Nanomodem v2.1

User guide

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1. Introduction

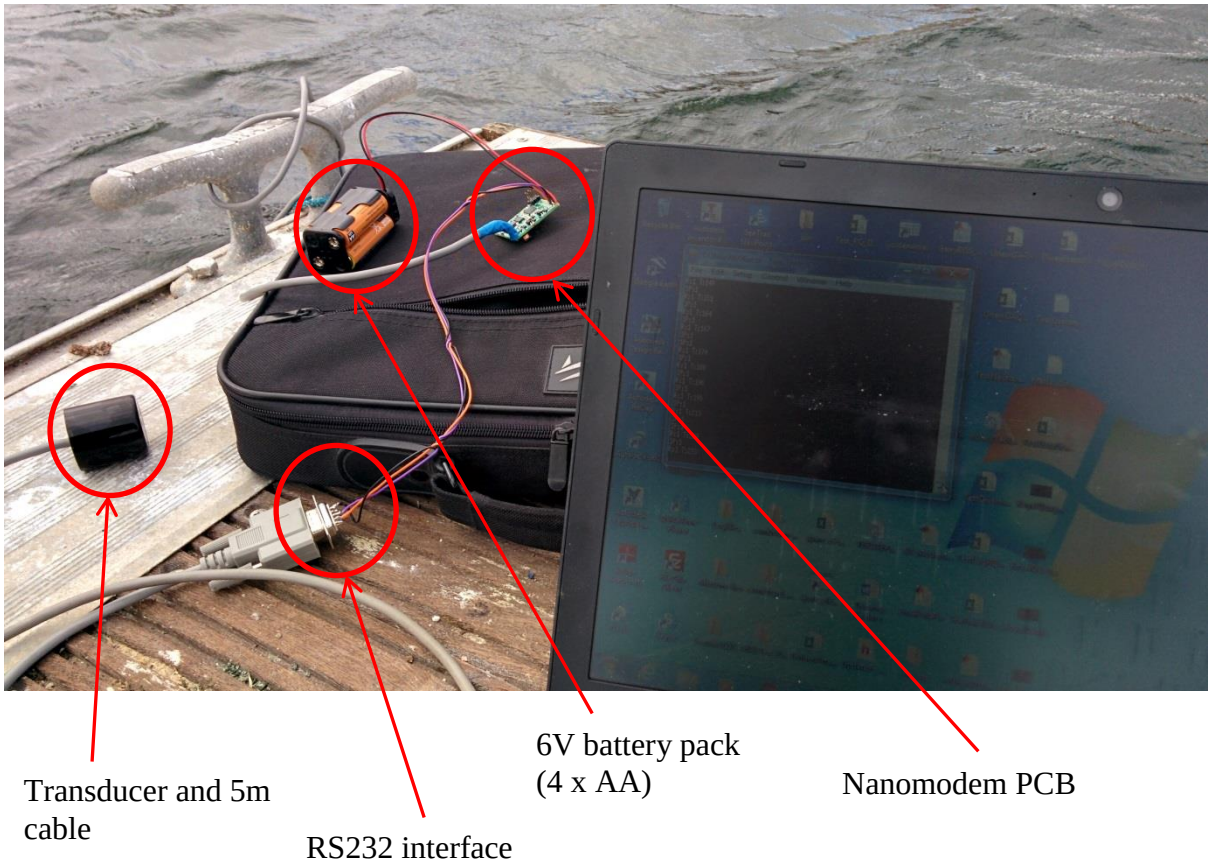
Nanomodems are a low cost, miniature acoustic communication and ranging device for underwater vehicles, divers and subsea instruments. Short data messages may be exchanged between units and an efficient "ping" protocol is implemented for range measurement by transponder operation. If multiple units are deployed in known locations, then long baseline positioning (LBL) operation is possible.

This document describes the operation, electrical interfacing and protocols for these devices.

2. Specification

Supply voltage	3 – 6.5V dc
Supply current (5V supply)	Receiving: max 2mA Transmitting: max 400mA
Acoustic frequency	24-28kHz
Acoustic source level	168 dB re 1uPa @ 1m
Acoustic data rate	40 bits/s, unicast and broadcast data messages up to 7 bytes in length.
Addressing	Up to 256 units (addresses 0-255)
Ranging increment	9.375 cm (c=1500m/s)
Ranging variance	~20 cm
Maximum Range	> 2 km
RS232 interface	9600 Baud, 8-bit, no parity, 1 stop bit, no flow control

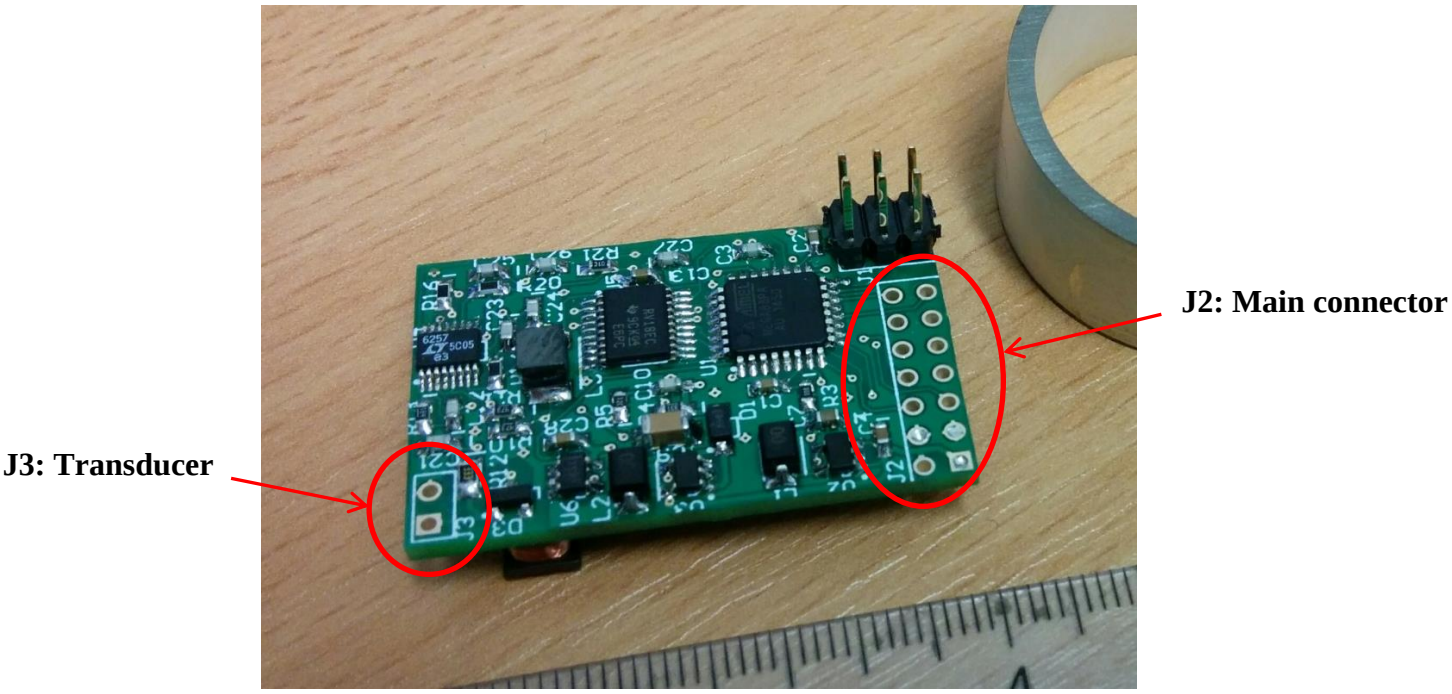
3. Components



Nanomodems may be supplied in 2 different forms:

1. Modems comprising transducer on a 5m cable and a bare PCB for integration with existing housings.
2. A single polyurethane moulded unit incorporating transducer and electronics with 4 way flying lead for power supply and data interface.

Connection details are provided below:



J2 – Main connector		J3 - Transducer	
1	Vbat (+ve supply) *	1	Inner electrode (red wire)
2	Vbat (+ve supply) *	2	Outer electrode (black wire)
3	GND (0V) *		
4	GND (0V) *		
5	Serial TXD (RS232 output)		
6	I/O 1 (not yet implemented)		
7	Serial RXD (RS232 input)		
8	I/O 2 (not yet implemented)		
9	I/O 3 (not yet implemented)		
10	I/O 4 (not yet implemented)		
11	I/O 5 (not yet implemented)		
12	I/O 6 (not yet implemented)		
13	RxS flag 1 (2.5V logic)		
14	RxM flag 2 (2.5V logic)		

The transducer signal on J3 during transmission will reach 200Vp-p so electrical safety precautions must be observed when the device is activated.

* Care must be taken to connect the power supply/battery with the correct polarity as no reverse polarity protection is provided on board.

4. Connection

1. Connect 6V battery pack or power supply (5V recommended) to each modem. (Each modem will start up in receiving mode and draw no more than 2mA of current).
2. Place each transducer in water.
3. Connect unit(s) via RS232 serial cable to PC running a terminal programme (e.g. hyperterminal, Putty etc) and configured with serial port settings (9600, 8, n, 1).

5. Serial Communication protocol

5.1 Format

Serial communication format is (9600, 8, n, 1) with no flow control. All commands issued to the Nanomodem are prefixed with '$'. All responses from the Nanomodem are prefixed with '#' and terminated with <CR><LF>. Unrecognised or invalid commands return 'E' to indicate an error.
Serial commands may be entered as a contiguous string (one byte immediately after the other) or can be typed in manually from a terminal program. If the delay between entered bytes exceeds ~2s the serial handler will time out and return 'E'.

5.2 Node addressing

Each Nanomodem must be allocated a unique 8-bit node address (0-255) which is stored in EEPROM on the device. This is set and queried via a modem command as described in section 5.2.

5.2 Modem commands

Command string	Description	Response string
$Axxx	Set node address to xxx (ascii decimal e.g. 123)	#Axxx – confirms node address has been set to xxx

$?	Query Nanomodem status	#AxxxVyyyy – where xxx is node address and yyyy is 10-bit battery voltage monitor value. To convert to a voltage:
		v = yyyy * 1.1*6/1024

$Pxxx	Ping unit with address xxx	$Pxxx to acknowledge command. #RxxxTyyyyy is then returned if response is received from unit xxx. Range to unit xxx is given by R = yyyyy * c * $6.25e^{-5}$ where c is the sound velocity (assume 1500 m/s if no data is available).

$Vxxx	Query battery voltage on unit xxx	$Vxxx to acknowledge command. #RxxxVyyyy is then returned if a response is received from unit xxx. To convert to a voltage:
		v = yyyy * 1.1*6/1024

$Uxxxnddd…	Unicast data message. Send n bytes (ddd…) to unit xxx. Data bytes (d) can be any printable or non-printable char.	$Uxxxn to confirm n bytes sent to unit xxx. Unit xxx will output #Unddd… when message has been received.
$Bnddd…	Broadcast data message. Send n bytes (ddd…) to all units. Data bytes (d) can be any printable or non-printable char.	$Bn to confirm n bytes have been broadcast. All units will output #Bxxxnddd… (where xxx is the transmitting unit) when message has been received.

5.2 Acoustic packet durations

The following information can be used to calculate the expected transmission times for various acoustic message exchanges. Acoustic propagation delays should be added in calculating the expected duration of bidirectional data exchanges.

Ping message	0.275s
Command message e.g. ($Vxxx)	0.65s
Data message (n bytes)	0.65s + n * 0.2s

5.3 Acoustic receive flags RxS and RxM

When the start of any acoustic packet is detected by a Nanomodem, the RxS flag is raised. The timing of this rising edge coincides precisely with the detection of the packet header waveform and so it may be used for time difference of arrival (TDOA) estimates where multiple Nanomodems are placed in an array. The RxS flag returns to zero at the end of the acoustic packet.

When a Nanomodem receives a broadcast data message or a unicast data message addressed to that unit, the RxM flag is raised for a short period corresponding to the transmissions of the received serial data. This signal may be used, for example, to wake up connected circuitry from a low power state.