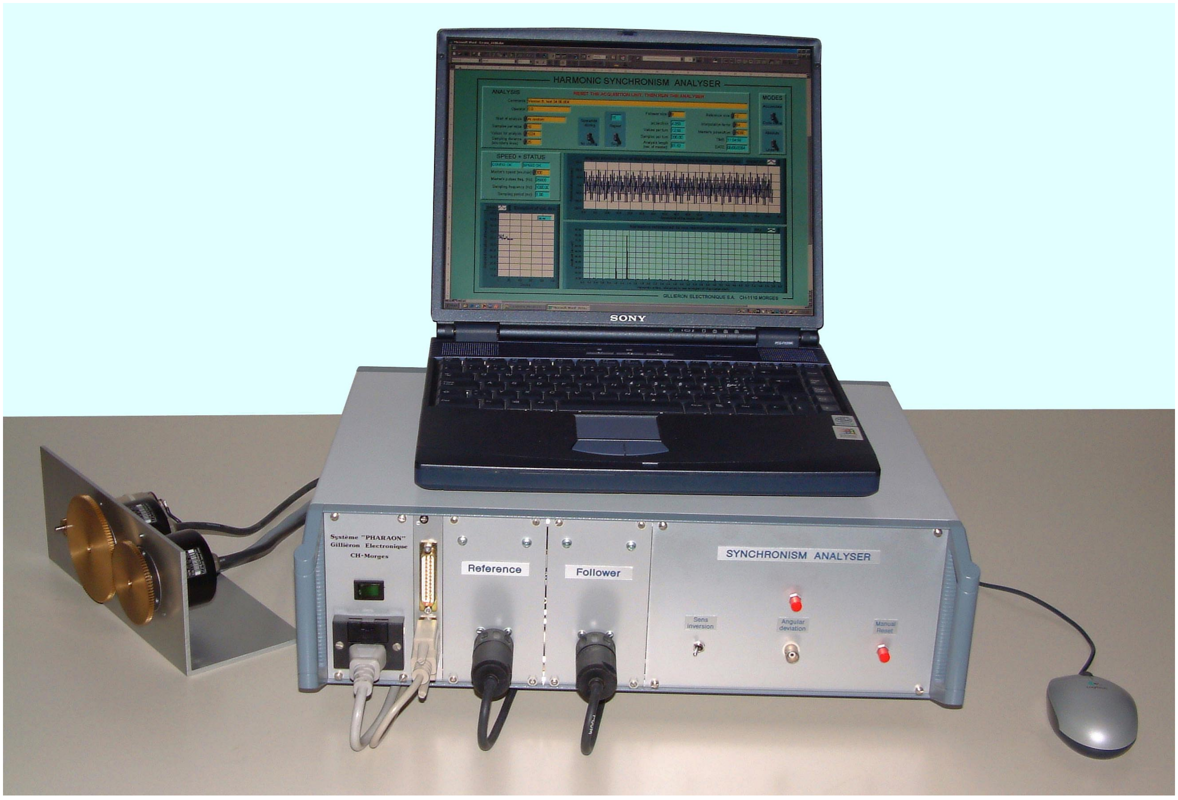
Synchronism analyser.

Technical documentation and user's guide.



The synchronism analyser with the test and demonstration equipment

Note.

This is the technical documentation and the characteristics of our standard synchronism analyser.

As a small engineering company, we always try to fit our products to your needs. Don't hesitate to propose us modifications or adaptations for your application.

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Siège principal Gillièron Electronique S.A.
Chemin Buvelot 2
CH-1110 Morges
Tél. : xx41 (0)21 802 13 01
Fax : xx41 (0)21 801 07 83

Niederlassung Giacobbo Microtechnique Engineering
Chemin de la Prairie 16
CH-1723 Marly
Tel. : xx41 (0)26 436 10 13
Fax : xx41 (0)26 436 30 86

www.g-plus.ch
E-mail : info@g-plus.ch

1 PRESENTATION

1.1 Introduction

Two questions are frequently asked in the field of the motion control:

- how good is the **speed stability** of an axis ?
- what is the **synchronism error** between two axis drived by a mechanical or electrical device ?

The speed stability can be calculated by observing the jitter of the frequency issued from a shaft encoder. The Fourier transformations will provide a more subtle analysis of the speed variation.

The error of synchronism is defined as the variation of the relative position between the concerned elements.

The frequency spectrum of the relative position provides also very useful informations to find the origin of the errors :

1.2 Short presentation of some real cases

We present here some typical cases. More information and details are given on the following pages.

Problem 1) On a new printing press, equiped with classical mechanical drives, it has been found some misajustment of the colors.
Diagnostic of the analysis : mechanical excentricity and pitch errors on the pinions of a right angle gearhead.

Problem 2) Poor accuracy on a packaging machine, also equiped with classical mechanical drives.
Diagnostic of the analysis : the tension of a notched driving belt was too loose. The mechanical tension of the belt was corrected using the "standard deviation graph" of the stability analyser.

Problem 3) Indexing errors on a machine generating identification hologramms . The machine is quite complex, with mechanical and electrical synchronous drives.
Diagnostic of the analysis : The spectrum shows an important spectral line : is it the sign of a mechanical or an electrical problem ?
We decide to increase the speed of the machine of 2 percent. The spectral line shifts of 2 %, indicating that this oscillation has a constant frequency. The trouble was eliminated by re-ajusting the parameters of a PID loop.

1.2.1 Remark

The synchronism analyser, is a relatively simple but very powerful tool. Like the stethoscope for the doctor, the synchronism analyser will give to the engineer valuable informations to locate the source of a malfunction or inaccuracies.

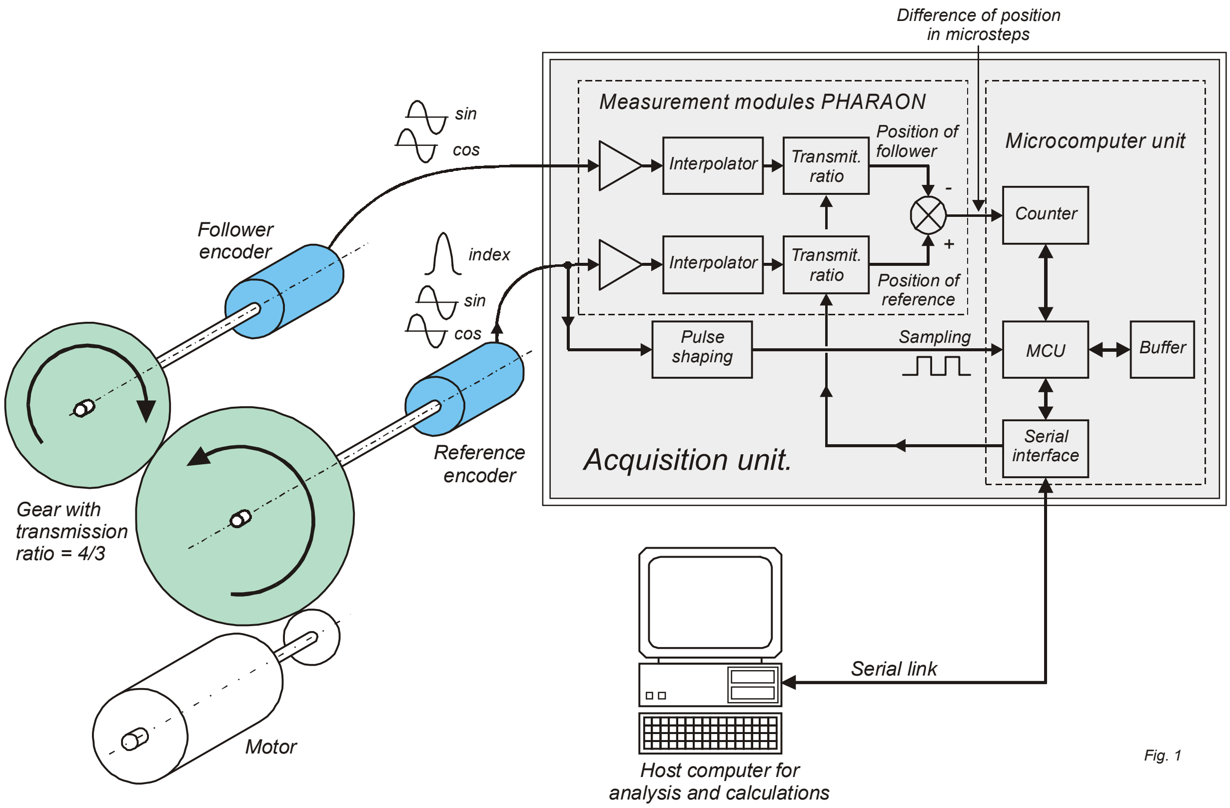
1.2.2 Structure of the analyser.

The accurate measurement of the synchronism of two movements is a little bit tricky: in theory, the comparison of the speed of the two axis could be the basis for calculating the synchronism error.
In practice, the measurement errors are so critical that this method doesn't gives useful results. So, the tacho-generators are not adapted to this application.

We must measure, record and analyse the relative position of the two axis during the rotation. The analysis should not be made in function of the time but in function of the movement of one axis that is defined as the reference.

By this method, the measurements are also independent of the speed of the machine.

The sensors used in the synchronism analyser are the shaft encoders (incremental encoders) with sinusoidal outputs. The resolution of the encoders is enhanced with the interpolation process of our **PHARAON**® system.



Principle of the synchronism analyser with the test and demonstration equipment

1.3 Working principle.

As said before, the measurement and the analysis is not made in function of the time but in function of the movement of one axis that is defined as the **reference**. The other axis is defined as the **follower**.

The unit of the sampling is the "step". A step is simply the distance of a line of the reference encoder.

The unit of the measurement is the "microstep". A microstep is the value of a step divided by the interpolation factor.

See fig. 4 below.

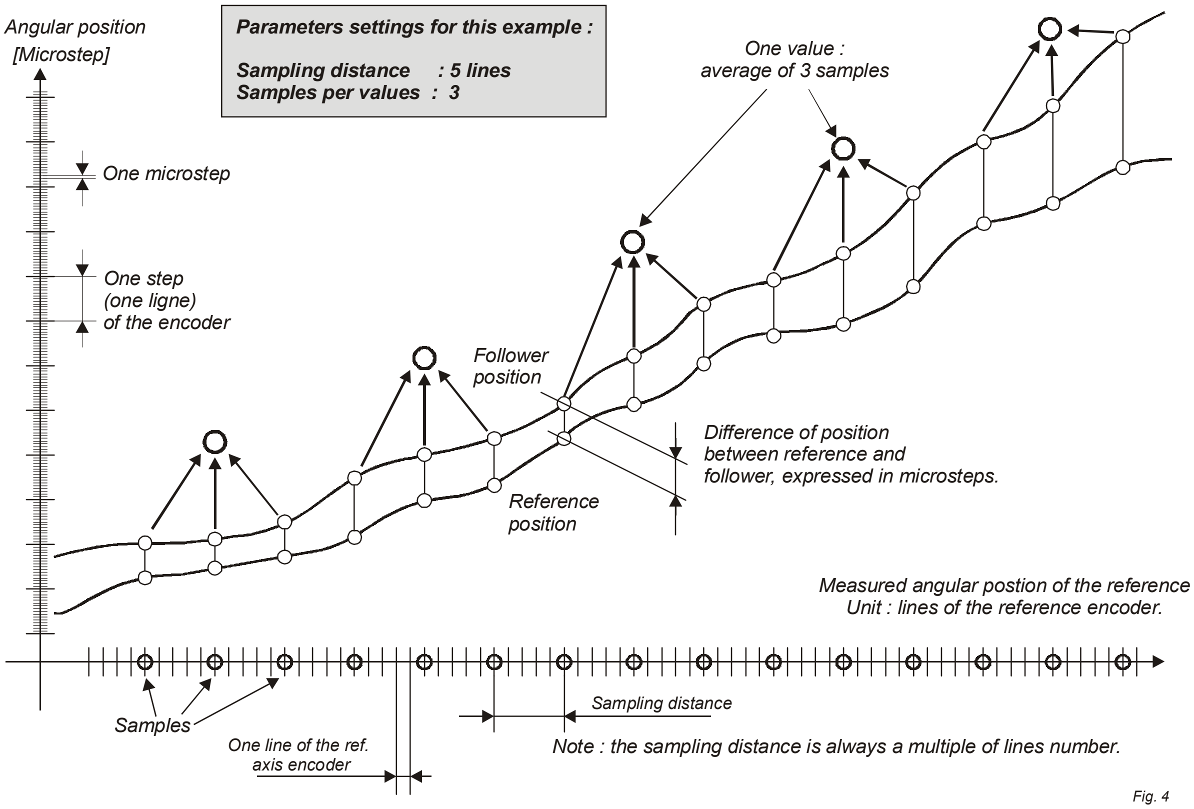


Fig. 4

Measurement and analysis of the synchronism : principle and definitions.

1.4 Architecture of the synchronism analyser.

Refering to the fig.1, the system is shared in two parts:

- the acquisition unit, mounted in a 19 inches cabinet.
- the computation unit. (PC)

The **acquisition unit** performs the critical real-time operations. It is built with the modules of the **PHARAON**® system and the **MICROFLEX** microcomputer.

The heart of the acquisition unit is formed by a special interpolation circuit that divides the distance between two lines of the encoder in 32, 64, 128 or 256 divisions, named "microstep". The high degree of resolution plus its high computational speed allows high performances in accuracy and velocity.

The measurement values are stored in the acquisition unit and sent to the PC for the analysis.

The **computation unit** (PC) executes the following functions:

- operator interface for parameters setting.
- calculations and analysis.
- presentation of results on the screen or to the printer.

The programm is written in "G" langage (Labview).

1.5 General properties.

- processing the signals of incremental encoders with analog output (sine and cosine).
- analysis of linear or rotational movements.
- measuring resolution up to the second of angle. (Depending on the incremental encoders).
- the transmission ratio between the two axis can have any value.
- Incremental speed :
  Guaranteed : 5 MHz.
  Can reach 15 MHz in most of the conditions.

2 MOUNTING OF THE ENCODERS.

If the system under test is equipped with the proper incremental encoders, we can use these encoders by derivation of their electrical signals.

If we have to add the measuring encoders, they should be tightly coupled to the axis under test. This rule is however not mandatory. We have made good experience with the apparatus described in fig 2, where the encoders are mounted on a tripod.

The magnetic adapter is aligned by a centering spike introduced into the conical hole which exists normally at both ends of the shafts.

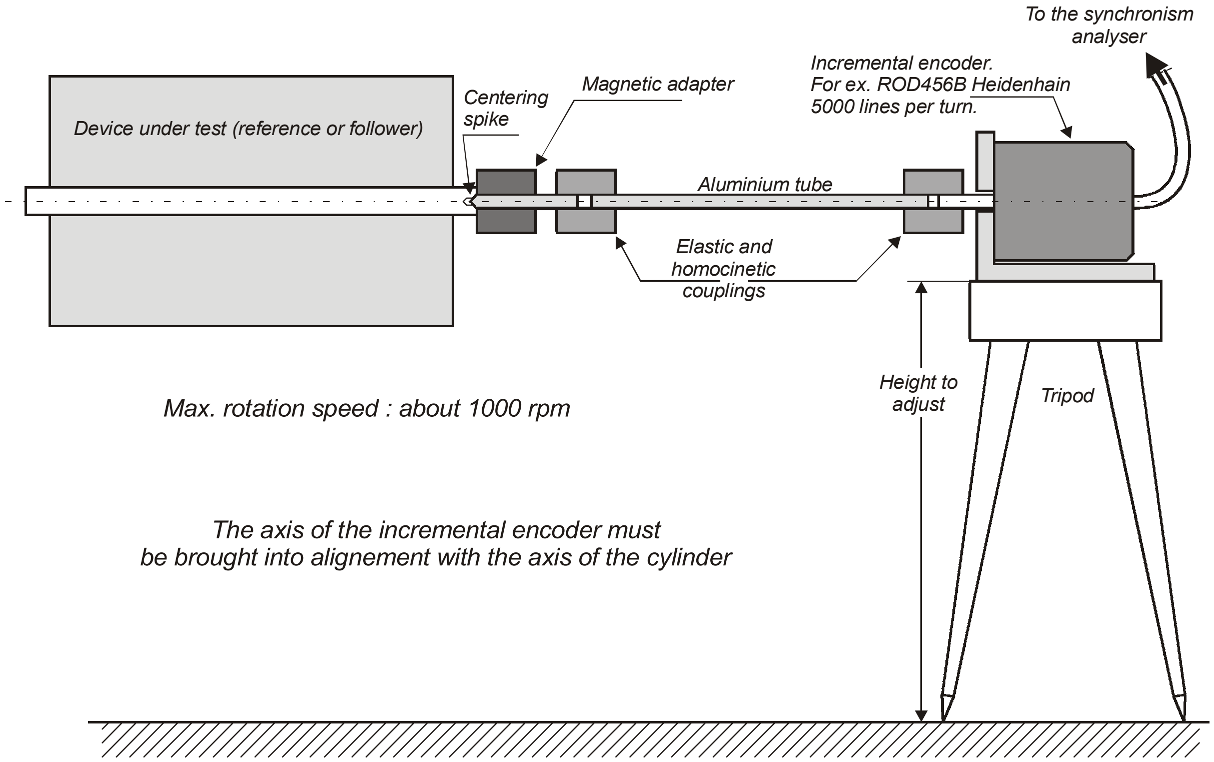
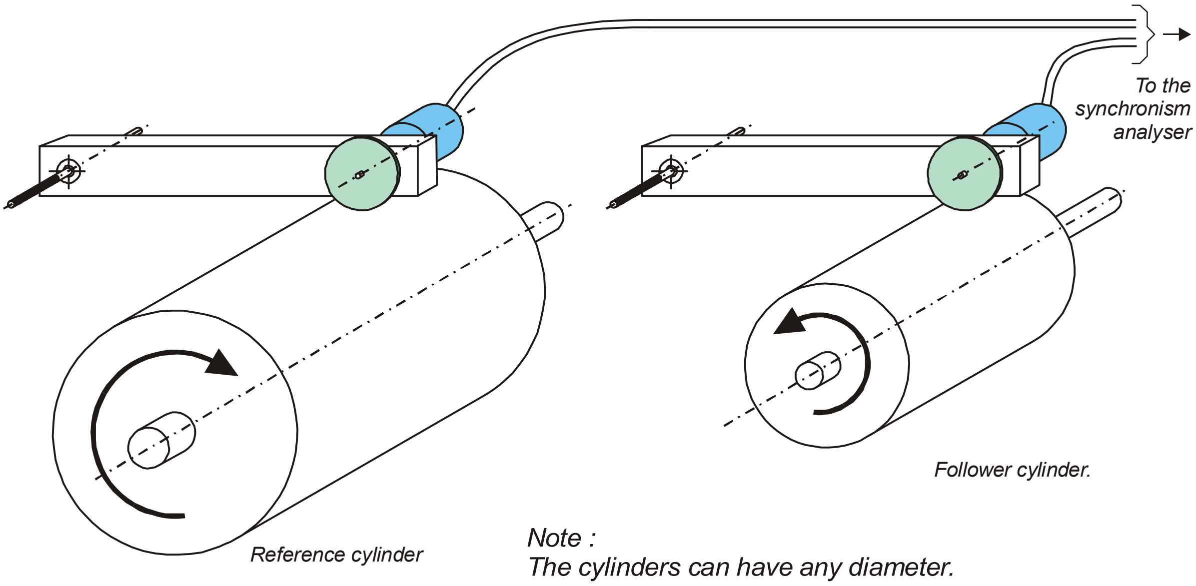


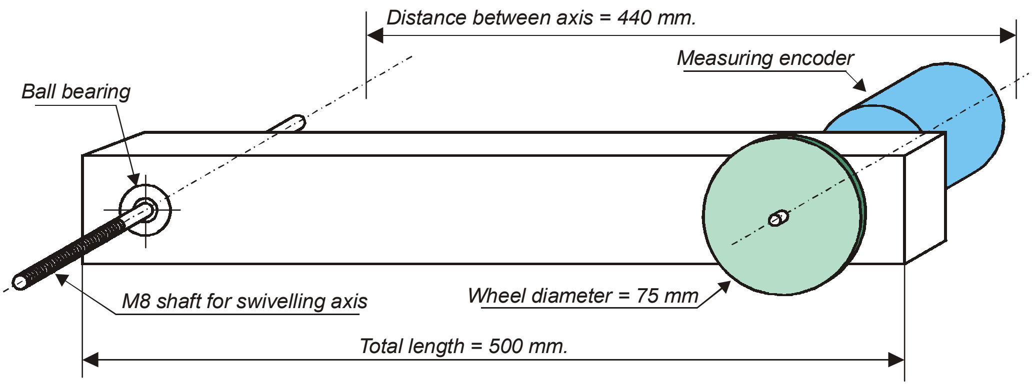
Fig. 2

Overview of the magnetic driving mechanism for encoders.

An another method is to mount disks on the shaft of each encoder and to drive them simply by the friction against the cylinder. Refer to fig 3, with disks in green and encoders in blue. These disks must be carefully machined in order to have a good concentricity.

In order to compensate the small amount of slipping between the cylinders and the disk, a special algorithm is incorporated in the analysis programm. This feature gives very good results in most of cases.





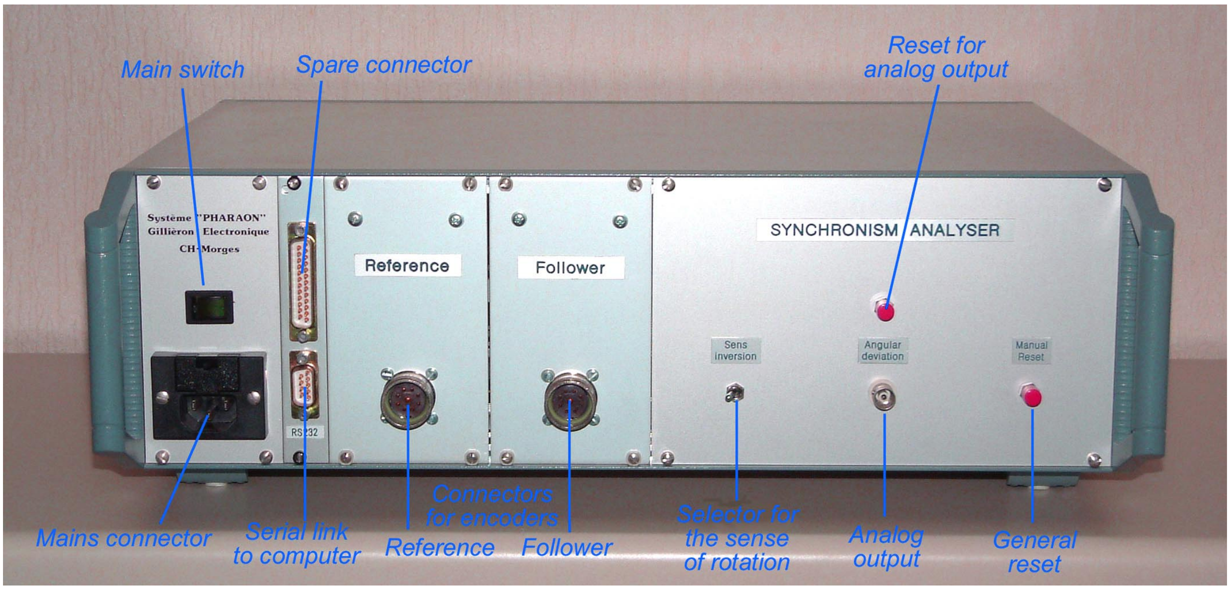
Dimensions of the arm

Fig. 3

Overview of the "friction" measurement system.

3 Description

3.1 The acquisition unit.



3.1.1 Description of the elements of the acquisition unit

Mains connector	230V, 50/60 Hz. Power about 40VA Connector with 2 fuses T 1A.
Main switch	No comment.
Spare connector	For special customisation.
Serial link to computer	RS 232 connection 9600 bds.
Connectors for encoders	Standard Heidenhain connector, for encoders with voltage symmetrical output, 1V pp.
Switch for the sense of rotation.	Left position : encoders rotating in CCW sense Right position : encoders rotating in CW sense.
Analog output	For direct monitoring purposes. 12 bits +/- 10 V range One microstep corresponds to one increment of the DAC. One analog increment of the DAC corresponds to 4,88 mV.
Reset button for analog output	Reset button only for the analog output. Without any action on the other functions of the analyser.
General reset	Hardware, cold reset for the acquisition unit.

3.2 The software running on the host computer .

The software programm is an autonomous executable module (.exe). The source is written in the G-langage LABVIEW.

When started, an operator panel with controls and indicators is displayed on the screen of the computer. (See example on the next page.)

Handlings are made with the mouse.

There are 3 categories of controls and indicators.

- The graphs and charts indicators.
- Digital **indicators**, in light **blue**. Show some useful data.
- Digital **controls**, in **yellow**. Used to set the working parameters.

The graph of the position represents the synchronism error of the follower in function of the angular movement of the reference axis. The scale is in seconds of arc.

The graph of harmonics is the FFT of the graph of position. The scale is also in seconds of angle.

The 3rd graph is the standard deviation of successive measurements. It represents the standard deviation of all the measured values relatively to the mean value of the reference-follower position. This graph is very useful for adjustment and optimization purposes, for example on electrical synchronous drives.

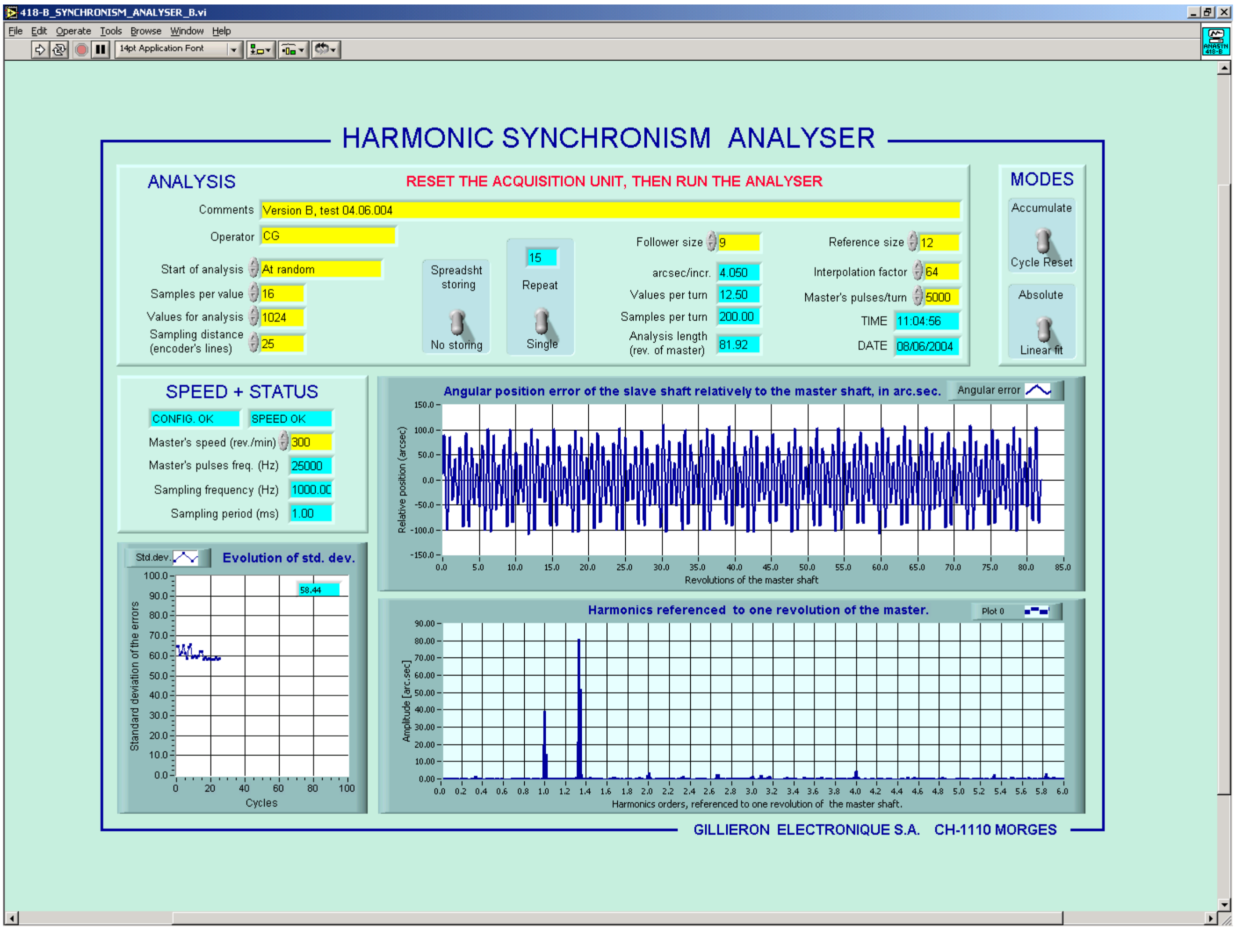
For that operating mode, the operator should run the synchronism analyser in continuous mode. For each measurement/analysis cycle, the screen refreshes the graphs of position and spectrum.

A new point of the standard deviation is added on the graph at each new measurement/analysis cycle.

By this way you can easily record a change of the quality of the synchronism, consecutively to a modification of the regulation parameters or mechanical adjustments.

An HELP function is provided with the software. It is activated by the "Help" command on the top of the screen.

When the HELP function is active, a description of the element pointed by the mouse is displayed on the screen.



On this example, the conditions of the measurements are as following :

- Incremental encoder : 5'000 lines.
- Interpolation factor : 64 -> 320'000 pulses per revolution of the reference.
- Sampling each 25 lines of the encoder -> 200 samples per turn.
- One value for display and FFT calculation is defined as the mean value of 16 samples. So, the sampling length of one value is : 16 * 25 lines = 400 lines of the encoder.
- Number of values : = 1024 values. (81.92 revolutions)

3.2.1 Measurement of a right angle gearhead.

To close this presentation, we show bellow the results of the analysis of a real case: the test of a right angle gearhead, mounted in a rotary printing press. This gearhead is formed of two conical toothed wheels, diam. of about 300 mm. and 33 teeth for each wheel.

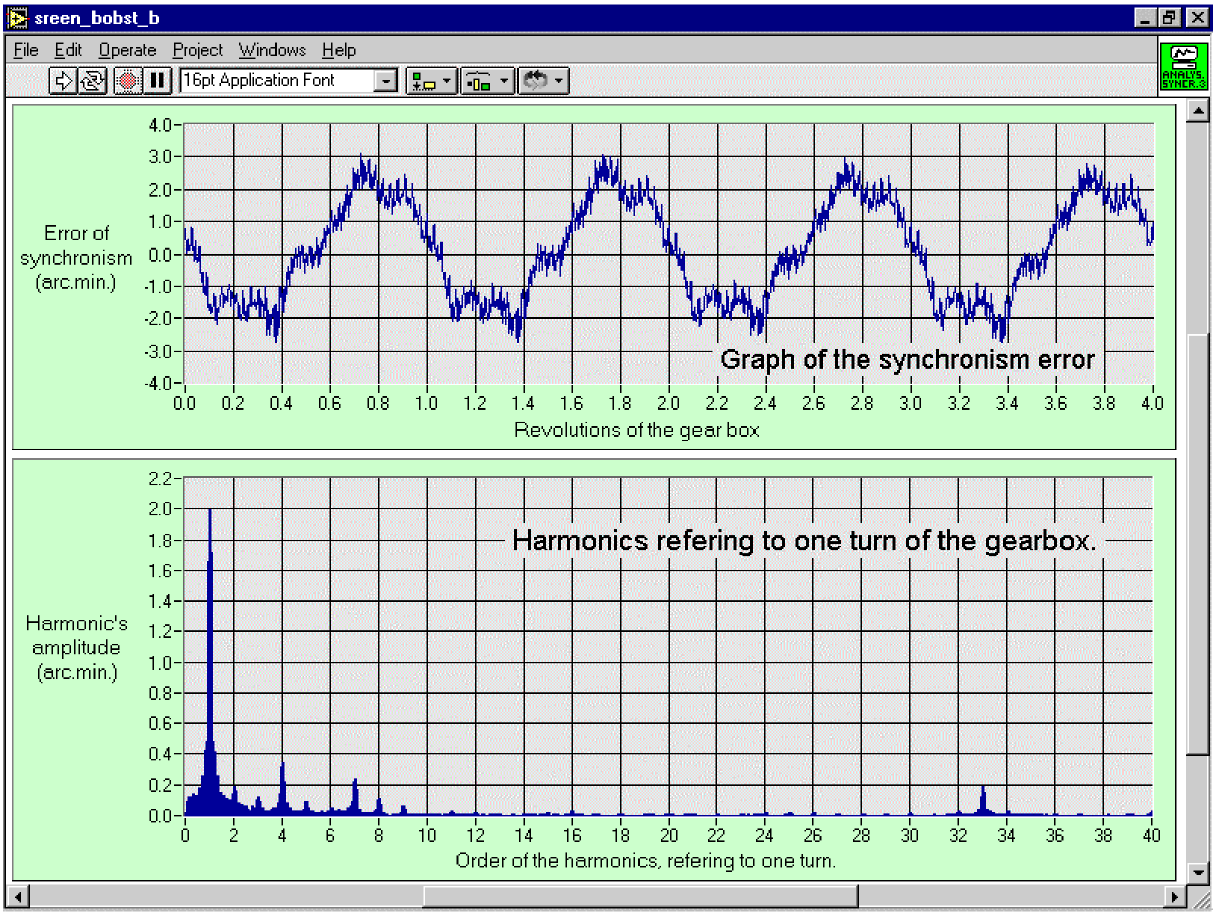
The screen is different of the present screen and was recorded with an ancient version of the analyser.

The total error is about +/- 3 minute of angle.

The main cyclic error is at "n = 1" : +/- 2.0 minute of angle.

The next important error is at "n = 4" : +/- 0,4 minute of angle.

Note the presence of the 33th harmonic corresponding to the number of teeth.



Morges, July 16 2004.

Phone : xx41 21 802 13 01 Fax : xx41 21 801 07 83 E-mail : gillieron.electronique@bluewin.ch