SiTek® ELECTRO OPTICS
Non-Contact
3/95
PEOPLE, PRODUCTS & NEWS

FIXTUR LASER

Accuracy and time

Two patrol boats with an unusual power transmission system have been built in Holland. The measurement task was to align the propeller shafts to prevent vibration and consequent bearing damage. Instead of the traditional arrangement with a straight driveline, the two engines were installed directly above the propellers, see figure 1. It was therefore necessary to join up the intermediate shaft coming from the engine to the gearbox input shaft via two universal joints. The angle between the two universal joints was about 7°. The angles did not need to be exactly 7°, but they had to be equal. If they were not, the rotation of the engine and gearbox would not be synchronised, which would lead to considerable vibration.

The problem was solved by using laser-based measurement equipment. This gives more accurate and considerably faster measurement than using conventional technology, involving tense piano wires, protractors, spirit levels and plumb lines. This example demonstrates an opportunity for applying the technology and the possibility of long-term savings. The pay-off time for the investment in a measurement system is very short.

To achieve the requirement for exactly equal angles, it was necessary that the two distances L, between the point of intersection B and the gearbox input shaft A, and between the point of intersection B' and the intermediate shaft A' were exactly equal. An adjustable dummy shaft was located at the point of intersection and a transmitter/detector unit (Combi-laser) was mounted on it.

Alignment took place in three stages:

1. The dummy shaft was lined up with the gearbox input shaft.
2. The dummy axle was angled 14° and the intermediate shaft was aligned with the dummy shaft.
3. The engine was aligned with the intermediate shaft.

Sea trials showed that the alignment was very successful. There was not the slightest sign of vibration.

If the same alignment work had been done with traditional technology, the work on the two boats would have taken two men 64 hours each. As it was, the alignment was carried out by one man in a total of 12 hours. The yard thus saved 116 man hours.

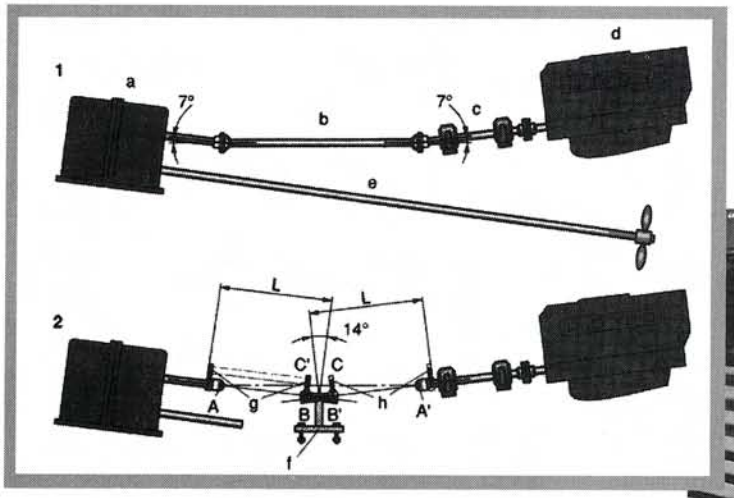


Figure 1. Alignment of the propeller shafts in the patrol boat.

1. The angles of the two universal joints must be exactly equal.
2. The position of the dummy axle during alignment.

a. gearbox
b. shaft with both universal joints
c. intermediate shaft with support bearings
d. engine
e. propeller shaft
f. dummy propeller shaft with adjustment screws
g. Combi-laser at stage 1
h. Combi-laser at stage 2

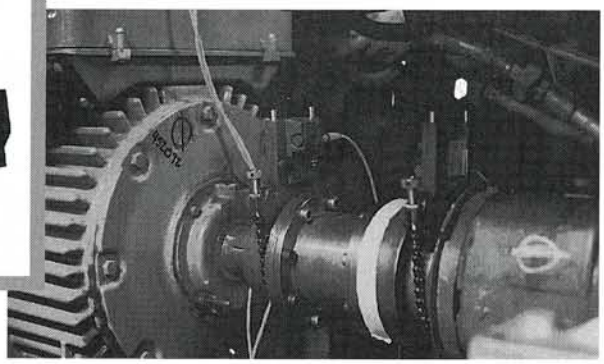


Figure 2. Alignment of a shaft journal using a Combi-laser.

The Combi-laser is a laser-based measurement equipment made by Fixturlaser in Mölndal. The system consists of two transceivers. Each unit contains a laser transmitter and a SiTek PSD detector. The system also contains a microprocessor which processes the measurement values and provides information about the relationship of the machines to each other. The Combi-laser is equipped with 6 different programs for specific applications and is available in an EX-classified version.

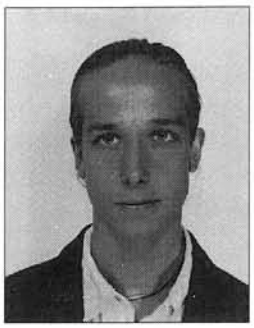
Reflections about climbing and the risks involved

You can wonder what it is that makes climbers invest thousands of crowns in safety equipment and spend their winter evenings practising their steps and movements on climbing walls indoors. Just to allow them to conquer a particular cliff wall or glacier.

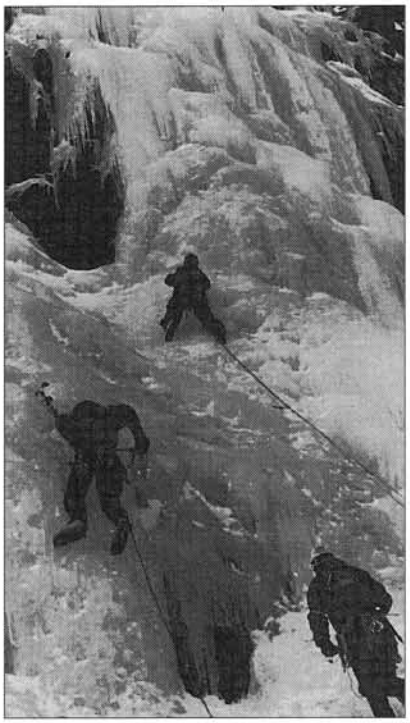
Is it the longing to manage to do something with the help of technique and knowledge which would appear at first sight to be impossible? Or is it the adventure, with excitement and risks which attracts?. Personally, I think that the risks are a very important part of climbing. There is no room for carelessness, every safety detail must be followed to the last full stop, since the slightest mistake could lead to a severe accident. The number of accidents is thankfully low, even if those which do occur are generally serious. It is a natural consequence of the extreme conditions involved, with high fall heights, transport difficulties and a long way to professional medical care. It should be mentioned in this connection that the majority of the climbing fans who die in accidents actually do so on the roads and not in the mountains. The risks involved in traffic are considerably more difficult to calculate. In comparison, the risks involved in climbing would appear to be primitive.

Be that as it may, the calculated risks involved in climbing are what makes it interesting. In many cases, you can put anchor points in the rock (to shorten any falls) as close together as you want. But, this takes time and time can also involve a risk since an overnight stay in the wrong place can be critical. The business of climbing means weighing risks, in other words, and solving problems on the basis of knowledge and experience.

The reward for this so-called risk exposure is to experience nature at close hand, often with animals nearby. To climb a route, use all your strength and technique, make the correct decisions and exert yourself to the uttermost to finally reach an isolated cliff shelf gives considerable satisfaction. In supreme collaboration with your rope partner, you anchor each other during the climb, get your breath back on the cliff shelf, and share a simple lunch whilst you sit there and look out over the landscape from a place which few are privileged to visit. Then all your everyday cares disappear and you can enjoy life to the full. You realise that it was worth all the hard work and the high price.



Christer Sjöback is a devoted climber. Off duty assembling SiTek parts you find him trying to conquer the rocks of nearby climbers paradise in Utby not very far from our plant.



More space and lower price
The SP series is now available

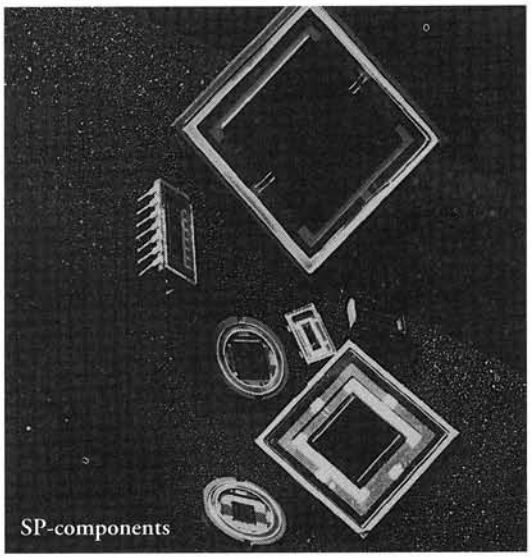
SiTek has now announced a new series of specially designed ceramic packages for most of our standard components. These packages are of a uniform design and are, to a greater or lesser extent, smaller, cheaper and of higher quality than the packages we have used up to now. This means that we can actually cut the prices of our components by up to 25% in a couple of cases, despite the increased costs of other materials. Of course, the same high performance as regards linearity, noise, leakage current, rise time etc. still apply to components in the new packages. The components included in the new series, which we call the SP series, are as follows: 1L2.5SP, 1L5SP, 1L10SP, 2L2SP, 2L4SP, 2L10SP and 2L20SP.

We will however retain the "old" packages, so nobody will be forced to redesign their systems just for this reason.

1L2.5 and 1L5 now have a 4-pin DIL package with dimensions of 9,9 x 5,8 mm^2, compared with the previously used 14-pin DIL package with dimensions of 19,6 x 7,9 mm^2. For the 1L10 we use the same 14-pin DIL package as before, with only a few changes to the gold print.

The biggest changes are to the packages for our two-axis PSD. Until now, we have used metallic TO-8 packages for the smallest components and ceramic substrate for the two largest components. We can now offer the same type of package, a 4-pin ceramic package, for all four standard two-axis PSDs. For the 2L2 and 2L4, they have the same diameter as TO-8 packages, but are only half the height, 2,15 mm compared with 4,45 mm. For the 2L10 and 2L20, the new packages have the same external dimensions as our "old" ceramic substrates.

Please contact SiTek for more information.



SP-components

The SiTek PSD-school

Section 3 by Lars Stenberg, ESDE AB

Lars Stenberg

Designing a triangulation probe

In section 2 of SiTek's PSD school, we looked at the design parameters for a triangulation probe and derived the 11 formulae which can be used to design a triangulation probe. In this chapter, we will use these formulae to make a more detailed study of the procedure for designing a triangulation probe. To make the reasoning clearer to the reader of section 3, we have inserted figures 2 and 3 from section 2 into this section.

Let us assume for our design example, that we need a free air distance of 100 mm from the lower edge of our proposed triangulation probe and measurement object D, and that the measurement range D'D" will be 45 mm. These two distances are of course determined by the measurement application in question. Since the lens is inside the triangulation probe and we may want to put a protective window in front to protect the main lens E, we will set h = 120 mm.

After this, we must decide the magnitude of angle ADF. As shown in figure 2, our first assumption is that the greatest measurement range D'D" is obtained by alt. 2.1 since the angle ADF is smallest. Let us use formula (2) from the PSD school section 2, to investigate the difference between the three cases. (Due to lack of space, the reader is requested to refer to section 2 of the PSD school for the other formulae 1-11.) According to formula 2,

$$D'D'' = h \tan\alpha \left(\frac{1}{\tan(\alpha - \beta)} - \frac{1}{\tan(\alpha + \beta)} \right)$$

we obtain the length of the measurement range D'D" for differing values of α and β to

	$\alpha°$	β=4° D'D"=	β=5° D'D"=	β=6° D'D"=
2.1	30	39,334	49,631	60,252
2.2	45	33,730	42,319	51,014
2.3	60	38,820	48,615	58,470

In our table above, we find to our surprise that D'D" first falls when α increases from 30° to 45°, completely in accordance with our reasoning, but then increases as α increases from 45° to 60°. Why is this? The answer is obtained from the above formula 1, which specifies the distance from point D to the main lens E. The distance DE, which determines the measurement range together with angle β, quite simply increases faster than measurement range D'D" is reduced because angle α increases. In practice α angles greater than 35° to 45° are seldom used, so one seldom has to consider this fact in practice.

We have now found that if h is set to 120 mm and angle α is selected somewhere in the range of 30° to 45° and angle β is selected as 5°, we will obtain a triangulation probe of the required performance. Always attempt to keep angle β as small as possible since large β angles mean that main lens E will have large field angles and such lenses are always more expensive than lenses with small field angles. We will talk more about various types of lenses in future issues of SiTek's PSD school.

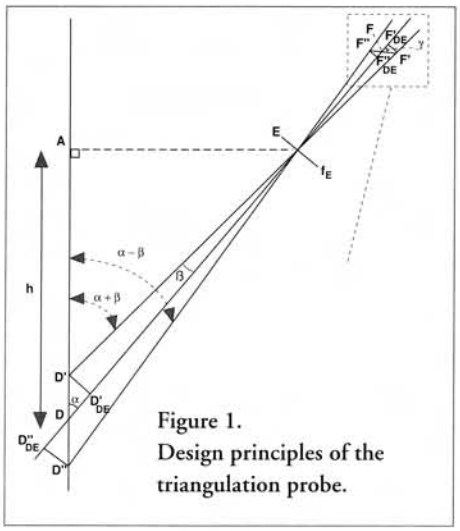


Figure 1. Design principles of the triangulation probe.

To calculate all the parameters in accordance with the above formulae 1-11 we need, finally, to set a value for the aperture f_E of main lens E. If you have written a computer program, you can quite simply select f_E = 20 mm for example and see what happens. After a couple of runs you have probably reached the specification you aimed at from the beginning. But it is not a bad idea to draw a scale illustration and use it to determine a value for EF (the distance between the lens and the image in the lens formula), which gives you a reasonably correct detector length. After this, you can use the lens formula to calculate a good start value for f_E. If we study fig. 1, we see that a detector length of about 12 mm is required (note that the scale have been changed compared with the same figure in section 2), if β = 5°. If we want to use a detector of length 10 mm, we must use an EF value in the range of 41,5 mm. To be able to use the lens formula, we also need to know the distance DE (the distance from the object, which in this case is the diffusely reflected laser beam,

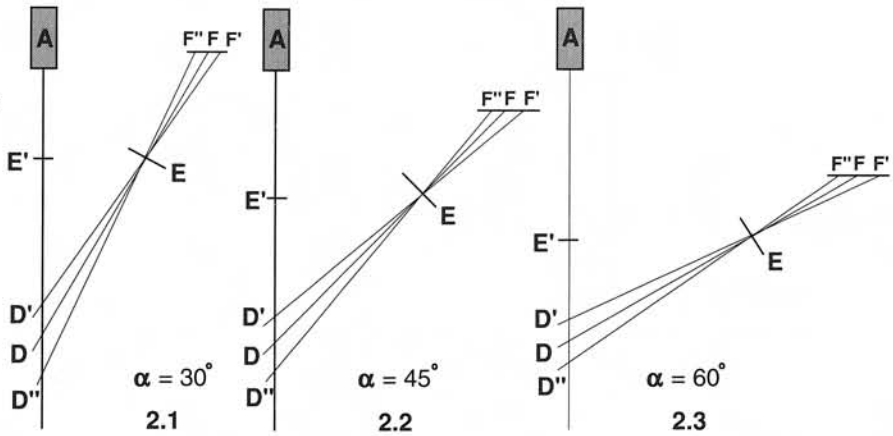


Figure 2. The geometry of the triangulation probe for three different choices of angle ADF.

to the main lens E). According to formula 1 for DE, we find that DE = 120/cos 40 = 156,65 mm. Putting these values into the lens formula (formula 6), gives f_E = 32,81 mm.

Since we now have values for the four start parameters, we can now calculate the 11 above-mentioned formulae to find the total measurement range of the triangulation probe, the exact length of the detector and the angle γ (angle between the detector plane and the optical axis of main lens E). For calculation 1, we thus use: h=120 mm, α=40°, β=5°, and f_E = 32,81 mm.

The 11 expressions which must be calculated are numbered and the results are:

		Calculation 1	Calculation 2	Calculation 3
(1)	DE =	156,649	156,649	156,649
(2)	D'D'' =	43,111	45,330	45,330
(3)	$D''_{DE}E$ =	174,883	175,913	175,913
(4)	$D'_{DE}E$ =	141,858	141,188	141,188
(5)	EF''_{DE} =	40,387	40,333	41,380
(6)	EF =	41,503	41,503	42,613
(7)	EF'_{DE} =	42,682	42,743	43,921
(8)	$F''_{DE}F$ =	1,116	1,170	1,233
(9)	$F''F''_{DE}$ =	3,533	3,706	3,802
(10)	γ =	72,477°	72,477°	72,038°
(11)	F''F'=	7,621	8,005	8,240

From (2) above, we see that the triangulation probe we are trying to design has a measurement range of 43,111 mm. The goal above was however that the measurement range should be 45 mm. There are two parameters we can change to increase the measurement range. We can either reduce angle α or increase angle β. Naturally, we can try several values of α and β to see what will happen. There is however another method which gives us a much better grasp, which is to use a calculation program such as Mathcad, and use it to plot a graph showing the correlation between α, β and measurement range D'D''. (See diagram 1.) It can of course be suitable to plot a graph as well, showing the correlation between angles β, γ and detector length F''F'. (See diagram 2.)

From diagram 1, we see that the measurement range is not affected so much if we change angle α as if we change angle β. Diagram 1 shows that if angle β is changed to 5,25°, the measurement range becomes 45 mm. For calculation 2, the values become h=120 mm, α=40°, β=5,25° and f_E=32,81 mm. The result of calculation 2 is shown in the table above.

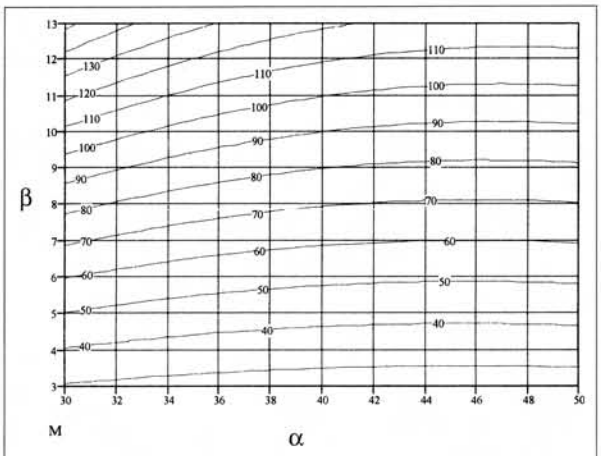


Diagram 1. The measurement range as a function of α and β

Since we increased angle β, this means that the detector length was increased from 7,621 mm to 8,005 mm. The logic of this is found by studying figure 3 above.

Assume that we want to use 8,25 mm of the detector length. (We will cover the reasons why we can not use the entire 10 mm length of the detector in section 4.) The best way for us to achieve this is by increasing the aperture of main lens E somewhat. A couple of iterations shows that if f_E is chosen to be 33,5 mm, the desired result is obtained. For calculation 3, the values become h=120 mm, α=40°, β=5,25° and f_E=33,50 mm. The result of the calculation is shown in the table above. We have therefore learnt in section 3 how to design a triangulation probe with the desired geometry by varying the four basic parameters. In section 4, I will cover how to select suitable optical parameters for the triangulation probe we are designing.

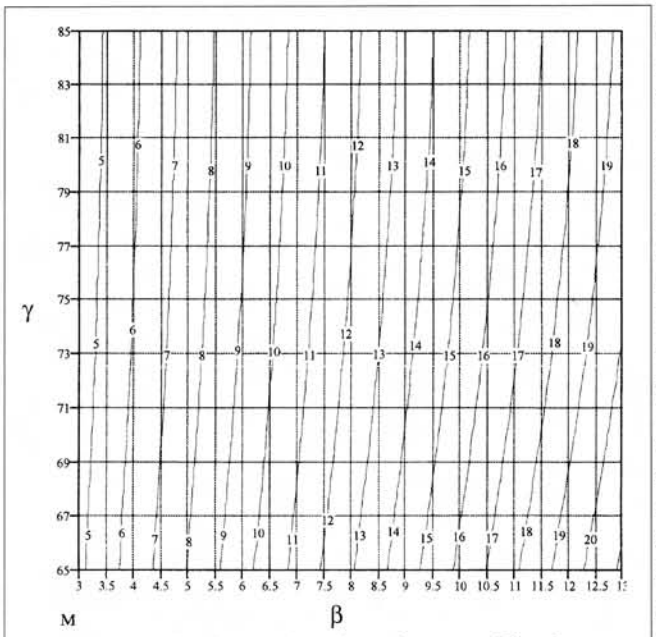


Diagram 2. The detector length as a function of β and γ

This is the third section of the PSD-school by Lars Stenberg. Previous sections will be sent to you on request.