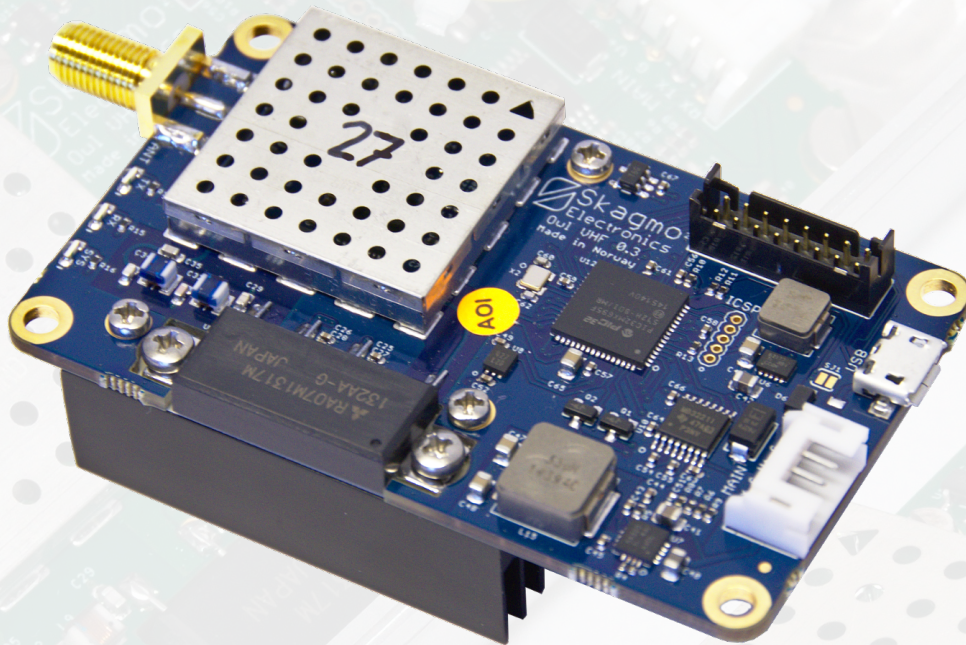

Owl VHF

High performance radio transceiver
Manual for firmware 0.3.8



 Skagmo
Electronics

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1 Getting started

The board layout is shown below. The minimum connections are a 50 ohm antenna to the ANT connector, 9-16 VDC power supply between V+ and G on the MAIN connector, as well as RS-232 communication (38400 baud 8N1 as default) on MAIN connector (Port 0).

Two additional serial ports are available on the EXPANSION connector, but these operate at 3.3 V and not +/- 12 V as the RS-232-level port 0.

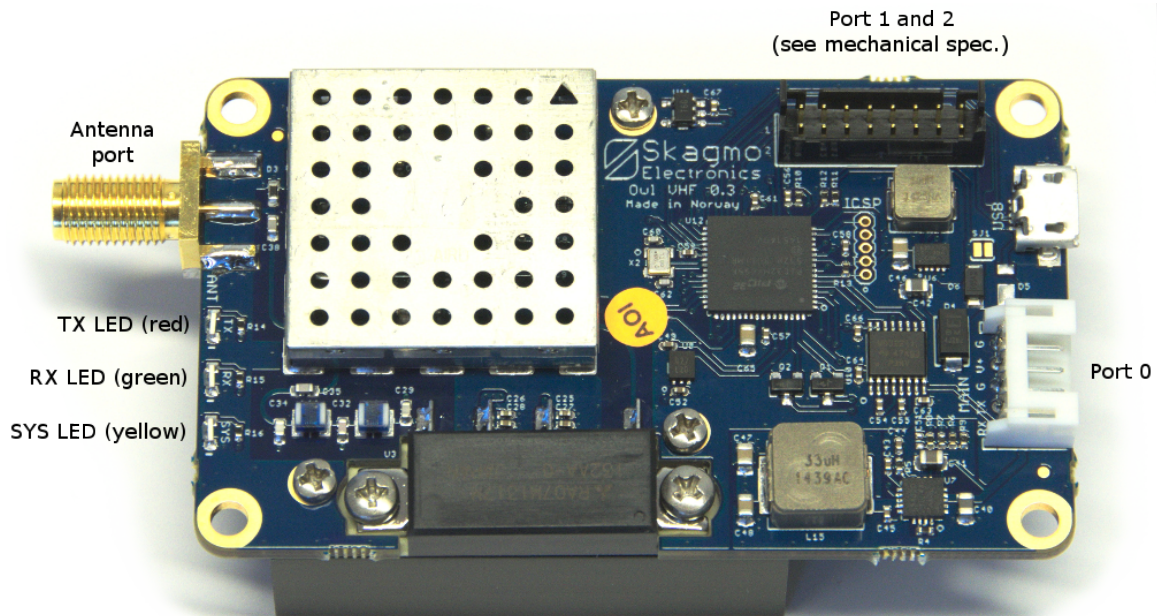


Figure 1: Board layout

When you start the Owl, its SYS-LED will light solid for 3 seconds then repeatedly blink a short blink followed by a one second delay, indicating a successful startup and that the radio is receiving. A double blink indicates that the radio has synchronized its local time to either a GNSS-receiver (connected by cable) or another Owl radio (over the air).

1.1 Configuration example

After startup, a command line interface is available on port 0 as default. You will need a computer running a serial terminal at this point. In Windows, try PuTTY. For full details, see the separate chapter regarding the menu system, but for now let's try some commands to send some FM-modulated voice samples:

Please note the following conventions:

Text	Command sent to radio
Text	Command from radio
[enter]	Carriage return, line feed or both
[crlf]	Carriage return and line feed
[tab]	Tabulator character
[space]	Space character
[ctrl]+C	Hold Control and press C

freq 14550000[enter]	Set frequency to 145.5 MHz
freq 145550000 ok[crlf]	Radio confirms new frequency
mode voice[enter]	Set radio mode to voice
mode voice ok[crlf]	
pac0 text[enter]	Set serial port packet protocol on port 0 to text
pac0 text ok[crlf]	
set[enter]	Apply port settings (serial port will now accept text data)
123[enter]	FM voice is now transmitted at 145.5 MHz (TX LED is lighting up)
[ctrl]+C	Exit text packer and go back to command input

2 Bootloader (firmware upgrade and factory reset)

The Owl comes with a built in bootloader for upgrading the firmware through port 0. Software can be downloaded from skagmoelectronics.com to load new firmware. This comes in three variants; uploader.py, which is a command line utility for firmware upgrade, gui-uploader.py, which is a graphic version, and gui-uploader.exe, which is a Windows executable. After connecting power to the Owl, the yellow SYS LED is constantly lit. This means the Owl is ready to connect to the bootloader on port 0. If no bootloader connects within three seconds, the Owl will do a self check and boot the radio firmware. To do a firmware upgrade, start the GUI-uploader, select a firmware file (.bin-extension) and serial port. Click Connect, then apply power to the Owl. The program should immediately connect and make the Owl ready to receive an update within the three second timeout. Click Flash to start the upgrade process, and finally click Run app. to start the new application. If you somehow lock yourself out from the command system on the Owl, you can restore the factory settings by sending a simple command. You will not use the bootloader application for this. This is done by sending exactly three plus-characters (“+++”) to the bootloader at 115200 baud within the three second timeout after powering on the Owl. A message will be sent back to the terminal acknowledging the reset.

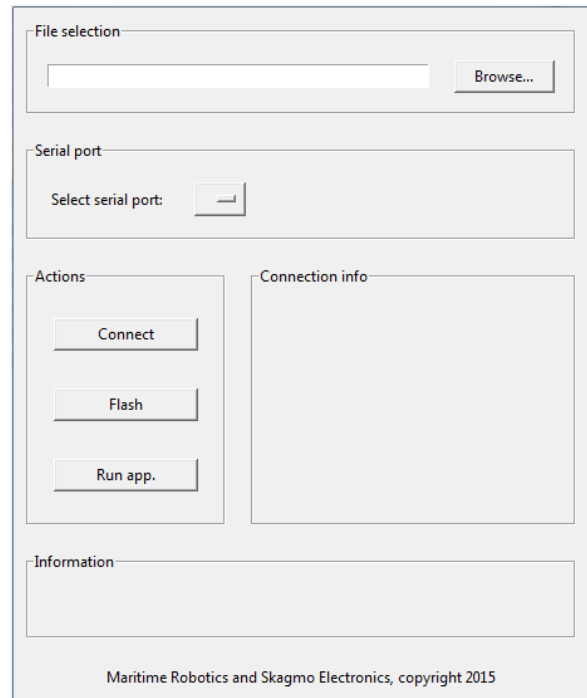


Figure 2: Bootloader

3 Command line menu system

The Owl features a comprehensive CLI (command line interface) for setting and reading parameters. It supports autocompleting in a known fashion. A single press on the tabulator button autocompletes the command as much as possible, and a double press lists all possible options. The special "help"-command will list all possible input if run alone, and will list all possible input for a given command if you type "help" followed by a command name. To see all possible commands, "[tab][tab]" and "help[enter]" does the same:

```
[tab][tab]
[crlf]access, baud0, baud1, bias-rx, cfg-def, cfg-save, cw-wpm, echo, fm- emphasis, freq, help, lna,
mice-cmt, mice-int, mode, pac0, pac1, portset, power, preamb, restart, stat-int, tdma-tper, tdma-
tslots, tdma-offset, tdma-guard, tnc2- dest, tnc2-path, tnc2-src, tow-rel, verbose[crlf]
```

To see possible parameters for a given command, autocompletion and help behaves a little different. First let's see what autocompletion will do:

```
mo[tab]
mode
[space][tab][tab]
[crlf]ais, ax25-1k2, ax25-9k6, cw, ngham, test, voice[crlf]
>mode[space]
n[tab]
>mode ngham
[enter]
[crlf]mode ngham ok[crlf]
>
```

Then using help and no autocompletion:

```
help mode[enter]
[crlf]help mode enum (ais, ax25-1k2, ax25-9k6, cw, ngham, test, voice)[crlf]
mode ngham[enter]
[crlf]mode ngham ok[crlf]
```

3.1 Serial port settings (menu items “pacN”, “baudN” and “set”)

Name	Description	Syntax
none	Disable this port. Always set an unused port to this mode to prevent noise from being interpreted as commands or data.	
aivdm	Used with Automatic Identification System. Encoded VDM NMEA-message.	\$AIVDM...[crLf]
cmd	Use port for command line menu system.	freq 144800000[enter] freq 144800000 ok[crLf]
kiss	Widely used transparent amateur radio host protocol.	http://www.ax25.net/kiss.aspx
ngham-spp	Structured protocol to allow both commands and data without escaping/states. See separate NGHAM protocol description document on https://github.com/skagmo/ngham/tree/master/documentation .	[start][crc0][crc1] [type][length>Hello
nmea	Use this port as an input for a GPS capable of sending GPRMC or GPGGA NMEA messages. Remember to set correct baud rate as well.	\$GPGGA...[crLf]
tnc2	The well known TNC2 style formatting of AX25-packets.	LA3JPA>LA1K>Hello [crLf]
text	Simply type in any data and terminate the string with "[enter]". Data received is terminated with "[crLf]". Somewhat like TNC2, but without the AX25 header. The text-packer can also parse certain escape sequences. "\t" = temperature, "\v" = voltage, "\h" = GPS HDOP.	Hello[enter] Hi there[crLf]
transp	Transparent mode: Data received on the serial port of the transmitting radio is buffered until a timeout (specified with “transp-time”) or maximum packet size is reached, then it is packed and sent. The exact same data is sent out on the serial port of the receiving radio.	

3.2 Radio operating modes (menu item “mode”)

The menu item “mode” defines the RF physical layer (modulation, forward error correction etc.) to the layer just below the serial port protocol (with some exceptions). By typing “help mode[enter]” the radio will return a list of possible modes. A quick description of the modes are shown below.

Name	Description	Technical details
ais	Automatic Identification System, RX only. Use with packer "AIVDM" and on frequencies 161.975 MHz and 162.025 MHz.	9600 sym/s 2-GMSK, bt=0.5, HDLC-coding.
ax25-1k2	1200 baud AX.25. A popular amateur radio mode used for APRS (144.800 MHz in Europe, 144.390 MHz in USA) and much more.	1200 sym/s 2-AFSK (FM-modulated FSK), HDLC-coding.
ax25-9k6	9600 baud AX.25. Not so widely used – mostly for satellite operation and some ground based packet nodes.	9600 sym/s 2-GFSK, 3 KHz deviation, K9NG scrambler polynomial, HDLC-coding.
cw	Morse code generator, TX only. Input ASCII text, for example with the text-packer.	
ngham	High performance FEC-protocol, suggested for amateur radio as well as other use. See separate NGHAM protocol description document on https://github.com/skagmo/ngham/tree/master/documentation .	9600 sym/s (default), GMSK, bt=0.5, short preamble, sync word correlator, lexicode size tag, Reed Solomon FEC code block. Max. 220 byte payload. Sensitivity below -120 dBm. See details in appendix A.
test	Generates a PN9 test sequence (pseudorandom number generator), and measures bit error rate in reception. Not finished.	
voice	Some pre-recorded voice samples played back in narrow band FM. TX only. Input ASCII text, for example with the text-packer.	

3.3 Channel access (menu items "access", "tdma-*")

The channel access method determines how the radio will go into transmission when it has data to send. In other words, it is the method used to determine if the channel is busy or free. A proper channel access method is crucial to avoid collisions between multiple radio nodes, and the Owl has three different methods which can be selected with the "access"-command.

Name	Description	Technical details
csma-pkt	Carrier Sense Multiple Access, packet state	The channel is considered free when receiver is not busy decoding a packet.
csma-rssi	Carrier Sense Multiple Access, packet- and RSSI state	The channel is considered free when receiver is not busy decoding a packet and the signal strength is 5 dB above the noise floor.
tdma	Time Division Multiple Access	Transmission is purely based on time. Each node will transmit in it's own dedicated time slot, which theoretically eliminates collisions and gives an extremely predictable throughput for each node. For many nodes and short packets, this will allow much better channel utilization than CSMA.

The TDMA method has quite a few dedicated commands:

Name	Description	Technical details
tdma-frame	Time in milliseconds for the whole TDMA frame.	
tdma-guard	Guard time after transmission, in milliseconds.	Some "dead-time" is needed between time slots to deal with non-perfect time synchronization, signal propagation time, and to allow a node to ramp down it's transmitter before the next node will access the channel.
tdma-offset	Selects time slot relative to the start of the period.	An offset of 0 means the node is using the first time slot in the frame. An offset of $\text{tdma-slots} - 1$ means the node is using the last slot.
tdma-slots	Number of slots in a whole frame.	
tdma-strrch	Allows "stretching" transmission over multiple time slots.	A stretch value of 2 means the radio will occupy two successive time slots.
tdma-tohloc	Time reference for TDMA will be based on local node uptime rather than GPS-referenced time of hour.	In the case where no radios are equipped with a GNSS-receiver, this command allows one node to provide a common time reference based on local uptime rather than absolute time of hour. If a node with a GNSS-receiver (and actual time of hour) enters the same network, all nodes will choose to adjust their timeframe to actual time of hour, including the one originally configured to use its local uptime as timing reference.

See the following figure for some examples on how to configure the TDMA system:

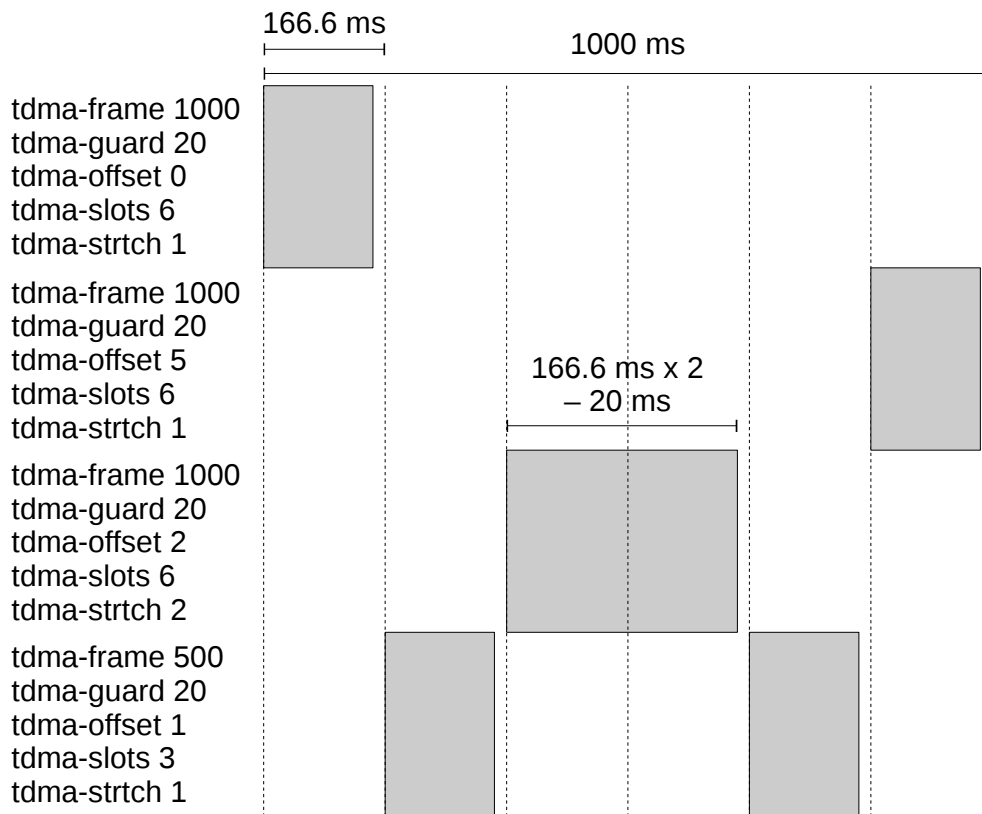


Figure 3: TDMA configuration examples

4 Advanced configuration examples

4.1 APRS

APRS is a popular positioning system used by amateur radio operators. A typical configuration will be like shown below. All commands should be succeeded by [enter].

```
freq 144800000
mode ax25-1k2
access csma-pkt
pac0 tnc2
set
```

Packets should now be printed on the TNC2-format as they are received.

4.2 NGHAM with TDMA and packer "transparent"

This is an advanced example for a robust and completely transparent link with injected statistics packets (contains a time stamp used for TDMA synchronization between nodes), but with a delay

up to one second due to the use of TDMA. All commands should be succeeded by [enter].

```
mode nghan
access tdma
pac0 transparent
stat-int 10      Inject statistics packet to sent data every 10 second
tdma-frame 1000 TDMA frame time 1000 ms
tdma-guard 10   Guard interval between time slots is 10 ms
tdma-offset 0   Select first slot in frame
tdma-slots 2
tdma-strrch 1
tdma-tohloc 1   Select this as the timing reference in the network – must send stat packets
set
```

Before the “set”-command, “cfg-save” could have been used to make the settings permanent and load immediately after a power cycle. Be careful though, as the transparent packer has no escape sequence. This means you are effectively locked out from the menu system unless you connect to one of the other ports on the Owl or do a factory reset on port 0. This procedure is described in the bootloader-chapter.

The next node in the same system should be configured similarly, but with “tdma-offset 1”, to use slot 2/2 in this TDMA-network, and not “tdma-tohloc 1”, as this will cause confusion when two nodes try to be the time reference in the network.

4.2.1 Using with Pixhawk

The Owl can be used as a telemetry radio for eg. Pixhawk, but it is important to ensure the telemetry rates are low enough to prevent overflow.

A few different ground control applications have been tested, and APM Planner is the recommended software to use as of today. Mission Planner and QGroundControl can not be used as they tend to increase telemetry rates under various conditions, whereas APM planner is consistent and will hold its settings. Go to “CONFIG/TUNING”, “APM Planner 2.0 Config”, “Advanced”, and set “Attitude”, “Position” and “Status/Mode” to 1 Hz (all else should be 0).

For this example, connect port 2 (3.3 V UART) on the Owl’s black expansion connector to the Pixhawk telemetry port 2, and configure Pixhawk with BRD_SER2_RTSCCTS as 0 and SERIAL2_BAUD as 38. It is now assumed that the command line interface is available on port 0 (“pac0 cmd”). Use port 0 (RS-232) on the Owl’s white main connector to connect a terminal and set the following settings:

```

freq 144925000    For use on amateur radio frequency 144.925 MHz
power mid
modulation 2-9600 4-9600 could be used for increased throughput
pac1 none        Always set unused ports to none to prevent false commands from being entered
pac2 transparent
baud2 38400
transp-time 50
stat-int 5       Inject statistics packet to sent data every 5 seconds
tdma-frame 1000  TDMA frame time 1000 ms
tdma-guard 10    Guard time between time slots is 10 ms
tdma-offset 0    Select first slot in frame
tdma-slots 3     Three slots in total
tdma-strtch 2    Use two consecutive slots
tdma-tohloc 0
cfg-save
set

```

On the ground side, the RS-232 port (port 0) is typically used for GCS communication. A separate serial port can be used for the command line interface as done on the airplane side, but it is also possible to configure the port and then switch to transparent mode.

```

freq 144925000
power mid
modulation 2-9600
pac1 none
baud2 38400
transp-time 50
stat-int 5
tdma-frame 1000
tdma-guard 10
tdma-offset 2    Select third slot in frame
tdma-slots 3
tdma-strtch 1
tdma-tohloc 1    Use local uptime as timing reference in this network
cfg-save         Save at this point...
pac0 transparent ...then switch packer to transparent on port 0
set

```

A reset will be necessary to enable the command line interface on port 0. It is possible to save configuration after setting the packer as transparent, but take caution as this will render the command

line interface inaccessible on this port. A configuration reset will then be necessary as explained in the separate bootloader chapter.

In APM Planner, go to "Tool Widgets", "MAVLink Inspector", and check that 10 messages are coming in at 1 hz. Transmitting parameters will take a while (typically 2 minutes), and they should be sent at about 5 Hz.

5 Full command list

Name	Description	Example
access	Select channel access method (how the radio goes into transmission on a shared channel). See separate chapter.	<code>access csma-rssi[enter]</code>
baudN (0-2)	Set baud rate of serial port N.	<code>baud0 9600[enter]</code>
bias-rx	Keep the power supply for the PA drain active during RX to get slightly faster RX to TX turnaround time on expense of higher RX power consumption. (PA gate will not be biased in RX, so the difference is small).	<code>bias-rx 1[enter]</code>
cfg-def	Load default "factory configuration" immediately. Will not overwrite saved configuration in flash and will only last until next power cycle.	<code>cfg-def[enter]</code>
cfg-save	Save current configuration to flash to make it load after power loss or a forced reboot.	<code>cfg-save[enter]</code>
cw-wpm	Set the keying speed for mode cw in words per minute.	<code>cw-wpm 15[enter]</code>
echo	Enable local echo and auto completion on the command line interface.	<code>echo 1[enter]</code>
fm-emphasis	Enable pre-emphasis on FM-modulated modes (AX25_1K2 and VOICE).	<code>fm-emphasis 1[enter]</code>
freq	Set operating frequency in hertz.	<code>freq 144800000[enter]</code>
help	Display available parameters and parameter type for one of the other command items.	<code>help freq[enter]</code>
kiss-smack	If set to "1", packer KISS will add a checksum according to the SMACK standard (Stuttgart Modified Amateurradio-CRC-KISS). Received KISS data will need a valid CRC to be accepted.	<code>kiss-smack 1[enter]</code>
mice-cmt	Comment field for the MIC-E protocol. Escape sequences such as used with the text-packer are valid.	<code>mice-cmt Testing Owl VHF. Voltage=\v.[enter]</code>
mice-cmtint	Comment interval in number of MIC-E-packets. For example, a value of 3 will send a comment with each third MIC-E-packet.	<code>mice-cmtint 3[enter]</code>
mice-int	Transmission interval in seconds for MIC-E protocol.	<code>mice-int 120[enter]</code>
mice-msg	Specifies the MIC-E message, from 0-7. These are Off duty, En route, In service, Returning, Committed, Special, Priority, Emergency.	<code>mice-msg 0[enter]</code>
mode	Radio operating mode / physical layer. See separate chapter.	<code>mode nghan[enter]</code>

modulation	NGHam modulation format. On the form "x-y", where "x" is bits per symbol and "y" is the symbol rate	modulation 2-9600[enter]
pacN (0-2)	Set packer / serial port protocol. See separate chapter.	pac0 ax25-1k2[enter]
power	Set power level in one of three steps. Low (0.2 W), mid (1 W) or hi (5 W).	power mid[enter]
preamb	Set length of preamble in bytes. Only valid for AX.25-modes.	preamb 50[enter]
restart	Make the radio do a restart immediately.	restart[enter]
set	Apply serial port settings (pacX and baudX). Not running this command after setting packer will allow configuration to be saved. Also serves the same purpose as the "CONVERSE" command in TNC2-modems. See separate chapter.	set[enter]
stat-int	Set interval in seconds for transmitting statistics packet as defined in the NGHAM extension protocol. Interval 0 is off.	stat-int 10[enter]
tdma-*	TDMA-related settings. See channel access chapter.	
tnc2-dest	Destination field for protocols TNC2 and MIC-E.	tnc2-dest APRS[enter]
tnc2-path	Path field for protocols TNC2 and MIC-E.	tnc2-path WIDE2-2[enter]
tnc2-src	Source field for protocols TNC2 and MIC-E.	tnc2-src LA3JPA-9[enter]
transp-time	Timeout before data will be sent using the transparent packer.	transp-time 100[enter]
verbose	Verbose level for messages printed on ports configured for cmd packer.	verbose 5[enter]

6 Pinout list

Table 2: Expansion connector (mates with Hirose DF11-16DS-2C)

GND	2	1	Port 1 RX, 3.3 V
(GPIO)	4	3	Port 1 TX, 3.3 V
(GPIO)	6	5	(reserved UART RX or SDA)
Port 2 RX, 5 V tolerant	8	7	(reserved UART TX or SCL)
Port 2 TX, 3.3 V	10	9	(GPIO)
3.3 V out	12	11	(GPIO)
DC in	14	13	DC in
GND	16	15	GND

Table 3: Main connector (mates with JST PHR-5)

1	Port 0 RX, RS-232 level
2	Port 0 TX, RS-232 level
3	GND
4	DC in
5	GND

Table 4: Professional version connector (mates with male DE-9 connector)

Port 2 TX	1	6	DC in
Port 0 TX, RS-232 level	2	7	(reserved)
Port 0 RX, RS-232 level	3	8	(reserved)
Port 2 RX, 5 V tolerant	4	9	GND
GND	5		

7 Other

The noise floor on the Owl is generally very low, but the internal 40 MHz oscillator is present in the received signal at multiples of 40 MHz. In other words there exists a birdie at 160 MHz in the reception range of the Owl VHF which has a power level of approximately -105 dBm.