



6Harmonics Inc.

GWS-3000 Operating Manual

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Revision Control

Issue	Editor	Date	Status	Notes
0.01	Steve Beaudin & Yu Zhou	June 9th, 2013	draft	Initial Release
0.02	Steve Beaudin & Yu Zhou	August 7 th , 2013	draft	Added SW interface and Power Control
0.03	Peter Sun	August 16 th , 2013	draft	Added 6.7.3 manually enable radio for non database application Added 6.7.4 to check if BTS and CPE work on same channel Typo fix
0.04	Steve Beaudin	September 12 th , 2012	draft	Changed Power Limits to 20 dBm, add explanation to several sections to provide insight, fixed a few typos and formatting issues. Removed the “settxatten” and “gettxatten” from the User Interface commands.
1.0	Steve Beaudin	September 13 th , 2014	Approved	Released for FCC submission

Table 1: Revision history of the document



3. FCC Regulatory Information

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Part 15 TV Band Device Notice

This equipment has been tested and found to comply with the rules for TV bands devices, pursuant to part 15 of the FCC rules. These rules are designed to provide reasonable protection against harmful interference. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- (1) Reorient or relocate the receiving antenna.
- (2) Increase the separation between the equipment and receiver.
- (3) Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- (4) Consult the manufacturer, dealer or an experienced radio/TV technician for help.

Caution: Exposure to Radio Frequency Radiation.

To comply with FCC RF exposure compliance requirements, for fixed configurations, a separation distance of at least 40 cm must be maintained between the antenna of this device and all persons.

This device must not be co-located or operating in conjunction with any other antenna or transmitter.

Only the following components are approved for use with the radio.

- Power over Ethernet Mid-Span: PowerDsine™ 9001G-40/SP



- Sector Antenna SL12948B, 11 dBi Gain
- Sector Antenna SL14198A, 7 dBi Gain
- Sector Antenna SL12948A, 6 dBi Gain
- OMNI Antenna SL13304A, 6 dBi Gain
- OMNI Antenna SL1330B, 6 dBi Gain
- OMNI Antenna SL15918A, 3.5 dBi Gain

4. Introduction

The GWS-3000 radio modules are a wireless access solution which utilize the unlicensed TV Band, also known as “White Space Spectrum.” These radio's are designed to provide high reliability, non line of sight (NLOS) point to point (PtP) or point to multi-point (PtMP) radio links at a very low cost of ownership. The devices are designed to be operated and to receive a useable channel list from an approved White Space Database

For more information on the electrical specifications of the product please see “GWS-3000 General Specification.” For instructions on the mechanical installation as well as power and grounding requirements please see “GWS-3000 Installation Guide”.

This document provides an outline for configuring and operating the GWS-3000 units in a live network. Specifically, this document “GWS-3000 Operating Manual” provides instruction on:

- a) Product Overview
- b) Configuring the IP address of the nodes
- c) Entering information for the White Space Data Base and Power Control such as
 - a. Global GPS coordinates
 - b. Installer name and contact information
 - c. Antenna height above ground (30m max)
 - d. Gain of Antenna used for the TV Band Device.
- d) How to verify that the node has connected to the network and registered with the database
- e) Perform the initial power control to comply with FCC rule 15.709 (a) (3)
- f) Planning a deployment
 - a. Choosing site location
 - b. Selecting the appropriate antenna for a fixed device
 - c. Minimizing interference between nodes on the network



4. Product Overview

The GWS-3000 and GWS-4000 radio modules are a wireless access solution which utilize the unlicensed TV Band, also known as “White Space Spectrum.” These radio’s are designed to provide high reliability, non line of sight (NLOS) point to point (PtP) or point to multi-point (PtMP) radio links at a very low cost of ownership. For more information on the electrical specifications of the product please see “GWS-3000 General Specification” or “GWS-4000 General Specification.” For information on how to operate and configure the devices please see “GWS-3000 Operating Manual” or “GWS-4000 Operating Manual.”

The mechanical solution comprises of two main parts. The first part is the radio enclosure and the second part is the mounting bracket which is used to fix the module to a post or a wall.

4.1 External Dimensions of the radio module

GWS3000 & GWS4000 External Dimensions

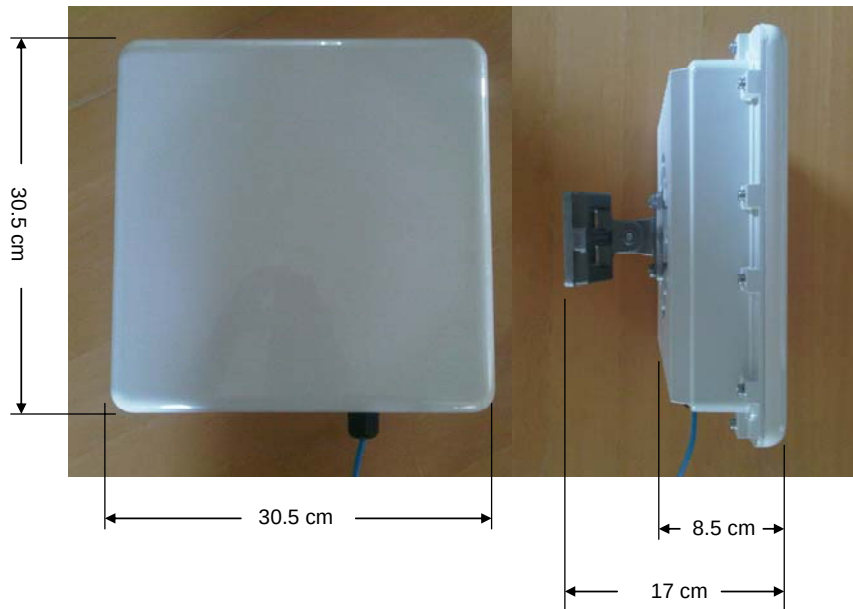


Figure 1: Diagram showing the external dimensions of the GWS-3000. The mounting bracket shown is for the standard Wall Mount Configuration.

A picture of the GWS-3000 can be seen in the diagram above. The module measures 30.5 cm in width, 30.5 cm in height. The thickness of the module is 8.5 cm from the front panel to the heat fins on the rear of the enclosure. If the mounting

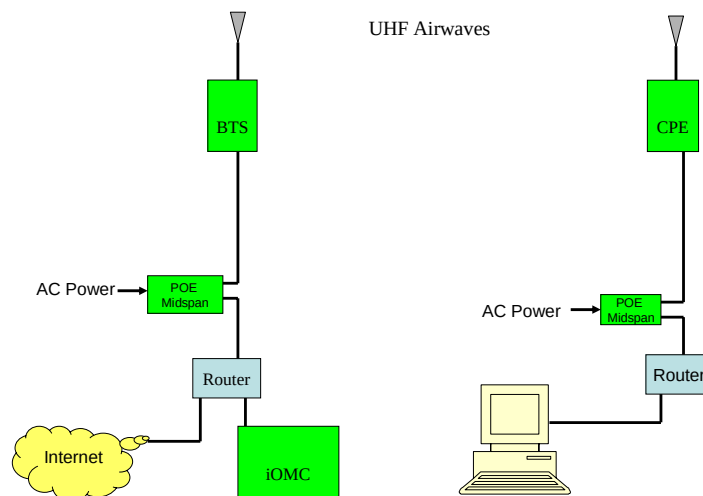


bracket is attached the module has a total thickness of 17 cm from the front of the module to the base of the wall mount bracket.

For a basic wall mount deployment, there is a clearance of 8.5 cm between the wall and the heat fins of the module to allow for air circulation. When the radio is in operation, the rear surface of the module can reach a temperature of $T_{\text{ambient}} + 20^{\circ}\text{C}$.

5. System Diagram

Below is a block diagram to show how the GWS radio can be used in a network. Both the BTS and CPE can be powered via a POE Midspan. The mid-span accepts AC power and is designed for international deployments with an input range of 100V-240V, 50-60 Hz. The mid-span then combines the Ethernet data along with a DC bias voltage on the Cat5e cable. The Ethernet cable from a personal computer can be directly connected into the POE Midspan, or router as shown.



6. Software Environment

6.1 Overview

This User's Manual is intended to provide guidance on what the Host Software does and how to use the Host Software to make the GWS node function properly.

The GWS-3000 Host Software provides the following functionalities:

- Initialize host board and GWS-3000 radio;



- b) Configure the host board and GWS-3000 radio
- c) Provide interface for users to manage and operate host board and GWS-3000 radio;
- d) Control the behaviors of GWS node, .e.g. set GWS Node acts as BTS or CPE

6.2 Node Initialization

After power up, the host software will load into RAM of host board from NAND, start to initialize and setup all the devices in good working status, including: initialize CPU and peripheral devices.

6.3 Setup and Communicate with Host Board

There are three ways to communicate with the Host Board: a) User Interface, b) Serial Port and c) SSH Interface.

6.3.1 User Interfaces

The host software also provides different sets of user interface for users to configure, manage and operate the host board or radio devices and the commands are distinguished by user commands and debug commands. User commands are intended to allow users to change configurable parameters to manage the host board or radio, and the debug commands are intended for the internal design/testing engineer to perform DVT or debug or set factory parameters.

The User Interface is the general purpose interface which should be used by the staff of the wireless operator to perform routine maintenance and management functions on the nodes.

6.3.2 Serial Port

Use the terminal on a PC to Connect to Host board with the following parameters:

Parameters

Baud rate:	115200
Data bits:	8
Parity:	None
Stop bits:	1
Flow control:	None

Warning: This connection is for a professional installer which has been trained by 6Harmonics and can damage the module if performed improperly. This connection is used to burn the first image on the host board. The module is shipped with the latest software pre-loaded and this procedure should not need to be performed by the customer. Only in extremely rare circumstances, such as if the flash becomes corrupted or a power failure occurs during a remote software upgrade,



will this procedure need to be performed. To perform the procedure the module must be taken to a maintenance point and the lid must be opened to access the serial connector on the host card.

6.3.3 SSH

SSH will provide all debug commands to configure, manage and operate the GWS Node

SSH Port 1440

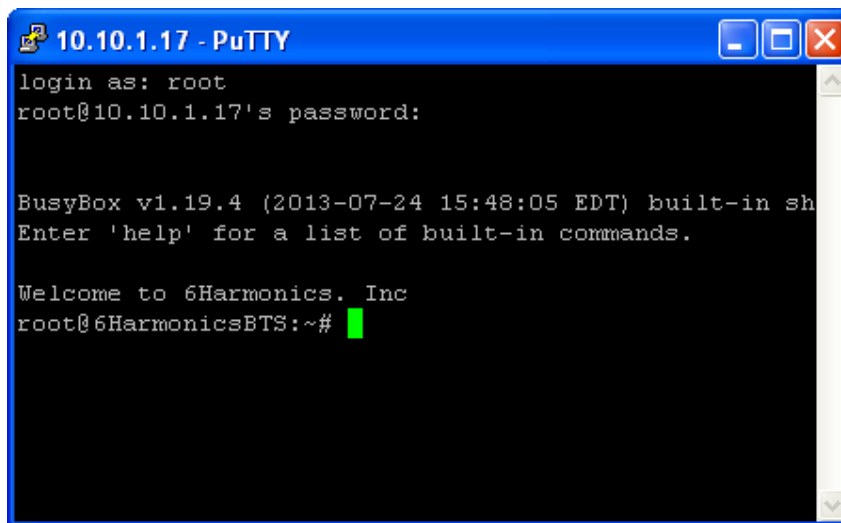
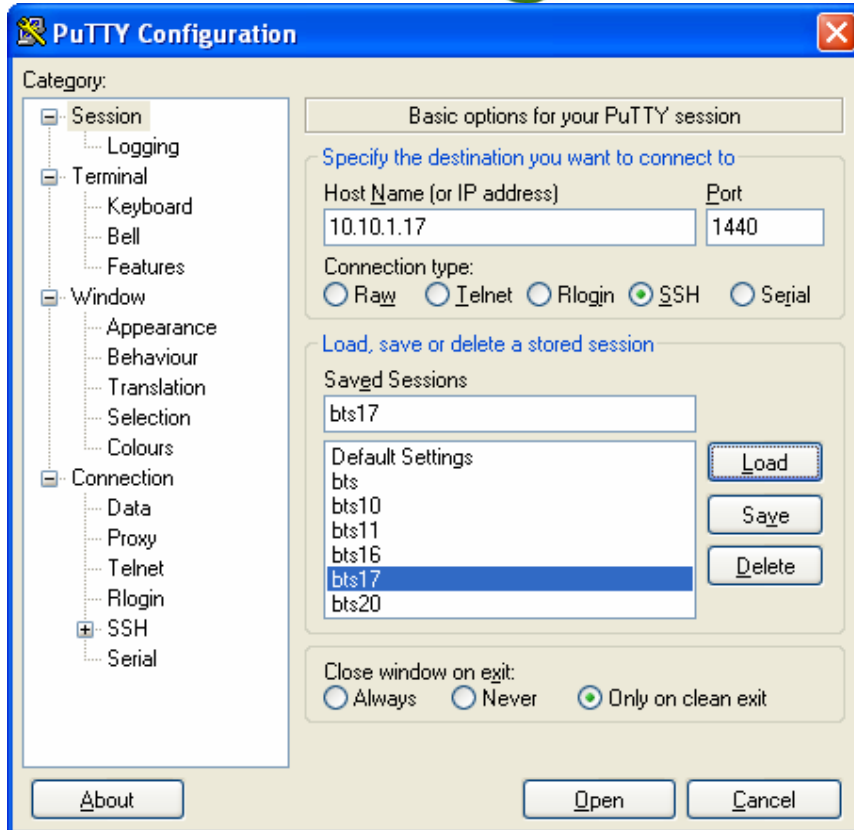
USER: *****

PWD:*****

Example:

Use putty on Windows XP to access the Node

Note: The SSH interface should only be used by qualified personnel trained by 6Harmonics. Root access requires a User Name and Password and is only available to 6Harmonics personnel or professional installers which have been trained and certified by 6Harmonics. This guide is meant for both non-certified users as well as professional installers which have been trained and certified by 6Harmonics and as such we provide instructions on how to use both the User Interface and the SSH interface.





6.4 Configure the IP Address of the Nodes

When the modules are shipped from the factory they will all have the same IP address, 192.168.1.1. Prior to deploying the modules, the installer should reprogram the IP address to a value appropriate for the network in question. The IP address can be rewritten by following the procedure below:

By default, the management IP ip address is 192.168.1.1
To change ip address, open /etc/config/network

```
10.10.1.17 - PuTTY
config 'interface' 'loopback'
    option 'ifname' 'lo'
    option 'proto' 'static'
    option 'ipaddr' '127.0.0.1'
    option 'netmask' '255.0.0.0'

config 'interface' 'lan'
    option 'ifname' 'eth0'
    option 'type' 'bridge'
    option 'proto' 'static'
    option 'ipaddr' '10.10.1.17'
    option 'netmask' '255.255.255.0'
    option gateway 10.10.1.1
    option dns 8.8.8.8

- /etc/config/network 1/19 5%
```

Modify the ip address and gateway, save it.
Then type /etc/init.d/network restart.

6.5 Image burn and upgrade

6.5.1 Burn image for first time

Connect serial cable to host board, assume boot environment is ready (image, tftp server and http server are ready).

On terminal of PC, when prompt press any key. Press any key to access the bios menu.

Choose boot over Ethernet. After boot success, in terminal, type
wget2nand <http://xx.xx.xx.xx/> xx.xx.xx.xx is ip address of http server, and assume all image are put in its root dir.

After downloaded the image, reboot the node and choose boot from NAND.
The default ip address for GWS node is 192.168.1.1
Default mode is BTS.



6.6.2 Upgrade Image

Assume boot environment is ready (image, ftp server and http server are ready).

SSH the GWS Node. Type

firmwareupgrade <http://xx.xx.xx.xx/>

The GWS node will reboot after upgrade finished.

Attention: Currently, when upgrading the host image, all current configuration will lost. The new image with default configuration will be used.

6.6.3 Upgrade the application

Assume upgrade environment is ready (application package and http server are ready).

In SSH shell type

wget <http://xx.xx.xx.xx/packageName.ipk>

After download the application package.

In SSH Shell , type

opkg install applicationpackage.ipk

6.7 Configurations

6.7.1 Configure GWS Node Mode as BTS or CPE

GW-3000 S Node can be configured as BTS or CPE. By default: GWS Mode is BTS

SSH to GWS Node, open /etc/init.d/config-wireless

```
10.10.1.17 - PuTTY
login as: root
root@10.10.1.17's password:

BusyBox v1.19.4 (2013-07-24 15:48:05 EDT) built-in shell (
Enter 'help' for a list of built-in commands.

Welcome to 6Harmonics. Inc
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~# vi /etc/init.d/config-wireless
```



```
10.10.1.17 - PuTTY
#!/bin/sh /etc/rc.common
# Copyright (C) 6Harmonics Inc.

START=99
STOP=99
start() {
    rfreset
    sleep 5
    settxcal 1
    sleep 5
    setrxcal 1
    config_ap
    getrfinfo&

- /etc/init.d/config-wireless 1/17 5%
```

By default: GWS Mode is BTS, to set it to CPE mode, change config_ap to config_sta

```
10.10.1.17 - PuTTY
#!/bin/sh /etc/rc.common
# Copyright (C) 6Harmonics Inc.

START=99
STOP=99
start() {
    rfreset
    sleep 5
    settxcal 1
    sleep 5
    setrxcal 1
    config_sta
    getrfinfo&

I /etc/init.d/config-wireless [Modified] 13/17 76%
```

Save it, type re in SSH shell



```
10.10.1.17 - PuTTY
sleep 5
setrxcal 1
config_sta
getrfinfo&

root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~# config_sta
```

```
10.10.1.17 - PuTTY
config_sta
getrfinfo&

)

root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~# config_sta
uci: Entry not found
uci: Entry not found
command failed: Device or resource busy (-16)
Successfully initialized wpa_supplicant
root@6HarmonicsBTS:~#
```

then type reset in SSH shell to reboot the GWS node

```
10.10.1.17 - PuTTY
getrfinfo&

)

root@6HarmonicsBTS:~#
root@6HarmonicsBTS:~# config_sta
uci: Entry not found
uci: Entry not found
command failed: Device or resource busy (-16)
Successfully initialized wpa_supplicant
root@6HarmonicsBTS:~# reset
root@6HarmonicsBTS:~#
```

Now GWS Node is acting as CPE



```
10.10.1.17 - PuTTY
login as: root
root@10.10.1.17's password:

BusyBox v1.19.4 (2013-07-24 15:48:05 EDT) built-in shell (
Enter 'help' for a list of built-in commands.

Welcome to 6Harmonics. Inc
root@6HarmonicsCPE:~#
```

To set CPE back to BTS, edit the /etc/init.d/config-wireless to change config_sta to config_ap , save it, type config_ap in SSH shell then reset the GWS Node.

6.7.2 Wireless Configuration

There are two ways to modify the wireless configuration

1. For temporary change. (No reset needed)

Open /etc/config/wireless

```
10.10.1.17 - PuTTY

config wifi-device 'radio0'
    option type 'mac80211'
    option macaddr 'd4:ca:6d:11:47:fa'
    option disabled '0'
    option channel '8'
    option txpower '9'
    option hwmode '11ng'
    option chanbw '5'
    option beacon_int '500'

config wifi-iface
    option device 'radio0'
    option network 'lan'
    option encryption 'none'
    option wds '1'
    option ssid 'gws2000'
    option mode 'sta'

~
- /etc/config/wireless 1/19 5%
```

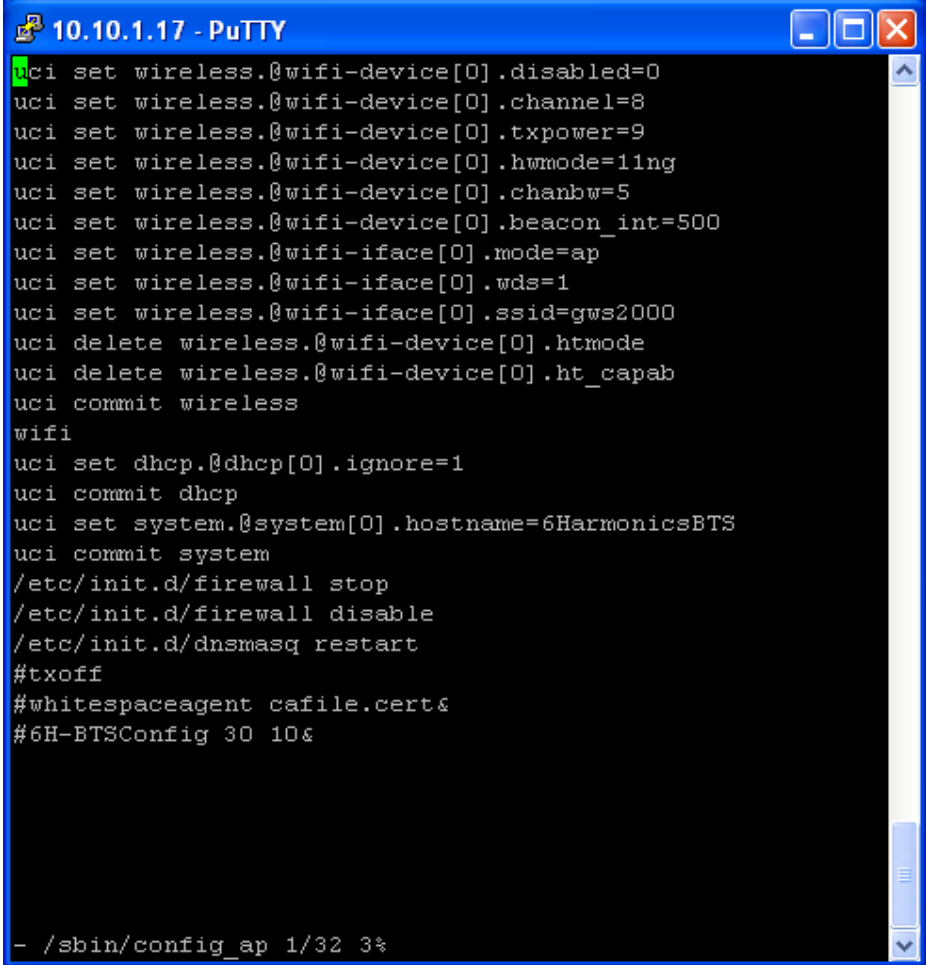


Attention: Modifying the wireless settings are for debug purposes only and you must be trained by 6Harmonics prior to attempting, otherwise you may impair performance of the wireless link.

After performing the changes, save it in SSH Shell.
For the changes to take effect you must issue the following commands: a) wifi down, and then b) wifi up. The new setting will be take effect but these are not permanent. Once the GWS Node is reset, the changes will be gone and the default configuration will be loaded from the file.

2. For permanent changes

Open `/sbin/config_ap` for BTS or `/sbin/config_sta` for CPE



```
10.10.1.17 - PuTTY
uci set wireless.@wifi-device[0].disabled=0
uci set wireless.@wifi-device[0].channel=8
uci set wireless.@wifi-device[0].txpower=9
uci set wireless.@wifi-device[0].hwmode=11ng
uci set wireless.@wifi-device[0].chanbw=5
uci set wireless.@wifi-device[0].beacon_int=500
uci set wireless.@wifi-iface[0].mode=ap
uci set wireless.@wifi-iface[0].wds=1
uci set wireless.@wifi-iface[0].ssid=gws2000
uci delete wireless.@wifi-device[0].htmode
uci delete wireless.@wifi-device[0].ht_capab
uci commit wireless
wifi
uci set dhcp.@dhcp[0].ignore=1
uci commit dhcp
uci set system.@system[0].hostname=6HarmonicsBTS
uci commit system
/etc/init.d/firewall stop
/etc/init.d/firewall disable
/etc/init.d/dnsmasq restart
#txoff
#whitespaceagent cafile.cert&
#6H-BTSConfig 30 10&

- /sbin/config_ap 1/32 3%
```

Attention: Modifying the wireless settings are for debug purposes only and you must be trained by 6Harmonics prior to attempting, otherwise you may impair performance of the wireless link.



After changes, save it, then reset.

6.7.3 Radio turn on (For non database application)

The default setting radio is off. To turn on the radio with out database access, in SSH Shell

Type txresume, the radio will be enabled.

Note: This functionality is only available for units shipped to countries which do not use a White Space Database. For US customers this capability is not provided.

6.7.4 Check channel number (For non database application)

For non database application, after the radio has been enable, expect the connection is up at this time. If not, please check if BTS and CPE are configured to the same channel.

7.0 User Commands

As stated previously, users commands are a set of commands for users to configure the radio and get information from the radio. The supported commands are listed in table 1 and can be exercised by telnetting to the node.

Table 1. General User Commands

Commands	Description
<i>setchan</i>	Set Channel Number
<i>getchan</i>	Show Channel Number
<i>setagcmode</i>	Set AGC mode
<i>getagcmode</i>	Show AGC mode
<i>rfinfo</i>	Show RF informations
<i>u</i>	Tx power up 0.5dBm
<i>c</i>	Tx power down 0.5 dBm
<i>cu</i>	Tx power up 5 dBm
<i>cd</i>	Tx power down 5dBm
<i>settxpwr</i>	Set Tx Power
<i>gettxpwr</i>	Show current Tx power
<i>monitor</i>	Show Node status
<i>setinstaller</i>	Set installer
<i>getinstaller</i>	Show information about who install the node
<i>getchanlist</i>	Show channel list
<i>getsubchanlist</i>	Show sub channel list
<i>txoff</i>	Turn off Tx
<i>txresume</i>	Resume the Tx
<i>gettxstatus</i>	Show tx status
<i>getrxstatus</i>	Show rx status
<i>setchanlist</i>	Set channel list
<i>setsubchanlist</i>	Set Sub Channel list
<i>setrxgain</i>	Set Rx Gain
<i>getrxgain</i>	Show Rx Gain



`reboot`
`--help`

Reboot the GWS node
Help command to list all above commands

7.1 help command

This command lists all available commands. If you type help during the telnet session, you'll see the followings:

```
C:\> Telnet 10.10.1.17
GWS Cmd > --help
Support Commands:
--help
setchan xx
getchan
settxatten xx
gettxatten
getagcmode
setagcmode x
rfinfo
u /*tx power up 0.5dBm*/
d /*tx power down 0.5 dBm*/
cu /*tx ppwer up 5 dBm*/
cd /*tx power down 5 dBm*/
settxpwr xx
gettxpwr
setrxatten xx
getrxatten
monitor
setinstaller
getinstaller
getchanlist
getsubchanlist
txoff
txresume
gettxstatus
getrxstatus
setchanlist
setsubchanlist
setrxgain
getrxgain
reboot
GWS Cmd >
```

7.2 setchan command

The “setchan” command is to set what channel the radio is going to work on. The channel number range will vary from region to region. For example for US, the number would be 14~51, except channel 36, 37 and 38. For operation in the US, the module needs to query the available channel from FCC database and the SW will only allow the module to tune to a channel which is part of the channel list received from the data base.

GWS Cmd >setchan 35



7.3 getchan command

The “getchan” command returns the current channel setting. The following returns that the current channel is set to channel 33:

```
GWS Cmd >getchan  
Channel: 33
```

7.4 txresume command

The “txresuem” command is to resume radio tx chain, otherwise tx will not transmitting. The syntax would be:

```
GWS Cmd >txresume
```

7.5 txoff command

The command “txoff” is to turn tx chain off and cease transmission:

```
GWS Cmd >txoff
```

7.6 gettxstatus command

To know what tx status is and what tx parameters are set to, you can use “gettxstatus” command:

```
GWS Cmd >gettxstatus  
TX : OFF  
Tx_Atten : 10  
TV Channel : 41  
CurTxPower : 20.0 dbm  
MaxTxPower : 20.0 dbm  
MinTxPower : -6.5 dbm  
TX Power Cal: ON  
GWS Cmd >
```

7.7 getrxstatus command

The “rxstatus” command will return the current RX status:

```
GWS Cmd >getrxstatus  
RX : ON  
AGC Mode : 2  
RF IFOUT : IFOUT2  
Rx_F_Atten : 0  
Rx_R_Atten : 22  
RX Gain : 12.0 dB  
RX Gain Cal : ON  
GWS Cmd >
```

7.8 settxpwr command

The “settxpwr” command allows the user to set the tx power in 0.5dbm steps. The following is to set the tx power to 11.5dbm:

```
GWS Cmd >settxpwr 11.5  
GWS Cmd >
```



Note1: The Software will only allow the user to increase the maximum power up to the maximum permissible power.

Note2: If manual power control has been implemented, the user should refer to the section in the document which details the power control procedure to ensure the link is configured properly.

7.9 gettxpwr command

The “gettxpwr” command will return the current tx power setting in dbm:

```
GWS Cmd >gettxpwr
```

```
CurTxPower: 11.5 dbm
```

```
GWS Cmd >
```

7.10 rfinfo command

The “rfinfo” command will return the current radio configuration:

```
GWS Cmd >rfinfo
```

```
6 Harmonics GWS-1100 - Rev 04
```

```
Firmware #601100-410 Generated at: Jul 9 2013 16:25:19.
```

```
Radio SNO : 19
```

```
TX : DOWN
```

```
RX : DOWN
```

```
Region : 0
```

```
Channel : 41
```

```
CurTxPower : 20.0 dbm
```

```
MaxTxPower : 20.0 dbm
```

```
MinTxPower : -6.5 dbm
```

```
RX Gain : 12.0 dbm
```

```
Temperature : 38.0 C
```

```
GWS Cmd >
```

7.11 u command

The “u” command will set tx power up 0.5dBm:

```
GWS Cmd >u
```

7.12 d command

The “d” command will set tx power up 0.5dBm:

```
GWS Cmd >d
```

Note: The “u” and “d” commands are used to perform manual power control and load balancing to optimize network performance. The can be used to increase or decrease transmit power during while the node is in service and carrying traffic.



7.13 setchanlist command

The “setchanlist” is to set channel list. The following is to set channel list 14 15 35:

```
GWS Cmd > setchanlist 14 15 35  
GWS Cmd >
```

Note1: For markets such as the USA, where the regulatory rules require the node to access a database, the radio will only accept a channel list from an approved database with whom it has registered.

Note 2: This command is intended for countries where a database is not prescribed and allows the user to program the allocated channels into memory. In this way, the node can only be tuned to a channel which is part of the channel list, which will accelerate handoff and the scanning process and will ensure that node does not attempt to transmit on a channel which is not permitted. The software will only attempt to establish communication links on a channel which is part of the “channel list” and the user will only be permitted to change the channel, to a channel which is part of the “channel list.”

7.14 getchanlist command

The “getchanlist” will return the current channel list stored in memory:

```
GWS Cmd > getchanlist  
GWS Cmd >  
14  
15  
35
```

If the radio has received the channel list from a white space database, then this command can be used by the operator to determine which channels are available. The command does not query the database but produces the channel list which was last provided by the database to be displayed.

7.15 getrxgain command

getrxgain to return the current rx gain in dbm:

```
GWS Cmd >getrxgain
```

Note: The rxgain which is reported is the gain of the White Space radio front end, and does not include the baseband gain. The system provides reasonably good performance with an rxgain of 12 dB. For short links where RX sensitivity is not critical, the gain can be reduced accordingly. The receive chain includes two attenuators, “rxatten0” and “rxatten1”. “rxatten0” is situated after the LNA but before the downconverter and for maximum sensitivity should be left at a value of 0. “rxatten1” is located at IF



and can be used to trim the RX gain up or down by a few dB without adversely affecting sensitivity.

7.16 setrxgain command

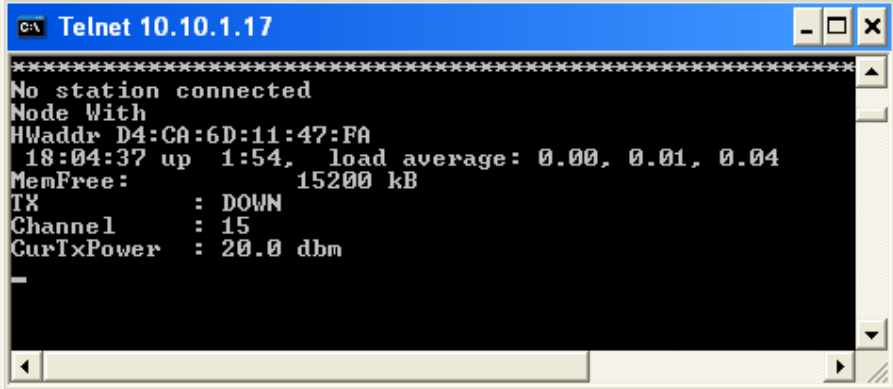
The “setrxgain” command is to set rx gain.

GWS Cmd >setrxgain 10

7.17 monitor command

The “monitor” command is to start program to monitor status of Node. Typing “monitor” in the telnet window will initial the program which allows the status of the radio link to be monitored real time. Below is an example of the parameters which are displayed.

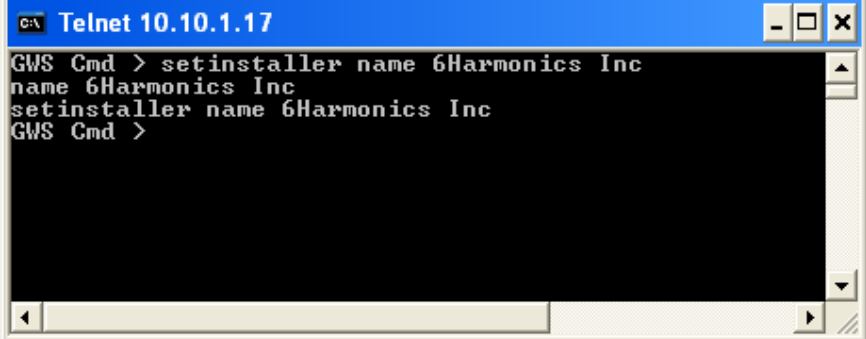
GWS Cmd>monitor



```
C:\> Telnet 10.10.1.17
*****
No station connected
Node With
HWaddr D4:CA:6D:11:47:FA
18:04:37 up 1:54, load average: 0.00, 0.01, 0.04
MemFree: 15200 kB
TX : DOWN
Channel : 15
CurTxPower : 20.0 dbm
-
```

7.18 setinstaller command

The “setinstaller” command is to record who installed the GWS Node. For US customers this field is made available to the White Space database and the node will not be allowed to connect to the database unless there is a valid entry.



```
C:\> Telnet 10.10.1.17
GWS Cmd > setinstaller name 6Harmonics Inc
name 6Harmonics Inc
setinstaller name 6Harmonics Inc
GWS Cmd >
```

7.19 getinstaller command

The “getinstaller” shows who installed the GWS Node



```
Telnet 10.10.1.17
GWS Cmd > getinstaller
name 6Harmonics Inc
getinstaller
GWS Cmd > _
```

7.20 setsubchanlist command

The “setsubchanlist” command is to set sub channel list

```
Telnet 10.10.1.17
GWS Cmd > getinstaller
name 6Harmonics Inc
getinstaller
GWS Cmd > setsubchanlist 14
subchanlistStr[0]=14
setsubchanlist 14
GWS Cmd > _
```

There is an important distinction between the “setchanlist” and the “setsubchanlist” which we will explain here. The “chanlist” can be programmed and read using the “setchanlist” and “getchanlist” commands and these are the channels on which the node is permitted to transmit. This list will be provided by the White Space Database in countries such as the US, and in countries which do not use a database it will be dependent on local regulatory rules or the license an operator may have in place and must be programmed by the professional installer. For US customers the software will not allow the user to manually program the channel list.

The “subchanlist” does not come from the database but is meant to further restrict the channels which are used based on the hardware configuration. A situation where the user may want to reduce the number of channels would be if a Combiner or Narrow Band Filter is placed between the radio module and the antenna. For example, if the passband of a filter covers Channels 14 to 22, the user would use the following command”

Setsubchanlist 14 15 16 17 18 19 20 21 22

The software will then know that the node can only transmit on a channel between 14 and 22, inclusive.



The actual channel which is used must be part of both the “chanlist” and the “subchanlist”. The “chanlist” is from the database while the “subchanlist” is from the installer and used to configure hardware limitations such as a narrow band filter which is inline with the antenna. The Software will only attempt to use a channel which are part of both lists.

By default, the “subchanlist” includes all channels for a given market. For the USA this would be channels 14-35, and 39-51. To restrict this further the professional installer must rewrite the subchanlist.

Ensuring that the “subchanlist” is properly programmed will improve network performance by ensuring nodes do not try to transmit at frequencies for which an in-line filter or combiner might be attenuating the signal.

7.21 getsubchanlist command

The “getsubchanlist “ is used to read the sub channel list

7.22 cu command

The “cu” command is to set tx power up 5 dBm

7.23 cd command

The “cd” command is to set tx power down 5 dBm

Note: The “Cu” and “cd” commands are to perform course power adjustments in the field and can be used to adjust transmit power while a node is in service. The software will only allow the user to increase the power up to the limit allowed by the regulatory standard in a given market. For the GWS-3000 in the US, this is 20 dBm.

7.24 setagcmode command

The “setagcmode” is to set the Receiver AGC mode. The choices are 0, 1, and 2.

GWS Cmd >setagcmdoe 2



GWS Cmd >

The choices are:

- 0 is fixed mode,
- 1 is maximum attack mode,
- 2 is minimum attack mode.

The standard deployment and default configuration is to use AGC mode 2. For deployments where the node is subjected to very harsh interference, the user can use the “setagc” command to try to improve the throughput on the link. In general, AGCmode2 will provide the best protection from IM3 products which fall in channel. As such, if there are two or more interfering carriers which result in an Intermodulation Product falling in channel, AGC mode 2 will give the best performance.

If however the interference comes primarily from a single carrier which results in Gain Drop and hence a loss of RX sensitivity, the user might get slightly better performance by increasing the attack point of the AGC by using the “setagcmode 1” command, or even turning off the AGC completely using the “setagcmode 0” command.

The receiver of the GWS-3000 has been designed to sustain fairly high levels of interference and for the vast majority of deployments leaving the radio in “agcmode 2” (the default configuration) will provide good results. This information is purely to give our customers some insight and help them optimize network performance in the even that a node is subjected to very strong interference. Another approach to reduce severe interference is to decrease the front end RX attenuator by using the “setrxatten” command. Please see Section 7.26 for more details.

7.25 getagcmode command

The “getagcmode” command will return the current agc mode setting:

```
GWS Cmd >getagcmode
AGC Mode : 2
GWS Cmd >
```

7.26 setrxatten command

The “setrxatten” command is to set the attenuation values for two of the RX attenuators, the syntax is: setrxatten x n; here x means attenuator (0 means front attenuator, 1 means rear attenuator).

To set front attenuator:

```
GWS Cmd >setrxatten 0 10
GWS Cmd >
```

To set rear attenuator:



```
GWS Cmd >setrxatten 1 30  
GWS Cmd >
```

The attenuator values will be set at the factory to provide the best combination of RX Sensitivity and RX Linearity. The first attenuator is located between the LNA and downconverter and is therefore at RF. In general this attenuator will be set to its minimum attenuation “setrxatten 0 0”. The second attenuator is at the IF frequency and is located after the channel select filter. The second attenuator is typically used to trim the gain up or down in the factory to adjust for part to part variation during the fabrication process. The gain of the GWS receiver is carefully set to allow the best combination of RX linearity and sensitivity and is factored into the calculation of RSSI.

In rare cases the user may find it beneficial to adjust the attenuator values. For short links where the radio does not need to receive near its sensitivity, or which are susceptible to strong interference, the user may find the radio performs better if the first attenuator value is increased slightly, since this will reduce the amount of interference incident upon the demodulator.

7.27 getrxatten command

The “getrxatten” command will return current setting for both attenuators:

```
GWS Cmd >getrxatten  
FRxAtten : 10  
RRxAtten : 30  
GWS Cmd >
```

7.28 reboot command

The “reboot” command is to reboot GWS Node
GWS Cmd>reboot

8 Power Control and Link Configuration

For certain jurisdictions such as the USA the FCC has mandated that a TV Band Device must use the minimum amount of power necessary in order to successfully establish/maintain the communication link. In other jurisdictions there may not be a requirement yet, but implementing good power control at the network level is nevertheless recommended to minimize interference between nodes and to optimize the aggregate throughput at the network.

8.1 Manual Power Control

For small networks the user may prefer to perform the power control manually to have a good control over the interference and to balance the load between links.



Below is a description of how to perform power control manually using the GWS-3000 user interface. 6Harmonics is currently developing a SON algorithm which will perform power control at the network level. This algorithm is not yet released but should become available sometime late in 2013 or early 2014.

8.1.1 Point to Point Link

For a point to point link, one BTS connected to a single CPE, we will adjust the power of both the uplink and downlink to have an RSSI (Received Signal Strength) of about -75 dBm at both nodes. To operate at our highest modulations, 64 QAM 5/6 encoding, we require a CINR of about 24 dB. For a 5 MHz modulation bandwidth, $kTb_f = -107$ dBm/5MHz. The noise figure of the radio is 5.0 dB and hence the noise floor of the radio referred to the antenna port is -102 dBm/5MHz. To maintain an SNR of 24 dB, the RSSI must be at -78 dBm/5 MHz carrier. An extra 3 dB is provided as margin and hence the recommended receive signal strength is -75 dBm.

In certain deployments the noise floor of the channel may be higher than thermal noise, due to interference power from nearby transmitters which are co-channel or even adjacent or alternate channel to the link being configured. 6Harmonics has surveyed the noise floor of UHF channels in several US and Canadian cities and some channels are very clean with an integrated noise power near -102 dBm/5MHz but many channels have a noise floor which is 3-6 dB above kTb_f . If the RSSI is at -75 dBm but the MCS is low, not consistently shown as MCS6 or 7, then the power may need to be increased by a few dB until a satisfactory MCS is achieved.

8.1.1.1 Configure the link:

- Telnet into the BTS and CPE.
- From the telnet session type “monitor”
 - The monitor session will show you the RSSI as well as the MCS for both the BTS and CPE.
- Adjust the Uplink TX Power of the CPE.
 - Telnet to the CPE
 - If the RSSI at the BTS is below or above, - 75 dBm, increase or decrease the CPE TX Power by using the following commands:
 - U → Increases power by 0.5 dB (fine adjustment)
 - C → Decreases TX power by 0.5 dB (fine adjustment)
 - Cu → Increases power by 5 dB (course adjustment)
 - Cd → Decreases TX power by 5 dB (course adjustment)
 - Between each adjustment observe the RSSI and MCS value at the BTS RX until the desired value is achieved.
- Adjust the Downlink TX Power of the BTS
 - Telnet to the BTS
 - If the RSSI at the CPE is below or above - 75 dBm, increase or decrease the CPE TX Power by using the following commands:



- U → Increases power by 0.5 dB (fine adjustment)
- C → Decreases TX power by 0.5 dB (fine adjustment)
- Cu → Increases power by 5 dB (course adjustment)
- Cd → Decreases TX power by 5 dB (course adjustment)
- o Between each adjustment observe the RSSI and MCS value at the CPE RX until the desired value is achieved.
- o The following commands can be used to read the transmitter configuration:
 - Gettxstatus : Will show the TX power as well as the value of the TXattenuator. The TX attenuator cannot be accessed using the User Interface but is provided for diagnostic purposes.

\

Note: If the User tries to increase the TX power beyond the maximum power for which the device has been certified, the software will not allow the TX power to be increased beyond the maximum permissible value. Furthermore, for some links it may not be possible to achieve an RSSI of -75 dBm, at which point the link should be set to transmit at the maximum permissible power to get the best RSSI and hence SNR.

8.1.2 Point to Multi-Point Link

The power control for a point to multi-point link can be performed in a similar manner with a few small but important differences. The Uplink power control should be performed first to ensure that signals from the 2 or more CPE's arrives at the BTS at a similar power. This will prevent the creation of a near far issue for the BTS which can severely degrade throughput. For the Downlink power control, the BTS TX power should be decreased until the CPE with the weakest signal has an RSSI of about -75 dBm. If the furthest CPE cannot achieve an RSSI of -75 dBm when the BTS is transmitting at full power, then the BTS should be configured at full power in order to provide a reasonable level of service to the furthest CPE.

It is important to ensure we do not have a very large spread of RSSI's on the uplink, from the multiple CPE's. Acceptable values are from Sensitivity (-100 dBm to about -70 dBm). The presence of a strong signal , > -60 dBm will actuate the RX AGC of the BTS and will degrade the quality of the connection for CPE's which are arriving at low powers near sensitivity. If the Uplink power control is performed properly, the signals from all CPE's should be between -100 dBm and -70 dBm and no near far issue will be present. Ideally, the signal from all CPE's should be received by the BTS at about -75 dBm.

8.1.2.1 Configure the link:

- Telnet into the BTS and each of the CPE's.
- From the telnet session type "monitor"



- o The monitor session will show you the RSSI as well as the MCS for both the BTS and CPE's.
- Adjust the Uplink TX Power for each of the CPE's in sequence.
 - o Telnet to the CPE
 - o If the RSSI at the BTS is above or below – 75 dBm, increase the CPE TX Power by using the following commands:
 - U → Increases power by 0.5 dB (fine adjustment)
 - C → Decreases TX power by 0.5 dB (fine adjustment)
 - Cu → Increases power by 5 dB (course adjustment)
 - Cd → Decreases TX power by 5 dB (course adjustment)
 - o Between each adjustment observe the RSSI and MCS value at the BTS RX until the desired value is achieved.
 - o Repeat for the Next CPE.
- Next, adjust the Downlink TX Power of the BTS
 - o The BTS will transmit at a constant power to all CPE's. As such, the BTS TX Power should be reduced only as much as is allowed to provide an acceptable signal level to the furthest CPE, or CPE with the weakest RSSI. Some CPE's which may be closer to the BTS will receive the downlink signal at a power greater than -75 dBm. This is not an issue. The AGC in the CPE is capable of receiving the downlink signal from near -100 dBm to as high as -15 dBm.
 - o Telnet to the BTS
 - o If the RSSI at the furthest CPE is below or above – 75 dBm, increase or decrease the BTS TX Power by using the following commands:
 - U → Increases power by 0.5 dB (fine adjustment)
 - C → Decreases TX power by 0.5 dB (fine adjustment)
 - Cu → Increases power by 5 dB (course adjustment)
 - Cd → Decreases TX power by 5 dB (course adjustment)
 - o Between each adjustment observe the RSSI and MCS value at the CPE RX until the desired value is achieved.
- Before finalizing the setup, observe the RSSI and MCS for each of the links. The RSSI for the furthest CPE should be at about -75 dBm or lower. Other CPE's should have a higher RSSI. For Uplink signals, all CPE's should be at about -75 dBm, or lower for long links where the CPE is transmitting at full power.

Note: If the User tries to increase the TX power beyond the maximum power for which the device has been certified, the software will not allow the TX power to be increased beyond the maximum permissible value. Furthermore, for some links it may not be possible to achieve an RSSI of -75 dBm, at which point the link should be set to transmit at the maximum permissible power to get the best RSSI and hence SNR.



8.2 Automatic Power Control

6Harmonics is in the process of developing and testing an automatic power control algorithm. This capability will be important for larger deployments and will be introduced later in 2013. The feature is not yet available.

END OF DOCUMENT