Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN
Technik & Architektur
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HSLU SPACE

Astrocast Transceiver and Rotator Remote Control Base

Specifications and Interface Description

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RECORD OF REVISIONS

ISS/REV	Date	Modifications	Created/modified by
0/8	10/08/2018	Initial release	Martin Klaper
0/9	12/08/2018	captions, config ctl, context diagram architecture & context	Martin Klaper
0/91	12/08/2018	Chapter numbering, screenshots added	Martin Klaper
0/92	15/08/2018	improved display for reservation state	Martin Klaper

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TABLE OF CONTENTS

REFERENCES

Applicable Documents

[A1] Groundstation HB9HSLU-V2.0, Martin Klaper, 07-SEP-2017, Astrocast meeting in Horw

[A2] 73-Astrocast-HSLU-Ground Station Description-2-3, 12-MAR-2018, Martin Klaper

[A3] Agenda Astrocast Meeting 19-JUNE-2018, Ecublens

[A4] Minutes of the meeting, 19-JUNE-2018, Florian George

References Documents

[R1] N. N. Ham Radio Control Libraries, version 3.0.1, 6 January 2016 [1]

[1] The GNU Lesser General Public License LGPL for the "front end" and "back end" library source code files, and the GNU General Public License GPL for the supplied programs source code files apply. Extracts from the hamlib manual are covered by the GNU Free Documentation License GFDL. Our software makes use of the unaltered HAMLIB library.

Typesetting conventions:

- Text is written in Calibri font.
- `Commands and responses are written in Courier New.`

List of figures

List of tables

LIST OF ACRONYMS

AZ	Azimuth
CAT	computer aided tuning
EGSE (router)	Electrical Ground Support Equipment
EL	Elevation
HSLU	Hochschule Luzern – Technik & Architektur
I/F	Interface
rig	transceiver
rot	Rot rotator (AZ/EL)
RX	Receiver
SCOE	Special Checkout Equipment
S Band	2.4 GHz Band
TRX	Transceiver, i. e. TX and RX
TX	Transmitter
UHF	Ultra High Frequency
VHF	Very High Frequency
VFO	Variable Frequency Oscillator

1. Introduction

This document describes the Astrocast's "Remote Ground Station Base" (RGSB). The Remote Ground Station Base (RGSB) constitutes a virtual **transceiver** and a virtual **rotator controller** with interlocking facilities. The current implementation instantiates Command and Control for

- One VHF/UHF transceiver[2]
- One VHF/UHF rotator controller AZ/EL

- One S-Band transceiver
- One S-Band rotator controller AZ/EL

The entity for the interlocking is either the VHF/UHF transceiver and VHF/UHF antenna rotator or the S-Band transceiver and S-Band antenna rotator as a compound unit. If the VHF/UHF transceiver consists of separate Uplink und Downlink Transceivers, both belong to the VHF/UHF entity.

This solution encapsulates transceivers and rotators by providing virtual transceivers and rotators.

The entries in the configuration file named "`GroundStation.exe.config`", which can be altered without recompiling the project, select the concrete transceiver and antenna rotator. After altering a transceiver or a rotator, a restart of the program "`GroundStation.exe`" is necessary. A list in the appendix shows all available concrete transceivers and rotators.

The "`GroundStationTransceiverController`" serves as a simple test environment and permits activation of all commands on a command line. A graphical user interface is not part of this project.

GroundStationTransceiverController and GroundStation communicate via an EGSE router.

This document summarizes all available commands and responses, which closely follow the Hamlib definition.

For test purposes a "`GroundStation.exe`" is running at HB9HSLU via the EPFL EGSE router.

[2] The VHF/UHF transceiver can optionally use two distinct radio devices, one for the uplink and another one for the downlink.

2. Functionality

Full remote control via the Electrical Ground Support Router (EGSE) infrastructure of up to three transceivers and up to two AZ/EL antenna rotators is required. This control software supports all common brands of ham radio transceivers and antenna controllers. The caller gets a response to issued commands. Depending on the type of radio, the scope of Computer Aided Tuning (CAT) is different. [3] The aim is to control all commands and responses that are possible for each specific type of radio. Changing a radio or a radio interface (RS-232, USB) requires a restart of the program at the premises of the ground station.

Commands for Locking / Unlocking (reservation of equipment)
Relating to the interlock concept there are two units, a VHF/UHF unit and an S-Band unit. Each of the unit is in one of the states *free* (green) or *occupied* (red). It is therefore possible to operate VHF/UHF and S-Band independently, e.g. for student's project work. The current state is graphically displayed at the groundstation. Remote station can check the current state. It is therefore necessary to request (and release) access to the equipment.

Commands to get access to the equipment (reservation of equipment) [4]

• "***requestVHFUHF***"
• "***releaseVFUHF***"
• "***requestSband***"
• "***releaseSband***"
• "***getReservationState***"

TABLE 1 COMMANDS FOR RESERVATION OF EQUIPMENT

[3] The original HAMLIB documentation lists restrictions for some brands of equipment. There are no restrictions known for the Kenwood TS-2000 and many others brands.
[4] All commands are case sensitive.

Commands to select devices (Selector for transceivers, rotators)

• ***"rigctlVHFUHF01:<command to transceiver[5]>"***
• ***"rigctlVHFUHF02:<command to transceiver>"***
• ***"rigctlSband:<command to transceiver>"***
• ***"rotctlVHFUHF:<command to rotator>"***
• ***"rotctlS-Band:<command to rotator>"***

TABLE 2 COMMANDS FOR SELECTION OF TRANSCEIVER OR ROTATOR (DEVICE SELECTOR)

[5] Commands and parameters: see next chapter

3. Commands and Parameters for transceivers

Commands and parameters are according to the following definition.

- Command short name (usually a single letter) is followed by the long name which is followed by any variable names (parameters).
- Some short commands are noted as hexadecimal digits due to the limitation of upper and lower case letters available. Use the associated long command name instead.
- While a comma is used to separate variable names in this document, they are not part of the command syntax used by rigctl. Use a space to separate values.
- In the case of "set" commands the variable name is replaced by the value in the description.
- Commands in **green** colour are often used basic commands.
- This list contains only a selection of commands in order to keep this description short. The HAMLIB documentation lists all commands.
- **Capitalized letters are set commands. Lower case letters are get commands.**

Short name, long name parameter(s)	comment
F, set_freq Frequency	**Set Frequency, in Hertz.**
f, get_freq	**Get Frequency, in Hertz.**

M, set_mode Mode, Passband	• Set Mode to one of: USB, LSB, CW, CWR, RTTY, RTTYR, AM, FM, WFM, … • Set Passband frequency in Hertz, or 0 for the Hamlib backend default • Passing a "?" (query) as the first argument instead of Mode will return a space separated list of radio backend supported Modes. Use this to determine the supported Modes of a given radio backend.
m, get_mode	Returns Mode as a string from set_mode above and Passband frequency in Hertz.

V, set_vfo VFO	Set VFO to one of: VFOA, VFOB, ….
v, get_vfo	Get current VFO.

T, set_ptt PTT	**Set PTT to one of: 0 (RX), 1 (TX), 2 (TX mic), 3 (TX data).**
t, get_ptt	**Get PTT status.**

I, set_split_freq Tx Frequency	**Set TX Frequency, in Hertz for "split" frequency operation.**
i, get_split_freq	**Get TX Frequency, in Hertz for "split" frequency operation.**

N, set_ts Tuning Step	Set Tuning Step, in Hertz.
n, get_ts	Get Tuning Step, in Hertz.

U, set_func Func, Func Status	Set Func, Func Status. • Func is one of: FAGC, NB, NR, AFC, SATMODE, … • Func Status argument is 1 for "activate", 0 for "deactivate. • Passing a "?" (query) as the first argument instead of Func will return a space separated list of radio backend supported "set" functions. Use this to determine the supported functions of a given radio backend.
u, get_func Func	Get Func Status.

L, set_level Level, Level Value	Set Level, Level Value. Level is one of: PREAMP, ATT, AF, RF, SQL, NR, RFPOWER, MICGAIN, AGC(0:OFF, 1:SUPERFAST, 2:FAST, 3:SLOW, 4:USER, 5:MEDIUM, 6:AUTO), SWR, ALC, ….
l, get_level Level	Get Level Value. The Level Value can be a float or an integer.

P, set_parm Parm, Parm Value	Set Parm, Parm Value • Parm is one of: ANN, **APO**, BACKLIGHT, BEEP, … Passing a "?" (query) as the first argument instead of Parm will return a space separated list of radio backend supported "set" parameters. Use this to determine the supported parameters of a given radio backend.
p, get_parm Parm	Get Parm Value. Returns Parm Value as a float or integer for the Parm passed. Parm is a token from the list in set_parm above

***, reset Reset**	**Perform rig Reset.** **0 = None, 1 = Software reset, 2 = VFO reset, 4 = Memory Clear reset, 8 = Master reset. Since these values are defined as a bitmask in rig.h, it should be possible to AND these values together to do multiple resets at once, if the backend supports it or supports a reset action via rig control at all.**

`0x87, set_powerstat` *Power Status*	Set power On/Off/Standby *Power Status*. `0` = Power Off, `1` = Power On, `2` = Power Standby.
`0x88, get_powerstat`	Get power On/Off/Standby *Power Status* as in `set_powerstat` above.

_, get_info	_ is underscore	Get misc information about the rig

1, dump_caps	Not a real rig remote command, it just dumps capabilities, i.e. what the backend knows about this model, and what it can do. This command will produce many lines of output so be very careful if using a fixed length array! For example, running this command against the Dummy backend results in over 5 kB of text output.

TABLE 3 DESCRIPTION OF COMMANDS FOR TRANSCEIVERS

4. Initial Setup parameters for transceiver

Caution: This suggestion is tentative and is subject to verification. [6]

Cold start procedure	Use of transceiver
1. Set power on 2. Reset all 3. Set VFO A 4. Set Mode to USB 2400 Hz 5. Set tuning step 10 Hz 6. Set Frequency 438abc MHz 7. Set VFO B (TRX 01) 8. Set Mode to USB 2400 Hz 9. Set tuning step 10 Hz 10. Set Frequency 145xyz MHz	1. Use Set Frequency to adjust for Doppler 2. Use get Frequency (maybe) 3. Use Set PTT [Data=3] (Push to Talk) for transmission.

These commands correspond to the above definitions and run with the virtual transceiver (m=1).

Cold start procedure, coded	Use of transceiver, coded
0. requestVHFUHF 1. rigctlVHFUHF1:set_powerstat 2. rigctlVHFUHF1:* 15 3. rigctlVHFUHF1:-V VFOA 4. rigctlVHFUHF1:-M USB 2400 5. rigctlVHFUHF1:-N 10 6. rigctlVHFUHF1:-F 438123456 7. rigctlVHFUHF1:-V VFOB 8. rigctlVHFUHF1:-M USB 2400 9. rigctlVHFUHF1:-N 10 10. rigctlVHFUHF1:-F 145876543	1. rigctlVHFUHF1:-F 438123987 2. rigctlVHFUHF1:-f 3. rigctlVHFUHF1:-T 3 99. releaseVHFUHF

[6] Depending on the reset state of the transceiver, additional setting may be necessary.

5. Commands and Parameters for rotators

Commands and parameters are according to the following definition.

- Command short name is followed by the long name which is followed by any variable names.
- While a comma is used to separate variable names in this document, they are not part of the command syntax used by rotctl. Use a space to separate values.
- In the case of "set" commands the variable name is replaced by the value in the description.
- In the case of "get" commands the variable name is the key name of the value returned.
- Commands in green colour are often used basic commands.
- This list contains only a selection of commands in order to keep this description short. The HAMLIB documentation lists all commands.
- **Capitalized letters are setters. Lower case letters are getters.**

P, set_pos Azimuth, Elevation	Set position: Azimuth and Elevation, double precision floating
p, get_pos	Get position: Azimuth and Elevation double precision floating

M, move Direction, Speed	• Move the rotator in a specific direction at the given rate. • Values are integers where Direction is defined as 2 = Up, 4 = Down, 8 = Left, and 16 = Right. Speed is an integer between 1 and 100. • Not all backends that implement the move command use the Speed [7]value.

S, stop	Stop the rotator.
K, park	Park the antenna.
R, reset Reset	Reset the rotator. Integer value of 1 for Reset All.
_, get_info // _ is underscore	Get misc information on the rotator. returns Model Name
w, send_cmd Cmd	Send raw command string to the rotator.

TABLE 4 DESCRIPTION OF COMMANDS FOR ROTATORS

[7] Probably unavailable for our rotator, but unchecked

6. Initial Setup parameters for rotators

Caution: This suggestion is tentative and is subject to verification. [8]

Cold start procedure	Use of rotator(s)
1. Reset 2. Park	1. Set Position AZ / EL

These commands correspond to the above definitions and run with the virtual rotator (m=1).

Cold start procedure, coded	Use of rotator(s), coded
0. requestVHFUHF // unless already done 1. rotctlVHFUHF:-R 2. rotctlVHFUHF:-K	1. rotctlVHFUHF:-P 303 45 2. rotctlVHFUHF:-P 304 47 3. rotctlVHFUHF:-P 305 49 4. and so on …….

[8] Depending on the reset state of the transceiver, additional setting may be necessary.

7. Configuration of Transceiver and Antennae Base

- These parameters are relevant only for ground station clients, i. e. for the location where the physical antennas, transceivers and rotators are located.
- It deals with the physical connections of transceivers and rotators
- It deals with the concrete transceiver type.
- For a complete list see the HAMLIB documentation.

Rig control		
Short form	**Long form**	**description**
-m	--model=id	Select radio model number. See model list (use rigctld –l)
-r	--rig-file=device	Often a serial port, but could be a USB to serial adapter. Typically /dev/ttyS0 or COM1 , COM2 , …
-s	--serial-speed=baud	Set serial speed to *baud* rate
-T	--listen-addr=IPADDR	Use *IPADDR* as the listening IP address / localhost
-t	--port=number	recommendation: even numbers for rig

Rot control		
Short form	**Long form**	**description**
-m	--model=id	Select rotator model number.
-r	--rig-file=device	Often a serial port, but could be a USB to serial adapter. Typically /dev/ttyS0 or COM1 , COM2 , …
-s	--serial-speed=baud	Set serial speed to *baud* rate
-T	--listen-addr=IPADDR	Use *IPADDR* as the listening IP address / localhost
-t	--port=number	recommendation: odd numbers for rot

TABLE 5 PARAMETERS FOR HAMLIB INVOCATION

Some examples of HAMLIB invocation parameters:

```
HamlibInvocationParametersTRX1 = "-m 1 -t 4534"  // dummy transceiver

HamlibInvocationParametersTRX2dummy = "-m 1 -t 4536"

HamlibInvocationParametersTRX2
                      = "-m 214 -r COM7 -s 9600 -C rts_state=ON -t 4536"  // TS-2000

HamlibInvocationParametersTRX_Sband_dummy = "-m 1 -t 4538"

HamlibInvocationParametersTRX_Sband
                           = "-m 214 -r COM99 -s 9600 -C rts_state=ON -t 4538"

HamlibInvocationParametersROT99 = "-m 1 -t 4535"    // dummy rotator

HamlibInvocationParametersROT1 = "–m 901 –r COM4 –s 115200 -t 4535"  // VHFUHF rotator

HamlibInvocationParametersROT_Sband_dummy = "–m 1 -t 4537"

HamlibInvocationParametersROT_Sband = "–m 901 –r COMx –s 115200 -t 4537"
```

	port number	COM port
VHFUHF transceiver 1	4534	COM7
VHFUHF transceiver 2	4536	tbd
VHFUHF rotators AZ/EL	4535	COM4
S Band transceiver [9]	4538	tbd
S Band rotator (dish) AZ/EL	4537	tbd

[9] It is desirable that the S-Band transceiver implements one of the common CAT protocols

8. Context and Architecture

HAMLIB offers an open source library for control of transceivers and rotators of almost any brand. The HAMLIB Core serves for transceivers (rigctl) or for rotators (rotctl) and is the base for remote controlling e. g. ground stations.

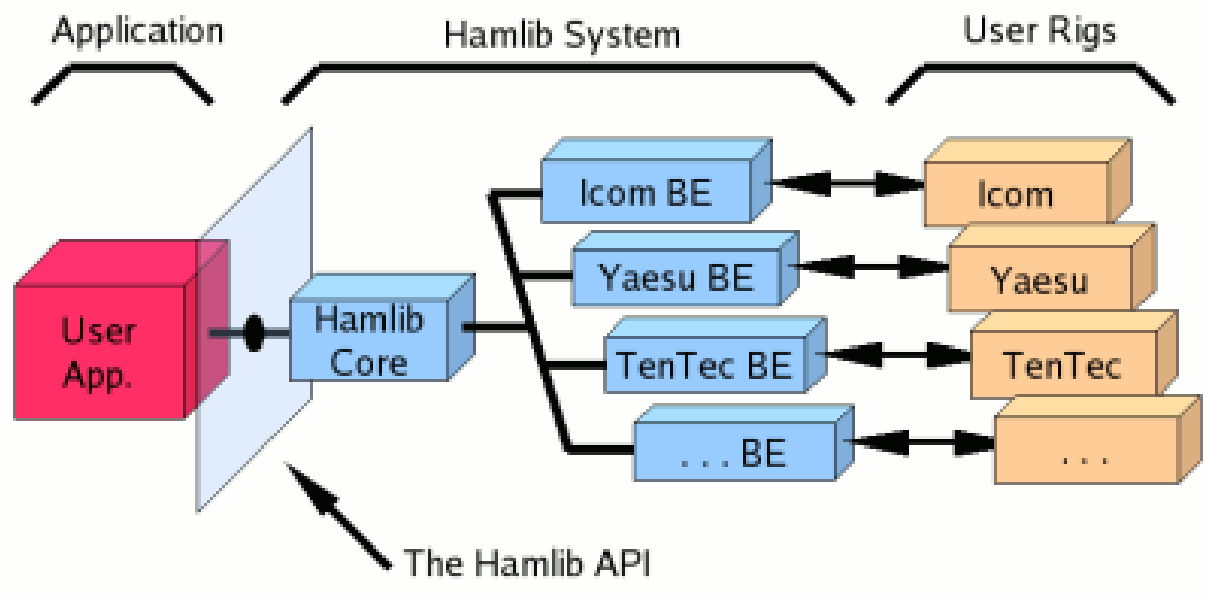

FIG 1 VIRTUALIZATION / ABSTRACTION OF TRANSCEIVERS AND ROTATORS

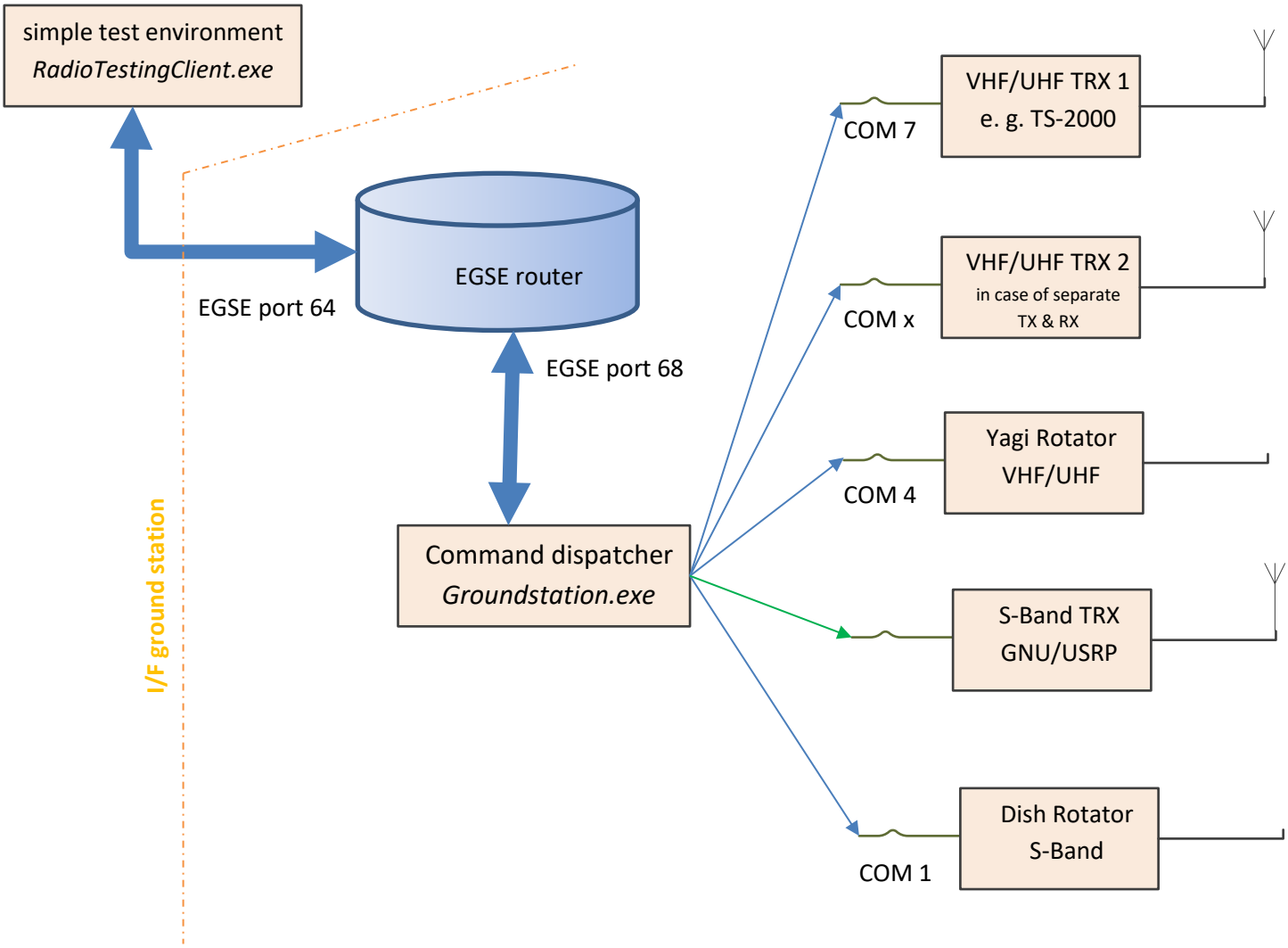

FIG 2 CONTEXT AND ARCHITECTURE DIAGRAM

9. **Appendix: Screenshots**

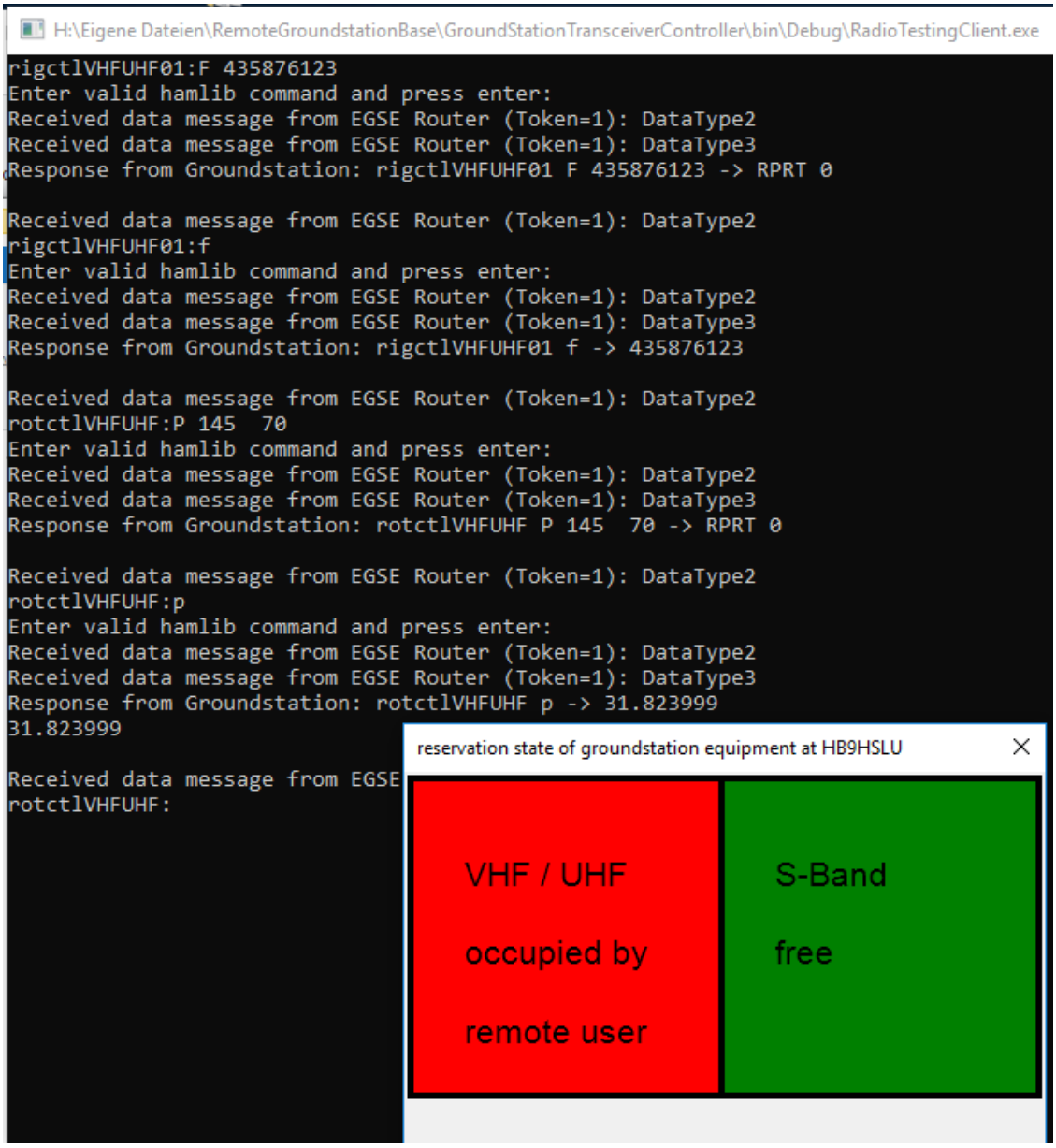

FIG 3 AT GROUNDSTATION: CONSOLE WINDOW & STATE DISPLAY

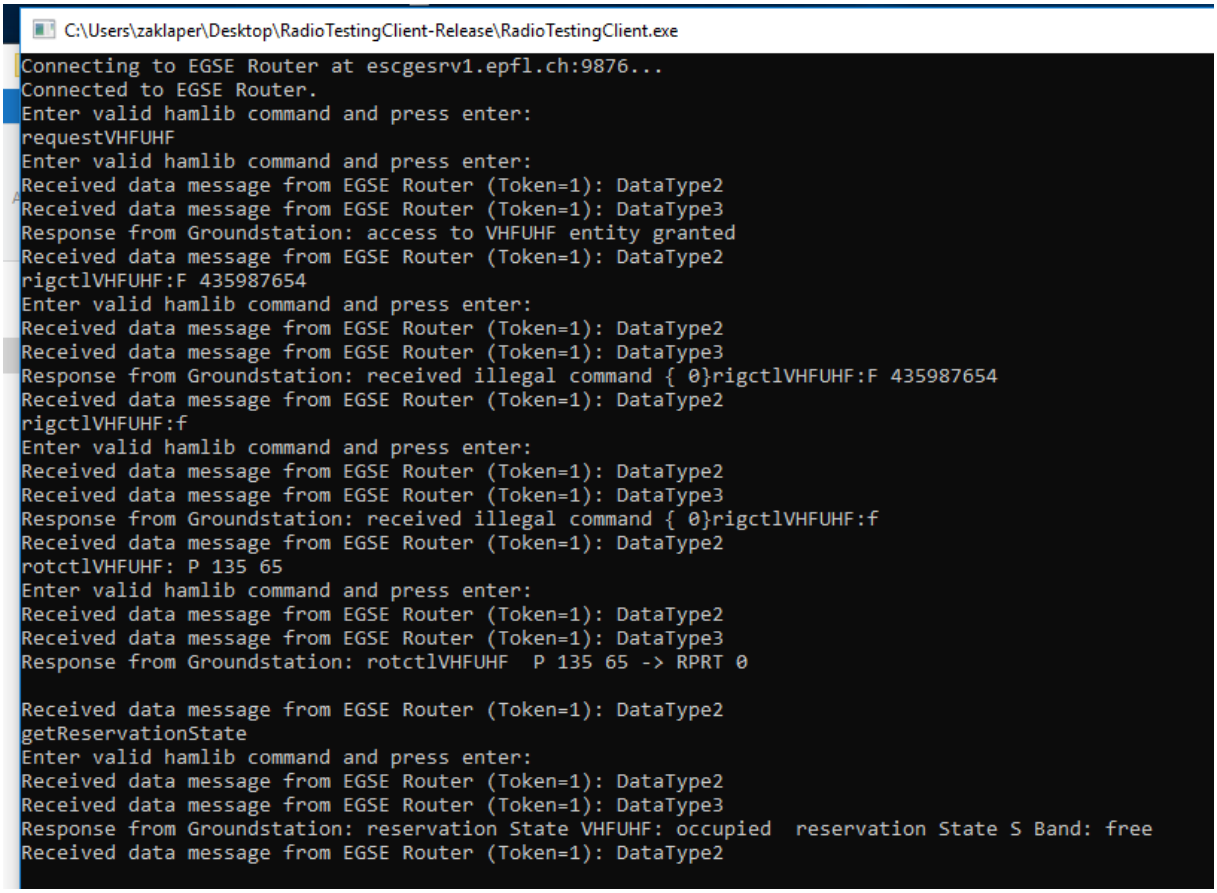

FIG 4 AT REMOTE LOCATION: TEST ENVIRONMENT

10. Appendix: Supported transceivers

Rig #	Manufacturer	Model
1	**Hamlib**	**Dummy**
2	Hamlib	NET rigctl
101	Yaesu	FT-847
103	Yaesu	FT-1000D
104	Yaesu	MARK-V FT-1000MP
105	Yaesu	FT-747GX
106	Yaesu	FT-757GX
107	Yaesu	FT-757GXII
109	Yaesu	FT-767GX
110	Yaesu	FT-736R
111	Yaesu	FT-840
113	Yaesu	FT-900
114	Yaesu	FT-920
115	Yaesu	FT-890
116	Yaesu	FT-990
117	Yaesu	FRG-100
118	Yaesu	FRG-9600
119	Yaesu	FRG-8800
120	Yaesu	FT-817
121	Yaesu	FT-100
122	Yaesu	FT-857
123	Yaesu	FT-897
124	Yaesu	FT-1000MP
125	Yaesu	MARK-V Field FT-1000MP
126	Yaesu	VR-5000
127	Yaesu	FT-450
128	Yaesu	FT-950
129	Yaesu	FT-2000
130	Yaesu	FTDX-9000
131	Yaesu	FT-980
132	Yaesu	FT-DX5000
133	Vertex Standard	VX-1700
134	Yaesu	FT-1200
135	Yaesu	FT-991

201	Kenwood	TS-50S
202	Kenwood	TS-440
203	Kenwood	TS-450S
204	Kenwood	TS-570D
205	Kenwood	TS-690S
206	Kenwood	TS-711
207	Kenwood	TS-790
208	Kenwood	TS-811
209	Kenwood	TS-850
210	Kenwood	TS-870S
211	Kenwood	TS-940S
213	Kenwood	TS-950SDX
214	**Kenwood**	**TS-2000**
215	Kenwood	R-5000
216	Kenwood	TS-570S
217	Kenwood	TH-D7A
219	Kenwood	TH-F6A
220	Kenwood	TH-F7E
221	Elecraft	K2
222	Kenwood	TS-930
223	Kenwood	TH-G71
224	Kenwood	TS-680S
225	Kenwood	TS-140S
226	Kenwood	TM-D700
227	Kenwood	TM-V7
228	Kenwood	TS-480
229	Elecraft	K3/KX3
230	Kenwood	TRC-80
231	Kenwood	TS-590S
232	SigFox	Transfox
233	Kenwood	TH-D72A
234	Kenwood	TM-D710
236	FlexRadio	6xxx
237	Kenwood	TS-590SG
238	Elecraft	XG3
239	Kenwood	TS-990s
302	Icom	IC-1275

303	Icom	IC-271
304	Icom	IC-275
306	Icom	IC-471
307	Icom	IC-475
309	Icom	IC-706
310	Icom	IC-706MkII
311	Icom	IC-706MkIIG
312	Icom	IC-707
313	Icom	IC-718
314	Icom	IC-725
315	Icom	IC-726
316	Icom	IC-728
319	Icom	IC-735
320	Icom	IC-736
321	Icom	IC-737
322	Icom	IC-738
323	Icom	IC-746
324	Icom	IC-751
326	Icom	IC-756
327	Icom	IC-756PRO
328	Icom	IC-761
329	Icom	IC-765
330	Icom	IC-775
331	Icom	IC-781
332	Icom	IC-820H
334	Icom	IC-821H
335	Icom	IC-970
336	Icom	IC-R10
337	Icom	IC-R71
338	Icom	IC-R72
339	Icom	IC-R75
340	Icom	IC-R7000
341	Icom	IC-R7100
342	Icom	ICR-8500
343	Icom	IC-R9000
344	Icom	IC-910
345	Icom	IC-78
346	Icom	IC-746PRO
347	Icom	IC-756PROII
351	Ten-Tec	Omni VI Plus
352	Optoelectronics	OptoScan535
353	Optoelectronics	OptoScan456

354	Icom	IC ID-1
355	Icom	IC-703
356	Icom	IC-7800
357	Icom	IC-756PROIII
358	Icom	IC-R20
360	Icom	IC-7000
361	Icom	IC-7200
362	Icom	IC-7700
363	Icom	IC-7600
364	Ten-Tec	Delta II
365	Icom	IC-92D
366	Icom	IC-R9500
367	Icom	IC-7410
368	Icom	IC-9100
369	Icom	IC-RX7
370	Icom	IC-7100
371	Icom	ID-5100
372	Icom	IC-2730
373	Icom	IC-7300
374	Microtelecom	Perseus
401	Icom	IC-PCR1000
402	Icom	IC-PCR100
403	Icom	IC-PCR1500
404	Icom	IC-PCR2500
501	AOR	AR8200
502	AOR	AR8000
503	AOR	AR7030
504	AOR	AR5000
505	AOR	AR3030
506	AOR	AR3000A
508	AOR	AR2700
513	AOR	AR8600
514	AOR	AR5000A
515	AOR	AR7030 Plus
516	AOR	SR2200
605	JRC	NRD-525
606	JRC	NRD-535D
607	JRC	NRD-545 DSP
801	Uniden	BC780xlt
802	Uniden	BC245xlt
803	Uniden	BC895xlt
804	Radio Shack	PRO-2052

806	Uniden	BC250D
810	Uniden	BCD-396T
811	Uniden	BCD-996T
812	Uniden	BC898T
902	Drake	R-8A
903	Drake	R-8B
1004	Lowe	HF-235
1103	Racal	RA6790/GM
1105	Racal	RA3702
1204	Watkins-Johnson	WJ-8888
1402	Skanti	TRP8000
1404	Skanti	TRP 8255 S R
1509	Winradio	WR-G313
1601	Ten-Tec	TT-550
1602	Ten-Tec	TT-538 Jupiter
1603	Ten-Tec	RX-320
1604	Ten-Tec	RX-340
1605	Ten-Tec	RX-350
1607	Ten-Tec	TT-516 Argonaut V
1608	Ten-Tec	TT-565 Orion
1609	Ten-Tec	TT-585 Paragon
1611	Ten-Tec	TT-588 Omni VII
1612	Ten-Tec	RX-331
1613	Ten-Tec	TT-599 Eagle
1701	Alinco	DX-77
1801	Kachina	505DSP
2201	TAPR	DSP-10
2301	Flex-radio	SDR-1000
2303	DTTS Microwave Society	DttSP IPC
2304	DTTS Microwave Society	DttSP UDP
2401	RFT	EKD-500
2501	Elektor	Elektor 3/04
2502	SAT-Schneider	DRT1
2503	Coding Technologies	Digital World Traveller
2506	AmQRP	DDS-60
2507	Elektor	Elektor SDR-USB
2508	mRS	miniVNA
2509	SoftRock	Si570 AVR-USB
2511	KTH-SDR kit	Si570 PIC-USB
2512	FiFi	FiFi-SDR
2513	AMSAT-UK	FUNcube Dongle
2514	N2ADR	HiQSDR
2515	Funkamatuer	FA-SDR
2516	AE9RB	Si570 Peaberry V1
2517	AE9RB	Si570 Peaberry V2
2518	**AMSAT-UK**	**FUNcube Dongle Pro+**
2701	Rohde&Schwarz	ESMC
2702	Rohde&Schwarz	EB200
2801	Philips/Simoco	PRM8060
2901	ADAT www.adat.ch	ADT-200A
3001	Icom	IC-M700PRO
3002	Icom	IC-M802
3003	Icom	IC-M710

TABLE 6 SUPPORTED TRANSCEIVERS

11. Appendix: Supported rotators

Rig #	Manufacturer	Model	Used at
1	Hamlib	Dummy	
2	Hamlib	NET rotctl	
201	Hamlib	EasycommI	
202	Hamlib	EasycommII	
204	Hamlib	EasycommIII	
301	XQ2FOD	Fodtrack	
401	Idiom Press	Rotor-EZ	
402	Idiom Press	RotorCard	
403	Hy-Gain	DCU-1/DCU-1X	
404	DF9GR	ERC	
405	Green Heron	RT-21	
501	SARtek	SARtek-1	
601	Yaesu	GS-232A	
602	Yaesu/Kenpro	GS-232	
603	Yaesu	GS-232B	
604	F1TE	GS232/F1TE Tracker	
701	WA6UFQ	PcRotor	
801	Heathkit	HD 1780 Intellirotor	
901	**SPID**	**Rot2Prog**	**HB9HSLU**
902	SPID	Rot1Prog	
1001	M2	RC2800	
1101	EA4TX	ARS RCI AZ&EL	
1102	EA4TX	ARS RCI AZ	
1201	AMSAT	IF-100	
1301	LA7LKA	ts7400	
1401	Celestron	NexStar	
1501	DG9OAA	Ether6 (via ethernet)	
1601	CNCTRK	CNCTRK	
1701	Prosistel	Prosistel D	

TABLE 7 SUPPORTED ROTATORS