AN5 **Measuring RF Performance** CONFIDENTIAL

Application Note 5

Sensor Node Software

Measuring GS1010 RF Performance

INTRODUCTION

^THIS DOCUMENT describes a simple method for measuring GainSpan GS1010 RF performance. The method involves uploading GS1010 WFW (WLAN firmware) and forming an IBSS (independent BSS), also known as an *ad hoc* network. In an IBSS the device transmits periodic beacons that can be detected by any device capable of scanning for Wi-Fi networks. These beacons can be analyzed with an RF test equipment such as a spectrum analyzer or a power meter. The IBSS is initiated by using the GainSpan software configuration tool WiLDConfigurator.

This method involves interacting directly with the GS1010 WFW. This requires erasing any application firmware (AFW) that may be programmed into the device. Unfortunately, this also erases any applicationor device-specific configuration, such as the device's unique MAC address. Care must be taken to restore this configuration information after reloading AFW.

UPLOAD WFW

Use WiLDConfigurator to upload WFW to the GS1010.

- 1. On a PC with a serial port, start WiLDConfigurator.
- 2. Ensure that *WiLDConfigurator* is using the correct COM port to talk to the GS1010 board (see the WiLDConfigurator User Manual for details).
- 3. Power off the GS1010.
- 4. Force the GS1010 to boot into BootROM:
 - A. On the TLS board, short Test Point E13 to TP6.
 - B. On the DB, set Switch 3 of INT2 to ON
- 5. Power on the GS1010.

The GS1010 should now be running from BootROM. Verify communication with BootROM by verifying that memory address 0x0000000 contains the BootCode reset vector (0xEA000008).

- 6. Select the Loader panel of *WiLDConfigurator*.
- 7. In the ROM debugging panel, read address 0x00000000. The value read should be 0xEA000008.
- 8. Erase WLAN, APP1, and APP2 firmware by checking their boxes and pressing the Erase Flash button. The WiLDConfigurator screen should appear as in Figure 1.

GainSpan



Nu Untitled - Wild Config	urator: 0.0.1 📃 🗖 🔀
<u>File O</u> ptions <u>?</u>	
D 🚅 🖬 X 🖻 💼 Æ) ?
 Station Manager Config Network scan Misc Statistics MIB NVDS Version Loader IEEE1588 	Filename(s) C:\GainSpan\GS1010\1.0.0\WLAN\ NVDS WLAN APP 1 C:\GainSpan\GS1010\1.0.0\Applical NVDS APP APP 2 C:\GainSpan\GS1010\1.0.0\Applical APP 2 C:\GainSpan\GS1010\1.0.0\Applical APP 2 C:\GainSpan\GS1010\1.0.0\Applicat Erase Flash Erase Flash
	ROM debugging Size Write Modify Address: 0x00000000 0xEA000008 Read Dump
Window of a started	Mask/Size:
Ready	

Figure 1: BootROM confirmed and all Flash erased.

Now, upload just the release version of WFW to WLAN flash.

- 9. Uncheck APP1 and APP2, but leave WLAN checked.
- 10. Select the WFW file to upload by clicking on the "..." button next to the WLAN box. The WFW file should have a name like WFW-A1-REL-DBBA-M_m_b.bin, where M_m_b means "Major Version _ Minor Version _ Build Number."
- 11. Upload the WFW image by clicking the Copy button (result shown in Figure 2).
- 12. Power off GS1010.
- 13. Force the GS1010 to boot into WFW:
 - A. On the TLS board, remove short between Test Points E13 and TP6.
 - B. On the DB, set Switch 3 of INT2 to OFF.
- 14. Power on the GS1010.
- 15. In the ROM debugging panel, read address 0x00000000. The value read should now be 0xEA00000E. This is the WFW reset vector.

NL Untitled - Wild Config	urator: 0.0.1
<u>File O</u> ptions <u>?</u>	
D 🚅 🖬 X 🖻 🖻 🍜	8
 Station Manager Config Network scan Misc Statistics MIB NVDS Version Loader IEEE1588 	Filename(s) Shared RAM size ✓ WLAN Bin\WFW-A1-REL-DBBA-0_9_30.bin NVDS WLAN APP 1 C:\GainSpan\GS1010\1.0.0\Applical NVDS APP APP 2 C:\GainSpan\GS1010\1.0.0\Applicat FLASH ERASED: APP Flash 1 erase sent Erase Flash FLASH ERASED: WLAN Flash erase sent Write 0K Write 0K Write 0K
	Write DK Write DK Write DK Write DK Start updating firmware (C:\GainSpan\GS1010\1.0.0\WLAN\Bin\WFW-A1-REL-DBBA- 0_9_30.bin) Update firmware finished, 100 % done. Sending Copy request done. Read OK Read OK Read OK
	ROM debugging Size Write Modify Address: 0x00000000 C 8 bits End 10 Dump
	Mask/Size: 0xEA00000E
Window cfg started	
, Ready	NUM //

Figure 2: WFW uploaded to GS1010

SETTING GS1010 WFW MAC ADDRESS

Starting an IBSS is easy using *WiLDConfigurator*. When new WFW is uploaded into the GS1010, the default MAC address is 00:00:00:00:00:00. Unfortunately, most Wi-Fi devices will ignore IBSS beacons from a station with an all-zero MAC address. So, first a new WLAN MAC address must be stored in the GS1010 flash memory.

- 1. Select the MIB (Managed Information Base) frame of *WiLDConfigurator*.
- 2. Select the APP_CONF_MIB (application configuration MIB).
- 3. The MAC address is the dot11StationID MIB element. Double click to change its value to something like 00 1D C9 FF AB CD. 00 1D C9 is the OUI (Organizationally Unique Identifier) for Gain-Span.

┖ Untitled - Wild Confi	gurator: 0.0.1					
<u>Eile O</u> ptions <u>?</u>						
🗅 🚅 🔛 🐰 🖻 💼 🖉	3 ?					
🖃 Station Manager	MIB Name	Element Name	Value (hexa)	Value (decimal)	Туре	Rights
Config	APP STAT MIB	dot11StationID	00 1D C9 FF AB CD	00:1D:C9:FF:AB:CD	MAC ADDR	BW
Network scan	APP_CONF_MIB	Bssid	00 00 00 00 00 00 00	00:00:00:00:00:00	MAC_ADDR	BW
🖃 Misc	HD_STAT_MIB	Ssid	00		MAC_SSID	BW
Statistics	ME_CTE_MIB	dot11BeaconPeriod	64 00	100	U16	R
MIB	ME_CONF_MIB	dot11CurrentChannelNumber	09	9	U8	R
NVDS	ME_STAT_MIB	CapaInfo	02 82 84	33282	U16	R
Version	MM_CONF_MIB	Rates	01	1b;	MAC_RATESET	R
Version	MM_STAT_MIB	Dtim	01	1	U8	RW
Loader	DP_STA_STAT_MIB	Infrastructure	14	20	08	R
IEEE1588	DP_MDS_CUNF_MIB	SlotTime	00 00 20 00	U	08	н
	DP_MUS_STAT_MIB					
	DP_SEC_CONF_MID					
	DP_PP_CONF_MIB					
	TBC STAT MIB					
	DBG_STAT_MIB					
	DB PHY CONE MIB					
	DR PHY STAT MIB					
	HI_STAT_MIB					
	CI_CONF_MIB					
	PS_CONF_MIB					
	PS_STAT_MIB					
	PTP_STAT_MIB					
· · · · · · · · · · · · · · · · · · ·		1	1			
Window cfg started	Version The MIB version is	up to date Mib v0.24.13			AutoRefresh	Refresh
Ready	1				NU	M /

Figure 3: WiLDConfigurator MIB frame, showing MAC address (dot11StationID).

Changes to the WFW MIB via *WiLDConfigurator* are not written to the flash immediately. To force this change to become permanent, the GS1010 must be forced to Standby, which will cause any MIB changes to be flushed to the flash.

- 4. Select the IEEE1588 frame of *WiLDConfigurator*, shown in Figure 4.
- 5. Press the Standby Request button. This will write all MIB changes to the flash.



NL Untitled - Wild Config	urator: 0.0.1	
<u>File O</u> ptions <u>?</u>		
D 🚅 🖬 X 🖻 🖻 🍜	8	
 Station Manager Config Network scan Misc Statistics MIB NVDS Version Loader 	PTP Debug Info (may not work on some firmwares) Current RTC time Current RTC Offset Current PTP time Current PTP Offset Current PTP OneWayDelay	
ILLE 1900	StandBy Standby Time requested 0000 days 00 h 00 m 00 s 000 ms 000 us Alarms Alarm1 Active Level C Low Enabled Yes C High C No	
	WakeUpCounter & RTC WakeUp Reference Time 2006/09/01, 00 h 00 m 00 s 000 ms 000 us WakeUp Period 0000 days 00 h 00 m 00 s 000 ms 000 us WakeUp Activation Time 0000 days 00 h 00 m 00 s 000 ms 000 us	
	StandByModeReq: preparing Request + WakeUpTime binary format: 0x0000000.11836c34 + WakeUpTime string format: 1970/01/01, 00 h 37 m 21 s 711 ms 334 us -> success: Request sent (no Confirmation expected) CiBootInd: Analyzing Indication + WakeUpTime (earliest read): * binary format:0x00000000.11838464 * string format:1970/01/01, 00 h 37 m 21 s 758 ms 575 us Info Reg: 0x1 0x0 0x000 + WakeUpSource: Normal WakeUp (after standby period)	
Window cfg started		
Ready	NUM	11.

Figure 4: *WiLDConfigurator* IEEE1588 frame.



SCANNING FOR BSSS

NL Untitled - Wild Confi	gurator: 0.0.1								
<u>File O</u> ptions <u>?</u>									
🗅 🚅 🔒 X 🖻 🖻 4	B 8								
Station Manager Config Network scan	Scan Passive Scar	n	C Activ	e Scan	SSID :				
Statistics	SSID	BSSID	CHAN	TYPE	SECURITY	RATE	BEACON	RSSI	QoS
MIB NVDS Version Loader IEEE1588	Minekey Wireless GainSpanDemo6 Canesta_Guest GAINSPAN	00:13:10:B3:F8:A6 00:14:70:32:D0:17 00:18:11:58:B0:EC 00:16:B6:C6:88:27 00:18:11:55:42:D3	10 6 2 1	AP AP AP AP AP	WPA-PSK WPA-PSK NONE WPA-PSK WPA-PSK	1b;2b;5b;11b;6b;9;12b;18;24b;36;48;54; 1b;2b;5b;11b;18;24;36;54;69;12;48; 1b;2b;5b;11b;69;12;18;24;36;48;54; 1b;2b;5b;11b;18;24;36;54;69;12;48; 1b;2b;5b;11b;6;12;24;36;9;18;48;54;	100 100 100 100 100	-72 -91 -66 -87 -70	No No No No
Window cfg started							Connect	S	can

Figure 5: WiLDConfigurator Network Scan frame.

To verify that the WLAN radio is working, *WiLDConfigurator* provides a scan function. *WiLDConfigurator* supports both passive and active scanning. In passive scan, the GS1010 listens for beacon frames on each 802.11b/g channel for a fixed amount of time. It compiles a list of the first five beacons that it receives. For an active scan, the GS1010 first sends a Probe Request frame, and then compiles a list of the received Probe Response frames. It is also possible to active scan for a particular SSID. The Network scan frame of *WiLDConfigurator* is shown in Figure 5.

STARTING AN IBSS

The Config frame of *WiLDConfigurator* provides an interface for joining a BSS (either infrastructure or *ad hoc*) and also for starting an IBSS.

- 1. Select the Config frame of *WiLDConfigurator*.
- 2. Enter an SSID for the IBSS. For example, GS1010_AdHoc.
- 3. Select an 802.11b/g channel (1-14) on which to start the IBSS. For example, 3.
- 4. Select Ad Hoc for Network Type.
- 5. Select Basic Rates for the IBSS. Typically check both 1.0 and 2.0 for both Allow and Basic.
- 6. Click Create IBSS.



🔤 Untitled - Wild Config	urator: 0.0.1	
<u>File O</u> ptions <u>?</u>		
D 📽 🖬 X 🖻 💼 6	ð 😵	
 Station Manager Config Network scan Misc Statistics MIB NVDS Version Loader IEEE1588 	Basic Settings SSID GS1010_AdHoc Channel Regional Settings Image: Channel Network Type Image: Channel Rate Allow Basic Image: Channel 1.0 Image: Channel 2.0 Image: Channel Channel Image: Channel Image: Channel Security Image: Channel Image: Channel Image: Chann	Station Status State STARTED BSSID 00:00:00:00:00 Power Save Mode Active Passive Advanced Settings Short Preamble WMM
Window ofg stopped		Stop Create IBSS Connect
, Ready		

The Station Status will change to indicate that the IBSS has been STARTED.

DETECTING THE IBSS

Any device capable of scanning for Wi-Fi networks should be able to detect the IBSS. Ensure that the device is configured to detect and report *ad hoc* (IBSS) networks.





CONFIGURING BEACON INTERVAL

When the GS1010 WFW creates an IBSS, it periodically sends beacon frames with a period specified by a WFW MIB (DesiredBeaconPeriod). By default, DesiredBeaconPeriod is set to 100msec. For RF testing, it is often convenient to decrease this period to make beacons more frequent.



🚧 Untitled - Wild Config	urator: 0.0.1								
<u>File O</u> ptions <u>?</u>									
D 🚅 🖬 X 🖻 🖻 4	3 ?								
Station Manager	MIB Name	Element Name	Value (hexa)	Value (dec	;imal) Type	Rights			
Config	APP_STAT_MIB	DesiredBeaconPeriod	0A 00	10	U16	RW			
Network scan	APP_CONF_MIB	DesiredChannel	03	3	U8	BW			
🖃 Misc	HD_STAT_MIB	Capainfo	02 00	2	U16	BW			
Statistics	ME_CTE_MIB	SupportedRates	02 82 84	1b;2b;	MAC	BW			
MIR	ME_CONF_MIB	Dtim	03	3	U8	RW			
MID C	ME_STAT_MIB	Atim	00 00	0	U16	BW			
NYUS	MM_CONF_MIB	Infrastructure	00	0	U8	BW			
Version	MM_STAT_MIB	ChannelSet	15 D4 70	not availab	ole MAC	BW			
Loader	DP_STA_STAT_MIB	PassiveMaxScanTime	FA 00	250	U16	BW			
IEEE1588	DP_MDS_CONF_MIB	ActiveMaxScanTime	05 00	5	U16	BW			
	DP_MDS_STAT_MIB	ActiveMinScanTime	05 00	5	U16	BW			
	DP_SEC_CONF_MIB	ActiveProbeDelay	00 00	0	U16	BW			
	DP_SEC_STAT_MIB	Listen	C5 4D	19909	U16	RW			
	DP_PP_CONF_MIB	dot11AuthenticationAlgorithm	01	1	U8	BW			
	DP_PP_STAT_MIB	EncryptionStatus	00	0	U8	BW			
	TRC_CONF_MIB	dot11PHYType	02	2	U8	BW			
	TRC_STAT_MIB	MacCountry	00 22 94 81 3	not availab	ole MAC	BW			
	DBG_STAT_MIB	MacChannelDomain	OE 01 02 03 0	1;2;3;4;5;6	5;7;8; MAC	BW			
	DR_PHY_CONF_MIB	WmeRequested	00 FALSE		CO	BW			
	DR_PHY_STAT_MIB	dot11MultiDomainCapabilityEnabled	00	FALSE	CO	BW			
	HI_STAT_MIB	RawForcedChannelDomain	03 07 00 00		MAC	BW			
	CI_CONF_MIB	DesiredRates	02 82 84	1b;2b;	MAC	BW			
	PS_CONF_MIB	DisablePhy11g	01	TRUE	CO	BW			
	PS_STAT_MIB	RoamingCheckingTime	8813	5000	U16	RW			
	PTP_STAT_MIB	ProbeReqPropInfo	00	not availab	ole MAC	RW			
Window cfg stopped The MIB version is up to date Mib v0.24.13 AutoRefresh Re									
Ready					NU	M			

Figure 6: Setting DesiredBeaconPeriod in WFW MIB

- 1. Select the MIB frame of *WiLDConfigurator*.
- 2. Select ME_CONF_MIB.
- 3. Double click DesiredBeaconPeriod.
- 4. Set a new value. *NOTE: This unsigned 16-bit (U16) value is stored "little endian." In other words, enter the LSB MSB in hexadecimal. For example, for a 10msec period, enter 0A 00.*
- 5. Remember to enter Standby to make this MIB change permanent (see *Setting GS1010 WFW MAC Address*).

ENABLING THE EXTERNAL POWER AMP

By default, the WFW uses the internal power amp (IPA). On boards that include the external power amp (XPA) circuitry, such as the DB/BE, it is possible to enable XPA while sending IBSS BEACON frames by using *WildConfigurator*.

- 1. Select the MIB frame of *WiLDConfigurator*.
- 2. Select DR_PHY_CONF_MIB.
- 3. Set PAOffset = 00 to enable XPA. PAOffset = 08 enables IPA.
- 4. Remember to enter Standby to make this MIB change permanent (see *Setting GS1010 WFW MAC Address*).



⊷ Untitled - Wild Confi	gurator: 0.0.1						
<u>File O</u> ptions <u>?</u>							
D 🚅 🔒 X 🖻 🖻 é	B 💡						
🖃 Station Manager	MIB Name	Element Name	Value (hexa)	Value (decimal)	Туре	Rights	
Config	APP_STAT_MIB	PAOffset	08	8	U8	BW	
Network scan	APP_CONF_MIB	BgPeriodBit	16	22	U8	RW	
🖃 Misc	HD_STAT_MIB	TempAverage	08 7C	31752	U16	BW	
Statistics	ME_CTE_MIB	PIIStartUpTime	DC 05	1500	U16	RW	
MIB	ME_CONF_MIB						
NVDS	ME_STAT_MIB						
Version	MM_CONF_MIB						
Version	MM_STAT_MIB						
Loader	DP_STA_STAT_MIB						
IEEE1588	DP_MDS_CUNF_MIB						
	DP_MUS_STAT_MIB						
	DP_SEC_CONF_MID						
	DP_PP_CONF_MIB						
	TBC STAT MIB						
	DBG_STAT_MIB						
	DB PHY CONE MIB						
	DR PHY STAT MIB						
	HI_STAT_MIB						
	CI_CONF_MIB						
	PS_CONF_MIB						
	PS_STAT_MIB						
	PTP_STAT_MIB						
Window cfg started	Version The MIB version is u	, up to date Mib v0.	24.13	4	AutoRefr	esh	Refresh
Ready	,					NUN	1

Figure 7: Set PAOffset = 0 to Enable XPA

MEASURING RF PERFORMANCE

Now that the GS1010 is pumping out IBSS beacons every 10msec, it is possible to attach the GS1010 directly to RF test equipment to measure such performance parameters as output power, spectrum, constellation, EVM, or power envelope. Below is a table relating the 802.11b/g channels numbers to their actual frequencies.

Channel	Start	Center	Stop	Regions
1	2.401	2.412	2.423	NA, ETSI, J
2	2.406	2.417	2.428	NA, ETSI, J
3	2.411	2.422	2.433	NA, ETSI, J
4	2.416	2.427	2.438	NA, ETSI, J
5	2.421	2.432	2.443	NA, ETSI, J
6	2.426	2.437	2.448	NA, ETSI, J
7	2.431	2.442	2.453	NA, ETSI, J
8	2.436	2.447	2.458	NA, ETSI, J
9 2.441 2		2.452	2.463	NA, ETSI, J
10 2.446		2.457	2.468	NA, ETSI, J



Channel	Start	Center	Stop	Regions		
11	2.451	2.462	2.473	NA, ETSI, J		
12	2.456	2.467	2.478	ETSI, J		
13	2.461 2.472		2.483	ETSI, J		
14	2.473	2.484	2.495	J		

Figure 8: 802.11b/g Channels – NA = North America, ETSI = Europe, J = Japan

®						IEEE 80	2.11	b						
Freque	ncy:	2.412 GHz Ref L			Ref Level: 3.2 dBm				External Att: 3 dB					
Sweep	Mode:	Continuou	JS	Trigger	Mod	e: I	Power			Trig	ger Offset:	-10	-10 µs	
Pream	ble Type:	Long PLC	Р	Modula	tion:		1 Mbp	s DBP	SK	PSE	OU Data Length	n: 1/4	095 Byte	s
	Spectrum Emission Mask													
Tx (Channel:	Bandwidth	22	2 MHz		Power		-8.6	2 dBm					
Start	Freq. rel.	Stop Freq. rel.	RB	W	Freq	. at Delta to	Limit	Pw	∧rAbs.		PwrRel.	Delta	to Limit	
-50.0	000 MHz	-22.000 MHz	100	kHz	2.3	68089744	GHz	-61	21 dBm	1	-52.60 dB	-2.6	0 dB	
-22.0	000 MHz	-11.000 MHz	100	kHz	2.4	00942308	GHz	-51	54 dBm		-42.92 dB	-12.	92 dB	
11.0	000 MHz	22.000 MHz	100	kHz	2.4	23057692 (GHz	-45	40 dBm		-36.79 dB	-6.7	9 dB	
22.0	000 MHz	50.000 MHz	100	kHz	2.4	34115384 (GHz	-60	85 dBm		-52.23 dB	-2.2	3 dB	
										_				
										_				
									+					
	Spectrum						DR\M	1	 10 kHz		 Markor 1			IRm
	Speetrum						VBW	/ 1	00 kHz				2.412 (GHz
	Ref 3	3.2 dBm	Att/EL	0.00/	/15.0)0 dB	SWT	1	00 ms		Swee	p	1	of 1
						CHECK RES	ULT	Pass						*
	-4					-Spect Mask	dBr-l	Pass						
	-14						<u>(" myy</u>	η.					+	— B
4.014	-24	+				<u> </u>		14					-	
	-34					<u> </u>								
									7		┣			GAI
					V				hm					TRG
	-5 Spect	t MaskdBr		1	~				1	M	<u></u>			
	64	~~	A. A	M	V				₩	ľή				
	74	MMMMMM M	<u>nv 'hui v</u>								V MW V MW			ution
												~ V	1	~ •
	-84													
	2262.00 M			ļ		10.00.1		liv.	ļ		↓↓		2462.00	
	2302.00 Minz 10.00 Minz/div 2402.00 Minz													

Figure 9: Spectrum Mask Test Using a Rohde & Schwarz FSG Spectrum Analyzer



GainSpan Corporation • 121 Albright Way • Los Gatos, CA 94032-1801 • U.S.A. +1 (408) 689-2129 • <u>info@GainSpan.com</u> • <u>www.GainSpan.com</u>

Copyright © 2008 by GainSpan Corporation. All rights reserved.

GainSpan and GainSpan logo are trademarks or registered trademarks of GainSpan Corporation. Other trademarks are the property of their owners.

Specifications, features, and availability are subject to change without notice.

080127TE