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TECHNICAL REPORT	
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MOTION SENSORS AND LINEAR ENCODER SIGNALS

1-INTRODUCTION.

The PMAC motion controller, the power amplifier and the digital integrator need information signals to determine :

- The plate position during each motion computed from incrementation signals.
- The starting point used in motion programs and defined from overtravel limit and index signal.
- Alarm zones located at both ends of plate motion when an alarm sensor is activated. These alarm sensors determine power line cutoff. After execution of a reinitialisation proceeding a special program computes new direction to move out of these zones.
- The integration periods and subperiods from incrementation and index signals. Like voltage integration for field processing is done for the both direction the first index is working as a start the second as a stop.

In this paper we will design how sensors are working, where they are set up and what kind of signal they are generating.

2-SPECIFICATIONS AND USING.

2.1- Position sensors.

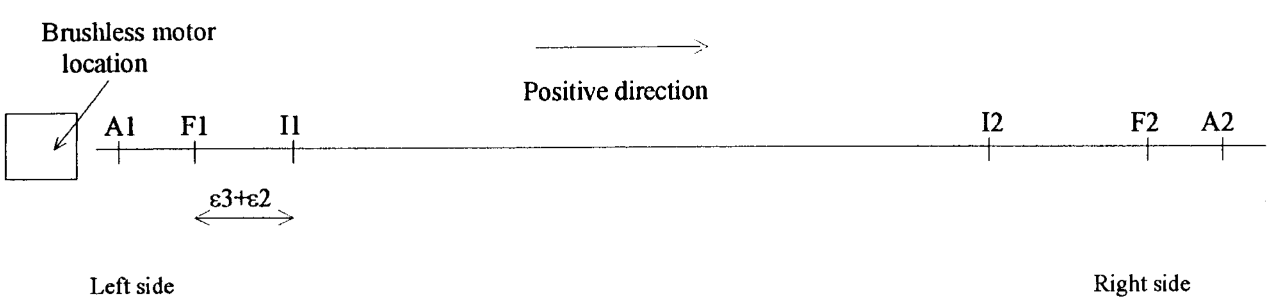
2.1.1- Sensors position referred to the full motion.

Six motion sensors determining plate positions (figure N°1) are used :

- Two alarm sensors : A1 and A2.
- Two overtravel limits : F1 and F2.
- Two index sensors I1 and I2 included in the linear incremental encoder.

Position of sensors is referred to the motor location. The starting point for magnetic measurements is near F1 sensor. Like indexes sensors are generating signals on the same channel we have defined two area called :

- "Left side" when the plate is near the motor.
- "Right side" when the plate is at the opposite position.



Sensors position and their place along the displacement.

Figure 1.

2.1.2- Alarm sensors.

Two alarm sensors called A1 and A2 are set (cf. fig N°1) on the both ends of the full motion. These sensors are electrical micro-switches. They are active only when motions have not normally stop or when the position servo loop is not working conveniently.

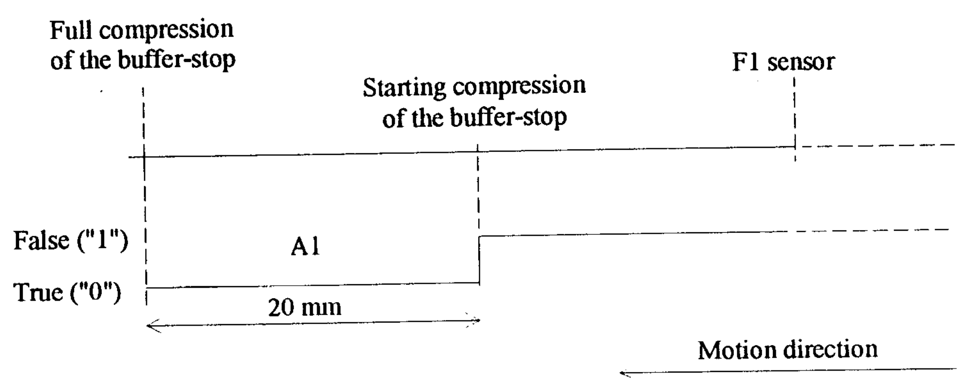
It is necessary these sensors are active when the buffer-stop is working. Each buffer-stop is compressed on a distance called "ε5".

Each of these sensors generates a signal that after processing is used in two electronic modules :

- In the PMAC motion controller to determine motion direction in the program to move the plate out of an alarm area.
- To an electromagnetic relay connected at the input of the power amplifier to cutoff without delay power line to avoid mechanical destruction when the motion system has not seen overtravel limit.

Each sensor status is low true (open switch contact). So if the switch is destroyed or its cable is cut this working default will be detected.

These switches are high reliability components and work with a low current (minimum current :1 milliamp.).



A1 alarm sensor status signal.
Figure 2.

2.1.3- Overtravel limits.

Overtravel limits (F1 and F2) determine a zone in which the plate with field sensors is normally moving. These limits are defining a motion area in which the plate motion is possible when no default appears.

When executing motion programs with no default for field, B0 and NMR measurements these overtravel limits are never reached.

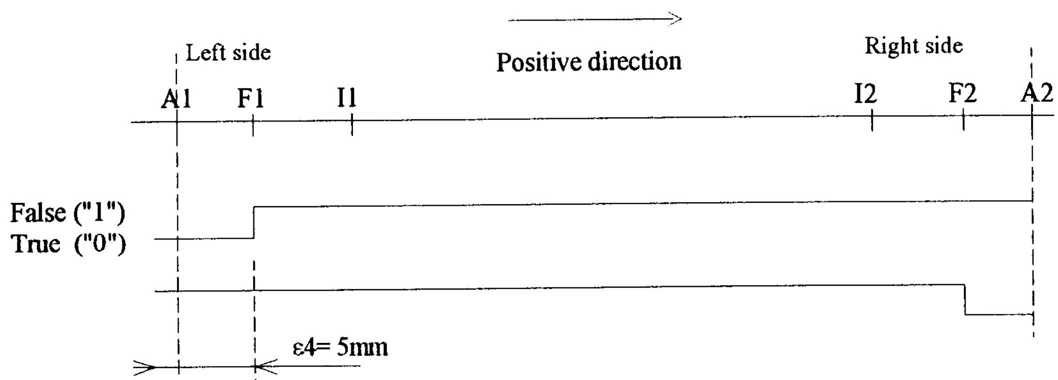
These overtravel limits will be reached in several ways :

◊ F1 (left side) overtravel limit is reached and detected during the starting point research proceeding.

◊ F1 or F2 overtravel limits could be reached when a motion program for measurements is not working conveniently or don't get convenient information or status. If the motor doesn't stop alarm limit will become true. For such a working the motion controller is not testing overtravel limits.

The F1 overtravel limit don't give a sufficiently accurate position to define the motion starting point. It's used to guide motion controller to know the plate position and search linear encoder index.

When an overtravel limit become active (or true) and the motion is continuing in the same direction the alarm limit will become active without change of overtravel limit status. For a sufficient accuracy optoelectronic sensors are used.



Overtravel limits status.
Figure 3.

2.1.4- Linear incremental encoder indexes.

When the plate is moving it is possible to set up indexes that give position references with the encoder accuracy. Incrementation signals and index signals accuracy is more over improved thanks to the interpolator circuit.

Several indexes can be set every 50 millimeters along the plate motion. Two indexes are used in our experiment and special reed relays from Heidenhaim (encoder supplier) are placed on the convenient positions. Each of these relays gives an authorization signal for an accurate opto-electronical signal.

Due to the very low distance between each desired index position and the start or stop motion position ($\varepsilon 2$ = 4 mm), due to the distance between these two indexes not far from the most greatest length measured with this encoder, the position of the encoder must be fitted very accurately.

As the step between two possible index positions is equal to 50 millimeters the distance between the used indexes is determined with an integer "N" :

$$\text{Distance [index1-index2]} = N \bullet 50 \text{ mm}$$

Indexes signals are added in the encoder head electronic circuit and generated on a single channel. There is no possibility to determine if the received signal is generated from index N°1 or index N°2.

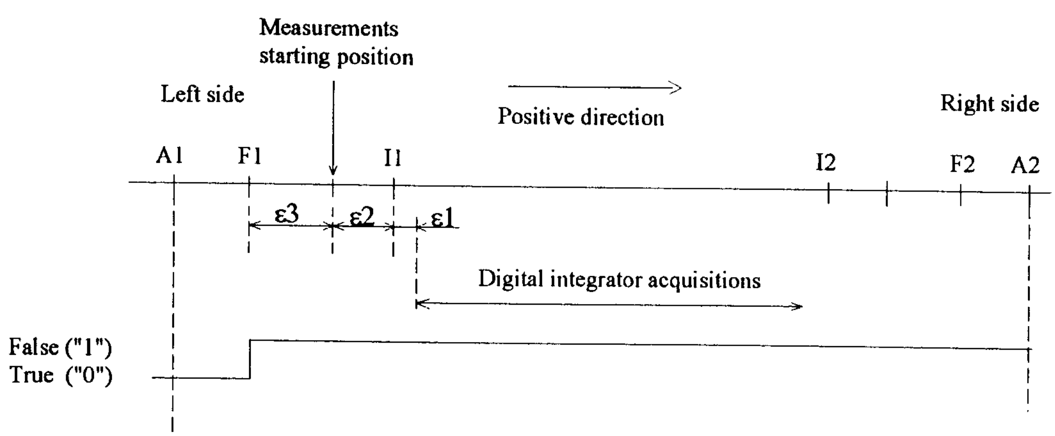
Indexes signal are transmitted after processing in the interpolator module to :

- The digital integrator to determine beginning and ending integration period according the plate motion direction.
- The PMAC motion controller.
- The displacement visualization box.

2.2- Motion sensors and starting point research proceeding.

Four status signal or level transition are used during the execution of the starting point research proceeding :

- A1 and A2 alarm limits in alarm test program (PLC2).
- F1 overtravel limit in left side overtravel test program (PLC4).
- I1 linear encoder index in the Home search program (PLC5).



Motion sensors and measurements starting position.
Figure N°4.

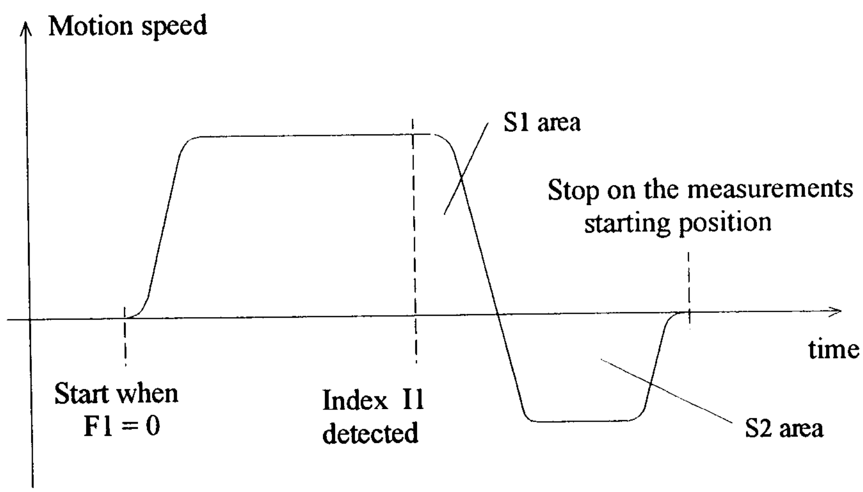
These programs are loaded in the motion controller and executed under control of EPICS software. These programs are executed in the order determined below.

1. PLC2 test if an alarm limit status is true (0) by means of M13 and M14 parameters in the motion controller. If true EPIC software stops the starting point research proceeding and execute motion out of alarm area.

2. PLC4 test if F1 overtavel limit status is true and stops motion in the negative direction when it become true. If at the beginning of PLC4 execution F1 is soon true no motion is commanded.

3. PLC5 is waiting for a positive transition level of I1 index. When the positive transition is detected the motion in the positive direction stops. A motion in the negative direction is then commanded that stop 4 millimeters after the positive index transition.

Due to low distances (ε4 = 5 mm, ε3 = 5 mm, ε2 = 4 mm, ε1 = 5 mm) motion velocity will be reduced and slower than measurements velocity.



Velocity diagram for PLC5 program.
Figure N°5

The starting point research proceeding is executed before each field or NMR measurement.

2.3- Linear encoder and associated modules .

2.3.1- Features and accuracy.

The linear incremental encoder (LB301 from Heidenhaim, Germany) generates during motion two sinusoidal current signals. The phase difference between these signals is equal to 90° in the positive motion direction and –90° in the negative motion direction. The mechanical period of these signals is equal to 100 microns and the current pick is equal to 11 micro-amps.

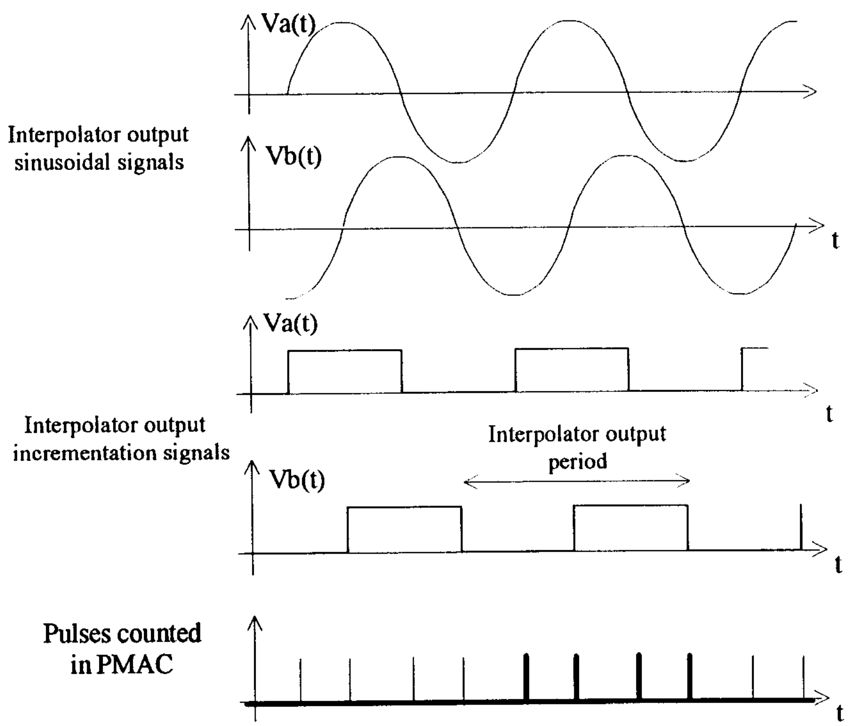
To improve encoder accuracy and resolution an interpolator (EXE 932 from Heidenhaim) is used. The interpolation coefficient "k" is wired to 10. That means the output signal period "Po" is equal to 10 microns when the input signal period "p" is equal to 100 microns.

$$Po = \frac{p}{k} = 10\mu m$$

It has been necessary to take care of the maximum electronic frequency "fi" that determine the maximum motion speed "vm" from the following relation.

$$v_m = p \cdot fi$$

with v_m in meter/second, "p" in meter and "fi" in hertz.



Interpolator output signals and derived pulses counted in motion controller.
Figure 3.

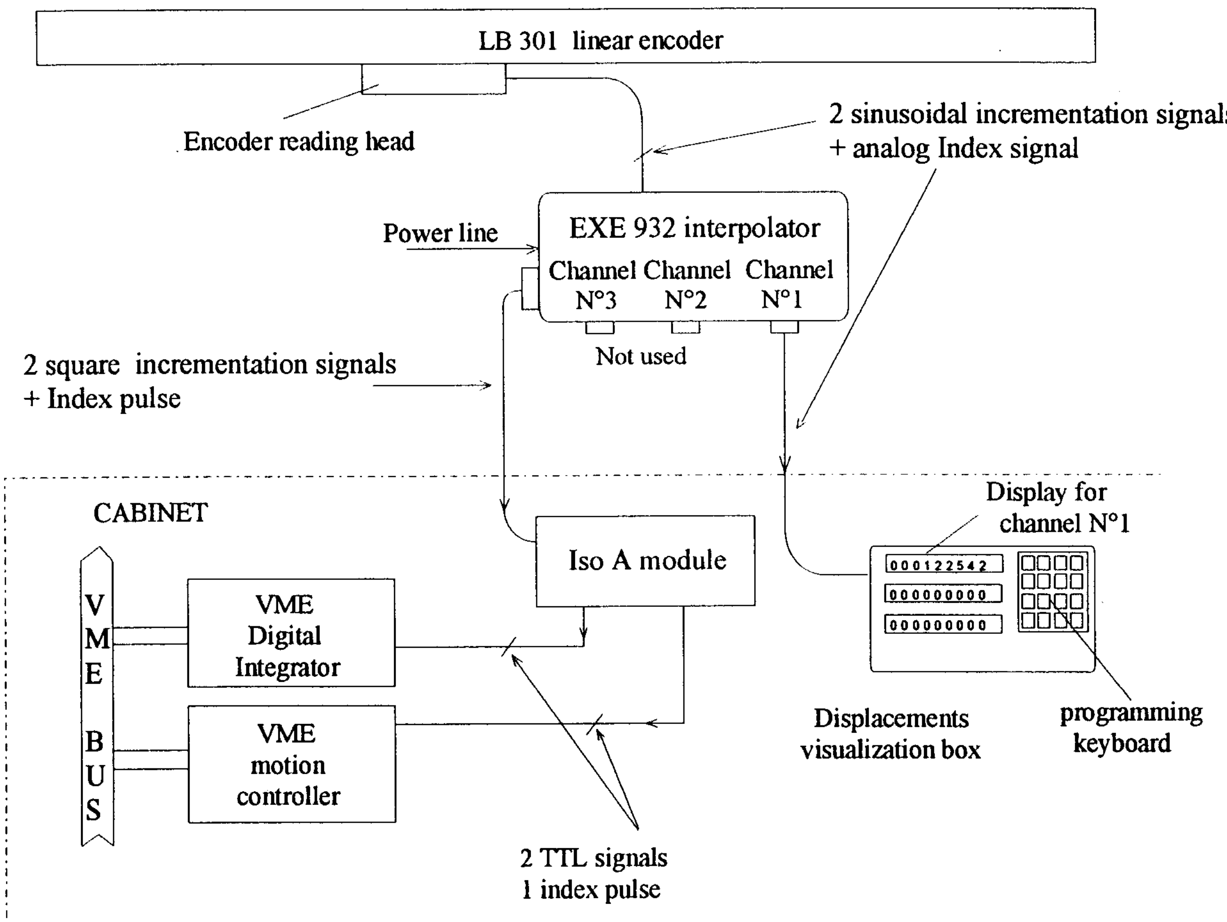
The interpolator generates two groups of output signals :

1. To an opto-isolating module (Iso A) to measure motion length with incrementation signals and to determine motion starting position with index signal. These signals have TTL levels and a differential mode is used to avoid electro-magnetic interference. Output signals of Iso A are transmitted to the PMAC motion controller and the digital integrator. The motion length measurement is processed from positive and negative level transitions.

2. To a displacements visualization box that needs a setting processing to show on a display the motion length from the starting point. The first index signal received clears the display. Incrementation signals are sinusoid signals.

2.3.2- Linear encoder signals features.

Frequency characteristics and timings are given below in relation to the maximum motion velocity (0.6 m/s).



Electronic modules for encoder signal processing.
Figure 3.

EXE 932 Interpolation module (channel N°1 used only) :

A- Signals measuring displacements (incrementation signals) :

Input signals (from encoder reading head):

Current amplitude	:	11µA pick (sinusoidal) ,
Frequency	:	6 kHz with velocity = 0,6 m/s ,

Sampling frequency : 2 MHz.

Output N°1 signals :

Voltage amplitude	: 5 volts (differential mode),
Frequency	: 60 kHz.
Signal link	: RS 422 @ Zc= 120Ω, differential mode,
Receiver circuit	: AM 26 LS 32
Using	: Iso A isolator board.

N°2 Output signals :

Current amplitude	: 11µA pick (sinusoidal),
Frequency	: 60 kHz.
Using	: Displacements visualization box.

B- Index signals.

Input signal (from encoder reading head) :

Type	: analog current.
Amplitude	: 8.5 µAmps pic

N°1 Output signal :

Type	: pulse.
Voltage amplitude	: standard TTL LS
Duration	: A quarter of an interpolator output period

N°2 output signal :

Type	: analog current.
Amplitude	: 8.5 µAmps pic
Duration	: reduced from input signal with interpolator Coefficient equal to 10.

3- CONCLUSIONS.

This paper gives some informations about motion sensors and encoder signals before and after processing in the interpolator module. We have explained how the starting point research proceeding is working during execution of programs PLC2, PLC4 and PLC5. In such a proceeding we explained how informations from motion sensors are used.

ANNEXE 1