User Manual
for the
Multi-Return Altimeter
Model 11001

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1. Scope

1.1 Identification

This document is the user manual for the Multi-Return Altimeter Model 11001. The altimeter is available in a range of frequency and depth options to suit a variety of applications. The higher frequency units (1.1MHz and 700kHz) are better suited for short range high precision measurements or for use in enclosed spaces, whereas the lower frequency units (200kHz, 300kHz and 500kHz) provide longer range performance in open water.

1.2 Introduction

The Multi-Return Altimeter is used to obtain ranges to the seabed when operating with a high level of suspended sediments. Simple altimeters use a threshold comparator on the acoustic receiver output to trigger the range measurement thus are susceptible to false returns from suspended solids in the water column. The Multi-Return Altimeter uses a high-speed analogue to digital converter to capture the analogue receiver output data from the complete water column. An on-board microcontroller then analyses the captured data and extracts the strongest signal, which is usually from the seabed. The output from the altimeter can be either in digital form via either RS232 or RS422/RS485 serial data links or in analogue form from a 12-bit D/A converter with either 0-5v or 0-10v scaling. The altimeter is powered from an external supply in the range 12v to 24v and typically draws an operating current of 120mA.

The housing for the Multi-Return Altimeter may be manufactured from either μPVC, anodised aluminium or stainless steel depending on the operating depth requirements. The unit is housed in a tube with the acoustic transducer mounted on one end-cap and an underwater connector on the other end-cap. Typically the altimeter is mounted vertically, looking down at the seabed, and calculates the range to the seabed for every acoustic transmission.

The Multi-Return Altimeter is fully programmable via the RS232 or RS485 serial connection from a host P.C. Supplied with the unit is a Windows program for setting the internal sampling parameters and for testing the altimeter on a direct cable connection in either imaging or ranging modes. With the altimeter linked to a P.C. the program can be used to display all the captured data for every acoustic transmission to produce a scrolling imaging display like a "fish-finder" sonar or an Acoustic Backscatter Sonar (ABS).

The configuration parameters, which are set up whilst connected to a P.C., are stored in flash memory inside the altimeter and so the altimeter may be completely powered down and only switched back on when it is desired to take readings. The power up time should be at least twice the programmed "ping rate" to allow the unit to stabilise. When the altimeter powers up it defaults to transmitting a 9600 baud NMEA style ASCII depth message on the RS485 and RS232 ports at the programmed repeat rate. Any character sent to the altimeter will stop the NMEA message being sent and put the altimeter in a "Slave" mode waiting for further commands from a host computer. The analogue output is always present regardless of whether the digital output is sending or not.

The firmware for the altimeter is stored in a flash programmable eeprom and may be upgraded without opening the underwater unit via the RS232 link.

1.3 System Overview

The Multi-Return Altimeter comprises the following items as shipped from the factory:-

1.   Altimeter underwater unit

2.   Multi-Return Altimeter Setup and Test Software

3.   User manual

4.   Packing case for the above items.

1.4 Document Overview

The purpose of this document is to provide user instructions for setting up and operating the Multi-Return Altimeter.

This section, Section 1, provides an overview and general introduction

Section 2 details the documents applicable to this document

Section 3 details the system hardware

Section 4 details the system software

2. Applicable Documents

The following documents are applicable to this document:-

1. Interface Control Document for Multi-Altimeter

3. System Hardware

3.1 Multi-Return Altimeter Underwater Unit

The Multi-Return Altimeter contains the acoustic transducer, acoustic transmitter/receiver PCB and microcontroller PCB.

3.1.1 Microcontroller PCB DM02A0106

External d.c. power for the microcontroller PCB is connected from the external underwater connector to PL3 and is in the voltage range 12VDC to 24VDC. Diode D6 protects against power reversal. The L1/C1 low-pass filter conditions the incoming d.c. supply to the input of IC5 an LM2940 +10v regulator. The regulated 10v supply is only used on this PCB for the Op-Amp IC7 which buffers the d.c. analogue output voltage.

Regulator IC6 is a 7805, which steps down the +10v to +5v to power everything on this PCB except IC7.

To generate a –5v d.c. for the Rx/Tx PCB a MAX660 (IC11) switched-capacitor regulator inverts the +5v and provides up to 100mA at –5v.

The main microcontroller is IC3 a PIC16F876 clocked at 16MHz using its internal oscillator driven by XTAL1. IC3 is both in-circuit programmable via its main flash program memory and can store data variables in its internal EEPROM without external power. Connector PL1 is used to connect an in-circuit programmer to IC3 to load new versions of the operating firmware. Twin diode D1 isolates power to the microcontroller so that the programmer does not power-up the whole PCB.

Port B of IC3 connects to a 4kx9 FIFO memory IC12 which buffers the data from the flash A/D converter IC2 (AD775). The write clock for the FIFO and A/D combination is derived from the Pulse-Width Modulated output from the PIC microcontroller, which in this case is programmed with a 0.5μsec pulse width and a period from 1μsec to 100μsec.

The analogue input range of the A/D converter (IC2) is set to 2VDC using pre-set R7. One half of IC10 (OP284) buffers the reference voltage to the A/D, the other half of IC10 buffers the incoming receiver envelope from the Rx/TX PCB.

Pins RA0-RA3 of PortA of IC3 are used to control the digital to analogue converter output of the unit. IC1 is a dual serial 12-bit D/A converter with channel A providing the gain control for the Rx/Tx and channel B being the altimeter range output. One half of Op-Amp IC7 buffers the gain voltage, which is in the range 0v to 4v, and the other half of IC7 buffers the range output. Mos-Fet TR1 is used to switch the gain of IC7B such that the output voltage may be either in the range 0-5v or 0-10v under control of the software. R18 is used to trim the +5v output first then R17 is used to trim the +10v output. The analogue output has an output impedance of around 50ohms therefore should not be connected to an input impedance of less than 250k ohms if full 12-bit accuracy is to be preserved.

RS232 serial communications is handled by IC9 a MAX202, which both inverts and level shifts the microcontroller signals to standard RS232 levels. The RS232 transmit and receive pins are protected by transient surge protection diodes D7 and D2 as well as in-line "PTSR's" F3 and F4 which are solid state re-settable fuses.

RS485/RS422 differential communication (half-duplex) is provided for by IC4 (MAX483). The line direction defaults to receive unless the altimeter is responding to a message when the altimeter switches the line to transmit. The line is terminated in 100ohms and also has both transient and solid-state fuse protection through D3,D4,F1 and F2.

The receiver/transmitter PCB is "piggy-backed" onto the logic PCB via PL2 which provides power and control signals to the Rx/Tx PCB and receives the acoustic echo envelope from the receiver.

3.1.2   Transmitter/Receiver PCB DM02A0206

The Transmitter/Receiver PCB is plugged into the microcontroller PCB via PL2. Power for the PCB comes from the microcontroller PCB, the transmitter being powered from +10v and the receiver from +/-5v.

The Transmitter oscillator frequency is generated by the 74HC4047 astable IC6 and the frequency is adjusted to suit the acoustic transducer with R1. Normally the oscillator is disabled by a low level at its enable pin 5. The TXGATE signal on PL2 pin 1 is an active high (+5v) pulse of width set by the transmit pulse width parameter. The oscillator IC6 then generates anti-phase clocks at pins 10 and 11, which are gated by IC4 before driving the dual mos-fet driver IC5 (TC4427). The push pull outputs of IC5 are connected to the gates of the MOSFET transistors TR1 and TR2. The drains of TR1/TR2 are connected to the centre tapped toroidal output transformer T1 which steps up the transmit pulse to drive the transducer. Capacitors C1, C2 and C3 along with the inductance of T1 combine to tune the waveform applied across the transducer to an approximation of a sine-wave. Diode networks D5/D6 and D1/D2 provide the transmit/receive gating function such that high voltages are not applied across the receiver input and low level receive signals are not shunted by T1.

The receiver input pre-amplifier stage is an AD603 (IC1), which is a voltage controlled variable gain amplifier with up to 40dB of gain, and very low input noise into its 100ohm input impedance. The output of IC1 is coupled through a bandpass filter around L1,L2 and L3 to the AD829 operational amplifier IC2 which has a fixed gain of 40dB. The bandpass filter has a bandwidth of around half of the acoustic frequency, i.e. a "Q" factor of 2 and a loss of -6dB at its centre frequency.

The output stage around IC3 (AD828) is a precision active full-wave rectifier, which produces the envelope of the received echoes ready for digitisation on the microcontroller PCB. A simple low-pass filter of R14 and C4 reduce the ripple amplitude of the full-wave rectifier.

4.   System Software

4.1   How to Program the Altimeter

The Multi-Return Altimeter is supplied with a Windows'95/'98/XP program which provides a means for programming the sampling schedule of the altimeter, and viewing live data without opening the underwater pressure housing. To use the software the P.C. requires a spare RS232 port (can be any of COM1: to COM8:), or an RS485 to USB adaptor may be used. However, for upgrading the altimeter firmware the RS232 connection must be used.

4.1.1   Connecting the P.C.

The following connections should be made between the P.C. serial port and the Altimeter.

P.C. 9-way D-type	Signal	Altimeter 8-pin Burton
2	RS232 input to P.C.	2
3	RS232 out from P.C.	1
5	0v ground return	7

Note that the Altimeter will require power whilst connected to the P.C. so a battery pack or bench power supply of between 12v and 24v should be connected with the +12v to pin 3 and the 0v to pin 4.

See Section 5 for full connection details.

4.2   Software Installation

There is a setup.exe program on the supplied software disk which should be executed using the "Run..." option from the "Start" button on the Taskbar. The setup program will suggest an installation directory, which may be modified if really necessary but should not conflict with any other software if the default is selected. When the setup program completes the program may be run by selecting the "Multi-Return Altimeter" program via "Start" then "Programs" from the Taskbar.

4.3   Communications Port

When the program is run, the first dialogue that appears offers the choice of serial port from COM1: to COM8: for communication with the altimeter. If using the altimeter with an RS232 to RS485 adapter without automatic line direction switching then the "Enable RTS Control" checkbox should be ticked. Most USB to RS485 or RS232 adapters are auto-switching and so this box must be unchecked to disable the RTS control. If having difficulty with a particular installation and the altimeter functions correctly when tested via a direct RS232 connection then contact your supplier for assistance.

Also on the communications port setup screen is the option to enable a second serial port for output of an NMEA format depth string for connection to external equipment via RS232. The NMEA depth string is output in a fixed format at 4800 baud with 8

data bits, no parity and one stop bit. The data string output from the port is of the following format:-

$MEALT,00.000*63

Where the "$" signals the start of the message, the message type is MEALT, the range is output in metres in a fixed decimal point format. The "*" signals the end of the string and the last two digits are the checksum which is the exclusive OR of all the characters between the $ and the * but not including the $ or *.

The appearance of the Comms Port Setup is shown below.
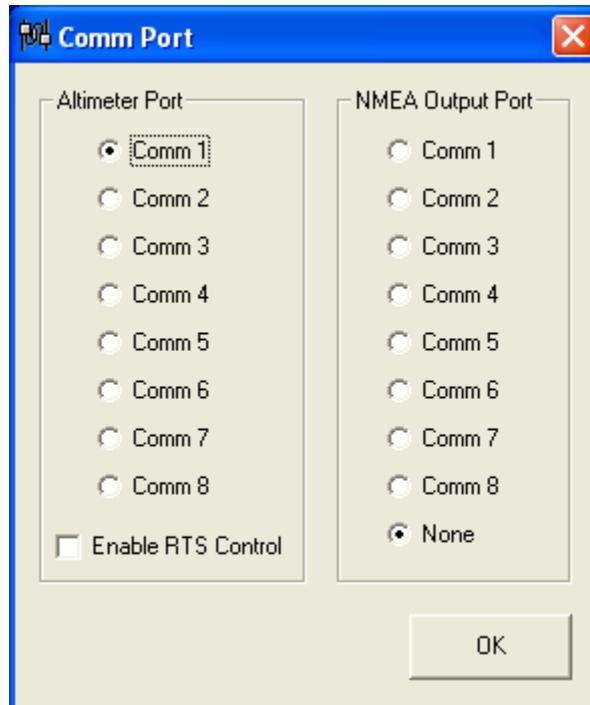
4.4   Main Program Screen

The main program screen is shown below and is where all the Altimeter programming parameters are entered.

The left-hand frame shows the parameters that may be sent to the altimeter to control how it samples the receiver data. Parameters are modified by using the slider controls, the only text box that requires typing a value in is the number of averages field. The option buttons select either 0v to 5v or 0v to 10v output voltage scales.

The upper right-hand frame labeled "Command" sends the specified command directly to the altimeter.

The Display Features frame opens either the imaging or ranging display windows to use the altimeter live on-line for viewing seabed data.

The Message bytes and Sample Count values are for information only, they update as messages pass between the P.C. and the Altimeter.

The status bar shows the date and time along with descriptive messages at the left-hand side depending on what commands were sent to the altimeter. When the software is first run whilst connected to a powered-up altimeter the serial number of the altimeter should be shown on the status bar. If the software cannot talk to the altimeter an "offline" message will show and you should check the serial connections and the power to the altimeter.
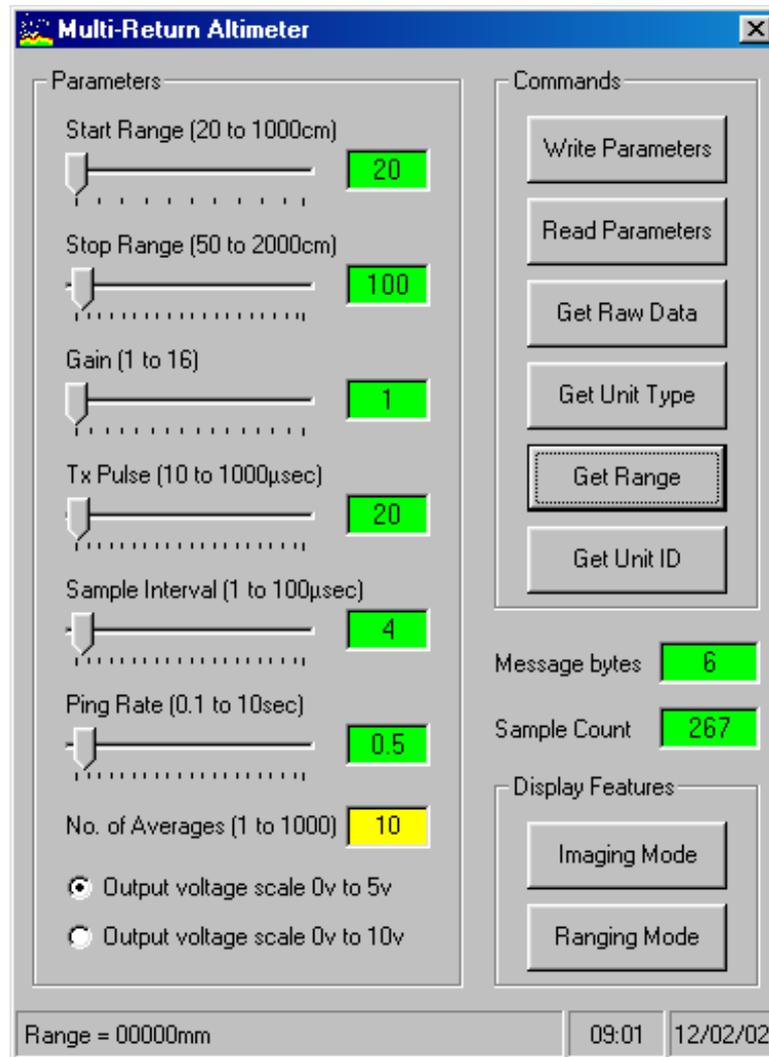
4.4.1 Start Range

The Start Range represents the time/distance from when the sonar transmits to when sampling of the receive data starts and may usefully be used to limit the size of the data gathered by ignoring data near to the transducer before the acoustic beam has reached the sea-bed. With all sonars that utilise a single transducer for both transmit and receive there is an amount of "transmit breakthrough" that occurs at the receiver output. This results in a bright spot centred on the transducer position and gradually fading out into the background colour when the data is viewed graphically. This control may also be used to blank out any near echoes to the unit. The Start Range is modified by moving the slider control with the mouse (place pointer over the knob on the slider and drag whilst holding down the left mouse button). The value of

the Start Range is shown in units of centimetres (cm) and may be adjusted over the range 20cm to 1000cm.

4.4.2   Stop Range

The Stop Range is the distance from the transducer where the Altimeter stops sampling the received echoes. This control corresponds to the full-scale range setting for the unit. The value of the Stop Range is shown in units of cm and may be adjusted over the range 50cm to 4900cm.

NOTE:- The Stop Range MUST be more than the Start Range

4.4.3   Gain

The Gain setting is used to control the gain of the first stage of the acoustic receiver in the Altimeter to allow for different echo strengths dependent on the range selected. The gain is set in units from 1 to 16, which represents a 40dB range of adjustment in the receiver. A gain of 1 is the lowest setting and 16 is the highest gain setting. Ideally the gain should be set so that the echo from the seabed is just below the clipping threshold of the A/D converter.

4.4.4   Transmit Pulse

The acoustic Transmit Pulse may be set in the range 10usec to 1000usec with shorter pulses generally giving higher resolution but the trade-off is that the gain is less with shorter pulses. The Transmit Pulse should always be larger than the Sample Interval otherwise received echoes may be missed. It is recommended that the Transmit Pulse width should be at least twice the sample interval to ensure that pulses are not missed.

4.4.5   Sample Interval

The Sample Interval is literally the time between successive readings of the A/D that is sampling the receiver output. The range of values that may be programmed is from 1µsec to 100µsec. The resolution of the altimeter is increased by making the Sample Interval small but the trade-off is a larger dataset and/or a shorter range coverage.

4.4.6   Ping Rate

When the Altimeter is running by itself without a P.C. connected the Ping Rate specifies how often the unit will transmit an acoustic pulse. The range of adjustment is from 0.1secs to 10secs.

4.4.7   Number of Averages

The No. of Averages specifies how many times the Altimeter will transmit and gather data before outputting a new range value. The range calculated for each transmit pulse is summed in a 32-bit register and then when the specified number of averages is complete the sum is divided by the number of echoes received and a new range sent to the analogue output. When operating the altimeter via a serial data link the "Get Range" command may be issued at any time and the latest averaged range is returned. When polling for a range on the serial data link the poll frequency should be at least as long as the time taken to gather the number of samples being averaged otherwise the same value will be read out several times before its gets updated.

4.4.8   Output Voltage Scale

The output voltage scale may be selected as either 0v to 5v or 0v to 10v by clicking on the adjacent option buttons. Note that the analogue output voltage is scaled to fit the selected "Stop Range", i.e. if the Stop Range is 200cm then either 5v or 10v will represent 200cm and is the seabed is at 100cm the output voltage will be either 2.50v or 5.00v. Note that the "Start Range" setting does not affect the analogue output voltage. The full scale output when using the 0v to 10v range may be slightly less than 10v due to the tolerance of the +10v regulator used, however, the output is linearly scaled to a theoretical 10v full scale reading. In practice once the output reaches say 9.80v (or whatever the tolerance on the actual regulator is) no further voltage increase from the DAC is possible. This limitation does not occur when using the 0v to 5v range.

4.4.9   Command Buttons

There are six command buttons to the right and top of the main program screen. The buttons may be selected by a single left click of the mouse or by using the Tab or Shift Tab key combination to highlight the required button and press ENTER to select it.

NOTE:- *The commands will not be recognised by the Altimeter unless the unit ID has been read correctly by the Windows Program. When the Multi-Altimeter program is first run it interrogates the Altimeter to find its "Unit ID" which usually corresponds to the Altimeter Serial Number. If the commands do not seem to be working then press the "Get Unit ID" button first and check that the Altimeter responds with its Serial Number. Once the Windows program knows the Unit ID it can communicate with the specified Altimeter only until the software is restarted after connecting a different Altimeter.*

4.4.9.1 Write Parameters Button

The Write Parameters button downloads the current contents of the "Parameters" section of the main program screen to the altimeter. The altimeter stores the values in its internal EEPROM and reloads them internally so that sampling continues with the new parameters.

NOTE:- *Because the Altimeter has to re-boot to re-initilaise its internal parameters after the Write Parameters button is pressed the user should wait until the staus bar reports "Unit nnn parameters read" to indicate that the unit is ready for more commands.*

4.4.9.2 Read Parameters Button

The Read Parameters button uploads the current contents of the Altimeters EEPROM and fills in the "Parameters" section of the main program screen according to the values stored.

4.4.9.3 Get Raw Data

When the Get Raw Data button is pressed the Altimeter transmits and receives a frame of data, uploads the data to the host P.C. and displays the raw data in an Ascan window. If the number of samples is large then there may be a small

delay before the data appears on the screen due to the time taken for the serial data transfer.

4.4.9.4 Read Unit Type

When the Read Unit Type button is pressed the Multi-Return Altimeter should reply with a type "F". This code may be used by other Marine Electronics software to recognise the type of commands that the underwater unit will respond to.

4.4.9.5 Get Range

When the Get Range button is pressed the Altimeter responds with the current target range that it has processed from its most recent transmit/receive averaging period. The range measured is displayed on the Status Bar at the bottom left of the main program window.

4.4.9.6 Get Unit ID

When the Get Unit ID button is pressed the Altimeter should reply with its serial number, which is the Unit ID.

NOTE:- *If the Altimeter is powered down and then re-started or a different Altimeter is connected this button should be pressed so that the Windows program knows which unit it should communicate with.*

4.4.10 Display Features Buttons

The display features buttons enable use of the Altimeter as an on-line sonar instrument whilst connected via the serial link to a P.C.

4.4.10.1 Imaging Display

The Imaging Display button opens a new graphical window as shown below and then repeatedly executes "Get Raw Data" commands to the Altimeter. The raw data from the Altimeter is plotted on a scrolling colour screen in the manner of a fish-finder sonar with the most recent data on the right of the screen. Section 4.5 describes the Imaging Display screen.

4.4.11.1 Ranging Display

The Ranging Display button opens a new graphical window, which plots the processed range calculated by the Altimeter as a red line on a scrolling window as for the imaging display. To make it easier to see the red line when the window size is small a graduated yellow band is drawn under the red line fading out as the range increases. Section 4.6 describes the Ranging Display screen.

4.5 Imaging Display Window

The Imaging Display window is shown below. The signal strengths of the received echoes are displayed using a rainbow colour palette as drawn at the base of the display window with red being the strongest signal and blue the weakest. The range increases down the screen so the transducer is at the top and the seabed nearer the bottom of the screen.
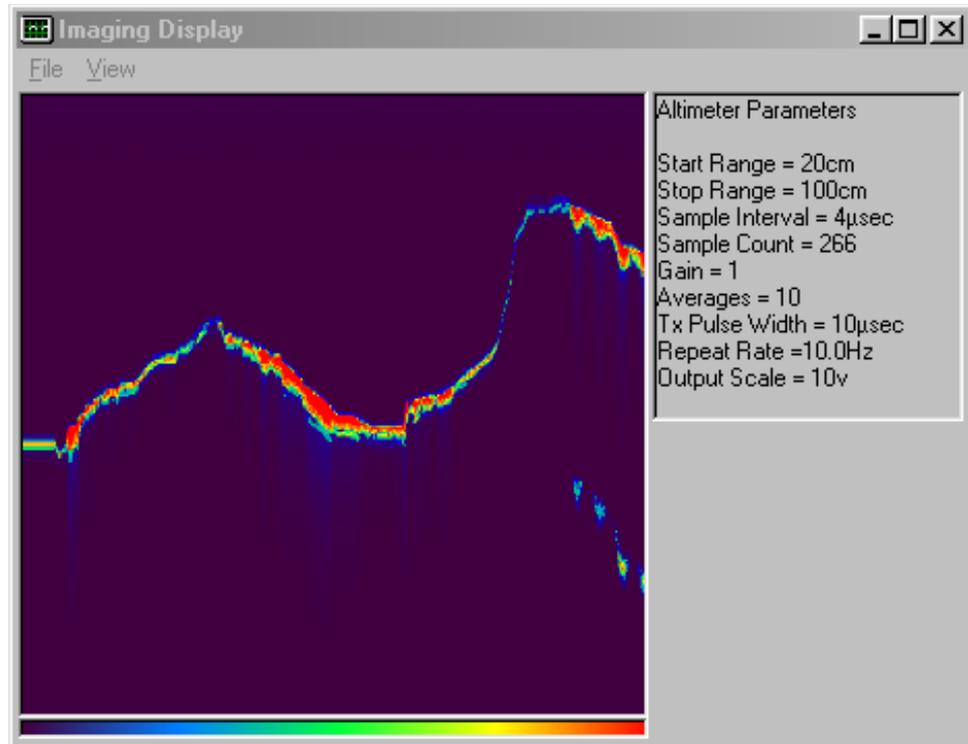

The View menu provides the facilities for overlaying a range "graticule" over the data and a text overlay "annotation" that indicates the start and stop ranges. Also on the View menu is an option to open the Ascan display window, which is configured to always be the top-most window on the screen. Even if the Imaging Display window is resized to fit the full screen dimensions the Ascan window will still be visible over the top (provided the Ascan option is enabled). See section 4.7 for a description of the Ascan Window.

The Imaging Display window is re-sizable and can be "maximised" to the screen dimensions. Whilst the Imaging Display window is open it is not possible to access the Main Program Screen even though it may still be visible on the screen. The Imaging Display must be closed before any other commands can be sent to the Altimeter.
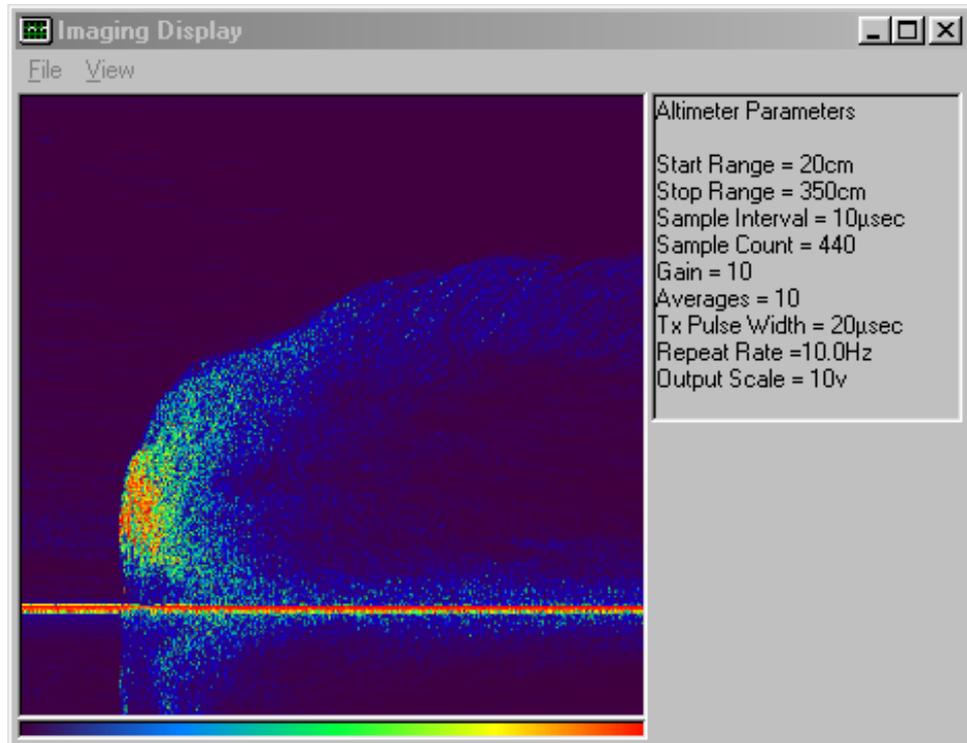
The Imaging Display shown above shows how the Altimeter can see the side of a 3m test tank despite vigorously agitating the water with a stick to generate a bubble cloud which can be seen getting closer to the transducer and fading with time. The dense bubbles near the left of the screen show as full-scale targets which the altimeter will detect as they are the strongest signal present. This false detection is shown in the Ranging Display section 4.6 below.
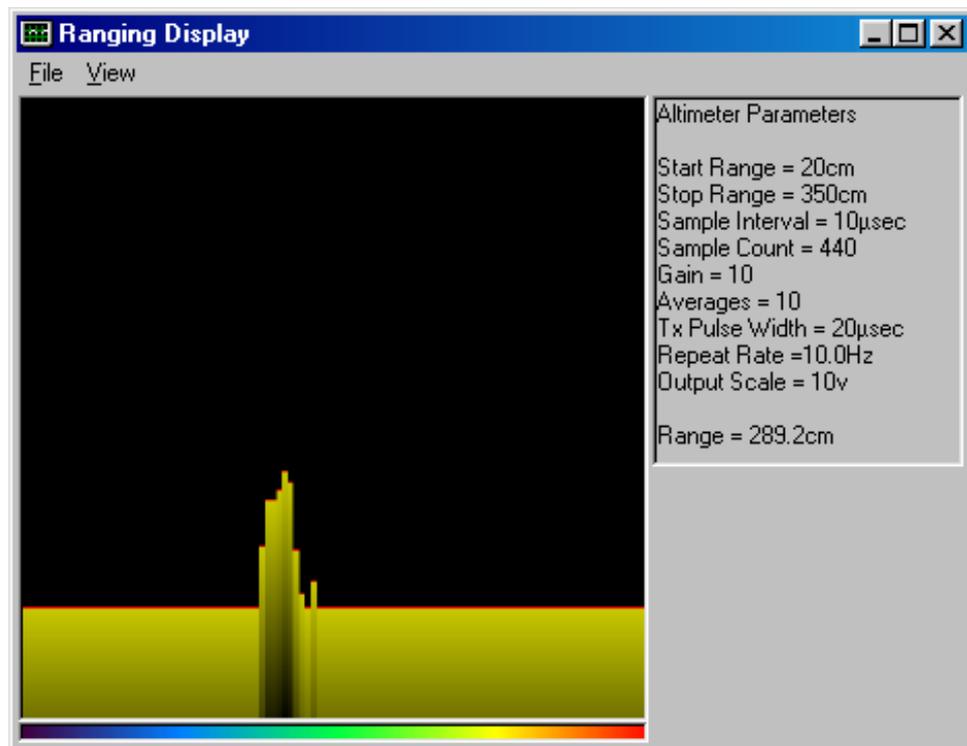
4.6   Ranging Display Window
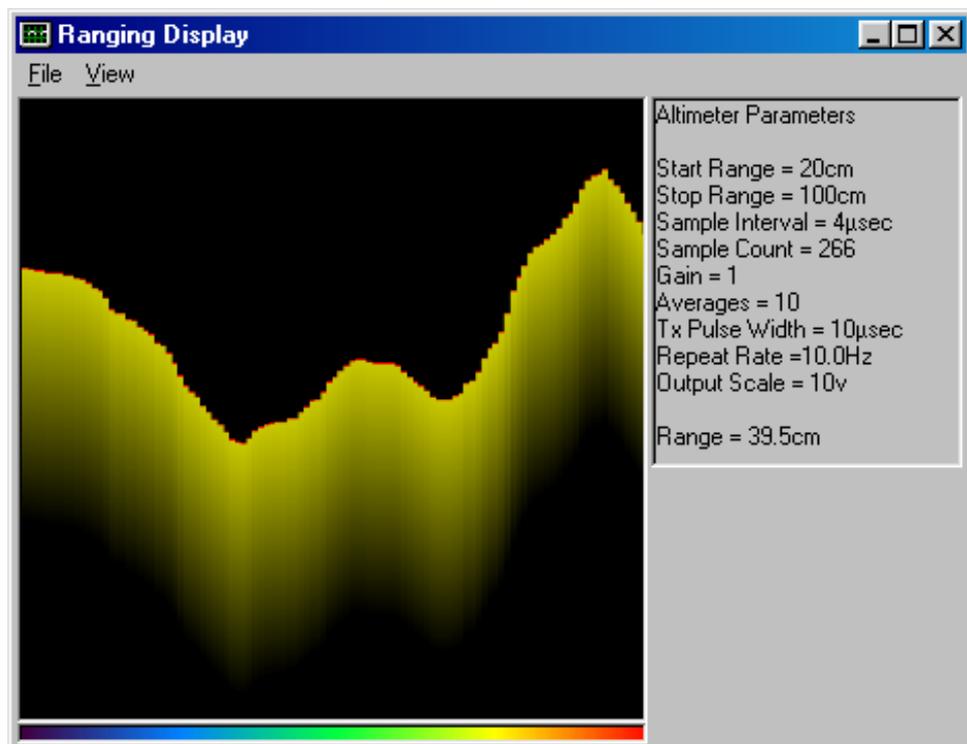
The Ranging Display window is shown above. The most recent range is drawn at the right side of the screen and the display scrolls towards the left. The current range at the right side of the screen is shown under the Altimeter Parameters.

The above image was created by repeatedly raising and lowering the altimeter in a shallow test tank. The profile looks stepped due to the fact that the altimeter is averaging 10 acoustic transmissions to generate a range, during which time the range is being repeatedly read by the program generating the display. Thus the range does not change for every increment along the x-axis. If the averages were set to 1 then the "staircase" effect would not occur, and if the number of averages were increased to 100 then the profile would be even more stepped.

The second picture of the Ranging Display mode shown below was taken using the same conditions as for the second Imaging Display screen, which showed the bubble clouds resulting from agitating the water in the test tank. What can be seen on the Ranging Display screen is that the range to the tank wall is only disrupted during the period that the echo strength from the bubble cloud reaches full-scale output from the receiver (i.e. when the red dots appear on the Imaging Display). The unit then quickly returns to displaying the tank wall range when the echo from the bubble cloud drops below full-scale. If the gain were reduced slightly to avoid the bubble echoes reaching full-scale then the tank wall range would be displayed all the time.

4.7   Ascan Display Screen

The Ascan Display screen may be activated by either pressing the "Get Raw Data" button on the Main Program Screen or selecting the Ascan Display from the View menu of the Imaging Display window. The display format is as shown below and consists of an oscilloscope type display of the output of the sonar receiver with distance from the sonar increasing along the x-axis and signal amplitude increasing up the y-axis.
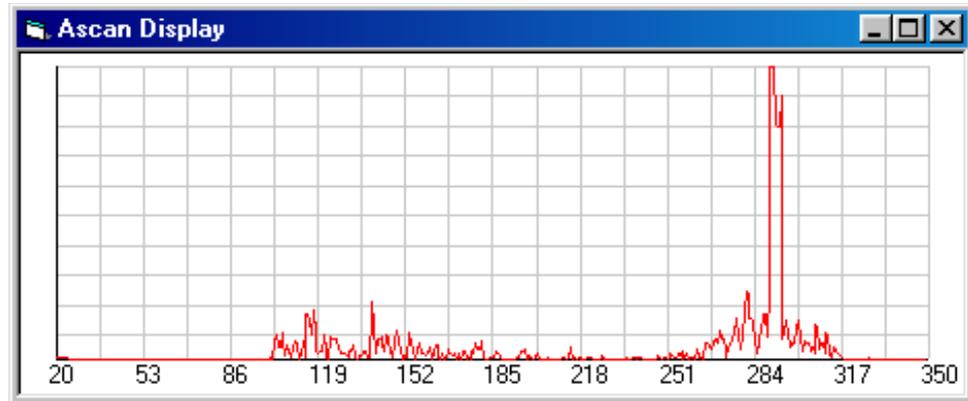
The Ascan Display above was taken whilst there were still bubbles in the water from the agitation experiments above. The test tank wall can be clearly seen at around 2.9m from the Altimeter. Selecting either the Cancel button or the close button in the top right corner of the window will close the Ascan Display. The Ascan Display will always be the top-most window when multiple windows are open and it may also be re-sized by dragging to suit the space available on the computer screen.

5. Connection Details

5.1 Option 1 – Mini Burton 8 way Underwater Connector

5.1.1 Bulkhead Connector Type
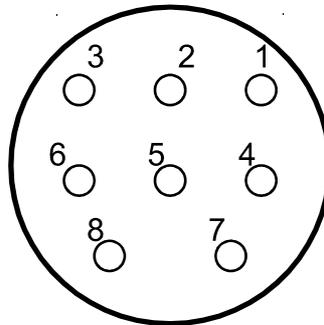
Burton Mini 5506-1508-0001 (or equivalent)

5.1.2 Mating Cable Connector Type

Burton Mini 5501-1508-nnnn (where nnnn is length in feet)

5.1.3 Connector Supplier

Scorpion Oceanics Ltd.,
Unit 2 Park Farm,
Great Chesterfield,
Saffron Walden,
Essex,
CB10 1RN
Tel. +44 (0) 1799 531632
Fax. +44 (0) 1799 531634

5.1.4 Pin Connections

View looking into bulkhead connector on base of Altimeter

Pin 1   RS232 Receive data from host
Pin 2   RS232 Transmit data to host
Pin 3   +12v to +24v d.c. power input (120mA)
Pin 4   0v (Power ground return)
Pin 5   RS485 Data +ve
Pin 6   RS485 Data -ve
Pin 7   0v (RS232, RS485 and analogue ground return)
Pin 8   Analogue Output (0-5v or 0-10v)

5.2 Option 2 – Mini Subconn 8 way Underwater Connector
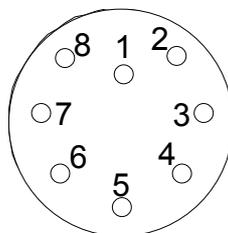
5.2.1 Connector Type

Sub Conn FCR1508M

5.2.2 Mating Cable Connector Type

Subconn MCIL8F

5.2.3 Connector Supplier

MacArtney UK Ltd.
Howmoss Drive,
Kirkhill Industrial Estate,
Dyce,
Aberdeen
AB21 0GL
Tel: +44 (0)1224 358500

5.2.4 Pin Connections

View looking into bulkhead connector on base of Altimeter

Pin 1   RS232 Receive data from host
Pin 2   RS232 Transmit data to host
Pin 3   +12v to +24v d.c. power input (120mA)
Pin 4   0v (Power ground return)
Pin 5   RS485 Data +ve
Pin 6   RS485 Data -ve
Pin 7   0v (RS232, RS485 and analogue ground return)
Pin 8   Analogue Output (0-5v or 0-10v)