Subnero Underwater Modem
User Manual

M25M series

WNC-M25MSN3, WNC-M25MSS3, WNC-M25MSE3

v1.1

May 25, 2019

Contents

CHAPTER 1

The Modem

1.1 Introduction

The software-defined Subnero underwater modem provides a flexible platform for a variety of underwater networks and applications. With substantial computing power packed into a compact form factor, users are able to implement and deploy complex algorithms in the modem, hence allowing robust communication between underwater nodes as well as driving the innovation of new protocols and applications. The modem provides options for customization and extension at many levels, allowing network protocols as well as physical layer algorithms to be implemented and tested easily.

Subnero modems are available in 3 different configurations for various deployment scenarios:

1.1.1 Node configuration

In this configuration, the modem includes a battery pack, a pressure housing and can be deployed to operate in a standalone mode, i.e., without any external supply. This configuration is ideal for cases such as; the modem used as navigational beacon, modem with external sensors etc.

Figure 1.1: Node Configuration

1.1.2 Surface configuration

In surface configuration, the modem is deployed from the surface (of a barge/boat etc.) and is usually connected to the user's computer/machine or a terrestrial network for the user to communicate with other modems that are deployed in the waterbody (e.g. bottom mounted nodes, autonomous underwater vehicles (AUVs) etc.)

Figure 1.2: Surface Modem Deployment

1.1.3 Embedded configuration

This configuration is used to embed/integrate the modem to a bigger platform such as an AUV and depends on the platform to which it is integrated to, for its power, pressure housing etc.

Figure 1.3: Embedded Configuration

1.2 Technical Specifications

Edition	Silver Edition		
Configuration	**Surface**	**Node**	**Embedded**
Model number	WNC-M25MSS3	WNC-M25MSN3	WNC-M25MSE3
Data rate	Up to 15 kbps (depending on channel conditions and reliability requirements)		
Operating range	3-5 km (nominal, depending on channel conditions)		
Ranging precision	0.1 m		
Doppler resilience	±4 knots or better		
Modulation (software defined)	PSK-OFDM, FH-BFSK		
FEC (Forward Error Correction)	LDPC, up to 1/6th rate code		
Software framework	UnetStack3 (www.unetstack.net)		
Software interface	UnetStack3 (Java, Groovy, Python, C, Matlab, Javascript), interactive web UI, JSON/TCP		
Hardware interface	Ethernet, power		
Transducer beam pattern	Omnidirectional		
Carrier frequency	24 kHz		
Bandwidth	18 kHz (18 - 36 kHz)		
Source level	185 dB re 1 µPa @ 1 m rms (nominal)		
Power consumption	< 4 W (receive mode, nominal) < 60 W (transmit mode, avg.) < 80 W (transmit mode, max.)		
Power source	External power: 22-28 V DC (24 V DC recommended)	1.5 V D size battery x 16*	External power: 22-28VDC (24VDC recommended)
Operating depth	100 m (Aluminium hull)		2000 m (Transducer depth rating)
Dimensions	⌀ 127 x 280 mm	⌀ 127 x 700 mm	⌀ 104 x 147 mm
Weight (in air)	4.0 kg	6.0 kg (without batteries)	1.0 kg
Weight (in water)	- 1.0 kg	- 0.5 kg	n/a
JANUS compatibility	Yes, subject to operating frequency band		
Wake up module	Included (Ethernet)		
Onboard storage	32 GB		
Arbitary waveform transmission & reception	Included		
Qualification testing	Not available		
	Optional upgrades		
Low drift clock	OCXO (25 ppb)		
Hull	Stainless steel, delrin		n/a
Depth rating	up to 2000 m		
Additional storage	up to 1 TB		
Additional coprocessor	Available		
Additional interface support	USB, I2C (for external sensors), RS232		
	Accessories		
Data & power cable	25 m underwater cable	5 m underwater cable	1 m Ethernet, power & transducer
Mounting clamps	Optional	2x recommended	n/a

Figure 1.4: Technical specifications of node, surface and embedded configuration of modems.

CHAPTER 2

Modem Operations

2.1 Node configuration

The standard node configuration ships with power and communication cable to be used to power up and configure the modem prior to deployment.

There are various types of cables that ship with the node configuration modem:

1. Lab Cable - This cable is not underwater rated and can only be used in dry areas (e.g. Laboratory, deck of boat, etc.)
2. Underwater Power Cable - This cable is underwater rated and can be used to externally power the modem.
3. Underwater Ethernet Cable - This cable is underwater rated and will turn on the modem when the batteries are inserted. It can be used to connect to the modem when it has been deployed.

Figure 2.1: Underwater cable

If unsure of the cable, check the shipping contents at the front of the documentation packet or contact Subnero.

One end of the cable is a bulkhead connector used to connect to the modem and the other end is terminated with Ethernet (RJ45) connector and power terminal (banana plugs). The node configuration also comes with an ON/OFF key for powering up the modem during deployment.

2.1.1 Powering up the modem using external power supply

(a) Connect the cable bulkhead connector to the modem's bulkhead connector.

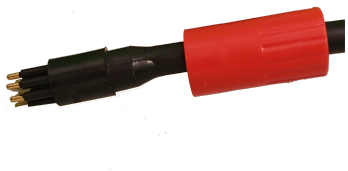


Figure 2.2: Cable bulkhead connector.

(b) Connect the power cable to 24 V power supply. Limit the current to a maximum of 3.5 A.

Figure 2.3: Power and ethernet connector.

(c) Connect the Ethernet connector to the user's computer (in internet sharing mode) or a network that has a DHCP server (e.g. router). The modem expects a DHCP server to assign an IP address to it (e.g. connect it to a wireless router that runs a DHCP server).

(d) Switch on the power supply.

(e) Find the IP address assigned to the modem from the DHCP server. The MAC address of the modem's Ethernet interface is located on the modem's hull.

(f) Once the IP address is listed, the modem is ready to use.

2.1.2 Powering up the modem using internal battery pack

(a) After installing the batteries (see section 2.1.4 for how to complete this), connect the ON/OFF key to the bulkhead of the modem.

Figure 2.4: ON/OFF key.

(b) Modem will boot up using supply from the battery pack. This method is typically used for deployment.

2.1.3 Connecting to the modem

(a) Once the IP address of the modem is identified, open an internet browser in a computer.

(b) Type the IP address of the modem in the address bar and hit enter.

(c) The browser will load the landing page of the modem's web interface.

2.1.4 Inserting and changing batteries

The node configuration's battery compartment is pressure sealed. The web interface displays the battery voltage. Once the battery voltage falls below a certain threshold (differs between various battery chemistries, check the battery's specifications), user should replace the battery pack as listed below:

(a) Battery compartment can be accessed from the top of the mechanical hull by 4 Phillip's head screws.

Figure 2.5: Battery compartment end cap.

Figure 2.6: Battery compartment and o-ring.

(b) Remove each screw.

(c) To seal the end cap, an o-ring sits between the cover and the hull. This should be greased between uses and the o-ring should be checked for debris.

(d) The cable connecting the power and ethernet to the modem runs through the battery compartment. Special care should be taken while handling the end cap in order to avoid strain on the cables.

(e) Remove two thumb screws holding the lid on the battery casing.

Figure 2.7: Battery compartment.

(f) Remove old batteries from compartment.

(g) Install new batteries.

(h) Replace lid, taking care to apply even pressure across the surface.

(i) Check o-ring for damage or debris and apply grease if needed.

(j) Coil wire back up and slot into cable hole, if required.

(k) Close the end cap and fasten with the 4 screws.

(l) Connect the cable or key, power up the modem, launch the web interdace and verify the battery voltage.

2.1.5 Deployment of modem

Below is a rough guideline that the user may follow before deployment of the modem:

(a) Install new set of batteries.

(b) Power up the modem using external cables provided.

(c) Connect to the modem using a computer and open the web interface.

(d) Add one or multiple sleep-wakeup schedules based on the deployment scenario.

(e) Power off the modem and remove the external cable.

(f) Connect the modem ON/OFF key to the modem bulkhead connector.

(g) Deploy the modem in the designated area.

(h) The modem will power up, ready to transmit and receive based on the schedules set by the user.

NOTE: In case the user would like to add/modify/delete a schedule or a configuration parameter after the modem is powered down, simply power on the modem using the external cable. After the modem boots up, it waits for 5 minutes for a user input. If no input is received and if there is a sleep schedule configured, the modem will enter sleep state.

2.1.6 Deploying modem with clamp

The modem ships with a clamp used for deployment. Below is the steps to attach the clamp to the modem:

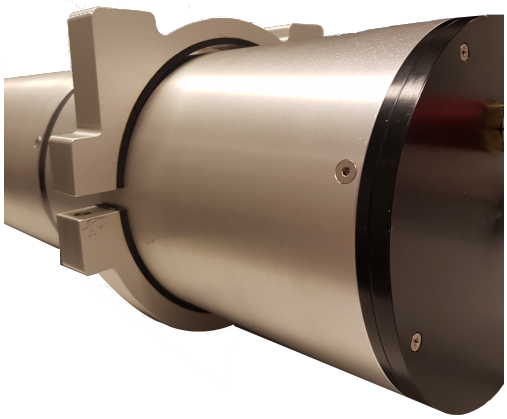
(a) Each clamp consists of two c-shape parts, two eye bolts with nuts and two M8 size bolts (see Fig. 2.8a).

(b) Align each c-shape component around the modem (see Fig. 2.8b).

(c) Screw in each bolt, taking care to tighten each side equally (see Fig. 2.9a).

(d) If not already done so, screw each eye bolt with nuts into the top of the clamp (see Fig. 2.9b).

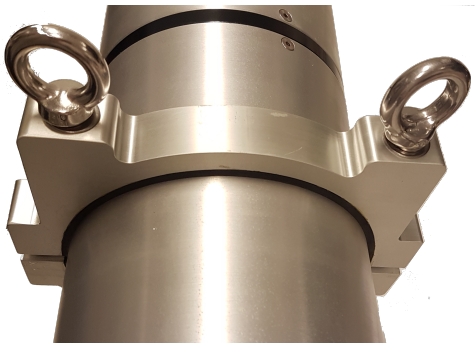
(a) Deconstructed clamp.



(b) Aligning clamp.

Figure 2.8

(a) Fastened clampa



(b) Clamp with eye bolt and nuts .

Figure 2.9

Once complete, modem is ready to be attached to a rope and deployed.

2.2 Surface configuration

2.2.1 Powering up the modem

Refer to 2.1.1.

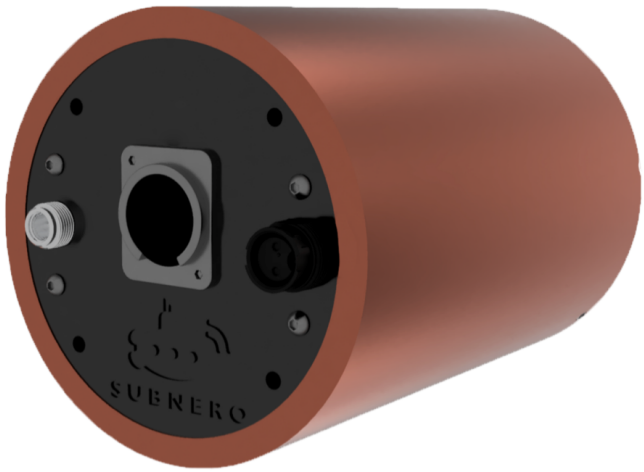


Figure 2.10: Embedded configuration.

2.2.2 Connecting to the modem

Refer to 2.1.3.

2.3 Embedded configuration

The embedded configuration, shown in Fig. 2.10, is designed to be installed into a larger platform such as an AUV. The following sections detail how to power, connect and deploy this configuration.

2.3.1 Powering up the modem

The modem can be powered up with an external lab cable. Once the modem is installed, power is supplied from the platform's power supply. The modem can be connected to via an ethernet cable, which is terminated with RJ45 on both ends. The acoustic transducer can be connected directly to the end cap.

WARNING: DO NOT power up the modem without connecting the transducer.

For details on the cables mentioned above, refer to Appendix 1.

To power on the EC:

a) Connect all cables mentioned above.

b) Connect the power cable to 24 V power supply. Limit the current to a maximum of 3.5 A.

c) Connect the Ethernet connector to the user's computer (in internet sharing mode) or a network that has a DHCP server (e.g. router). The modem expects a DHCP server to assign an IP address to it (e.g. connect it to a wireless router that runs a DHCP server).

d) Switch ON the power supply.

e) Find the IP address assigned to the modem from the DHCP server. The MAC address of the modem's Ethernet interface is located on the modem's hull.

f) Once the IP address is listed, the modem is ready to use.

WARNING: The modem is meant to be operated underwater. It is NOT recommended to transmit signals while in air. However, if the user has to transmit it air, set the transmit power level to -35dB or lower.

2.3.2 Connecting to the modem

Refer to Section 2.1.2.

2.3.3 Mounting to the modem

Refer to Appendix 1 for details on how to mount the modem.

Refer to Appendix 2 for details on how to mount the transducer.

CHAPTER 3

Web Interface

All Subnero underwater acoustic modems ship with a web interface that users can use to operate or configure the modem. Once the modem is powered up and connected to a network or user's computer, open a web browser and type the IP address and hit enter. The user will see the landing page of the modem's web interface as shown below:

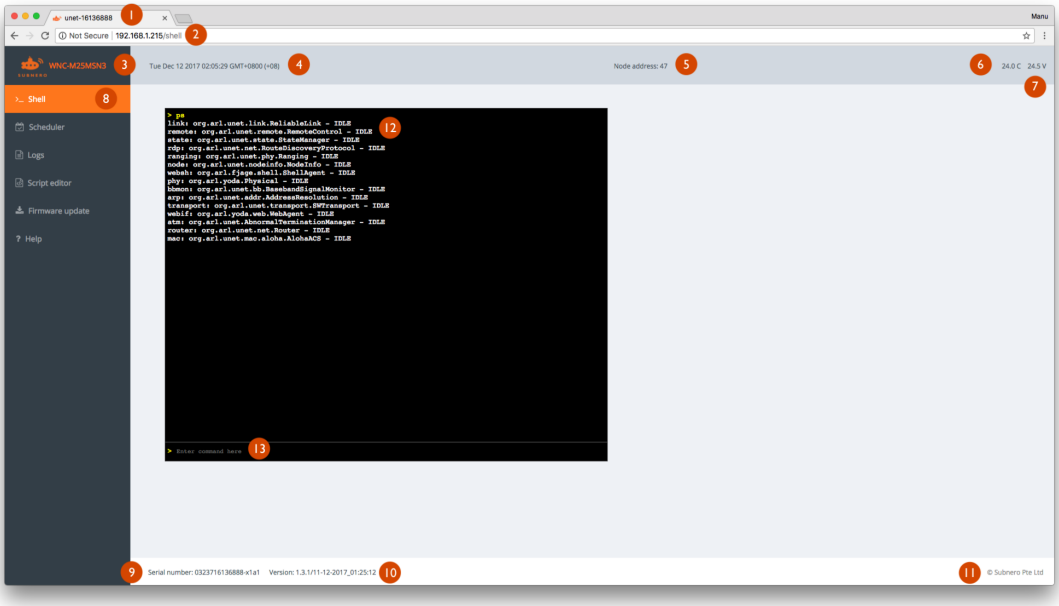


Figure 3.1: Modem Landing Page

1. Modem name.
2. IP address.
3. Model number.
4. Current date and time (shown in local timezone). Modem's internal time is

maintained in UTC.

5. Node address (For acoustic interface).
6. Internal temperature.
7. Battery voltage (for node configuration) NOTE: For other configurations such as surface or embedded, this setting is not applicable.
8. Navigation menu: Various modem functionalities such as shell, scheduler etc. are listed here.
9. Serial number.
10. Software version.
11. Vendor information.
12. Shell display window.
13. Command line, where the user types various commands.

3.1 Shell

The shell provides the primary user interface to interact with the modem. A user can enter commands to transmit or receive packets, signals or configure the modem using various commands. Most of the modem operations are executed using shell commands.

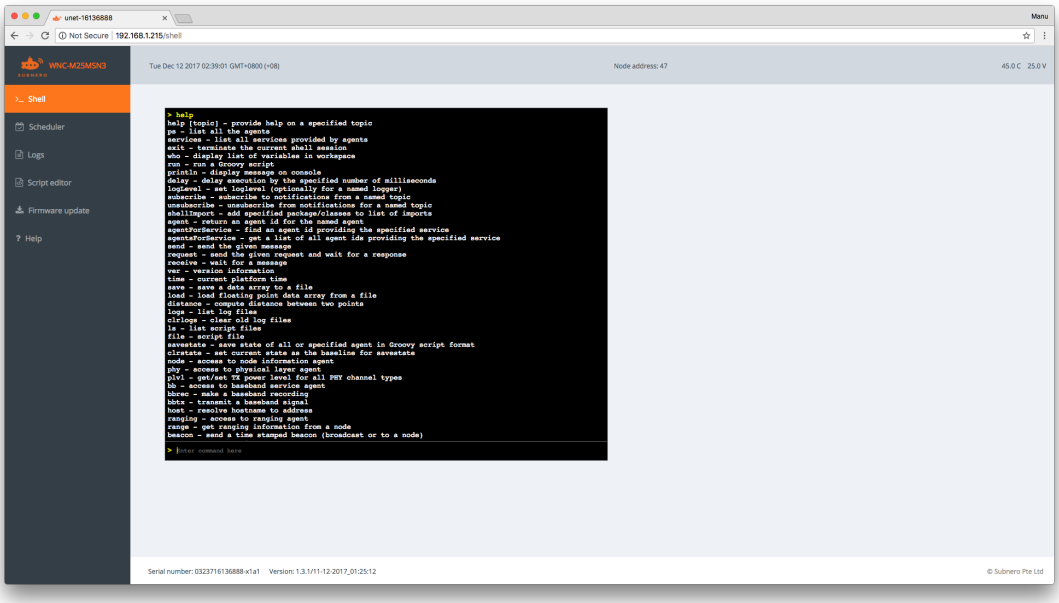


Figure 3.2: Help Command

The modem's shell is provided by the standard Groovy command line utility. The command "help" lists out most of the major user commands.

```
> help
help [topic] - provide help on a specified topic
ps - list all the agents
services - list all services provided by agents
exit - terminate the current shell session
who - display list of variables in workspace
run - run a Groovy script
println - display message on console
delay - delay execution by the specified number of milliseconds
logLevel - set loglevel (optionally for a named logger)
subscribe - subscribe to notifications from a named topic
unsubscribe - unsubscribe from notifications for a named topic
shellImport - add specified package/classes to list of imports
agent - return an agent id for the named agent
agentForService - find an agent id providing the specified service
agentsForService - get a list of all agent ids providing the specified service
```

```
send - send the given message
request - send the given request and wait for a response
receive - wait for a message
ver - version information
time - current platform time
save - save a data array to a file
load - load floating point data array from a file
distance - compute distance between two points
logs - list log files
clrlogs - clear old log files
ls - list script files
file - script file
savestate - save state of all or specified agent in Groovy script format
clrstate - set current state as the baseline for savestate
node - access to node information agent
phy - access to physical layer agent
plvl - get/set TX power level for all PHY channel types
bb - access to baseband service agent
bbrec - make a baseband recording
bbtx - transmit a baseband signal
host - resolve hostname to address
ranging - access to ranging agent
range - get ranging information from a node
beacon - send a time stamped beacon (broadcast or to a node)
mac - access to MAC agent
link - access to link agent
transport - access to transport agent
abort - abort all transport datagram transfers
router - access to routing agent
routes - print routing table
addroute - add a route to the routing table
delroute - delete a route from the routing table
delroutesto - delete all routes to specified node from the routing table
delroutes - delete all routes from the routing table
rdp - access to route discovery protocol agent
rreq - initiate route discovery
```

```
trace - trace route
remote - access to remote agent
rnode - to create proxy of remote node
tell - send a text message to another node
fput - transfer a file to a remote node
fget - transfer a file from a remote node
addsleep - schedule sleep and wakeup of the modem
showsleep - shows sleep/wakeup schedule
rmsleep - removes sleep/wakeup schedule
reboot - restart network stack
selftest - run diagnostics
fan - cooling fan control
```

The command "ps" lists all the current running processes.

```
> ps
link: org.arl.unet.link.ReliableLink - IDLE
remote: org.arl.unet.remote.RemoteControl - IDLE
state: org.arl.unet.state.StateManager - IDLE
rdp: org.arl.unet.net.RouteDiscoveryProtocol - IDLE
ranging: org.arl.unet.phy.Ranging - IDLE
node: org.arl.unet.nodeinfo.NodeInfo - IDLE
websh: org.arl.fjage.shell.ShellAgent - IDLE
phy: org.arl.yoda.Physical - IDLE
bbmon: org.arl.unet.bb.BasebandSignalMonitor - IDLE
arp: org.arl.unet.addr.AddressResolution - IDLE
transport: org.arl.unet.transport.SWTransport - IDLE
webif: org.arl.yoda.web.WebAgent - IDLE
atm: org.arl.unet.AbnormalTerminationManager - IDLE
router: org.arl.unet.net.Router - IDLE
mac: org.arl.unet.mac.aloha.AlohaACS - IDLE
```

NOTE: The output of these commands may change depending on the modem configuration and software version. Please refer to the "help" command for more details. Most parameters can be read from and written to. However, some commands are readonly. If a user attempts to write to readonly parameter, it will return an error message. An example is given below.

```
> phy.MTU
13
> phy.MTU=17
org.arl.unet.UnetException: Parameter MTU could not be set [empty response]
```

Any configuration changes are not retained unless the user stores them using the "savestate" command. If the changes are not saved, the settings will revert back to factory default after power cycling the modem.

```
> savestate
AGREE
```

NOTE: The "savestate" script file will be listed under the scripts page. It contains the changes that are saved. User can choose to modify the file directly using the script editor.

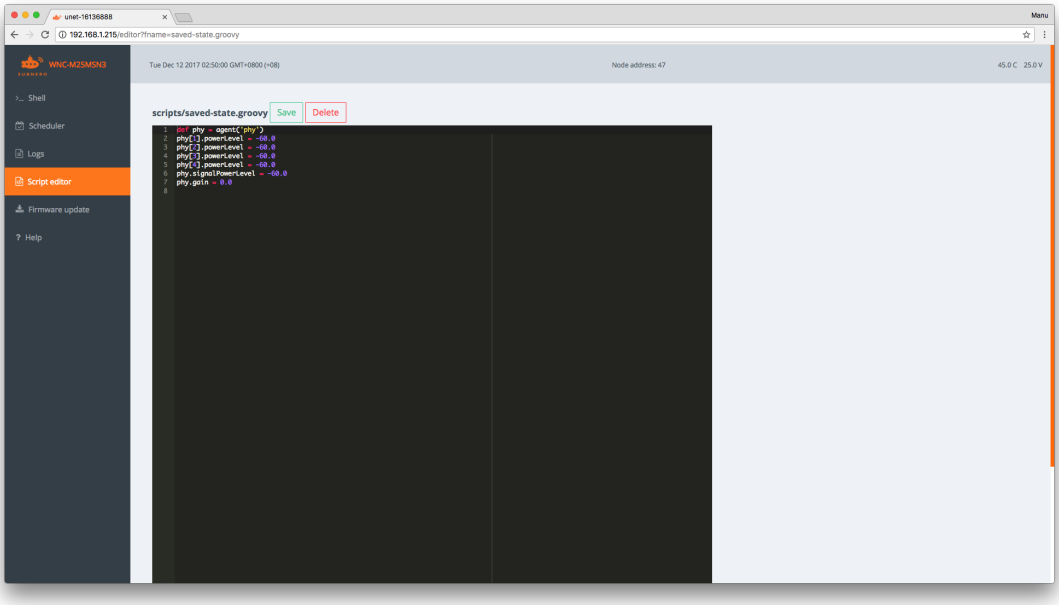


Figure 3.3: saved-state.groovy file

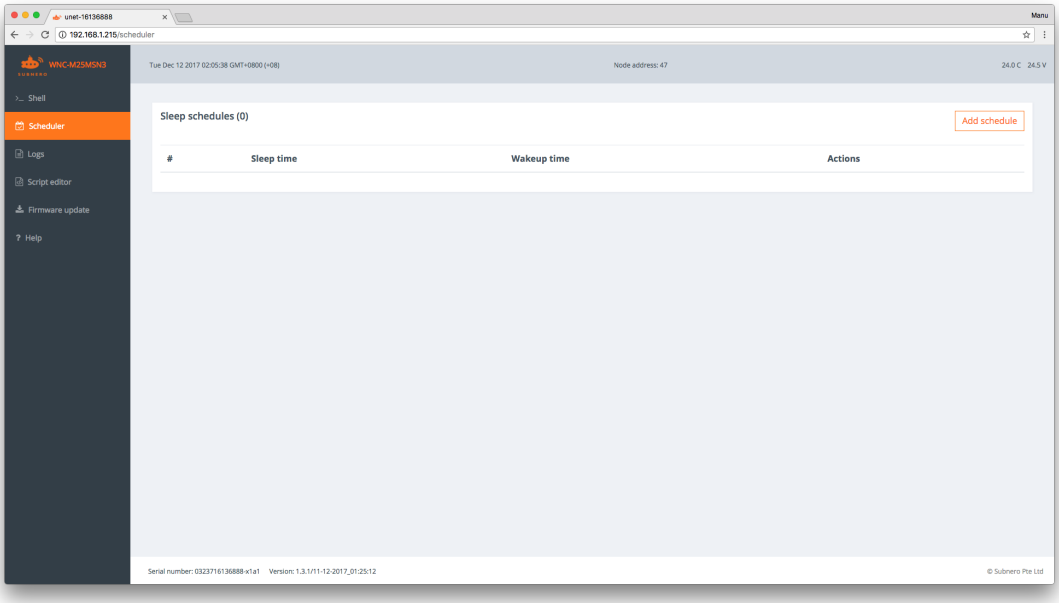
For details on various shell commands, refer to UnetStack documentation at `https://www.unetstack.net/docs.html`

3.2 Scheduler

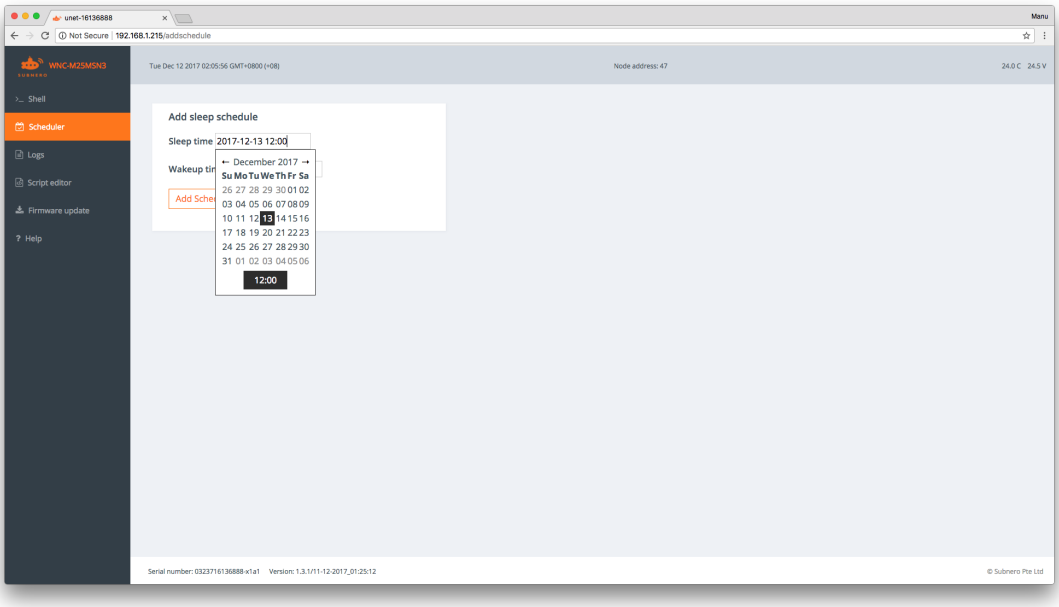
The scheduler allows the user to configure sleep and wakeup schedules so that the modems can enter power save (sleep) mode. This setting is most useful for node configuration of the modem. A user can schedule specific time slot for a bottom mounted node configuration modem to be powered up and ready to transmit and receive data/signals.

3.2.1 Adding a schedule

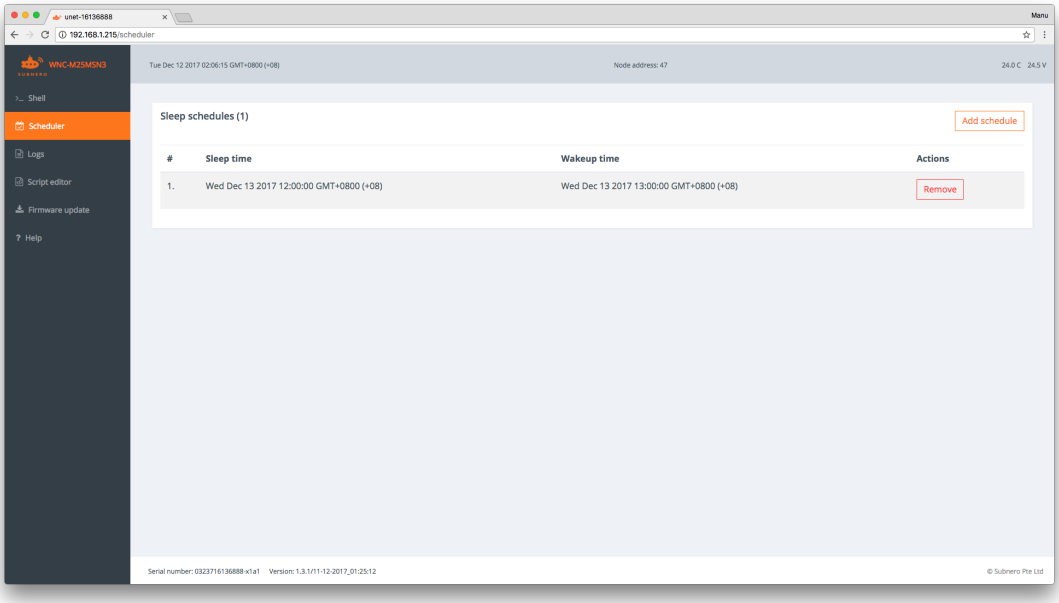
The steps to add a schedule is explained below:



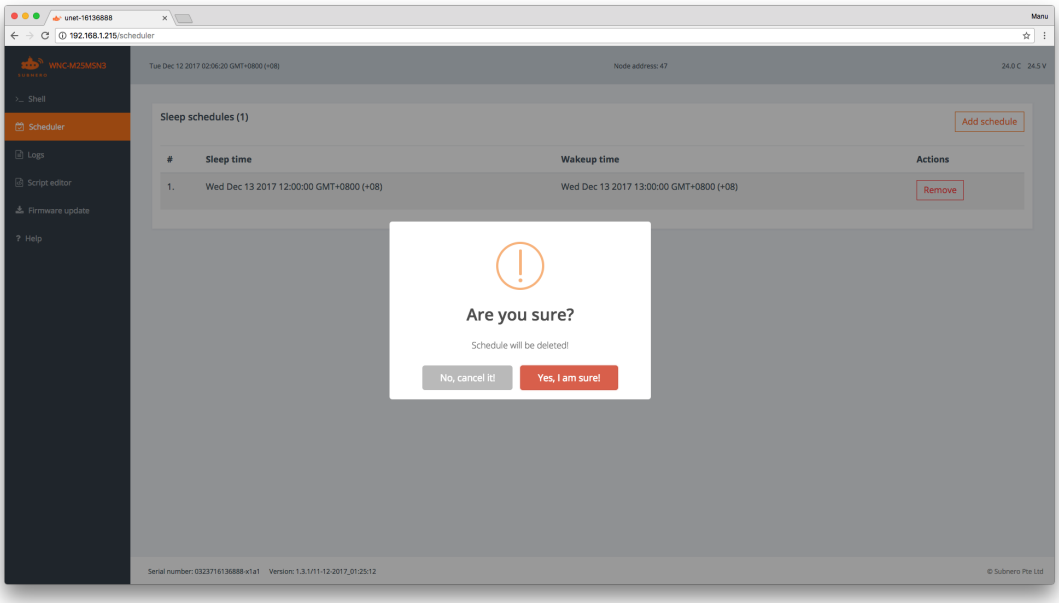
1. Click "Add schedule" button:



2. Add the sleep and wake up time and click "Add Schedule" button.



3. New schedule is listed in the Scheduler page.



4. Click "Remove" button to delete an existing schedule.

NOTE 1: In case if the user would like to add/modify/delete a schedule or a configuration parameter after the modem is powered down, simply power on the modem. After the modem boots up, it waits for 5 minutes for a user input. If no input is received and if there is a sleep schedule is configured, the modem will enter sleep state.

NOTE 2: Make sure the schedules added are well planned. Once the modem is deployed in water, it is not possible to communicate with the modem while it is in sleep state.

3.3 Logs

The logs page displays the current and the past logs of the system.

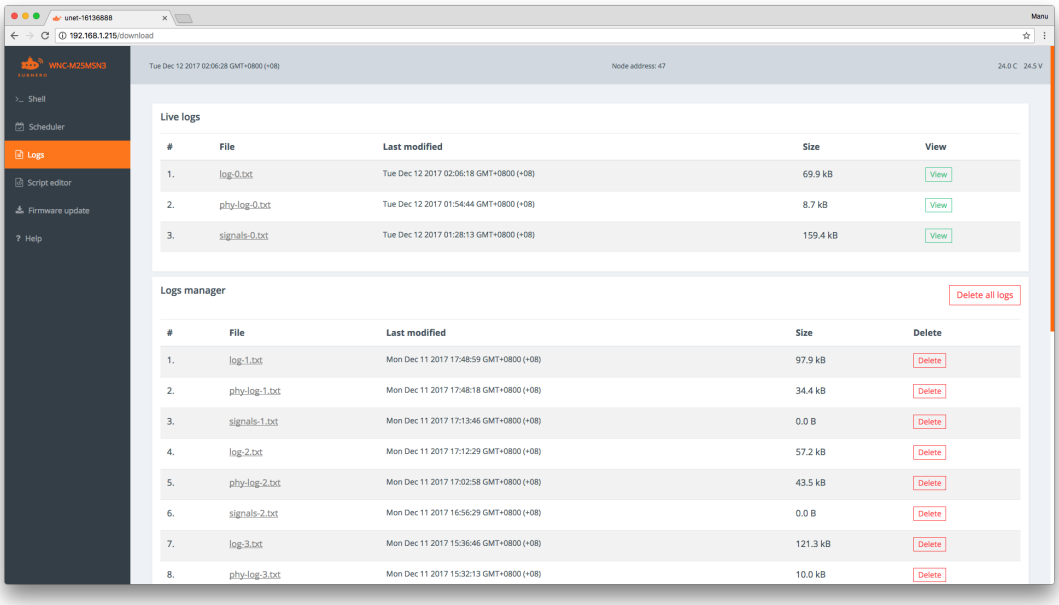


Figure 3.4: Logs

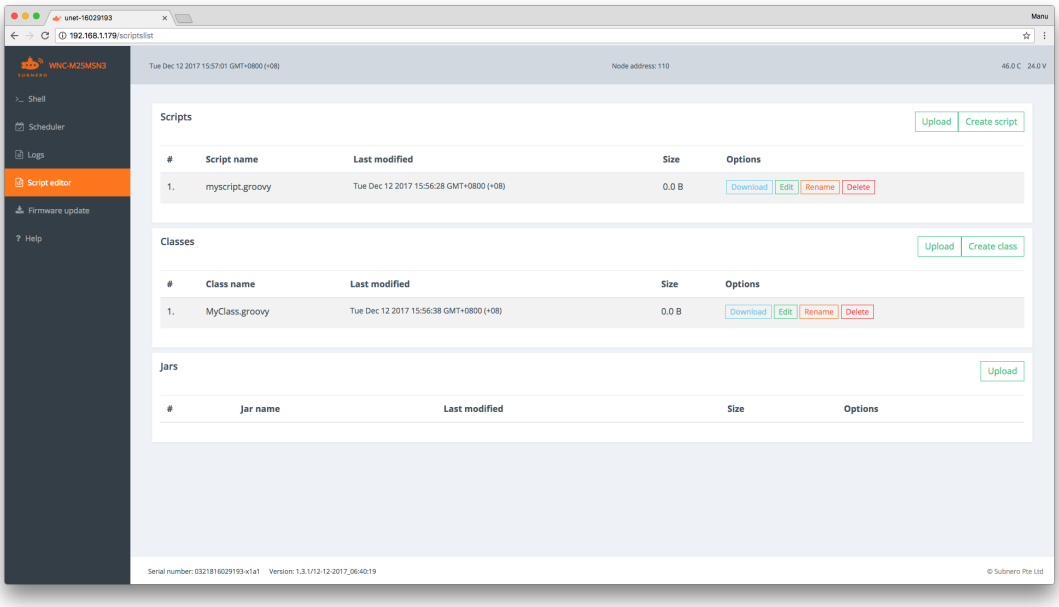
There are two kinds of log files:

- log-0.txt: This file contains network stack (UnetStack) logs.
- phy-log-0.txt: This file contains firmware logs.

A user can view the logs by clicking the files or download the logs for further analysis. Every time the modem is power cycled, a new log file is generated. The log files marked with "-0.txt" is the current set of log files. The modem implements log rotation. The maximum number of log files is 20 (this number may change in future). Once this limit is reached, the modem automatically deletes the oldest file. A user can delete the log files using the "Delete" button.

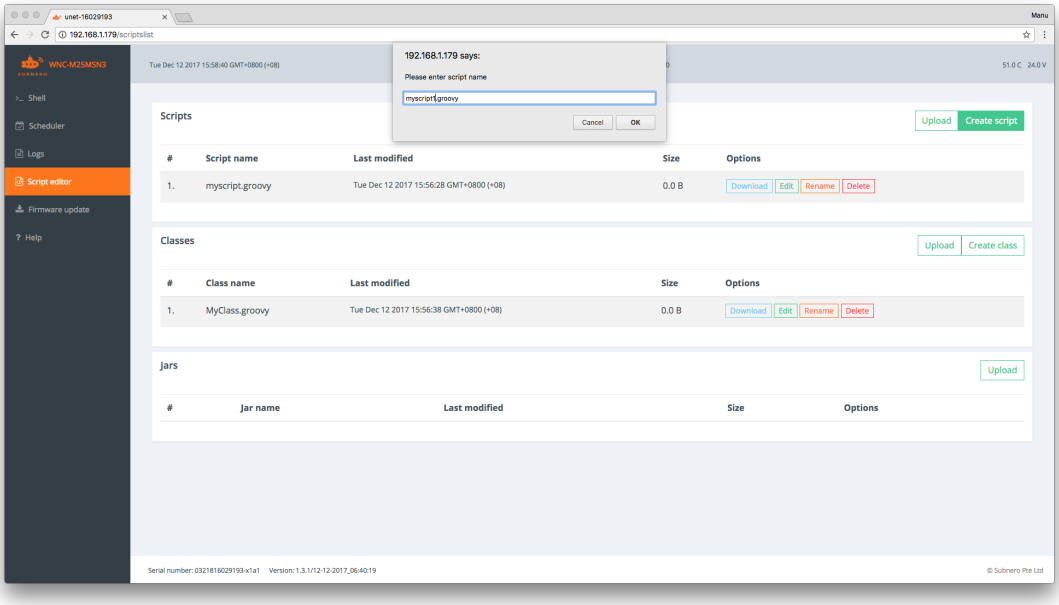
3.4 Script Editor

The script editor allows the user to create/edit/delete scripts, classes (e.g. UnetStack agents) and save directly in the modem using the web interface. It also allows uploading scripts or classes or jar files. Various scripts, classes and jar files in the respective folders are listed in the web page.

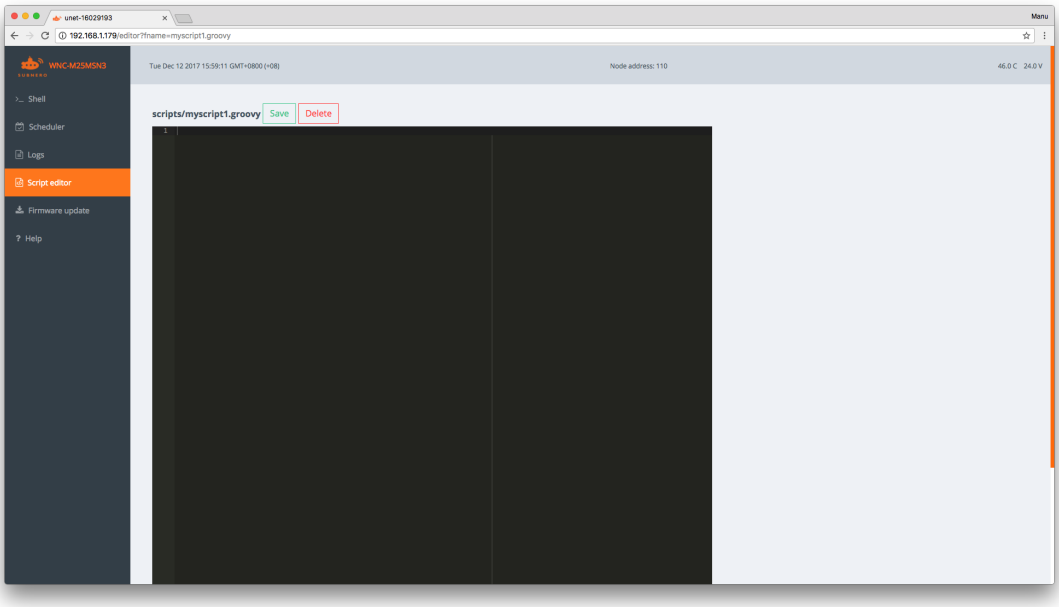


The steps to create/edit a script or class is listed below.

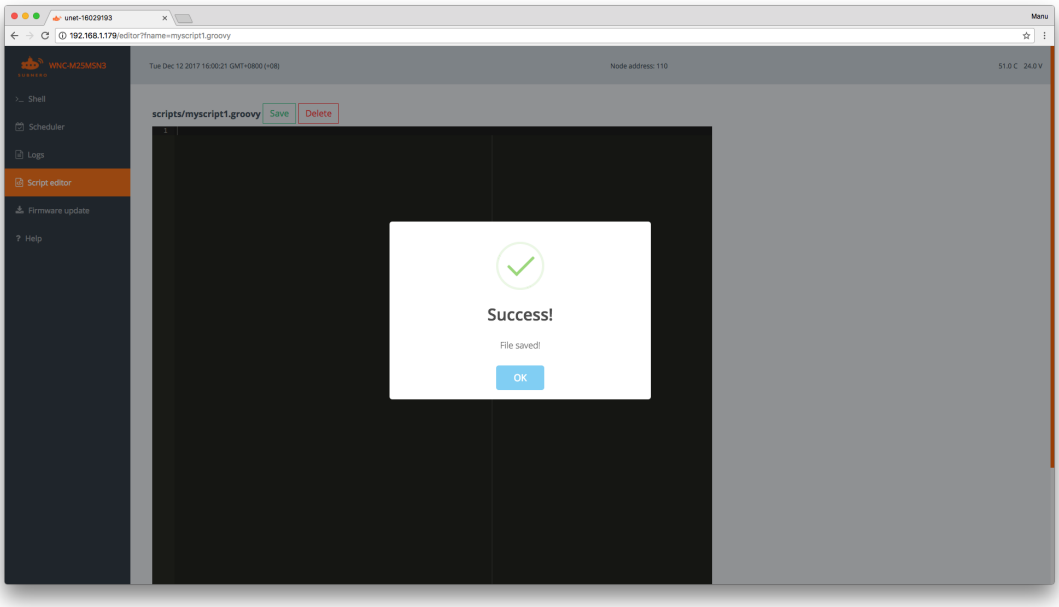
1. Click "Create Script" or "Create Class" button.



2. Give a name to the script or class file.

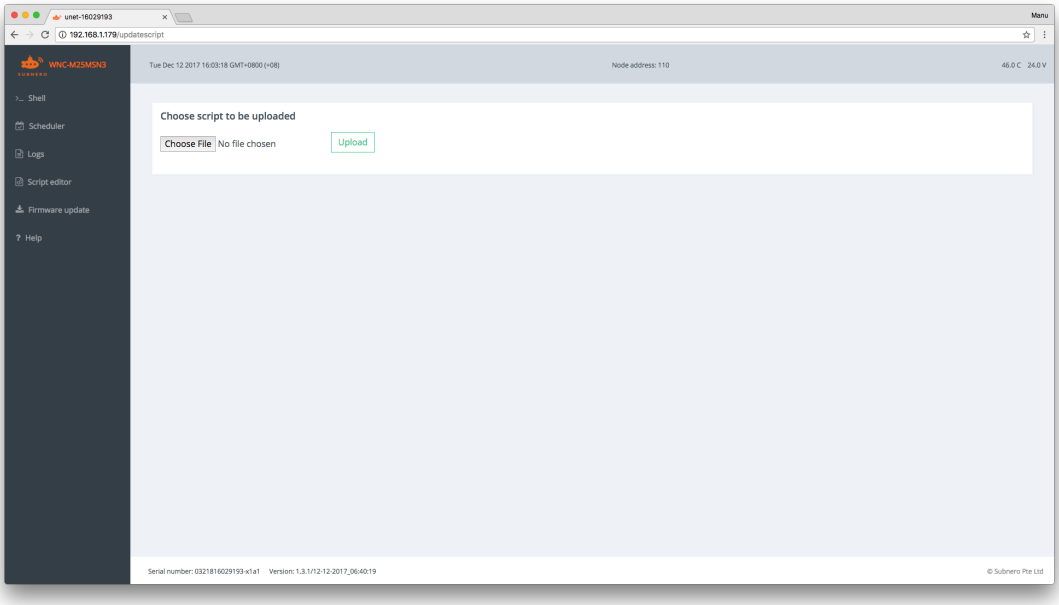


3. This will open an editor window where the user can write their own scripts or classes.



4. Once done, click “Save” button to save the script.

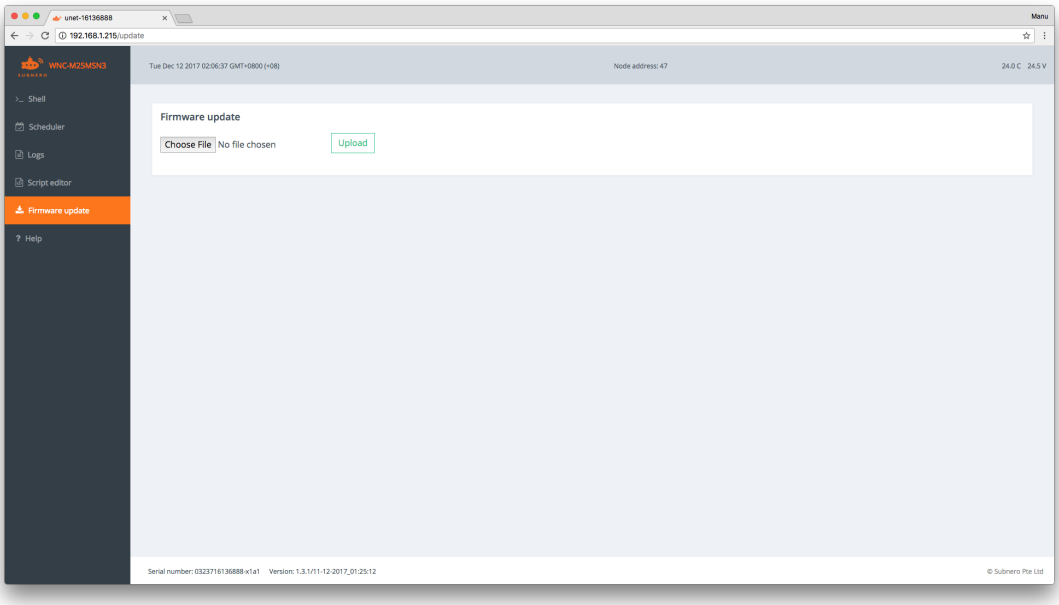
If the user prefer to create/write the script or class in his/her own computer, they can choose to upload the script to the scripts folder later. To upload a script or class or a jar file, click the "Upload" button, choose the file and click "Upload" button again. Once completed, the script, class or jar file can be accessed from the shell.



The various folders listed in the "Script Editor" page are as follows. Scripts folder: All scripts located in this folder can be accessed from the shell by the user. Classes folder: All classes or groovy files in this folder will be in the CLASSPATH so that users can access them from their scripts. Jars folder: Any jar files in this folder will be in the CLASSPATH.

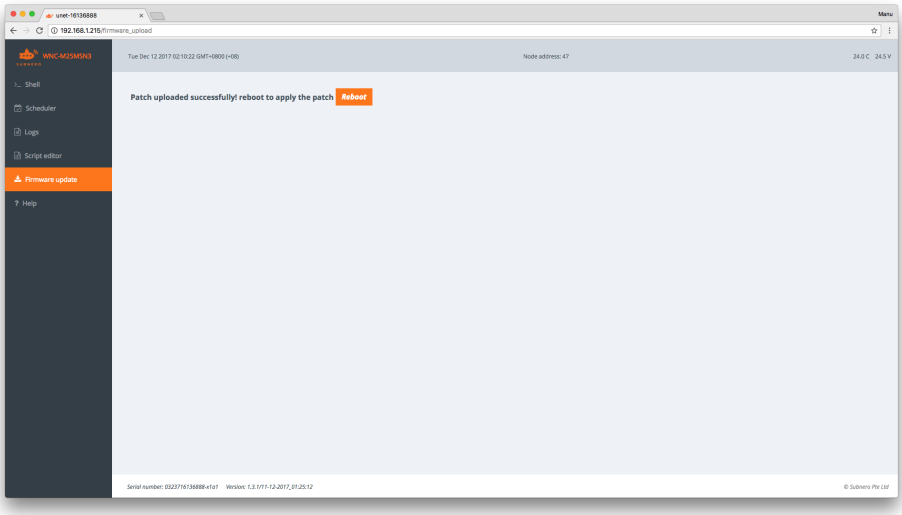
3.5 Firmware update

The firmware update page lets the user update the modem firmware. Users can download latest firmware for their modem configuration at `https://www.subnero.com/support/wnc/downloads`



The steps to update the modem firmware is listed below:

1. Download the latest firmware from Subnero support page.
2. Click "Choose File" button and point to the downloaded firmware file.
3. Click upload.
4. Reboot the modem.



CHAPTER 4

General Modem Maintenance

1. After each marine deployment, wash off the sea water from the pressure hull and any underwater cables with fresh water. Wash thoroughly before long term storage to remove any sea water residue.
2. Unplug and remove any batteries from the battery compartment before storage.
3. Clean the O-rings with a clean cloth or tissue and apply grease before deployments.
4. Store in a dry, cool place.

CHAPTER 5

Support

- For support on UnetStack and related API usage, user can post questions on StackOverflow `https://stackoverflow.com/questions/tagged/unetstack`.
- For any technical queries on the modem operations, contact us at: `support@subnero.com`

APPENDIX 1

Subnero Embedded Configuration (EC) External Assembly

Subnero Embedded Configuration (EC) External Assembly

- The EC can be mounted to the external platform using a rear mounting plate (not included as part of the standard offering), as shown in figures 3 & 4. The modem can be mounted using 9x M4 bolts.
- Additional mounting plate can be added to the front end cap, if required.
- Refer to attached drawing file for dimensions.
- Three external cable assemblies, as shown in figure 5, are provided with the modem;
    1. Power,
    2. Ethernet,
    3. Transducer.

Figure 1 - EC front with 3 connectors for power(1), RJ45(2) and transducer(3)

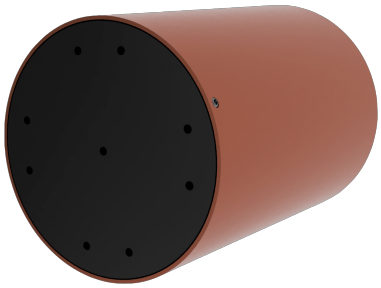


Figure 2 - EC rear with mounting points

APPENDIX 2

Subnero Transducer Assembly Drawing

Subnero Acoustic Transducer Assembly Drawing

- The acoustic transducer is assembled to a flat plate by 5x M5 bolts.
- The hole pattern has a diameter of 35mm (see drawing for further details).
- A central clearance hole of 16.50mm allows the cabling to enter the AUV/Modem/etc.
- The transducer is sealed to the flat plate with an o-ring of size 44ID x 2.5 (included in purchase).

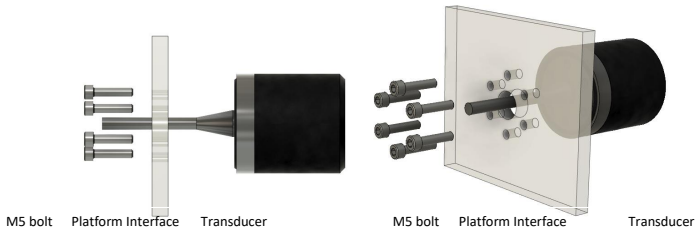


Figure 1 – Exploded view of transducer

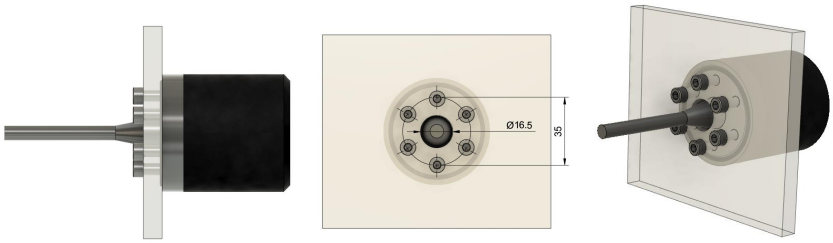


Figure 2 – Transducer fastened to interface plate