Fact Sheet No: 19/7

ALPHA*tracka* II

Highly accurate, transmissometer for suspended and dissolved solids. Blue, green, yellow or red wavelength versions available.

ALPHA*tracka* II is an accurate (<0.3% fullscale) trans-missometer that, as standard, measures the beam attenuation coefficient alpha(a) at 660nm(red). Green, yellow and blue variants are available to special order. ALPHA*tracka* is used in a wide range of oceanographic systems to monitor suspended and dissolved materials. It can be mounted on a towed underwater vehicle or used in a moored or profiling system.

INTRODUCTION

The optical housing is manufactured in titanium, and rated to 6000m. It is mounted on a light robust titanium support frame which maintains the stability of the optical alignment during operational use. For optimum measurement in a wide range of environments ALPHA*tracka* is available in 5, 10 and 25cm path length versions. Output can be factory set for either 2.5V or 5.0V systems; it is normally set for 2.5V unless otherwise requested.

A modulated light source and a coherent detector give excellent rejection of interference due to ambient light, even in the presence of wave glitter. The collimated light source and detection optics have minimal beam divergence and acceptance angle to reduce errors due to scattered light. The internal reference beam and ratiometric signal processing system combine to give an effective ageing rate of the source of <0.01 percent of full scale per 1000 hours usage, this provides long-term calibration stability.

After manufacture, ALPHA*tracka* is calibrated in pure water (See Calibration Section for definition). An air reading is also taken and recorded; this can be used later to check that the windows are clean. The beam attenuation coefficient alpha(a) measured by ALPHA*tracka* includes both absorption and light scatter losses. Since the effects due to particle type and concentration vary from region to region, it is necessary for the user to build up a local database and "calibrate" the instrument output against particle density in the survey area.

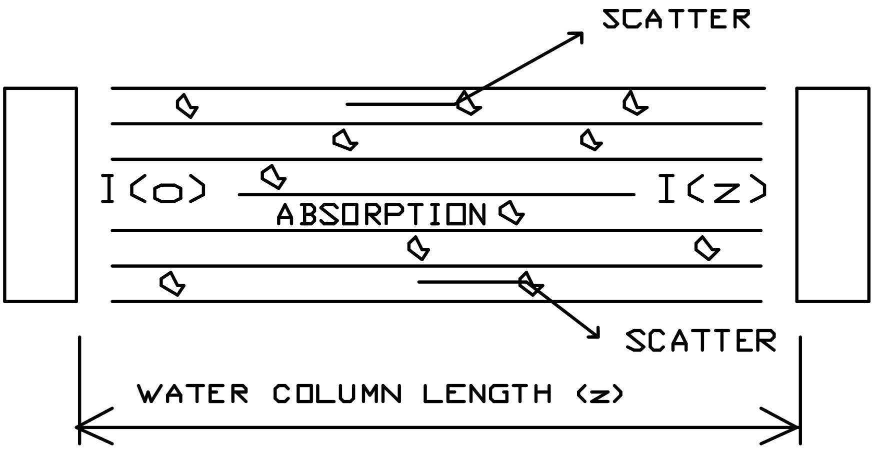
NOTE: The construction of this instrument is such that optical alignment and calibration is maintained throughout its operational life, unless there is premature damage. If damage occurs the instrument must be returned to Chelsea Technologies Group for repair and calibration. Any attempt by the user to open the instrument will disturb the optical set-up and invalidate any warranty conditions.

SPECIFICATION

Water path	5, 10 or 25cm		
Overall length	320, 370 or 520mm		
Diameter	65mm		
Weight	**5cm**	**10cm**	**25cm**
Standard and Deep Sea (Kg) air	3.55	3.6	3.75
water	1.9	1.95	2.1
Material Standard/Deep Sea	Titanium		
Depth rating Standard	6000 metres		
Beam diameter	15mm		
Beam divergence	< 6 mrads		
Acceptance angle	< 16 mrads		
Wavelength	660nm (option 470nm, 565nm, 590nm)		
Source line half width	20nm		
Optical ports Standard	Sapphire		
Response time (63%)	0.2sec (nominal)		
Warm up time	10 sec		
Accuracy	< 0.3% full-scale		
Output (Factory Set)	Zero to +2.5V d.c. (or zero to +5.0V d.c. option)		
Temperature coefficient	< 0.05% full-scale / ^{0}C		
Temperature range	1 – 30^{0}C		
Zero offset	0 to +0.4% full-scale		
Power supply	+7V to + 18V d.c. (nominal 20 mA)		
Transient surge from start-up	50mA for 100ms.		

TECHNOLOGY

Light Loss



Light Loss Pattern

For a collimated monochromatic beam traveling through a water column containing particles, light loss is either by absorption into other forms of energy, or scatter outside of the collimated beam. The amount of light loss depends upon the length of the water column(z) and the coefficients of absorption [Beta(b)] and scatter [Gamma(g)].

These coefficients have units of m-1 and are independent of the length of the water column; however, the total light loss is dependent upon the length of the water column, so it is always related to the path length.

Light loss due to absorption is given by:

$I(z) = I(o)e^{-bz}$ (b = coefficient of absorption)

and light loss due to inelastic scatter, (i.e. no loss of energy, only change of direction) is given by:

$I(z) = I(o)e^{-gz}$ (g = coefficient of scatter)

Total light loss is the sum of that by both absorption and scatter, so the beam attenuation coefficient alpha(a) = b + g.

Therefore:

$I(z) = I(o)e^{-az}$ (a = beam attenuation coefficient)

Light Transmission T(z) is given by:

$$T(z) = \frac{I(z)}{I(o)} = e^{-az}$$

Beam Attenuation Coefficient

The beam attenuation coefficient alpha(a) is contributed to by three factors; firstly that due to the basic water sample(Aw), secondly that due to suspended particles(Ap), and thirdly that due to organic decay (humic acids)(Ah). At 660nm (red) as used by ALPHA*tracka*, the attenuation due to humic acids (yellow) is so small that it can be safely ignored for most purposes. Therefore:

$$a = Aw + Ap$$

Beam attenuation due to suspended particles(Ap) is dependent upon the optical characteristics of the particles. This varies from region to region, but not to any great extent within a specific survey area. Thus ALPHA*tracka* can be used to determine particle concentrations.

At up to moderate concentrations, the relationship between particle concentration and percentage light transmission T(z) can be assumed to be linear with an off-set due to the loss in the basic water sample(Aw).

The beam attenuation coefficient due to suspended particles(Ap) depends upon the specific characteristics of each particle(Ap1) and the quantity(N) per unit volume of water sample. Therefore:

$$a = Aw + N(Ap1)$$

From the previous page we have Light Transmission(Tz):

$$T(z) = e^{-az}$$

so we now have:

$$T(z) = e^{-(Aw+N(Ap1))z}$$

$$= e^{-Awz}\, e^{-N(Ap1)z}$$

The light loss for ALPHA*tracka* due to water is e^{-Awz} which can be set as a constant(Tw). This gives:

$$T(z) = Tw\, e^{-N(Ap1)z}$$

Taking the logarithm of each side gives:

$$\text{Log } T(z) = \text{Log } Tw\, (-N(Ap1)z)$$

Therefore, as both Tw and (Ap1)z are constant, the logarithm of the light transmission(Tz) is proportional to the particle concentration.

TECHNICAL DESCRIPTION

Construction

ALPHA*tracka* consists of a Transmitter/Reference Assembly and a Detector Assembly aligned and spaced apart by a robust open support frame. Figure 1. shows the main component layout.

a) Transmitter/Reference

The Transmitter/Reference Housing is sealed by an end cap which supports a four way subsea connector for power input and the signal output. Inside the housing is a LED light source and a reference diode mounted within the transmission cone of the LED. Adjustment is included to allow precision factory adjustment of the beam alignment and collimation which is then set and sealed. The collimated beam leaves the housing through a sealed window. The circuitry for controlling the drive to the LED and feedback from the reference diode, is mounted on two surface mount PCBs.

b) Detector

The Detector Housing is also sealed by an end cap. Inside the housing is the signal photodiode, which is mounted in an adjustable sleeve to allow positioning. The collimated beam enters the housing through a sealed window onto the focusing lens. The circuitry associated with the signal photo diode is mounted on a single surface mount PCB, mounted within the housing.

c) Support Frame

A Titanium open support frame provides a robust mounting for both of the optical housings, and fixes the spacing between the two optical systems. The robust but light construction ensures that the precise factory alignment and calibration is maintained during operational use, baffles are provided to assist ambient light rejection.

Optical Layout

The LED light source assembly is adjustable to position the LED at the focal point of the collimating lens. The light cone from the LED is collimated into a 15mm dia. parallel beam with minimal divergence. Mounted close to the LED is a reference photodiode which monitors the LED output; this is used as feedback into the signal processing circuitry and enables ALPHA*tracka* to achieve excellent long-term calibration stability.

The collimated beam enters the Detector Assembly through a window onto a focusing lens. The signal photo diode assembly has a screw thread on the outer diameter which allows it to be positioned correctly.

The optical system is accurately set-up during manufacture and all components are sealed in position before calibration. The basic light path is shown in Figure 1.

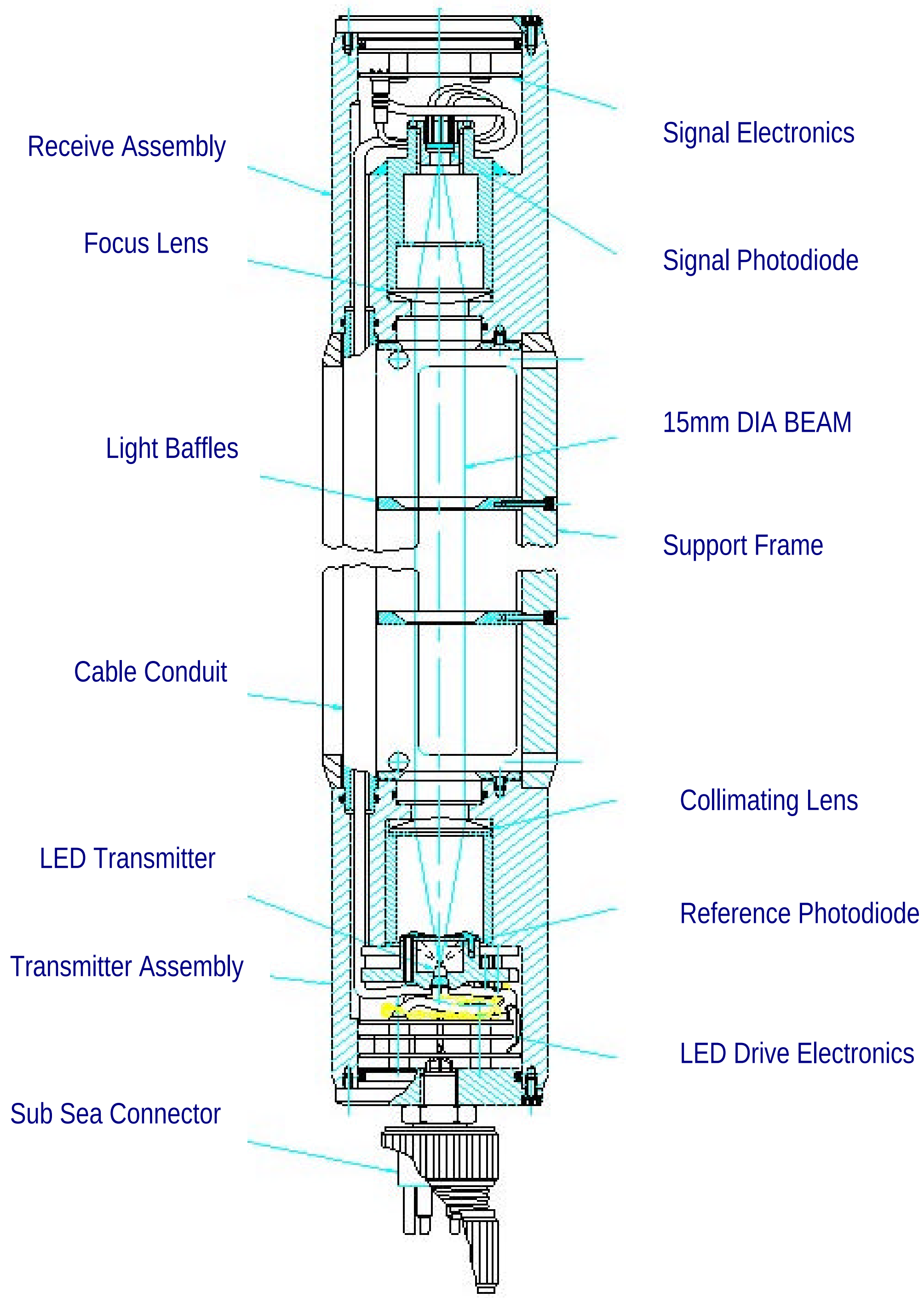


Figure 1 - ALPHA*tracka* II GA & Optical Layout

Control Electronics

The electronics are mounted on three surface mount PCBs, two controlling the LED transmitter and reference photodiode and one controlling the signal photodiode. A screened cable connects the two transmitter PCBs to the detector PCB, via a Titanium tube running along the titanium support frame defining the optical path. The LED transmitter is driven by a modulated source and viewed by a reference photo diode. The signal channel uses a carrier frequency of 340Hz which is suitable to give effective rejection of wave glitter when operating near the surface. A digitally controlled servo loop balances appropriate fractions of the signals received by the reference and signal photo diodes. The user output voltage is, in principle, independent of LED output ageing and LED temperature coefficient effects.

The resulting stable performance of ALPHA*tracka* is obtained by locking the optical and electrical characteristics together in a null seeking servo loop. This interaction between a precision optical system and sophisticated electronics does mean that the instrument should be returned to the factory for any repairs that require the instrument to be opened up.

DEPLOYMENT AND CALIBRATION

ALPHA*tracka* has been designed to make it both electrically and optically rugged. However it is important to observe the following points if satisfactory data is to be obtained.

Deployment

a) To ensure that the optical system is not strained during deployment, four M4 mounting holes have been machined in the Support Frame, they must be used to mount ALPHA*tracka* to the deployment system.

b) ALPHA*tracka* may be mounted either vertically or horizontally. If mounted vertically for long periods beware of a build-up of deposits on the lower window. (Anti - fouling coatings are being investigated, contact Chelsea Instruments Ltd for latest information.)

c) The deployment system must provide support for the connecting cable, which should be routed and clamped so as not to put strain on the bulkhead connector.

d) After deployment, wash the instrument in fresh water to remove all traces of salt and debris. Lightly dry the instrument, taking care not to scratch the two windows (see paragraph e). The calibration of the instrument relies on the integrity of the optical system.

e) Keep the windows clean using soft, clean, lint free cloth, and plenty of distilled water. If there are stubborn deposits, a small amount of household detergent can be added.

An air reading can be taken, and compared with that obtained at the time of manufacture, to confirm the condition of the windows. This is **NOT** a calibration.

Calibration

Note: The beam attenuation coefficient in pure water at 660nm has been determined as 0.364m-1 (Spinard 1986). For a 25cm water column transmissometer this gives a transmission of 90.5%

The nominal calibration parameters for a 25cm ALPHA*tracka* are as follows:

		Output Voltage
Option	2.5V	5.0V
100% Transmission - full scale	2.3V	4.6V
90.5% ± 1.4% Transmission pure water.	2.1V	4.2V

ALPHA*tracka* is calibrated at the factory at 20^{o}C in distilled water with an electrical conductivity less than one microSiemen/cm and filtered to better than 5 microns.

It is possible that the user will encounter water which is purer than that used during the calibration. In this situation ALPHA*tracka* will give a higher output voltage which may be substituted for the "90.5%" voltage on the calibration record.

NOTE: Great care is needed when preparing pure water samples for use as a reference. Due to bacterial and algae growth the sample quickly deteriorates and the transmission level drops. Any observed reduction in instrument output is more likely to be due to this deterioration than instrument malfunction.

a) V(offset) is measured prior to delivery and recorded on the calibration certificate. It can be checked by blocking the receiving window completely and checking the signal output.

b) An air reading is also taken prior to delivery and entered on the calibration certificate. This can be repeated before each deployment to confirm that the windows are clean. This is NOT a calibration but is a convenient way to confirm the operation of the instrument. The windows must be clean and dry as any small deposit or fluid will modify the voltage output.

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