

TVWS Devices User Manual and Installation Guide

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1) FCC Regulatory Information

This device complies with Part 15 of 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 §15.706 TV Band Device Notice

This equipment has been tested and found to comply with the rules for white space 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 40cm 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.

Part §15.105 Information to the user

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. 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. However, there is no guarantee that interference will not occur in a particular installation. 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:

-Reorient or relocate the receiving antenna.

—Increase the separation between the equipment and receiver.

- -Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- -Consult the dealer or an experienced radio/TV technician for help.

Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

Unique Identifier: Meghdoot Base station (FCC ID – 2AUUC-MEGHDOOT) and Dhaval CPE (FCC ID – 2AUUC-DHAVAL)

Responsible Party – U.S. Contact Information

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FCC Compliance Statement

This device complies with Part 15 of 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.

2) Abbreviations

Acronym	Expansion			
ACLR	Adjacent channel leakage ratio			
BS	Base station			
BER	Bit Error Rate			
CPE	Customer Premise Equipment			
EIRP	Effective Isotropic Radio Power			
GI	Guard Interval			
GPS	Global Positioning System			
PoP	Point of presence			
TVWS	TV white space			
WRAN	Wireless Regional Area Network			
WSD	White Space Device			
WSDB	White Space Database Provider			
PAWS	Protocol to Access White-Space Database			
PoE	Power over Ethernet			

3) Glossary

Base Station or Base Unit is the WSD which is configured to bridge the packet flow to a router or point of presence (PoP). Several CPEs or Client Units connect to the Base Unit

Bit Error Rate is the %age of bits which are in error on the radio link. The target BER can be configured based on the current deployment conditions

Customer Premise Equipment or Client Unit is the WSD at the user end and registers with the Base Unit.

Effective isotropic radiated power is the radio power in dBm measured at the output of antenna. It is equal to the total conducted power + the antenna gains in dBi

TV White spaces are the unoccupied bands between TV channels which are used for broadband service

Wireless Regional Area Network is a wireless broadband specification defined by IEEE802.11a specifications

White Space Device is a wireless communication device that works in TVWS

White Space Database is the database of usage of TVWS in a given region

4) TVWS Meghdoot (Base Station) and Dhaval (Customer Premise Equipment) radio

Saankhya TVWS devices are <u>fixed</u> cognitive radio devices operating in TVWS bands ranging from 470-608 MHz. The devices can be configured as either Base radio or Client radio and are compliant with rules specified in CFR 47 Part 15 subpart H of FCC regulations. When acting as a Base radio, device acts as a master and Client radios act as slave. All the communication with external network (including with WSDB) is handled through the Base radio

Performance					
Maximum data rate	26Mbps/8MHz, 16M	bps/6MHz	Air interface data rates, can be multiples of these with channel bonding		
User throughput	25Mbps/8MHz, 14M	bps/6MHz	UDP, measured be multiples of channel bondin	with iperf3, can these with g	
Spectral efficiency	3.4b/s/Hz				
Link Latency	35ms typical				
Radio Characteristics					
Operating Frequencies	470 to 608 MHz		Center frequent per TV bands	cies aligned as	
Channel Bandwidths	6, 7, 8MHz				
Modulations supported	QPSK, QAM16, QAM rates up to 5/6	64 with code			
Maximum EIRP	Meghdoot: 31.5 dBm	ו	With 6dBi antenna gain		
	Dhaval: 34.5 dBm		With 9dBi antenna gain		
Maximum conducted power	25.5 dBm		Including all tolerances		
ACLR (adjacent channel leakage ratio)	-55 dB				
Duplexing	TDD		Allows configur	able UL-DL split	
Receiver Sensitivity	Modulation	SNR (dB)	Sensitivity	Data rate	
	QPSK 1/2	4	-94.0 dBm	5 Mbps	
	QPSK 3/4	9.8	-90.2 dBm	8 Mbps	
	QAM 16 3/4	14.6	-84.4 dBm	16 Mbps	
	QAM 64 3/4	21	-78.8 dBm	24 Mbps	
	QAM 64 5/6	21.7	-76.8 dBm	28 Mbps	
Power					
Power supply	48V DC, 110V-230V A	A/C	DC Using PoE injector and adaptor		
			Solar power option available		
Power Consumption	25W typical		With 60:40 TDD split		
External Interfaces					
Antenna interface	N-type (male)		Impedance 50ohm		

GPS Antenna	N-type (male)	
Data	10/100Mbps Ethernet (RJ45)	
Recommended Antenna		
BS Antenna Omni antenna with 6dBi gain w vertical polarization		Antenna mounted with clamps provided with package
CPE Antenna	Yagi Antenna with 9dBi gain with vertical polarization	
GPS Antenna	Right hand circular polarized with 50-ohm impedance	
Mechanical specifications		
Dimensions (LxBxW)	481mm x 127.5mmx 111.5mm	
Weight	2.5 kg	
Water resistance	IP65 compliant	
Operating temperatures	-10° to 50° Celsius	
Regulatory Approvals		
FCC		Meets FCC specifications for RF mask as per FCC part 15 sub- part H

5) TVWS Debug Application

Saankhya[™] TVWS Application is used to configure and monitor the TVWS devices. The tools are provided both for 64-bit Windows 10 and Ubuntu Linux platforms. Follow the steps indicated in Figure 1 to install the TVWS Application.



Figure 1 TVWS GUI Application Installation

On Successful installation a shortcut icon will be created on Desktop and configuration files will be copied under c:\Users\<profile name>\.saankhya\.atconfig. Follow the steps indicated in Figure 2 to start the TVWS GUI Application.

a a a a a a a a a a a a a a a a a a a				MainWindow	-	×
TvwsApplicat						
ion	5	Open Select Left File for Compare		Saankhva Labs S)	
	0	Scan with ESET Internet Security Advanced options	>			
		Open file location		Username:		
	R	TortoiseSVN	>	Password:		
	V	Run as administrator		Login		
				Copyright (c) Saankhya Labs Private Ltd, No 3 Infantry Road, Bangalore	KA 560001	



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6) BS Installation

Meghdoot BS should be installed by an authorized professional only. Installation and operation of the devices by persons other than the professional installers might cause permanent damage to the device and malfunction.

Saankhya TVWS devices have 3 ports – 2 for antenna and 1 for PoE as shown in Figure 4. These devices are mounted on a pole with the help of clamps and screws provided with standard shipment. The antenna are connected to the N-type connectors for the purpose on the top section of the devices. The RJ45 PoE port on the device is connected to PoE injector (Figure 3) using Ethernet cable.



Figure 3 PoE Injector and connections

The Ethernet cable on the PoE injector which forks from the power connector should be connected to backhaul – either a switch or a router depending on the operator topology.



Figure 4 Saankhya TVWS Device

Notes:

- 1) The devices should be mounted vertically with the PoE port facing earth in order to reduce wind resistance
- 2) Clamps should be secured firmly in order to avoid any injury or damage resulting from the box slipping down the pole

7) BS Configuration

Make sure that all the connections are done as described in Section 6) Launch the TVWS GUI Application by double clicking on the application icon. Follow the steps as described below to configure the base station

7.1 Configure a WSDB provider

Note:

3) This step is optional and required only if TVWS databases need to be accessed. Otherwise go directly to Section 7.3 (at locations where WSDB services are not mandated by law)

Database services might be required as per the regulations of the country where TVWS device is being operated. One needs to configure the URL and the API-key provided by the service provider before accessing the database

If you operate in a region where database services are not mandatory, this step can be skipped. Please ensure that in such a case DB query option is disabled on TVWS. On launching the gui_app_v3.exe application for the first time, the user should go through steps shown in Figure 5 to logon to the application with both user name and password as *admin*¹

No provider	Saankhya TVWS A	pplication		5	_	_	×
No WSDB provider is provisioned. Please Add a provider and restart App.	Devices Providers	View Mode Configuration	Help				
A	- Aller	IP Address	MAC Address	Location	Band (MHz)	Frame count	Software Version
ОК	S	255.255.255.255	00:00:00:00:00:00				
(A)							
	De	evice Config	Register	ed BS		Historical Chart	
•	TVWS DB Query	Enabled •		 BER On 	• +	Clear Graph	• -
₹	Location Input	Manual					
•	Latitude	0	RSSI (dBm) ESNR(d	8) TxPwr(dBm)			
MainWindow	Longitude	0	SNR Max T	A Temp(C)			
	Channels	479 🗘 To 695 🗘 MHz					
	Antenna Ht.(AGL)	1.00	UL Mode Code	Burst Size			
	Device Mode	Operational	DL Mode Code	Burst Size			
	Network Mode	Router	FreqOffset UL Mb;	s DL Mops			
Saankhya Labs D	IP Address Mode	DHCP •					
	IP AddressMask		HCS Brors ORC Br	ors Pkt Err(%)			
	Default Gateway		BER Status Value	Block Size			
Username: admin	Bandwidth	6MH2 *	Var Noise	SDRAM Capture			
Password:	Duplex Mode	(TDD) •					
raswora.	Security Mode	Security Off	2019:02:08-12:19:02 No WSD8 pr	ovider is provisioned. Please Add a provider a	nd restart App.		
Login	Security Key						
Copyright (c) Saankhya Labs Private Ltd, No 3 Infantry Road, Bangalore KA 560001		Apply					

Figure 5 TVWS GUI Log on and Opening Screen

From here, add the service provider details (URL and the API-key) as shown in Figure 6 and restart the application as requested below. These parameters are used to make HTTPS/POST requests to the service provider. The security of the connection to the PAWS server is guaranteed by use of HTTPS

¹ The username and password cannot be changed in this version (v1.0.10-fcc) of application

Saankhya TVWS Application	Add a New WSDB Provider
Devices Providers View Mode Configuration Help Add IP Address Ma Delete 255.255.255.255 00:00:1 Image: Configuration Device Config Image: Configuration Configuration (A) (A) (A) (A) (A)	Revider URL API Token Add (B)
Please Restart the application OK (D)	Add a New WSDB Provider X3 Name Nominet Technologies Provider URL https://sandbox-paws.wsdb.uk API Token u-acfd4431-ed9f-40b8-8275-ab0cbe5ebff4 Add
	(C)

Figure 6 Adding WSDB provider

7.2 Provision the BS and CPE devices

To use any device (BS or CPE) it should first be provisioned into the system. There are several parameters which need to be specified. Incorrect provisioning will result in the WSDB rejecting the requests and failure to operate the device. Please consult your data base provider for the details required and their respective ranges²

Illustrative values for Nominate WSDB services provider are shown in Figure 7

² Master MAC-ID is not required while provisioning the base station

Saankhya TVWS Ap	pplication		Dialog		9 X
Devices Providers Provision	View Mode Configuration H	i a construction of the second s		Provision New Device	
Discover	255,255,255,255	00:00	MAC Address	70:83:D5:CA:30:40	
Ungrade			Device Type	master	-
Reboot			Master MAC		
Disconnect	vice Config		Serial Number	SL80001	
TWIS DB Query	Enabled *		Manufacturer	Seankhya Labs	
Location Input	Manual		Model	Dhaval3p1	
			Ruleset	FccTvBandWhiteSpace-2010	•
		64	FCC ID	TEST-PCC-ID	
Saackburg TVAVS A	Application		FCC Device Type	Fixed	•
Devices Providers	View Mode Configuration		Owner Name	Mutturaj K	
Derices Thomasis	then more configuration			Is Organization	
	IP Address	MAC Address Location Band (PHz) Frame count Software Version	Owner Address 1	Infantry road	
S	255.255.255.255		Owner Address 2	Pasadena	
			Owner Address State	ca	
De	evice Config	Registered BS Historical Chart	Owner Address Zipcode	90100	
TVWS DB QUERY	Probled *	There can be a first the second secon	Owner Address Country	usa	
			Owner Telephone	tel:+1-404-384-3333	
Location Input	Manual		Owner Email	mutturaj.karalatti@seankhyalabs.com	
Latitude	0	RSSI (dBm) ESNR(dB) TxPwr(dBm)	Operator Name	Harsha MK	
Longitude	0	SNR Max TA Temp(C)	Operator Address 1	Infentry road	
Channels	479 🗘 To 695 🗘 MHz		Operator Address 2	Pasadena	
Antenna Ht. (AGL)	1.00	UL Mode Code Burst Size	Operator Address State	ca	
		Di Mode Code Burst Stre	Operator Address Zipcode	90100	
Device Mode	Operational		Operator Address Country	usa	
Network Mode	Router	Precoffset UL Mops DL Mops	Operator Telephone	tel:+1-404-384-3334	
IP Address Mode	DHCP •		Operator Email	[harsha@saankhyalabs.com]	
IP AddressMask		HCS Errors CRC Errors Pitt Err(%)		Add	ancel
Default Gateway		BER Status Value Block See			
Bandwidth	64Hz *	Var Noise SDRAM Capture			
Duplex Mode	TD0 •				
Security Mode	Security Off	2019t02:08-13:28:51 Device with MAC Address 70:83:05:CA:30:40 provisioned successfully.			
Security Key					
	Αρρίγ				

Figure 7 Provisioning Base station with TVWS GUI

On successful provisioning, a message is displayed in the log window at the bottom. Also ensure that the DB query parameter as shown in above figure is set to enabled.

7.3 Discover BS devices

After provisioning, we need to connect to the device and apply configuration and start the radios. The devices can be discovered if they are on the same IPv4 subnet as that of the PC running the TVWS Application. Follow the steps in Figure 8 to discover the devices. Once discovered, select the device based on the MAC address



Figure 8 Discovering TVWS devices

On successful connection to the device, the following screen appears please note the 3 important points marked on the screenshot

Saankhya TVWS A	Application (INSTALLATION) (ADM	MIN)					X
Devices Providers	View Mode Configuration	Help					
	IP Address	MAC Address		Location	Band (MHz)	Frame count	Software Version
∦ вэ	172.16.240.129	70:B3:D5:CA:30):40 0.0	0000:0.0000	0	0	REL_5_0_RC7-build-82
De	evice Config	Regist	ered CPEs			Historical Chart	
TVWS DB Query	Enabled 🔻			BER On	RSSI	- Clear Graph	▼ _
Location Input	Manual						
Latitude	0.0000	RSSI (dBm) E	SNR(dB)	TxPwr(dBm)			
Longitude	0.0000	SNR	Max TA	Temp(C)			
Channels	479 🗘 To 695 🗘 MHz						
Antenna Ht. (AGL)	1.00	UL Mode	Code	Burst Size			
Device Mode	Installation 💌	(2)L Mode	Code	Burst Size			
Network Mode	Bridge 💌	FreqOffset	II Mhos	DI Mhos			
IP Address Mode	DHCP 💌						
IP AddressMask	192.168.88.100/24	HCS Errors CF	RC Errors	Pkt Err(%)			
Default Gateway	192.168.88.1	BER Status	Value	Block Size			
Bandwidth	6MHz 💌	Var Noise		SDRAM Capture			
Duplex Mode	TDD 💌						
Security Mode	Authentication 🔻	2019:02:08-16:20:49 Conne 2019:02:08-16:20:53 Conne	cting to Device 17	2.16.240.129			
Security Key	•••••	2019:02:08-16:20:53 Device	Mac Mode is: atconfi	g (3)			
	Apply						
Device Mac Mode is:	atconfig						.41

Figure 9 TVWS BS Opening Screen

Notes:

- 8) All devices are shipped in 'Installation' mode. In this mode, the device radios are not turned on unless user applies a valid configuration
- 9) On successful application of configuration, device moves to 'Operational' mode. No parameter change is allowed in this state

7.4 Configure the BS device

Before we load the configuration files, please check that the selected source of location information shows GPS on the GUI. Please ensure that the GPS is latched on by checking the appropriate LED at the bottom of device. Use of GPS for geolocation is mandatory on devices certified under FCC.

The above steps are to be performed by a professional installer conversant with the operations of the device.

🔝 Saankhya TVWS A	pplication - (INSTALLATION) - (ADN
Devices Providers	View Mode Configuration
BS	IP Address
ABS	172.16.240.129
De	evice Config
TVWS DB Query	Enabled 👻
Location Input	Manual
Latitude	Manual GPS
Longitude	0.0000
Channels	479 🗭 To 695 🌩 MHz
Antenna Ht. (AGL)	1.00

Figure 10 Location Data source selection

Configuration files are provided for devices with following naming convention:

<Duplex Mode>_<Device Type>_<Description>_<GI length>_<Bandwidth>_<Device Model>_<Antenna Gain>.ini where

Duplex Mode: TDD or FDD

Device Type: BS or CPE

GI length is the length of cyclic prefix in terms of symbol size (1by32, 1by16, 1by8, 1by4)

Bandwidth: 6MHz or 8MHz

Device Model: Dhaval2p1 or Dhaval3p1

Antenna Gain: (0 dBi, 6 dBi, 9 dBi)

For use with 6MHz channel, the suggested profile is TDD_BS_TPC-DSM-SCU_1by4_6MHz.ini whereas for 8MHz channel it is TDD_BS_TPC-DSM-SCU_1by16_8MHz.ini. These files are available in "C:\Users\profile>\.saankhya\.atconfig". Refer to Figure 11 for list of configuration files. At this stage the configuration is loaded into the TVWS internal database but not applied to the device. Follow the steps indicated in Figure 12.

▶ Computer ▶ E6430-W7p6408032018 (C:) ▶ Users ▶ Saankhya76 ▶ .saankhya ▶ .atconfig
✓ Include in library ✓ Share with ✓ Burn New folder
Name
TDD_CPE1_TPC_DSM_SCU_1by16_8Mhz_Dhaval3p1_AG_9dbi.ini
TDD_CPE1_TPC_DSM_SCU_1by16_8Mhz_Dhaval3p1_AG_0dbi.ini
TDD_CPE1_TPC_DSM_SCU_1by16_8Mhz_Dhaval2p1_AG_9dbi.ini
TDD_CPE1_TPC_DSM_SCU_1by16_8Mhz_Dhaval2p1_AG_0dbi.ini
TDD_CPE1_TPC_DSM_SCU_1by4_6Mhz_Dhaval3p1_AG_9dbi.ini
TDD_CPE1_TPC_DSM_SCU_1by4_6Mhz_Dhaval3p1_AG_0dbi.ini
TDD_CPE1_IPC_DSM_SCU_1by4_6Mhz_Dhaval2p1_AG_9dbi.ini
TDD_CPEI_IPC_DSM_SCU_IDy4_6Minz_Dnavaizp1_AG_0dbi.ini
TDD BS WO RNG 1by16 8Mhz.ini
TDD_BS_TPC_DSM_SCU_1by16_8Mhz_Dhaval3p1_AG_6dbi.ini
TDD_BS_TPC_DSM_SCU_1by16_8Mhz_Dhaval3p1_AG_0dbi.ini
TDD_BS_TPC_DSM_SCU_1by16_8Mhz_Dhaval2p1_AG_6dbi.ini
TDD_BS_TPC_DSM_SCU_1by16_8Mhz_Dhaval2p1_AG_0dbi.ini
TDD_BS_TPC_DSM_SCU_1by4_6Mhz_Dhaval3p1_AG_6dbi.ini
TDD_BS_TPC_DSM_SCU_1by4_6Mhz_Dhaval3p1_AG_0dbi.ini
TDD_BS_TPC_DSM_SCU_1by4_6Mhz_Dhaval2p1_AG_6dbi.ini
TDD_BS_TPC_DSM_SCU_1by4_6Mhz_Dhaval2p1_AG_0dbi.ini
ECC BS TPC DSM_SCU_1by16_8Mhz_AG_0dbi.ini
ECC BS TPC DSM SCU 1by4 6Mbz AG 0dbi ini
FCC BS TPC DSM SCU 1by4 6Mhz AG 6dbi.ini
ChangeBandwidth.ini

Figure 11: List of available configuration files

Before applying the configuration to the device (using the 'Apply' button as shown in Figure 9) please double check the following:

- TVWSDB Query is set to Enabled
- The location co-ordinates are correct or if using GPS, it is in locked state (using the LED status)
- The Antenna Height above ground level (AGL)
- The range of channels is set appropriately. The start and the stop bands increment in multiples of the selected bandwidth
- The bandwidth is selected correctly

It takes a while (about 60 seconds) for the configuration to be applied and a message is displayed at the bottom of the TVWS GUI application.

Saankhya TVWS Applicat	tion - (INSTALLATION) - (ADM	(IN) Help		Radio Parameters			andre ber Diej	8
BS	IP Ac Import Save to File	AC Address	_				Browse Import Export (1)	oad From Device Done
	Арріу АТ Со	mmanu	\Box	MAC Params				
Devideo	C	Destates		EIRP Data	МА	C Scheduler Enabled	WDT Timeout	
Device	Config	Register		Target BER	SN	R Margin	TPC Enabled	
	(A)			WDT Enabled	AR	Q Support ID	Uplink Frequency	
				Downlink Frequency	Ra	nging DSM Enabled	Resync Dump Status	
				Resync Status Flag	Mo	dulation Ceiling	Resync File Dump	
				Ranging Enabled				
			(B)	Phy Params				
				Demod Support ID	BSRSS	Data	OFDM Symobis/SuperFrame (D	S)
				Cydic Prefix DS	Chann	el Bandwidth (DS)	Initial Ranging CDMA Codes	
				Cyclic Prefix (US)	Chanr	nel Bandwidth (US)	Start of CDMA Code Groups	
				Downlink Gap Filler	Timer	ISR Enabled	Timer ISR Timeout(sec)	
				OFDM Symbols/Frame (DS)	Requi	red SNR	Calibration K1 Default	
				Calibration PTH Default	Calbr	ation CAL1 Default	Calibration CAL2 Default	
				Default UL Modulation	Defau	lt UL Coderate	Default UL Burstsize	
				Default DL Modulation	Defau	It DL Coderate	Default DL Burstsize	
				OEDM Symphis/Frame (US)	TTG V	alue in Samples	PTG Value	
				¢				
				Г				
R-J:- D		(C)		Ł	ን	9 x		
Radio Parameters		(C)		}	ን 	8		
Radio Parameters D:/FCC/REL_ <u>5_0_</u> RC7-Dh	aval3p0-6M+z/At/TDD_BS_TPC_6	(C) DSM_SCU_1by4_6Mtx.ini	Brown	e Inport Export	Load From Device	Done		
Radio Parameters D:/FCC/REL_ <u>5_0_</u> RC7-Dh MAC Params	sval3p0-6Mtz/At/TDD_BS_TPC_C	(C) DSM_SCU_1by4_64hs.ini	Brows	e port Export	Lead From Device	Oone (3)		
Radio Parameters D:/FCC/REL_5_0_RC7-Dh MAC Params EIRP Data	wval3p0-644tr/AU/TD0_BS_TPC_J 170	(C) DSM_SCU_1by4_64hz.ini MAC Scheduler Enabled	Brows	e mport Export (2) W0T Timeout	Load from Device	Done (3)		
ladio Parameters D:/PCC/REL_S_0_RC7-0h MAC Params IRP Data arget BER	avalgo 494tr/At/TDD_BS_TPC_J 170 6144	(C) DSM_SCU_Iby4_6Htrz.H MAC Scheduler Enabled SR Margin	Brows d 2 0	re Inport Export (2) W0T Timeout TPC Enabled	Load From Device	2 X Done (3)	(0)	
ladio Parameters D:/FCC/REL_5_0_RC7-0h MAC Params IRP Data arget EER INT Enabled	avalsp-6M4t/AU/TDD_B5_TPC_f 170 6144 1	(C) DSM_SCU_Iby4_6Htruin MAC Scheduler Enabled SR Margin ARQ Support ID	Brows 0 0	e Inport Export (2) W07 Timeout TPC Exabled UpHr Frequency	50 1 491	2 X	(0)	
ladio Parameters ://FCC/REL_5_0_RC7-0h MAC Params IRP Data arget BER. 1007 Enabled downlink Frequency	avvalspo-6446/AU/TOD_BS_TPC_J 170 1844 1 91	(C) DBM_SCU_Iby4_6Hrb.in MAC Scheduler Enabled SRR Margin APQ Support ID Raming DSM Enabled	Brows 0 0	e mport Export (2) WOT Timeout TFC Existend Upint Frequency Reyne Chang Status	50 1 491 0	Done (3)	(D)	
adio Parameters ;;FCC/REL_5_0_RC7-0h IAC Params IRP Data arget EER IOT Enabled ownink Frequency spin: Status Flag	wwalipo-644+r/AV/TDO_BS_TPC_f 170 6144 1 491 0	(C) DSM_SCU_tby4_6Htutin MAC Scheduler Enabled SRR Margin ARQ Support ID Ranging DSM Enabled Modulation Calling	1 2 0 0 0 1 1	e Inport Export () W0T Timeout TPC Exabled Usin Frequency Resync Duro Statu Resync Plano Statu	Load From Device	2 2 2 Done (3)	(D)	
kadio Parameters Dr./FCC/REL_5_0_RC7-Dh MAC Params IRP Data arget BER. VOT Enabled VOT Enabled Anonink Frequency tesmo: Status Flag tanging Enabled	avviligio 6444/AU/TOD_BS_TPC_[170 6144 1 491 0 1	(C) DBM_SCU_Iby4_6Htv:in MAC Scheduler Enabled SRR Margin ARQ Support ID Raming DBM Enabled Modulation Celling	8 2 0 0 1	e moot Export () WOT Timeout The Freeder Reyne Pile Dump	50 1 491 0 0	2 X	(D) T Done Parama changes captur (d)	red for device.
Nadio Parameters	avalipo 4944/AUTDO_BS_TPC_E 170 6144 1 491 0 1	C) DSM_SCU_Iby4_8/Hrb.in MAC Scheduler Enabled SRR Margin ARQ Support ID Ranging DSM Enabled Modulation Celling	2 Drove	e moot Export (2) WOT Treewark VOT Treewark Resync Dung Statu Resync Pile Dung	Lead From Device	2 Z	(D) The Done Params changes captur (4)	red for device.
adio Parameters #ACC/REL_5_0_RC7-0h #AC Params ERP Data arget BER. #OT Enabled anging Enabled anging Enabled Phy Params emod Support ID	avvalspo-64945/AL/TOD_BS_TPC_J 170 5144 1 91 0 1 0 0	C) DRL_SCU_Iby4_6Htu2H MAC Scheduler Enabled SRR Margin ARQ Support ID Ramping DRI Enabled Modulation Caling	8	e Export () VOT Timeout TC Exhelled Upin Krean Stat Resync File Dunp	50 1 491 0 0 (25) 15	2 X	(D) The Done Params changes capture (a)	red for device.
adio Parameters precorded a second s	avva3p0-4944z/A1/TDD_BS_TPC_J 170 6144 1 901 0 1	C3	Brown 0 0 1 8 6	vot Timeout (0) Vot Timeout Upike Frequency Respire Diano Satur Respire Diano Satur Re	50 1 491 00 0 (CS) 15 5 4	2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	(0) The Done Params changes capture (1) (1)	red for dexice.
Ladio Parameters processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes processes proce	aval3p0-6M4+t/A1/TD0_B5_TRC_B 170 6144 1 491 0 1 0 0	C) DSM_SCU_Iby4_6Mtx.in MAC Scheduler Enabled SR4 Margin ARQ Support ID Ranging DSM Enabled Ranging DSM Enabled BRSSS Data Channel Bandwidth (DS) Channel Bandwidth (DS)	Brown 2 0 0 1 8 6	e most Export (7) WOT Treeout USPIK Frequency Resync Duro Statu Resync Pike Duro OPDM Symobio Super-Fram Instal Ranging CDMA Code State of CDM Code Coop	Content of the second from Device Conten	2 X	(0) I Done Params changes captur (4)	red for device.
Addio Parameters Dr./FCC/REL_5_0_RC7-Dh MAC Params IRP Data arget BER VDT Enabled VDT Enabled Phy Params hemod Support ID yde hrefix DS Syde hrefix US) sourisk fag Her	avvilapo 64447/AU/TOD_BS_TPC_[170 5144 1 491 0 1 0 0 0 0 0	C) DRM_SCU_Iby4_6MtrLin MAC Scheduler Enabled SRR Margin ARQ Support ID Ramging DBM Enabled Modulation Celling BRSSS Data Oriennel Bandwidth (US) Oriennel Bandwidth (US) Timer IDR Enabled	Bread	e Export () WOT Timeout TTC bailed Upink Frequencian Status Resync Plin Dump Resync Plin Dump Initial Ranging CDMA Code Group Time USR Timeos(Sed Group Time Sed Gr	Load From Device 50 1	9 X	(D) T Done Params changes captur (a)	red for device.
Adio Parameters D:,FCC,REL_5_0,RC7-Dh MAC Params IRP Data arget BER UDT Enabled NDT Enabled Invinitik Frequency tesync Status Flag Langing Enabled Phy Params Vide Prefx US Vide Prefx US Vide Prefx US Vide Prefx VS	avva3p0-694tr/AL/TDD_BS_TPC_J 170 6.144 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1	C3	Brees 0 0 1 8 6 1 6 6 6	e mort Export () VOT Timeout TPC Enabled Uptik Frequency Resync File Dunp OPEM Symobio (SuperFram Instal Ranging CDMA Code Start of CDMA Code Group Time TSR Timeout(sec) Collection (La fecture	S0 1 491 0 0 0 *(DS) 15 a 4 4 5 0 0	Dore (3)	(0) The Done Params changes capture (1) (1)	red for device.
Adio Parameters Du/FCC/REL_5_0_RC7-0h MAC Params URP Data arget BER. UDT Enabled bownink Frequency teeryn: Status Plag tanging Enabled Phy Params hemd Support ID Systic Frefix (US) bownink (Sap Filer SPCM Symbols/Trame (DS) alloration PIP Default	avviltp0-6M4+t/At/TD0_B5_TPC_f 170 6144 1 	C) DSM_SCU_IByA_6Mto.in MAC Scheduler Envioled SRR Margin ARQ Support ID Ranging DSM Enabled BRSSS Data Channel Bandwidth (DS) Channel Bandwidth (DS) Timer SIR Enabled Required SIR Collarbeits (A) Lieffakt	Brews 2 0 0 0 1 8 6 6 1 64 660000	e ment Expert (7) WOT Treext USPIK Frequency Resync Duro Statu Resync Pile Surger OPM SyndbigSuperFram Instal Ranging CDMA Code State of CDMA Code	Content of the second from Device Conten		(D) T Done Params changes captur (a)	red for device.
Addio Parameters DU/FCC/REL_5_0_RC7-Dh MAC Params IRP Data arget ERR. VOT Enabled OT Enabled DT Enabled DT Params bernd Support ID yde Prefix DS yde Prefix DS yde Prefix DS DYde Prefix D	avvilap-04944/AU/TOD_BS_TPC_E	C) DRM_SCU_Iby4_6MtrLini DRM_SCU_Iby4_6MtrLini ARC Scheduler Enabled SRR Margin ARC Scheduler Enabled Ranging DSM Enabled Modulation Celling BSRSS Data Channel Bandwidth (US) Channel Bandwidth (US) Channel Bandwidth (US) Channel Bandwidth (US) Channel Bandwidth (US) Channel Bandwidth (US) Channel Bandwidth (US)	Brews 2 0 0 1 1 8 6 1 1 4 6 6 1 1 1 1 1 1 1 1 1 1 1 1 1	e most Export () WOT Timeout TI°C braked Upbik frequency Resync Duno Statu OPDM Symbols/SuperFram Intik Ranging CDMA Code Statist OCMA Code Group Time Stat Timeos(leg) Calaration CL42 Default Calaration CA12 Default	S0 1 1	2 2 1	(D) T Done Params changes captur (a)	red for device.
Radio Parameters Dr./FCC.REL_5_0_RC7-0h MAC Params ERP Data Target BER WDT Enabled WDT Enabled WDT Enabled Phy Params Demod Support ID Cycle Prefix US Downlink Frequency Cycle Prefix US Downlink Cap Filer PDM Symboling/Frame (DS Cycle Prefix US) Cabration PTH Default Default UM Modulation	avvalapo-64945/AL/TDD_BS_TPC_U 170 170 19 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	CG DBM_SCU_Iby4_6Htv.in DBM_SC	Brews 2 0 0 1 1 8 6 1 64 64 1 1 1	e Import Export () VOT Timeout TPC Ensible Upink Frequency Resync File Dunp OFDM Symobio/SuperFram Instal Ranging CDMA Code Start of CDMA Code Group Timer JSR Timeout(sed) Calibration CL4 Zoefault Default U. Burstation Default U. Burstation	S0 1 491 0 0 0 x 4 S 5 x 4 S 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0 x 0		(0) The Done Params changes capture (1) (1)	red for device.
Radio Parameters Dr./FCC/REL_S_0_RC7-0h MAC Params ERP Data Target BER NOT Enabled Downlink Frequency Resyn: Status Flag Ranging Enabled Phy Params Demod Support ID Cycle Prefix (US) Downlink Gap Filer OPCM Synoble/Trane (US) Default UL Modulation Default UL Modulation Default UL Modulation Default UL Modulation	avvilapo 644 tr/At/TDD_BS_TRC_f 170 6144 1 491 0 1 0 0 1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	C) DSM_SCU_IBY4_6Mto.in MAC Scheduler Envioled SR Margin ARQ Support ID Ranging DSM Enabled Modulation Celling BSSSS Data Churnel Bandwidth (10) Churnel Bandwidth (10) Timer IJR Enabled Reguled SIR Collerions Collerions Sandwidth (20) Timer IJR Enabled Reguled SIR Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled Collerions Enabled	Brever 2 0 0 1 1 6 6 6 1 1 1 1 1 1 1 1 1 1 1 1 1	e ment Expert () WOT Treext TPC Enabled Upfik Frequency Reync Duro Statu Reync Pile Surger OFM Syndbil/Super Fram Instal Ranging CMA Code Stati of CMA Code	Control Device		(0) T Done Params changes captur (a)	red for device.

Figure 12 Loading Configuration from INI files

Once the configuration is applied, the TVWS Application queries the WSDB for available spectrum and the same is presented to user for selection as shown in Figure 13.

evices Providers	View Mode Configuration	Help					
M DC	IP Address	MAC Address		Location	Band (MHz)	Frame count	Software Version
¥ 82	172.16.240.129	70:B3:D5:CA:	30:40 4	1.2120:-75.2420	491	0	REL_5_0_RC8-build-151
De	evice Config	R	Select Frequence	2	×	Historical Cha	rt
TVWS DB Query	Enabled 💌		Joneen	.,	ISSI	Clear Graph	-
Location Input	Manual		Freque	ency Max EIRP			
Latitude	41.2120	RSSI (dBm)	10 55100000	.0 40.0			
Longitude	-75.2420	SND	11 557000000	.0 40.0			
Channels	479 🐳 To 695 🖨 MHz	SHIC	12 56300000	.0 40.0			
Antenna Ht. (AGL)	1.00	UL Mode	13 569000000	.0 40.0			
Device Mode		DL Mode	14 575000000	.0 40.0			
Network Mode	Bridge V		15 581000000	.0 40.0			
TP. Address Mode		FreqOffset	16 597000000	0 400			
ID AddressMack	102 169 99 100/24	HCS Errors		Select			
Defeult Cetenner	192.108.00.100/24		Walter	alution.			
Derduit Gateway	192.100.00.1	BER Status	value	Block Size			
DariuWidth		Var Noise		SDRAM Capture			
Duplex Mode	(IIU) •						
Security Mode	Authentication 🔹	2019:02:20-17:48:17 Co 2019:02:20-17:48:29 Co 2019:02:20-17:48:29 Co	onnecting to Device onnecting to Device	172.16.240.129 172.16.240.129			
Security Key	•••••	2019:02:20-17:48:33 Co 2019:02:20-17:48:33 De 2019:02:20-17:49:24 Ap	vice Mac Mode is: a plying Device Conf	atconfig figuration. Please Wait			
	Apply	2019:02:20-17:49:38 W	SDB_APP: process SDB_APP: MESSAGE	E_TYPE_SPECTRUM_REQ for 70:8	3:D5:CA:30:40 master 70:B3:D5	5:CA:30:40	

Figure 13 Frequency Selection for Base Station

After selection of suitable frequency, the radios are turned on which can be seen from the items marked in figure below

💵 Saankhya TVWS A	pplication-v0.8.1 (MAC_STARTED)	- (ADMIN)						
Devices Providers	View Mode Configuration	Help						
DC	IP Address	MAC Addr	ess	Location		Band (MHz)	Frame count	Software Version
¥ 83	172.16.240.129	70:B3:D5:C	A:30:40	41.2120:-75.2	420	551	4225	REL_5_0_RC8-build-151
De	vice Config	R	egistered CP	Es			Historical Chart	
TVWS DB Query	Enabled 💌			•	BER	RSSI	+ Clear Graph	· - ·
Location Input	Manual							
Latitude	41.2120	RSSI (dBm)	ESNR(dB)	TxPwr(dBm)	27.0			
Longitude	-75.2420	SNR	Max TA	Temp(C)	52			
Channels	479 📩 To 695 📩 MHz							
Antenna Ht. (AGL)	1.00	UL Mode	Code	Burst Size				
Device Mode	Operational	DL Mode	Code	Burst Size				
Network Mode	Bridge	FreqOffset	UL Mbps	DL Mbps				
IP Address Mode	DHCP	HCS Errors	CRC Errors	Pkt Err(%)				
IP AddressMask	192.168.88.100/24							
Default Gateway	192.168.88.1	BER Status	Value	Block Size				
Bandwidth	6MHz 👻	Var Noise		SDRAM C	apture			
Duplex Mode	TDD		_					
Security Mode	Authentication	2019:02:20-17:51:1 2019:02:20-17:51:1	7 WSDB_APP: _proce 7 WSDB_APP: MESSA	ss_message: 9 GE_TYPE_SELECT_FREG	_RESP for	0:B3:D5:CA:30:40		•
Security Key	•••••	2019:02:20-17:51:1 2019:02:20-17:51:1 2019:02:20-17:51:1	7 WS Device 70:B3:D 7 WS Device 70:B3:D 7 WSDB Registration	uery response for devic 5:CA:30:40: curr_freq = SLICCESS for Master 70	= /U:B3:D5:C = 491000000 B3:D5:CA:3	A:30:40 (70:83:D5:CA:30:40): res Hz, new_freq = 551000000 Hz h:40: freq=551000000 Hz max_eirn	uit: 1, cause: None =40 dBm valid till 2019-02-20T18+48+1	7 2460007
	Apply	2019:02:20-17:51:1 2019:02:20-17:51:1 2019:02:20-17:51:4	7 BS MAC Started St 8 Switching to Opera 8 WSDB_APP: Proces	arting periodic Status up tional Mode. sing UPDATE_SPECTRUI	date thread	B3:D5:CA:30:40	- 10 GUN YANG IN 2013-02-20110-10.1	= +

Figure 14 Successful Triggering of Base Station into Operational Mode

Notes:

- 1) TVWS Base Station GUI application acts as proxy for all the devices connected to it. It must be kept running all the time
- TVWS Base Station GUI application will prompt user for frequency selection only in Installation Mode. In Operational mode it selects the last selected frequency on subsequent interactions with the WSDB. If this frequency is not available, it selects the first frequency available in the range of operation.

7.5 Monitoring the operation of BS device

Once the BS is in operational state, user can monitor the uplink state of the registered CPEs on the dashboard. These parameters can be plotted in the 'Historical Chart' shown alongside.

7.5.1 Selecting the CPE to monitor UL parameters

Registered CPEs			Regi	stered C	PEs		
2:(70:B3:D5:CA:30:2D/172.16.240.108)		1:(70:B3:D5	5:CA:30:3D,	/172.16.240.	107)	T	BER
3:(70:B3:D5:CA:30:2A/172.16.240.121) 4:(70:B3:D5:CA:30:35/172.16.240.105) 5:(70:B3:D5:CA:30:26/172.16.240.106) 5:(70:B3:D5:CA:30:26/172.16.240.106)	⇔	RSSI (dBm)	-83.00	ESNR(dB)	33.11	TxPwr(dBm)	27.0
SNR 33.11 Max TA 273 Temp(C) 55		SNR	30.34	Max TA	1784	Temp(C)	55
		UL Mode	QAM-64	Code	5/6	Burst Size	1342
		DL Mode	QAM-64	Code	5/6	Burst Size	1046
		FreqOffset	525.19	UL Mbps	0.000	DL Mbps	0.000
		HCS Errors	7	CRC Errors	0	Pkt Err(%)	0.00
		BER Status	0	Value	0	Block Size	0
		Var Noise	0.5]		SDRAM (Capture

Figure 15 Selecting CPE for UL parameter monitoring

7.5.2 Plotting charts for selected CPE

Follow the steps indicated in Figure 16. One or more parameters can be viewed at the same time as shown in Figure 16. Scale is displayed for selected parameter from added group.







Figure 17 Plotting Multiple Parameters

7.5.3 Changing BS parameters in Operational Mode

To make any change in parameter, user needs to move to 'Installation' mode from the Mode-> Installation menu option.

Notes:

1) Switching to installation mode will cause the BS to reboot

8) CPE Installation

Dhaval CPEs should be installed by an authorized professional only. Installation and operation of the devices by persons other than the professional installers might cause permanent damage to the device and malfunction.

Installation of the CPE devices is identical to that of the Base station devices except for connecting the laptop directly to the Ethernet cable. In case a WiFi router is to be used, the Ethernet cable from CPE should be connected to the WAN port of WiFi router.

The CPE is configured to act as a router and assign IP addresses to the devices connected to it. The IP addresses assigned by the CPE are in subnet 192.168.88.0/24. This can be changed once the CPE is discovered through the GUI.

9) CPE Configuration

On CPE devices, it is not mandatory to program the WSDB service provider and any other device details. User can directly proceed to connect to CPE devices

9.1 Discover CPE devices

The discovery mechanism is identical to that of the Base station. Few points to note in the process:

Saankhya TVWS A	Application		Discover Devices			
Devices Providers	View Mode Configuration	Help		Discover Devices)
Provision	IP Address	MAC Address	IP Address	MAC Address	Device Type	
Discover	255.255.255.255	00:00:00:00:0	1.92.163.88.1	70:B3:D5:CA:30:3E	CPE	
Upgrade						
Reboot	uias Canfin	Dee				
Disconnect		Reg				
TVWS DB Query	Enabled					
Location Input	Manual		4		II	
				<i>(</i> -)		
	(A)			(B)		



Notes:

- CPE devices by default come with DHCP option enabled, hence any laptop or device connected to CPE should be configured to work with DHCP. CPE always allocates IP address in range 192.168.88.0/24 unless it is changed by the user. This allows CPE to be connected at a well-known address
- 2) A CPE is also discoverable from the Base station once it is attached to the BS

On logging into CPE device, the screen should show as in Figure 19. The devices are always shipped in installation mode, so the title bar should show that device is in installation mode

Saankhya TVWS Ap	plication-v0.8.1 - (INSTALLATION)	- (ADMIN)				
Devices View Mo	de Configuration Help					
	IP Address	MAC Address	Location	Band (MHz)	Frame count	Software Version
CPE	192.168.88.1	70:B3:D5:CA:30:3E	0.0000:0.0000	0	0	REL_5_0_RC8-build-151
De	vice Config	Registered	i BS		Historical Chart	
TVWS DB Query	Enabled 💌	0:(00:00:00:00:00 / 0.0.0.0)	▼ BER	RSSI	+ Clear Stats	·
Location Input	Manual					
Latitude	0.0000	RSSI (dBm) 0.00 ESNR(dB)	TxPwr(dBm)			
Longitude	0.0000	SNR 0.00 Max TA	Temp(C)			
Channels	479 荣 To 695 荣 MHz					
Antenna Ht. (AGL)	1.00	UL Mode Code	Burst Size 0			
Device Mode	Installation 💌	DL Mode Code	Burst Size 0			
Network Mode	Router	FregOffset 0.00 UL Mbps	0.000 DL Mbps 0.000			
IP Address Mode	DHCP					
IP AddressMask	192.168.88.1/24	HCS Errors 0 CRC Error	s 0 Pkt Err(%) 0.00			
Default Gateway	192.168.88.1	BER Status 0 Value	0 Block Size 0			
Bandwidth	6MHz 🔻	Var Noise -2	SDRAM Capture]		
Duplex Mode						
Security Mode	Authentication -	2019:02:20-15:46:48 Connecting to 2019:02:20-15:46:50 Connected to	Device 192.168.88.1 levice.			
Security Key	•••••	2019:02:20-15:46:51 Device Mac Mo	de is: atconfig			
	Apply					
Device Mac Mode is: a	tconfig					

Figure 19 CPE Login Screen

9.2 Configure CPE device

CPE configuration files naming convention is similar to BS configuration files. Refer Section 7.4 for the naming convention and select appropriate file as indicated in Figure 20.

Saankhya TVWS Application-v0.8.1 - (INSTALLATION) - (ADMIN) Devices View Mode Configuration Help		Radio Parameters					
CPE Import MAC	N	C:/Users/Saankhya76/De	sktop/REL_5_0_RC8-Dhaval2p1-6MHz/	At/TDD_CPE1_TPC_DSM_SCU_1by-	e_6Mhz.ini Browse		d F the N aclick impor
Apply AT Command	\Box	MAC Params			brows	e to file location	
Device Config		Transmit EIRP	170	Uplink Frequency 515		Downlink Frequency 515	
Device coning		Target BER	6144	SNR Margin 0		Ranging DSM Enabled 1	
(A)		Ranging Enabled	1	WDT Timeout 60		WDT Enabled 1	
		MAC Scheduler Enabled	1	Resync Status 0		Resync File Dump 0	
		TPC Enabled	1				
		Phy Params					
		Demodulation Support Id	0x000000003ffc180	Max IQ Gain	22938	RTG Value	573
		Timer ISR Enabled	1	Timer ISR Timeout(sec)	5	MCS Threshold	25
	(B)	TDD AGCH Sleep		AGCH Dummpy Framecount Three	h	Calibration (k1)	0xFF58
		Calibration PTH Default	0xE700	Calibration CAL1 Default	0x0100	Calibration CAL2 Default	0x0200
		Calibration PTH (C8F8)	0xE700	Calibration CAL1 (C8F8)	0xffc0	Calibration CAL2 (C8F8)	0x0340
Done	1	Calibration PTH (C8FB)	0xE700	Calibration CAL1 (C8FB)	0x0000	Calibration CAL2 (C8FB)	0x0180
Params changes captured for device.	$(\Box$	Calbration PTH (C8FE)	0xE700	Calibration CAL1 (C8FE)	0xffc0	Calibration CAL2 (C8FE)	0x0000
	N	MAC ID	:0x20:0x22:0x33:0x44:0x55:0x66	OFDM Symbols/SuperFrame (DS)	15	Channel Bandwidth (DS)	6
ОК		Cyclic Prefix DS		OFDM Symbols/SuperFrame (US)	11	Channel Bandwidth (US)	
		OFDM Symbols/Fram (US)		OFDM Symbols/Frame (DS)	15	TTG Value in Samples	1433
(C)	ļ						

Figure 20 Selecting CPE configuration

On coming back to main screen, enter the location information manually or select GPS as source. Also enter the antenna height above ground level (AGL) and frequency bands to scan.

Note:

3) Depending on the Bandwidth selected, the frequency bands will increment by multiples of the bandwidth

Devices View M	ode Configuration Help	/ - (ADIVILIA)						
	IP Address	MAC Addr	ess	Loca	ion	Band (MHz)	Frame count	Software Version
CPE	192.168.88.1	70:B3:D5:C	A:30:3E	0.0000:	0.0000	0	0	REL_5_0_RC8-build-151
De	evice Config		Registered	BS			Historical Cha	rt
TVWS DB Query	Enabled 💌	0:(00:00:00:00:00):00 / 0.0.0.0)		▼ BER	RSSI	+ Clear Stats	
Location Input	Manual							
Latitude	12.00	RSSI (dBm) 0.00	ESNR(dB)	TxPv	r (dBm)			
Longitude	77.00	SNR 0.00	Max TA	Ter	np(C)			
Channels	539 🜩 To 557 🜩 MHz							
Antenna Ht. (AGL)	1.00	UL Mode	Code	Bur	st size 0			
Device Mode	Installation 💌	DL Mode	Code	Bur	st Size 0			
Network Mode	Router	FreqOffset 0.00	UL Mbps	0.000 DL	Mbps 0.000			
IP Address Mode	DHCP 🔻	100 5	000 5					
IP AddressMask	192.168.88.1/24	HCS Errors 0	CRC Errors	U PKL	57(%) 0.00			
Default Gateway	192.168.88.1	BER Status 0	Value	0 Bloc	k Size 0			
Bandwidth	6MHz 🔹	Var Noise -2			DRAM Capture			
Duplex Mode	TDD							
Security Mode	Authentication 👻	2019:02:20-16:24:1 2019:02:20-16:24:2 2010:02:20-16:24:2	2 Device Mac Mod 8 Connecting to D	e is: atconfig evice 192.168.8	8.1			*
Security Key	Apply	2019:02:20-16:24:3 2019:02:20-16:24:3 2019:02:20-16:24:3 2019:02:20-16:24:4 2019:02:20-16:24:4	D Error in Parsing 1 Limited connecting 0 Connecting to D 2 Connecting to D	evice 192, 168,8 Response for AT Ci on to device. Funct evice 192, 168,8	onality available ma 8.1	G=0,0,0,2,1,178,4,0 Attempting y be limited.	limited connection.	
		2019:02:20-16:24:4 2019:02:20-16:24:4	3 Connected to de 3 Device Mac Mod	e is: atconfig				-

Figure 21 Additional CPE configurations

9.3 Scan for Available Networks

On applying the configurations above, CPE starts scanning for available networks. It might take a while depending on the range of scan. For entire TV band it might take as long as 15-20 minutes. Once the scan is complete, the following pop-up shows up:

II Se	lect BS		? ×
	Frequency	ļ	RSSI
1	551	-44	
			Select

Figure 22 Frequency selection at CPE

In case there are multiple networks shown, select the desired frequency to register with the network. It takes a while (about 5minutes) to complete the registration and on successful registration, CPE moves to operational mode

Notes:

- 4) If there are no networks found the CPE will reboot on its own
- 5) After moving to operational mode if CPE loses the network it will perform scan for the last registered band and then full range of frequencies automatically.

9.4 Register with selected Network

On successful registration, the CPE screen should display the following information as indicated in Figure 23

- The frequency at which CPE is registered
- Incrementing values of frame count
- Base station MAC address and IP address (IP address always shown as 0.0.0.0 in current release)

Saankhya TVWS A	oplication-v0.8.1 - (INSTALLATION)	- (ADMIN)										
	IP Address	MAC Addres	s		Location		Band (MH	iz)		Frame count		Software Version
CPE	192.168.88.1	70:B3:D5:CA	:30:3E	12.00	000:77.000		551			3748		REL_5_0_RC8-build-15
De	vice Config	R	egistered	BS					н	istorical	Chart	
TVWS DB Query	Enabled 💌	0:(00:00:00:00:00:00:	0 / 0.0.0.0)			BER	RSSI	•	+	Clear St	ats	
Location Input	Manual											
Latitude	12.00	RSSI (dBm) 0.00	ESNR(dB)		TxPwr(dBm) -4	2.5						
Longitude	77.00	SNR 0.00	Max TA		Temp(C) 5	4						
Channels	539 × To 557 × MHz											
Antenna Ht. (AGL)	1.00	UL Mode	Code		Burst Size 0							
Device Mode	Operational 🔻	DL Mode	Code		Burst Size 0							
Network Mode	Router	FregOffset 0.00	UL Mbps	0.000	DL Mbps 0.0	00						
IP Address Mode	DHCP		_		–							
IP AddressMask	192.168.88.1/24	HCS Errors 0	CRC Errors	; <u>0</u>	Pkt Err(%) 0.0	0						
Default Gateway	192.168.88.1	BER Status 0	Value	0	Block Size 0							
Bandwidth	6MHz 💌	Var Noise -2			SDRAM Capt	Jre						
Duplex Mode	TDD											
Security Mode	Authentication 💌	2019:02:20-16:24:31 2019:02:20-16:24:40	imited connecti Connecting to D	ion to device. Device 192	. Functionality avai 2.168.88.1	able may b	limited.					•
Security Key	•••••	2019:02:20-16:24:43 2019:02:20-16:24:43 2019:02:20-16:27:77	Connected to de Device Mac Mod Saving WSDB Pa	evice. le is: atconfig arams to Devi	j ice.							
	Apply	2019:02:20-16:27:23 2019:02:20-16:31:19 2019:02:20-16:31:52	Searching for A Attaching to BS CPE Connected	vailable Base with frequen to BS.	Stations. This may acy 551	take a whil	e. Please Wait					E

Figure 23 CPE successful registration at CPE GUI

Similarly, on the Base station side, you would see logs corresponding to CPE registration as indicated in Figure 23.

9) White Space Database Usage

In geographies which have regulations on usage of TV white space frequencies, the sharing of the spectrum is controlled by White Space Data Base (WSDB). Saankhya Labs sells devices with the WSDB feature enabled in these geographies and the configuration of the service providers described in Section 7) and 9)

It is advised that the source of location information be set to GPS as against manual while using this feature, although it is not mandatory. The GPS device used provides 95% location accuracy when latched.

10) FCC Test Mode

In this mode device continuously transmits without any quite period. It is supported as per the FCC test requirements. In this mode ACLR and transmit power can be measured more accurately.

11.1 FCC test for Base Station

11.1.1 Switch to FCC mode

Connect TVWS GUI Application to Base Station and follow the steps indicated in Figure 24 to configure the device to FCC test Mode. Please make sure TVWS DB Query is disabled for FCC testing.

Use the TVWS DB Query dropdown in Device-Config section to disable the TVWS DB Query.



Figure 24 Switch BS to FCC test mode

11.1.2 Trigger Device in FCC mode

Follow the steps indicated in Figure 25 to trigger the device in FCC mode.

	Devi	ices Providers Vie	ew Mode	Configuration Help				
			IP Address	Import				
		-(C 197	2.168.21	Save to File				
				Apply AT Comma	nd			
_			Ţ					
Radio Parameters			\sim				?	\times
								^
19_3P1/v5.0.5-Dhaval3p0-6	MHz/At/FCC_BS_TPC_D	5M_SCU_1by4_6Mhz_A	G_0dbi.ini	Browse Import	Load Fro	m Device	Done	
			1. browse to	file location 2. click o	n Import		3. click on done	
MAC Params								
Conducted Tx Power	178	MAC Schedule	er Enabled	2	WDT Timeout	50		
Target BER	6144	SNR Margin		0	TPC Enabled	1		
			J.				I	
		Done	· · ·	×				
		Para	ms changes	captured for device				
			ins changes	captured for device.				
				OK				
				OK				
			Л					
Dunle	v Mode EDD	•	\sim			_		
Sogue	ritu Modo Authontic	ation 7	019:04:16-10	1:28:23 Connecting to Devic	re 192.168.21.24			
Secur	ity Mode Addiendo		019:04:16-10	28:27 Connected to devic	e.			
Secur		2/	019:04:16-10	28:47 Applying Device Co	nfiguration. Please Wai	t		
	Apply click on (019:04:10-10	1.29:02 BS MAC Started. SI	arting periodic status t	ipuate thread.		
BS MAG	C Started. Starting pe	eriodic Status update	e thread.					
			Л					
			\sim					
Saankhya TVWS Applic	ation-v0.8.7 - (MAC_	STARTED) - (SUPER)						
evices Providers View	Mode Configurat	tion Help						
	P Address	MAC Address		Location	Band (MHz	<u>z</u>)	Frame count	1
192.1	168.21.24 7	0:B3:D5:CA:3	80:83	0.0000:0.0000	485		1631	
								1
Device Co	nfig	Registe	ered CPE	s			Historical C	:ha
TVWS DB Query Disabled	-			T REP	RSSI	• +	Clear Graph	1
Location Input Manual				DER				
				5-5(d2) 25-45	1			
Latitude 0.0000		SSI (dBm ES	SNK(OB)	TXPWr(dBm) 25.16				

11.2 FCC test for CPE

11.2.1 Switch to FCC mode

Connect TVWS GUI Application to CPE and Follow the steps indicated in Figure 26 to configure the device to FCC test Mode. Please make sure TVWS DB Query is disabled for FCC testing. Use the TVWS DB Query dropdown in Device-Config section to disable the TVWS DB Query.



Figure 26 Switch CPE to FCC test mode

11.2.2 Restart the TVWS GUI Application

Close and open the TVWS GUI Application and connect back to CPE.

11.2.3 Trigger Device in FCC mode

Follow the steps indicated in Figure 27 to trigger the device in FCC mode.



Figure 27 Trigger CPE in FCC mode

11.3 Switch from FCC mode to Normal mode

Follow the steps indicated in Figure 28 to configure the device to Normal mode.



Figure 28 Switch form FCC mode to Normal mode

11) Upgrading Firmware

Firmware upgrade procedure is identical for both BS and CPE. The new firmware is updated on the device via FTP server hosting the release package. The FTP server needs to point to the release package as shown inFigure 29. Follow the steps indicated in Figure 30 to upgrade the firmware.

🕞 🔍 🔻 🕨 🗸 Computer 🕨 Sw_tvws (\\19	92.168.10.120) (Z:)	ases 🕨 Firmware	REL_5_0-Dhaval2p1-	6MHz 🕨
Organiza - Russ Newfolder			set the file server	to main
Organize + Burn New folder			software package	folder
🖌 🔆 Favorites	Name		Date modified	Туре
📃 Desktop	퉬 At		3/1/2019 6:16 PM	File folder
Downloads	퉬 def		3/1/2019 6:16 PM	File folder
🕮 Recent Places	퉬 DhavalBs		3/1/2019 6:16 PM	File folder
퉬 Muttu	퉬 DhavalCpe		3/1/2019 6:16 PM	File folder
퉬 REL_5_0-Dhaval2p1-6MHz	鷆 FirmwareBs		3/1/2019 6:16 PM	File folder
	🌗 FirmwareCpe		3/1/2019 6:16 PM	File folder



💵 Saankhya TVWS A	pplication-v0.8.2 - (MAC_STARTED) ·	
Devices Providers	View Mode Configuration I	🔝 Dialog
Provision Discover Connect	IP Address 172.16.240.129	Upgrade Config
Upgrade		
Reboot Disconnect	vice Config	Username tvws Password
TVWS DB Query	Disabled 💌	liperada
Location Input	Manual	
Latitude	0.0000	л
2019:03:12-10:49:20 Cd 2019:03:12-10:49:24 Cd 2019:03:12-10:49:24 Dd 2019:03:12-10:49:44 Re 2019:03:12-10:49:44 Re 2019:03:12-10:50:01 W 2019:03:12-10:50:01 W	onnecting to Device, 172. 16. 240, 129 onnected to device. evice Mac Mode is: flashconfio ebooting,GUI will disconnect soon, S Device 70:B3:D5:CA:30:40 disconnect SDE_APP: process_message: 10 SDB_APP: MESSAGE_TYPE_DELETE_DEV:	gui_app_v3 Applying Changes will Reboot the system. Click 'Cancel' to Discard Changes. Cancel Update and Reboot
Frame count 2333	Software Version REL_5_1	

Figure 30 Firmware Upgrade Procedure

On successful upgrade of the firmware, the device comes up with the new version as indicated in the Software version field of the GUI.

Notes:

- 1) The file server should be running on the same IPv4 subnet as that of the PC running the TVWS Application
- 2) Do not try to upgrade CPE package on BS device or vice versa. Doing so might render the device unusable
- 3) Do not try to upgrade an 8MHz package on 6MHz or 7MHz device or vice versa. Doing so might render the device unusable

12) Troubleshooting and Maintenance

12.1 Decoding the LED status

TVWS devices are fitted with 4 LED at the bottom of the panel as shown in Figure 31. Combination of these LED states indicate various states of the system as indicated in Table 1



Figure 31 Status LED position and numbering

LED state combination ³			n ³	Interpretation
White	Amber	Green	Red	
G	Х	Х	Х	Power ON – indicates if system is powered up
G	В	Х	Х	GPS signal acquiring
G	G	Х	Х	GPS signal latched
G	В	Х	Х	GPS signal acquiring
G	Х	OFF	Х	NO network connection
G	Х	В	Х	Network connection acquiring
G	Х	G	Х	Connected to Backhaul
G	Х	Х	OFF	System booting up
G	Х	Х	В	DSP code download in progress or resync occurred
G	Х	Х	G	Device operational
G	В	В	В	Malfunction device needs reboot

Table 1LED states

12.2BER (Bit Error Rate) measurement

This feature allows to measure the BER which helps observe the performance w.r.t channel quality index.

12.2.1 Enable BER

³ G: glow (constant ON), B: Blink, X: Don't care

	Regi	stered C	:PEs			Registered CPEs					
1:(70:B3:D5:CA:30:54/192.168.21.8)						1:(70:B3:D5	5:CA:30:54/	192.168.21.8)	•	V BER
RSSI (dBm)	-86.00	ESNR(dB)	15.19	TxPwr(dBm)	27.06	RSSI (dBm)	-87.00	ESNR(dB)	15.05	TxPwr(dBm)	27.06
SNR	15.05	Max TA	57	Temp(C)	59	SNR.	15.56	Max TA	57	Temp(C)	59
UL Mode	QAM-16	Code	1/2	Burst Size	1219	UL Mode	QAM-16	Code	1/2	Burst Size	1219
DL Mode	QAM-16	Code	3/4	Burst Size	1066	DL Mode	QAM-64	Code	2/3	Burst Size	1060
FreqOffset	381.43	UL Mbps	0.000	DL Mbps	0.022	FreqOffset	381.86	UL Mbps	0.000	DL Mbps	0.000
HCS Errors	9	CRC Errors	1	Pkt Err(%)	0.00	HCS Errors	9	CRC Errors	1	Pkt Err(%)	0.00
BER Status	0	Value	0.00e+00	Block Size	0	BER Status	1	Value	1.70e-05	Block Size	0
Var Noise	0.5]		SDRAM (Capture	Var Noise	0.5]		SDRAM (Capture

Follow steps indicated in Figure 32 to start BER measurement.

Figure 32 Start BER measurement

12.2.2 Plot BER Historical chart

Refer Section 3.5.2 to start BER plot.





12.3 SDRAM Data Capture

SL SDR chipsets allow capture of the baseband samples to analyze the signal for debugging unexpected scenario and to store them in internal SDRAM. TVWS GUI application provides way of pulling out these samples for further analysis. The procedure for capturing this debug data is shown in Figure 34.

	Regi	stered (CPEs				
1:(70:B3:D5	5:CA:30:54/	172.16.240.	249)	•	BER		
RSSI (dBm)	-87.00	ESNR(dB)	21.79	TxPwr(dBm)	27.0		
SNR	22.17	Max TA	64	Temp(C)	51	🔳 gui_ap	مەر ₂ برم
UL Mode	QAM-64	Code	1/2	Burst Size	1251	1	SDRAM Data for Device is Being Captured and will be saved inside "/home/root/ SDRAMData.bin".Please Copy that data using FTP after 20 minutes.
DL Mode	QAM-64	Code	5/6	Burst Size	1046		ОК
FreqOffset	1.07	UL Mbps	0.000	DL Mbps	0.000		
HCS Errors	70	CRC Errors	0	Pkt Err(%)	0.00		
BER Status	0	Value	0	Block Size	0		
Var Noise	0.5			SDRAM C	Capture		

Figure 34 SDRAM Capture Procedure

12.4 TVWS Base Station & CPE GUI Uninstallation

Follow the steps indicated in Figure 35 to uninstall the TVWS GUI Application

Control Panel	Programs Programs and Features	Twws Application Uninstall					
Home updates features on or	Uninstall or change a program To uninstall a program, select it from the list and 1	Are you sure you want to completely remove Tyws Application and all of its components?					
	Organize Uninstall/Change	Yes No					
	Microsoft Visual C++ 2017 Redistributable (x64) - 14						
	😙 Tvws Application						
	Double click	 V 					
		Tvws Application Uninstall					
		Tvws Application was successfully removed from your computer.					
		ОК					

Figure 35: TVWS Base Station and CPE GUI Uninstallation