MM-8024

Installation & Maintenance Manual for Type 8024 HF USBL Digital Transceiver

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INSTALLATION & MAINTENANCE MANUAL

FOR THE

TYPE 8024 – HF USBL DIGITAL TRANSCEIVERS

ISSUE A

REVISION 0

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AMENDMENT RECORD

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A	0	25.04.08	Initial Issue	All	All

SECTION 1

1. INTRODUCTION AND OPERATING PRINCIPLES

The USBL Transceiver is not a customer serviceable item and should be returned to Sonardyne for repair.

1.1 STRUCTURE OF MANUALS

This manual is divided into sections, each dealing with a different aspect of the 8024 HF USBL Transceiver.

1. INTRODUCTION AND OPERATING PRINCIPLES. Provides a general introduction and a brief description of the operating principles.
2. DESCRIPTION OF USBL ACOUSTIC TRANSCEIVER - Detailed technical description of the Transceiver.
3. INSTALLATION AND CONNECTIONS - Contains all necessary procedures and recommendations for installing and connecting up the Transceiver
4. MAINTENANCE AND FAULT DIAGNOSIS - Description of principles, and trouble-shooting procedures.
5. TECHNICAL DRAWINGS - Full technical drawings of the transceiver and special cables.
6. INTERNAL SENSOR – programming and calibration of the internal sensor
7. FIRMWARE – Details on checking and loading the USBL Firmware
8. CALIBRATION – Internal and external sensor alignment and details on CASIUS calibration techniques.
9. FREQUENCY MAPS – Charts giving the navigation frequencies used during acoustic tracking
10. GLOSSARY

1.2 MANUALS REFERENCED

Calibration of Attitude sensors in the USBL system, CASIUS – **7942**

OM-7942 Operating Manual For Version 5.0 Of The Casius System Issue B Revision 0

Navigation Control Unit, NCU – **8020**

Um-8020 User Manual For The Type 8020 Navigation Controller Issue A Revision 2

Radian Tool – **8041**

UM-8041-000n System Manual for Radian Motion Sensor

Scout Software - **8068-008**

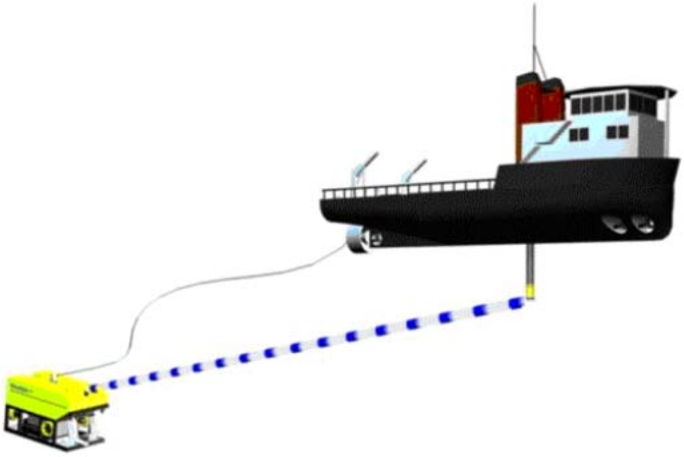
UM-8068-008 User Manual for Scout USBL System

1.3 PURPOSE OF THE TRANSCEIVER

The Sonardyne 8024 USBL Transceiver is used as part of a USBL tracking system. Such systems are generally used for:-

USBL - Remotely Operated Vehicle (ROV) tracking relative to a vessel.

- Tow fish tracking relative to a vessel.
- Diver tracking relative to a vessel.



1.4 DESIGN OF TRANSCEIVER

The USBL transceiver is specifically designed to:

- o Reject surface noise
- o Provide immunity to signal surface bounce
- o Provide 180 degree Omni-directional tracking

Each transceiver is made from corrosion resistant material and is encased in a tough aluminium bronze housing.

1.5 TRANSCEIVER SPECIFICATIONS

Operating Range	1 to 500 metres, >1000 If using MF frequencies <35KHz >500m only available with Scout Pro system
Acoustic Coverage	± 90°
Range Accuracy (Dependant on sound speed value)	< 0.2 metres
Directional Resolution (Transceiver Tank Test: >1 part in 1,000 e.g 1m horizontal in 1,000 slant range)	<0.1% of Slant Range
System Position Stability (63% of fixes within circle of 2m radius)	+/-1 metres in 500 metres
Frequency Band	Sonardyne HMF (27kHz to 55kHz)
Operating Temperature	0 to 50°C
Storage Temperature	-20 to 60°C
Operation Voltage	48V (38-50V) Can operate on 24V (18-30V)

Note: These values are indicative only as system performance depends on a number of factors such as the quality of external attitude sensors, the deployment method and the noise levels at the transceiver.

1.6 INTERNAL MOTION SENSOR SPECIFICATIONS

Dynamic Range	All angles 3D
Angular Resolution	0.05 Degrees
Pitch Accuracy	Better than 0.5 degrees
Roll Accuracy	Better than 0.5 degrees
Heading Accuracy	0.5 degrees in ideal conditions. Typically 1-2 degrees following magnetic field calibration in a real marine environment.

1.7 BRIEF SYSTEM DESCRIPTION

The equipment comprising a typical USBL system are a Windows based computer system a Surface interface unit providing power, a Monitor/Keypad/Mouse unit and a Transceiver. The connector pin listings can all be found in the appendices to this document.

FIG 1 TOPSIDE INTERFACE OPTIONS

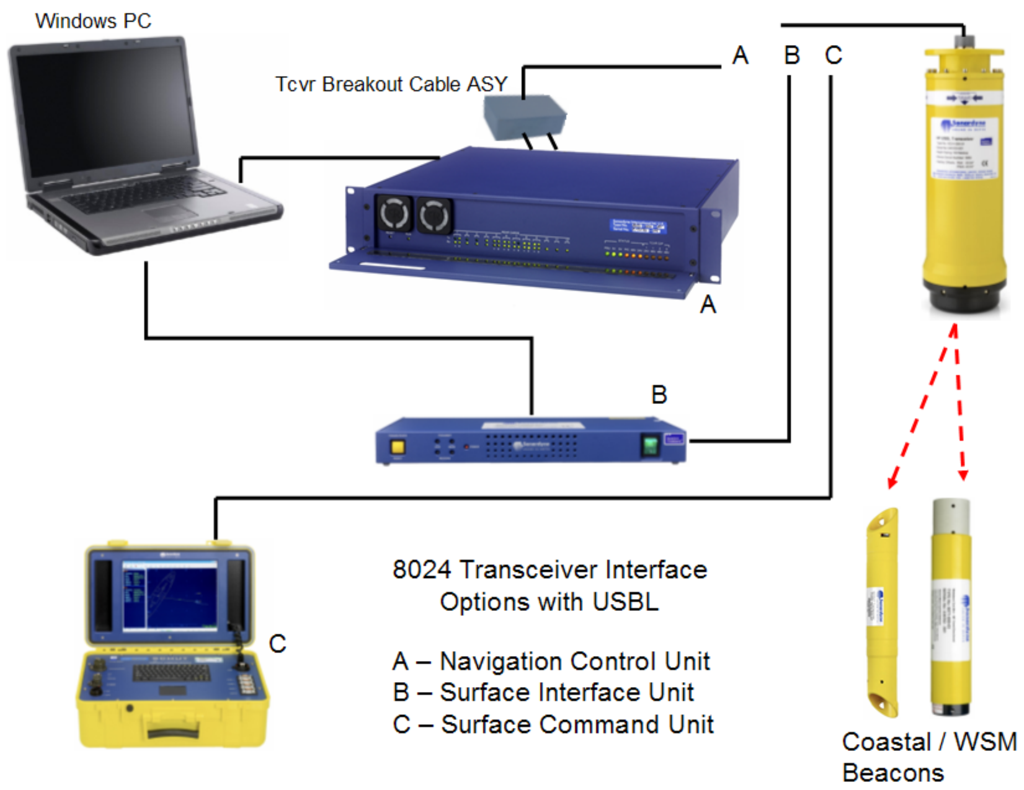
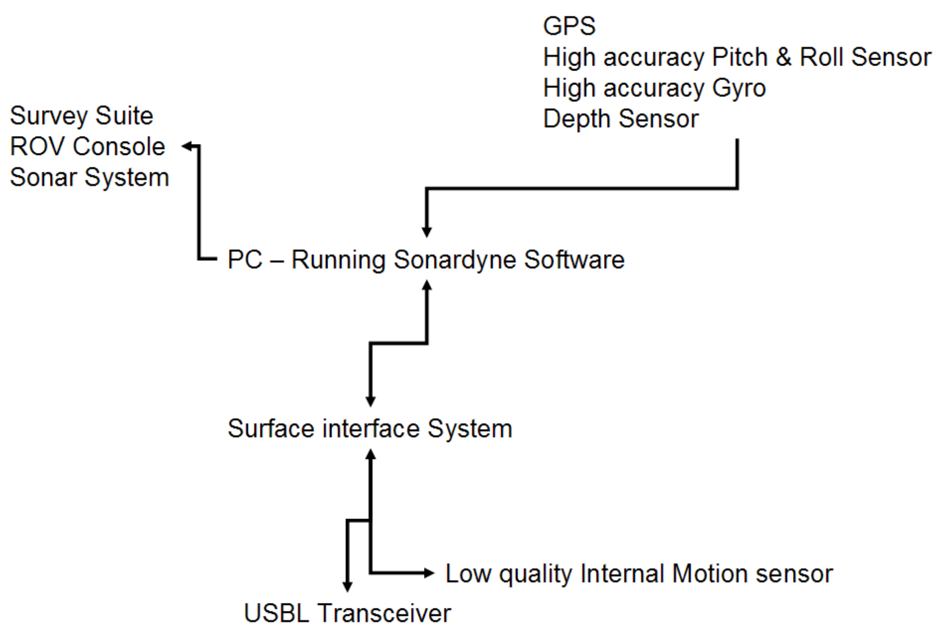


FIG 2 SCHEMATIC (CONTEXT) DIAGRAM - BASIC SYSTEM



Operation of the system is controlled by the computer set up and initiated by the operator. The operator uses the Monitor/Keypad/Mouse unit as his Man/Machine Interface. The computer software commands the Transceiver to emit acoustic signals to the Beacon(s) interpreting the responses as they are received by the Transceiver.

In a typical system set up, the Processor receives reference information from a VRU and a Gyro Compass enabling it to output data regarding beacon position to send to a 3rd party system.

The system measures the range and direction of a beacon relative to the known location and orientation of the Transceiver housing:-

- **Beacon range** is calculated by measuring the elapsed time between the interrogation signal and the detection of the beacon reply.
- **Beacon bearing** is calculated by measuring the difference in "time-phase" between signals in a number of pairs of acoustic receiving elements on the front face of the Transceiver. (This is sometimes referred to as the Interferometer method)

In a typical navigation cycle:-

- The Software commands the Transceiver to transmit an interrogation signal.
- The Beacon reply is detected by the Transceiver which measures the elapsed time and the time-phases. The data is reported to the Software. Simultaneously, the Navigation PC will have received the vessel's attitude (roll, pitch) and, possibly, heading data.
- The Sonardyne Software computes the position of the beacon relative to the vessel and reports the data in the form of telegrams.
- Subsequent navigation cycles may be used to position other beacons up to a maximum of 10 beacons in total, dependant on functionality level. If the positions of the beacons in an array on the seabed (i.e. relative to each other) have previously been calibrated, the position of the vessel (relative to the array) may be calculated to a high degree of accuracy negating the need for GPS).

1.8 TYPICAL APPLICATIONS OF A USBL SYSTEM

1.8.1 Target Tracking

In this application, a beacon is placed on an ROV or Tow Fish as appropriate. The USBL system will then track the position of the ROV/Tow Fish in local or real world coordinates depending on the system configuration and GPS input.

A variation of this method is to place a beacon on an ROV which may be following a line feature such as a pipeline. The vessel's system will then control the vessel to follow the ROV. This is sometimes referred to as "Follow the Sub" principle.

Another application of the system is to derive the vessels position without the use of GPS. This can be achieved using a target beacon placed on the seabed at a known location from which the vessels position will be back calculated by the system using solely acoustic positioning. In this mode it is also possible to track targets at the same time.

SECTION 2

2. DESCRIPTION OF USBL ACOUSTIC TRANSCEIVER

2.1 OVERVIEW

The Transceiver is a complete microprocessor-controlled interrogator/receiver operating on commands from the Computer running Sonardyne software. The main functions of the Transceiver are:

- Interpretation of commands from the Software.
- Reception of transponder reply signals can be on frequency channels between 27 and 55 kHz.
- Coastal (Type 7815, 7986, 7835 & 8044) Beacons - Transmission of commands or transponder interrogation signals are via HF frequencies between 35 and 55kHz. The transmitted pulse can be variable in length between 1 or 2 mS. The output power is fixed at 185-187 dB re 1uPa @ 1m.
- WSM (Type 8070 & 8071) Beacons - Transmission of commands or transponder interrogation signals are via HMF frequencies between 27 and 35kHz. The transmitted pulse can be variable in length between 1 and 8 mS in steps of 2, 4 & 8mS. The output power can be adjusted between 196dB and 199dB for a directional whereas an omni-directional beacon can be set to either 185dB or 188dB.
- Decoding of Acoustic Telemetry.
- Measurement of time and phase information in the received transponder reply.
- Transmission of measured (range and bearing) data to the Navigation Processor.

The electronics comprise:

- Floating voltage regulation circuits
- A microprocessor subsystem with RS485 comms.
- Six pre-amp channels.
- Six receiver channels including mixers, and other signal conditioning circuits controlled by the processor.
- Sampling and analogue-to-digital conversion circuits.
- Transmit circuit controlled by the processor.

The transducer face comprises an array of a number of ceramic receiver elements arranged evenly around a transmit element. They are recessed into machined high grade plastic and encapsulated in polyurethane to form a strong smooth acoustic interface to the water.

The electronics chassis is attached to a metal base plate at the transducer face assembly. The chassis and face assembly are installed into a cylindrical housing which is secured in place by six recessed bolts. To ensure maximum resistance to corrosion the housing is constructed in Aluminium Bronze. Light weight aluminium versions of Transceiver are available for special applications.

An underwater connector situated at the top of the housing is used connection with the interface cable.

The microprocessor within the Transceiver runs a program stored in Flash EPROM on the CPU Card. This firmware (a software program stored in EPROM) controls all the functions of the unit.

2.2 FUNCTIONAL DESCRIPTION

Nominally 24 or 48V DC power is supplied to the unit using a single pair of conductors. Communications with the Navigation PC is implemented using a half-duplex RS 485 link. This uses a second pair of conductors. The four conductors linking the Transceiver with the Navigation Processor connect to the PSU/TX Board. The RS 485 communications are routed via the motherboard back plane straight through to the Host (CPU) Board.

The signal from the receiving elements are buffered and filtered by the pre-amplifiers. On the RX Card the six signals are again amplified and digitised before being processed by the three DSP devices. The digital outputs of the DSPs are collected by the Host CPU for further processing and passing on to the surface equipment.

All the power supply rails used by the instrument are generated on the PSU/TX Board. The ±12V, ±5V and 3V3 rails are produced by DC/DC converters.

5V is provided to an internal motion sensor. The sensor MTi is a miniature, gyro-enhanced Attitude and Heading Reference System (AHRS). Its internal low-power signal processor provides drift-free 3D orientation as well as calibrated 3D acceleration, 3D rate of turn (rate gyro) and 3D earth-magnetic field data. RS 485 protocol is used to send data directly up the secondary comms lines to provide the navigation PC with attitude information.

SECTION 3

3. INSTALLATION AND CONNECTIONS – HARDWARE

3.1 INSTALLING THE TRANSCEIVER

Outline drawings of the 8024 Transceivers can be found in the technical drawings section. They should be installed vertically, with the connector at the top and the "forward direction" mark pointing forward.

There are several ways of mounting the Transceiver on a ship:-

- Most transceivers are mounted on a through hole deployment pole which consists of a vertical tube, protruding 2m from the hull, of at least 228.6 mm or 9 inches diameter. An adapter can be used to convert from an 8021 standard MF Transceiver to a HF 8024 (6 inch diameter). This is sometimes referred to as the 'mini-moonpool' method and is detailed below:

- The Transceiver is mounted on the end of a flanged pole using a purpose designed flange adapter if necessary (see technical drawings and consult Sonardyne for advice). Alignment should be maintained to within 1 degree - which is similar to the accuracy of a typical Gyro-Compass. The pole will normally have a number of flanges with a compliant outer edge that contacts the inside wall of the tube. The alignment with true vertical is not critical, but the pole should not change its vertical alignment with respect to the ship by more than 0.5 degrees. For greater accuracy on long distance tracking good quality MRUs should be utilised.

- It is very important that the pole should not vibrate when moving through the water as this will significantly affect the accuracy of the system and potentially cause the pole to fail.

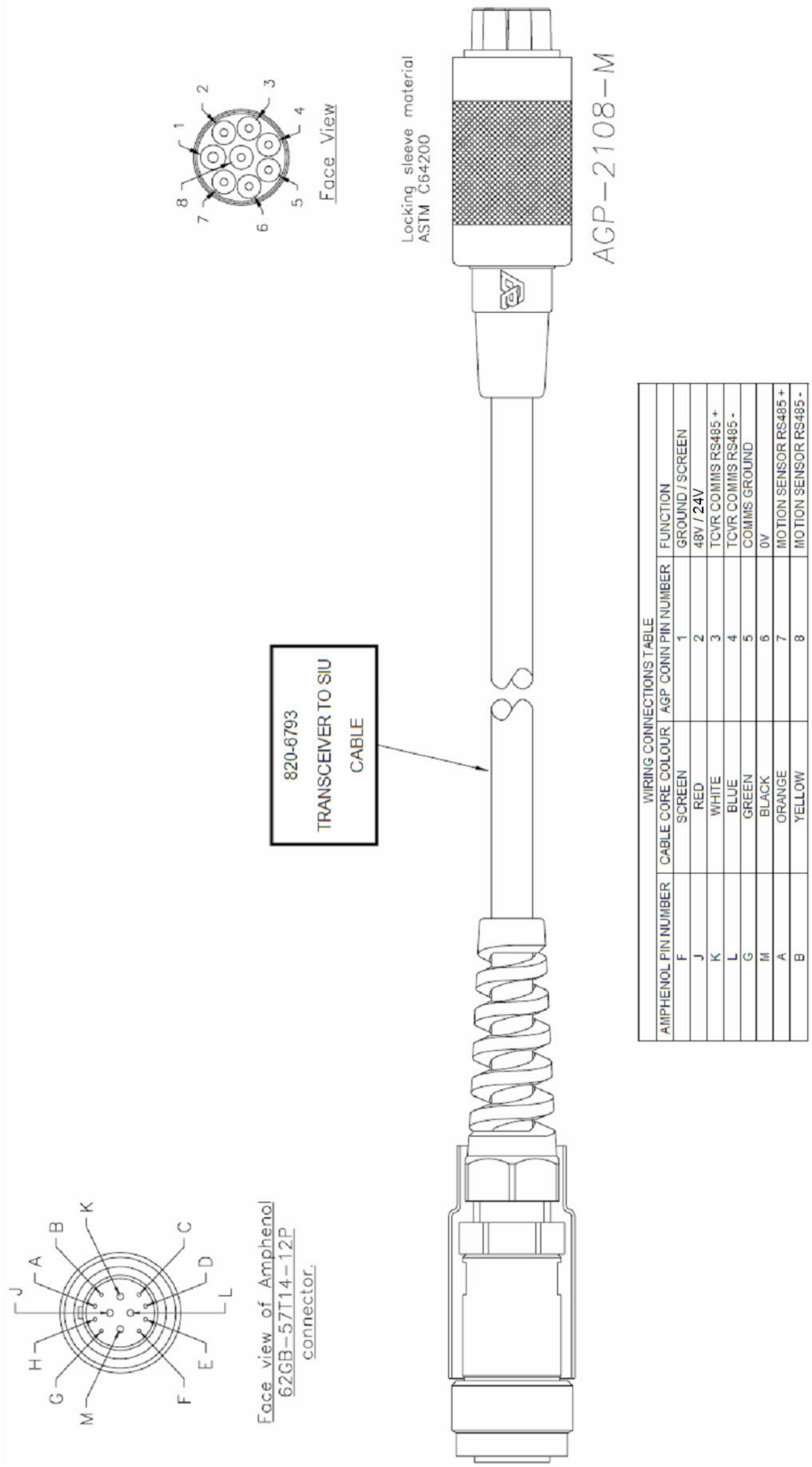
- If the mounting flange has the correct fixing holes then the transceiver can be bolted on without the use of the adapter ring (See technical drawing section) the isolation ring must be used if galvanic corrosion is a possibility.

- The second common deployment method is the use of a gate-valve and sea chest assembly that can accommodate the Transceiver. Above this sea chest is a deployment machine that is capable of raising and lowering the Transceiver and stem.

- The Transceiver housing is made of 10/5/5 Aluminium Bronze and the common material used for the tube and pole etc. is mild steel. It is good practice to isolate the two systems electrically and acoustically. Sonardyne provide an isolation adapter within the Installation kit. On no account should the Aluminium Bronze be in contact with a material nobler than itself (electro-chemically) - galvanic corrosion would be the result. A blue connector cover is provided to prevent the accumulation of rust etc.

- The transceiver face following installation must be clear of oil and inspected for damage. Any imperfections will trap air and affect the phase measurements by the elements. A light hand soap solution can be used to remove oil and grease.

FIG 3 TRANSCEIVER INTERCONNECTIONS



WIRING CONNECTIONS TABLE

AMPHENOL PIN NUMBER	CABLE CORE COLOUR	AGP CONN PIN NUMBER	FUNCTION
F	SCREEN	1	GROUND / SCREEN
J	RED	2	48V / 24V
K	WHITE	3	TCVR COMMS RS485 +
L	BLUE	4	TCVR COMMS RS485 -
G	GREEN	5	COMMS GROUND
M	BLACK	6	0V
A	ORANGE	7	MOTION SENSOR RS485 +
B	YELLOW	8	MOTION SENSOR RS485 -

SECTION 4

4. MAINTENANCE

4.1 HEALTH CHECKS

Using the topside software there is an option to conduct a phase calibration test (please refer to the appropriate software manual for details on this operation).

The Phase calibration test will initiate the USBL to transmit a range of frequencies which will be detected by the 5 receive elements. If any of the elements are damaged the response will be significantly different in phase from the other elements and will be highlighted as a fail.

FIG 4 PHASE CALIBRATION CHECK

Transceiver phase calibration

This utility tests the transceivers 5 internal receiver cards. It injects a test signal into all 5 receivers and monitors the difference that each receiver sees. If one or two frequencies fail then there is unlikely to be a problem and the test should be run again.

Frequency	Average Phase	Rcvr A	Rcvr B	Rcvr C	Rcvr D	Rcvr E	Rcvr F	Phase Span
24000 Hz	-0.57	0.57	-0.95	-0.31	0.19	-0.06	0.57	1.52
24500 Hz	-0.58	0.58	-0.92	-0.35	0.20	-0.09	0.58	1.51
25000 Hz	-0.60	0.60	-0.90	-0.38	0.20	-0.11	0.60	1.49
25500 Hz	-0.60	0.60	-0.87	-0.41	0.19	-0.13	0.60	1.47
26000 Hz	-0.61	0.61	-0.84	-0.42	0.20	-0.16	0.61	1.45
26500 Hz	-0.62	0.62	-0.82	-0.44	0.20	-0.17	0.62	1.43
27000 Hz	-0.63	0.63	-0.79	-0.45	0.19	-0.20	0.63	1.42
27500 Hz	-0.63	0.63	-0.77	-0.46	0.19	-0.22	0.63	1.40
28000 Hz	-0.64	0.64	-0.74	-0.47	0.18	-0.25	0.64	1.38
28500 Hz	-0.65	0.65	-0.72	-0.49	0.18	-0.27	0.65	1.37
29000 Hz	-0.66	0.66	-0.70	-0.50	0.17	-0.29	0.66	1.36
29500 Hz	-0.67	0.67	-0.68	-0.50	0.17	-0.32	0.67	1.35
30000 Hz	-0.68	0.68	-0.66	-0.51	0.17	-0.36	0.68	1.33
30500 Hz	-0.68	0.68	-0.64	-0.52	0.16	-0.36	0.68	1.32
31000 Hz	-0.69	0.69	-0.62	-0.52	0.15	-0.39	0.69	1.31
31500 Hz	-0.69	0.69	-0.59	-0.53	0.15	-0.41	0.69	1.29
32000 Hz	-0.70	0.70	-0.58	-0.54	0.14	-0.43	0.70	1.27
32500 Hz	-0.70	0.70	-0.55	-0.54	0.14	-0.46	0.70	1.26
33000 Hz	-0.51	0.51	-0.73	-0.73	0.53	-0.09	0.51	1.27
33500 Hz	-0.71	0.71	-0.51	-0.54	0.13	-0.50	0.71	1.25
34000 Hz	-0.71	0.71	-0.49	-0.53	0.13	-0.53	0.71	1.24
34500 Hz	-0.71	0.71	-0.48	-0.53	0.12	-0.53	0.71	1.24
35000 Hz	-0.71	0.71	-0.46	-0.53	0.12	-0.54	0.71	1.25
35500 Hz	-0.71	0.71	-0.45	-0.53	0.12	-0.56	0.71	1.27
36000 Hz	-0.71	0.71	-0.44	-0.52	0.11	-0.57	0.71	1.28
36500 Hz	-0.71	0.71	-0.42	-0.51	0.11	-0.60	0.71	1.30
37000 Hz	-0.71	0.71	-0.41	-0.50	0.11	-0.61	0.71	1.32
37500 Hz	-0.70	0.70	-0.40	-0.49	0.11	-0.62	0.70	1.32
38000 Hz	-0.70	0.70	-0.38	-0.49	0.10	-0.64	0.70	1.34
38500 Hz	-0.70	0.70	-0.38	-0.48	0.10	-0.64	0.70	1.34
39000 Hz	-0.70	0.70	-0.37	-0.46	0.10	-0.66	0.70	1.35
39500 Hz	-0.69	0.69	-0.36	-0.46	0.09	-0.65	0.69	1.34
40000 Hz	-0.69	0.69	-0.34	-0.44	0.09	-0.68	0.69	1.37
40500 Hz	-0.68	0.68	-0.33	-0.43	0.08	-0.69	0.68	1.37
41000 Hz	-0.68	0.68	-0.33	-0.42	0.08	-0.69	0.68	1.37

Close

4.2 FIRMWARE

Firmware – It is important to check on the Sonardyne website to ensure the USBL is installed with the latest Firmware thereby guaranteeing up-to-date functionality.

4.3 PHYSICAL DAMAGE

Frequently inspect the transducer surface for visible signs of damage such as scratches. If the Array is damaged it should be replaced otherwise position quality will be affected.

- **Grease** - The transceiver face must be clear of oils and inspected for damage. A light hand soap solution can be used to remove oil and grease.

- **Scratches** - Imperfections will trap air and affect the phase calculations. If any scratches greater that 1mm deep have occurred the array will need to be replaced as there is risk of water ingress.

- **Marine growth** - The build up of marine growth on the face of the transceiver could reduce the acoustic performance and should be removed. Where you have barnacles or limpets, these should be removed by using a blunt scraper. Obviously great care must be taken to not damage the face by ripping or tearing the PU. However, the PU face does not have to be perfectly smooth so any small parts or the remaining ring of a limpet for instance can be left if that reduces the possibility of further damaging the surface.

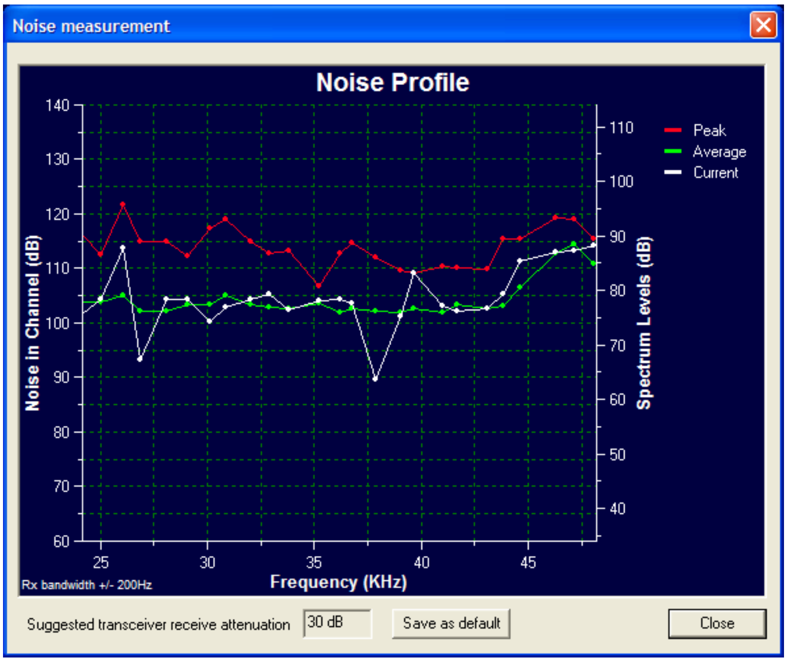
4.4 ENVIRONMENTAL CHECKS

The USBL can be driven by the software as a hydrophone. In this mode the transceiver can detect other signals in the water and will display these as a noise plot.

This routine is very useful for trouble-shooting acoustic noise problems at sea. It causes the system to go through a transmit/receive sequence on each channel and displays the results as total noise and in-band noise for each channel. A line graph is displayed showing current trace, peak hold trace, and average trace. Wait until at least 1 minute to stabilise the data.

In a reasonably quiet environment, the average trace peaks and troughs will be within a 6dB spread and will be in the region of 55dB to 70dB. If a particular frequency shows a high level, avoid using transponders on that channel. Care must also be taken not to track beacons that clash with other instrumentation.

FIG 5 NOISE PLOT



4.5 SIGNAL RECEIVED BY THE TRANSCEIVER

Using the surface software the signal received by the transceiver can be analysed. Refer to the appropriate software manual on specific details of this window.

FIG 6 SIGNAL FROM A SONARDYNE WIDEBAND BEACON

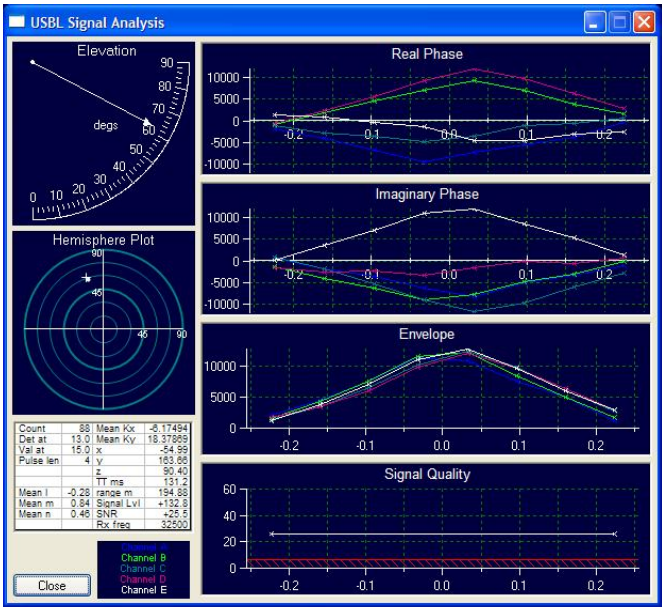
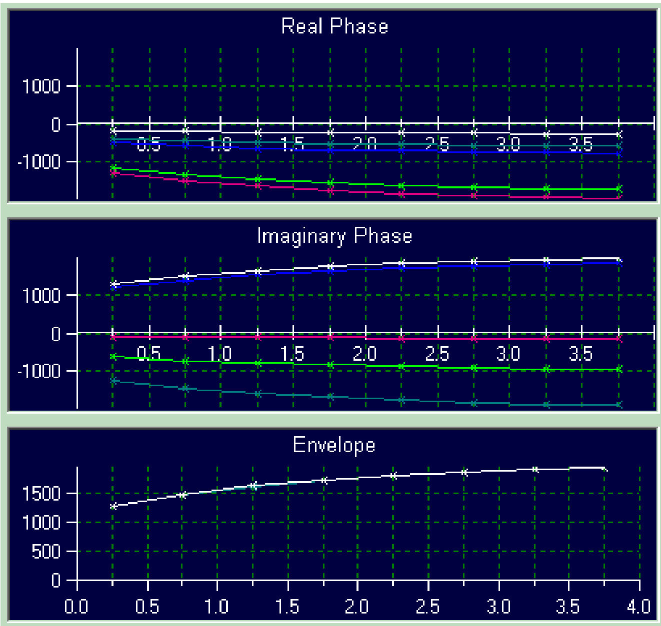


FIG 7 SIGNAL FROM TONE BEACON

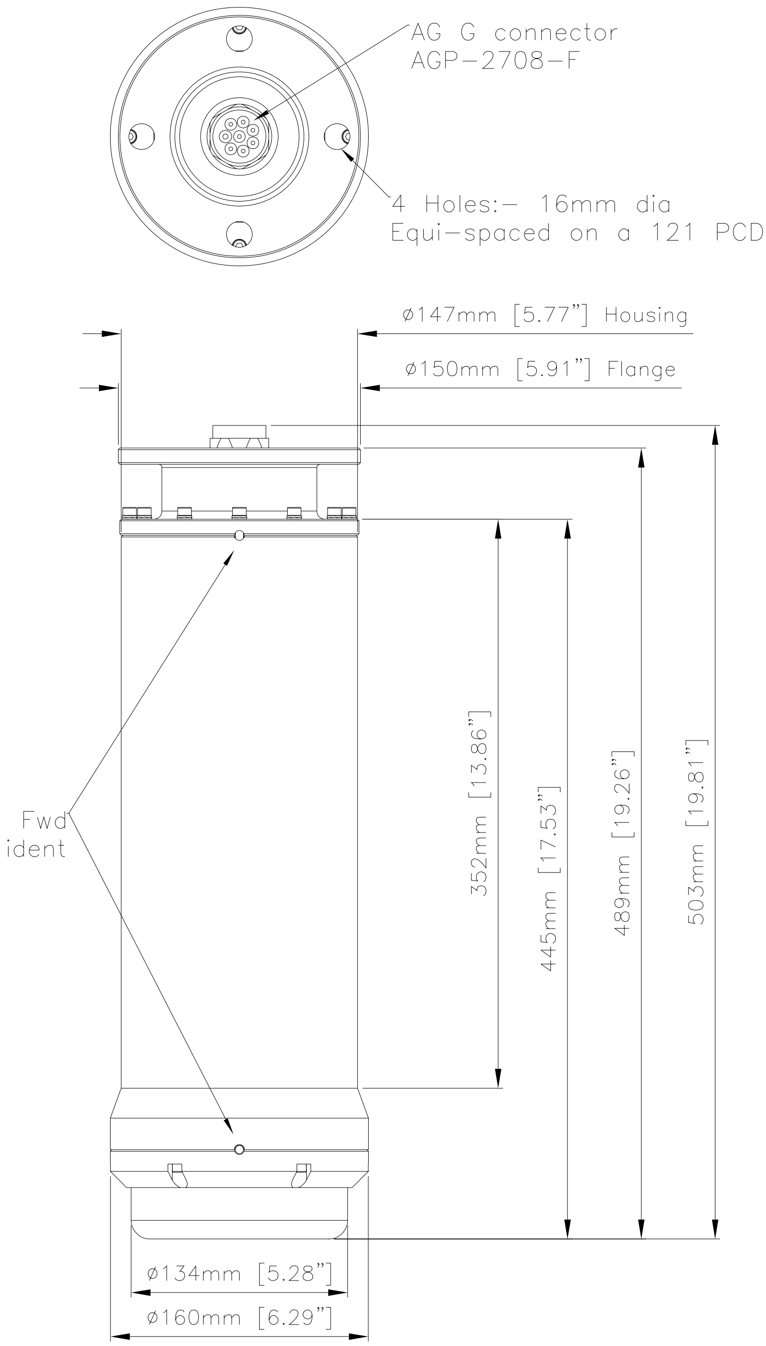


SECTION 5

5. TECHNICAL DRAWINGS

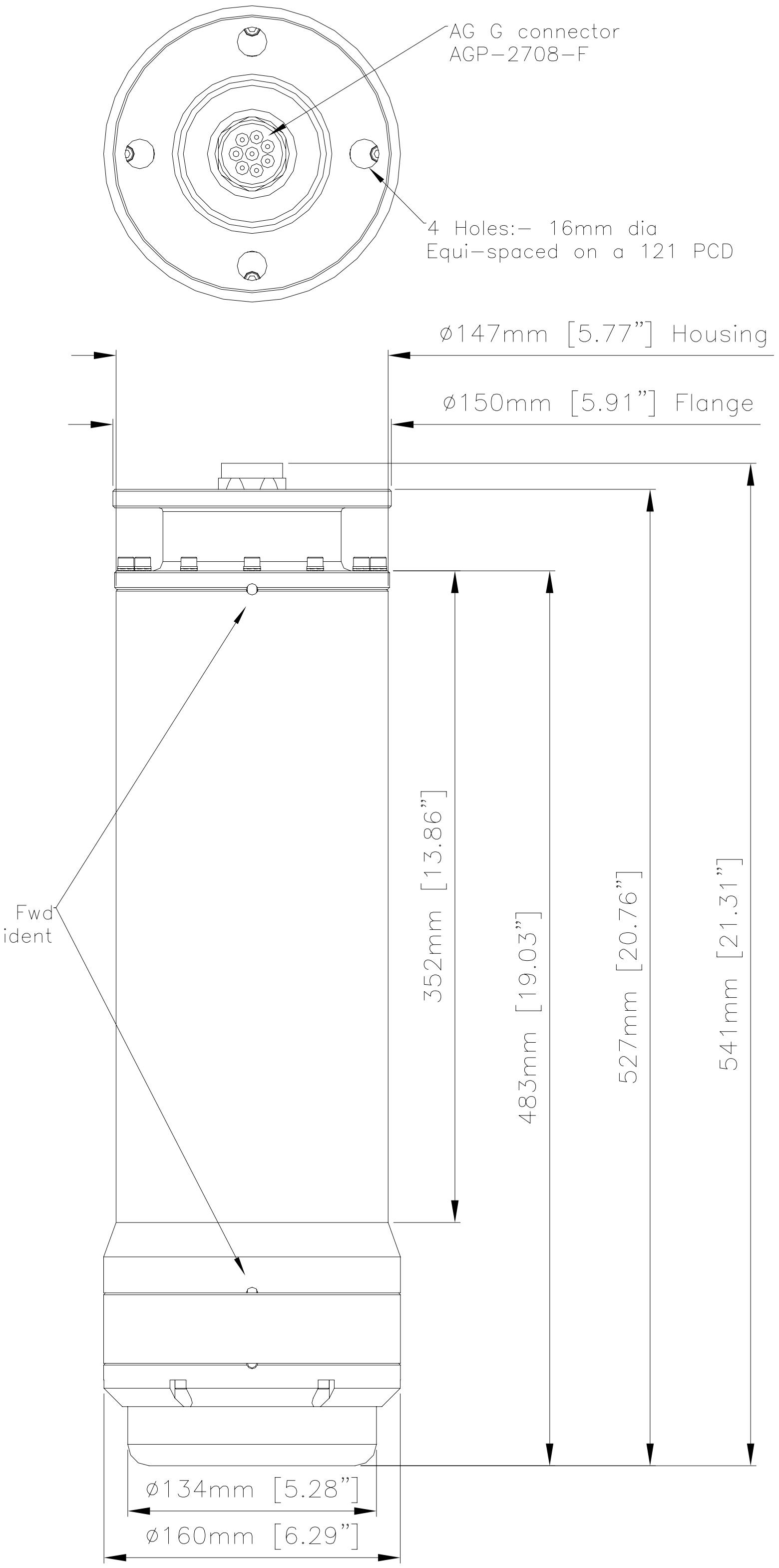
5.1 OUTLINE DRAWING TYPE 8024-000 'STANDARD' USBL

FIG 8 OUTLINE DRAWING TYPE 8024-000 'STANDARD' USBL



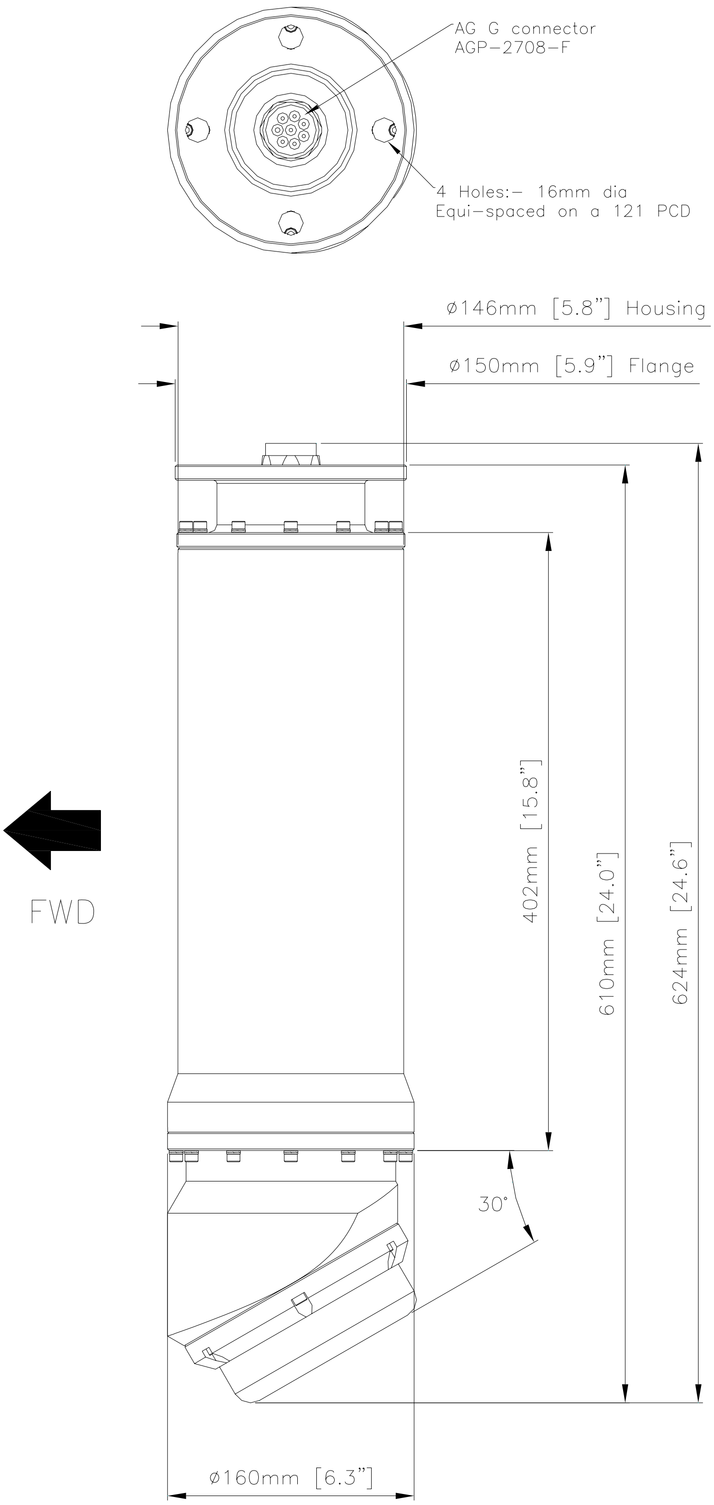
5.2 OUTLINE DRAWING TYPE 8024-000 USBL WITH LEVEL 2 WATER BLOCK

FIG 9 OUTLINE DRAWING TYPE 8024-000 USBL WITH LEVEL 2 WATER BLOCK



5.3 OUTLINE DRAWING TYPE 8024-000 USBL WITH LEVEL 2 WATER BLOCK & TILT ADAPTOR

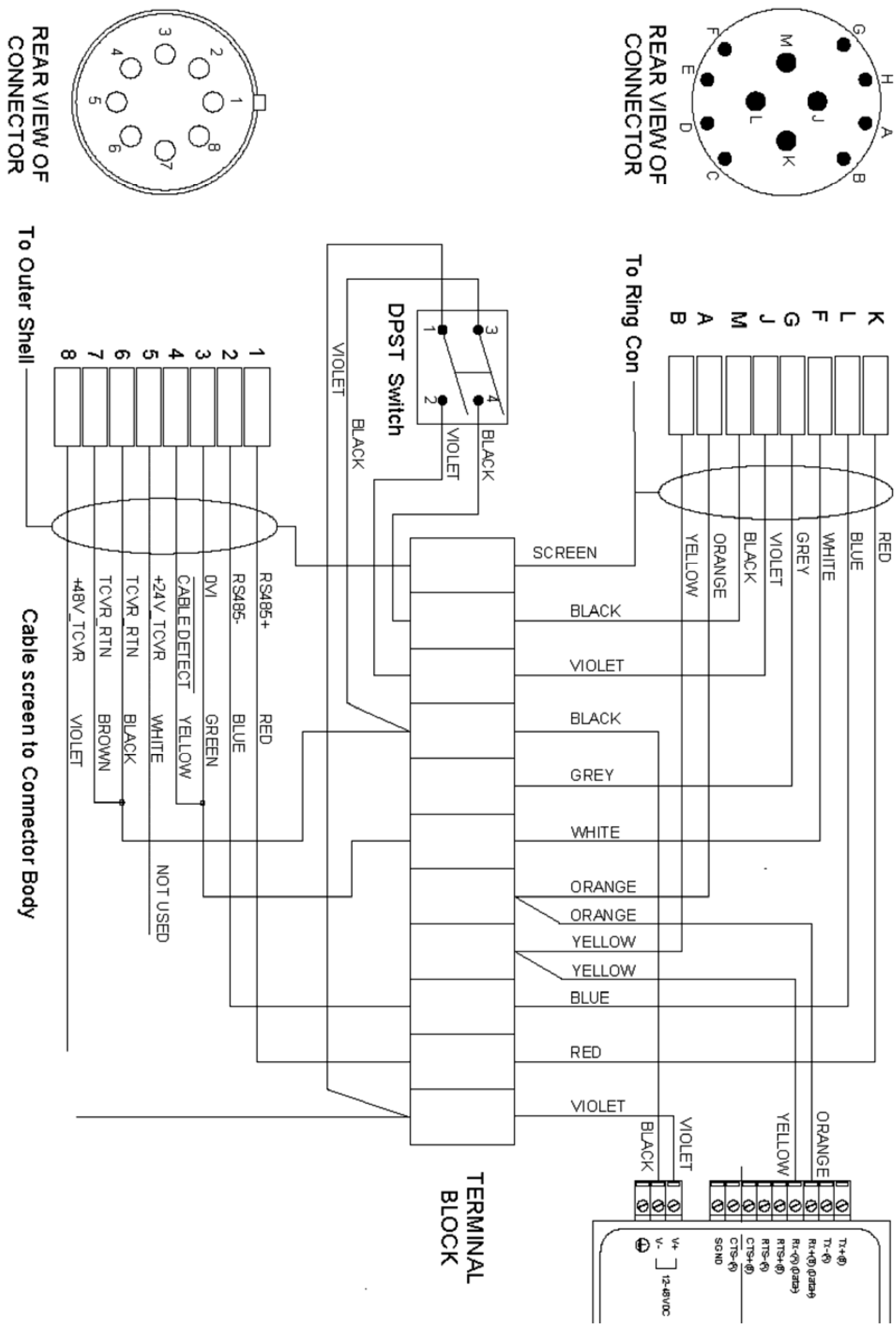
FIG 10 OUTLINE DRAWING TYPE 8024-000 USBL + L2 WATER BLOCK & TILT ADAPTOR



5.4 SCOUT PRO 485/232 BREAKOUT FOR MOTION SENSOR TO NCU

FIG 11 SCOUT PRO 485/232 BREAKOUT FOR MOTION SENSOR TO NCU

Type: 8024-127



SECTION 6

6. INTERNAL MOTION SENSOR

6.1 SENSOR INFORMATION

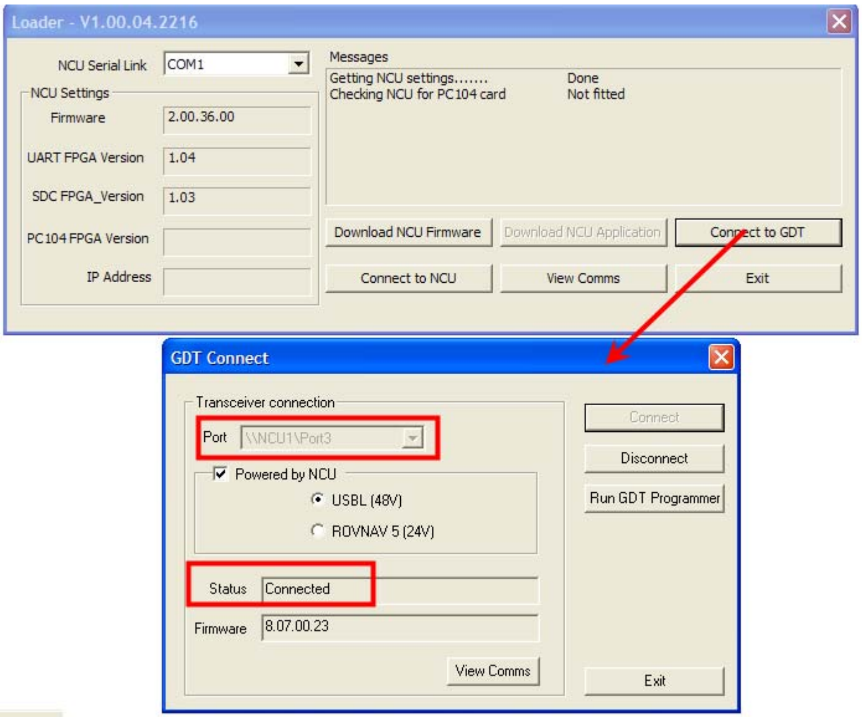
The Transceiver is fitted with a miniature, gyro-enhanced Attitude and Heading Reference System. It's internal low-power signal processor provides drift-free 3D orientation as well as calibrated 3D acceleration, 3D rate of turn (rate gyro) and 3D earth-magnetic field data.

In Scout and Scout+ systems the internal motions sensor comms are split inside the SIU and SCU and separately wired to a 9 way D-type comms port. On Scout Pro systems a breakout box, supplied with the system, must be used to allow communications directly with internal sensor. Once the internal sensor is programmed correctly, via a RS232 PC port, it can be plugged into a NCU RS232 port or left as a serial input to the PC. It is recommended to configure the sensor to 10Hz TSS2 format at 9600 baud. This is an ascii output string where the Pitch Roll and heading fields can be read by a basic terminal package.

6.2 ESTABLISHING COMMUNICATIONS

The USBL tracking software will hold on to comm ports even if they are not being used therefore it is advisable to close the tracking software when using Magfield Mapped or Radian Tool. The transceiver must be **powered up to communicate with the internal sensor**!

With SCU and SIU based systems power hard wired to the transceiver whereas the NCU base system requires initialisation before 48V is supplied to the transceiver. This can be achieved using the “Loader” application (section 7) to establish communications with the USBL whilst leaving other comms ports available to run the programming or calibration software.



6.3 PROGRAMMING THE INTERNAL SENSOR

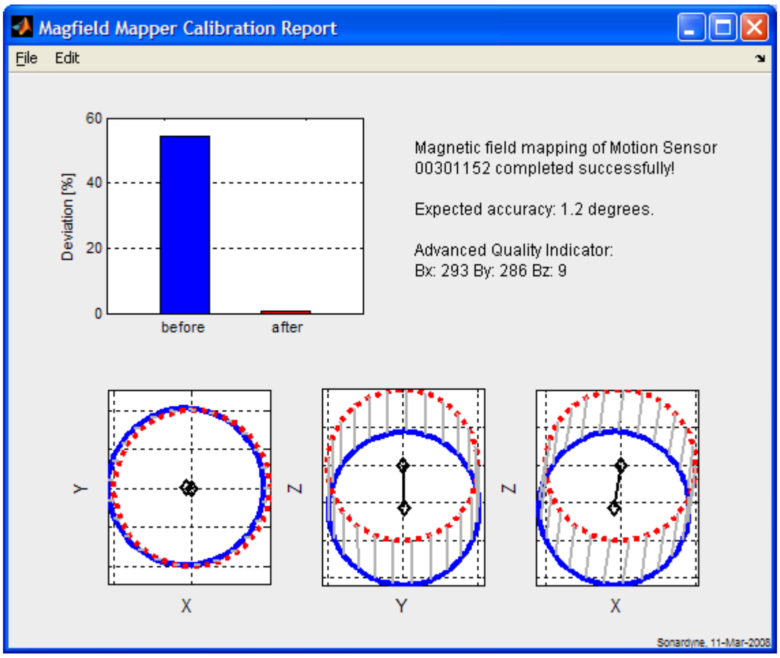
Radian Tool software supplied with the system can be used to configure the internal motion sensor (MTi). The Radian Tool is a generic software product that is also used with the standalone subsea AHARS which shares the same electronics as the Scout. Please refer to the Radian Tool software manual for detailed information on configuring the miniature AHARS in the Scout.

- 1-100Hz output rate
- Digital output strings: TSS2, PHTRO, HCHDM, PRDID, EM1000
- Configurable baud rates

6.4 CALIBRATING THE MAGNETIC SENSOR

Prior to use the sensor must be calibrated to compensate for local and regional distortion on the earth's magnetic field. This should be performed with the **MagField Mapper** software supplied with the system. Please refer to the software manual for detailed information.

FIG 12 MAGFIELD CALIBRATION REPORT



SECTION 7

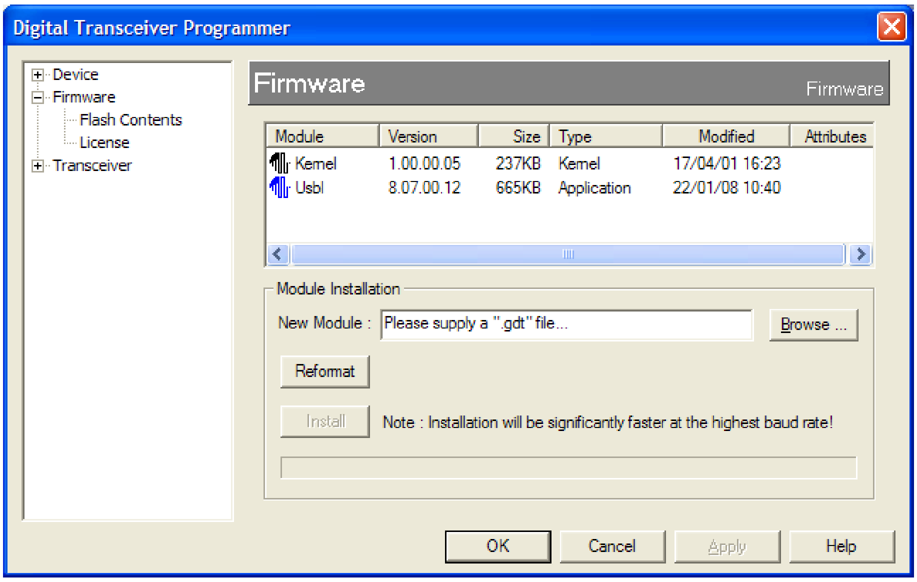
7. FIRMWARE

Refer to the **Loader** Software documentation for detailed information on installing firmware.

GDT-USBL firmware is separated into two distinct types, the **Kernel** and the **Application**.

The **Kernel** firmware is programmed in the factory and can not be upgraded in the field via a serial downloaded. Kernel firmware can therefore only be upgraded by returning to the factory. The Kernel provides the functionality required to install or upgrade application firmware via serial download and boot the application firmware on power-up or reset.

The **Application** firmware can be upgraded in the field via a serial download, using a suitable PC programming utility such as Loader. This software package is installed with a desktop icon along with the navigation software.



7.1 KERNEL FIRMWARE HISTORY

VERSION	DATE	DESCRIPTION
1.00.00.05	17/04/01	First Release

7.2 APPLICATION FIRMWARE HISTORY

VERSION	DATE	DESCRIPTION
8.01.00.23	*13/04/06*	Initial Release in HF USBL Products
8.03.00.00	*13/04/06*	Monitor for errors in USBL Multifix phase data
8.04.00.07	29/09/06	Admittance test functionality
8.05.00.01	29/01/07	Implementation of the RAS command DPTi Support
8.07.00.00	06/03/08	Changes to USBL reset criteria

SECTION 8

8. USBL TRANSCEIVER HEADING ALIGNMENT

8.1 INTERNAL SENSOR

The MTi sensor, described in section 6, is aligned to the USBL Transceiver face in the factory and therefore doesn't require a heading miss-alignment correction. However it is important to conduct a Magnetic field correction for every installation and new site. Additionally the heading sensor aligns to the Magnetic North therefore it is important to put a correction value within the software for declination.

8.2 USBL TRANSCEIVER AHRS ALIGNMENT (EXTERNAL GYRO/VRU)

8.2.1 Casius

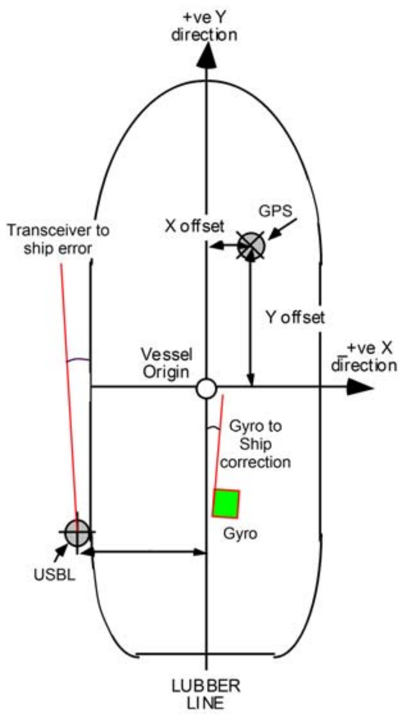
CASIUS is an acronym that stands for **C**alibration of **A**ttitude **S**ensors **I**n the **U**SBL **S**ystem. It is a standalone application that uses iterative mathematical methods to resolve the errors in the system. A manual is provided with the CASIUS software which gives details on the procedure.

In general, pitch and roll alignment errors will have a greater effect on beacons directly below the vessel (especially in deep water), and heading errors will have a greater effect at horizontal offsets from the beacon.

It is important to ensure the ships motion is sampled sufficiently it is therefore recommended that the sensors are configured to output 10Hz data rate. Details on this procedure can be found in the specific instrument manual.

When using a USBL with external sensors first calculate the alignment of the Ship with the pitch and roll output from the peripheral sensors. This ensures when the ship is level on the water line the pitch and roll values are reading zero otherwise the GPS and Tcvr position will be miscalculated.

FIG 13 VESSEL OFFSETS



The heading sensor can be aligned to the vessel centre line using a number of survey techniques, failure to conduct this will result in incorrect offset calculations. An indication of heading misalignment can be seen from the GPS course made good not agreeing with the compass output when the vessel is moving in the same axis to the tide.

SECTION 9

9. ACOUSTIC FREQUENCY CHANNELS

Frequency clashes with a USBL system can be avoided by a prudent choice of interrogate and reply channels for the Beacons being utilised by the system. This is particularly true in the case of multiple target tracking and where other acoustic systems are in use in the same area of sea.

The general rule is:

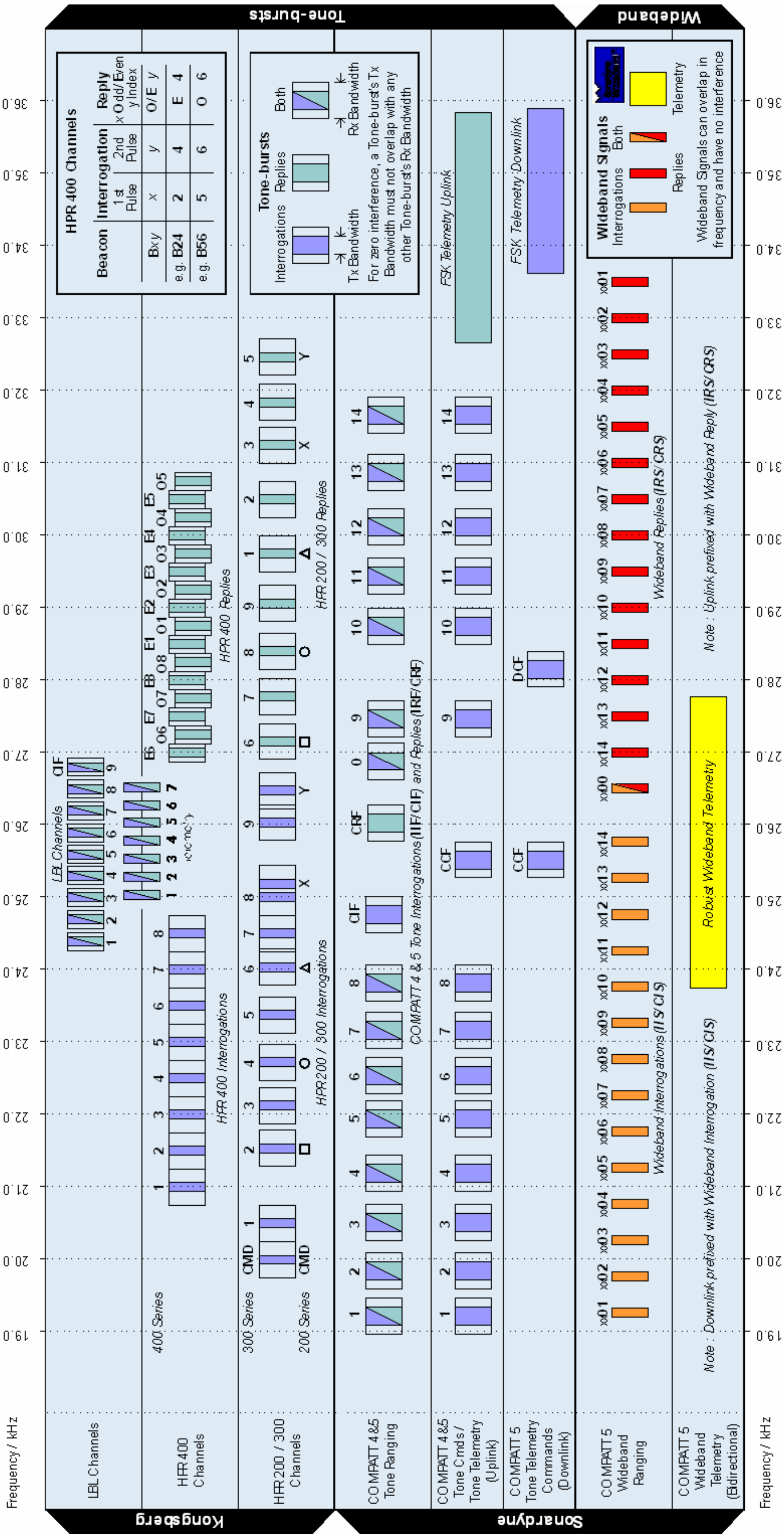
Choose frequencies that are well separated from those being used by other Beacons in the vicinity

For example if tracking 4 targets it is safest to pick four separate IIFs and a different four separate IRFs. However, in many cases, it is possible to economise on frequencies and still achieve sufficient discrimination - this can be done by setting one CIF and four different IRFs together with four different turn-around times.

The diagrams which follow summarise the range of Sonardyne frequencies associated with acoustic transmissions. Assuming other frequencies being used in the area are known, it is possible, using these diagrams, to select frequencies for the current job that are well separated from each other and all other known frequencies.

9.1 COMMONLY USED FREQUENCIES

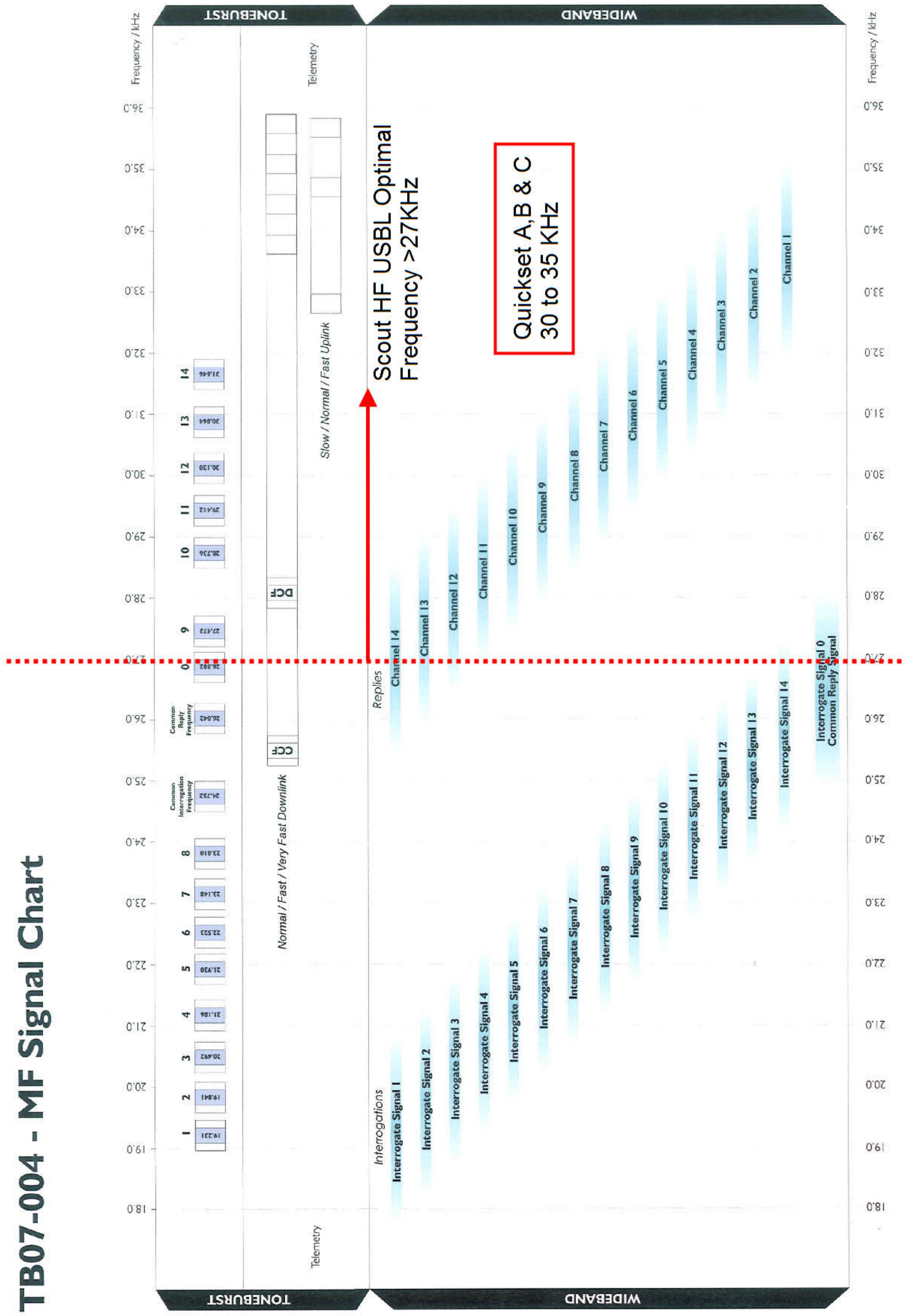
FIG 14 COMMONLY USED FREQUENCIES



9.2 SONARDYNE MF WIDEBAND FREQUENCIES

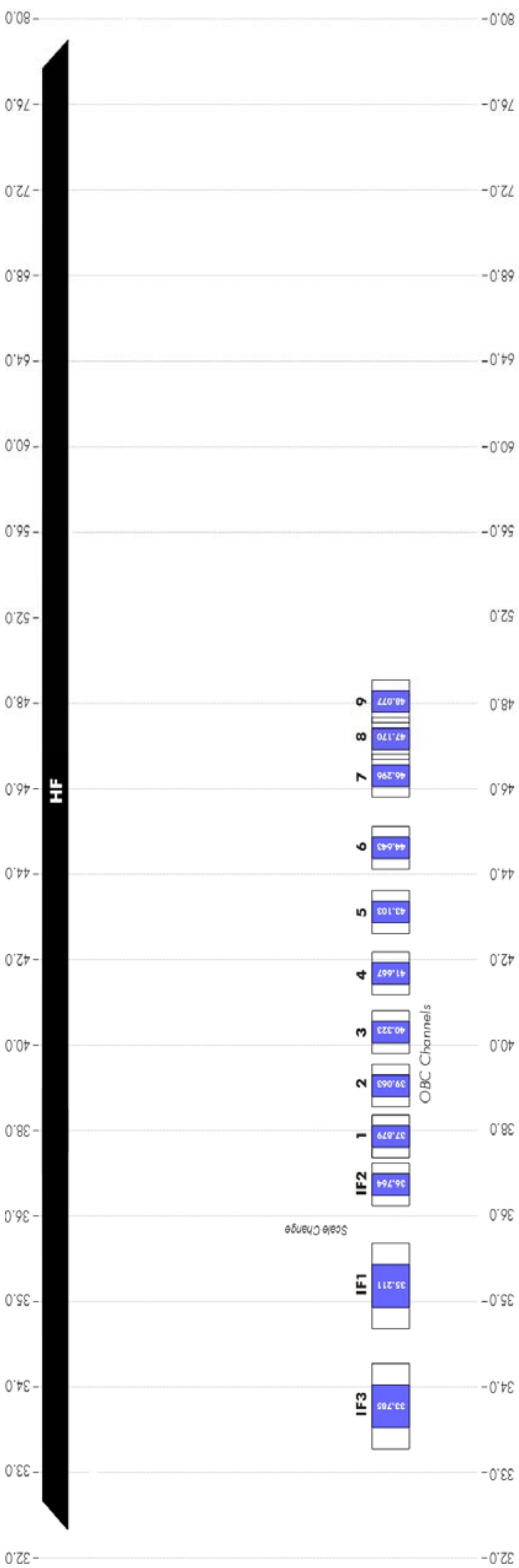
Note: HF USBL underperforms below 27KHz. Therefore it is important to use High frequency replies

FIG 15 SONARDYNE MF WIDEBAND FREQUENCIES



9.3 SONARDYNE HF OBC FREQUENCIES

FIG 16 SONARDYNE HF OBC FREQUENCIES



SECTION 10

10. GLOSSARY OF TERMS

- **Acoustic (Beacon)**

  An instrument that emits acoustic signals. It can be used to mark a point on the seabed or be fixed to a Mobile so that it can be tracked or positioned in space.

  The main types of beacon are described below but some beacons can be configured as several or any of the types.

- **Acoustic (Transponder) Beacon**

  A particular type of beacon that emits an acoustic signal when it detects an interrogating acoustic signal.

- **Acoustic (Responder) Beacon**

  A particular type of beacon that emits an acoustic signal in response to an electrical signal carried to it by cable.

- **Acoustic (Pinger) Beacon**

  A particular type of beacon that emits signals regularly without an interrogating signal. A SYNCHRONOUS pinger is one that can be synchronised to an external master signal. A PRECISION pinger is one with an accurate internal time standard.

- **Acoustic Transducer**

  A device that converts electrical signals into acoustic signals and vice-versa. A HYDROPHONE is a device used to convert acoustic signals into electrical signals only.

  Note: Often the term is applied to a complete instrument that contains pre-amplifiers, matching networks etc.

- **Acoustic Transceiver**

  An instrument that can generate electrical signals suitable for conversion to acoustic signals by a transducer. It can detect received signals and extract information from them.

  For example some transceivers can measure the time it takes a signal to travel from a transducer to a transponder and return. Some can encode and send data in a message and extract digital data from a message (Acoustic Telemetry).

- **Acoustic (Intelligent Transponder Beacon)**

  A particular type of transponder beacon that is managed by a micro-controller. It is commonly referred to as a COMPATT. It can decode acoustic telemetered commands from a transceiver and can send telemetered data to the transceiver. It can measure the distance between itself and other transponder beacons and then telemeter the data to a transceiver.

Usually the instrument is capable of measuring its depth and the temperature of the water and may be commanded to telemeter its own internal state back to the surface. It may be used to measure a variety of underwater parameters and telemeter these back to the surface. It is used, for example, as an intelligent angle-measuring device in a Riser Angle Monitoring System. Very often is fitted with a release mechanism enabling it to be returned, on command, back to the surface at the end of a mission (or if battery power is low).

The intelligent beacon can be developed to the state where it becomes a remotely operated transceiver.

- **Acoustic Signal**

  A message carried by sound pressure waves through the water. In the Sonardyne case, the message has finite length in time.

- **AHARS**

  Attitude Heading and Reference System

- **COMPATT**

  COMPuting And Telemetry Transponder (see Acoustic Intelligent Transponder Beacon). A range of COMPATTs is available from Sonardyne to perform a variety of tasks.

- **Co-ordinate Frame**

  A system that is used to define the position of body in space. The system used is a right-handed Rectangular Cartesian co-ordinate system in three dimensions where the three axes used are orthogonal.

  [Sometimes "polar" co-ordinates may be used. The z co-ordinate is the same as above but the position reflected in the x-y plane is expressed as a radius from the z axis and a bearing in degrees measured clockwise from the y axis].

  A frame with its z axis vertical and stationary with respect to the seabed is known as a SEABED FRAME or an INERTIAL FRAME. (Normally for convenience the x,y plane where z = 0 is at or just below the lowest point on the seabed in the area. Positions above this plane have a positive z co-ordinate or height. Depth is considered as negative height and is measured from the sea-surface or from a height close to it).

  A vessel frame is a frame that is fixed to a vessel.

  An RPH (Roll, Pitch and Heading) compensated vessel frame is a frame sharing the same origin as the vessel frame but with the z axis vertical and the y axis parallel with a meridian passing through the origin (points true north).

- **Database**

  A Database is a body of data stored in a computer memory or on magnetic disc media such as an embedded hard disc or on portable disc.

- **Geodetic Co-ordinates**

  The earth is modelled by a reference spheroid (of which there is a large selection). The position of any point on or near the earth surface is defined by an angle of latitude and an angle of longitude.

For a point on the spheroid P:-

Latitude is defined as the angle between the normal plane at P and the plane of the spheroidal equator.

Longitude is defined as the angle between the meridian plane through P and the arbitrarily defined zero meridian plane or the "Greenwich" plane. (See Geodesy, fourth edition, Bomford, Oxford, sections 2.03 and 4.10(d) for more precise definitions.)

Note: This co-ordinate system is not the same as the astronomical co-ordinate system.

- **GPS (Global Positioning System) Attitude Sensor**

  A system based on the GPS system and a receiver using three or more antennae with known baselines. It is able to compute the instantaneous attitude of a vessel about the roll, pitch and yaw axes.

- **GPS (Global Positioning System)**

  A multi-user, 24 hour, world-wide radio navigation system using the NAVSTAR constellation of satellites. GPS receivers are capable of tracking and decoding the data from the satellites and computing the position and velocity of a vehicle in space. The system uses the WGS 84 Geodetic Co-ordinate system.

- **Gyro Compass**

  A North-seeking Gyroscope uses the properties of a gyroscope when its spin axis is maintained horizontal. The gyroscope senses the spin axis of the earth and will align itself with true north.

- **Inclinometer**

  An analogue device, usually fitted into a COMPATT, which measures the angle of the transponder in which it is mounted with respect to the local vertical.

- **Mobile**

  A body that is free to move relative to the seabed through the space between the sea surface and the seabed.

- **Navigation Processor**

  An instrument that:-

  - Acts as the system controller.
  - Accepts operator input from the keypad.
  - Generates the display signals for the Monitor.
  - Processes the data from the transceiver into a form suitable for display to the operator and output to a DP system.
  - Interfaces to various "attitude" sensors and other navigation systems.

- **Riser Angle Monitoring System (RAMS)**

  Used for measuring the differential angle between a BOP (Blow-Out Preventer) on the seabed and the Riser, connecting the BOP to the rig. Comprises a COMPATT type transponder which is rigidly mounted to the BOP and an external inclinometer unit mounted on the Riser and connected by cable to the COMPATT. On command, the system measures the angle of the BOP with respect to the local vertical and reports this back to the surface and can then repeat this process for the Riser using the external inclinometer, or the difference between the Compatt and the remote can be reported.

- **ROV (Remotely Operated Vehicle)**

  A vehicle controlled and powered over a cable connection so that it can travel in the space between the sea surface and the seabed

- **USBL (Ultra Short Base Line) System**

  A system where three or more elements in a single transducer array are separated by a known distance. By measuring the time of arrival of the signal from a beacon at each transducer the position of the beacon in the vessel frame can be computed. The measurements it makes are the differences in "time-phase" of the signals from each element.

  The co-ordinate frame is fixed to the transducer array which must be oriented in the vessel frame.

- **Sound Speed**

  For seawater, for constant temperature, salinity and pressure the speed at which sound travels in seawater is constant.

- **Sound Speed Profile**

  At different depths the temperature, salinity and pressure vary; therefore the local sound Speed varies.

  In practice the depth cannot be measured directly. Therefore pressure measurements are made, and depth computed, using a knowledge of density. Derivation of density requires a knowledge of temperature and salinity. Salinity cannot be measured directly but conductivity can be measured. Therefore a popular method of measuring the sound Speed profile is from a profile of pressure, temperature and conductivity and the use of empirically derived formulae to compute depth and sound Speed.

  Sound Speed can be measured directly using a dedicated and calibrated instrument called a sound Speed sensor (Frequently referred to as a velocimeter). (One still needs a set of depth measurements.)

- **True North**

  The direction of the shortest line that can be drawn, across the surface of the earth, from the observer and the north pole. (The north pole is where the north end of the spin axis of the earth meets the surface.)

- **UTM (Universal Transverse Mercator)**

  A Projection system that is used to transform Geodetic co-ordinates into an orthogonal two dimensional system suitable for representation on a plane such as a chart. Normally the co-ordinates are called easting and northing which are equivalent to x and y respectively.

The UTM system is a world wide system. Each projection covers 6 degrees of longitude with the central meridian at 3, 9 degrees etc east of Greenwich and from 84 degrees north to 80 degrees south. The scale factor on a central meridian is 0.9996 (with some exceptions).

The projection is orthomorphic which means that at a point the scale in all directions is the same and there is no LOCAL distortion. However it should be noted that the scale factor changes with distance from the central meridian. For points away from the central meridian grid north and true north diverge. The difference is called the CONVERGENCE which is positive when grid north is east of true north.

Usually, the point where the central meridian meets the spheroid equator is given a false easting of 500,000 m.

Many countries' mapping systems are based on the same system but use a particular reference spheroid, non standard central meridians, scale factors and different false eastings and northings.

The polar regions are covered by two Zenithal orthomorphic projections.

- **VRU (Vertical Reference Unit)**

  An instrument that measures the instantaneous roll and pitch of a vessel.

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