Application Report
SWRA131–March 2007

BRF6300/BRF6350 WLAN Coexistence

Bluetooth Applications Group

ABSTRACT

This document specifies a mechanism for coexistence between Texas Instruments' Bluetooth® chips BRF6300/BRF6350 (BRF63xx) and TI WLAN devices. The document discusses the signal interfaces, timing and functionality. The document also describes the BRF63xx scripts that support the coexistence mechanism.

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1 Introduction

This document contains the specifications of a mechanism for coexistence between TI's BRF63xx Bluetooth (BT) chip and TI's WLAN devices. In this document, this mechanism is referred to as ***SG*** (Soft Gemini). The specification uses signals available on the TI WLAN modems and the TI Bluetooth devices, the BRF63xx (BRF6300 and BRF6350).

Three signals on the BRF63xx support the coexistence mechanism. These signals are multiplexed on General Purpose Input/Output (GPIO) pins according to a vendor-specific command. The BRF63xx vendor-specific command establishes the configuration of the SG IO pins.

This document details the signal interfaces, timing and functionality for the TI WLAN modem and the BRF63xx. The document also discusses the BRF63xx scripts that support the coexistence mechanism and throughput optimization.

2 Theory of Operation and Performance

The collaborative architecture allows for the BT link and the 802.11 WLAN link to share time between the two devices. The objectives of the collaborative coexistence mechanism are:

- The BT PA should not be turned on or off during transmission, because spurious transmissions could result and cause regulatory certification problems
- If the BT device does not have traffic, 802.11 performances should not be impacted
- If the 802.11 WLAN link does not have traffic, BT performance should not be impacted
- If both the BT device and the 802.11 link have traffic, there should be a fair sharing of the available bandwidth that provides the maximum available throughput. Of course, throughput reduction will occur in both the BT and WLAN.
- High-priority BT traffic (such as voice) should take priority over all 802.11 traffic

To achieve these objectives, three signals are provided by the BRF63xx to indicate and control BT activity. The WLAN software uses this information to manage the priority assignment and balancing between the BT chips and the WLAN devices.

3 System Architecture

Three wires connect the WLAN modem and the BRF63xx:

- BT_RF_ACTIVE (BT output)
- BT_PRIORITY (BT output)
- BT_TX_CONFX (BT input)

The following diagrams describe the allowable interfaces between the BRF63xx and TI WLAN devices. Details of the respective signals are available in Section 4.

Figure 1 describes the WLAN/BT Soft Gemini coexistence architecture.

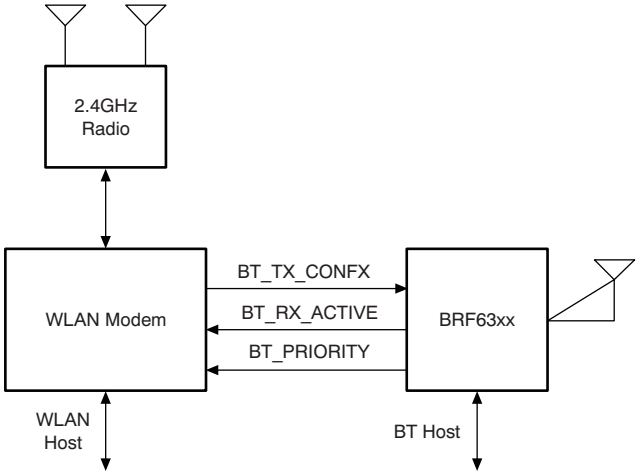

Figure 1. WLAN/BT Coexistence Architecture

BRF63xx and WiLink™ 4.0 coexistence signaling is termed *SG2.0*. The following sections discuss this mode of signaling in greater detail.

Note: Other signaling modes (although supported by the BRF63xx) should not be used with WiLink 4.0.

4 Signals Description

There are three output signals, one inputs signal, and one bidirectional signal that are required by the BRF63xx to provide proper coexistence functionality with the WLAN; see Table 1. Signal polarity (low/high) can be configured by the ***HCI_VS_Write_WLAN_Configuration*** command.

Table 1. BRF63xx Coexistence Input/Output Signals

Signal Name (Symbol)	In/Out	Description
RF Shutdown (BT_TX_CONFX)	I	When asserted, this input signal disables the internal Power Amplifier (PA) of the BRF63xx. When the signal is not asserted, the PA state is control by internal BRF63xx logic. Refer to Section 5.3 for information regarding asserting and de-asserting this signal during transmission of a packet.
BT_RF_ACTIVE	O	This output signal is active high when the Bluetooth PA is on or when BT is receiving.
BT_PRIORITY	O	This output signal is asserted by the BRF63xx to indicate that a priority data transaction is about to occur or is presently occurring on the Bluetooth link. The various types of priority data are described below.

Notes:

- The BT_RF_ACTIVE and BT_PRIORITY (outputs from the BRF63xx) should be pulled down in the WLAN controller
- With HV1 packets, the BRF63xx transmits and receives every Bluetooth frame. The only spacing is between RX to TX and TX to RX; spacing is approximately 250µs. With HV1 traffic, the WLAN may not be able to successfully receive or transmit traffic.
- On the BRF63xx platform, the three signals are multiplexed with GPIO pins.Table 2 lists the multiplexing possibilities

Table 2 describes the different possibilities to multiplex the coexistence signal on IO pins. The script detailed in Section 8 shows an example of how to multiplex these pins. The signals are active high (default).

Table 2. Bluetooth GPIO Assignment

	BRF63xx Signal	Pull Direction at Shutdown
BT_TX_CONFX (PA shutdown)	IO1	PD
	TX_DBG	PU
BT_PRIORITY	IO4	PD
	IO15	PD
BT_RF_ACTIVE	IO2	PD
	IO4	PD
	IO5	PD
	IO7	PD
	IO14	PD
	IO17	PD

5 BT Signals: Timing and Description

This section describes the BT signal timings.

5.1 BT_RF_ACTIVE

The signal is active during the BT TX or BT RX phase, as shown in Figure 2. The WLAN controller senses the signal, triggering the coexistence algorithm.

The activity of the BT_RF_ACTIVE signal during the DH1 TX packet and the DH5 RX packet is described below. The signal is active only when BT data exists.

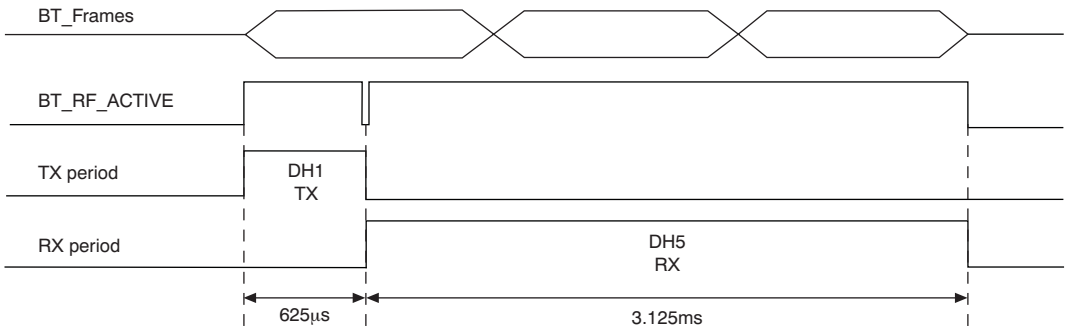

Figure 2. BT ACL Channel: DH1 and DH5 Packets

5.2 BT_PRIORITY

This output signal is asserted by the BRF63xx to indicate that a priority data transaction is about to occur or is currently occurring on the Bluetooth link. When the signal is active, the BT transaction takes priority over any WLAN activity and is performed immediately.

It is the responsibility of the BT Host to determine the list of events for which the BT_PRIORITY signal is asserted. This signal can be activated according to one or more of the events detailed in the list below. The configuration is performed by the ***HCI_VS_Write_WLAN_Configuration*** command, according to the following bits.

- 0x0000: Priority disabled
- 0x0001: SCO/eSCO instant
- 0x0002: Priority asserted during whole eSCO window
- 0x0004: Priority asserted during FHS/ID slots
- 0x0008: Priority asserted during SNIFF
- 0x0010: Priority asserted during Hold attempts
- 0x0020: During Inquiry Scan
- 0x0040: During Inquiry
- 0x0080: During Page Scan
- 0x0100: During Page
- 0x0200: During Park
- 0x0400: During TDD (Microsoft software)
- 0x0800: During first successful sniff attempt only
- 0x1000: During park beacon only
- 0x2000: During eSCO window only in master mode

Notes:

- Activation of Page and Page Scan also includes the FHS/ID packets.
- The activity timing of BT_PRIORITY during Synchronous Connection Oriented Channels (SCO) (HV3) and extended SCO (eSCO) (EV4) packets are detailed in Figure 3 and Figure 4.

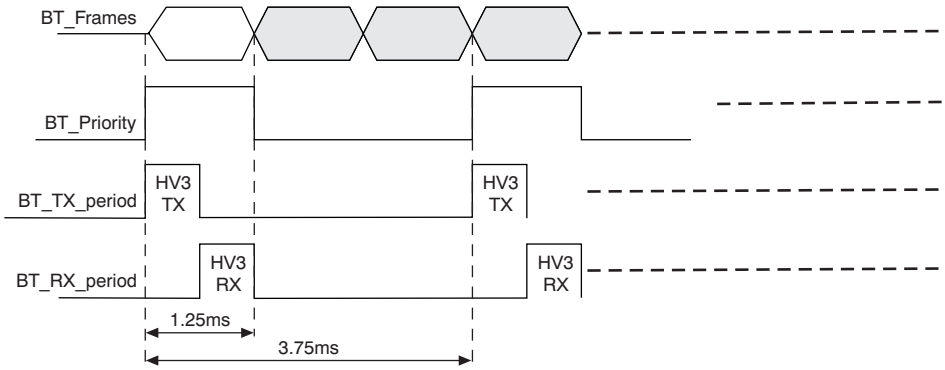

Figure 3. : Master BT SCO Channel: HV3 Packets

For the eSCO timing, it is possible to activate the BT_PRIORITY according to the instant eSCO (marked as ***1***) or according to the entire eSCO cycle, including instant and retransmission (marked as ***2***) in Figure 4.

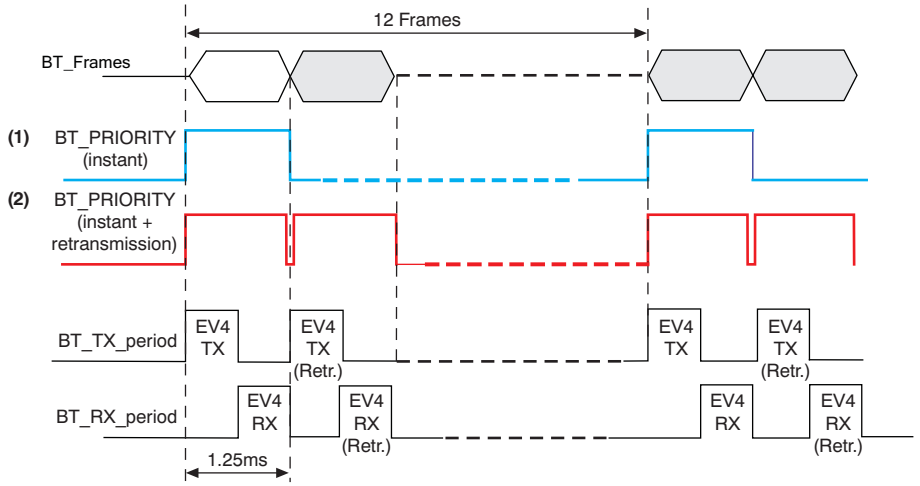

Figure 4. Master BT eSCO Channel: EV4 Packets

The parameters for the timing are:

t_{eSCO} = 12 frames and retransmission # = 1

5.3 BT_TX_CONFX (Power Amplifier Shutdown)

When this input signal is asserted, it disables the internal power amplifier (PA) of the BRF63xx.

When the signal is not asserted, internal BRF63xx logic controls the PA state.

The BT_TX_CONFX signal is active before and after the WLAN transmission. If BT starts transmission after the WLAN blocks the BT PA, no BT output power is emitted.

The signal is activated by the WLAN controller coexistence algorithm.

In general, the WLAN beacon takes priority over BT activities, except when the BT_PRIORITY line is active. Usually, the WLAN beacons appear every 100ms, but this rate can be manually configured.

BT activity during WLAN activity is detailed in Figure 5; note that while BT_TX_CONFX is high, the BT transmission is blocked.

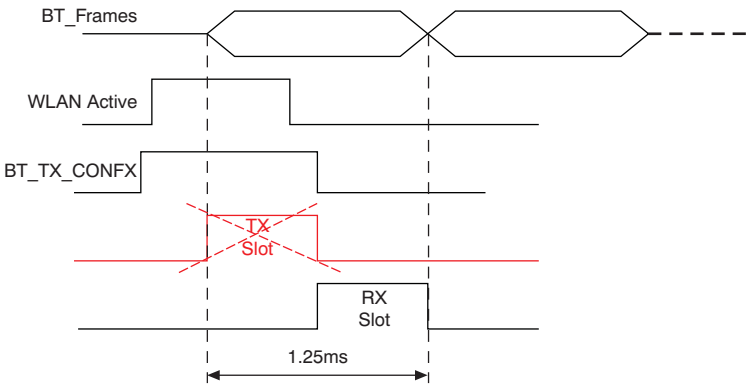

Figure 5. BT Transmission During WLAN Transmission

Note: There may be scenarios in which the BT transmission will be cut off while transmitting a packet because of WLAN high priority data. However, there is an option to eliminate this possibility by special configuration of the BT and/or WLAN side.

For the BRF6300: The default mode is such that the BT_TX_CONFX is ignored until the end of the packet transmission. To enable stopping the BT transmission during the middle of a packet, a VS command must be sent. (refer to Section 8.1.2 for details about these VS commands).The BRF6300 returns to its default mode every time the ***HCI_VS_Write_WLAN_Configuration*** command is sent by the Host.

For the BRF6350: Selecting the operating mode is done by one of the parameters in the ***HCI_VS_Write_WLAN_Configuration*** command. Refer to Section 8.1.3 for details.

6 Timing Requirements

Figure 6 and Figure 7 illustrate the timing of the coexistence signals for both high and low priority BT signals, respectively. The diagrams detail an SCO packet scenario, but they are identical to ACL packet timings. Table 3 lists the timing parameters.

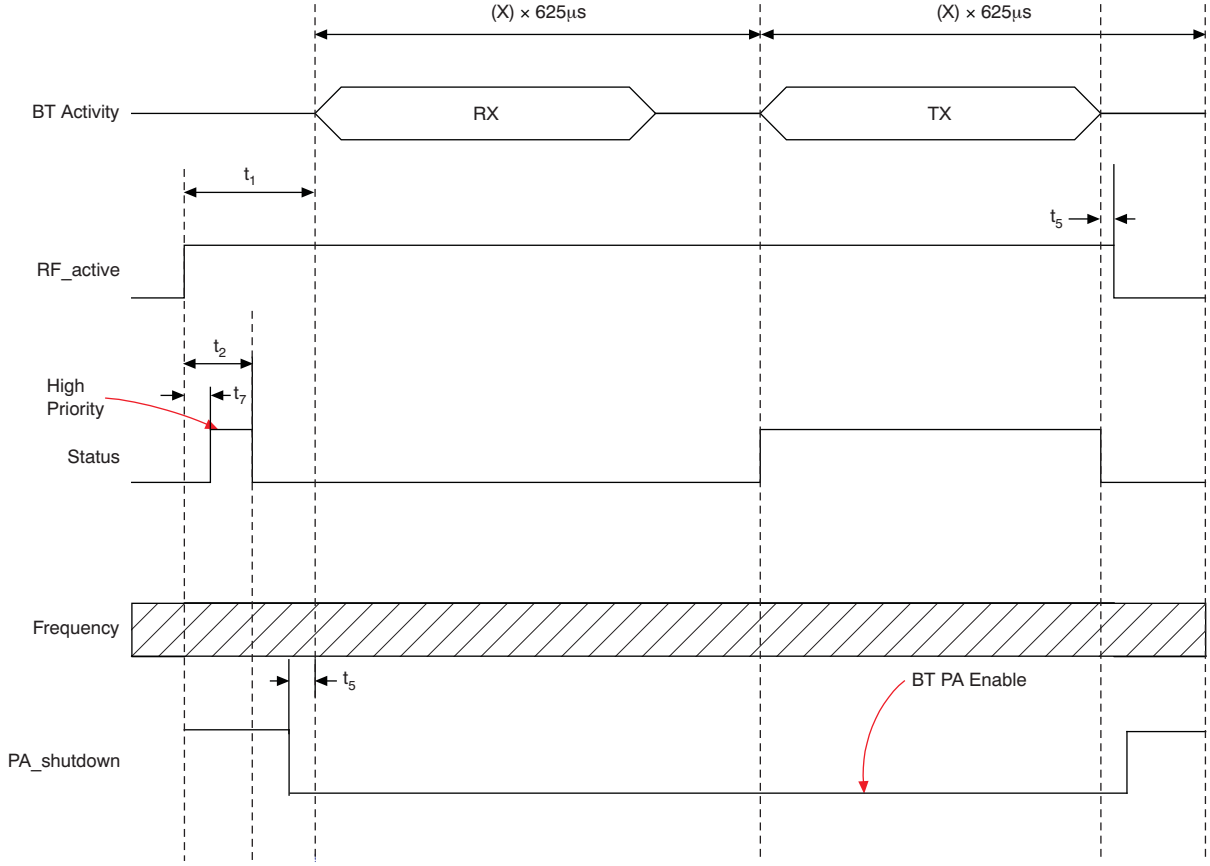

Figure 6. SG2.0 Timing Diagram—BT High Priority

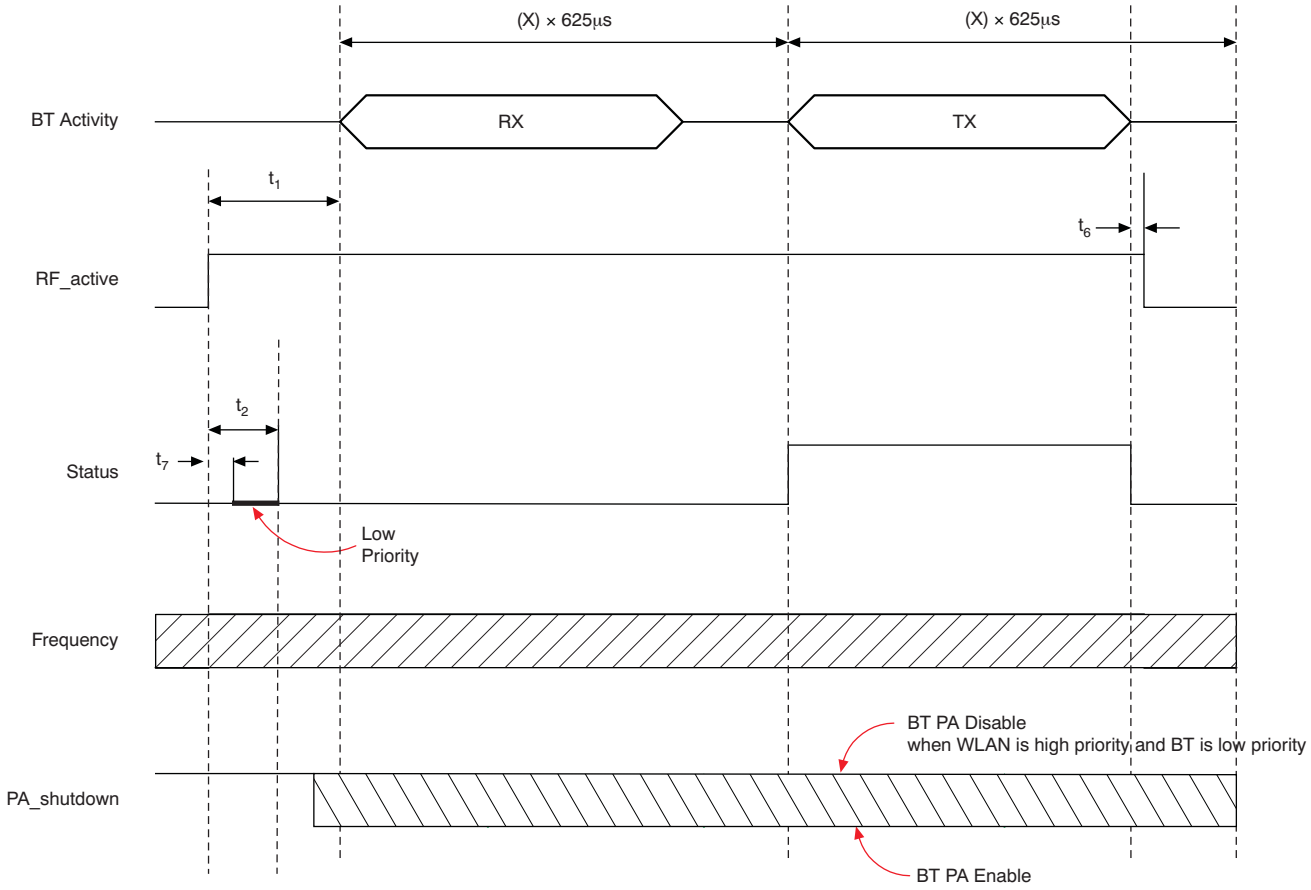

Figure 7. SG2.0 Timing Diagram—BT Low Priority

Table 3. SG2.0 Timing Parameters

Timing Parameter	Min Time (µs)	Max Time(µs)	Remarks
t_1	150	—	Max time should be as low as possible for optimized performance
t_2	15	21	**For high priority identification:** The signal can be asserted or deasserted with no impact on performance after the specified min time has passed
t_5	75	—	The BT chip reaction time can be lower than the min design target
t_6	0	30	Max time should be as low as possible for optimized performance
t_7	0	1	

7 Single Antenna Application

Because the BT and WLAN devices operate on the same frequency range (2.4GHz), it is possible to use a single antenna for both BT and WLAN channels without additional components on the WiLink 4.0 platform.

Figure 8 describes the antenna switching configuration between the BT and WLAN devices.

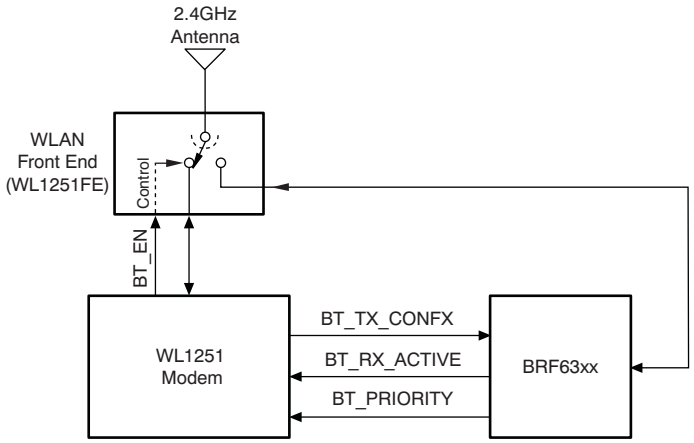

Figure 8. Single Antenna with Switch Configuration

This configuration consists of the BRF63xx and the WiLink 4.0 chipset, including the following components:

- WL1251—WLAN modem
- WL1251FE—Front end
- WL1251PM—Power management chip

The WL1251FE also includes an internal switch that is available to connect the single antenna to the BT input or the WLAN input.

8 Coexistence Operation Script

On the BT side, the coexistence mechanism is activated by the ***HCI_VS_Write_WLAN_Configuration*** command (op code 0xFD1D). Additional information is available in the HCI Vendor-Specific documents. For the BRF6300, see application report BT-SW-0030; for the BRF6350, see SWRU115.

The script should be executed during the system initialization task after power on completes.

8.1 Example Script

8.1.1 WLAN Configuration Command for BRF6300

The following command enables the co-existence mechanism for the BRF6300:

```
Send_HCI_VS_Write_Wlan_Configuration 0xFD1D, 0x4, 0x1, 0x05e9, 0x0000, 0x0, 0xFF,
"FFFFFFFFFFFFFFFFFF7F", 0x04, 0x1, 0x0, 0x1, 0x2, 0x1, 0x0, 0xFF, 0x0
Wait_HCI_Command_Complete_VS_Write_Wlan_Configuration_Event 5000, any,
HCI_VS_Write_Wlan_Configuration, 0x00
```

with the configuration:

- SG2.0 (this is the only mode to be used with WiLink 4.0)
- Priority is asserted for the following BT events:
  - SCO/eSCO instant
  - Sniff
  - Inquiry
  - Inquiry Scan

  - Page
  - Page Scan
  - TDD (Microsoft software)
- BT_RF_ACTIVE is output on IO14
- BT_PRIORITY is output on IO4
- BT_TX_CONFX is input on IO1

8.1.2 BT_TX_CONFX During Packet Transmission in BRF6300

8.1.2.1 Disabling BT_TX_CONFX During TX (Default)

Use this command to disable BT_TX_CONFX during transmission:

```
Send_HCI_VS_Read_Modify_Write_Hardware_Register 0xFD09, 0x001918b0, 0x0000, 0x0080
Wait_HCI_Command_Complete_VS_Read_Modify_Write_Hardware_Register_Event 5000, any,
HCI_VS_Read_Modify_Write_Hardware_Register, 0x00
```

8.1.2.2 Enabling BT_TX_CONFX During TX

Use this command to enable BT_TX_CONFX during transmission:

```
Send_HCI_VS_Read_Modify_Write_Hardware_Register 0xFD09, 0x001918b0, 0x0080, 0x0080
Wait_HCI_Command_Complete_VS_Read_Modify_Write_Hardware_Register_Event 5000, any,
HCI_VS_Read_Modify_Write_Hardware_Register, 0x00
```

8.1.3 WLAN Configuration Command for BRF6350

The following command enables the co-existence mechanism for the BRF6350:

```
Send_HCI_VS_Write_Wlan_Configuration 0xFD1D, 0x2, 0x7, 0x05e9, 0x0000, 0x0, 0xff,
"FFFFFFFFFFFFFFFFFF7F", 0x04, 0x1, 0x0, 0x1, 0x2, 0x1, 0x0, 0xFF, 0x0
Wait_HCI_Command_Complete_VS_Write_Wlan_Configuration_Event 5000, any,
HCI_VS_Write_Wlan_Configuration, 0x00
```

with the configuration:

- SG2.0 (this is the only mode to be used with WiLink 4.0)
- Priority is asserted for the following BT events:
  - SCO/eSCO instant
  - Sniff
  - Inquiry
  - Inquiry Scan
  - Page
  - Page Scan
  - TDD (Microsoft software)
- BT_RF_ACTIVE is output on IO14
- BT_PRIORITY is output on IO4
- BT_TX_CONFX is input on IO1
- BT_RF_ACTIVE is active high
- Shared antenna enabled
- BT PA shutdown during TX is enabled

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