PicoSonar Integration Manual

This page is left blank intentionally

VOIDS

Void	Section	Notes
10		
9		
8		
7		
6		
5		
4		
3		
2		
1		

LIST OF MODIFICATIONS

Version	Date	Modifications	Pages	Writer	Checker
1.08	28/11/16	Update drawings for PicoFLS-120		AW	MT
1.07	29/09/16	Update drawings for short PicoMBES TX XDCR		AW	MT
1.06	20/06/16	Add ZDA baud		AW	MT
1.05	29/05/16	Add In-system Reprogramming		AW	
1.04	10/05/16	PPS polarity when ZDA over RS232		AW	
1.03	05/05/16	Testing, TVG, pulse and rate commands		AW	
1.02	23/02/16	Operation without transducers for test		MFG	
1.01	25/11/15	New transducer shape		MFG	
1.00	25/09/15	Review and void fill from Allan		MFG	AW
0.02	24/09/15	More information from Allan		MFG	AW
0.01	23/09/15	Initial document		MFG	AW

TABLE OF CONTENTS

1 INTRODUCTION

1.1 REFERENCES

Ref 1 Picotech website http://www.picotech-ltd.com/
Ref 2 Android 120 app https://play.google.com/store/apps/details?id=com.picosonar.app120
Ref 3 Android 40 app https://play.google.com/store/apps/details?id=com.picosonar.app40
Ref 4 TP-LINK™ TL-WR702N WiFi router https://www.tp-link.com/en/download/TL-WR702N.html
Ref 5 Android Network Monitor Mini app https://play.google.com/store/apps/details?id=info.kfsoft.android.TrafficIndicator

1.2 GLOSSARY & ACRONYMS

WORDS & ACRONYMS	DEFINITION
ARP	Address Resolution Protocol
AUV	Autonomous Underwater Vehicle
CW	Continuous Wave
DC	Direct Current
FPGA	Field-Programmable Gate Array
ICMP	Internet Control Message Protocol
INS	Inertial Navigation System
IO	Input - output
LFM	Linear Frequency Modulation
MRU	Motion Reference Unit
NMEA 0183	A standard interface format for data sent between marine data systems
OEM	Original Equipment Manufacturer
PGA	Programmable Gain Amplifier
PC	Personal computer
PDU	Protocol Data Unit, i.e. a data “packet”
PPS	Pulse Per Second: a system of timing pulses typically output by GPS systems
PRF	Pulse (or Ping) Repetition Frequency
PRI	Pulse Repetition Interval (the inverse of PRF)
ROV	Remotely-Operated underwater Vehicle
SAS	Synthetic Aperture Sonar
Sonar head	The active part of the sonar, the transducers
TVG	Time Varying Gain
USV	Unmanned Surface Vehicle (radio-controlled or autonomous boat)
UUV	Unmanned Underwater Vehicle: includes AUVs and ROVs
ZDA	An NMEA 0183 message, defining timing, used together with PPS pulses

1.3 SCOPE

This document provides instructions for integrating PicoSonar systems into systems and vehicles.

It covers the PicoMBES multibeam sonar and PicoFLS forward-look sonar.

1.4 PICOMBES AND PICOFLS

PicoMBES is a small beam-forming bathymetric sonar. It forms a fan of beams extending from the sonar head, and measures the distance to the seabed (or other hard objects) in each beam. The amplitude signal for the whole of each beam can also be used, thus giving an image similar to PicoFLS.

PicoFLS is a forward-looking sonar. It provides an image of objects in front of it, and is useful for mounting on the front of vessels or vehicles to look for obstacles. It also provides information on distance travelled and speed, which can help the vehicle INS (inertial navigation system). It is also used to look for objects in the water, such as fish, divers, etc.

PicoMBES and PicoFLS are based on the same components, and therefore their functionality is exchangeable. The main difference is in the sonar transmitter (projector), which sends out the pulse of sound. In PicoMBES, the transmitted signal forms a beam that is narrow in one direction (1.6°) and wide in the other (120°). When used for bathymetry, this transmit “beam” is arranged so that the wider axis is at right angles to the direction of travel, so that a “swath” of measurements is built up as the vessel moves forwards. In PicoFLS, the transmitted beam is wider, 16° by 120°. This is usually configured to point forwards, in the same direction as the receive array, so that signals are returned from a wider set of items on the seabed or in the water.

1.5 PRECAUTIONS

Precautions should be taken while working on PicoMBES and PicoFLS:

1. ***When operating the system, the transducers must be fully immersed in water. Never operate the system in air as this may cause permanent damage. For testing ashore, immerse the sonar in a bucket of fresh water. The electronics bottle may be mounted/operated in air or water.***
2. ***The power amplifier inside the electronics bottle has high voltage on it, do not touch it with bare hands or tools when it is live; there is sufficient energy stored in the board to cause injury or death.*** (There should be no need to access the inside of the electronics bottle in normal integration and use; see the note below).
3. There are no user-serviceable parts inside the electronics bottle, so do not open it. Opening the electronics bottle may invalidate the product warranty.
4. Clean the transducers and bottle with warm, soapy water. Do not use abrasive or scouring tools or cleaning products.
5. Do not turn on the power supply before all the connections are made.

2 OVERVIEW

2.1 SYSTEM COMPONENTS

PicoMBES and PicoFLS both consist of the following components:

- Transmit transducer
- Receive transducer
- Electronics bottle
- Umbilical cable

The electronics bottle can be supplied in aluminium or stainless steel. It may also be supplied with an additional bulkhead connector to interface with an external ValePort MiniSVS sound velocity sensor to aid computation of ranges and angles.

The Umbilical cable connects the Electronics bottle to the user's equipment.

The systems work with the PicoSonar Android app (Ref 2 and Ref 3) and drivers for the following software are in development;

- ITER Bathyswath®
- OIC GeoDAS® and SAMM®
- Xylem HYPACK®
- QPS QINSy®

2.2 PICOMBES

PicoMBES-120 is a small, low-cost multibeam echosounder, developed by Picotech Ltd. PicoMBES-120 has a wide 120° swath and is intended for bathymetric survey using 3rd party acquisition and processing software. It is small enough to fit within a USV's ADCP moon pool.

2.2.1 Specifications, PicoMBES-120

Item	Dimensions Height / length (mm)	Width / diameter (mm)	Depth (mm)	Weight in air (kg)	Weight in water (kg)
Transmit transducer	36.0	142.0	84.0	0.831	0.30
Receive transducer	36.0	170.0	84.0	1.084	0.56
Electronics bottle, Aluminium	164	72	-	1.28	0.60
Electronics bottle, Stainless Steel	164	72	-	2.486	1.80

Operational Parameters	
Swath sector	120°
Beam width	1.4° x 1.6°

Operational Parameters	
Frequency	337-450 kHz
Pulse length	500us, 5ms
Number of beams	256 spaced @ 0.47°
Maximum range	240 m
Range Resolution	37mm
Power	24 to 36 VDC, 12 W
Pressure depth	300 m

2.3 PICOFLS

2.3.1 Description

PicoFLS is a small, low-cost forward-looking imaging sonar, developed by Picotech Ltd. It is ideal for many imaging applications, for use from boats, ROVs, autonomous vehicles or by divers.

PicoFLS can be used stand-alone, hand-held, on remotely-operated and autonomous vehicles, or on pan-and-tilt heads, to view items on the seabed and in the water.

PicoFLS is provided with imaging and control software for use on Android tablets and Windows PC computers.

2.3.2 Specifications

Item	Dimensions			Weight in air (kg)	Weight in water (kg)
	Height / length (mm)	Width / diameter (mm)	Depth (mm)		
Transmit transducer	36.0	142.0	84.0	0.759	0.23
Receive transducer	36.0	170.0	84.0	1.053	0.53
Electronics bottle, Aluminium	164	72	-	1.28	0.60
Electronics bottle, Stainless Steel	164	72	-	2.486	1.80

Operational Parameters	
Field of view	120° azimuth x 16° elevation
Beam width	1° x 16°
Centre Frequency	350-500 kHz
Bandwidth	25/50 kHz
Range Resolution	2 cm
Number of beams	256 spaced @ 0.47° (PicoFLS-120), 64 spaced @ 0.7° (PicoFLS-40)
Maximum range	120m
Maximum PRF	15 Hz
Power	24 to 36 VDC, 9 W
Focus	Fully focussed over swath/sector

Operational Parameters	
Compensation	Roll & yaw compensation available
Pressure depth	300 m

2.3.3 DPCA Micro-Navigation

“DPCA” stands for “displaced phase-centre antenna”, and is an algorithm used in sonar and radar to correlate the data from successive “pings” to give a measurement of the movement between them, and therefore the velocity of the vehicle over the seabed.

PicoFLS uses DPCA processing to give an accurate measurement of the velocity of the vehicle that it is mounted on.

The velocity data from PicoFLS is typically fed into the vehicle’s inertial navigation system to help provide accurate position information. Inertial navigation systems (INS) contain gyroscopes to measure rotational velocity, and accelerometers to measure linear acceleration. These INS measurements are integrated (for angular velocity) and double-integrated (for acceleration) to obtain an estimate of the position of the vehicle as time passes. But each integration stage includes some error, causing the result to drift with time, so that the position estimation gets worse with time. DPCA measures the linear displacement in metres between pings; knowing the ping rate allows that displacement to be converted to velocity if necessary. Adding a measurement of linear displacement and velocity over the seabed helps considerably to reduce this drift and so give more accurate position estimates.

The pulse repetition frequency (PRF) of the FLS needs to be increased in order to give surge measurements at increasing forward speed; the current firmware limits are shown in the following table.

PRF /Hz	Surge Measured to / m/s	knots
1	+/-0.24	+/-0.47
2	+/-0.48	+/-0.93
4	+/-0.96	+/-1.87
8	+/-1.92	+/-3.73

As with SAS, a stable vehicle is needed for DPCA to work, in order that the area ensonified by the FLS does not change too much between pings. So, it will work well on AUVs, but will probably not work on surface vessels, where wave-induced roll and pitch move the pointing angle of the FLS too much between pings.

3 SOFTWARE

3.1 INTERFACING

PicoMBES and PicoFLS can be interfaced to software applications directly through their data interfaces, which operate over Ethernet.

The systems work with the PicoSonar Android app (Ref 2 and Ref 3).

PicoSonar drivers for the following software are in development;

- ITER Bathyswath®
- OIC GeoDAS® and SAMM®
- Xylem HYPACK®
- QPS QINSy®

See section 5.3 for the details of the software interfaces.

3.2 PICOSONAR ANDROID APP

The PicoSonar app is available free of charge from the Google Play Store (Ref 2 and Ref 3) and runs on Android mobile phones and tablets. The PicoSonar Android app allows the sonars to be controlled, the data to be viewed in real time or on replay from file, and for the data to be stored to file. It offers a convenient way of testing the systems and visualising and recording real-time sonar and bathymetry data at sea.

4 INITIAL TESTING

4.1 SETTING TO WORK

4.1.1 Hardware

For initial testing and to familiarise yourself with PicoSonar systems we recommend the following setup

- PicoSonar electronics bottle and umbilical cable
- Android Tablet or Phone with PicoSonar Android app installed
- Bench power supply capable of 24V @ 4A or 20C NiMH battery pack
- TP-LINK™ TL-WR702N WiFi router

Configure the bench power supply for 24V @ 4A. Connect the electronics bottle, umbilical cable, TP-LINK™ TL-WR702N WiFi router and bench power supply but do not power on yet. Do not connect the transducers at this stage.

4.1.2 Configuring the Wi-Fi Router

Configure the TP-LINK[tm] TL-WR702N WiFi router with SSID PicoSonar and static IP address 10.0.100.254. The user guide for the router is available from Ref 4. A small USB battery bank offers a convenient power source for the WiFi router at sea.

4.1.3 Configuring the Android Device

Configure the Android mobile phone or tablet with static IP address 10.0.100.70 on the PicoSonar network. To do this;

- Power on the TP-LINK[tm] TL-WR702N WiFi router and wait for it to boot.
- On the Android device go to Settings->Wi-Fi, long press the 'PicoSonar' network and configure as shown in Figure 1 below.

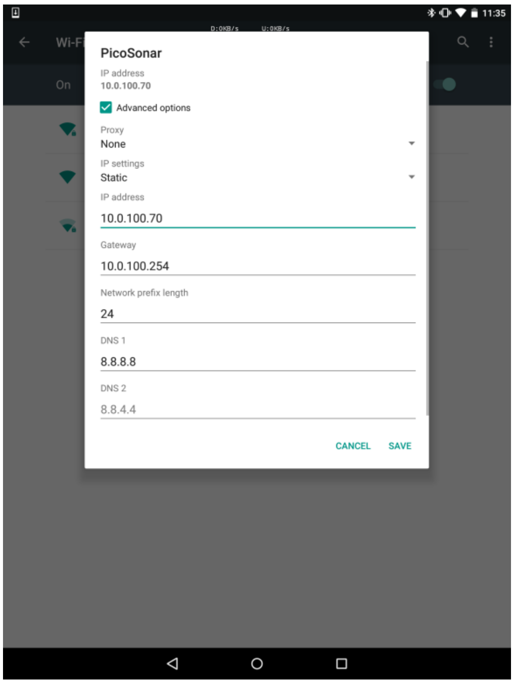


Figure 1 Setting up Android static IP address:
Long press PicoSonar SSID and configure as shown.

Install the PicoSonar-40 and PicoSonar-120 Android apps from the Google Play Store (Ref 2 and Ref 3). Ensure that the mobile device has plenty of free storage space for sonar and bathymetry data.

Install the Android Network Monitor Mini app from the Google Play Store (Ref 5) and configure it such that download and upload rates are visible at the top of the Android device's screen. This app is useful for diagnosis.

4.2 TESTING

4.2.1 Testing without transducers

For initial testing, without transduces attached, follow this procedure;

- Power on the TP-LINK[tm] TL-WR702N WiFi router.
- On the Android mobile phone or tablet, go into Settings->Wi-Fi and connect to the PicoSonar network.
- Power on the sonar and wait ~10s for the sonar to boot.
- Start the Android PicoSonar app (PicoSonar-120 app for PicoMBES-120, PicoSonar-40 app for PicoFLS-40).
- In the Android PicoSonar app, from the options menu, select set BIT->No transducer. (An Android app's 'options menu' is accessed by pressing the 3 vertically aligned dots in the top right corner of the app's title bar, or by pressing the device's *Menu* button if available).

In this test mode, the sonar will output an undulating (test) seabed on the Android device's point cloud display as shown in Figure 2 below.

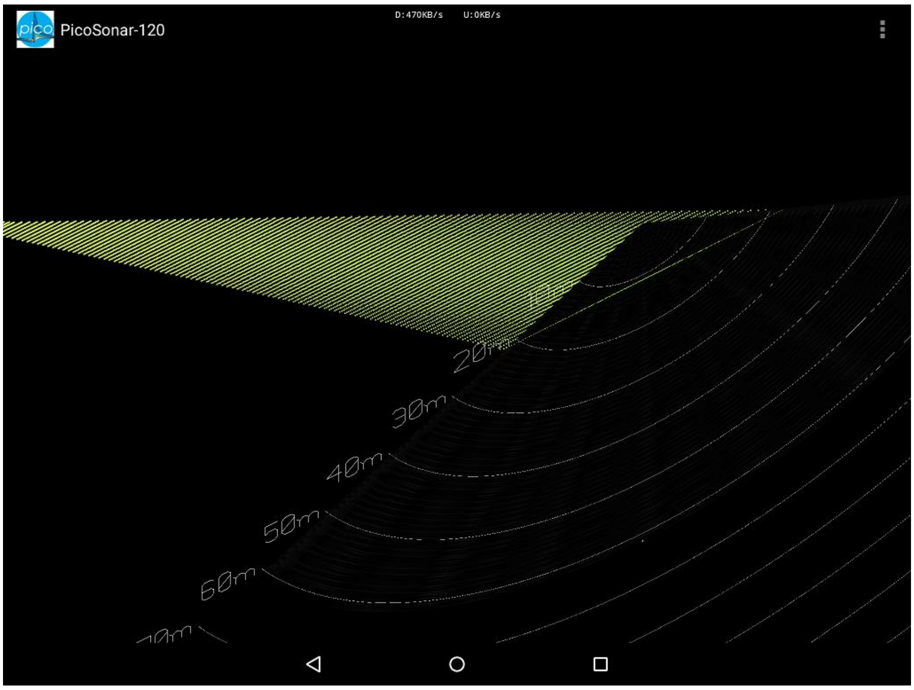


Figure 2 PicoSonar App displaying PicoMBES-120 test data in BIT->No transducer mode.

Explore the app;

- Pinch to zoom and swipe to scroll the Android Point cloud and B-scan displays.
- Explore the other options menu items applicable to this test mode;
  - Turn up the contrast to see a test pattern on the B-scan display.
  - Increase and decrease the PRF.
  - Increase the Data Rate (this controls how much water column data is transferred from the sonar to the Android device)
  - Change between Point cloud, B-Scan and Hydrophone displays

4.2.2 Precautions during testing

During testing, please be aware of the following points;

- The hosts Ethernet interface must be configured to 100Mbps full duplex and not to auto-negotiation or any other link speed/duplex.
- Under normal operation PicoSonars consume very little power, but during the boot phase there may be high inrush current when the sonars charge their internal high voltage power supplies. Please ensure the bench supply or battery pack can supply 4A peak current or the sonar may fail to boot.
- PicoSonars will connect to the first host they discover on the network with IP address 10.0.100.70. If there is another device on the network with the same IP address, PicoSonar may connect with this and not the intended device. Remove the conflicting device from the network.
- Once connected to a host, PicoSonar will not reconnect to a different host (for example by moving the Ethernet RJ45 to a different PC configured with the correct IP address) without power cycling the sonar.
- PicoSonars initiate and respond to ARP but will not respond to ICMP (ping) messages. However after pinging PicoSonar, issuing arp –a from the command line will give PicoSonars IP and MAC address.
- During the boot phase PicoSonar first searches the network for IP address 10.0.100.69. If a host exists on the network with this IP address, PicoSonar will wait 1 minute for firmware in-system reprogramming commands before booting into its normal operating mode.
- To save power, PicoSonars use a complex power management scheme. Supply current will vary during the boot and ping cycles – this is normal.

4.2.3 Initial Tests with Transducers

Power off the system, connect the transducers and immerse them completely in fresh water. Repeat the procedure in 4.2.1 but **do not** select BIT->No transducer. With transducers attached the sonar will automatically boot and commence pinging and the Android display will automatically update without any input required from the user.

Explore the Android app’s options menu items applicable to normal operation; change the contrast, gain, PRF, pulse type etc.

5 INTEGRATION

5.1 MECHANICAL INTEGRATION

5.1.1 Safety

When powered up, the electronics bottles have stored energy inside. **This could cause serious injury to people if it is accidentally touched.** There are no user-serviceable parts inside the electronics bottles, so do not open them.

5.1.2 Dimensions

See the specifications in sections 2.3.2 and 2.2.1.

5.1.3 Drawings

PicoMBES-120, PicoFLS-120 and PicoFLS-40 receive transducers are the same size. Drawings are available on the Picotech website Ref 1.

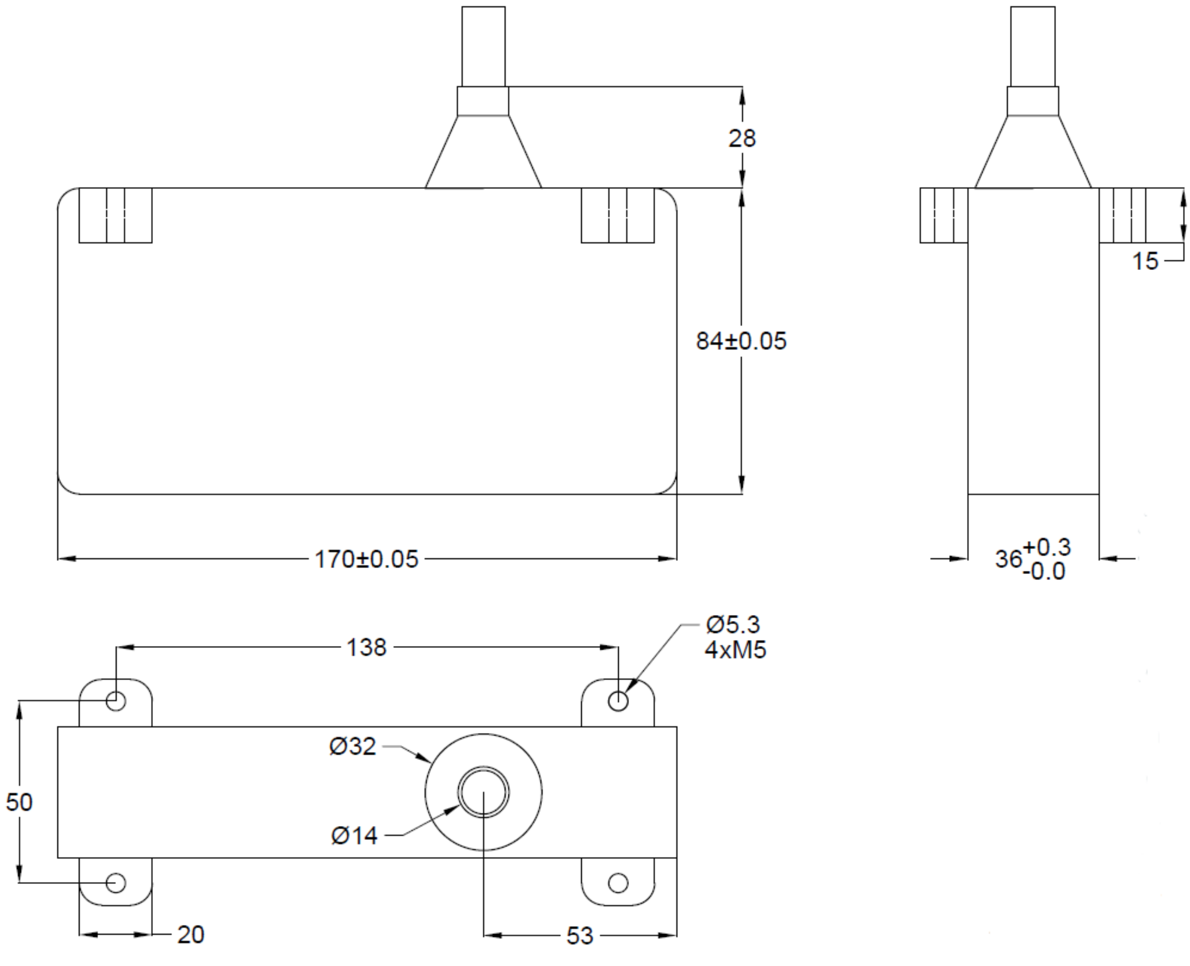


Figure 3 PicoMBES-120, PicoFLS-120 and PicoFLS-40 receive transducers.

The standard PicoMBES-120 transmit transducer is the same size as the receive transducer, whilst the PicoMBES-120SF transmit transducer, for Seafloor System's EchoBoat^{tm}, are shorter.

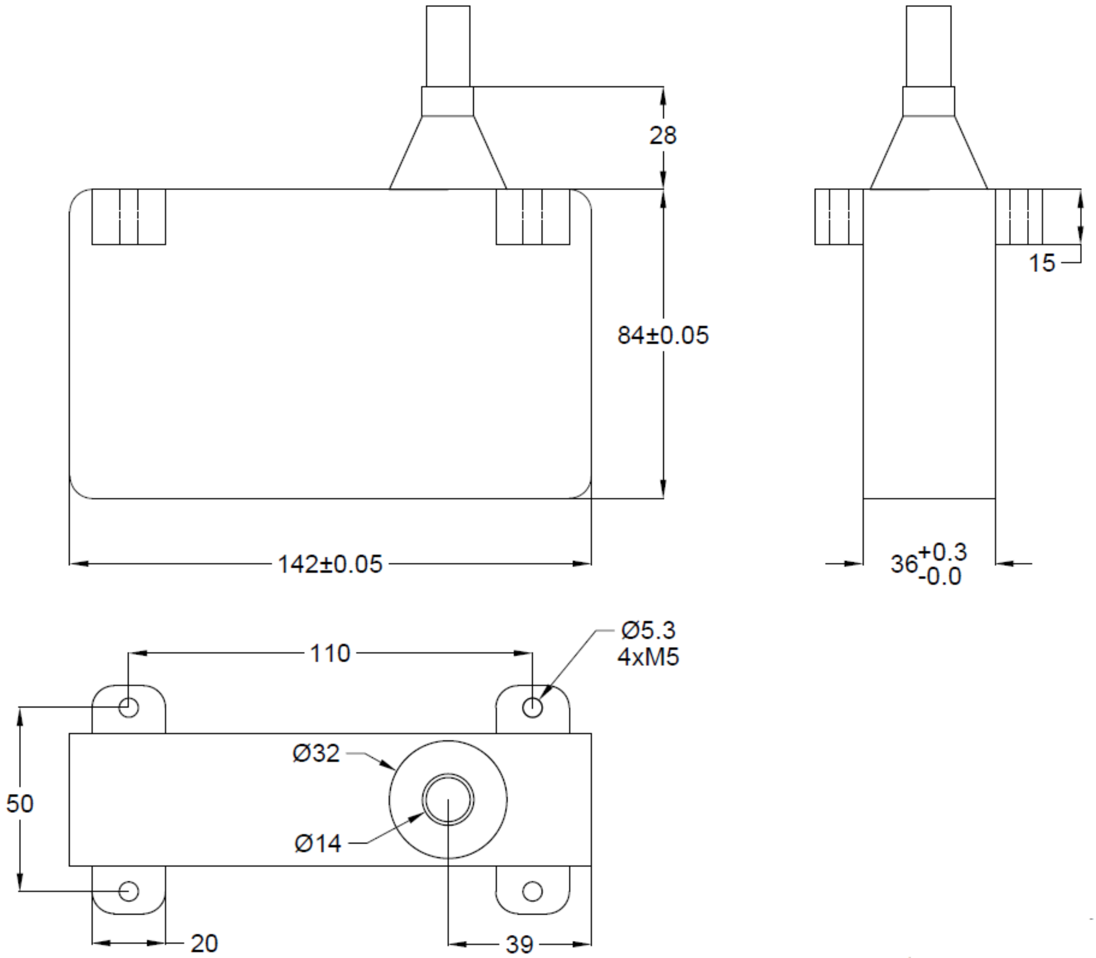


Figure 4 PicoMBES-120SF transmit transducer for Seafloor System's EchoBoat^{tm}.

The PicoFLS-120 transmit transducer is also shorter than the receive transducer.

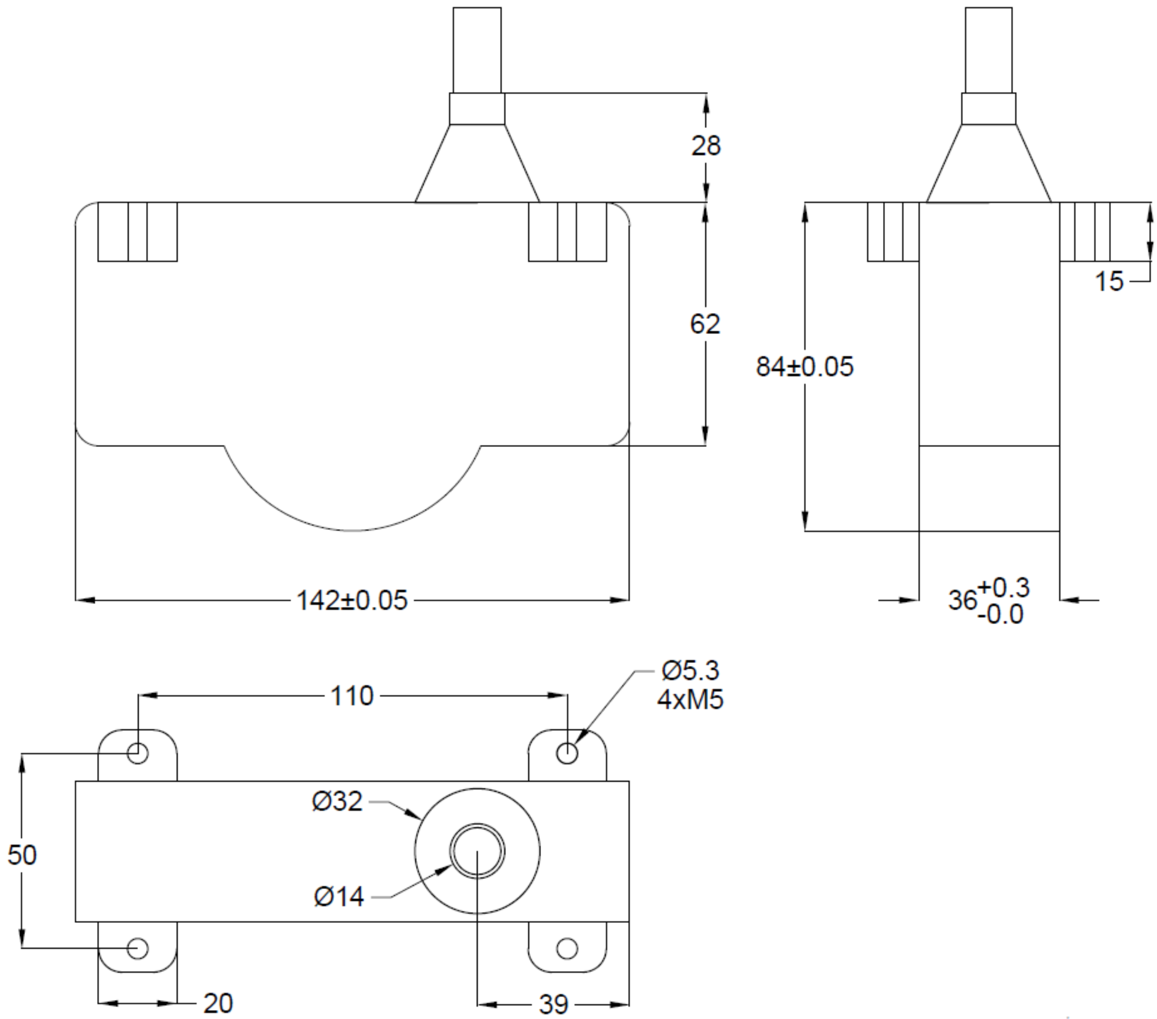


Figure 5 PicoFLS-120 transmit transducer.

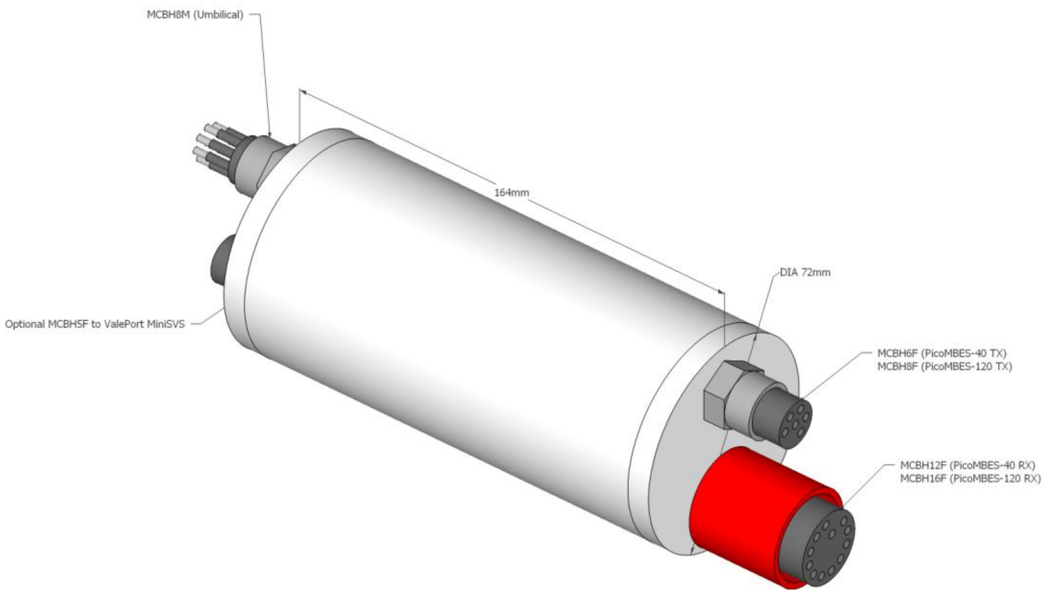


Figure 6 PicoMBES and PicoFLS Electronics Bottle

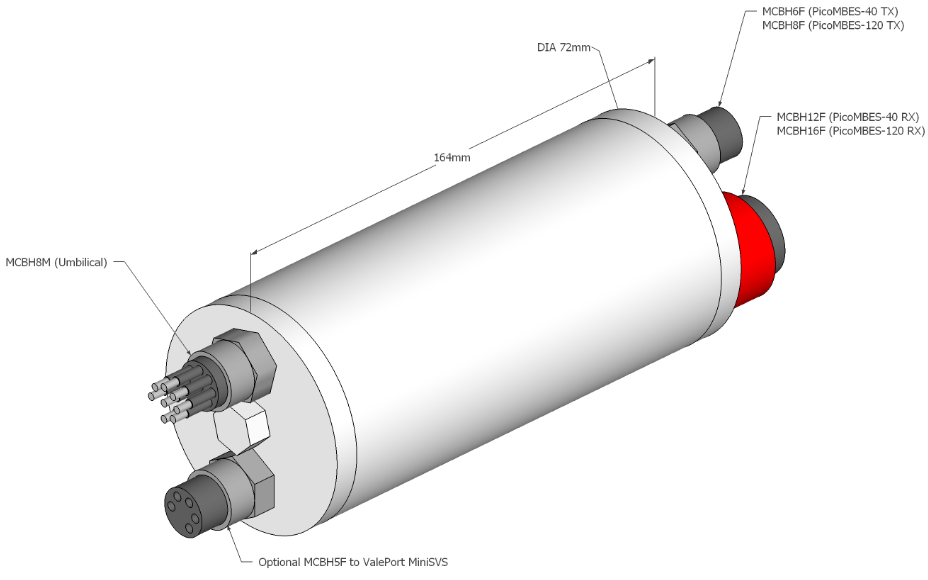


Figure 7 PicoMBES and PicoFLS Electronics Bottle

5.1.4 Mounting the Transducers

All the transducer types are fitted with 4-off lugs with 5.3mm holes, to take M5 fixings. Use marine-grade stainless steel screws, washers and nuts to fix the transducers to a baseplate. Drawings are available on the Picotech website Ref 1.

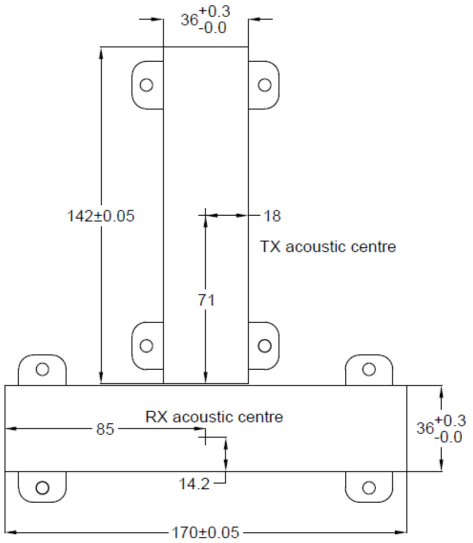


Figure 8 PicoMBES-120SF, for Seafloor System's EchoBoat[tm], mounting drawing

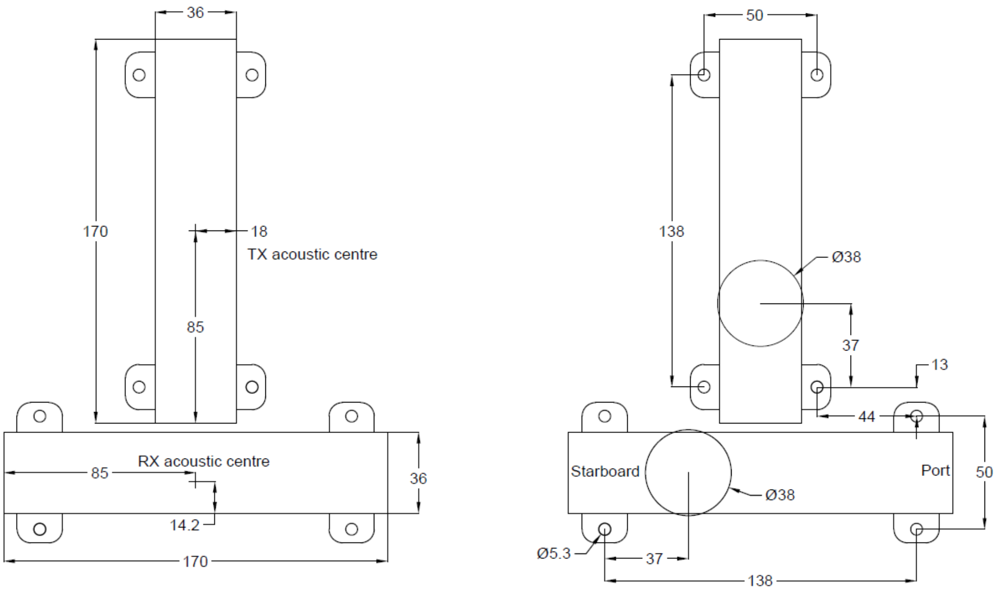


Figure 9 PicoMBES-120 mounting drawing

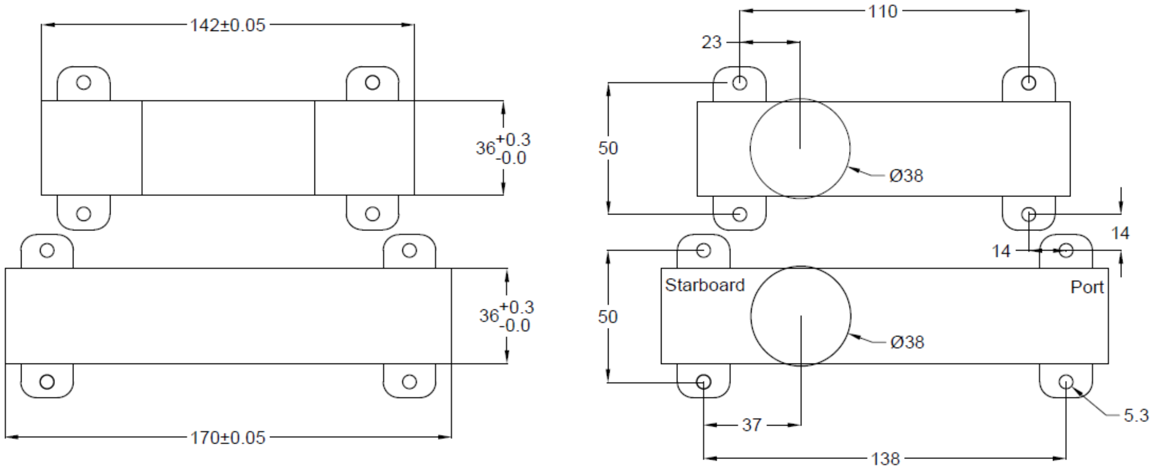


Figure 10 PicoFLS-120 mounting drawing

The PicoMBES transducers are typically mounted pointing straight down, with the long axis of the transmit array in the direction of travel, and the long axis of the receive array across the direction of travel, Figure 11 below. The transducers may be identified by their underwater connectors;

- The receive transducers have a 16-way connector
- The transmit transducers have an 8-way

The RX lead should be on the starboard side of the RX transducer, the TX lead forward or aft. The TX transducer may be mounted in front or behind the RX transducer.

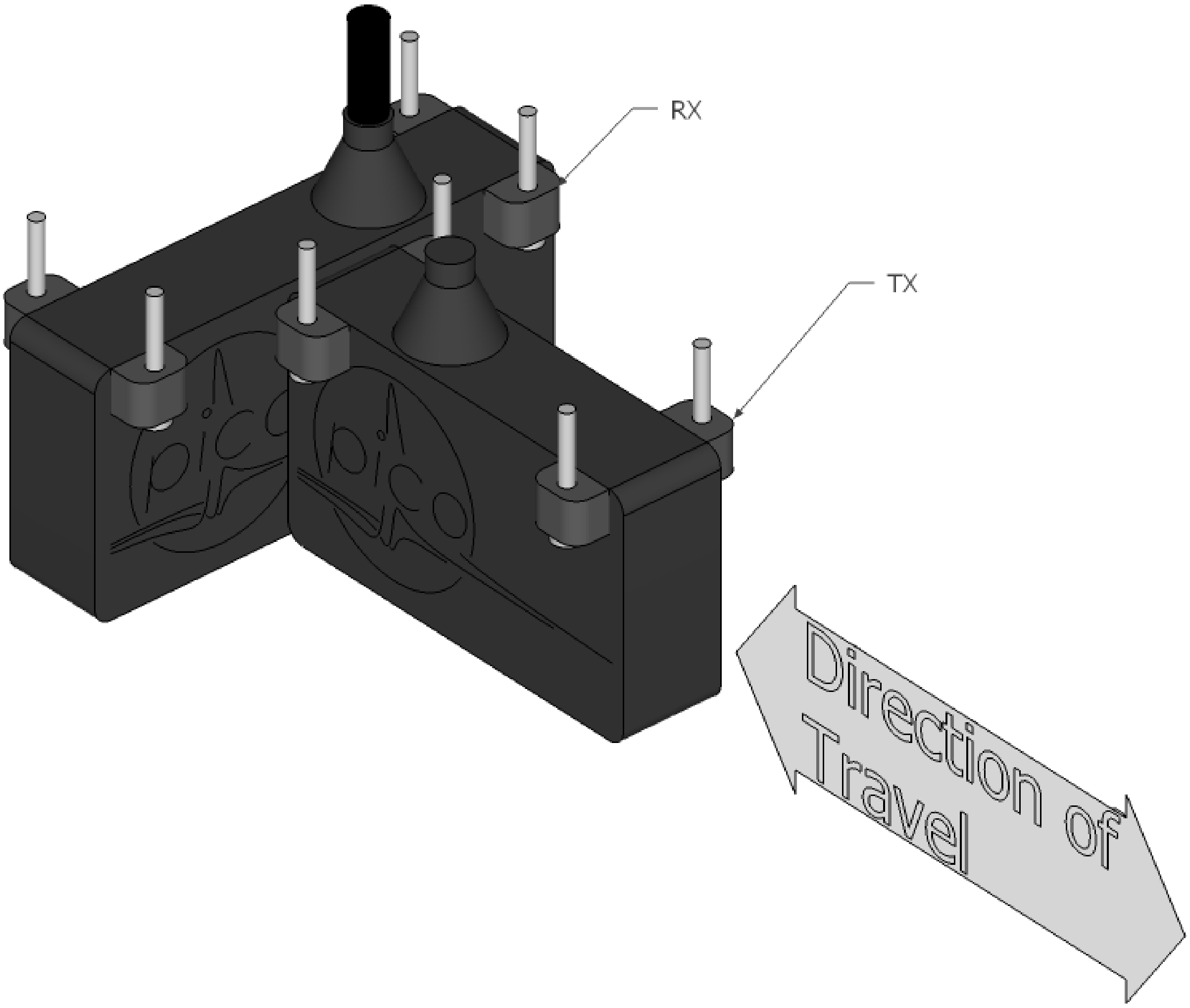


Figure 11 PicoMBES transducer arrangement

he PicoFLS transducers are typically mounted together, facing in the same direction, approximately 20° down from horizontal with no obstacles in front or immediately above, below or to the sides, Figure 12 below. The transducers may be identified by their underwater connectors;

- The receive transducers have a 16-way connector
- The transmit transducers have an 8-way

The RX lead should be on the starboard side of the RX transducer, the TX lead port or starboard. The RX transducer may be mounted above or below the TX transducer.

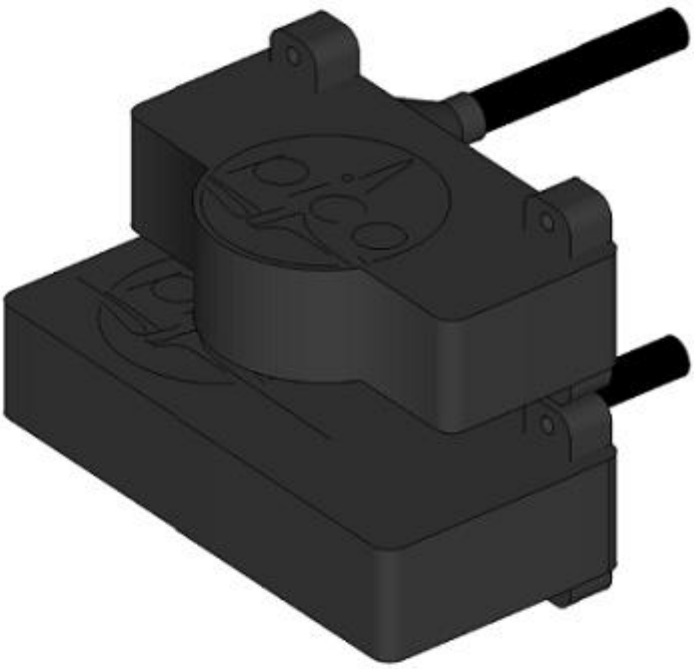


Figure 12 PicoFLS transducer arrangement

5.1.5 Tools

No special tools are required to install and maintain PicoFLS or PicoMBES. All fixings are metric, except where otherwise stated (the Subconn wet-mate connectors are sized in inches).

5.2 ELECTRICAL INTEGRATION

5.2.1 Summary of Electrical Connections

The transducers are connected to the electronics bottle using the cables supplied.

The bottle also includes a wet-mate connector for connection to external systems. Users may provide their own cables to connect to their systems, or cable sets are available on request.

5.2.2 Cathodic Mitigation

No metal bonds are exposed to sea water.

5.2.3 External Connections

The PicoMBES and PicoFLS bottle is connected to external systems using an 8-pin MCBH8M Subconn connector.

Pin	Function
1	0V
2	24-36V
3	RS422(A) PPS / TTL PPS
4	RS422(B) PPS / RS232 ZDA
5	100BaseT-RXD+
6	100BaseT-RXD-
7	100BaseT-TXD+
8	100BaseT-TXD

Electronics Bottle MCBH8M Male Connector   Umbilical Cable MCIL8F Female Connector

5.2.4 Power

PicoMBES and PicoFLS take 24 to 36 V DC power, at 9 W (PicoFLS-40) and 12 W (PicoFLS-120 and PicoMBES-120).

5.2.5 Ethernet

PicoMBES and PicoFLS support 100BaseT (100 Mbit/s) Ethernet communications, on four wires. **The hosts Ethernet interface must be configured to 100Mbps full duplex not auto-negotiation.**

Ethernet connections should be made through CAT5 cables. Short wire runs should at least be twisted in pairs: “pair 1 +” with “pair 1 -” and “pair 2 +” with “pair 2 -”.

5.2.6 PPS

PPS timing signals are used in PicoMBES and PicoFLS to maintain the systems’ internal clocks, which are used to time-stamp the sonar data packets that are sent to the software. PPS signals are typically provided by GPS positioning systems. PPS signals are used together with ZDA timing messages. These can either be NMEA 0183 messages input as RS232 serial, or as Ethernet packets.

5.2.7 PPS & RS232 ZDA

Pins 3 and 4 of the umbilical connector can be configured to work as *either*:

- Pin 3: TTL PPS in (relative to 0V on pin 1); Pin 4: RS232 ZDA message input 9600-8-N-1, *or*
- Pins 3 & 4: RS422 differential line, PPS in only

The firmware boots in the first mode but automatically switches over to the second mode on receipt of the first ZDA character over Ethernet. A multi-protocol transceiver within the PicoSonar electronics bottle handles these different protocols.

5.2.8 Transmit Synchronisation

PicoMBES and PicoFLS can synchronise their sonar transmit pulses to external input trigger messages over Ethernet.

5.3 DATA INTEGRATION

5.3.1 General

Data is provided over an Ethernet connection, using UDP/IP. Users may connect PicoMBES and PicoFLS direct to their own logging systems using the data formats below.

Alternatively the PicoSonar Android app (Ref 2 and Ref 3) may be used to log and view the data in real-time and control the sonar systems.

PicoSonar drivers for the following software are in development;

- ITER Bathyswath®
- OIC GeoDAS® and SAMM®
- Xylem HYPACK®
- QPS QINSy®

5.3.2 UDP Ports

PicoMBES outputs both range-angle data from the bottom detection process and the full water column data, on different UDP/IP port numbers, so the user can choose to record one or the other or both. The address/port set up is as follows:

Android/Windows Client	PicoMBES/PicoFLS	Data	Direction
10.0.100.70:13000	10.0.100.120:9000	MBES angle/range data from sonar	From Pico
		Commands	To Pico
10.0.100.70:13001	10.0.100.120:9001	Water column data @25kHz (PicoMBES-120) @50kHz (PicoFLS-40 & 120 systems)	From Pico
		Hydrophone stimulation data to the sonar for BIT=pod mode	To Pico
10.0.100.70:13002	10.0.100.120:9002	Micro-Nav/Bathymetry PDUs	From Pico
10.0.100.70:13003	10.0.100.120:9003	AUX PDUs	From Pico

Note that this means that the receiving computer must be set to the static IP address of 10.0.100.70.

5.3.3 Modes

PicoSonar systems exhibit the following modes.

Mode	Code	Description
Off	OFF	All components of the PicoSonar system are powered OFF. There is no shut down mode for PicoSonar; power may be removed at any time.
Start	START	The PicoSonar system is powering up, authenticating, and initialising essential functions
Offline	OFFL	The PicoSonar system is in an installed or deployed state and is ready to acquire data and make transmissions. This mode is used for test, calibration, re-configuration, training and "wait" activities.
Online	ONL	The PicoSonar system is acquiring and processing acoustic and nonacoustic data. The PicoSonar system may be making acoustic transmissions if they have been enabled. If the Picotech solid state recorder is installed, data is being recorded.
Test	BIT	The PicoSonar system is performing built-in self-tests

The system changes between modes as shown in the diagram below.

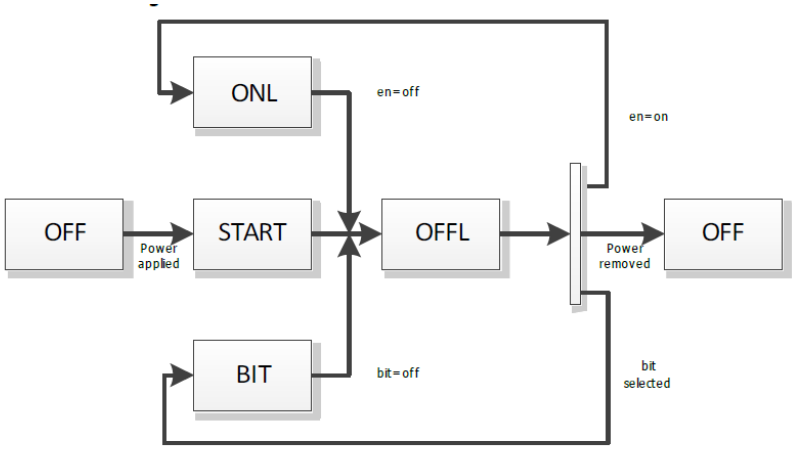


Figure 13 PicoSonar Mode Transition Diagram

5.3.4 Commands

PicoMBES and PicoFLS receive commands from the host system by the host system setting registers in the sonars' register set.

5.3.5 PicoSonar Register Set

PicoSonar has a set of internal registers that can be accessed through its UDP/IP command interface.

Each register is 28 bits wide plus a 4 bit address, so 32 bits are sent for each command. Some registers within the set expose FIFO inputs; successive writes to these registers load FIFOs behind the register.

5.3.6 PRI Register

The PRI register, address 0x8, is written with the required Pulse Repetition Interval (PRI) expressed with 20µs resolution as follows;

PRI register value = floor(PRI*50e3) - 1

- where PRI is the required Pulse Repetition Interval in seconds. For example, to set a 1 second PRI the command sent to PicoSonar would be `0x8000c34f`.

PicoSonar imposes a lower limit to the PRI to prevent over-stressing the sonar's power amplifiers and high voltage power supplies. The limit depends upon the particular PicoSonar configuration

5.3.7 Pulse Type Register

The pulse type register, address 0x5, configures the transmit pulse type. The lower byte of the register defines the pulse type, for example

- `0x50000000` Pulse type 0
- `0x50000001` Pulse type 1
- `0x50000002` Pulse type 2
- `0x50000003` Pulse type 3

Pulse Type	Centre Frequency	Bandwidth	Pulse Length	Description
0	337kHz	20kHz	5ms	LFM Up CHIRP
1	337kHz	20kHz	500us	LFM Up CHIRP
2	360kHz	20kHz	5ms	LFM Up CHIRP
3	360kHz	20kHz	500us	LFM Up CHIRP
4	380kHz	20kHz	5ms	LFM Up CHIRP
5	380kHz	20kHz	500us	LFM Up CHIRP

Figure 14 PicoMBES-120 Pulse Types

Pulse Type	Centre Frequency	Bandwidth	Pulse Length	Description
0	337kHz	40kHz	5ms	LFM Up CHIRP
1	337kHz	40kHz	500us	LFM Up CHIRP
2	360kHz	40kHz	5ms	LFM Up CHIRP
3	360kHz	40kHz	500us	LFM Up CHIRP
4	380kHz	40kHz	5ms	LFM Up CHIRP
5	380kHz	40kHz	500us	LFM Up CHIRP

Figure 15 PicoFLS-120 Pulse Types

Pulse Type	Centre Frequency	Bandwidth	Pulse Length	Description
0	500kHz	40kHz	5ms	LFM Up CHIRP
1	500kHz	40kHz	500us	LFM Up CHIRP
2	450kHz	40kHz	5ms	LFM Up CHIRP
3	450kHz	40kHz	500us	LFM Up CHIRP

Figure 16 PicoFLS-40 Pulse Types

5.3.8 ZDA Register

GPS ZDA strings are sent to PicoSonar over Ethernet by writing the ZDA string characters to the lower byte of the ZDA register at address 0xC.

ADDRESS IN HEX	D 27	D 26	D 25	D 24	D 23	D 22	D 21	D 20	D 19	D 18	D 17	D 16	D 15	D 14	D 13	D 12	D 11	D 10	D 9	D 8	D 7	D 6	D 5	D 4	D 3	D 2	D 1	D 0
C		1	x																		x	x	x	x	x	x	x	x

- Bit D26 must be set to '1'.
- Bit D25 defines the PPS polarity; '0' => rising edge, '1' => falling edge.
- Bits D0-D7 are written with the ZDA characters
- The ZDA characters are pushed into the register at 0xC, one character at a time
- The commands may be sent 4 bytes at a time in separate UDP/IP datagrams, or be coalesced and sent as a single UDP/IP datagram.

For example, to write the ZDA string corresponding to 2015-05-01 19:22:11, the following commands would be sent to PicoSonar;

```
0xc4000024
0xc4000047
0xc4000050
0xc400005a
0xc4000044
0xc4000041
0xc400002c
0xc4000031
0xc4000038
0xc4000032
0xc4000032
0xc4000031
0xc4000030
0xc400002e
0xc4000036
0xc4000035
0xc400002c
0xc4000030
0xc4000031
0xc400002c
0xc4000030
0xc4000035
0xc400002c
0xc4000032
0xc4000030
0xc4000031
0xc4000035
0xc400002c
0xc4000078
0xc4000078
0xc400002c
0xc4000079
0xc4000079
0xc400002a
0xc4000063
0xc4000063
```

Alternatively GPS ZDA strings may be sent to PicoSonar via RS-232 (baud 9600-8-N-1), pin 4 of the 8-pin MCBH8M Subconn connector. In this instance pin 3 of the Subconn connector is for TTL PPS and the ZDA register at address 0xC is used to configure the PPS polarity;

- Bit D26 must be set to '0'.
- Bit D25 defines the PPS polarity; '0' => rising edge, '1' => falling edge.

5.3.9 Time Varying and Programmable Gain

To compensate for attenuation and spreading losses, PicoSonar applies a time varying gain (TVG) curve. The start and end gain of the TVG curve may be configured. In addition PicoSonar features programmable gain amplifiers which allow gain to be pre-set to four levels. TVG and PGA are specified by writing register at address 0x1.

ADDRESS IN HEX	D 27	D 26	D 25	D 24	D 23	D 22	D 21	D 20	D 19	D 18	D 17	D 16	D 15	D 14	D 13	D 12	D 11	D 10	D 9	D 8	D 7	D 6	D 5	D 4	D 3	D 2	D 1	D 0
1			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

- Bits D11 down to D0 set TVG Min register
- Bits D23 down to D12 set TVG Max register
- Bits D25 down to D24 set PGA

TVG Min and Max registers are calculated as follows;

TVG register value = floor(gain/46*4000)

- where gain is in dB and lies between 0 and 46. Setting the Min register value greater than the Max creates constant gain with range set at the Min value.

PGA is specified as follows;

D25	D24	PGA GAIN
0	0	20dB
0	1	25dB
1	0	27dB
1	1	30dB

5.3.10 Range Gate

The bottom detection range gate may be specified by writing register at address 0x7. Bits D13 down to D0 specify the start sample, bits D27 down to D14 the end sample. The sample is calculated from range as follows;

Sample register value = floor(range*bw/1500*2)

- where range is in metres and bw is 25000 for PicoMBES-120 and PicoFLS-120 and 50000 for PicoFLS-40. The maximum range is 240m for PicoMBES-120 and PicoFLS-120 and 120m for PicoFLS-40.

5.3.11 Bottom Detection (PicoMBES-120 only)

PicoMBES-120 bottom detection algorithm may be selected by writing register at address 0xF as follows;

D0	Bottom Detection Algorithm
0	Amplitude

1	Amplitude and Phase

5.3.12 Water Column Data Rate

PicoSonar outputs water column data in real-time, the format is described in 5.3.15 below. The data rate of water column data may be throttled to reduce network bandwidth and storage file size by writing to register at address 0xD;

- `0xd00000fc` rate = 1/8
- `0xd00000fe` rate = 1/4
- `0xd00000fd` rate = 1/2
- `0xd00000ff` rate = 1

The water column data rate command has no effect on PicoSonar internal processing - it only controls the water column data output rate over Ethernet.

5.3.13 Operation without Transducers

To test PicoSonar systems with no transducers attached, the following command should be sent:

`0x00450002`

This causes the sonar to return a test pattern in the water column data output in lieu of transducer data and an undulating seabed test pattern in the MBES bottom detection data.

5.3.14 PicoMBES-120 Data Format

Byte Num	Num Bytes	Encoding	Item	Notes
0	4	-	Magic	PicoMBES - '51C03BE5'
4	4	unsigned int	Version	System type & version. eg.0x0120.0402 => v4.2
8	8	unsigned int unsigned int	Time	Timestamp expressed as seconds and micro-seconds since Thursday 1 Jan 1970.
16	4	float	Sound Speed	Speed of sound in m/s.
20	4	-	Engineering	Internal use only.
24	4	unsigned int	N	Number of beams.
28	4	float	Angle	Angle of first beam in degrees, typ. -60.0f
32	4	float	Angle	Angle of Nth beam in degrees, typ. 60.0f
36+i*4	4	float	Range	Beam range in metres. i=0,1,2,...N-1
36+N*4	N/4	-	Quality	Beam quality

Notes:

1. Little-endian, least significant byte first.
2. For N=256 beams, PDU size is 1124 octets.

3. Emitted once per ping.
4. The angle of the i[th] beam is **first + i * (last - first) / (N – 1)**
5. Quality is encoded as bitfields, 2 bits per beam.
6. Timestamp ordering is micro-seconds then seconds.

5.3.15 PicoSonar Water Column Data Format

Each beam has 64 one-byte amplitude samples, written out in order at the sample rate (see below). Each PDU sends the beam data for eight beams.

Byte Num	Num Bytes	Encoding	Item	Notes
0	4	unsigned int	Index	PDU Index i (see note 5)
4	64	unsigned char	Magnitude	Beam i magnitude
68	64	unsigned char	Magnitude	Beam i+1 magnitude
132	64	unsigned char	Magnitude	Beam i+2 magnitude
196	64	unsigned char	Magnitude	Beam i+3 magnitude
260	64	unsigned char	Magnitude	Beam i+4 magnitude
324	64	unsigned char	Magnitude	Beam i+5 magnitude
388	64	unsigned char	Magnitude	Beam i+6 magnitude
452	64	unsigned char	Magnitude	Beam i+7 magnitude

Notes:

1. Little-endian, least significant byte first
2. PDU size is 516 octets
3. Emitted
   @ 6.25kHz*rate, rate = 1, ½ , ¼ , 1/8 , sampled at 50kHz (PicoFLS-40)
   @ 12.5kHz*rate, rate = 1, ½ , ¼ , 1/8 , sampled at 25kHz (PicoMBES-120)
4. Index is reset to zero at the start of each ping
5. Beam number i,
   i= mod(Index,8) *8 (PicoFLS-40)
   i=mod(Index,32)*8 (PicoMBES-120)

5.3.16 DPCA Micro-Nav PDU Format

Byte Num	Num Bytes	Encoding	Item	Notes
0	4	-	Magic	PicoDPCA - '51C0D5CA'
4	4	unsigned int	Version	System version number.
8	8	unsigned int unsigned int	Time	Timestamp expressed as seconds and micro-seconds since Thursday 1 Jan 1970.
16	4	float	Sound Speed	Speed of sound in m/s.
20	8	double	Roll	Roll in degrees.
28	8	double	Pitch	Pitch in degrees.
36	8	double	Yaw	Yaw in degrees.
44	8	double	Surge	Surge in metres.

52	8	double	Sway	Sway in metres.
60	8	double	Heave	Heave in metres.
68+i*8	4	float	Range	Plan range in metres. i=0,1,2,...57
72+i*8	4	float	Depth	Depth in metres. i=0,1,2,...57

Notes:

1. Little-endian, least significant byte first.
2. PDU size is 532 octets.
3. Emitted once per ping.
4. Firmware versions to date (<5.2) do not populate Roll, Pitch, Yaw, Sway & Heave.
5. Current f/w Surge limits;
   @1Hz PRF => +/-0.24m/s = +/-0.47kts
   @2Hz PRF => +/-0.48m/s = +/-0.93kts
   @4Hz PRF => +/-0.96m/s = +/-1.87kts
   @8Hz PRF => +/-1.92m/s = +/-3.73kts
6. Timestamp ordering is micro-seconds then seconds.

5.3.17 PicoSonar AUX PDUs

PicoSonar features a virtual COM port; any valid GPS NMEA string received on PicoSonar's RS232 or RS422 input, or via the ZDA register described above, is zero padded to 128 bytes and transmitted to the host in a UDP/IP datagram. These virtual COM port datagrams are recorded by the host Android and PC apps with the beamformed data, MBES and Micro-Nav PDUs and may be accessed on replay.

6 UPDATING PICOSONAR FIRMWARE

6.1 OVERVIEW

The firmware in the electronics bottle may be updated with new revisions. New firmware revisions address bugs and add important new features. The firmware update process is simple, requires no special tools and takes approximately 20 seconds. There is no risk of ‘bricking’ the sonar system during the update process as PicoSonars have a ‘golden image’ which cannot be overwritten by the firmware update process.

The firmware in the transducers may also be updated with new revisions. A similar process is used to that for the bottle. However in the unlikely event of the transducers requiring a firmware update, this is best undertaken by the supplier.

6.2 UPDATING THE ELECTRONICS BOTTLE FIRMWARE

6.2.1 Setting to Work

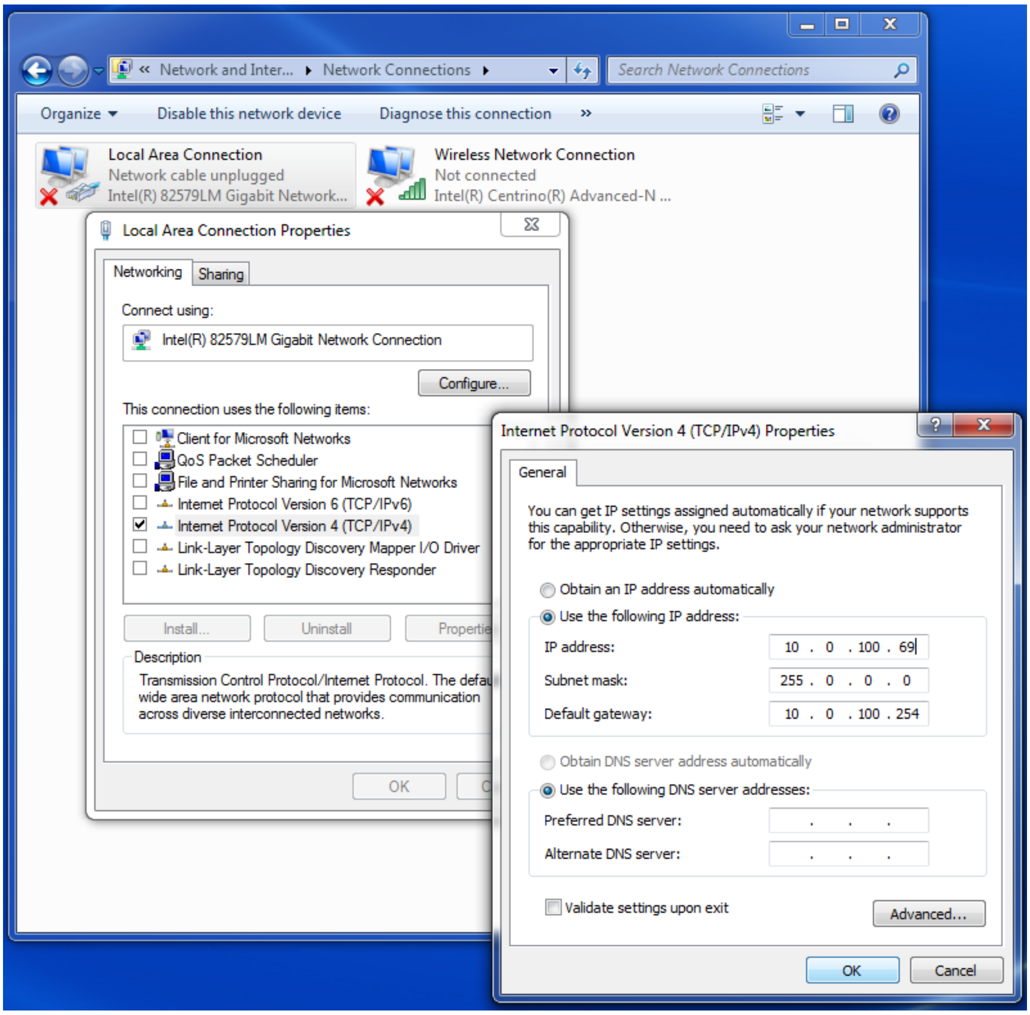
To update the PicoSonar electronics bottle firmware the following items are required;

- PicoSonar electronics bottle and umbilical cable
- Windows PC running Windows 7 or higher
- Bench power supply capable of 24V @ 4A or 20C NiMH battery pack

Configure the bench power supply for 24V @ 4A. Connect the electronics bottle to the umbilical cable. Connect the umibilcal cable’s RJ45 to the PC’s Ethernet socket and its banana plugs to the bench power supply but do not power on yet.

6.2.2 Setting up the Windows PC

Configure the PC's wired Ethernet adapter with IP address 10.0.100.69 as shown below.

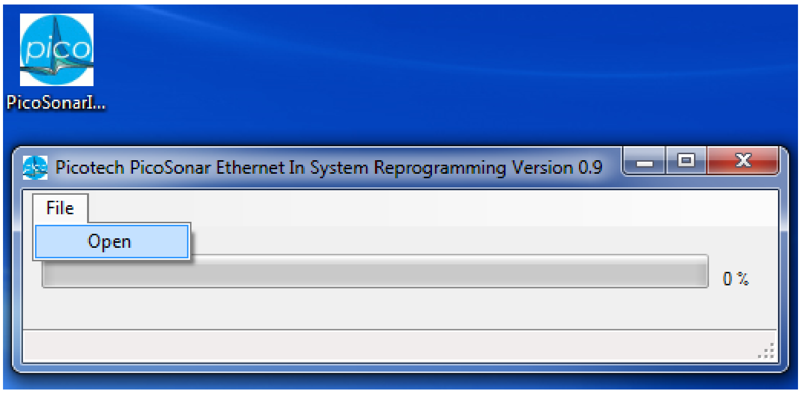


Note: the PC's wired Ethernet adapter must be configured to **100Mbps full duplex** and not to auto-negotiation or any other link speed/duplex

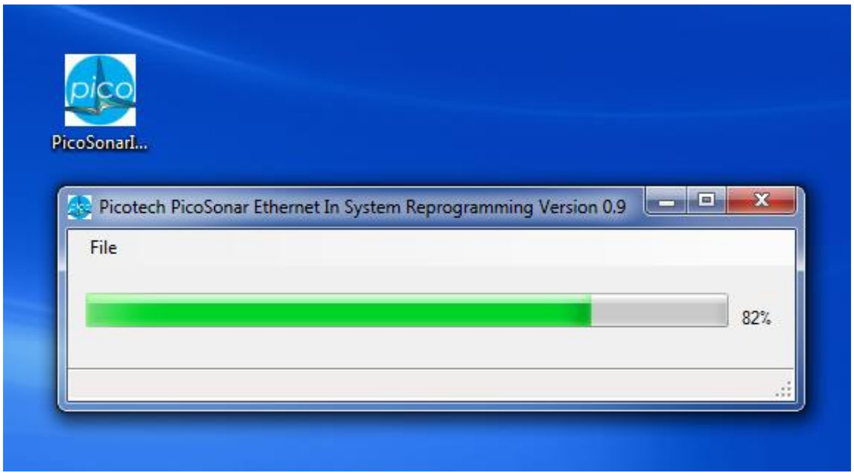
6.2.3 Updating the Firmware

- Power on PicoSonar, wait 10s, then power off.
- Power on PicoSonar, wait 10s, then launch the PicoSonar In-System Reprogramming application by double clicking its icon.

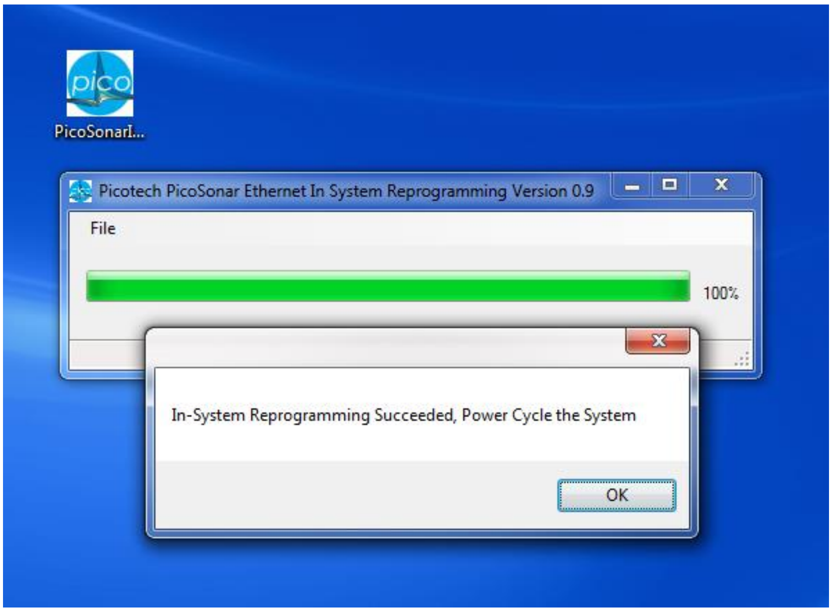
- In the PicoSonar In-System Reprogramming application, select File->Open, and navigate to the firmware image – a 4MB file with **.bin** extension – open the file. **Note:** *the firmware image file must be opened within 1 minute of powering on PicoSonar, otherwise the sonar will boot into its normal operating mode, and not accept reprogramming commands. If this occurs simply repeat the process from the beginning.*



- Reprogramming will now commence with a progress bar showing completion.
  Note: *there will be an initial delay whilst the PicoSonar flash is being erased.*



- Upon completion, the PicoSonar In-system Reprogramming application will display the following message.



- Power off the sonar, disconnect the Ethernet RJ45 and reconfigure the PC with IP address 10.0.100.70
- In the unlikely event of reprogramming failing, simply repeat the above process.