# ACRS 2.0 User Manual

# **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.

# Introduction

ACRS 2.0 is the second generation Adaptrum cognitive radio system covering spectrum bands from 400 MHz to 1 GHz. Although capable to operate in other spectrum bands below 1 GHz, Adaptrum ACRS 2.0 is specifically designed to operate in the UHF TV Band (470 MHz – 698 MHz), as TV Band Devices compliant to the rules specified in CFR 47 Part 15 Subpart H. To be rules-compliant, **ACRS 2.0 systems must operate as Fixed TV Band Devices and must be professionally installed**. ACRS 2.0 system specifications are shown in the following table.

General Specifications					
Regulatory Compliance	FCC Part 15 Subpart H				
Technology	TDD OFDMA				
Network topology		Point to	o Multi-Point		
Mobility Support	Nom	adic & Ve	hicular up to 40 m/s		
Frequency Range		400 MH	z – 1000 MHz		
Channel Bandwidth		Flexible	up to 10 MHz		
	Supp	orting 6, 7	, 8 MHz TV channels		
Aggregated Layer 2 Data Rate		1 Mbp	s – 16 Mbps		
(Uplink + Downlink) / 6MHz					
Uplink/Downlink Ratio			Any		
		e.g. 1	.:1, 1:3, 4:1		
Transmit Power	100 mW conducted				
Channel Bandwidth Efficiency	hannel Bandwidth Efficiency 94 percent		percent		
Adjacent Channel Emission	< -55 dBc				
Receiver Sensivity	Level	SNR	Data Throughput		
(6 MHz Channel)	-98 dBm	3.5 dB	2.7 Mbps (QPSK 1/2)		
	-90 dBm	11.5 dB	7.1 Mbps (16 QAM 2/3)		
	-81 dBm	20.5 dB	12 Mbps (64 QAM 3/4)		
Interface Specifications					
Optional external antenna connector	SMA Female				
Data/Control	10/100 Ethernet				
Electrical and M	echanical S	pecificatio	ons		
Supply		43	8 V PoE		
Physical Dimensions	Dimensions 8.5 inches x 7.5 inches x 1.5 inches				
Weight	3.6 LB				

Table 1: Adaptrum ACRS 2.0 system specifications.

ACRS 2.0 radio has a fully enclosed weather-proof aluminum construction as shown in the following pictures. There are status 4 LEDs on the front and an SMA antenna port and an Ethernet port on the back. The unit is powered through Ethernet and there is no separate power connector. The last picture below shows an example pole-mount installation. Both the base and the client stations use the same radio unit.









ACRS 2.0 system must be professionally installed. Please refer to "ACRS 2.0 Professional Installer Manual" for detailed discussion on hardware installation. After installation, the base station and client station system configurations are illustrated in the following figures.









A whitespace communication link is established between the base station and client station allowing the client side networking devices to connect to the Internet. Multiple client units may connect to the same base station. From the IP networking perspective, the base station acts like a layer 2 bridge to the client-side networking devices connected to the client control PC. As shown in the following figure, both the base control PC and the client side broadband router will have IP addresses on the hosting subnet. Multiple client side devices may be visible on the subnet if the broadband router is replaced with a switch.





## **System Operation**

Please refer to "ACRS 2.0 Professional Installer Manual" for detailed discussion on hardware and software installation. Once installed, the main software can be launched on the control PCs through the shortcut in the "Start Menu" folder. The software will be launched in the "User" mode. When running in the "User" mode, the software only has access to limited database functions.

### **GUI Control Interface**



Base station GUI control panel "Link" pane in the "User" mode.

The GUI control panel is shown in the above figure. The GUI panel has a main frame body and 6 panes: Log, Link, System Information, Diagnostics, Database and Installation. Among them, the "Link" and "Database" panes are most useful in terms of monitoring system performance and interacting with TVWS database. The figure above and figure below show the base station "Link" and "Database" panes respectively.

Referring to the "Database" pane below, in the "User" mode, the information entries for device registration and channel list request are disabled. These information are entered during installation and loaded directly from the system registry in the "User" mode. Note further that the channel list request is sent periodically with the period specified in the field "Update Interval" which is 300 seconds by default – there is an additional 30 seconds delay applied to any channel request so the actual channel list request period will be (300 + 30) seconds.

Adaptrum TVBD Control Panel :: Base			
Log Link System Information Diagnostics Database Ins	Istallation		
Registration	Contact	Begistrant	
DEV ID: A2UACRS10	First Name: In Last Name: Sun	First Name: In Last Name: S	in
DEV_SN: U0007	Addr1: 25 E. Trimble Road	Addr1: 25 E. Trimble Road	
DEV_MODE: F	Addr2:	Addi2:	Device
LAT: 41.40809	City: san jose State: CA	City: san jose State: C	registration
LNG: -75.64332	Zip Code: 95131 Country: US	Zip Code: 95131 Country: U	information
Height AGL: 10 meters	Email: lin@adaptrum.com	Email: Iin@adaptrum.com	
	Work Phone: 408-850-0545 Mobile Phone: 408-850	0-0545 Work Phone: 408-850-0545 Mobile Phone: 4	08-850-0545
			Register Device
Channel Request			
Device Information	Other Information:		Database
DEV_ID: A2UACRS10		Database: www.googleapis.com/spectrum/v0 💌	selection
DEV_SN: U0007	Update Interval: 300 seconds		Jerection
DEV_MODE: F	$\wedge$	BASE MAC: FF:FF:FF:FF:FF:FF 16, 17, 19, 20, 21, 26, 27	, 29, 35, 39
LAT: 41.40809		CLIENT MAC ACC1/DE/CC/0363 16,17,19,20,39	
LNG: -75.64332			
Height AGL: 10 meters		Res	et Channel Request
Device & Channel		Start/Stop	atus
C Fixed C PPI C PPII C Test 10 dB	💽 🔲 Full Power Bloadcast 🕅 Auto Chann	el CH 20 (509 MHz) V Start Service Stop Service	Update Status 🔽 Auto Update
ar:f1:df:cr:03:63 Device Channel List	t	21:21:29 04/24/2013	
Expires in 47Hours 59Mins 59Secs		21:21:29 04/24/2013	
✓ ac:f1:df:cc:03:63 Channel List Succes	ssful (5 Channels)	21:21:29 04/24/2013	Alert area
			x I
Channel request	Channel request		
channerrequest	channerrequest		
information	period		

#### Base station GUI control panel "Database" pane.

The base and client control panels are only slightly different. The following two figures show the client station "Link" and "Database" panes. Again, the client software will operate in the "User" mode and the information entries for device registration and channel list request are disabled and loaded directly from system registry. Except the device and location information, the client station "Database" pane doesn't contain other device registration information which is retrieved from the base station side. The client station "Database" pane allows the user to change scan channel list in case the connection to the base station is lost – the scan channel list has been set during installation and loaded from system registry but the user is able to modify it.



#### Client station GUI control "Link" pane.

Adaptrum TVBD Control Panel :: Client		_ 🗆 🗙
Log Link System Information Diagnostics Database	Installation	
Device Configuration		
Device Information	Sana Channel Set 20, 21, 23, 23	
DEV_ID: A2UACRS10		
DEV_SN: U0009		
DEV_MODE: F		
LAT:  41.50809		
-75.64332		
Height AGL: 5 meters	Set Device Info	
Device & Channel	Start/Stop	la data
Fixed C PPI C PPII C Test 0 dB	Auto Channel CH 20 (509 MH2)	Spuale
Channel Search Failed On Channel -	.1	
Channel Search Started On Channel	20	
✓Channel Search Success On Channel	2021:16:00 04/24/2013	Ţ
L		

Client station GUI control "Database" pane.

#### **Base Station Operation**

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The base station operation is discussed in the following.

 When the software launches on the base control PC, it will prompt connection IP address at 169.254.0.9 which is a fixed IP address used to communicate with Adaptrum ACRS 2.0 radio. Click "Connect" button to continue.

AdaptrumTVBD	X
TVBD IP address:	Connect
	Cancel

2) The software will automatically contact the database to retrieve the available channels which are shown after "BASE MAC...". The prompt "Select From Available Channels" requests the user to select a valid channel from the channel list returned from the database. Note further that device registration is not performed in the "User" mode but during installation – see "ACRS 2.0 Professional Installer Manual".

Adaptrum TVBD Control Panel :: Base								_1
g Link System Information Diagnostics Database	Installation							
Registration	-Contact				Begietrant			
DEV. ID: A2UACES20E	First Name:	lin	Last Name:	sun	First Name:	lin	Last Name:	sun
DEV_ID: A2E0JA07	Addr1:	25 E. Trimble Road			Addr1:	25 E. Trimble Road		
DEV_MODE:	Addr2:				Addr2:			
LAT: 41.40809	City:	san jose	State:	CA	City:	san jose	State:	CA
LNG: -75.64332	Zip Code:	95131	Country:	US	Zip Code:	95131	Country:	US
Height AGL: 10 meters	Email:	lin@adaptrum.com			Email:	lin@adaptrum.com		
	Work Phone:	408-850-0545	Mobile Phone	e: 408-850-0545	Work Phone:	408-850-0545	Mobile Phone	408-850-0545
								Register Device
Channel Request         Device Information         DEV_ID:       N2UACRS20F         DEV_SN:       N2EQUAD7         DEV_MODE:       F         LAT:       41.40809         LNG:       -75.64332         Height AGL:       10         meters       Elect From Avaiable D8 Channels								
Device & Channel       Statu Stop       Status         Image: Status Status       Status Status       Status         Image: Status Status Status       Status Status       Status Status         Image: Status Status Status       Status Status       Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status Status       Status Status       Image: Status Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status         Image: Status Status       Status       Status <tr< td=""></tr<>								
					,,			

3) Select a channel from the pull down menu on the prompt and click "Select" to set the base operating channel as shown in the following.

Select From Avaiable DB Cha	nnels	×
CH 20	Select	Cancel

4) After the channel selection, the link pane is shown as following. Click "Start Service" to start transmission on the base station.

Adaptrum TVBD Control Panel :: Base		
og Link System Information Diagnostics Database	Installation	
Device Information DEV_ID: A2UACRS201 DEV_SN: Incompared to the second s	Contact         First Name:         Im         Last Name:         Run           Addr1:         25 E. Timble Road	Registrant           First Name:         In           Addr1:         25 E. Trimble Road
DEV_MODE:	Addr2:	Addr2:
LAT: 41.40809 LNG: -75.64332	Zip Code:         95131         Country:         US	Zp Code: 95131 Country: US
Height AGL: 10 meters	Email:         lin@adaptrum.com           Work Phone:         408-850-0545         Mobile Phone:         408-850-0545	Email:         In@adaptrum.com           Work Phone:         408-850-0545
		Register Device
Device Information           DEV_ID:         A2UACRS20F           DEV_SN:         A2F0JA07           DEV_MODE:         F           LAT:         41.40809           LNG:         -75.64332           Height AGL:         10	Other Information:	Database:       www.googleapis.com/spectrum/v0 x         BASE MAC: FF:FF:FF:FF:FF       16, 17, 19, 20, 21, 26, 27, 29, 35, 39         Client MAC:
Device&Channel ■ Fixed ● PPI ● PPII ● Test □ dB Base Device Channel List Expires in 24Hours 1Mins 11Secs ✔ ff:ff:ff:ff:ff:ff Channel List Succ	Full Power Broadcast M Auto Channel CH 20 (509 M	Stat/Stop         Status           Image: Stat Service         Status           Stat Service         Status           Stat Service         Update Status           Stat Service         Status           Status         Auto Update           Status         Auto Update           Status         Auto Update           Status         Auto Update

5) After the client station successfully connects to the base station, the "Link" pane will show uplink and downlink data rates, modulation schemes, BERs, PERs and signal power estimations as shown in the following figure. Note once connected to the base station, the client station will also send periodical channel list request to the database through the base station.



#### **Client Station Operation**

The client station operation is discussed in the following.

1) When the software first launches on the client station control PC in the "User" mode, the client will automatically scan all channels specified in the scan channel list. Once the client identifies an active base station signal on a scan channel, it will try to connect to the base station on that channel and once the base station verifies that the client can operate on the channel after contacting an authorized TV White Space Database, it will grant the connection session from the client.

Adaptrum TVBD Control Panel :: Client	×
Log Link System Information Diagnostics Databas	Installation
Device Configuration           Device Information           DEV_JD:         A2UACRS10           DEV_SN:         A2F0JA10           DEV_MODE:         F           LAT:         41.50809           LNG:         -75.64332	Scan Channel Set: 20, 21, 22, 23 Update Now
Height AGL: 5 meters	Set Device Info
■ Device & Channel ● Fixed ● PPI ● PPII ● Test 0 dB ★ Channel Search Failed On Channel Channel Search Started On Channel ✓ Channel Search Success On Channel	X       Auto Channel       CH 20 (509 MHz)       Stat/Stop       Status         23

2) Once the client successfully connects to the base station, it will enter the normal operation mode. During normal operation, the client will send channel list request periodically to the base station. When the current base station operating channel is no long in the client channel list, the base station will terminate the connection session with the client. Subsequently, the client will enter scanning mode again and rescan all the channels in the scan channel set.

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