BT-AN-0047 (BRF6300/BRF6350 WLAN Coexistence, Rev 0.6)

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ABSTRACT

This document contains the specification of a mechanism for coexistence between TI Bluetooth chips BRF6300/BRF6350 (BRF63xx) and TI WLAN devices. The document describes the signal interfaces, timing and functionality.

The document also details the BRF63xx scripts that support the coexistence mechanism.

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Revision Control

Author Name	Description	Revision	Date
Asher Golomb	Creation	0.1	March 15th 2005
Asher Golomb	Addition of single antenna section	0.2	June 8th 2005
Asher Golomb	Addition of notes in sections 2, 4.3.2, and 5	0.3	June 28th 2005
Anthony Levine	- Changed document to BRF6300/BRF6350 - Changed names of signals - Removed SG2.0 - Updated description of BT_TX_CONFX	0.4	April 30, 2006
Dana Ram	Updated defaults parameters for the VS command and added an example	0.5	June 5, 2006
Dana Ram	Updated timing diagrams	0.6	September 5, 2006

1 Introduction

This document contains the specification of a mechanism for coexistence between TI's BRF63xx Bluetooth 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 TI Bluetooth chip, the BRF63xx. From BRF63xx side, 3 signals support the coexistence mechanism. The BRF63xx vendor specific command establishes the configuration of the IO pins of the SG. Coexistence is also supported by the BT Automatic Frequency Hopping (AFH) mechanism. The AFH mechanism drops detected WLAN working frequencies from the BT hopping frequencies list. This increases the BT and WLAN throughput.

This document details the signal interfaces, timing and functionality for the TI WLAN (WiLink™ 4.0) modem and the BRF63xx. The document also details the BRF63xx scripts that support the coexistence mechanism and throughput optimization.

2 Theory of Operation and Performance

The collaborative mechanism allows for the sharing of time between the Bluetooth link and the 802.11 WLAN link.

The objectives of the collaborative coexistence mechanism are:

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

To achieve these objectives, 3 signals are provided by the BRF63xx to indicate and control BT activity.

The WLAN software uses this information to manage the priority between the Bluetooth and WLAN.

3 System Architecture

3 wires connected between WLAN modem and BRF63xx:

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

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

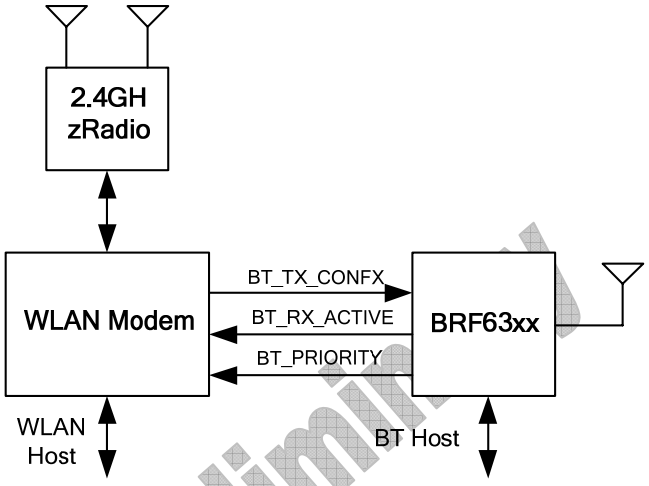

Figure 1: WLAN/BT Coexistence Architecture

4 Signals Description

4.1 Function Description

There are three outputs, one input and one bidirectional signals that are required by the BRF63xx to provide proper coexistence functionality with the WLAN. 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. When the signal is asserted or de-asserted and the BRF63xx is currently attempting to transmit (as indicated by BT_RF_ACTIVE being valid), de-assertion of the RF_shutdown will cause unknown transients on at the PA output.
BT_RF_ACTIVE	O	This output signal is active high when 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 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, is ~250usec. With HV1 traffic, the WLAN may not be able to successfully receive or transmit traffic.
- In BRF63xx, the 3 signals are multiplexed with General Purpose Input Output (GPIO) pins. **Error! Reference source not found.** below describes the Multiplexing possibilities.

5 Signaling

BRF63xx and WiLink™ 4.0 co-existence signaling is termed S.G. 2.0. The following sections describe to more details this mode of signaling.

Note: other signaling mode (though supported by the BRF63xx) should not be used with WiLink™ 4.0.

The Table below describes the different possibilities to multiplex the coexistence signal on IO pins. The script which is detailed in section 9 is corresponding to these recommended pins. The signals are active high, as default.

Table 2. Bluetooth GPIO Assignment

	BRF63xx signal	Pull @ 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

6 Bluetooth signals timing and description

6.1 BT_RF_ACTIVE

The signal is active during BT TX or RX phase, as shown in Figure 2 below. The signal is sensed by the WLAN controller and triggers the coexistence algorithm.

The activity of the BT_RF_ACTIVE signal during DH1 TX packet and DH5 RX packet is described below.

The signal is active only when BT data exists.

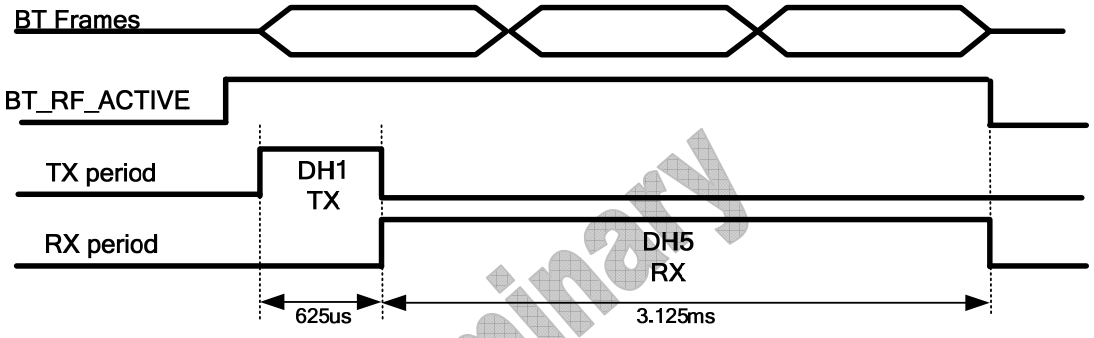

Figure 2: Master BT ACL Channel - DH1 and DH5 packets

6.2 BT_PRIORITY

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

It is the host's responsibility 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 table 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 (M/S sw.)
- 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 SCO (HV3) and eSCO (EV4) packets are detailed below in Figure 3 and Figure 4.

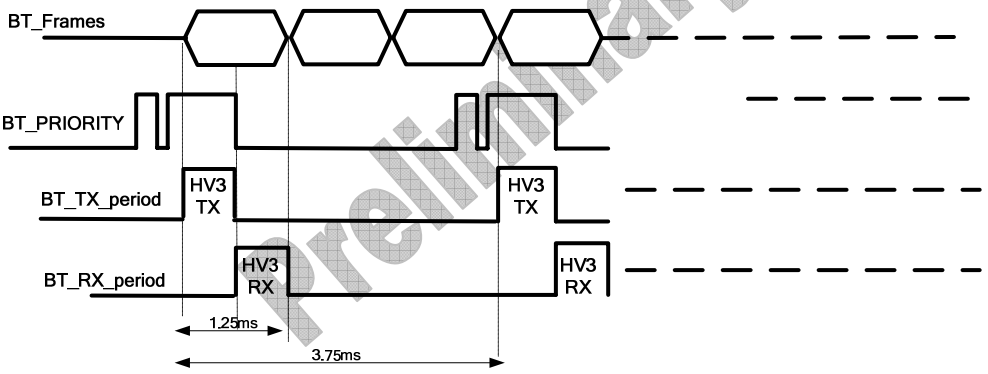

Figure 3: Master BT SCO Channel – HV3 packets

For the eSCO timing, it is possible to activate the BT_PRIORITY according to the instant eSCO (in blue) or according to whole eSCO cycle (instant and retransmission), marked in red.

The parameters for the timing are:

TeSCO = 12 frames and retransmission # = 1.

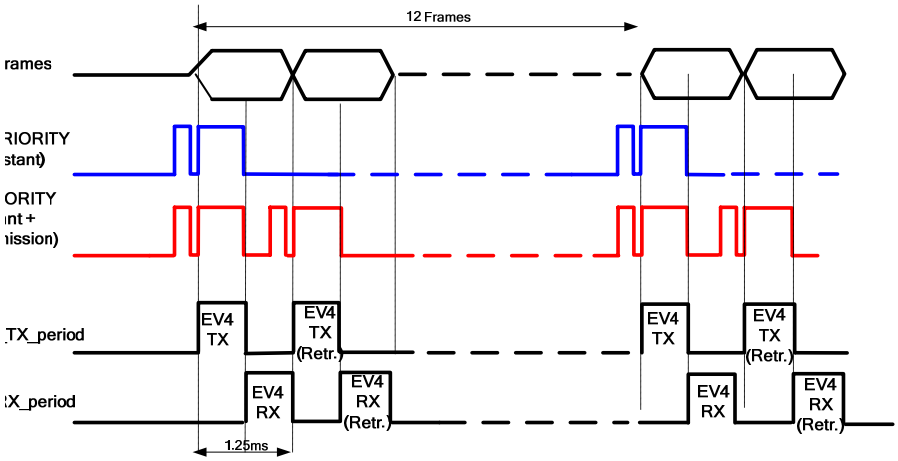

Figure 4: Master BT eSCO Channel – EV4 packets

6.3 BT_TX_CONFX (PA shutdown)

When asserted this input signal disables the internal Power Amplifier (PA) of the BRF63xx.

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

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

The signal is activated by the WLAN controller coexistence algorithm.

In general, the WLAN beacon gets priority over the BT activities, except when the BT_PRIORITY line is active. Usually, the WLAN beacons appear every 100mS, but can be configured.

BT activity during activity of WLAN is detailed in

below. It is clear that during BT_TX_CONFX high, the BT transmission will be blocked.

Note: *There maybe scenarios in which the BT transmission will be cut off while in transmission of a packet due to WLAN high priority data*.

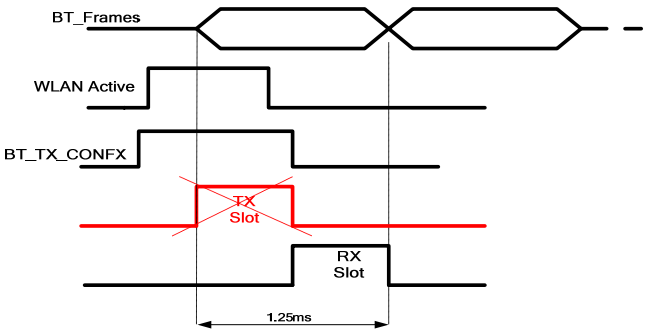

Figure 5: BT transmission during WLAN transmission

7 Timing requirements

The timing diagram of the coexistence signals is given in **Error! Reference source not found.** below. The diagram details a SCO packet scenario, but it is identical to ACL packets.

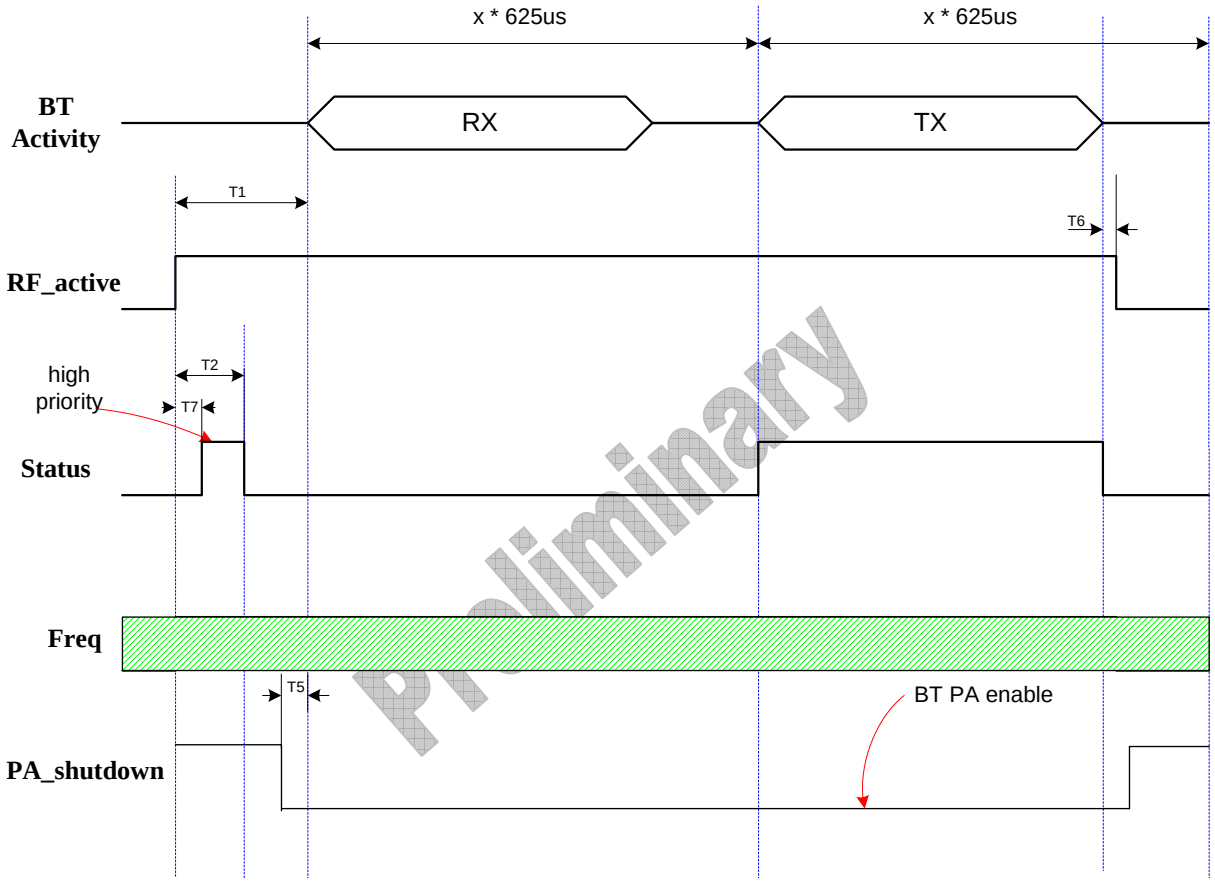

Figure 6: SG2.0 timing diagram – BT high priority

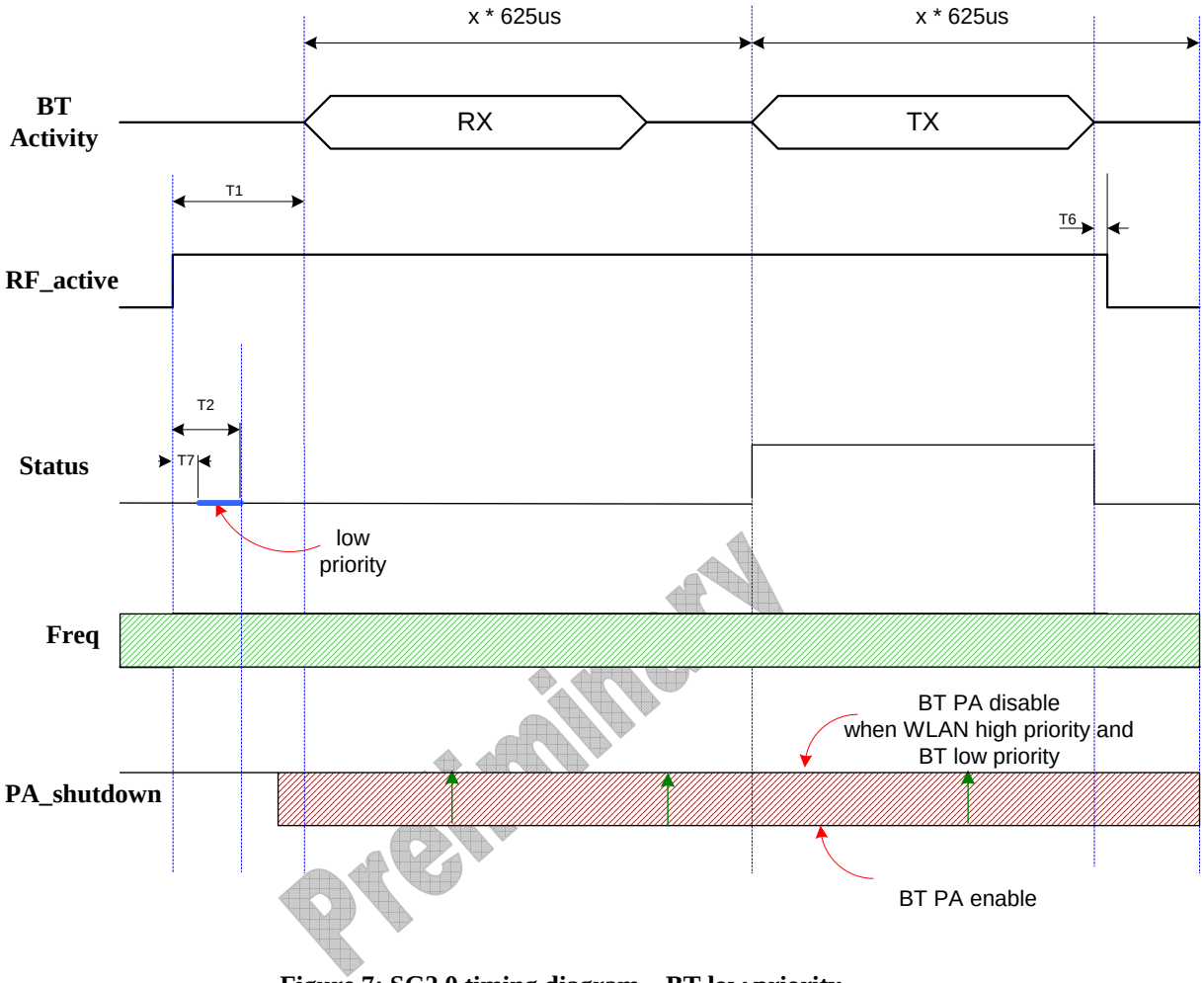

Figure 7: SG2.0 timing diagram – BT low priority

Table 3. SG2.0 timing parameters

Timing parameter	Min time (us)	Max time (us)	Remarks
T1	150	N/A	Max time should be as low as possible for performance optimization
T2	15	21	For high priority identification: The signal can be asserted or de-asserted w/o any impact on the performance after the min time specified had passed
T5	75	N/A	The BT chip reaction time can be lower than min design target
T6	0	30	Same as T1 comment
T7	0	1	

8 Single Antenna Application

Since BT and WLAN work at the same frequency range (2.4 GHz), it is possible to use a single antenna for both BT and WLAN channels without addition components on the WiLink™ 4.0 platform.

The configuration of antenna switching between BT and WLAN is described in **Error! Reference source not found.** below:

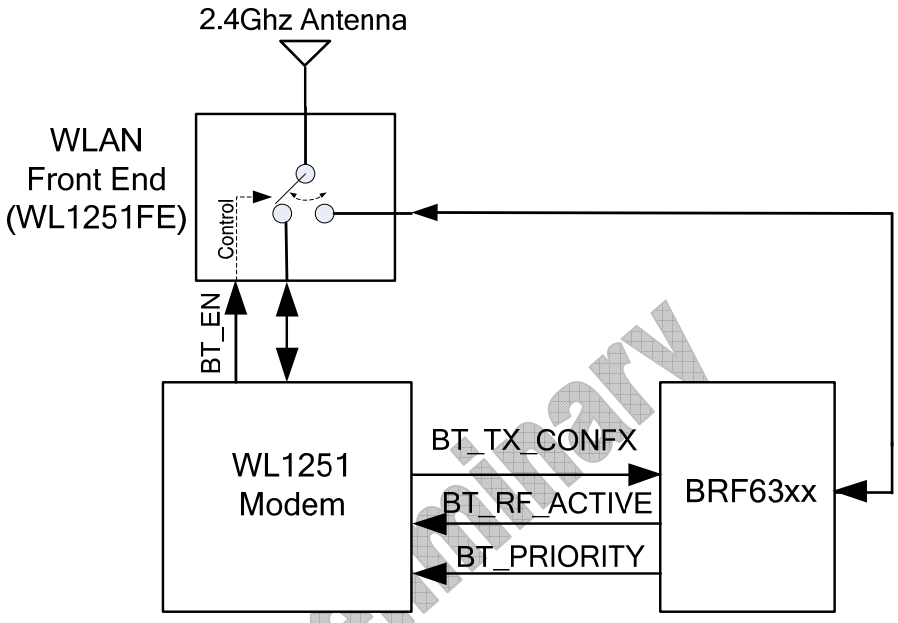

Figure 8: Single antenna with switch configuration

This configuration consists of the BRF63xx and the WiLink™ 4.0 chipset that includes the following:

WiLink™ 4.0 - WLAN modem

WiLink™ 4.0 FE – Front end

WiLink™ 4.0 PM – Power management chip

The WiLink™ 4.0 FE includes an internal switch which is available to connect the single antenna to the BT input or to WLAN input.

9 Coexistence operation script

In the BT side, the coexistence mechanism is activated by the HCI_VS_Write_WLAN_Configuration command (op. code 0xFD1D). More detailed information is available in the HCI Vendor Specific document.

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

The description of the HCI_VS_Write_WLAN_Configuration command is detailed below in section 10.

9.1 Example Script

The following command:

Send_HCI_VS_Write_Wlan_Configuration 0xFD1D, 0x4, 0x1, 0x05e9, 0x0000, 0x0, 0x00, "FFFFFFFFFFFFFFFFFF7F", 0x04, 0x1, 0x1, 0x1, 0x2, 0x1, 0x0, 0xFF, 0x0

Wait_HCI_Command_Complete_VS_Write_Wlan_Configuration_Event 5000, any, HCI_VS_Write_Wlan_Configuration, 0x00

Enables the co-existence mechanism with the following configuration:

- S.G. 2.0 *(this is the only mode to be used with WiLink™ 4.0)*
- The priority is asserted for the following BT events:
    - SCO/eSCO instant
    - Sniff
    - Inquiry
    - Inquiry scan
    - Page
    - Page scan
    - TDD (m/s switch)
- BT_RF_ACTIVE is output on IO14
- BT_PRIORITY is output on IO4
- BT_TX_CONFX is input on IO1

10 HCI_VS_Write_Wlan_Configuration command

Please refer to the BT-SW-0030 (BRF6300 3.11 HCI Vendor Specific Command) – for the updated version of this command.

Command	Opcode	Command Parameters	Return Parameters
	0xFD1D	Enable Mode PA_OFF_polarity Priority_select Connection_handle_select Connection_handle_enable_disable Freq_mask_enable Freq_mask WLAN0_mux WLAN0_pull_enable WLAN1_mux WLAN1_pull_enable WLAN2_mux WLAN2_pull_enable WLAN3_mux WLAN3_pull_enable Disable_WLAN	

Command Parameters:

Enable Mode	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – 1.0 Mode 0x1 – For internal use 0x2 – For internal use 0x3 – For internal use 0x4 – 2.0 Mode - *to be used with WiLink™ 4.0* 0x5 – Internal use mode 0xff – Do not change	Defines the operation mode of the WLAN interface	0x0

PA_OFF_polarity	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – PA off is active low 0x1 – PA off is active high 0xff – Do not change	Defines operation of PA	0x1

Priority_select	2 Byte

Value	Parameter Description	Default Value
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 (M/S sw.) 0x0800 – During first successful sniff attempt only 0x1000 – During park beacon only 0x2000 – During eSCO window only in master mode	Defines operations that should have priority lines on	0x0

Connection_handle_select	2 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – 0xEFF – Connection handle 0xF000 – Disable at all handles 0xFFFF – Do not change	Defines the behavior with respect to connection handles	0x0

Connection_handle_enable_ disable	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – Disable 0x1 - Enable	Disable/Enable priority on the given handle	0x0

Freq_mask_enable	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – No freq mask is given 0x1 – Enable on WLAN0 (*BT_RF_ACTIVE*) pin 0x2 – Enable on WLAN1(*BT_PRIORITY*) pin 0x3 – For future use	Defines behavior with respect to the freq mask	0x0

0xFF – Do not change value		

Freq_mask	2 Byte	
Value	**Parameter Description**	**Default Value**
0xffff:ffff:ffff:ffff:ffff – Do not change 0x1-0x7fff:ffff:ffff:ffff:ffff - Enable each one of the frequencies that should be masked by this bit map	Defines frequency mask to give rise to the priority signals	0x0

WLAN0_mux	1 Byte	
Value	**Parameter Description**	**Default Value**
0X0 - WLAN0 on IO2 0X1 - WLAN0 on IO4 0X2 - WLAN0 on IO5 0X3 - WLAN0 on IO7 0x4 - WLAN0 on IO14 0x5 - WLAN0 on IO17 0xff - Don't change	Defines the output of WLAN0 (*BT_RF_ACTIVE*) signal	N/A

WLAN0_pull_enable	1Byte	
Value	**Parameter Description**	**Default Value**
0x0 - Input pull (on selected input IO) is disabled 0x1 - Input pull (on selected input IO) is enabled 0xff - Don't Change	Defines WLAN0 (*BT_RF_ACTIVE*) pull	N/A

WLAN1_mux	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 – WLAN1 on IO4 0x1 – WLAN1 on EXT_CLK_REQ 0xff – Don't change	Defines the output of WLAN1 (*BT_PRIORITY*) signa1	N/A

WLAN1_pull_enable	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 - Input pull (on selected input IO) is Disabled 0x1 - Input pull (on selected input IO) is enabled	Defines the behavior of the pull on the WLAN1 (*BT_PRIORITY*) input	N/A

0xff – Don't change		

WLAN2_mux	1 Byte	
Value	**Parameter Description**	**Default Value**
For future use	For future use	N/A

WLAN2_pull_enable	1 Byte	
Value	**Parameter Description**	**Default Value**
For future use	For future use	N/A

WLAN3_mux	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 - BT_TX_CONFX on IO1 0x1 - BT_TX_CONFX on TX_DBG 0xff - Don't Change	Defines the output of WLAN3 (BT_TX_CONFX) signal	N/A

WLAN3_pull_enable	1 Byte	
Value	**Parameter Description**	**Default Value**
0x0 - Input pull (on selected input IO) is Disabled 0x1 - Input pull (on selected input IO) is enabled 0xff – Don't change	Defines the behavior of the pull on the WLAN3 (BT_TX_CONFX) input	N/A

Disable	1 Byte	
Value	**Parameter Description**	**Default Value**
0x1 – Disable WLAN interface 0x0 – Do not do anything	Disables WLAN interface	0x1

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