Singapore Amateur Radio Transmitting Society
Robinson Road P.O. Box 2728, Singapore 904728
www.sarts.org.sg

9V1RS-U
SARTS Multimode UHF Repeater

BY 9V1LH, 29.04.2021

Picture source: [1]

Scope of the presentation

- Motivation and History
- Hardware overview
- Functionality
- Outlook

Motivation

- Local VHF-Repeater currently only supports analogue FM voice communication with EchoLink

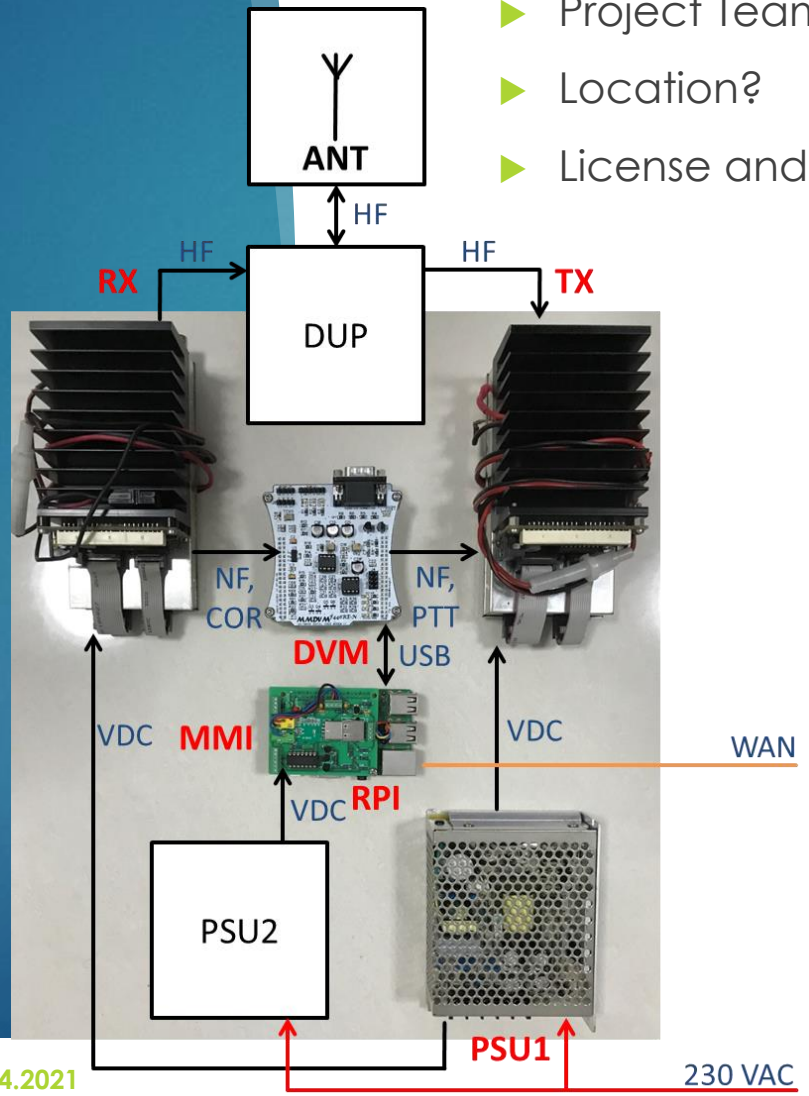
- Deploy infrastructure for local HAM RF experiments:

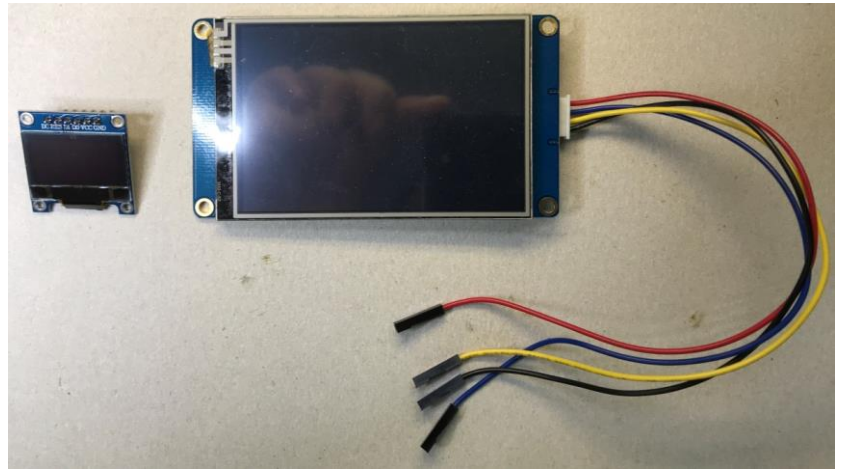
  Encourage activities of local 9V1 HAMs (and neighbours)

  By support of common analogue and digital HAM Radio voice and data modes

History

- Idea was born in June 2017
- First project draft only in June 2018
  - Project Team: 9V1KB, 9V1AW, 9V1LH
  - Location?
  - License and UHF frequency-pair allocation?





ICOM IC-FR6000 Hardware overview

Picture source: [1]

ICOM IC-FR6000

Picture source: [1]

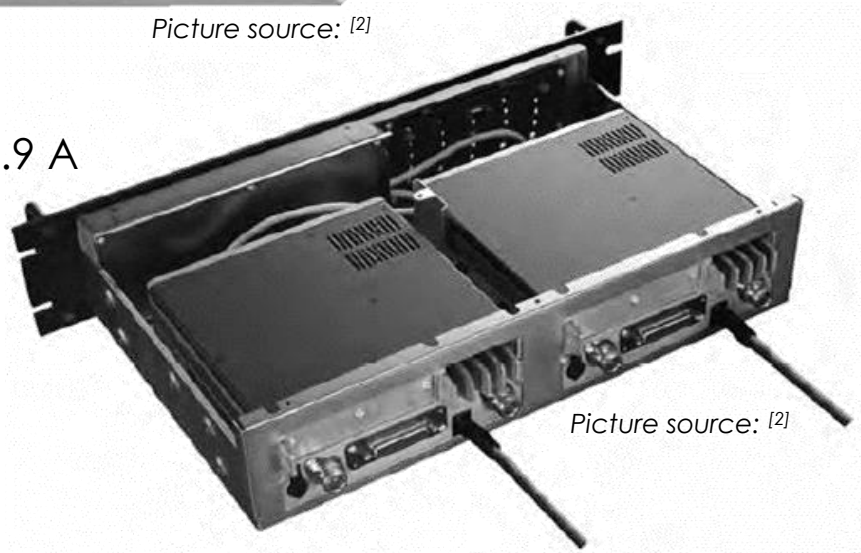
iDAS™
ICOM DIGITAL ADVANCED SYSTEM

Picture source: [2]

SPECIFICATIONS

Picture source: [2]

- Frequency coverage: 400-470 MHz
- Number of channels: Max 32 channels
- Channel spacing: 6.25 / 12.5 / 25 kHz
- Frequency stability: +0.5 ppm
- Operating temperature: -30 ˚C to +60 ˚C
- Power supply voltage: 13.6 V DC
- Current drain (at 13.6 V DC): @TX 50 W = 15 A, @RX with max. audio = 1.9 A
- Stand-by 500 mA (400 mA @Fan off)
- Output power: 50 W (adjustable to 5W) 25 W at 100% duty cycle
- Max frequency deviation: +5.0 / 2.5 kHz (wide / narrow)
- Sensitivity FM (WIN): 0.30 µV typ. (at 12 dB SINAD)
- Digital 0.25 µV typ. (at 5% BER)



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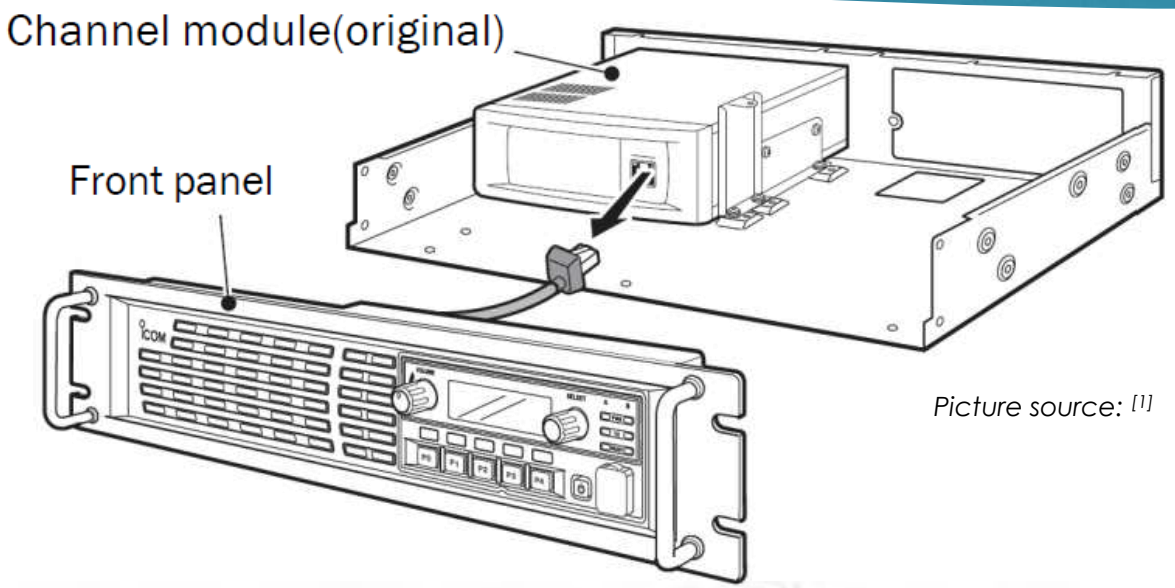
ICOM IC-FR6000



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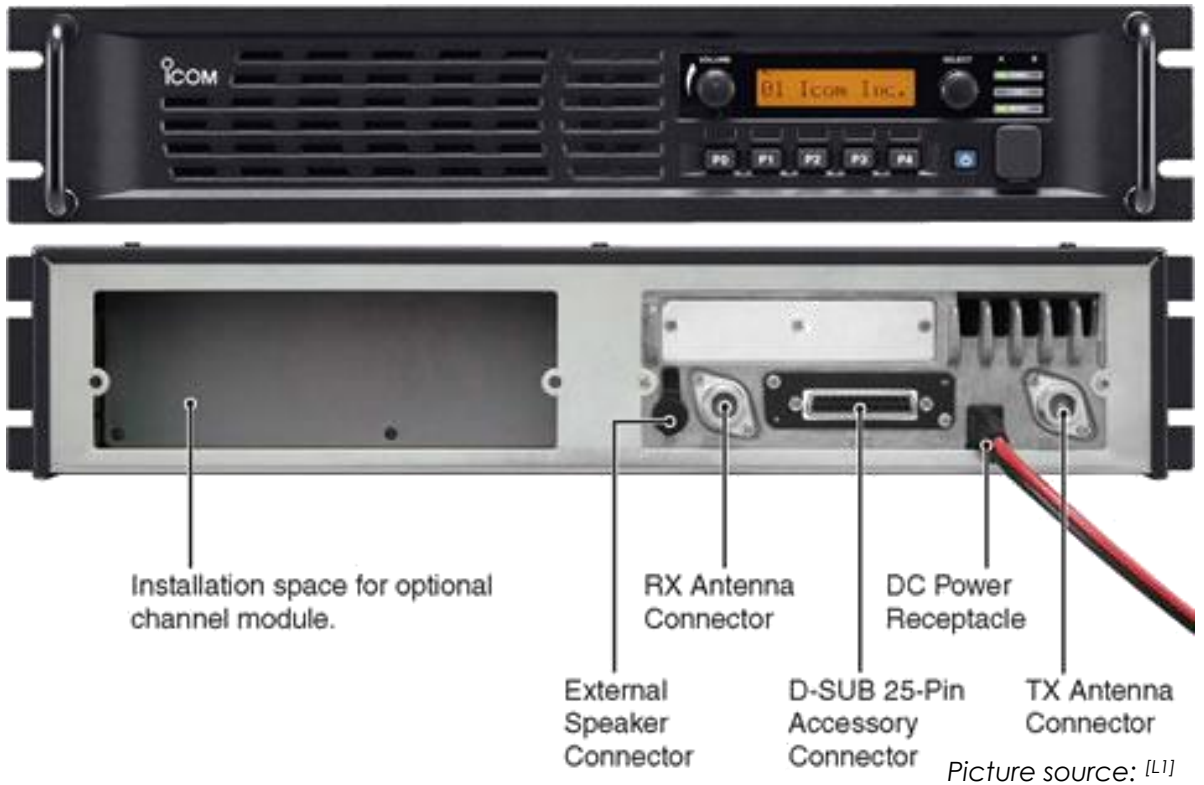
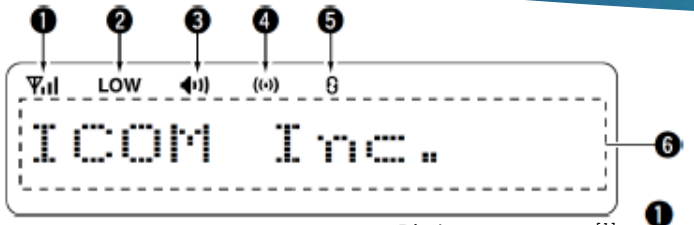


Picture source: [L1]

ICOM IC-FR6000



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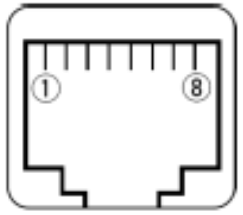
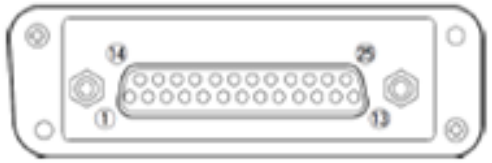


①+8 V DC output (Max. 15 mA)
②I/O port for PC programming
③NC
④M PTT (Input port for TX control)
⑤Microphone ground
⑥Microphone input
⑦Ground
⑧M MONI (Input port for monitor control)

Picture source: [1]

❑ Accessory connector



Source: [1]

Pin No.	Pin Name	Description	Specification
1	NC	No connection	—
2	TXD	Output terminal for serial communication data.	—
3	RXD	Input terminal for serial communication data.	—
4	RTS	Output terminal for request-to-send data.	—
5	CTS	Input terminal for clear-to-send data.	—
6	NC	No connection	—
7	GND	Serial/digital signal ground	—
8	MOD IN	Modulator input from an external terminal unit.	Input level: 300 mV rms
9	DISC OUT	Output terminal for AF signals from the AF detector circuit. Output level is fixed, regardless of [AF] control.	Output level: 300 mV rms
10	EXT. D/A	The desired function can be assigned.* (Default: Null)	—
11	VCC	13.6 V DC output	Output current: Less than 1 A
12	EXT. A/D	Customize A/D input (Not used)	—
13	NC	No connection	—
14	GND	Ground	—
15	EXT.I/O 15	The desired function can be assigned.* (Default: Null)	+5 V pull up, Active=L
16	EXT.I/O 16	The desired function can be assigned.* (Default: P0 Monitor Output)	+5 V pull up, Active=L
17	EXT.I/O 17	The desired function can be assigned.* (Default: Busy Output)	+5 V pull up, Active=L
18	EXT.I/O 18	The desired function can be assigned.* (Default: Null)	+5 V pull up, Active=L
19	EXT.I/O 19	The desired function can be assigned.* (Default: EPTT Input)	+5 V pull up, Active=L
20	DATA IN	Input terminal for data.	—
21	EXT.I/O 21	The desired function can be assigned.* (Default: Analog Audible Output)	+5 V pull up, Active=L
22	AF OUT	The AF detector Output.	—
23	EXT.I/O 23	The desired function can be assigned.* (Default: Mic Mute Output)	+5 V pull up, Active=L
24	EXT.I/O 24	The desired function can be assigned.* (Default: Null)	+5 V pull up, Active=L
25	EXT.I/O 25	The desired function can be assigned.* (Default: Mic Hanger Output)	+5 V pull up, Active=L

* The desired function can be assigned using the optional CS-FR5000 cloning software. Ask your dealer for details.

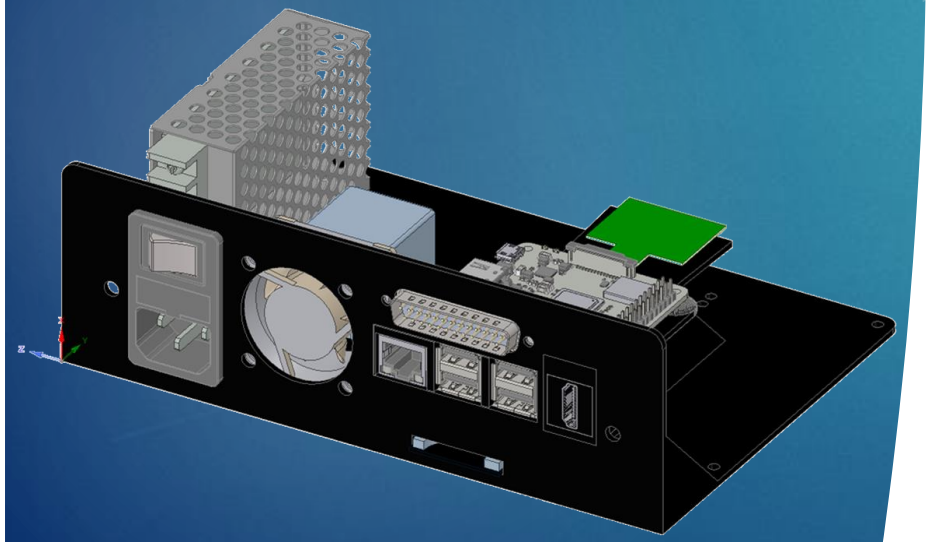
Source: [1]

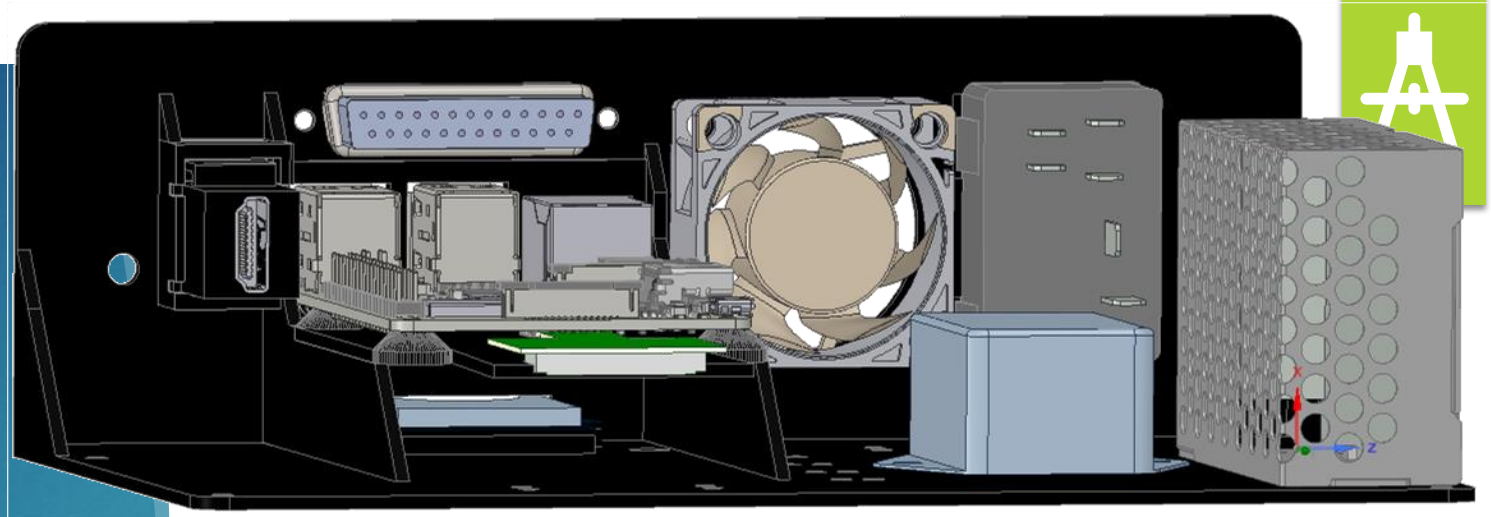
ICOM IC-FR6000

Picture source: [1]

Multimode Module by 9V1LH

Hardware BOM



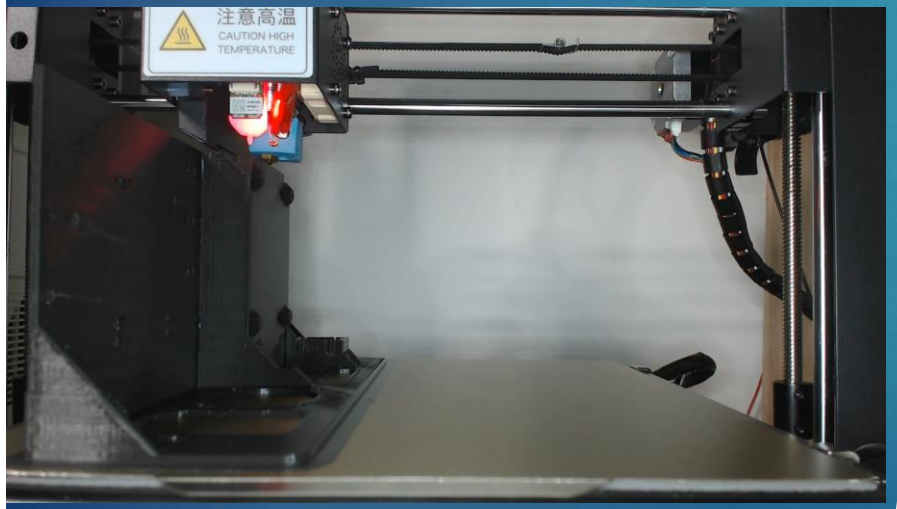


- Raspberry Pi 4 Model B, 2 GB
- SD-card adapter + extender
- ICFR6000-Rmt RPi-Hat by 9V1LH
- MMDVM V3F4 repeater board by BI7JTA
- PSU: Mean Well RS-25-5 5 VDC / 5 A+ Filter + Fused IEC switch socket
- FANS: NOCTUA 5V PWM NF-A6x25 + NF-A4x20
- Connectors: Sub-D25 Male + HDMI Type A Keystone

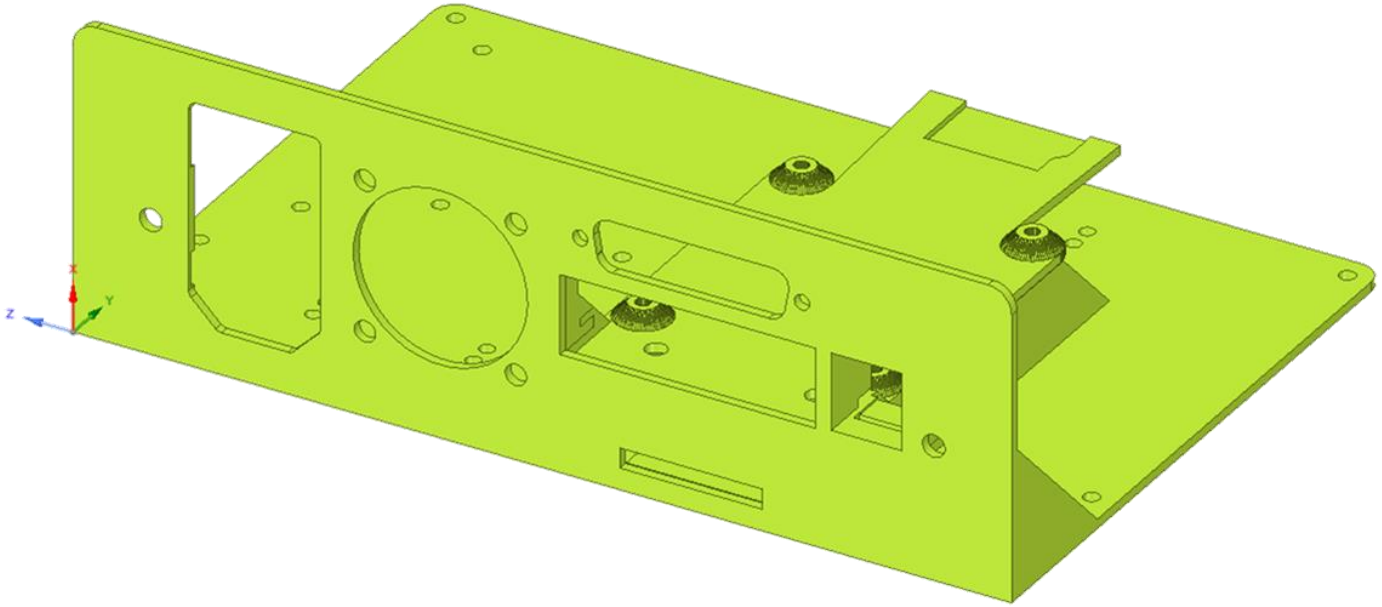
- *Display: OLED I²C 0,96" + 3D printed housing by 9V1AQ*
- *BME280 I²C temperature / humidity sensor*

ICFR6000-Rmt RPi-Hat by 9V1LH

3D printed mounting bracket

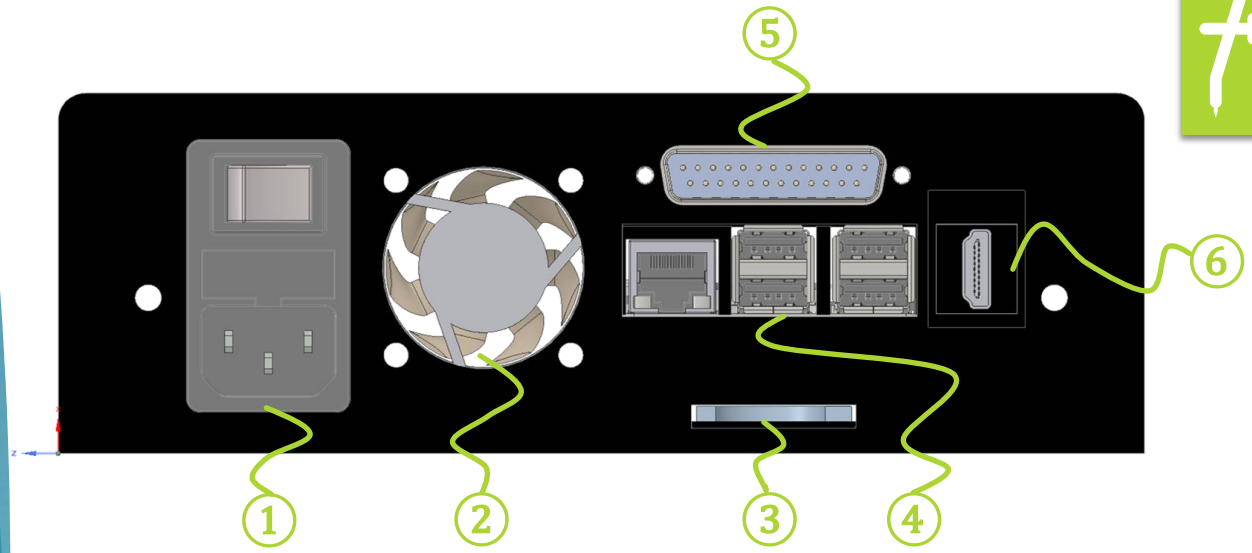


- Mechanical design in DesignSpark Mechanical 5.0
- First prototype printed with black PLA filament
- Printer: Modified Anycubic i3 Mega S



Multimode Module by 9V1LH

Back panel



- ① Power: IEC 230 VAC fused socket with switch
- ② FAN
- ③ SD-Card slot (full-size)
- ④ Raspberry Pi 4B:
  - 1x RJ45 1000 Gbps Network
  - 2x USB Type A 3.0
  - 2x USB Type A 2.0
- ⑤ Radio interface: Sub-D25 male connector
- ⑥ HDMI type A socket for external display

Multimode Module

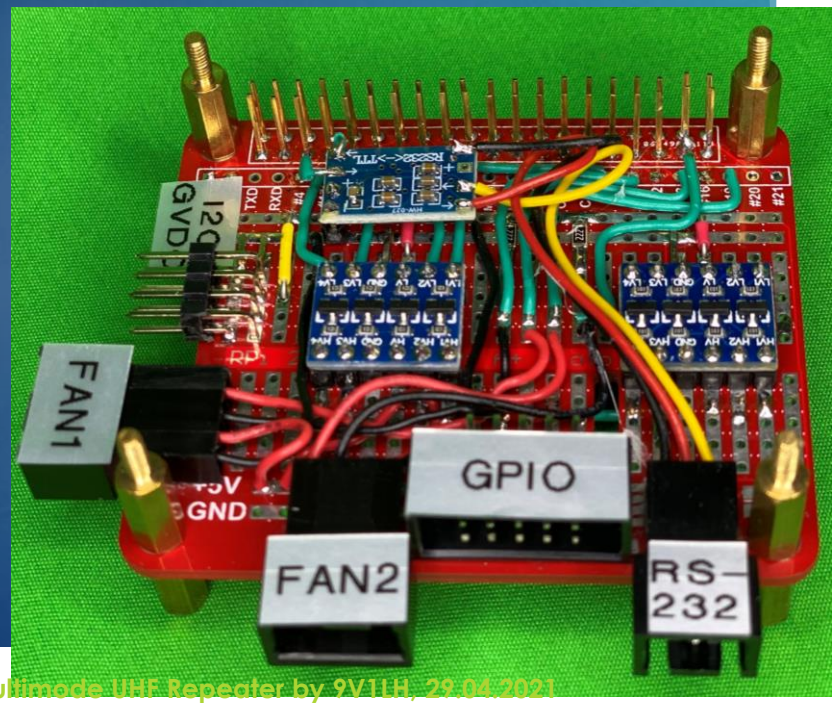
Software list

- MMDVM Firmaware and Host by Jonathan G4KLX
  - https://github.com/g4klx
- Pi-Star by Andy MW0MWZ
  - https://www.pistar.uk
- MMDVM WS-Dashboard by Kim DG9VH
  - https://github.com/dg9vh
- TelegramBot* by Stephan 9V1LH
  - https://www.qrz.com/db/9v1lh
- ICFR6000-Rmt GPIO and Serial driver* by Stephan 9V1LH
  - https://www.qrz.com/db/9v1lh

*under development

ICFR6000-Rmt RPi-Hat by 9V1LH

Hardware overview

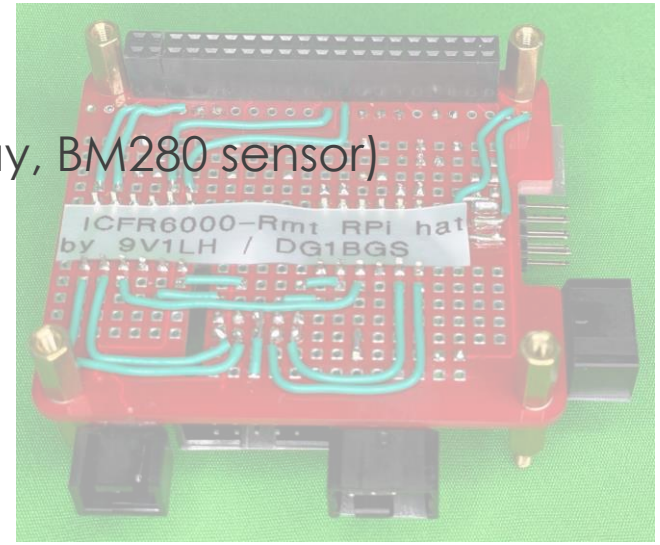


Modules:

- 8x bidirectional 3.3 V to 5 VTTL level shifters
- 1x TTL to RS232 converter (TX, RX)

Interfaces:

- 2x I²C headers (OLED display, BM280 sensor)
- 2x 5V PWM Fan connectors
- 1x GPIO header
- 1x RS232 connector

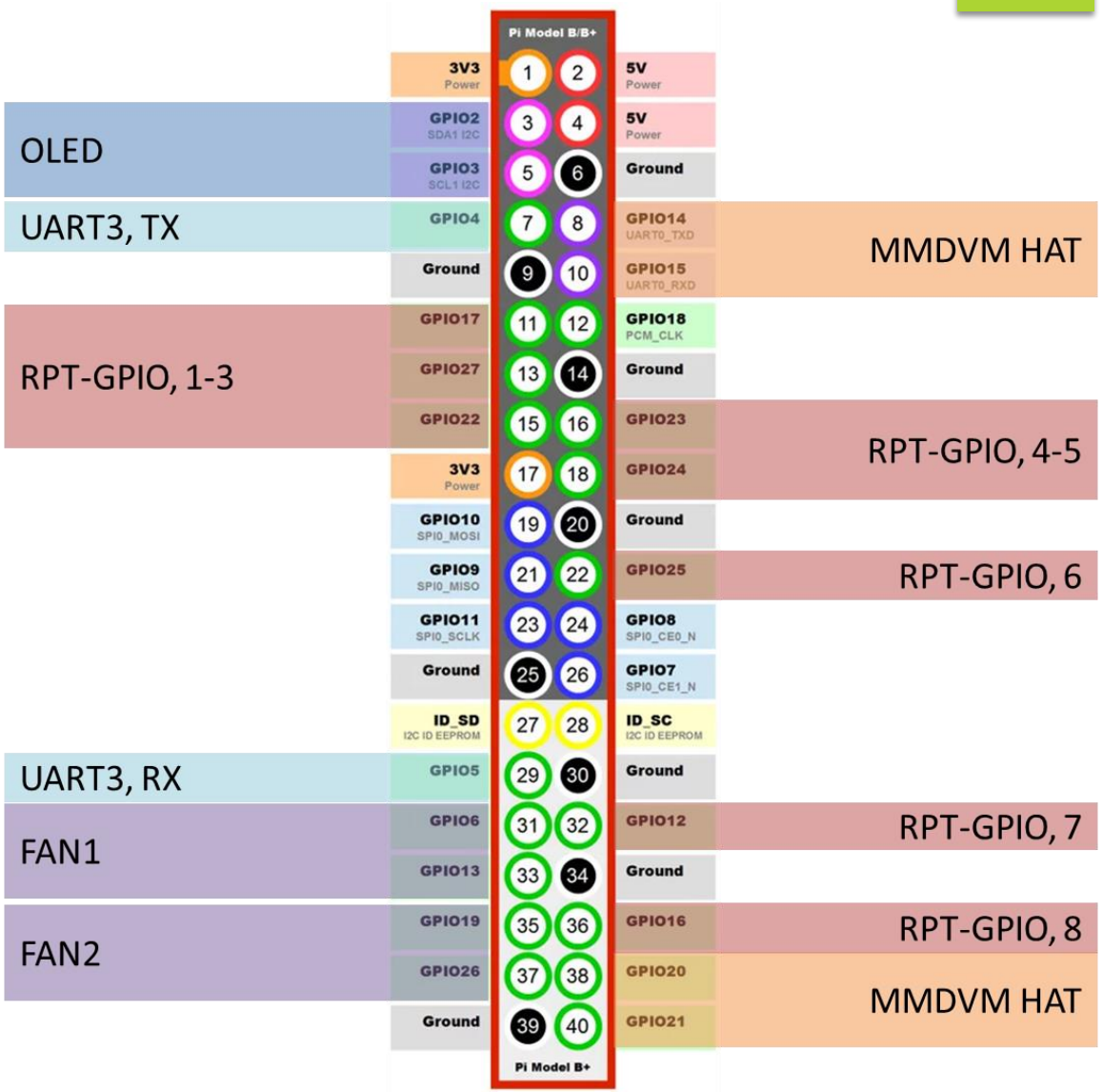


Homebrew prototype might be replaced by manufactured PCB with more features like a 5 VDC power input.

ICFR6000-Rmt RPi-Hat by 9V1LH

RPi 4B – pins in use

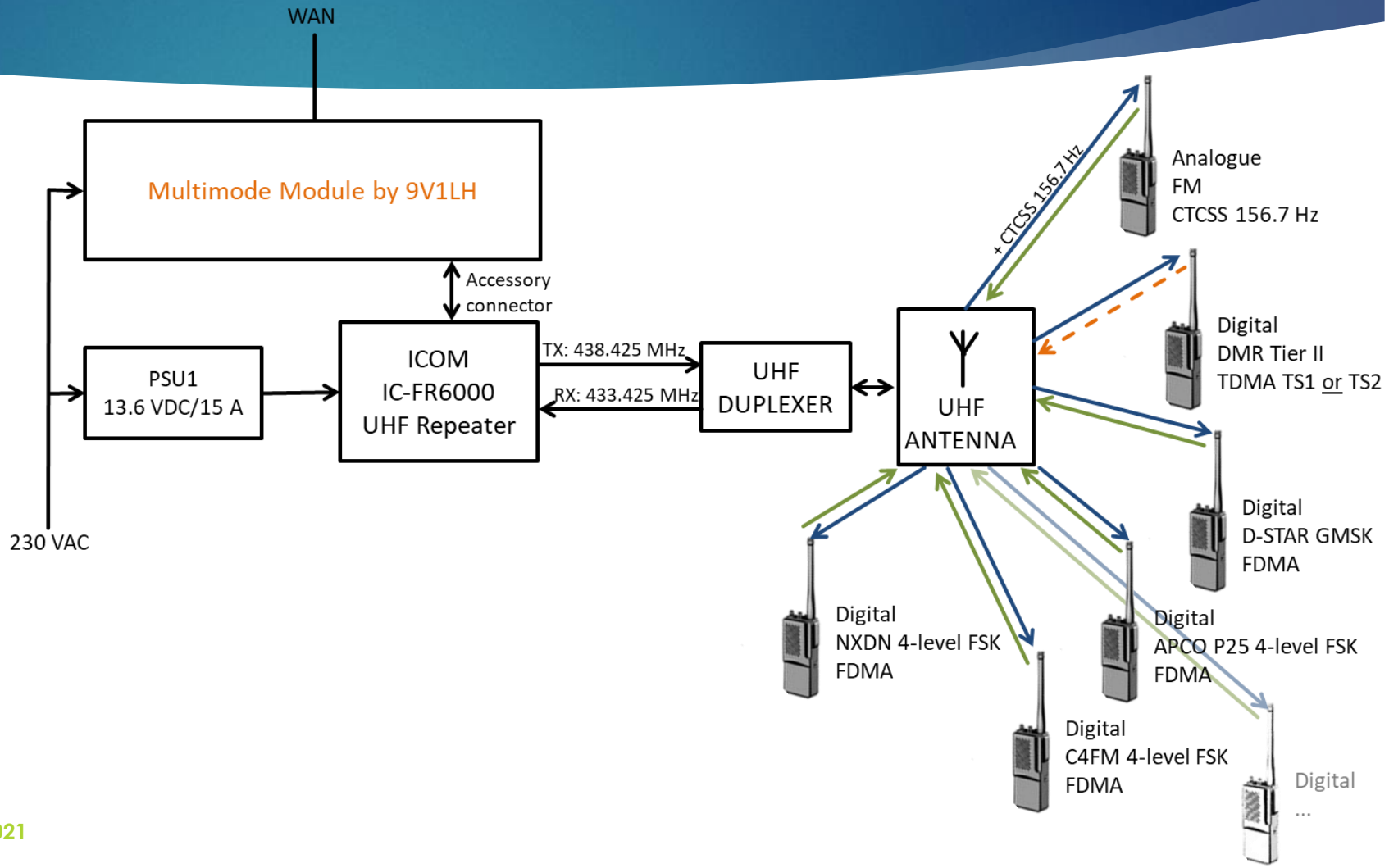
D-Sub25 Pin	Port	In/Out	Function	Active Logic	Connected to	Pin RPi-Breakout Board	Ribbon cable colour
14	GND					5, 6	Blue, Green
15	Ext.I/O 15	Input	Key: Lock	Low	RPi PIN13, GPIO27 / wp2	10	Brown
16	Ext.I/O 16	Input	TX Disable	Low	RPi PIN15, GPIO22 / wp3	9	Red
17	Ext.I/O 17	Input	Key: High/Low	Low	RPi PIN11, GPIO17 / wp0	8	Orange
18	Ext.I/O 18	Input	MCH Select : 1	Low	RPi PIN16, GPIO23 / wp4	7	Yellow
19	Ext.I/O 19	Input	EPTT	Low	Modem, Radio	3	-
21	Ext.I/O 21	Input	MCH Select : 2	Low	RPi PIN38, GPIO16 / wp27	4	Purple
23	Ext.I/O 23	Input	MCH Select : 3	Low	RPi PIN18, GPIO24 / wp5	3	Grey
24	Ext.I/O 24	Input	MCH Select : 4	Low	RPi PIN32, GPIO12 / wp26	2	White
25	Ext.I/O 25	Input	MCH Select : 5	Low	RPi PIN22, GPIO25 / wp6	1	Black
10	Ext.D/A 10	Output	RSSI	-	Modem, Radio	8	-



Repeater Functionality

- ANALOGUE: FM
- DIGITAL: DMR, D-STAR, C4FM
- REMOTE CONTROL

Repeater Functionality



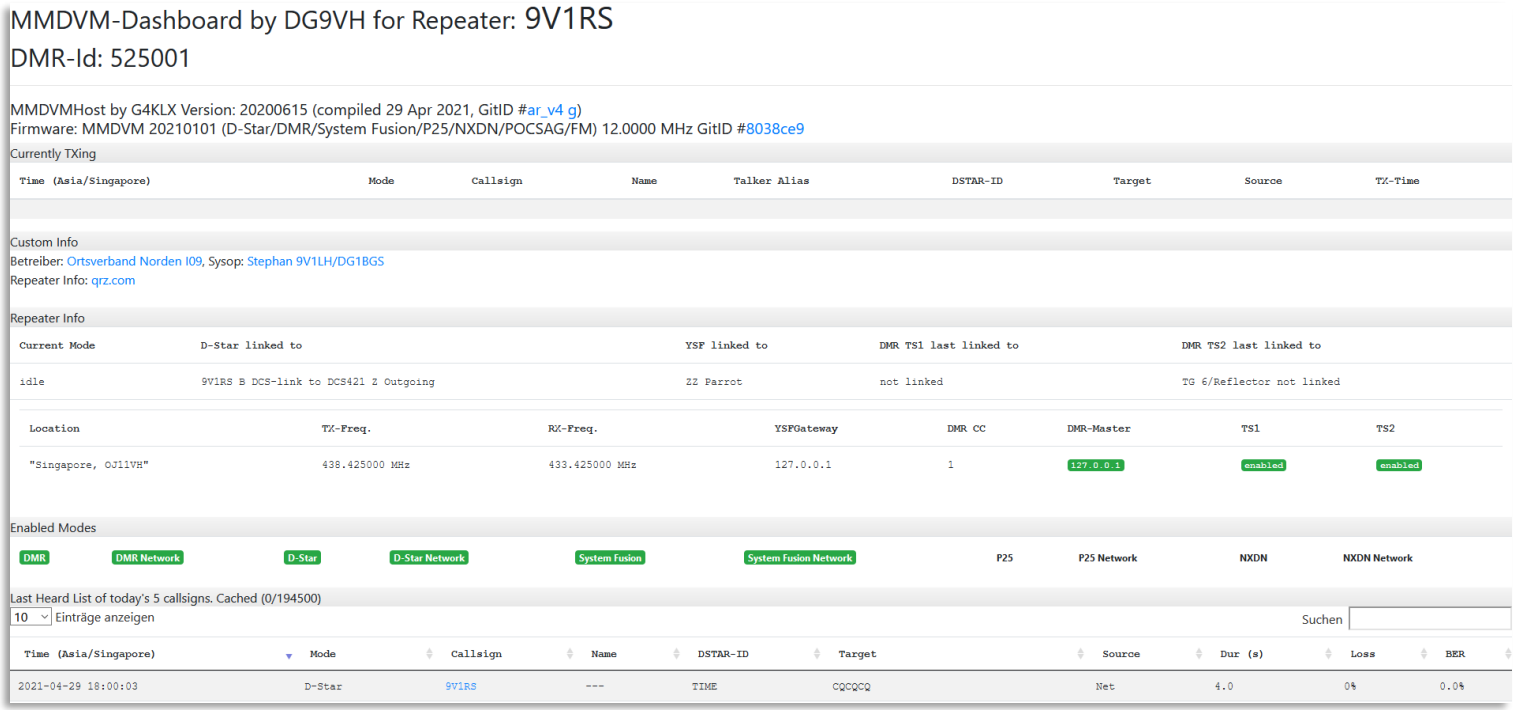
Remarks
- only one mode at a time!

Legend
Downstream: FM, 12.5 kHz
Upstream FDMA: 12.5 kHz
Upstream TDMA: 12.5 kHz

Repeater Functionality: Remote control

- What can be remotely controlled?
  - *Basically everything!*
  - (Microphone) Key functions via GPIO
  - Repeater status via Serial communication
  - Remote programming
- Real time configuration change via
  - Dashboard
  - SSH session
  - Telegram Bot

Remote control: Dashboard



MMDVM-Dashboard by DG9VH for Repeater: 9V1RS

DMR-Id: 525001

MMDVMHost by G4KLX Version: 20200615 (compiled 29 Apr 2021, GitID #ar_v4 g)
Firmware: MMDVM 20210101 (D-Star/DMR/System Fusion/P25/NXDN/POCSAG/FM) 12.0000 MHz GitID #8038ce9

Currently TXing

Time (Asia/Singapore)	Mode	Callsign	Name	Talker Alias	DSTAR-ID	Target	Source	TX-Time

Custom Info

Betreiber: Ortsverband Norden I09, Sysop: Stephan 9V1LH/DG1BGS
Repeater Info: qrz.com

Repeater Info

Current Mode	D-Star linked to	YSF linked to	DMR TS1 last linked to	DMR TS2 last linked to
idle	9V1RS B DCS-link to DCS421 Z Outgoing	ZZ Parrot	not linked	TG 6/Reflector not linked

Location	TX-Freq.	RX-Freq.	YSFGateway	DMR CC	DMR-Master	TS1	TS2
"Singapore, OJ11VH"	438.425000 MHz	433.425000 MHz	127.0.0.1	1	127.0.0.1	enabled	enabled

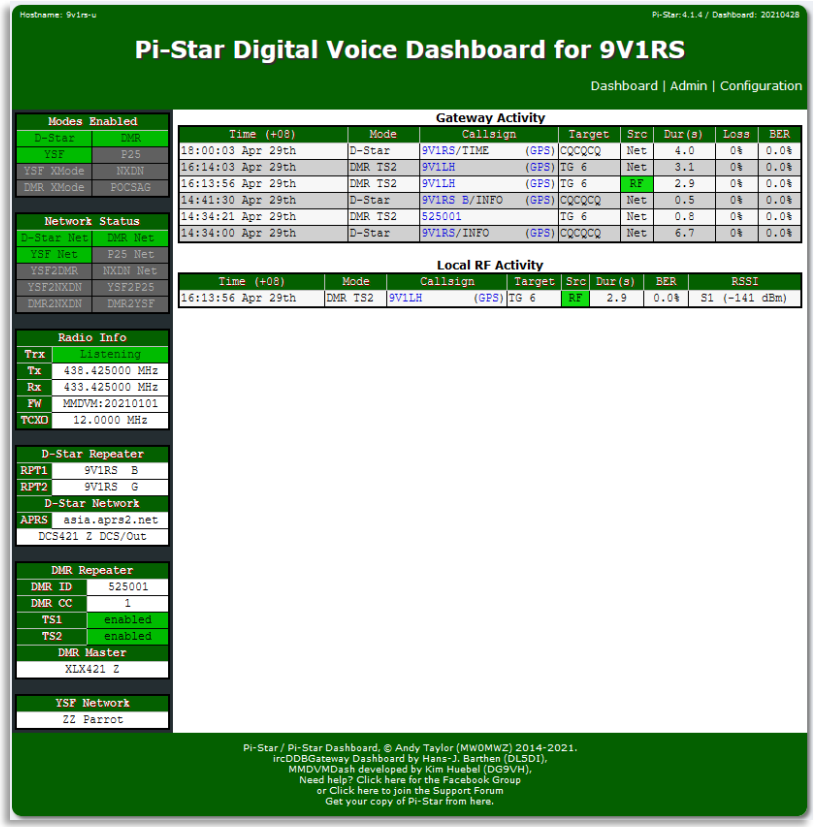
Enabled Modes

DMR | DMR Network | D-Star | D-Star Network | System Fusion | System Fusion Network | P25 | P25 Network | NXDN | NXDN Network

Last Heard List of today's 5 callsigns. Cached (0/194500)

10 Einträge anzeigen Suchen

Time (Asia/Singapore)	Mode	Callsign	Name	DSTAR-ID	Target	Source	Dur (s)	Loss	BER
2021-04-29 18:00:03	D-Star	9V1RS	---	TIME	CQCQCQ	Net	4.0	0%	0.0%



Hostname: 9v1rs-u Pi-Star: 4.1.4 / Dashboard: 20210428

Pi-Star Digital Voice Dashboard for 9V1RS

Dashboard | Admin | Configuration

Modes Enabled

D-Star	DMR
YSF	P25
YSF XMode	NXDN
DMR XMode	POCSAG

Network Status

D-Star Net	DMR Net
YSF Net	P25 Net
YSF2DMR	NXDN Net
YSF2NXDN	YSF2P25
DMR2NXDN	DMR2YSF

Radio Info

Trx	Listening
Tx	438.425000 MHz
Rx	433.425000 MHz
FW	MMDVM:20210101
TCXO	12.0000 MHz

D-Star Repeater

RPT1	9V1RS B
RPT2	9V1RS G

D-Star Network

APRS	asia.aprs2.net
	DCS421 Z DCS/Out

DMR Repeater

DMR ID	525001
DMR CC	1
TS1	enabled
TS2	enabled

DMR Master

XLX421 Z

YSF Network

ZZ Parrot

Gateway Activity

Time (+08)	Mode	Callsign	Target	Src	Dur(s)	Loss	BER
18:00:03 Apr 29th	D-Star	9V1RS/TIME (GPS)	CQCQCQ	Net	4.0	0%	0.0%
16:14:03 Apr 29th	DMR TS2	9V1LH (GPS)	TG 6	Net	3.1	0%	0.0%
16:13:56 Apr 29th	DMR TS2	9V1LH (GPS)	TG 6	RF	2.9	0%	0.0%
14:41:30 Apr 29th	D-Star	9V1RS B/INFO (GPS)	CQCQCQ	Net	0.5	0%	0.0%
14:34:21 Apr 29th	DMR TS2	525001	TG 6	Net	0.8	0%	0.0%
14:34:00 Apr 29th	D-Star	9V1RS/INFO (GPS)	CQCQCQ	Net	6.7	0%	0.0%

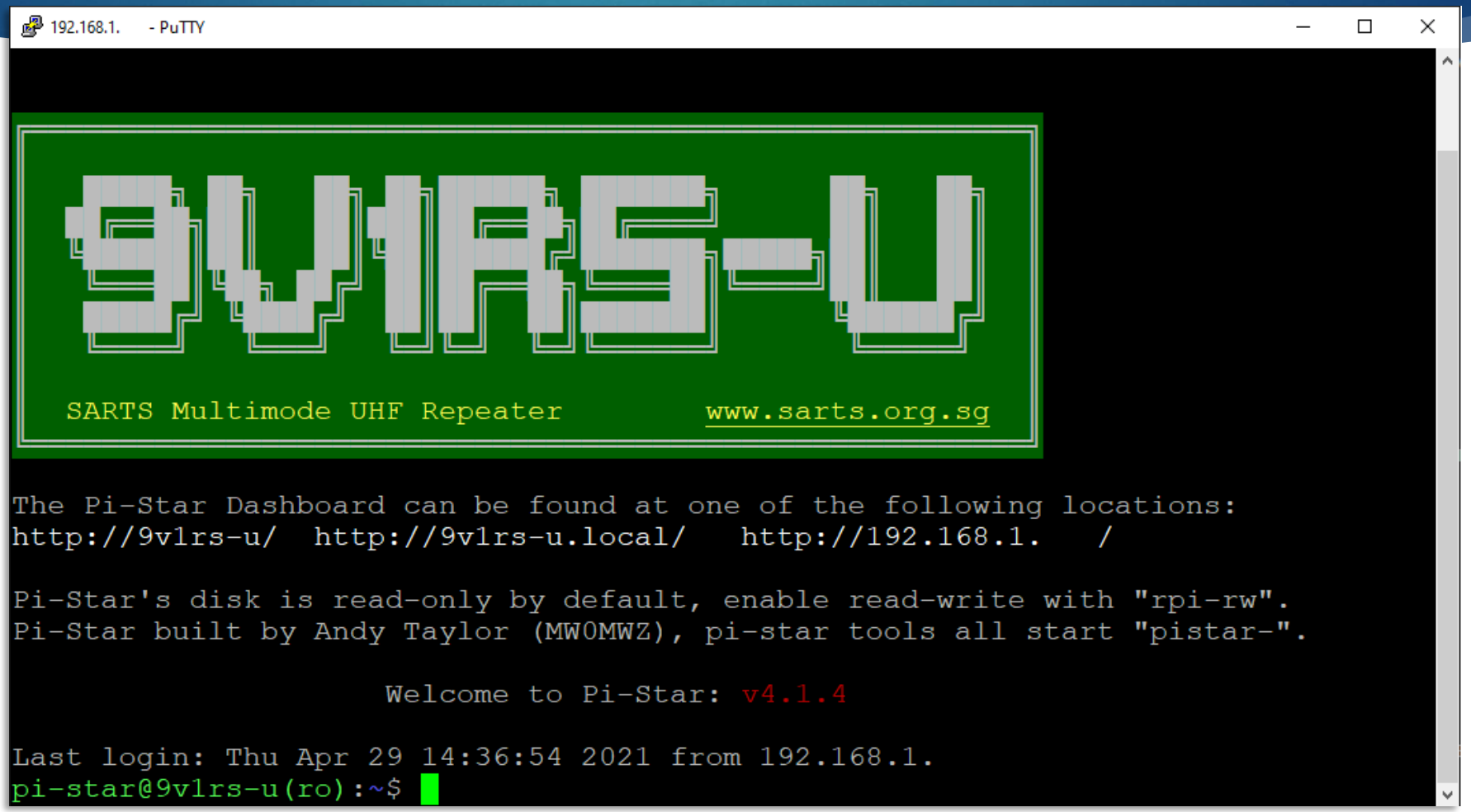
Local RF Activity

Time (+08)	Mode	Callsign	Target	Src	Dur(s)	BER	RSSI
16:13:56 Apr 29th	DMR TS2	9V1LH (GPS)	TG 6	RF	2.9	0.0%	S1 (-141 dBm)

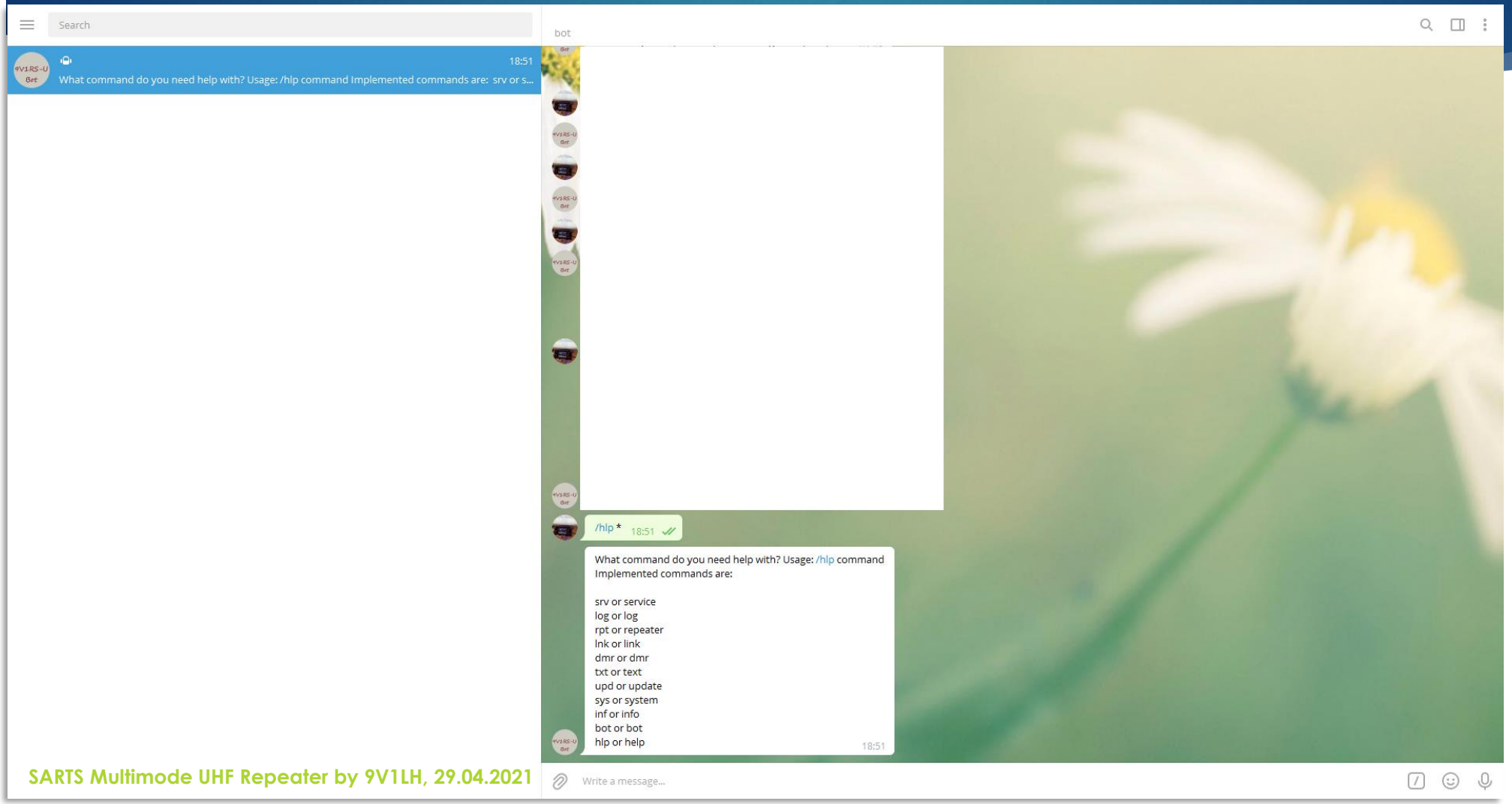
Pi-Star / Pi-Star Dashboard, © Andy Taylor (MW0MWZ) 2014-2021.
ircDDBGateway Dashboard by Hans-J. Barthen (DL5DI),
MMDVMDash developed by Kim Huebel (DG9VH),
Need help? Click here for the Facebook Group
or Click here to join the Support Forum
Get your copy of Pi-Star from here.

SARTS Multimode UHF Repeater by 9V1LH, 29.04.2021

Remote control: SSH



Remote control: Telegram Bot



Outlook

TO-DO LIST

FUTURE ENHANCEMENTS

To-Do list

- Software development
  - OS boot from USB3-Stick
  - Fan PWM control by BM280 reading
  - Driver for IC-FR6000 GPIO remote control
  - Driver for IC-FR6000 serial communication
  - TelegramBot: Adding additional features
- Hardware
  - RSSI adjustment
  - Design and print front fan funnel
- Documentation

Future enhancements

- Hardware:
  - Design and manufacture PCB to replace ICFR6000-Rmt RPi-Hat prototype board
  - Re-design mounting bracket and printing in ABS+ or ASA
  - Design and print holder for UHF cavity and cable protectors
- Software: Configure and calibrate additional modes
  - Analog / FM: Add EchoLink and/or Allstar
  - Digital: M17, NXDN, P25, POCSAG, AX25 (APRS)

! M17 is a open source digital voice codec by Wojciech SP5WWP[L2]. With a small hardware modification, Tytera MD-UV380 and similar radios can transmit and receive in M17 by using the OpenTRX[L3] firmware.

Contributors

- Emma XYL
- Bert DD5XL
  - Digital Input hardware modification
- Take JQ1SRN and Global ICOM support
  - Software activation of digital input
- Claudio 9V1AQ
  - OLED Mounting frame + 3D bracket print support

- Further more …
  - BI7JTA, 9V1AN, 9V1OG, 9V1HY, 9V1KB, 9V1AW

Sources

Documents and pictures:

- [1] Icom Inc., 2018-05, IC-FR5000/FR6000 Series Sales Handbook v1.0
- [2] Icom America Inc., 2019, FR5000 / FR6000 Configuration Guide

Internet links

- [L1] http://www.icomamerica.com/en/products/systems/IDAS/fr5000_fr6000/specifications.aspx
- [L2] https://github.com/sp5wwp
- [L3] https://openrtx.org/#/mduv380_mods

9V1LH

SINGAPORE
AMATEUR RADIO
STATION

Stephan
9V1LH / DG1BGS
qrz.com/db/9v1lh
dl-nordwest.com

Johor Straits Lighthouse,
Raffles Marina

SARTS Multimode UHF Repeater by 9V1LH,
29.04.2021

Op: Stephan • Loc: OJ11XJ • ITU Zone: 54 • CQ Zone: 28 • IOTA: AS-019