interfaces include:

- Tx Activity Indicator (TX_ON) on page 89
- WWAN_LED_N on page 89
- WAKE_ON_WWAN on page 90
- Ring Indicator on page 90
- SAFE_PWR_REMOVE on page 90
- UIM1_DET/UIM2_DET on page 90

## 4.25.1 Tx Activity Indicator (TX_ON)

The AirPrime WP75xx/AirPrime WP8548 module provides a digital output signal to indicate the occurrence of Tx activity.

**Table 4-31: Tx Activity Indicator States**

| Pin | Signal name | Direction[a] | I/O type | Module state | Signal State |
|-----|-------------|-------------|----------|--------------|--------------|
| 60 | TX_ON | Output | 1.8V | During Tx activity | High |
| | | | | No Tx | Low |

a. Signal direction with respect to module—TX_ON (pin 60) is an output from the module to the host.

## 4.25.2 WWAN_LED_N

The AirPrime WP75xx/AirPrime WP8548 provides an LED control output signal pad. This signal is an open drain output.

**Table 4-32: LED Interface Pin**

| Pin | Signal name | Direction[a] | Voltage / Current | Function | If Unused |
|-----|-------------|-------------|-------------------|----------|-----------|
| 106 | WWAN_LED_N | Output | • Voltage (max)=VBAT_BB + 0.5 V<br>• Maximum current sink capability=300 mA | LED driver control | Leave open |

a. Signal direction with respect to module—WWAN_LED_N (pin 106) is an output from the module to the host.
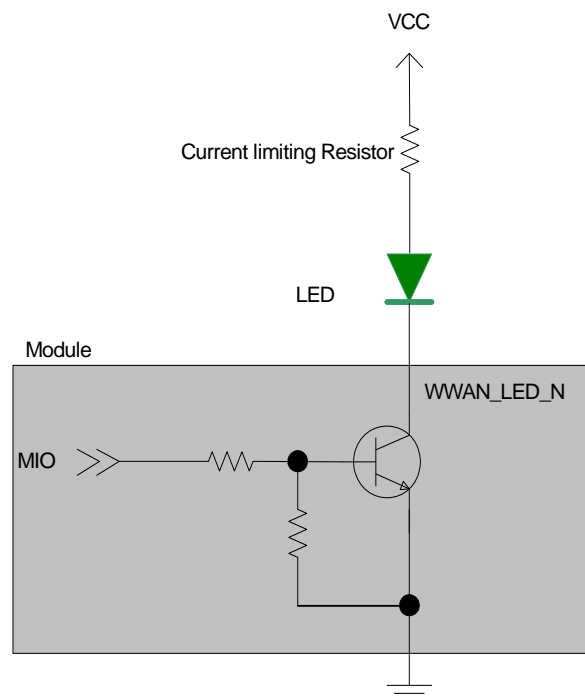


*Figure 4-13: LED Reference Circuit*

## 4.25.3 WAKE_ON_WWAN

The AirPrime WP75xx/AirPrime WP8548 drives WAKE_ON_WWAN high to wake the host when specific events occur.

See Figure 4-14 for a recommended implementation.
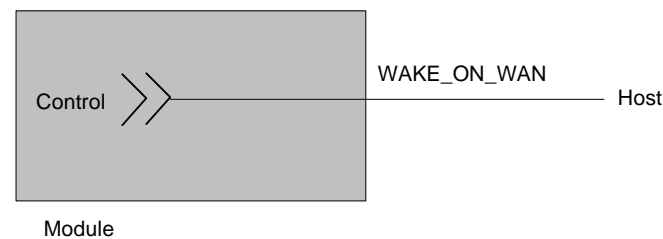


*Figure 4-14:  Recommended WAKE_ON_WWAN Connection*

## 4.25.4 Ring Indicator

The ring indicator (UART1_RI) may be used to notify an external application of several events such as an incoming call, timer expiration, or incoming SMS. The AirPrime WP75xx/AirPrime WP8548 pulses the signal high when an event occurs.

**Table 4-33:  UART1_RI Pin**

| Pin | Name | Direction[a] | Function | If unused |
|-----|------|-----------|----------|-----------|
| 2 | UART1_RI | Output | Ring Indicator<br>Signal incoming calls (voice and data), SMS, etc. | Leave open |

a. Signal direction with respect to the module—UART1_RI (pin 2) is an output from the module to the host.

For additional details, refer to the Legato API documentation for Legato.io.

## 4.25.5 SAFE_PWR_REMOVE

The SAFE_PWR_REMOVE signal is used by the AirPrime WP75xx/AirPrime WP8548 to indicate to the host device that VBAT_BB/VBAT_RF can be removed. The signal is driven high when it is safe to remove the power supply.

REV12For timing details, refer to Figure 4-1 on page 67.

## 4.25.6 UIM1_DET/UIM2_DET

The UIM Detect signals (UIM1_DET, UIM2_DET) are used to detect the physical presence of UIM cards in the UIM holders. Each UIM Detect signal has a pull-up internal to the AirPrime WP75xx/AirPrime WP8548. It should be set to GND when a UIM is not present. All signals near the UIM holder must be ESD-protected.

The UIM Detect signals transition:
• When a UIM is inserted—high (logic 0 to logic 1)
• When a UIM is removed—low (logic 1 to logic 0)

# 4.26 DR_SYNC

The AirPrime WP75xx/AirPrime WP8548 provides DR_SYNC, an output used for GPS dead reckoning synchronization.

The module pulses the DR_SYNC signal once every integer GPS second. While position fixes are occurring, the DR_SYNC pulse is aligned precisely with the GPS time. When a position fix cannot be made (for example, when a vehicle has entered a tunnel), the module continues to pulse the DR_SYNC signal every second while the level of uncertainty of the GPS time is low. When the uncertainty level is high, the module stops pulsing the signal.

**Table 4-34: DR_SYNC Pin Details**

| Pin | Signal name | Direction[a] | Function | If Unused |
|-----|-------------|-----------|----------|-----------|
| 42 | DR_SYNC | Output | GPS dead reckoning sync signal | Leave open |

    a.  Signal direction with respect to the module—DR_SYNC (pin 42) is an output from the module to the host.

# 4.27 W_DISABLE_N—Wireless Disable

*Note: Host support for wireless disable signals is optional.*

The host device uses W_DISABLE_N (pin 151) to enable / disable the WWAN or radio modem. When disabled, the modem cannot transmit or receive information.

Letting this signal float high allows the module to operate normally. The pin has an internal pull-up resistor. See Figure 4-15 for a recommended implementation.

When integrating with your host device, keep the following in mind:
• The signal is an input to the module and should be driven LOW only for its active state (controlling the power state); otherwise it should be floating or (High impedance). It should never be driven to a logic high level. The module has an internal pull-up resistor to an internal 1.8V rail, so if the signal is floating or (high impedance), then the radio is on.
• If the host never needs to assert this power state control to the module, leave this signal unconnected from the host interface.
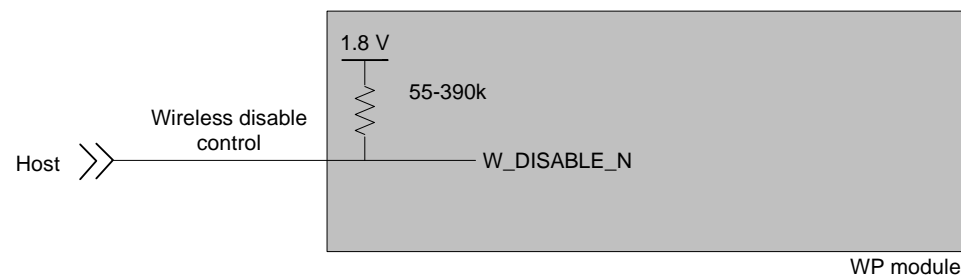


*Figure 4-15: Recommended Wireless Disable Connection*

# 5: Routing Constraints and Recommendations

This section describes general routing constraints and recommendations for the AirPrime WP75xx/AirPrime WP8548 module.

*Note: This is a non-exhaustive list of suggested design guidelines. The developer is responsible for deciding whether to implement these guidelines.*

## 5.1 General Rules and Recommendations

Clock and other high-frequency digital signals (e.g. serial buses) should be routed as far as possible from the module's analog signals.

If the application design makes it possible, all analog signals should be separated from digital signals by a ground trace on the PCB.

**Tip:** *Avoid routing any signals under the module on the application board.*

## 5.2 PCB Layout Recommendations

Ground pads should be re-flowed on to the host PCB with < 30% voiding to allow effective heat dissipation.

## 5.3 Power Supply

When designing the power supply, make sure that VBAT_BB/VBAT_RF meet the requirements listed in Power Supply Ratings on page 35.

Careful attention should be paid to the following:
- Power supply quality—PFM, or PSM systems should be avoided; Low ripple, linear regulation or PWM converters are preferred for low noise.
- Capacity to deliver high current peaks in a short time (for pulsed radio emission)
- VBAT_BB/VBAT_RF must support peak currents with an acceptable voltage drop that guarantees the minimum required VBAT_BB/VBAT_RF value.
- VBAT_BB/VBAT_RF signal pads must never exceed the maximum required VBAT_BB/VBAT_RF value, otherwise the module's power amplifier and GPS chipset may be severely damaged.
- A weakly-designed (not robust) power supply could affect EMC performance, the emission spectrum, and the phase error and frequency error.

# 5.4 Antenna

Sierra Wireless strongly recommends working with an antenna manufacturer either to develop an antenna adapted to the application, or to adapt an existing solution to the application.

For information on routing constraints for the RF circuit, see RF Circuit on page 94.

# 5.5 PCB Specifications for the Application Board

Sensitive signals (such as audio, UIM, and clocks) should be protected by ground planes/fills. Routing sensitive signals close to noisy signals could result in noise being coupled.

# 5.6 Recommended PCB Land Pattern

Refer to the AirPrime WP75xx/AirPrime WP8548 Customer Process Guidelines document, available at http://source.sierrawireless.com.

# 5.7 Routing Constraints

## 5.7.1 Power Supply

If the following design recommendations are not followed, phase error (peak) and power loss could occur.

*Note: The recommended power supply capacity (Table 3-4 on page 36) is greater than the maximum peak current to provide an operating margin.*

- Since the maximum peak current can reach 2.5 A, Sierra Wireless strongly recommends having a large width for the layout of the power supply signal (to avoid voltage loss between the external power supply and VBAT_BB/VBAT_RF.
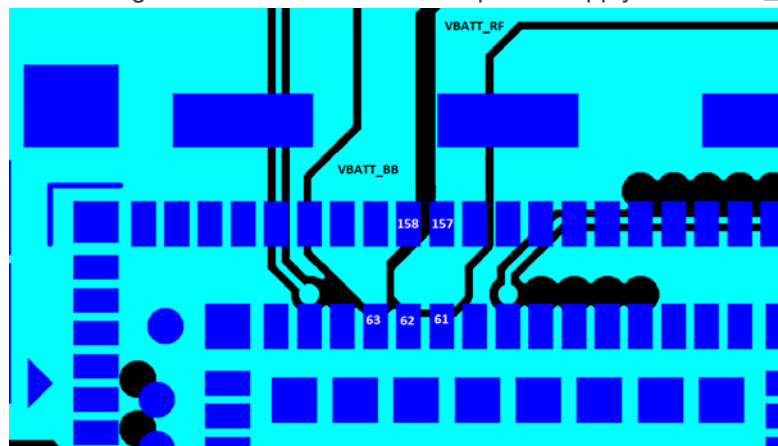


Figure 5-1: Power Supply Routing Example

*Note: Figure 5-1 shows separate traces for VBAT_BB and VBAT_RF. If VBAT_BB and VBAT_RF share a single power supply, these traces should be connected.*

*Note: For optimal decoupling, place the capacitors on the underside of the board, directly under the pins.*

- Filtering capacitors (100 nF to 1500 μF) are recommended near the module's power supply.
- Attention should be paid to the ground trace or the ground plane on the application board for the power supply that supplies the module. The ground trace or ground plane, as well as the VBAT trace, must be able to support current peaks.
- If the ground trace between the module and the power supply is a copper plane, make sure it is a solid plane.
- Design routing to make sure total line impedance does not exceed 10 mΩ @ 217 Hz.

### 5.7.1.1 Ground Plane Connection

The AirPrime WP75xx/AirPrime WP8548 module requires a solid, central ground plane (with solder mask defined pads) located directly under the module. This will:
- Ensure high current signal returns
- Provide heat dissipation under higher operating temperatures

The ground plane should be connected (with vias) to the reference ground layer of the application board.

## 5.7.2 UIM Interface

- The length of the tracks between the AirPrime WP75xx/AirPrime WP8548 and the UIM socket should be as short as possible. Maximum recommended length is 10cm.
- ESD protection is mandatory on the UIM lines unless:
  - (WP8548 only) An ESIM is being used, or
  - There is no physical access to the UIM
- The decoupling capacitor(s) should be placed as close as possible to the UIM card connector for the UIM1_VCC signal.

## 5.7.3 RF Circuit

The RF signal must be routed on the application board using tracks with a 50Ω characteristic impedance.

The characteristic impedance depends on the dielectric, the track width and the ground plane spacing.

It is recommended to use stripline design if the RF path is fairly long (more than 3cm), since microstrip design is not shielded. Consequently, the RF (transmit) signal may interfere with neighboring electronic circuits. In the same way, the neighboring electronics (micro-controllers, etc.) may interfere with the RF (receive) signal and degrade the reception performance.

The RF trace on the development board is routed from the AirPrime WP75xx/ AirPrime WP8548 antenna port to the RF connector (IPEX MHF-4). The RF trace is designed as a 50Ω coplanar stripline and its length is 20.7 mm.

The following drawings show the location of the AirPrime WP75xx/AirPrime WP8548 on the development board, the routing cross-section, and the top view of the RF trace on the development board.
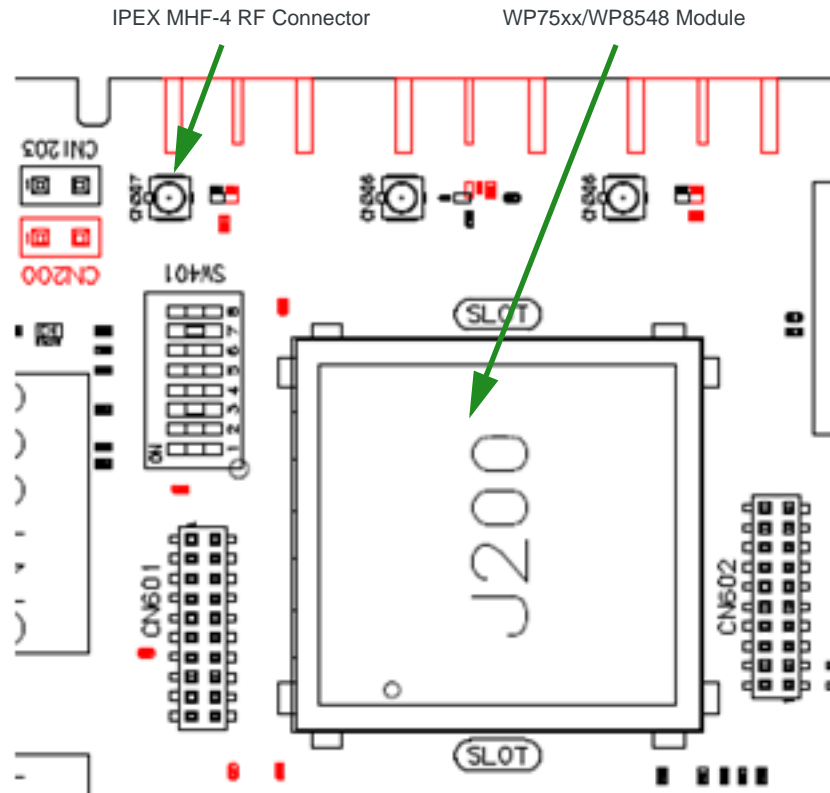


*Figure 5-2: Module Location on Development Board*

RF trace end vias to connect to the
WP75xx/WP8548 Antenna port at one end
and the RF connector at the other end

Copper Layer:
Substrate (Er=3.8~4.2):

RF Trace
W=7 Mil
G=13.7 Mil

L1
S1
L2
S2
L3

H1=9.3 Mil
T=0.6 Mil
H2=6 Mil

G    W    G

Ground Vias

**PCB Cross-section**

**RF Trace Routing**
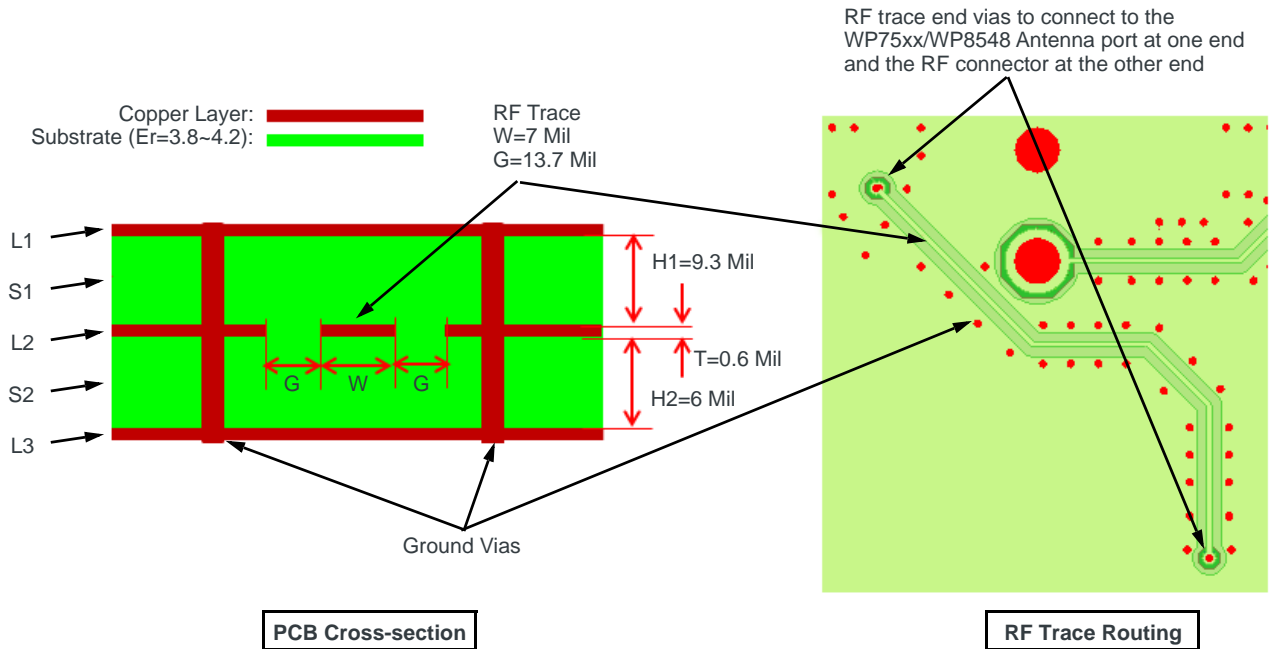
*Figure 5-3:  Development Board RF Trace Design*

## 5.7.4 USB Interface

When the USB interface is externally accessible, ESD protection is required on the USB_VBUS, USB_D+, and USB_D- signals.

# 5.8 Thermal Considerations

When transmitting, the AirPrime WP75xx/AirPrime WP8548 can generate significant amounts of heat (due to the internal Power Amplifier) that must be dissipated in the host device for safety and performance reasons.

The amount of thermal dissipation required depends on the following factors:
- Supply voltage—Maximum power dissipation for these modules can be up to 3 W at voltage supply limits.
- Usage—Typical power dissipation values depend on the location within the host, amount of data transferred, etc.

To enhance heat dissipation:
- Maximize airflow over / around the module
- Locate the module away from other components that generate heat
- Ensure the module is connected to a solid ground plane

# 5.9 EMC and ESD Recommendations

EMC tests must be performed on the application as soon as possible to detect any potential problems.

When designing, special attention should be paid to:
- Possible spurious emissions radiated by the application to the RF receiver in the receiver band
- ESD protection—Typically, ESD protection is mandatory for externally accessible signals, including:
  - VBAT_RF/VBAT_BB
  - UIM (if accessible from outside)
  - Serial link
  - USB
  - Antennas
- Length of the UIM interface lines (preferably <10 cm)
- Length of the HSIC interface lines (<10 cm, as required by the HSIC specification)
- EMC protection on audio input/output (filters against 900 MHz emissions)
- Ground plane: Sierra Wireless recommends a common ground plane for analog/digital/RF grounds

*Note: The AirPrime WP75xx/AirPrime WP8548 does not include any protection against over-voltage.*

The host device must provide adequate ESD protection on digital circuits and antenna ports as detailed in the following table.

*Note: The level of protection required depends on your application.*

**Table 5-1: ESD Specifications [a,b]**

| Category | Connection | Specification |
|---|---|---|
| Operational | • RF ports<br>• UIM connector<br>• USB connector<br>• UART connector | IEC-61000-4-2 - Level (Electrostatic Discharge Immunity Test)<br>  · ± 6kV Contact<br>  · ± 8kV Air |
| Non-operational | Host connector interface | Unless otherwise specified:<br>• JESD22-A114 ± 1kV Human Body Model<br>• JESD22-A115 ± 100V Machine Model<br>• JESD22-C101C ± 500V Charged Device Model |

a. ESD specifications are preliminary, subject to change.
b. ESD protection is highly recommended at the point where the UIM contacts are exposed, and for any other signals that would be subjected to ESD by the user.

# 5.10 Mechanical Integration

Attention should be paid to:
- Antenna cable integration (bending, length, position, etc)
- Pads of the AirPrime WP75xx/AirPrime WP8548 to be soldered to the ground plane
- Ensuring proper board layout
- Providing sufficient space around the module for heat dissipation

# 5.11 Signal Reference Schematics



*Figure 5-4: UIM Interface*

## USB Interface

Note: schedule footprint for additional 2pF capacitor between D+ and D- data lines to meet USB compliance.

Note: Ensure low line capacitance across high speed USB data lines.

*Figure 5-5: USB Interface*

VCC_5V0

Replace with FPF2163 if Autorestart is required

USB_VBUS

VCC_1V8

VCC_1V8

USB_ID
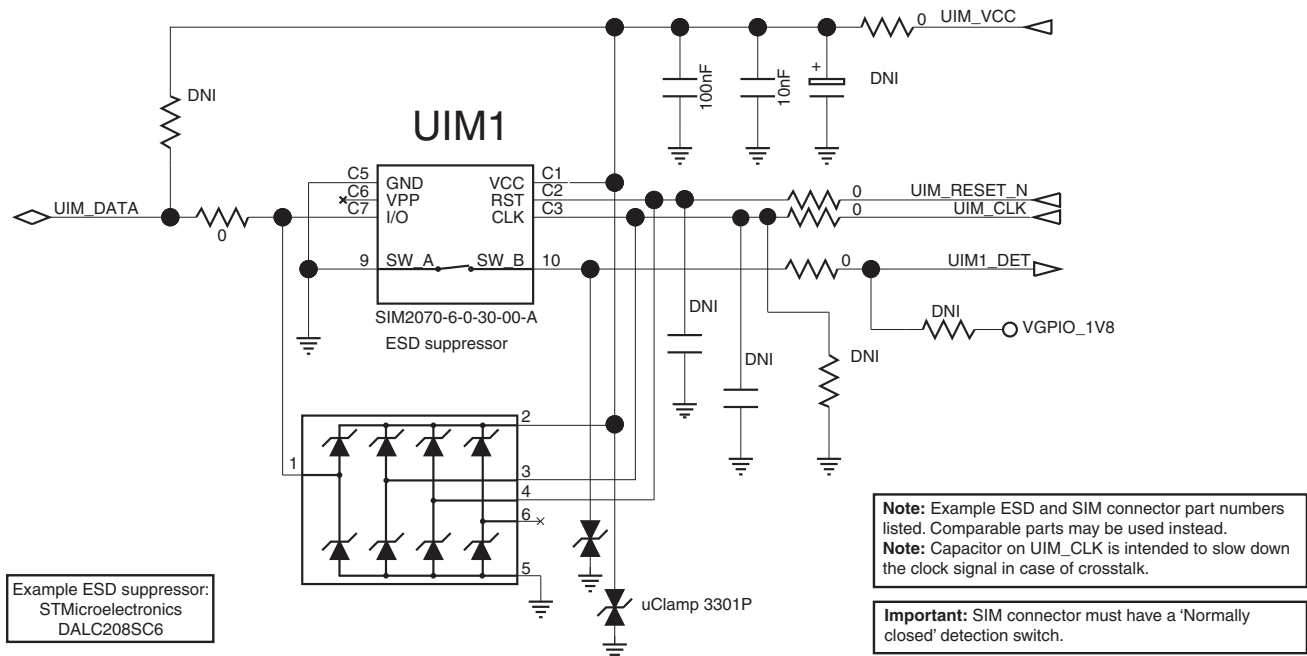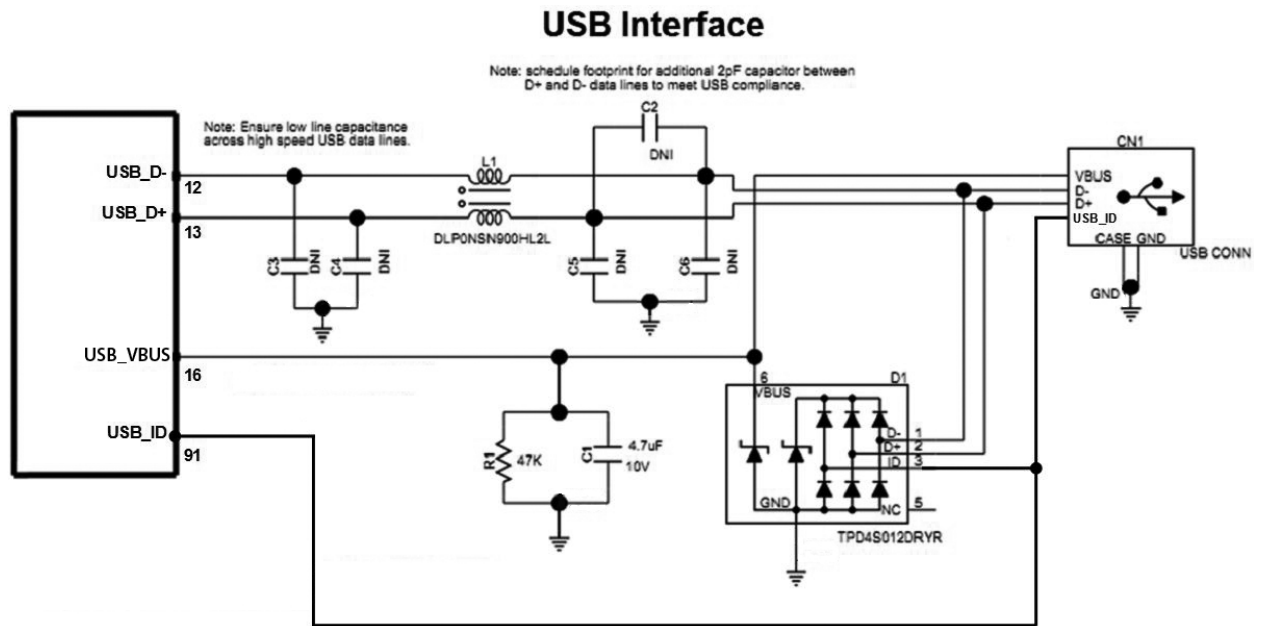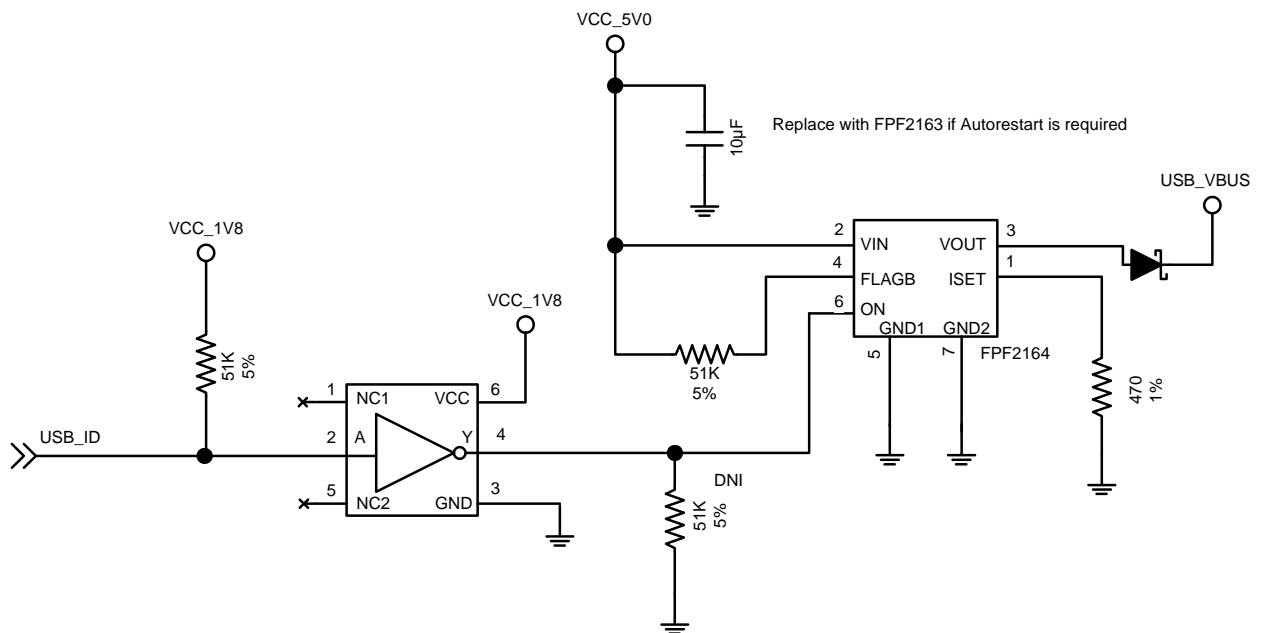
*Figure 5-6: USB OTG Interface*

# >>|6: Software and Tools

## 6.1 Support Tools

The AirPrime WP75xx/AirPrime WP8548 is compatible with Sierra Wireless' SwiLogPlus trace tool that allows users to send error logs to Sierra Wireless.

## 6.2 SED (Smart Error Detection)

The AirPrime WP75xx/AirPrime WP8548 uses a form of SED to track unexpected/ spontaneous module resets (resets that are not deliberately initiated). In such cases, the module automatically forces a pause in boot-and-hold mode at power-on to accept an expected firmware download to resolve the problem.

1. Module tracks consecutive unexpected/spontaneous resets within 30 seconds of power-on.
2. After a sixth consecutive unexpected/spontaneous reset, the module waits in boot-and-hold mode (up to 30 seconds) for a firmware download to resolve the power-cycle problem.

A RAM dump tool that can be used to help isolate the cause of unexpected/ spontaneous resets is available from Sierra Wireless. Contact your Sierra Wireless account representative for assistance.

## 6.3 Firmware Upgrade

Firmware upgrades are downloaded to the embedded module over the USB or UART interfaces, or over the air via Sierra Wireless' AVMS (AirVantage Management System). Contact your Sierra Wireless account representative for assistance.

## 6.4 Operating System Upgrade

The AirPrime WP75xx/AirPrime WP8548 module's operating system is stored in flash memory and can be easily upgraded.

---

**Tip:** *To follow regular changes in the 3GPP standard and to offer a state-of-the-art operating system, Sierra Wireless recommends that the application designed around an embedded module (or embedded module based product) should allow easy operating system upgrades on the embedded module via the recommended firmware download protocol. Therefore, the application shall either allow a direct access to the embedded module USB interface through an external connector or implement any mechanism allowing the embedded module operating system to be downloaded.*

---

# 6.5 Labeling

Pin 1

```
Sierra Wireless™                    ●
XXXXXXXXXXXXXXX
IMEI: 00000000000000



1100000             S/N: XX00000000000
                            XXXXXXXXXXX
Made in XXX          FCC ID: XXXXXXX
                         IC: 0000X-XX0000
                     ANATEL: XXXX-XX-XXXX
                  KC ID: XXXX-XXX-XXX-XXXXXX
```
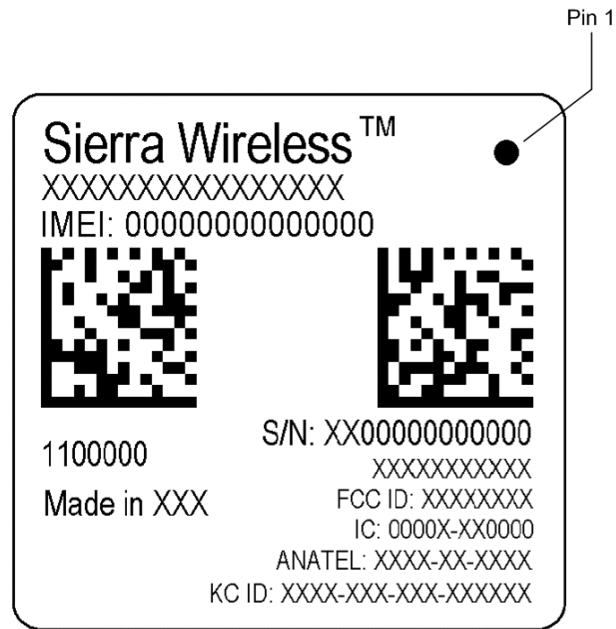
*Figure 6-1:  Unit Label Example (Contents will vary by SKU)*

The AirPrime WP75xx/AirPrime WP8548 label is non-removable and may contain:
- Product identification (Model name, serial number)
- IMEI or MEID number and barcode
- Fabrication country
- Required regulatory markings (FCC ID, IC certification number, etc., as appropriate)
- Pin 1 indicator

*Note:  The AirPrime WP75xx/AirPrime WP8548 supports OEM partner specific label requirements.*

# 7: Debug and Assembly Considerations

## 7.1 Testing Assistance Provided by Sierra Wireless

Sierra Wireless offers optional professional services based assistance to OEMs with regulatory approvals.

## 7.2 Integration Requirements

When integrating the AirPrime WP75xx/AirPrime WP8548 module, the following items must be addressed:
- Mounting—Effect on temperature, shock, and vibration performance
- Power supply—Impact on battery drain and possible RF interference
- Antenna location and type—Impact on RF performance
- Regulatory approvals—As discussed in
- Service provisioning—Manufacturing process

Sierra Wireless provides guidelines for successful AirPrime WP75xx/AirPrime WP8548 module integration with the document suite and offers integration support services as necessary.

## 7.3 IOT/Operator

Interoperability and Operator/Carrier testing of the finished system is the responsibility of the OEM. The test process will be determined with the chosen network operator(s) and will be dependent upon your business relationship with them, as well as the product's application and sales channel strategy.

Sierra Wireless offers assistance to OEMs with the testing process, if required.

## 7.4 Module Testing Recommendations

When testing your integration design:
- Test to your worst case operating environment conditions (temperature and voltage)
- Test using worst case operation (transmitter on 100% duty cycle, maximum power)
- Monitor the module's junction temperature using AT!PATEMP. This command polls a thermistor located near the module's power amplifier (typically the hottest spot on the module).

---

*Note: Make sure that your system design provides sufficient cooling for the integrated module. The RF shield temperature should not be exposed to an ambient temperature greater than 85 °C to prevent damage to the module's components.*

---

# 7.5 Serial Link Access

Direct access to the UART1/UART2 serial link is very useful for:
- Testability operations
- Firmware download (for more information on firmware upgrade, see SED (Smart Error Detection) on page 100
- Accessing the module's Linux console for debugging

Refer to the following figure for a level shifter implementation that allows UART1 serial link access. (A UART2 (2-wire interface) level shifter would use the corresponding WP75xx/WP8548 UART2 pins—UART2_TX (pin 96), UART2_RX (pin 97).)
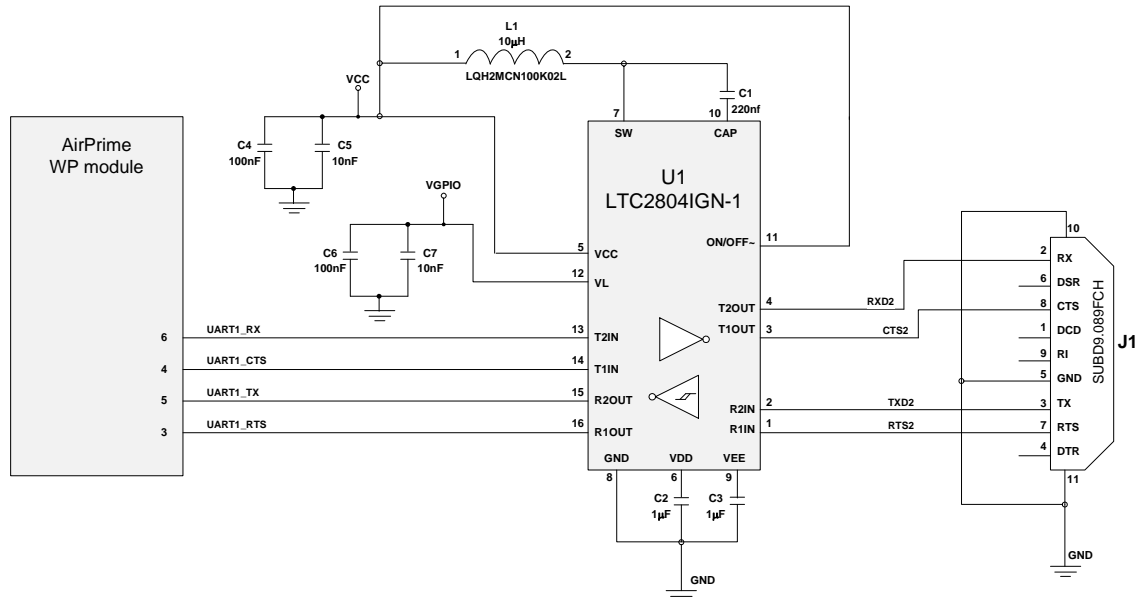


*Figure 7-1: Level Shifter Implementation for UART1 Serial Link Access*

# 7.6 RF Output Accessibility

During the integration phase of the AirPrime WP75xx/AirPrime WP8548, it can be helpful to connect the module to a simulator to check critical RF TX parameters and power behavior for supported RATs (LTE (WP75xx), WCDMA, HSDPA, HSUPA, CDMA (WP7504), and GSM/EDGE/GPRS (WP7502/WP8548)).

Although the AirPrime WP75xx/AirPrime WP8548 module has been certified, some parameters may have degraded if some basic precautions have not been followed (poor power supply, for example). This may not affect the functionality of the product, but the product may not comply with 3GPP specifications.

The following TX parameters can be checked using a Radio Communication tester:
- Phase & Frequency Error
- Output Power and Burst Time
- Output Spectrum (Modulation and Switching)

The following are available typical Radio Communication testers:
- Rohde & Schwarz: CMU200, CMW500
- Keysight (formerly Agilent): 8960
- Anritsu: MD8475

Because of the high prices associated with Radio Communication testers and the necessary RF know-how to perform simulations, customers can check their applications in the Sierra Wireless laboratories. Contact the Sierra Wireless support team for more information.

# >>|8: Reliability Specification

AirPrime WP75xx/AirPrime WP8548 modules are tested against the Sierra Wireless Industrial Reliability Specification defined below.

## 8.1 Reliability Compliance

AirPrime WP75xx/AirPrime WP8548 modules connected on a reliability test board are compliant with the requirements in Table 8-1.

**Table 8-1:  Standards Conformity**

| Abbreviation | Definition |
|---|---|
| IEC | International Electrotechnical Commision |
| ISO | International Organization for Standardization |

## 8.2 Reliability Prediction Model

### 8.2.1 Life Stress Test

The following tests the AirPrime WP75xx/AirPrime WP8548 module's product performance.

**Table 8-2:  Life Stress Test**

| Designation | Condition |
|---|---|
| Performance Test PT3T & PTRT | Standard: N/A |
| | Special conditions:<br>• Temperature:<br>  · Class A: -30°C to +70°C<br>  · Class B: -40°C to +85°C<br>  · Rate of temperature change: 3 ± 0.6°C/min<br>• Recovery time: 3 hours |
| | Operating conditions: Powered |
| | Duration: 14 days |

## 8.2.2 Environmental Resistance Stress Tests

The following tests the AirPrime WP75xx/AirPrime WP8548 module's resistance to extreme temperature.
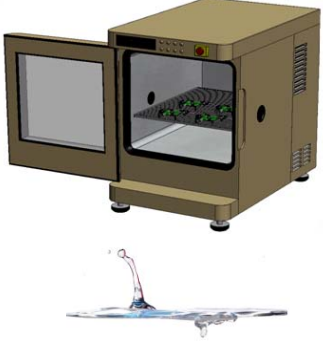
**Table 8-3: Environmental Resistance Stress Tests**

| Designation | Condition |
|---|---|
| Cold Test Active COTA  | Standard: IEC 680068-2-1, Test ad |
| | Special conditions:<br>• Temperature: -40°C<br>• Temperature variation: 1°C/min |
| | Operating conditions: Powered ON with a power cycle of 1 minute ON and 2 minutes OFF |
| | Duration: 3 days |
| Resistance to Heat Test RH  | Standard: IEC 680068-2-2, Test Bb |
| | Special conditions:<br>• Temperature: +85°C<br>• Temperature variation: 1°C/min |
| | Operating conditions: Powered ON with a power cycle of 15 minutes ON and 15 minutes OFF |
| | Duration: 50 days |
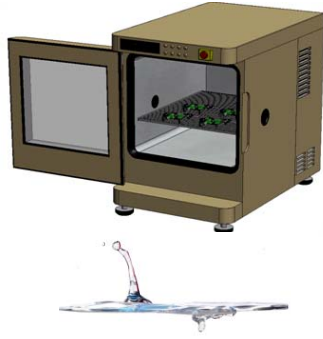
## 8.2.3 Corrosive Resistance Stress Tests

The following tests the AirPrime WP75xx/AirPrime WP8548 module's resistance to corrosive atmosphere.

**Table 8-4: Corrosive Resistance Stress Tests**

| Designation | Condition |
|---|---|
| Humidity Test HUT  | Standard: IEC 60068-2-3, Test Ca |
| | Special conditions:<br>• Temperature: +65°C<br>• RH: 95%<br>• Temperature variation: 3 ± 0.6°C/min |
| | Operating conditions: Powered ON with a power cycle of 15 minutes ON and 15 minutes OFF |
| | Duration: 10 days |

**Table 8-4: Corrosive Resistance Stress Tests (Continued)**

| Designation | Condition |
|---|---|
| Component Solder Wettability CSW  | Standard: JESD22-B102, Method 1/Condition C, Solderability Test Method |
| | Special conditions:<br>• Test method: Dip and Look Test with Steam preconditioning 8 h ± 15 min. Dip for 5 +0/-0.5 seconds |
| | Operating conditions: Unpowered |
| | Duration: 1 day |
| Moist Heat Cyclic Test MHCT  | Standard: IEC 60068-2-30, Test Db |
| | Special conditions:<br>• Upper temperature: +40 ± 2°C<br>• Lower temperature: +23 ± 5°C<br>• RH:<br>  · At upper temperature: 93%<br>  · At lower temperature: 95%<br>• Number of cycles: 21 (1 cycle/24 hours)<br>• Temperature variation: 3 ± 0.6°C/min |
| | Operating conditions: Powered ON for 15 minutes during each 3 hours ramp up and 3 hours ramp down (in middle) for every cycle |
| | Duration: 21 days |

## 8.2.4 Thermal Resistance Cycle Stress Tests

The following tests the AirPrime WP75xx/AirPrime WP8548 module's resistance to extreme temperature cycling.

**Table 8-5: Thermal Resistance Cycle Stress Tests**

| Designation | Condition |
|---|---|
| Thermal Shock Test TSKT  | Standard: IEC 60068-2-14, Test Na |
| | Special conditions:<br>• Temperature: -30°C to +80°C<br>• Temperature variation: 6–30 s<br>• Number of cycles: 600<br>• Dwell time: 10 minutes |
| | Operating conditions: Unpowered |
| | Duration: 9 days |
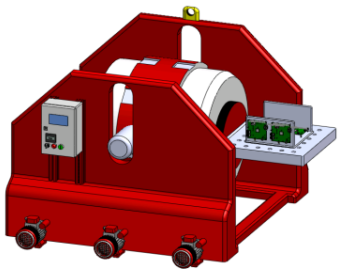
**Table 8-5:  Thermal Resistance Cycle Stress Tests (Continued)**

| Designation | Condition |
|---|---|
| Temperature Change TCH | Standard: IEC 60068-2-14, Test Nb |
| | Special conditions:<br>Temperature: -40°C to +90°C<br>Temperature variation: 3 ± 0.6°C/min<br>Number of cycles: 400<br>Dwell time: 10 minutes |
| | Operating conditions: Unpowered |
| | Duration: 29 days |
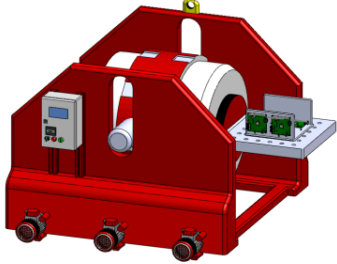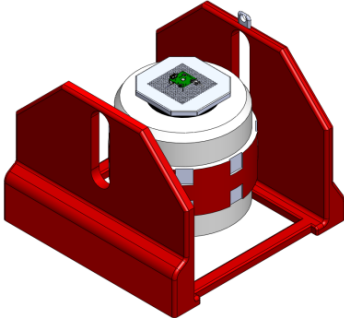
## 8.2.5 Mechanical Resistance Stress Tests

The following tests the AirPrime WP75xx/AirPrime WP8548 module's resistance to vibrations and mechanical shocks.

**Table 8-6:  Mechanical Resistance Stress Tests**

| Designation | Condition |
|---|---|
| Sinusoidal Vibration Test SVT | Standard: IEC 60068-2-6, Test Fc |
| | Special conditions:<br>• Frequency range: 16 Hz to 1000 Hz<br>• Displacement: 0.35 mm (peak–peak)<br>• Acceleration:<br>  · 5 g from 16 to 62 Hz<br>  · 3 g from 62 to 200 Hz<br>  · 1 g from 200 to 1000 Hz<br>• Sweep rate: 1 octave/minute<br>• Number of sweeps: 20 sweeps/axis<br>• Sweep direction: ± X, ± Y, ± Z |
| | Operating conditions: Unpowered |
| | Duration: 2 days |
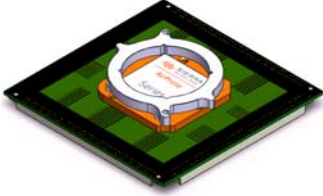
**Table 8-6:  Mechanical Resistance Stress Tests (Continued)**

| Designation | Condition |
|---|---|
| Random Vibration Test RVT  | Standard: IEC 60068-2-64, Test Fh |
| | Special conditions:<br>• Frequency range: 10 Hz to 2000 Hz<br>• Power Spectral Density in $[(m/s^2)^2/Hz]$<br>  · 0.1 $g^2$/Hz at 10 Hz<br>  · 0.01 $g^2$/Hz at 250 Hz<br>  · 0.005 $g^2$/Hz at 1000 Hz<br>  · 0.005 $g^2$/Hz at 2000 Hz<br>• Peak factor: 3<br>• Duration per axis: 1 hr/axis |
| | Operating conditions: Unpowered |
| | Duration: 1 day |
| Mechanical Shock Test MST  | Standard: IEC 60068-2-27, Test Ea |
| | Special conditions:<br>• Shock Test 1:<br>  · Wave form: Half sine<br>  · Peak acceleration: 30 g<br>  · Duration: 11 ms<br>  · Number of shocks: 8<br>  · Direction: ± X, ± Y, ± Z<br>• Shock Test 2:<br>  · Wave form: Half sine<br>  · Peak acceleration: 100 g<br>  · Duration: 6 ms<br>  · Number of shocks: 3<br>  · Direction: ± X, ± Y, ± Z |
| | Operating conditions: Unpowered |
| | Duration: 72 hours |

## 8.2.6 Handling Resistance Stress Tests

The following tests the AirPrime WP75xx/AirPrime WP8548 module's resistance to handling malfunctions and damage.

**Table 8-7: Handling Resistance Stress Tests**

| Designation | Condition |
|---|---|
| ESDC Test | Standard: JESD22-A114, JESD22-A115, JESD22-C101 |
| | Special conditions:<br>• HBM (Human Body Model): 1 KV (Class 1C)<br>• MM (Machine Model): 100 V<br>• CDM (Charged Device Model): 500 V (Class IV) |
| | Operating conditions: Powered |
| | Duration: 3 days |
| Free Fall Test<br>FFT 1 | Standard: IEC 60068-2-32, Test Ed |
| | Special conditions:<br>• Number of drops: 2 drops per unit<br>• Height: 1 m |
| | Operating conditions: Unpowered |
| | Duration: 6 hours |

# >>|9: Approval

## 9.1 RoHS Directive Compliance

The AirPrime WP75xx/AirPrime WP8548 module complies with the European Union's requirements on the restriction of the use of certain hazardous substances in electrical and electronic equipment—RoHS Directive 2011/65/EU, including Commission Delegated Directive (EU) 2015/863 amending Annex II of Directive 2011/65/EU.

## 9.2 Disposing of the Product

This electronic product is subject to the EU Directive 2012/19/EU for Waste Electrical and Electronic Equipment (WEEE). As such, this product must not be disposed of at a municipal waste collection point. Please refer to local regulations for directions on how to dispose of this product in an environmental friendly manner.

## 9.3 Important Notice

Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

## 9.4 Safety and Hazards

Do not operate your AirPrime WP75xx Embedded Module/AirPrime WP8548 Embedded Module:
- In areas where blasting is in progress
- Where explosive atmospheres may be present including refueling points, fuel depots, and chemical plants
- Near medical equipment, life support equipment, or any equipment which may be susceptible to any form of radio interference.

In such areas, the AirPrime WP75xx/AirPrime WP8548 modem **MUST BE POWERED OFF**. Otherwise, the AirPrime WP75xx/AirPrime WP8548 modem can transmit signals that could interfere with this equipment.

In an aircraft, the AirPrime WP75xx/AirPrime WP8548 modem **MUST BE POWERED OFF**. Otherwise, the AirPrime WP75xx/AirPrime WP8548 modem can transmit signals that could interfere with various onboard systems and may be dangerous to the operation of the aircraft or disrupt the cellular network. Use of a cellular phone in

an aircraft is illegal in some jurisdictions. Failure to observe this instruction may lead to suspension or denial of cellular telephone services to the offender, or legal action or both.

Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. The AirPrime WP75xx/AirPrime WP8548 modem may be used normally at this time.

# 9.5 Compliance Acceptance and Certification

The AirPrime WP75xx is designed to be compliant with the 3GPP Release 8 UTRA and Release 9 E-UTRA Specifications for Mobile Terminated Equipment. The AirPrime WP8548 is designed to be compliant with the 3GPP Release 8 UTRA Specification for Mobile Terminated Equipment.

Final regulatory and operator certification requires regulatory agency testing and approval with the fully integrated UE host device incorporating the AirPrime WP75xx/ AirPrime WP8548 module.

The OEM host device and, in particular, the OEM antenna design and implementation will affect the final product functionality, RF performance, and certification test results.

*Note:  Tests that require features not supported by the AirPrime WP75xx/AirPrime WP8548 (as defined by this document) are not supported.*

# 9.6 Certification Compliance

## 9.6.1 Important Compliance Information for North American Users

The AirPrime WP7504/AirPrime WP8548 module, upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the AirPrime WP7504/AirPrime WP8548 module in their final products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC approvals must be obtained.

1.  The end product must use the RF trace design approved with the AirPrime WP7504/AirPrime WP8548 module. The Gerber file of the trace design can be obtained from Sierra Wireless upon request.

2.  At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.

3.  (WP7504)To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including

cable loss in a mobile-only exposure condition must not exceed the limits stipulated in Table 9-1 on page 113.

**Table 9-1: WP7504 Antenna Gain Specifications**

| Device | Technology | Band | Frequency (MHz) | Maximum antenna gain (dBi) |
|---|---|---|---|---|
| AirPrime WP7504 | LTE | 2 | 1850–1910 | 6 |
| | | 4 | 1710–1755 | 6 |
| | | 5 | 824–849 | 6 |
| | | 12 | 699–716 | 6 |
| | | 25 | 1850–1910 | 6 |
| | | 26 | 814–849 | 6 |
| | UMTS | 2 | 1850–1910 | 6 |
| | | 4 | 1710–1755 | 6 |
| | | 5 | 824–849 | 6 |
| | CDMA | BC0 | 824–849 | 6 |
| | | BC1 | 1850–1910 | 6 |
| | | BC10 | 816–824 | 6 |

4.  (WP8548) To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed:

    *   4.0 dBi in Cellular band
    *   3.0 dBi in PCS band

5.  The AirPrime WP7504/AirPrime WP8548 module may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
    *   Each collocated radio transmitter has been certified by FCC/IC for mobile application.
    *   At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.

*Note: Gain values are preliminary and subject to change.*

- (WP7504) The output power of a collocated transmitter must not exceed the EIRP limit stipulated in Table 9-2 on page 114.

**Table 9-2: WP7504 Collocated Radio Transmitter Specifications**

| Device | Technology | Frequency (MHz) | EIRP Limit (dBm) |
|---|---|---|---|
| Collocated transmitters[a] | WLAN | 2400–2500 | 25 |
| | | 5150–5850 | 27 |
| | WiMAX | 2300–2400 | 25 |
| | | 2500–2700 | 25 |
| | | 3300–3800 | 25 |
| | BT | 2400–2500 | 15 |

a. Valid collocated transmitter combinations: WLAN+BT; WiMAX+BT.
(WLAN+WiMAX+BT is not permitted.)

- (WP8548) The output power and antenna gain in a collocated configuration must not exceed the limits and configurations stipulated in Table 9-3 on page 114.

**Table 9-3: WP8548 Collocated Configuration Specifications**

| Device | Technology | Band | Frequency (MHz) | Antenna Gain Limits (dBi) Standalone | Antenna Gain Limits (dBi) Collocated | EIRP Limits (dBm) |
|---|---|---|---|---|---|---|
| AirPrime WP8548 | UMTS | 2 | 1850–1910 | 3 | 3 | — |
| | | 5 | 824–849 | 4 | 3 | — |
| | GPRS/EDGE | 850 | 824–849 | 4 | 3 | — |
| | | 1900 | 1850–1910 | 3 | 3 | — |
| Collocated transmitters[a] | WLAN | 2.4 GHz | 2400–2500 | — | — | 27 |
| | | 5 GHz | 5150–5850 | — | — | 27 |
| | WiMAX | | 2300–2400 | — | — | 27 |
| | | | 2500–2700 | — | — | 27 |
| | | | 3300–3800 | — | — | 27 |
| | BT | | 2400–2500 | — | — | 20 |

a. Valid collocated transmitter combinations: WLAN+BT; WiMAX+BT.
(WLAN+WiMAX+BT is not permitted.)

6. A label must be affixed to the outside of the end product into which the AirPrime WP7504/AirPrime WP8548 module is incorporated, with a statement similar to the following:
   - **(WP7504)— This device contains FCC ID: N7NWP7/IC:2417C-WP7.**
   - **(WP8548)— This device contains FCC ID: N7NWP8/IC:2417C-WP8.**

7. A user manual with the end product must clearly indicate the operating require-
ments and conditions that must be observed to ensure compliance with current
FCC/IC RF exposure guidelines.

The end product with an embedded AirPrime WP7504/AirPrime WP8548 module
may also need to pass the FCC Part 15 unintentional emission testing requirements
and be properly authorized per FCC Part 15.

*Note: If this module is intended for use in a portable device, you are responsible for separate
approval to satisfy the SAR requirements of FCC Part 2.1093 and IC RSS-102.*

## 9.6.2 Japan Regulatory Compliance

The AirPrime WP8548 module has been granted regulatory approval in Japan with
the following certification numbers:

R 003-160101

T AD160053003
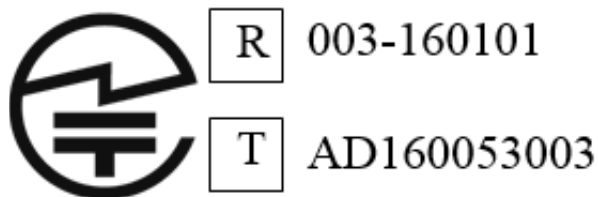
# ≫ 10: Pinout

The system interface of the AirPrime WP75xx/AirPrime WP8548 is through the LGA pattern on the bottom of the PCB.

AirPrime WP75xx/AirPrime WP8548 pins are divided into three functional categories:
- Core functions and associated pins—Cover all the mandatory features for M2M connectivity and will be available by default across all CF3 family of modules. These Core functions are always available and always at the same physical pin locations. A customer platform using only these functions and associated pins is guaranteed to be forward and/or backward compatible with the next generation of CF3 modules.
- Extension functions and associated pins—Bring additional capabilities to the customer. Whenever an Extension function is available on a module, it is always at the same pin location.
- Custom functions and associated pins—These are module-specific and make use of specific chipset functions and I/Os.

**Warning:** *Custom features should be used with caution as there is no guarantee that the custom functions available on a given module will be available on other CF3 modules.*

Pins marked as "Leave open" or "Reserved" should not be used or connected.

## 10.1 Pin Configuration

Figure 10-1 illustrates the pin configuration of the AirPrime WP75xx/AirPrime WP8548 module.



*Figure 10-1: Pin Configuration (Bottom View)*

## 10.2 Pin Description

Table 10-1 on page 118 lists detailed information for the LGA pins.

*Note: Some pin numbers (112, 126, 127, 137, 138, 235) do not appear in this table because there are no corresponding pads on the module's PCB.*

### Table 10-1: Pin Definitions

| Pin | Signal name | Group | I/O[a] | Voltage | PU/ PD[b] | Active | If unused | Function | Type |
|---|---|---|---|---|---|---|---|---|---|
| 1 | I2C1_CLK | I2C | I/O | 1.8V | PU | | Leave open | $I^2C$ clock | Core |
| 2 | UART1_RI[c] | UART1 | O | 1.8V | | H | Leave open | UART1 Ring indicator | Core |
| 3 | UART1_RTS[c] | UART1 | I | 1.8V | | L | Leave open | UART1 Request to send | Core |
| 4 | UART1_CTS[c] | UART1 | O | 1.8V | | L | Leave open | UART1 Clear to send | Core |
| 5 | UART1_TX[c] | UART1 | I | 1.8V | | | Leave open | UART1 Transmit data | Core |
| 6 | UART1_RX[c] | UART1 | O | 1.8V | | | Leave open | UART1 Receive data | Core |
| 7 | UART1_DTR[c] | UART1 | I | 1.8V | | L | Leave open | UART1 Data terminal ready | Core |
| 8 | UART1_DCD[c] | UART1 | O | 1.8V | | L | Leave open | UART1 Data carrier detect | Core |
| 9 | UART1_DSR[c] | UART1 | O | 1.8V | | L | Leave open | UART1 Data set ready | Core |
| 10 | GPIO2[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 11 | RESET_IN_N | Control signal | I | 1.8V | PU | L | Leave open | Input reset signal | Core |
| 12 | USB_D- | USB | I/O | | | | Leave open | USB Data negative | Core |
| 13 | USB_D+ | USB | I/O | | | | Leave open | USB Data positive | Core |
| 14 | HSIC_DATA | HSIC | I/O | | | | Leave open | High Speed Inter-Chip Data | Extension |
| 15 | HSIC_STRB | HSIC | I/O | | | | Leave open | High Speed Inter-Chip Strobe | Extension |
| 16 | USB_VBUS[e] | USB | I | 5V | | | Mandatory connection (Connect to USB_VBUS, or if unavailable, connect to VBAT_BB) | USB power supply | Core |
| 17–20 | Reserved | No Connection | | | | | See footnote[f]. | | Extension |
| 21 | BAT_RTC | Power | I/O | | | | Leave open | Power supply for RTC backup | Extension |
| 22 | SYS_CLK | Clock | O | | | | Leave open | 19.2 MHz digital clock output | Extension |
| 23 | SLEEP_CLK | Clock | O | | | | Leave open | 32.768 kHz digital clock output | Extension |
| 24 | ADC1 | ADC | I | | | | Leave open | Analog to digital conversion | Core |
| 25 | ADC0 | ADC | I | | | | Leave open | Analog to digital conversion | Core |
| 26 | UIM1_VCC | UIM1 | O | 1.8V/3V | | | Mandatory connection | 1.8V/3V UIM1 Power supply | Core |

**Table 10-1: Pin Definitions (Continued)**

| Pin | Signal name | Group | I/O[a] | Voltage | PU/PD[b] | Active | If unused | Function | Type |
|---|---|---|---|---|---|---|---|---|---|
| 27 | UIM1_CLK | UIM1 | O | 1.8V/3V | | | Mandatory connection | UIM1 Clock | Core |
| 28 | UIM1_DATA | UIM1 | I/O | 1.8V/3V | | | Mandatory connection | UIM1 Data | Core |
| 29 | UIM1_RESET_N | UIM1 | O | 1.8V/3V | | L | Mandatory connection | UIM1 Reset | Core |
| 30 | GND | Ground | 0V | 0V | | | Mandatory connection | (WP75xx) Diversity antenna ground<br>(WP8548) Ground | Extension |
| 31 | (WP75xx) RF_DIV<br>(WP8548) Reserved | RF | | | | | See footnote[f]. | | Extension |
| 32 | GND | Ground | 0V | 0V | | | Mandatory connection | (WP75xx) Diversity antenna ground<br>(WP8548) Ground | Extension |
| 33 | PCM_OUT | PCM | O | 1.8V | | | Leave open | PCM data out | Core |
| | I2S_OUT | I2S | O | 1.8V | | | Leave open | I2S data out | |
| 34 | PCM_IN | PCM | I | 1.8V | | | Leave open | PCM data in | Core |
| | I2S_IN | I2S | I | 1.8V | | | Leave open | I2S data in | |
| 35 | PCM_SYNC | PCM | Pri: I/O<br>Aux: O | 1.8V | | | Leave open | PCM sync | Core |
| | I2S_WS | I2S | O | 1.8V | | | Leave open | I2S word select | |
| 36 | PCM_CLK | PCM | Pri: I/O<br>Aux: O | 1.8V | | | Leave open | PCM clock | Core |
| | I2S_CLK | I2S | O | 1.8V | | | Leave open | I2S clock | |
| 37 | GND | RF | 0V | 0V | | | Mandatory connection | GNSS antenna ground | Core |
| 38 | RF_GNSS[g] | RF | | | | | Mandatory connection | RF GNSS input | Extension |
| 39 | GND | RF | 0V | 0V | | | Mandatory connection | GNSS antenna ground | Core |
| 40 | GPIO7[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 41 | GPIO8 | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 42 | DR_SYNC[g] | GPS | O | 1.8V | | | Leave open | GPS dead reckoning sync | Extension |
| 43 | Reserved | No Connection | | | | | | | Extension |
| 44 | GPIO13[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Extension |
| 45 | VGPIO | Voltage reference | O | 1.8V | | | Leave open | GPIO voltage output | Core |

**Table 10-1: Pin Definitions (Continued)**

| Pin | Signal name | Group | I/O[a] | Voltage | PU/PD[b] | Active | If unused | Function | Type |
|-----|-------------|-------|--------|---------|----------|--------|-----------|----------|------|
| 46 | RESET_OUT_N | Control signal | O | 1.8V | PD | L | Leave open | Reset | Core |
| 47 | TP1 (Boot pin) | Boot | I | 1.8V | | L | Mandatory test point | Test point 1 <br> • 0—Download mode <br> • Open—Normal mode | Extension |
| 48 | GND | RF | 0V | 0V | | | Mandatory connection | Main antenna ground | Core |
| 49 | RF_MAIN | RF | | | | | Mandatory connection | Main RF antenna | Core |
| 50 | GND | RF | 0V | 0V | | | Mandatory connection | Main antenna ground | Core |
| 51 | SPI1_MRDY | SPI1 | O | 1.8V | | | Leave open | SPI Master Ready | Core |
| 52 | SPI1_MISO | SPI1 | I | 1.8V | | | Leave open | SPI Master Input/Slave Output (output from slave) | Core |
| 53 | SPI1_CLK | SPI1 | O | 1.8V | | | Leave open | SPI serial clock (output from Master) | Core |
| 54 | SPI1_MOSI | SPI1 | O | 1.8V | | | Leave open | SPI Master Output/Slave Input (output from master) | Core |
| 55 | UIM2_VCC | UIM2 | O | 1.8V/3V | | | Optional connection | UIM2 Power supply | Core |
| 56 | UIM2_DATA | UIM2 | I/O | 1.8V/3V | | | Optional connection | UIM2 Data | Core |
| 57 | UIM2_RESET_N | UIM2 | O | 1.8V/3V | | L | Optional connection | UIM2 Reset | Core |
| 58 | UIM2_CLK | UIM2 | O | 1.8V/3V | | | Optional connection | UIM2 Clock | Core |
| 59 | POWER_ON_N | Control | I | 1.8V | PU | L | Mandatory connection | Power On control signal | Core |
| 60 | TX_ON | Indication | O | 1.8V | | H | Leave open | Tx activity indicator | Extension |
| 61 | VBAT_RF | Power | I | 3.4V (min) 3.7V (typ) 4.3V (max) | | | Mandatory connection | RF power supply (see Power Supply Ratings on page 35) | Core |
| 62 | VBAT_RF | Power | I | 3.4V (min) 3.7V (typ) 4.3V (max) | | | Mandatory connection | RF power supply (see Power Supply Ratings on page 35) | Core |
| 63 | VBAT_BB | Power | I | 3.4V (min) 3.7V (typ) 4.3V (max) | | | Mandatory connection | Baseband power supply (see Power Supply Ratings on page 35) | Core |

**Table 10-1: Pin Definitions (Continued)**

| Pin | Signal name | Group | I/O[a] | Voltage | PU/ PD[b] | Active | If unused | Function | Type |
|---|---|---|---|---|---|---|---|---|---|
| 64 | UIM1_DET | UIM1 | | 1.8V | | | Mandatory connection | Detect UIM1 insertion/ removal. (Pin must be open to detect the UIM, or grounded if no UIM is present.) | Core |
| 65 | UIM2_DET | UIM2 | | 1.8V | | | Ground | Detect UIM2 insertion/ removal (Pin must be open to detect the UIM, or grounded if no UIM is present.) | Extension |
| 66 | I2C1_Data | I2C | I/O | 1.8V | PU | | Leave open | $I^2$C data | Core |
| 67–70 | GND | Ground | 0V | 0V | | | Mandatory connection | Ground | Core |
| 71–90 | Reserved | No Connection | | | | | See footnote[f]. | | |
| 91 | USB_ID | USB | I | | | | Leave open | Reserved for use with USB OTG | Extension |
| 92 | GPIO38[h,i] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| 93 | GPIO39[h,i] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| 94 | GPIO40[h,j] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| 95 | GPIO41[h,j] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| 96 | UART2_TX[c] | UART2 | I | 1.8V | | | Leave open | UART2 Transmit data | Extension |
| 97 | UART2_RX[c] | UART2 | O | 1.8V | | | Leave open | UART2 Receive data | Extension |
| 98 | Reserved | No Connection | | | | | | | |
| 99 | Reserved | No Connection | | | | | | | |
| 100 | GPIO34[h] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| | (alternate function) COEX1 | COEX | I/O | 1.8V | | | Leave open | Coexistence | |
| 101 | GPIO35[h] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| | (alternate function) COEX2 | COEX | I/O | 1.8V | | | Leave open | Coexistence | |
| 102 | GPIO36[h,i] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| | (alternate function) COEX3 | COEX | I/O | 1.8V | | | Leave open | Coexistence | |
| 103 | GPIO37[h] | GPIO | I/O | 1.8V | NP | | Leave open | General purpose I/O | Extension |
| 104 | GPIO32[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Extension |
| 105 | GPIO33[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Extension |

**Table 10-1: Pin Definitions (Continued)**

| Pin | Signal name | Group | I/O[a] | Voltage | PU/PD[b] | Active | If unused | Function | Type |
|---|---|---|---|---|---|---|---|---|---|
| 106 | WWAN_LED_N | Indication | O | VBAT_BB[k] | | L | Leave open | | Extension |
| 107 | ADC2 | ADC | I | | | | Leave open | | Extension |
| 108 | ADC3 | ADC | I | | | | Leave open | | Extension |
| 109 | GPIO42[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Extension |
| 110 | WAKE_ON_WWAN | Indication | O | 1.8V | | H | Leave open | Driven high to wake the host when specific events occur. | Extension |
| 111 | GND | Ground | 0V | 0V | | | Mandatory connection | (WP75xx) Diversity antenna ground<br>(WP8548) Ground | Core |
| 113 | GND | Ground | 0V | 0V | | | Mandatory connection | (WP75xx) Diversity antenna ground<br>(WP8548) Ground | Core |
| 114–124 | Reserved | No Connection | | | | | See footnote[f]. | | |
| 125 | GND | RF | 0V | 0V | | | Mandatory connection | GNSS antenna ground | Core |
| 128 | GND | RF | 0V | 0V | | | Mandatory connection | GNSS antenna ground | Core |
| 129–135 | Reserved | No Connection | | | | | See footnote[f]. | | |
| 136 | GND | RF | 0V | 0V | | | Mandatory connection | Main antenna ground | Core |
| 139 | GND | RF | 0V | 0V | | | Mandatory connection | Main antenna ground | Core |
| 140–146 | Reserved | No Connection | | | | | See footnote[f]. | | |
| 147 | GPIO21[d] | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 148 | GPIO22 | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 149 | GPIO23 | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 150 | GPIO24 | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 151 | W_DISABLE_N | Control | I | 1.8V | | L | | Wireless disable (main RF radio) | Core |
| 152 | SAFE_PWR_REMOVE | Indication | O | 1.8V | | H | Leave open | Indicate to host that Main DC power can be removed | Extension |
| 153 | ANT_CNTL0 | Antenna control | O | 1.8V | | | Leave open | | Extension |
| | GPIO28[l] | GPIO | I/O | 1.8V | | | Leave open | General purpose I/O | Extension |

**Table 10-1: Pin Definitions (Continued)**

| Pin | Signal name | Group | I/O[a] | Voltage | PU/PD[b] | Active | If unused | Function | Type |
|---|---|---|---|---|---|---|---|---|---|
| 154 | ANT_CNTL1 | Antenna control | O | 1.8V | | | Leave open | | Extension |
| | GPIO29[l] | GPIO | I/O | 1.8V | | | Leave open | General purpose I/O | Extension |
| 155 | ANT_CNTL2 | Antenna control | O | 1.8V | | | Leave open | | Extension |
| | GPIO30[l] | GPIO | I/O | 1.8V | | | Leave open | General purpose I/O | Extension |
| 156 | ANT_CNTL3 | Antenna control | O | 1.8V | | | Leave open | | Extension |
| | GPIO31[l] | GPIO | I/O | 1.8V | | | Leave open | General purpose I/O | Extension |
| 157 | VBAT_RF | Power | I | 3.4V (min) 3.7V (typ) 4.3V (max) | | | Optional connection | RF power supply (see Power Supply Ratings on page 35) | Core |
| 158 | VBAT_BB | Power | I | 3.4V (min) 3.7V (typ) 4.3V (max) | | | Optional connection | Baseband power supply (see Power Supply Ratings on page 35) | Core |
| 159 | GPIO25 | GPIO | I/O | 1.8V | PD | | Leave open | General purpose I/O | Core |
| 160 | Reserved | No Connection | | | | | See footnote[f]. | | |
| 161 | SDIO_CMD | SDIO | O | 2.95V | | | Leave open | SDIO command | Extension |
| 162 | SDIO_CLK | SDIO | O | 2.95V | | | Leave open | SDIO clock | Extension |
| 163 | SDIO_DATA_3 | SDIO | I/O | 2.95V | | | Leave open | SDIO data bit 3 | Extension |
| 164 | SDIO_DATA_2 | SDIO | I/O | 2.95V | | | Leave open | SDIO data bit 2 | Extension |
| 165 | SDIO_DATA_1 | SDIO | I/O | 2.95V | | | Leave open | SDIO data bit 1 | Extension |
| 166 | SDIO_DATA_0 | SDIO | I/O | 2.95V | | | Leave open | SDIO data bit 0 | Extension |
| 167–234 | GND | Ground | 0V | 0V | | | Mandatory connection | Ground | Core |
| 236 | J1[m] | | | 1.8V | | L | Mandatory test point | Test point | Extension |
| 237 | J2[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |
| 238 | J3[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |
| 239 | J4[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |
| 240 | J5[m] | | | 1.8V | | L | Mandatory test point | Test point | Extension |
| 241 | J6[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |
| 242 | J7[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |

### Table 10-1: Pin Definitions (Continued)

| Pin | Signal name | Group | I/O[a] | Voltage | PU/PD[b] | Active | If unused | Function | Type |
|-----|-------------|-------|--------|---------|----------|--------|-----------|----------|------|
| 243 | J8[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |
| 244 | J9[m] | | | 1.8V | | | Mandatory test point | Test point | Extension |

a. Signal direction with respect to the module. Examples: PCM_OUT (pin 33) is an output from the module to the host; PCM_IN (pin 34) is an input to the module from the host.
b. NP—No Pull; PD—Pull Down; PU—Pull Up
c. (UART signals only) Signals are named with respect to the host device. For example, UART1_RX is the signal used by the host to receive data from the module.
d. Wakeable GPIO. See Wakeup Interrupt (USB-SS Mode) on page 74 for details.
e. Not currently connected internally, but customer solutions should provide this input for compatibility with future module revisions.
f. Pins are not connected internally, but are reserved for future use. Leave them unconnected to ensure compatibility with other Sierra Wireless CF3 modules.
g. (WP75xx) Support is SKU-dependent; (WP8548) Supported.
h. Accessible via sysfs/Legato only.
i. Can be configured as a wakeup trigger for ULPM. See Power Consumption States on page 38 for details.
j. GPIO40 and GPIO41 may be unavailable in future WP products.
k. Maximum rating is VBAT_BB + 0.5V, with maximum current sink capability of 300 mA.
l. GPIOs 28–31 are available for use when configured using AT+WIOCFG.
m. Accessibility restricted to soldered-down modules. Not available for socket-mounted modules.

### Table 10-2: RF Pin Information

| Signal name | Pin # | Description |
|-------------|-------|-------------|
| (WP75xx) RF_DIV | 31 | Diversity input |
| RF_GNSS[a] | 38 | RF GNSS input |
| RF_MAIN | 49 | Main RF port (input/output) |

a. WP75xx—Support is SKU-dependent; WP8548—Supported

### Table 10-3: Supply Pin Information

| Signal name | Pin # | Description |
|-------------|-------|-------------|
| VBAT_RF | 61, 62, 157 | RF power supply |
| VBAT_BB | 63, 158 | Baseband power supply |
| BAT_RTC | 21 | Power supply for RTC backup |
| USB_VBUS | 16 | Connected to VBAT_BB |

### Table 10-4: Ground & Reserved Pin Information

| Signal name | Pin # | Description |
|-------------|-------|-------------|
| Ground | 30, 32, 37, 39, 48, 50, 67–70, 111, 113, 125, 128, 136, 139, 167–234 | Ground connection |
| Reserved | 17–20, (WP8548) 31, 71–90, 114–124, 129–135, 140–146, 160 | Pins are not connected internally, but are reserved for future use. Leave them unconnected to ensure compatibility with other Sierra Wireless CF3 modules. |

# >> 11: Customization

Subject to commercial terms, Sierra Wireless can supply custom-configured modems to facilitate a carrier's network and performance requirements. Sierra Wireless also offers a standard configuration for each country.

Custom configurations are entered into a selector spreadsheet that Sierra supplies. A unique part number is assigned to each custom configuration to facilitate customer ordering.

**Table 11-1: Customizable Features**

| Name | Description | Default |
|---|---|---|
| Display of IMSI | Display of International Mobile Subscriber Identity via AT+CIMI command | Display enabled |
| UART baud rate | Default UART speed | 115200 bps |
| UART enabled | Defines whether UART port is enabled by default or not | UART disabled |

# ≫ 12: References

For more details, several references can be consulted, as detailed below.

## 12.1 Web Site Support

Check http://source.sierrawireless.com for the latest documentation available for the AirPrime WP75xx/AirPrime WP8548.

## 12.2 Reference Documents

**[1]** AirPrime WPx5xx AT Command Reference
Reference number: 4118047

**[2]** Inter-Chip USB Supplement to the USB 2.0 Specification Revision 1.0

**[3]** Legato.io for Legato API details

**[4]** AirPrime WPx5 Series Customer Process Guidelines

**[5]** The I$^2$C Bus Specification, Version 2.1, January 2000 (Phillips Semiconductor document number 9398 393 40011)

# 13: Abbreviations

**Table 13-1:  Acronyms and Definitions**

| Acronym or term | Definition |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| 8PSK | Octagonal Phase Shift Keying |
| ADC | Analog to Digital Converter |
| AF | Audio-Frequency |
| API | Application Programming Interface |
| AT | Attention (prefix for modem commands) |
| BeiDou | BeiDou Navigation Satellite System<br>A Chinese system that uses a series of satellites in geostationary and middle earth orbits to provide navigational data. |
| BER | Bit Error Rate—A measure of receive sensitivity |
| BLER | Block Error Rate |
| Bluetooth | Wireless protocol for data exchange over short distances |
| CEP | Circular Error Probable |
| CF3 | Common Flexible Form Factor |
| CLK | Clock |
| CMOS | Complementary Metal Oxide Semiconductor |
| CPU | Central Processing Unit |
| CQI | Channel Quality Indication |
| CS | Circuit-Switched |
| | Coding Scheme |
| CTS | Clear To Send |
| CW | Continuous waveform |
| DAC | Digital to Analog Converter |
| dB | Decibel = 10 x $\log_{10}$ (P1/P2)<br>*P1 is calculated power; P2 is reference power*<br>Decibel = 20 x $\log_{10}$ (V1/V2)<br>*V1 is calculated voltage, V2 is reference voltage* |
| dBm | A logarithmic (base 10) measure of relative power (dB for decibels); relative to milliwatts (m). A dBm value will be 30 units (1000 times) larger (less negative) than a dBW value, because of the difference in scale (milliwatts vs. watts). |
| DC | Direct Current |
| DCD | Data Carrier Detect |

**Table 13-1: Acronyms and Definitions (Continued)**

| Acronym or term | Definition |
|---|---|
| DCS | Digital Cellular System<br>A cellular communication infrastructure that uses the 1.8 GHz radio spectrum. |
| DL | Downlink (network to mobile) |
| DRX | Discontinuous Reception |
| DSR | Data Set Ready |
| DTR | Data Terminal Ready |
| E-GSM | Extended GSM |
| EDGE | Enhance Data rates for GSM Evolution |
| EFR | Enhanced Full Rate |
| EGPRS | Enhance GPRS |
| EIRP | Effective (or Equivalent) Isotropic Radiated Power |
| EMC | Electromagnetic Compatibility |
| EN | Enable |
| ERP | Effective Radiated Power |
| ESD | Electrostatic Discharges |
| ETSI | European Telecommunications Standards Institute |
| FCC | Federal Communications Commission<br>The U.S. federal agency that is responsible for interstate and foreign communications. The FCC regulates commercial and private radio spectrum management, sets rates for communications services, determines standards for equipment, and controls broadcast licensing. Consult www.fcc.gov. |
| FDD | Frequency Division Duplexing |
| FDMA | Frequency Division Multiple Access |
| firmware | Software stored in ROM or EEPROM; essential programs that remain even when the system is turned off. Firmware is easier to change than hardware but more permanent than software stored on disk. |
| FOV | Field Of View |
| FR | Full Rate |
| FSN | Factory Serial Number—A unique serial number assigned to the mini card during manufacturing. |
| Galileo | A European system that uses a series of satellites in middle earth orbit to provide navigational data. |
| GCF | Global Certification Forum |
| GLONASS | Global Navigation Satellite System—A Russian system that uses a series of 24 satellites in middle circular orbit to provide navigational data. |

**Table 13-1: Acronyms and Definitions (Continued)**

| Acronym or term | Definition |
| --- | --- |
| GMSK | Gaussian Minimum Shift Keying modulation |
| GND | Ground |
| GNSS | Global Navigation Satellite Systems (GPS, GLONASS, BeiDou, and Galileo) |
| GPIO | General Purpose Input Output |
| GPRS | General Packet Radio Service |
| GPS | Global Positioning System |
| | An American system that uses a series of 24 satellites in middle circular orbit to provide navigational data. |
| GSM | Global System for Mobile communications |
| Hi Z | High impedance (Z) |
| Host | The device into which an embedded module is integrated |
| HR | Half Rate |
| HSDPA | High Speed Downlink Packet Access |
| HSUPA | High Speed Uplink Packet Access |
| Hz | Hertz = 1 cycle/second |
| I/O | Input/Output |
| IC | Industry Canada |
| IC | Integrated Circuit |
| IMEI | International Mobile Equipment Identity |
| IMS | IP Multimedia Subsystem—Architectural framework for delivering IP multimedia services. |
| inrush current | Peak current drawn when a device is connected or powered on |
| IOT | Interoperability Testing |
| IS | Interim Standard. |
| | After receiving industry consensus, the TIA forwards the standard to ANSI for approval. |
| ISIM | IMS Subscriber Identity Module. |
| LED | Light Emitting Diode. |
| | A semiconductor diode that emits visible or infrared light. |
| LGA | Land Grid Array |
| LHCP | Left-Hand Circular Polarized |
| LNA | Low noise Amplifier |
| LTE | Long Term Evolution—a high-performance air interface for cellular mobile communication systems. |

**Table 13-1:  Acronyms and Definitions (Continued)**

| Acronym or term | Definition |
|---|---|
| MAX | Maximum |
| MCS | Modulation and Coding Scheme |
| MHz | Megahertz = 10e6 Hz |
| MIC | Microphone |
| MIMO | Multiple Input Multiple Output—wireless antenna technology that uses multiple antennas at both transmitter and receiver side. This improves performance. |
| MIN | Minimum |
| MO | Mobile Originated |
| MT | Mobile Terminated |
| N/A | Not Applicable |
| NMEA | National Marine Electronics Association |
| NOM | Nominal |
| OEM | Original Equipment Manufacturer—a company that manufactures a product and sells it to a reseller. |
| PA | Power Amplifier |
| packet | A short, fixed-length block of data, including a header, that is transmitted as a unit in a communications network. |
| PBCCH | Packet Broadcast Control Channel |
| PC | Personal Computer |
| PCB | Printed Circuit Board |
| PCL | Power Control Level |
| PCS | Personal Communication System<br>A cellular communication infrastructure that uses the 1.9 GHz radio spectrum. |
| PDN | Packet Data Network |
| PFM | Power Frequency Modulation |
| PLL | Phase Lock Loop |
| PMIC | Power Management Integrated Circuit |
| PSM | Phase Shift Modulation |
| PSS | Primary synchronisation signal |
| PST | Product Support Tools |
| PTCRB | PCS Type Certification Review Board |
| PWM | Pulse Width Modulation |

**Table 13-1: Acronyms and Definitions (Continued)**

| Acronym or term | Definition |
|---|---|
| QAM | Quadrature Amplitude Modulation.<br>This form of modulation uses amplitude, frequency, and phase to transfer data on the carrier wave. |
| QPSK | Quadrature Phase-Shift Keying |
| RAM | Random Access Memory |
| RAT | Radio Access Technology |
| RF | Radio Frequency |
| RHCP | Right Hand Circular Polarization |
| RI | Ring Indicator |
| RSE | Radiated Spurious Emissions |
| RSSI | Received Signal Strength Indication |
| RST | Reset |
| RTC | Real Time Clock |
| RTS | Request To Send |
| RX | Receive |
| SCLK | Serial Clock |
| SED | Smart Error Detection |
| Sensitivity (Audio) | Measure of lowest power signal that the receiver can measure. |
| Sensitivity (RF) | Measure of lowest power signal at the receiver input that can provide a prescribed BER/BLER/SNR value at the receiver output. |
| SIM | Subscriber Identity Module. |
| SKU | Stock Keeping Unit—identifies an inventory item: a unique code, consisting of numbers or letters and numbers, assigned to a product by a retailer for purposes of identification and inventory control. |
| SMS | Short Message Service |
| SNR | Signal-to-Noise Ratio |
| SPI | Serial Peripheral Interface |
| SPK | Speaker |
| SW | Software |
| TBC | To Be Confirmed |
| TBD | To Be Determined |

**Table 13-1: Acronyms and Definitions (Continued)**

| Acronym or term | Definition |
|---|---|
| TIA/EIA | Telecommunications Industry Association / Electronics Industry Association. A standards setting trade organization, whose members provide communications and information technology products, systems, distribution services and professional services in the United States and around the world. Consult www.tiaonline.org. |
| TIS | Total Isotropic Sensitivity |
| TP | Test Point |
| TRP | Total Radiated Power |
| TX | Transmit |
| TYP | Typical |
| UART | Universal Asynchronous Receiver-Transmitter |
| UE | User Equipment |
| UICC | Universal Integrated Circuit Card |
| UIM | User Identity Module. Generic term used in this document to refer to UICC, where the application on the UICC (USIM, ISIM, CSIM, etc.) varies depending on the provider of the card. |
| UL | Uplink (mobile to network) |
| UMTS | Universal Mobile Telecommunications System |
| USB | Universal Serial Bus |
| USB-SS | USB Selective Suspend/USB not enumerated |
| USIM | Universal Subscriber Identity Module (UMTS) |
| USSD | Unstructured Supplementary Services Data |
| UTRA | UMTS Terrestrial Radio Access |
| VBAT-BB | Baseband power supply |
| VBAT-RF | RF power supply |
| VCC | Supply voltage |
| VSWR | Voltage Standing Wave Ratio |
| WCDMA | Wideband Code Division Multiple Access (also referred to as UMTS) |
| WLAN | Wireless Local Area Network |
| WWAN | Wireless Wide Area Network |
| ZIF | Zero Intermediate Frequency |

# >> 14: Testing

## 14.1 Certification Testing

*Note: Typically, certification testing of your device with the integrated module is required one time only.*

The AirPrime WP75xx Embedded Module/AirPrime WP8548 Embedded Module has been certified as described in Regulatory Compliance and Industry Certifications on page 95.

When you produce a host device with a Sierra Wireless AirPrime embedded module, you must obtain certifications for the final product from appropriate regulatory bodies in the jurisdictions where it will be distributed.

The following are *some* of the regulatory bodies from which you may require certification—it is your responsibility to make sure that you obtain all necessary certifications for your product from these or other groups:
- FCC (Federal Communications Commission—www.fcc.gov)
- Industry Canada (www.ic.gc.ca)
- GCF (Global Certification Forum—www.globalcertificationforum.org) outside of North America
- PTCRB (PCS Type Certification Review Board—www.ptcrb.com) in North America

## 14.2 Production Testing

*Note: Production testing typically continues for the life of the product.*

Production testing ensures that, for each assembled device, the module is installed correctly (I/O signals are passed between the host and module), and the antenna is connected and performing to specifications (RF tests).

Typical items to test include:
- Host connectivity
- Baseband (host/module connectors)
- RF assembly (Tx and/or Rx, as appropriate)
- Network availability
- Host/device configuration issues

*Note: The number and types of tests to perform are **your** decision—the tests listed in this section are guidelines only. Make sure that the tests you perform exercise functionality to the degree that **your** situation requires.*

Use an appropriate test station and use AT commands to control the integrated module.

*Note: Your test location must be protected from ESD to avoid interference with the module and antenna(s), assuming that your test computer is in a disassembled state.*
*Also, consider using an RF shielding box—local government regulations may prohibit unauthorized transmissions.*

*Note: The tests described in this chapter are done using a Linux O/S (e.g. Ubuntu 12.04).*

# 14.3 Functional Production Test

This section presents a suggested procedure for performing a basic manual functional test on a laboratory bench using an AirPrime WP75xx Embedded Module/AirPrime WP8548 Embedded Module and a hardware development kit. When you have become familiar with the testing method, use it to develop your own automated production testing procedures.

## 14.3.1 Suggested Production Tests

Consider the following tests when you design your production test procedures for devices with the AirPrime module installed.
- Visual check of the module's connectors and RF assemblies
- Module is operational
- USB connection is functional
- LED is functional
- Power on/off
- Firmware revision check
- Rx tests on main and auxiliary paths
- Tx test

## 14.3.2 Production Test Procedure

The following is a suggested test plan—you must decide which tests are appropriate for your product. You may wish to add additional tests that more fully exercise the capabilities of your product.

Using an appropriate test station, and referring to the appropriate AT command references:

1. Visually inspect the module for obvious defects (such as tainted or damaged shields) before installing it in the test station.
2. Ensure that the module is powered off (no voltage on VBAT_BB/VBAT_RF) before beginning your tests.
3. Determine whether any USB devices are currently connected to the computer:
    a. Open a shell window and enter the command `ls /dev/tty/USB*`.
    b. Record the ttyUSB*n* values that are returned; these are the currently connected USB devices. If the command returns "no such file or directory", there are no devices currently connected.
4. Provide power to the module (voltage on VBAT_BB/VBAT_RF).

5. Test POWER_ON_N—Turn on the module by driving POWER_ON_N low, as shown in Figure 4-1 on page 67.

6. Test USB functionality—Check for USB enumeration.

   Enter the command **ls /dev/tty/USB\*** and then record and compare the results with those from Step 3. If there are any new ttyUSB*n* devices, then the modem has enumerated successfully. (The AT port is usually the *last* new device.)

7. Make sure your modem is connected and running, and then establish contact with the module:

   Use a terminal emulation/communications program such as minicom to connect over the device handle for AT commands (see listings in Step 6):

   i. Start minicom:
      - First use of the modem: From the command line, type minicom -s. (The '-s' switch shows the configuration menu.)
      - Subsequent uses: From the command line, type minicom. (The '-s' switch is assumed.)

      The minicom configuration details appear and the message OK appears when the connection is established.



8. Display the firmware version:
   - **ATI**

9. Unlock the extended AT command set. (Note: Use AT!ENTERCND? to check command syntax, which is SKU-dependent.):
   - **AT!ENTERCND="<password>"**

10. Test the LED—Visually confirm that the LED turns on and off using:
    - **AT!LDTEST=0,1** (LED on)
    - **AT!LDTEST=0,0** (LED off)

11. Put the module in diagnostic/factory test mode:
    - **AT!DAFTMACT**

12. Communicate with the SIM using **AT+CPIN** or **AT+CIMI**..

13. Test RF transmission, if desired:
    - (UMTS) See UMTS (WCDMA) RF Transmission Path Test on page 136.
    - (LTE) See LTE RF Transmission Path Test (WP75xx) on page 138.

14. Test RF reception, if desired:
    - (UMTS) See UMTS (WCDMA) RF Receive Path Test on page 141.
    - (LTE) See LTE RF Receive Path Test (WP75xx) on page 143.

15. Test standalone GNSS functionality—See GNSS RF Receive Path Test on page 145.

16. Remove power from the module.

### 14.3.2.1 Downloading and Configuring minicom for Linux Systems

*Note: This procedure is for Ubuntu systems. If you are using a different Linux distribution, use the appropriate commands for your system to download minicom.*

To download and configure minicom in a Ubuntu system:

*Note: To install minicom, you must have root access, or be included in the sudoers list.*

1. Download and install minicom—enter the following command:
     sudo apt-get install minicom

2. When prompted, enter your user password to begin the download and installation. When minicom is installed, the shell prompt appears.

3. Configure minicom to communicate with your modem:

   a. Start minicom with the following command:
        minicom -s

4. Use the down-arrow key to select the **Serial port setup** option.

5. Refer to Step 6 on page 135 to identify the device file handle (/dev/ttyUSBn) used for AT commands.

6. Indicate the file handle to use for AT commands—Enter A and then replace the serial device string with the AT file handle.

7. Press **Enter** twice.

8. Use the down-arrow key to select **Save setup as dfl**.

9. Select **Exit**.

# 14.4 UMTS (WCDMA) RF Transmission Path Test

*Note: This procedure segment is performed in Step 13 of the Production Test Procedure on page 134.*

The suggested test procedure that follows uses the parameters in the following tables.

**Table 14-1: Test Settings — WP7502 UMTS Transmission Path**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 2100 MHz | Band 1 | 9 | 9750 |
| 900 MHz | Band 8 | 29 | 2787 |

a. Channel values shown are at the center of the corresponding bands.

**Table 14-2:  Test Settings — WP7504 UMTS Transmission Path**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 1900 MHz | Band 2 | 15[b] | 9400 |
| 1700 MHz | Band 4 | 28 | 1412 |
| 850 MHz | Band 5 | 22 | 4182 |

a. Channel values shown are at the center of the corresponding bands.
b. Either 15 (WCDMA1900A) or 16 (WCDMA1900B) may be used for testing.

**Table 14-3:  Test Settings — WP8548 UMTS Transmission Path**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 2100 MHz | Band 1 | 9 | 9750 |
| 1900 MHz | Band 2 | 15[b] | 9400 |
| 850 MHz | Band 5 | 22 | 4182 |
| 900 MHz | Band 8 | 29 | 2787 |

a. Channel values shown are at the center of the corresponding bands.
b. Either 15 (WCDMA1900A) or 16 (WCDMA1900B) may be used for testing.

To test the DUT's transmitter path:

*Note:  This procedure describes steps using the "Power Meter: Gigatronics 8651A" (with Option 12 and Power Sensor 80701A).*

1.  Set up the power meter:



a.  Make sure the meter has been given sufficient time to warm up, if necessary, to enable it to take accurate measurements.

b.  Zero-calibrate the meter.

c.  Enable MAP mode.

2.  Prepare the DUT using the following AT commands:

a.  **AT!ENTERCND="<password>"** (Unlock extended AT command set.)

b.  **AT!DAFTMACT** (Enter test mode.)

c.  **AT!DASBAND=<bandValue>** (Set frequency band.)

   - See Table 14-1 on page 136, Table 14-2 on page 137, or Table 14-3 on page 137 for appropriate <bandValue> values

d.  **AT!DASCHAN=<channel>** (Set modem channel)

   - See Table 14-1 on page 136, Table 14-2 on page 137, or Table 14-3 on page 137 for appropriate <channel> values

      **e.**  **AT!DASTXON**       (Turns on the transmit path.)

      **f.**  **AT!DAWSTXCW=0**    (Use a modulated carrier.)
          **AT!DASPDM=2, 75**    (Set the power level. Repeat command with different offsets until desired Tx power is obtained.)

      **g.**  Set the PA gain state as appropriate:

        •  For high gain state:
          **AT!DAWSPARANGE=0**

        or

        •  For low gain state:
          **AT!DAWSPARANGE=1**

      **h.**  Offset the tracking (If necessary, repeat with different offsets until the desired frequency is obtained.)
          **AT!DASPDM=4,35100**

      **i.**  Take the measurement.

      **j.**  **AT!DASTXOFF**      (Turn off the transmitter.)

**3.**  Test limits—Run ten or more good DUTs through this test procedure to obtain a nominal output power value.

    •  Apply a tolerance of $\pm5$ to 6 dB to each measurement (assuming a good setup design).
    •  Monitor these limits during mass-production ramp-up to determine if further adjustments are needed.

*Note: The module has a nominal output power of +23 dBm $\pm1$ dB in WCDMA mode. However, the value measured by the power meter is significantly influenced (beyond the stated $\pm1$ dB output power tolerance) by the test setup (host RF cabling loss, antenna efficiency and pattern, test antenna efficiency and pattern, and choice of shield box).*

*Note: When doing the same test over the air in an RF chamber, values are likely to be significantly lower.*

# 14.5 LTE RF Transmission Path Test (WP75xx)

*Note: This procedure segment is performed in Step 13 of the Production Test Procedure on page 134.*

The suggested test procedure that follows uses the parameters in the following tables.

**Table 14-4: Test Settings—WP7502 LTE Transmission Path**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 2100 MHz | Band 1 | 9 | 9750 |
| 1800 MHz | Band 3 | 44 | 19575 |

**Table 14-4: Test Settings—WP7502 LTE Transmission Path (Continued)**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 2600 MHz | Band 7 | 35 | 21100 |
| 900 MHz | Band 8 | 29 | 2787 |
| 800 MHz | Band 20 | 56 | 24300 |

a. Channel values shown are at the center of the corresponding bands.

**Table 14-5: Test Settings—WP7504 LTE Transmission Path**

|  | Band | Band ID | Tx Channel[a] |
|---|---|---|---|
| 1900 MHz | Band 2 | 15[b] | 9400 |
| 1700 MHz | Band 4 | 28 | 1412 |
| 850 MHz | Band 5 | 22 | 4182 |
| 700 MHz | Band 12 | 50 | 23095 |
| 700 MHz | Band 17 | 37 | 23790 |
| 1900 MHz | Band 25 | 61 | 26365 |
| 850 MHz | Band 26 | 62 | 26865 |

a. Channel values shown are at the center of the corresponding bands.
b. Either 15 (WCDMA1900A) or 16 (WCDMA1900B) may be used for testing.

To test the DUT's transmitter path:

*Note: This procedure describes steps using the "Power Meter: Gigatronics 8651A" (with Option 12 and Power Sensor 80701A).*

1. Set up the power meter:
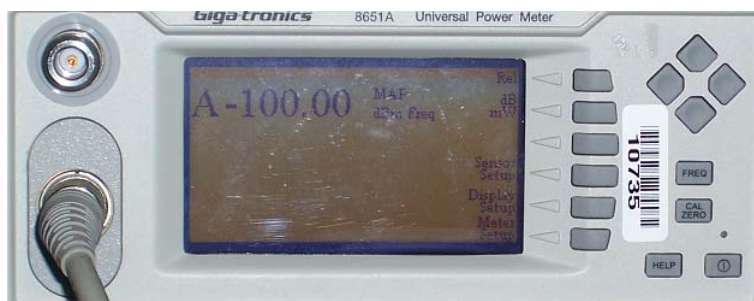


   a. Make sure the meter has been given sufficient time to warm up, if necessary, to enable it to take accurate measurements.

   b. Zero-calibrate the meter.

   c. Enable MAP mode.

2. Prepare the DUT using the following AT commands (adjusting the band, channel, bandwidth, modulation, RB allocation, NS, and power level as necessary):

   a. AT!ENTERCND="<password>"     (Unlock extended AT command set.)

   b. AT!DAFTMACT               (Enter test mode.)

     **c.**  **AT!DASBAND=\<bandValue\>**     (Set frequency band (e.g. 34 for LTE B1.)

- See Table 14-4 on page 138 or Table 14-5 on page 139 for appropriate \<bandValue\> values.

     **d.**  **AT!DALSTXBW=3**     (Set Tx bandwidth to 10 MHz.)

     **e.**  **AT!DALSRXBW=3**     (Set Rx bandwidth to 10 MHz.)

     **f.**  **AT!DASCHAN=\<channel\>**     (Set modem channel (e.g. 18300 for LTE B1).)

- See Table 14-4 on page 138 or Table 14-5 on page 139 for appropriate \<channel\> values.

     **g.**  **AT!DALSTXMOD=0**     (Set Tx modulation type to QPSK.)

     **h.**  **AT!DALSWAVEFORM=1,12,0,19**     (Set the Tx waveform characteristics. Make sure to set the correct resource block allocation (2nd parameter) appropriately. For example, 12 is used to produce max power—refer to 3GPP 36.521 table for Maximum Power Reduction (MPR) for Power Class 3 for more information.)

     **i.**  **AT!DALSNSVAL=1**     (Set the LTE NS (Net Sig) value.)

     **j.**  **AT!DASTXON**     (Turn on the transmitter. Note that the transmitter will put out the last power level that was programmed.)

     **k.**  **AT!DALSTXPWR=1,10**     (Begin transmitting at requested power level.)

     **l.**  Take the measurement.

     **m.**  Repeat steps k–l with different power levels if desired.

     **n.**  **AT!DALSTXPWR=0,0**     (Reduce Tx power to 0, so next time transmitter is turned on, it will come on with 0 dBm power.)

     **o.**  **AT!DASTXOFF**     (Turn off the transmitter.)

**3.** Test limits—Run ten or more good DUTs through this test procedure to obtain a nominal output power value.

- Apply a tolerance of $\pm5$ to 6 dB to each measurement (assuming a good setup design).
- Monitor these limits during mass-production ramp-up to determine if further adjustments are needed.

---

*Note: The module has a nominal output power of +23 dBm $\pm1$ dB in LTE mode. However, the value measured by the power meter is significantly influenced (beyond the stated $\pm1$ dB output power tolerance) by the test setup (host RF cabling loss, antenna efficiency and pattern, test antenna efficiency and pattern, and choice of shield box).*

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*Note: When doing the same test over the air in an RF chamber, values are likely to be significantly lower.*

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# 14.6 UMTS (WCDMA) RF Receive Path Test

*Note: This procedure segment is performed in Step 14 of the Production Test Procedure on page 134.*

The suggested test procedure that follows uses the parameters in the following tables.

**Table 14-6: Test Settings — WP7502 UMTS Receive Path**

|  | Band # | Frequency[a] (MHz) | Band ID | Rx Channel[b] |
|---|---|---|---|---|
| 2100 MHz | Band 1 | 2141.20 | 9 | 9750 |
| 900 MHz | Band 8 | 948.60 | 29 | 2787 |

    a.   Receive frequencies shown are 1.2 MHz offset from center
    b.   Channel values shown are at the center of the corresponding bands.

**Table 14-7: Test Settings — WP7504 UMTS Receive Path**

|  | Band # | Frequency[a] (MHz) | Band ID | Rx Channel[b] |
|---|---|---|---|---|
| 1900 MHz | Band 2 | 1961.20 | 15[c] | 9400 |
| 1700 MHz | Band 4 | 2133.20 | 28 | 1412 |
| 850 MHz | Band 5 | 882.60 | 22 | 4182 |

    a.   Receive frequencies shown are 1.2 MHz offset from center
    b.   Channel values shown are at the center of the corresponding bands.
    c.   Either 15 (WCDMA1900A) or 16 (WCDMA1900B) may be used for testing.

**Table 14-8: Test Settings — WP8548 UMTS Receive Path**

|  | Band # | Frequency[a] (MHz) | Band ID | Rx Channel[b] |
|---|---|---|---|---|
| 2100 MHz | Band 1 | 2141.20 | 9 | 9750 |
| 1900 MHz | Band 2 | 1961.20 | 15[c] | 9400 |
| 850 MHz | Band 5 | 882.60 | 22 | 4182 |
| 900 MHz | Band 8 | 948.60 | 29 | 2787 |

    a.   Receive frequencies shown are 1.2 MHz offset from center
    b.   Channel values shown are at the center of the corresponding bands.
    c.   Either 15 (WCDMA1900A) or 16 (WCDMA1900B) may be used for testing.

To test the DUT's receive path:

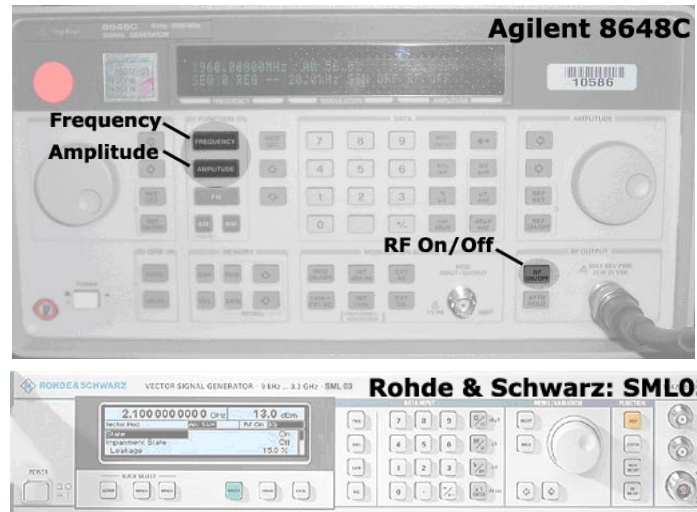**1.** Set up the signal generator:



 **a.** Set the amplitude to:

  • -80 dBm

 **b.** Set the frequency for the band being tested. See Table 14-6 on page 141, Table 14-7 on page 141, or Table 14-8 on page 141 for frequency values.

**2.** Set up the DUT:

 **a.** **AT!ENTERCND="<password>"** (Unlock extended AT command set.)

 **b.** **AT!DAFTMACT** (Put modem into factory test mode.)

 **c.** **AT!DASBAND=<band>** (Set frequency band.)

  • See Table 14-6 on page 141, Table 14-7 on page 141, or Table 14-8 on page 141 for <band> values.

 **d.** **AT!DASCHAN=<channel>** (Set modem channel)

  • See Table 14-6 on page 141, Table 14-7 on page 141, or Table 14-8 on page 141 for <channel> values.

 **e.** **AT!DASLNAGAIN=0** (Set the LNA to maximum gain.)

 **f.** **AT!DAWGAVGAGC=9400,0** (For PCS1900, channel 9400 as an example.)

  The returned value is the RSSI in dBm.

**3.** Test limits—Run ten or more good DUTs through this test procedure to obtain a nominal received power value.

 • Apply a tolerance of $\pm5$ to 6 dB to each measurement (assuming a good setup design).

 • Make sure the measurement is made at a high enough level that it is not influenced by DUT-generated and ambient noise.

 • The Signal Generator power level can be adjusted and new limits found if the radiated test needs greater signal strength.

 • Monitor these limits during mass-production ramp-up to determine if further adjustments are needed.

Note: The value measured from the DUT is significantly influenced by the test setup and DUT design (host RF cabling loss, antenna efficiency and pattern, test antenna efficiency and pattern, and choice of shield box).

**4.** (WP75xx only) Test diversity paths:

    **a.** Set up the signal generator as in Step 1.

*Note: Setup of the DUT is the same as in Step 2, except for a change to AT!DAWGAVGAGC and the addition of AT!DAWSSCHAIN.*

    **b.** Set up the DUT:

       **i.** **AT!ENTERCND="<password>"** (Unlock extended AT command set.)

       **ii.** **AT!DAFTMACT** (Put modem into factory test mode.)

       **iii.** **AT!DASBAND=<band>** (Set frequency band.)
          · See Table 14-6 on page 141, Table 14-7 on page 141, or Table 14-8 on page 141 for <band> values

       **iv.** **AT!DAWSSCHAIN=1** (Enable the secondary chain.)

       **v.** **AT!DASCHAN=<channel>** (Set modem channel)
          · See Table 14-6 on page 141, Table 14-7 on page 141, or Table 14-8 on page 141 for <channel> values

       **vi.** **AT!DASLNAGAIN=0** (Set the LNA to maximum gain.)

       **vii.** **AT!DAWGAVGAGC=9400,0,1** (The '1' indicates the diversity path is used.)

    **c.** Test the limits as in Step 3.

# 14.7 LTE RF Receive Path Test (WP75xx)

Note: This procedure segment is performed in Step 14 of the Production Test Procedure on page 134.

The suggested test procedure that follows uses the parameters in Table 14-9 and Table 14-10.

**Table 14-9: Test Settings — WP7502 LTE Receive Path**

|  | Band # | Frequency[a] (MHz) | Band ID | Rx Channel[b] |
|---|---|---|---|---|
| 2100 MHz | Band 1 | 2142.00 | 34 | 18300 |
| 1800 MHz | Band 3 | 1844.50 | 44 | 19575 |
| 2600 MHz | Band 7 | 2657.00 | 35 | 21100 |
| 900 MHz | Band 8 | 944.50 | 47 | 21625 |
| 800 MHz | Band 20 | 808.00 | 56 | 24300 |

    a. Receive frequencies shown are 2 MHz offset from center
    b. Channel values shown are at the center of the corresponding bands.

### Table 14-10:  Test Settings — WP7504 LTE Receive Path

|  | Band # | Frequency[a] (MHz) | Band ID | Rx Channel[b] |
|---|---|---|---|---|
| 1900 MHz | Band 2 | 1962.00 | 43 | 18900 |
| 1700 MHz | Band 4 | 2134.50 | 42 | 20175 |
| 850 MHz | Band 5 | 883.50 | 45 | 20525 |
| 700 MHz | Band 12 | 739.50 | 50 | 23095 |
| 700 MHz | Band 17 | 742.00 | 37 | 23790 |
| 1900 MHz (G Block) | Band 25 | 1964.50 | 61 | 26365 |
| 850 MHz | Band 26 | 878.50 | 62 | 26865 |

a.  Receive frequencies shown are 2 MHz offset from center
b.  Channel values shown are at the center of the corresponding bands.

To test the DUT's receive path (or diversity path, while connected to the diversity antenna):

**1.**  Set up the signal generator:
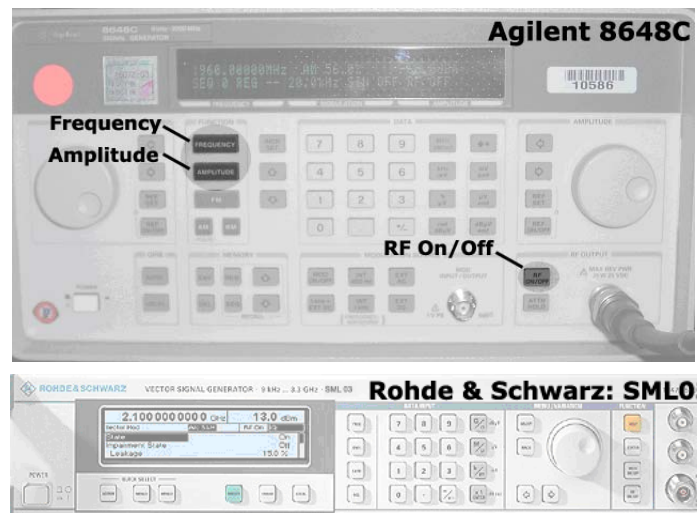


    **a.**  Set the amplitude to -70 dBm

    **b.**  Set the frequency for the band being tested. See Table 14-9 or Table 14-10 for frequency values.

**2.**  Set up the DUT:

    **a.**  **AT!ENTERCND="<password>"**  (Unlock extended AT command set.)

    **b.**  **AT!DAFTMACT**  (Put modem into factory test mode.)

    **c.**  **AT!DASBAND=<band>** (Set frequency band.)

      ·   See Table 14-9 or Table 14-10 for <band> values.

    **d.**  **AT!DALSRXBW=2**  (Set Rx LTE bandwidth to 5MHz.)

    **e.**  **AT!DALSTXBW=2**  (Set Tx LTE bandwidth to 5MHz.)

  **f.**  **AT!DASCHAN=\<channel\>** (Set modem channel)

    ·  See Table 14-9 or Table 14-10 for \<channel\> values.

  **g.**  **AT!DALGAVGAGC=\<channel\>,0** (Get averaged Rx AGC)

    ·  See Table 14-9 or Table 14-10 for \<channel\> values.

**3.** Test limits—Run ten or more good DUTs through this test procedure to obtain a nominal received power value.

 ·  Apply a tolerance of $\pm5$ to 6 dB to each measurement (assuming a good setup design).

 ·  Make sure the measurement is made at a high enough level that it is not influenced by DUT-generated and ambient noise.

 ·  The Signal Generator power level can be adjusted and new limits found if the radiated test needs greater signal strength.

 ·  Monitor these limits during mass-production ramp-up to determine if further adjustments are needed.

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*Note: The value measured from the DUT is significantly influenced by the test setup and DUT design (host RF cabling loss, antenna efficiency and pattern, test antenna efficiency and pattern, and choice of shield box).*

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# 14.8 GNSS RF Receive Path Test

The GNSS receive path uses the dedicated GNSS connector.

To test the GNSS receive path:

**1.** Inject a carrier signal at -110dBm, frequency 1575.52 MHz into the GNSS Rx path at the connector. (Note that this frequency is 100 kHz higher than the actual GPS L1 center frequency.)

**2.** Test the signal carrier-to-noise level at the GNSS receiver:

 **a.**  **AT!ENTERCND="\<password\>"** (Unlock extended AT command set.)

 **b.**  **AT!DAFTMACT** (Put modem into factory test mode.)

 **c.**  **AT!DACGPSTESTMODE=1** (Start CGPS diagnostic task.)

 **d.**  **AT!DACGPSSTANDALONE=1** (Enter standalone RF mode.)

 **e.**  **AT!DACGPSMASKON** (Enable log mask.)

 **f.**  **AT!DACGPSCTON** (Return signal-to-noise and frequency measurements.)

 **g.**  Repeat **AT!DACGPSCTON** five to ten times to ensure the measurements are repeatable and stable.

**3.** Leave the RF connection to the embedded module intact, and turn off the signal generator.

**4.** Take several more !DACGPSCTON readings. This will demonstrate a 'bad' signal in order to set limits for testing, if needed. This frequency offset should fall outside of the guidelines in the note below, which indicates that the CtoN result is invalid.

**5.** (Optional) Turn the signal generator on again, and reduce the level to -120dBm. Take more !DACGPSCTON readings and use these as a reference for what a marginal/poor signal would be.

*Note:  The response to* **AT!DACGPSCTON** *for a good connection should show CtoN within 58 +/- 5dB and Freq (frequency offset) within 100000 Hz +/- 5000 Hz.*

# 15: Safety Recommendations (For Information Only)

For the efficient and safe operation of your GSM application based on the AirPrime WP75xx Embedded Module/AirPrime WP8548 Embedded Module, please read the following RF safety information carefully.

## 15.1 RF Safety

### 15.1.1 General

Your GSM terminal is based on the GSM standard for cellular technology. The GSM standard is spread all over the world. It covers Europe, Asia and some parts of America and Africa. This is the most used telecommunication standard.

Your GSM terminal is actually a low power radio transmitter and receiver. It sends out as well as receives radio frequency energy. When you use your GSM application, the cellular system which handles your calls controls both the radio frequency and the power level of your cellular modem.

### 15.1.2 Exposure to RF Energy

There has been some public concern about possible health effects of using GSM terminals. Although research on health effects from RF energy has focused on the current RF technology for many years, scientists have begun research regarding newer radio technologies, such as GSM. After existing research had been reviewed, and after compliance to all applicable safety standards had been tested, it has been concluded that the product was fitted for use.

If you are concerned about exposure to RF energy, there are things you can do to minimize exposure. Obviously, limiting the duration of your calls will reduce your exposure to RF energy. In addition, you can reduce RF exposure by operating your cellular terminal efficiently by following the guidelines below.

### 15.1.3 Efficient Terminal Operation

For your GSM terminal to operate at the lowest power level, consistent with satisfactory call quality:
*   If your terminal has an extendable antenna, extend it fully. Some models allow you to place a call with the antenna retracted. However your GSM terminal operates more efficiently with the antenna when it is fully extended.
*   Do not hold the antenna when the terminal is "IN USE". Holding the antenna affects call quality and may cause the modem to operate at a higher power level than needed.

## 15.1.4 Antenna Care and Replacement

Do not use the GSM terminal with a damaged antenna. If a damaged antenna comes into contact with the skin, a minor burn may result. Replace a damaged antenna immediately. You may repair antenna to yourself by following the instructions provided to you. If so, use only a manufacturer-approved antenna. Otherwise, have your antenna repaired by a qualified technician.

Buy or replace the antenna only from the approved suppliers list. Using unauthorized antennas, modifications or attachments could damage the terminal and may contravene local RF emission regulations or invalidate type approval.

# 15.2 General Safety

## 15.2.1 Driving

Check the laws and the regulations regarding the use of cellular devices in the area where you have to drive as you always have to comply with them. When using your GSM terminal while driving, please:
- Give full attention to driving,
- Pull off the road and park before making or answering a call if driving conditions so require.

## 15.2.2 Electronic Devices

Most electronic equipment, for example in hospitals and motor vehicles is shielded from RF energy. However, RF energy may affect some improperly shielded electronic equipment.

## 15.2.3 Vehicle Electronic Equipment

Check with your vehicle manufacturer representative to determine if any on-board electronic equipment is adequately shielded from RF energy.

## 15.2.4 Medical Electronic Equipment

Consult the manufacturer of any personal medical devices (such as pacemakers, hearing aids, etc...) to determine if they are adequately shielded from external RF energy.

Turn your terminal **OFF** in health care facilities when any regulations posted in the area instruct you to do so. Hospitals or health care facilities may be using RF monitoring equipment.

## 15.2.5 Aircraft

Turn your terminal OFF before boarding any aircraft.
- Use it on the ground only with crew permission.
- Do not use it in the air.

To prevent possible interference with aircraft systems, Federal Aviation Administration (FAA) regulations require you should have prior permission from a crew member to use your terminal while the aircraft is on the ground. To prevent interference with cellular systems, local RF regulations prohibit using your modem while airborne.

## 15.2.6 Children

Do not allow children to play with your GSM terminal. It is not a toy. Children could hurt themselves or others (by poking themselves or others in the eye with the antenna, for example). Children could damage the modem, or make calls that increase your modem bills.

## 15.2.7 Blasting Areas

To avoid interfering with blasting operations, turn your unit OFF when you are in a "blasting area" or in areas posted "turn off two-way radio". Construction crew often uses remote control RF devices to set off explosives.

## 15.2.8 Potentially Explosive Atmospheres

Turn your terminal OFF when in any area with a potentially explosive atmosphere. Though it is rare, but your modem or its accessories could generate sparks. Sparks in such areas could cause an explosion or fire resulting in bodily injuries or even death.

Areas with a potentially explosive atmosphere are often, but not always, clearly marked. They include fueling areas such as petrol stations; below decks on boats; fuel or chemical transfer or storage facilities; and areas where the air contains chemicals or particles, such as grain, dust, or metal powders.

Do not transport or store flammable gas, liquid, or explosives, in the compartment of your vehicle which contains your terminal or accessories.

Before using your terminal in a vehicle powered by liquefied petroleum gas (such as propane or butane) ensure that the vehicle complies with the relevant fire and safety regulations of the country in which the vehicle is used.