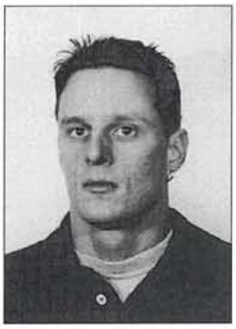
SiTek® ELECTRO OPTICS
Non-Contact
2/95
PEOPLE, PRODUCTS & NEWS

The Cello of the future

An instrument which is played like a cello and is optically controlled by laser technology. The signals in the instrument are converted to MIDI, the language of the electronic music industry. The cello is an instrument which is handled with a lot of feeling and close body contact. The relationship between man/machine is central to this instrument, in which the entire range of dynamic movement of the cello is used. The person playing puts his or her personal seal upon the synthetic sound. In most cases, synthetic sound is generated by means of a keyboard and buttons, rather than by feelings.



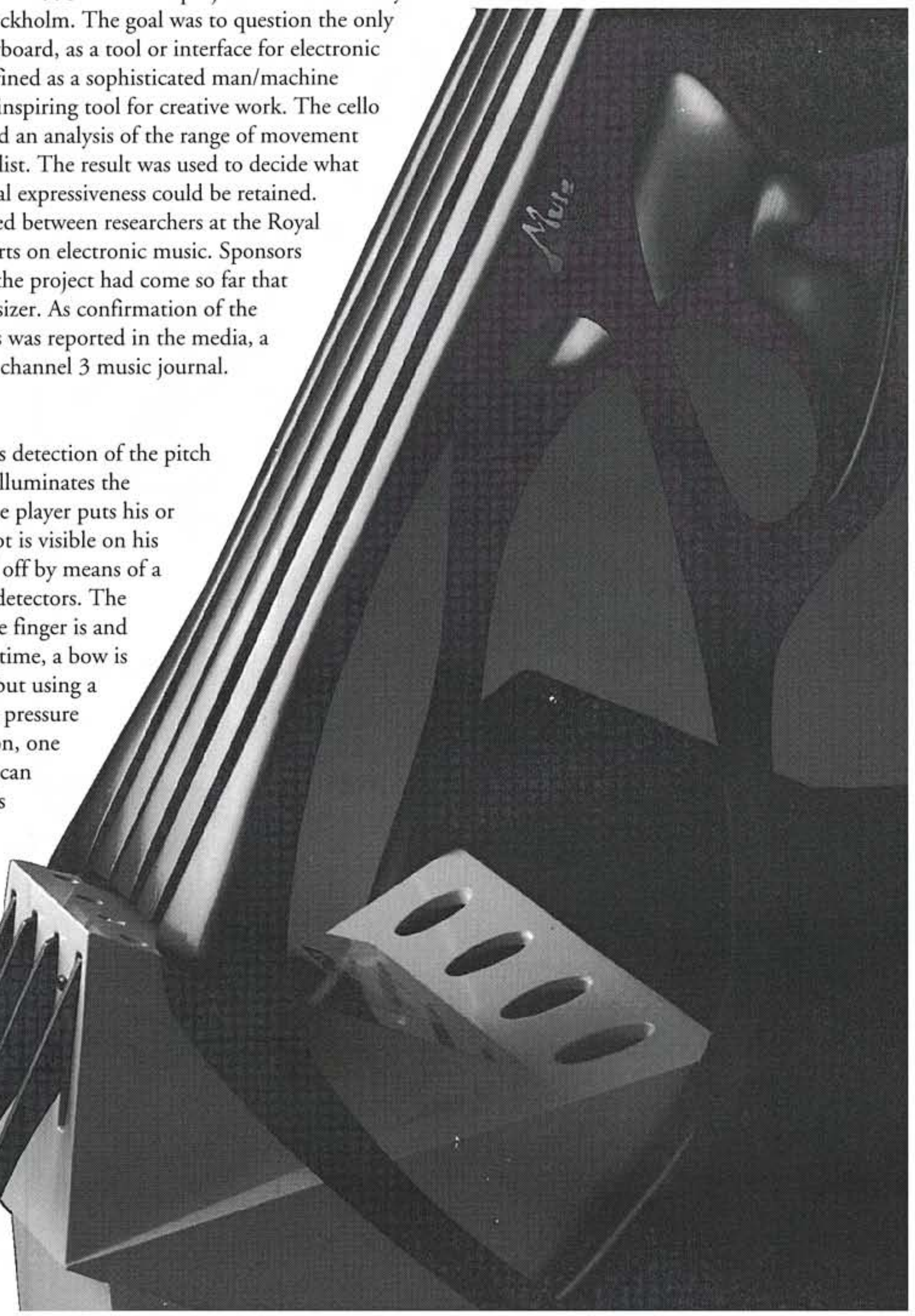
Jonas Ericsson created the laser cello as his thesis project at the University College of Arts, Crafts & Design in Stockholm.
He is a partner at NO PICNIC, the industrial design company, which is now managing the project.

The project

The cello project was started in December 1993 as a thesis project at the University College of Arts, Crafts & Design in Stockholm. The goal was to question the only alternative then available, the piano keyboard, as a tool or interface for electronic music generation. The problem was defined as a sophisticated man/machine relationship, which should result in an inspiring tool for creative work. The cello was selected as a suitable instrument and an analysis of the range of movement was initiated in collaboration with a cellist. The result was used to decide what should be detected, and how the original expressiveness could be retained.
An interesting collaboration was initiated between researchers at the Royal School of Engineering, KTH, and experts on electronic music. Sponsors provided material, and on the 14 July, the project had come so far that the cello could already control a synthesizer. As confirmation of the interest generated by the laser cello, this was reported in the media, a television news magazine and the radio channel 3 music journal.

The technology

The technical design is based on stepless detection of the pitch by optical means. A 5 mW laser diode illuminates the fingerboard from underneath. When the player puts his or her fingers on the fingerboard, a red spot is visible on his fingers. The position of the spot is read off by means of a SiTek one-dimension position sensing detectors. The signal is used to define exactly where the finger is and for how long it rests there. At the same time, a bow is used, just as with a conventional cello, but using a pressure-sensitive sensor to measure the pressure applied by the bow. In this configuration, one detector per "string" is required, which can probably be simplified. The laser cello is now being developed further, by rationalising the detector configuration to a single two-dimensional detector, which thus only needs one lens.



SiTek expands

In order to manage the ever-greater demand for our components, we have now engaged new personnel. As from the 26 January, when Yvette Larsson started, there are seven people employed at SiTek. Yvette will work on the production of our components, primarily assembly of the PSD chip in all the various types of encapsulations and substrates.

Yvette did a two-year Electrical-Telecom vocational training course and will be an asset to SiTek, thanks to her accuracy, great flexibility, feeling for customer service and her considerable feeling for order & tidiness. This means that we can continue to meet our customers' demands for special solutions and quick deliveries despite a growing order book.

When Yvette is not working in our clean room, she is the goalkeeper at HK Aranäs Division II hand ball team, or spends time with horses, which is just about her favourite pastime.

Yvette Larsson

Thank You

Thank you for the fantastic reception and all your valuable comments to our first issue of Non-Contact. The reaction was far greater than we ever dared hope for. We are going to consider all the opinions voiced, to make Non-Contact even more interesting for you. The first thing we are going to start with, as from this issue, is to present various applications and uses of PSDs. In this issue, we present an unusual application, the Laser Cello, which demonstrates the great possibilities offered by the PSD technology and triangulation techniques.

Despite all comments received, we would like you to send in even more comments. Is there something you think should be included in Non-Contact? In particular, we would like comments about our PSD school and questions if there is anything which is unclear, or if you wanted a more detailed account.

Your short cut to a finished measurement system

SiTek is improving its facilities for helping and supporting you to develop new non-contact measurement and inspection systems. Thanks to deepened collaboration with JA-Elektronikutveckling AB, we have access to professional expert help in measurement systems and applications based on PSD. We offer unbiased discussions, including an analysis of the measurement system and technical pilot studies of your own application. Under full confidentiality, of course. We can also supply finished prototypes which do the measurement you wanted. This includes advice and instructions about design and construction of the non-contact measurement or inspection system. This includes electronics, light source, optics, mechanical components and choice of PSD. The step from idea to finished product is now considerably shorter for you!

JA-Elektronikutveckling AB is a high-technology electronic company with expert knowledge of:

- Optronics: electronics, optics and precision mechanisms in collaboration.
- Non-contact PSD-based metrology
- Analog & Digital signal processing
- Measurement data acquisition and processing in real time
- Technical system design and programming.

JA-Elektronikutveckling AB has more than 20 years' experience of PSD-based measurement and inspection systems. Combined with SiTek's unique knowledge and experience of PSD technology, you have access to competence and resources in non-contact measurement which is among the best in the world.

Please phone us, and we will pop in for an unbiased discussion!

Competition

In our previous issue, we had a questionnaire entitled "Who said what?". This turned out to be quite difficult, so do not be disappointed if you did not get all four questions right. Here are the answers:

1."All people complain about their poor memory, but nobody about their intelligence" - François de la Rochefoucauld.

2."The clumsy smith blames the iron" - Dante Alighieri.

3."Better to light even a tiny lamp than to curse the darkness" - Confucius

4."The wise wish to know, the foolish to speak" - the Koran

The SiTek PSD-school

Section 2 by Lars Stenberg, ESDE AB

Design parameters for a triangulation probe.

In section 1 of the SiTek PSD School, we used the triangulation probe as an example of what a PSD detector can be used for. Since this is a very common application of PSD detectors, we will cover various design parameters which you will have to consider if you want to design one. We will do a detailed study, both to give tips and calculation material for the design of a triangulation probe, and also to give better understanding of the parameters which are particularly important for making the entire probe work satisfactorily.

Introduction

If you want to design a triangulation probe, you must consider the following parameters (see figure 1): geometry, light source (A), any filters, main lens (E), condenser optics, detector (F), electronics and mechanical components.

Since this is a question of non-contact distant measurement, the distance from the light source (A) to the measured object (D) can be varied within quite wide limits. As we will notice, the measurement accuracy or the measurement range D'D" are reduced as well, if distance AD is chosen to be unnecessarily large. In practice, one attempts to choose the distance AD to be no longer than necessary.

The Problem

You have to find a compromise between the various parameters, so that the requirements imposed by the application in question are met as far as possible. In figure 2 below, there is an angle ADF (referred to as α later in the article) of 30°, 45° and 60° in alternatives 2.1, 2.2 and 2.3 respectively.

The aperture of the main lens (E) is the same for each of the three alternatives, as is the angle of view (see fact box) of the main lens (E).

As shown in figure 2, the greatest measurement range (D'D") is obtained in alt. 2.1 since the angle ADF is smallest. This implies that distance AF is shortest in alt. 2.1. It is of course the distance AF, together with the size of the light source A and the detector F which determines the smallest linear extent of the triangulation probe along the plane of the paper. On the other side, it is obvious that alt. 2.1 makes greater demands on the resolution of the detector (F) than alt. 2.3. In addition, it is also obvious that the free air gap E'D' is reduced as the angle ADF increases. The choice of value of angle ADF thus affects: measurement distance AD, measurement range D'D", the free air gap E'D', resolution and the dimensions of the triangulation probe itself.

Some of the above mentioned parameters can be affected, as we will see below, by choosing a lens with another aperture and by choosing a detector with another effective measurement length. In practice however, it has been found that the angle ADF is mostly chosen to be in the range of 35° to 45°.

The most important thing about this explanation is that you should understand the factors involved. To find a suitable compromise, you need the expressions which we will develop below and may possibly have to spend one working day to find a suitable geometry, considering the size of the detector and the availability of suitable objectives E.

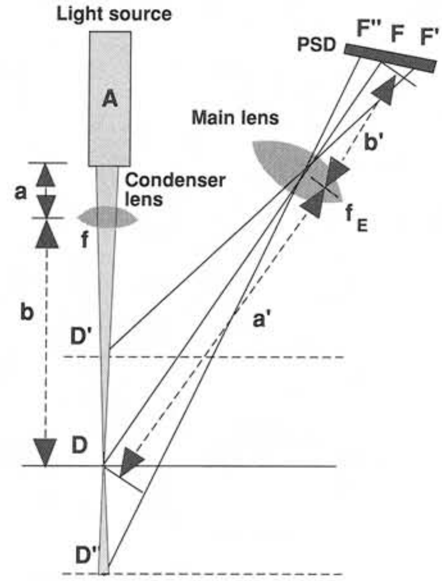


Figure 1.
Design principles of the triangulation probe.

Procedure

The most practical procedure for designing and calculating the various parameters in a triangulation probe is to begin by selecting suitable start values for the various parameters: (see figure 3): the free distance h between the object and the probe, the angles α and β plus the aperture f_E of the main lens. After this, you calculate the other parameters by means of the formulae which we will shortly derive: detector length F'F", the total measurement range D'D" and the angle γ, which specifies the angle at which the detector should be aligned relative to the main lens. If you are satisfied with the result obtained, all is well, but it is more probable that you are going to want to adjust one of the parameters. By re-doing the calculations one or several times with the following start values, you can work your way to a suitable compromise.

Lars Stenberg

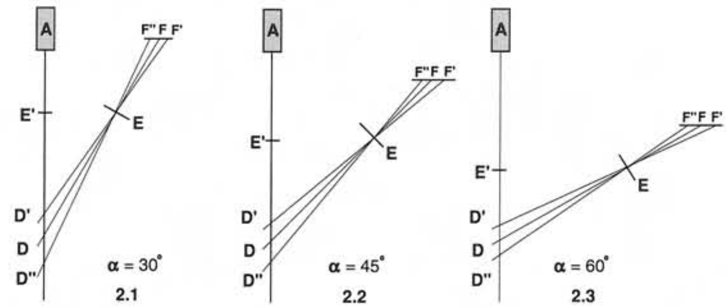


Figure 2. The geometry of the triangulation probe for three different choices of angle ADF.

Calculation formulae

Using figure 3, the usual trigonometric functions for triangle solution and the lens formula for thin lenses (see fact box).

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

where a is the distance from the object to the lens, b is the distance from the lens to the image and f is the aperture of the lens, the necessary expressions can be derived.

It all ends up with 11 equations which have to be calculated. The numerical calculations should preferably be done with a programmable calculator or computer, especially since a number of iterations are normally required before one is satisfied with the geometry of the triangulation probe.

We obtain the following expressions. (If you want a complete proof, please contact SiTek.)

$$DE = \frac{h}{\cos\alpha} \quad (1)$$

$$D'D'' = h\tan\alpha\left(\frac{1}{\tan(\alpha-\beta)} - \frac{1}{\tan(\alpha+\beta)}\right) \quad (2)$$

Measurement range distance.

$$D''_{DE}E = D''_{DE}D + DE = h\left(\cos\alpha\left(\frac{\tan\alpha}{\tan(\alpha-\beta)} - 1\right) + \frac{1}{\cos\alpha}\right) \quad (3)$$

$$D'_{DE}E = DE - DD'_{DE} = h\left(\frac{1}{\cos\alpha} - \cos\alpha\left(1 - \frac{\tan\alpha}{\tan(\alpha+\beta)}\right)\right) \quad (4)$$

$$\frac{1}{D''_{DE}E} + \frac{1}{EF''_{DE}} = \frac{1}{f_E} \quad (5)$$

$$\frac{1}{DE} + \frac{1}{EF} = \frac{1}{f_E} \quad (6)$$

$$\frac{1}{D'_{DE}E} + \frac{1}{EF'_{DE}} = \frac{1}{f_E} \quad (7)$$

$$F''_{DE}F = EF - EF''_{DE} \quad (8)$$

$$F''F''_{DE} = EF''_{DE}\tan\beta \quad (9)$$

$$\gamma = \arctan\left(\frac{F''F''_{DE}}{F''_{DE}F}\right) = \arctan\left(\frac{EF''_{DE}\tan\beta}{EF - EF''_{DE}}\right) \quad (10)$$

(10) Angle γ.

$$F''F' = \frac{\tan\beta}{\sin\gamma}\left(EF''_{DE} + EF'_{DE}\right) \quad (11)$$

(11) Detector length.

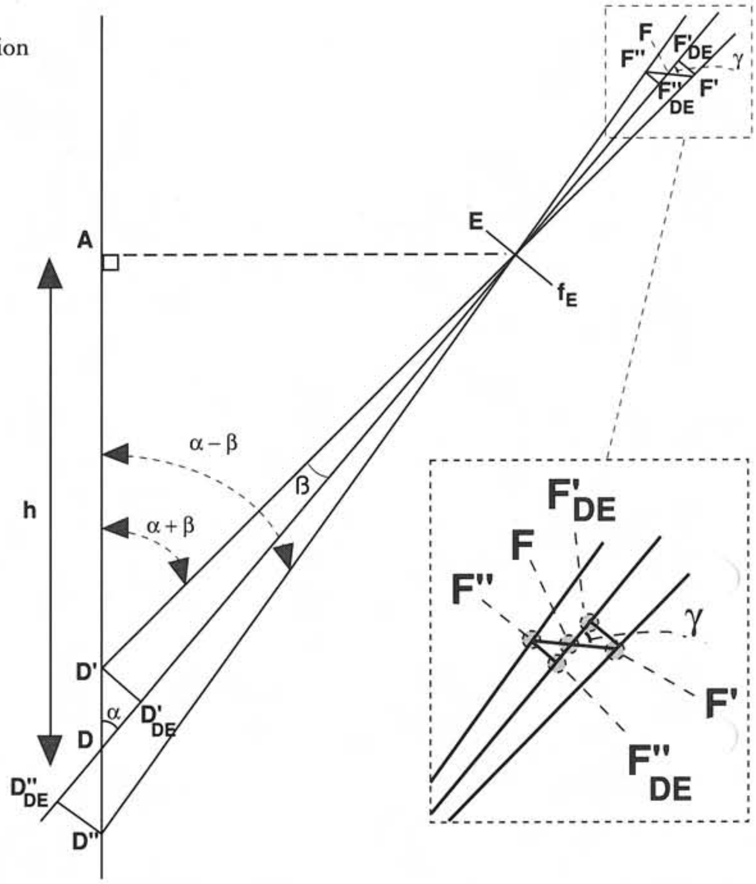
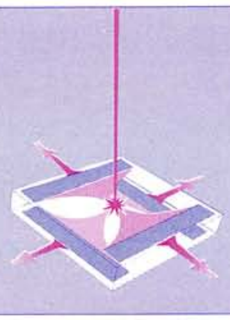


Figure 3. The various angles and distances of the triangulation probe.

We will do a numerical calculation in the next issue, discuss the result and possible changes, and the choice of various components.

> Fact box:
> There are various parameters which are used together to describe how well a lens will work in a specific application. Aperture and focal length are of course among these parameters. Another very important parameter is the so-called field of view angle, i.e. the angle inside which the lens can form a sharp image on the focal plane of the lens. Some companies specify half the field of view angle, others specify the entire included angle. So make a habit of always asking a supplier what is meant, unless it is unambiguously described in the lens specification and possible tender.
> A thin lens is termed as one which has a thickness of 0. They do of course not exist in reality, but for principle calculations such as those we are doing here, this simple formula is very usable. Later on, I will take up the question of what happens when a lens no longer can be regarded as being thin.



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