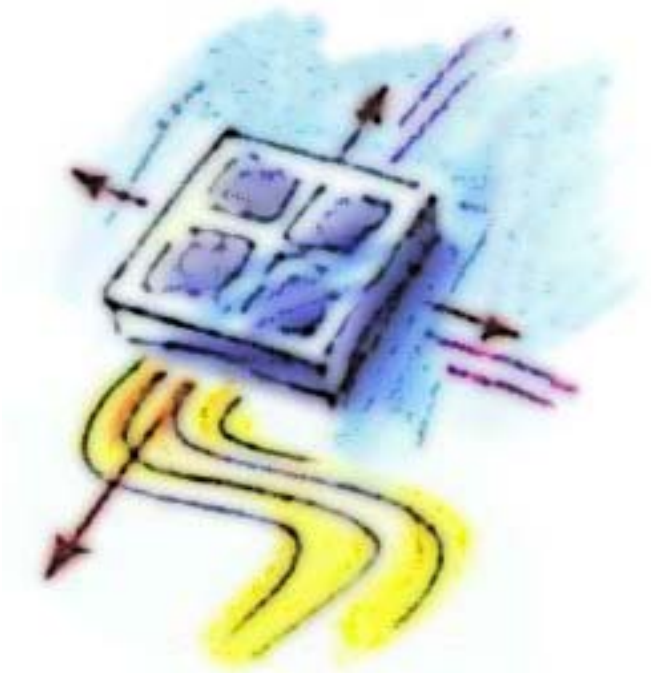
Application Solutions Case Study
Closed Loop Planar Servo Motor

Product Names: Whistle & Maestro

Elmo
Motion Control
www.elmomc.com

What is a planar motor?

A linear motor with two dimensions of freedom



The planar motor is based on the principles of linear direct motors. The axis system consists of two main components.

The primary component is a rotor structure made of cast aluminum or stainless steel that includes permanent magnets, inductor elements and air nozzles.

The secondary component, the stator, consists of a stainless steel plate with a closely spaced grid of intersecting grooves on its surface. The grid spacing may be 1 or 3 mm. The stator grooves are coated with molded polymer (or polymer epoxy resin) and function as a gear structure, with sets of stator teeth and tooth gaps at right angles to each other in the X-Y plane.

The functional area of the rotors has polymer-molded gear teeth that interlock with the gear teeth of the stator. The surface of the rotor structure that faces the stator has nozzles connected to a compressed air feed. When the air supply is switched on and current flows in the system, the interplay between the air gap and the induction coils creates an air bearing of 15 ± 7 μm between the stator and the rotor, which allows the free movement of the rotor in the X and Y plane.

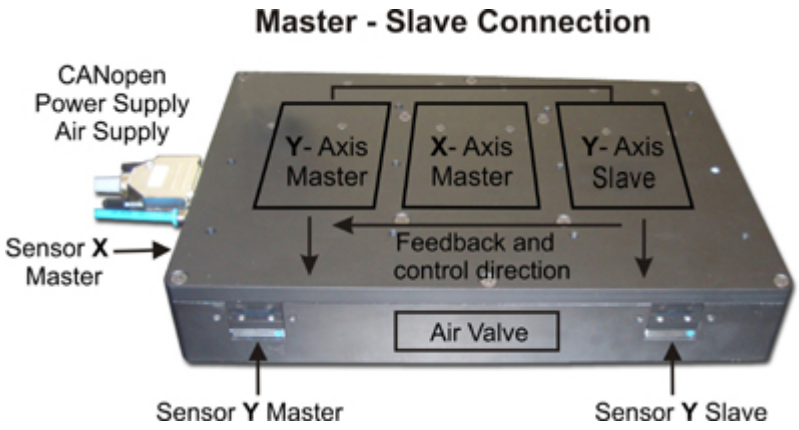
To achieve high power development and accuracy in movement and positioning, the hybrid stepper motors require faultless alignment of the rotor and stator. Incorrect alignment reduces operational efficiency.

Requirements

1. Wear-free bearings, constant parameters, with smooth movement that is not impaired by slipping and sticking.
2. Simultaneous and independent motion for several rotors on the stator.
3. Construction of complicated axis systems, cross tables, main opening, XYZ-plane systems.
4. Work in all the planes of the available space – both overhead and in the horizontal plane.
5. Excellent dynamics via high acceleration and speed.
6. Operation as a step motor or as a regulated micro step servo motor and controller combination.
7. Maintenance-free, frictionless and wear-free.

Planar Motor

The planar motor offers a unique design that enables new motion modes and protects the moving parts from losing force and "losing their grip". All devices in the mobile component are Plug and Play!



Planar Motor Data

Axis Name	Controller	Mission
Y-Axis Master	SOL-WHI-5/60E01	Obtain the Y position from the control unit
X-Axis Master	SOL-WHI-5/60E01	Obtain the X position from the control unit
Y-Axis Slave	SOL-WHI-5/60E05	Protect the Y-axis from rotation. The Y-axis Slave obtains the position from the Y-axis Master via the Master-Slave connection. This protects the planar motor from losing force since it is stabilized and controlled on the Y-axis.

Maestro

Axis Name	Controller	Mission
Control Unit	MAS-10012-1C	The Maestro obtains the command position from the PC and converts it to X- and Y-position coordinates.

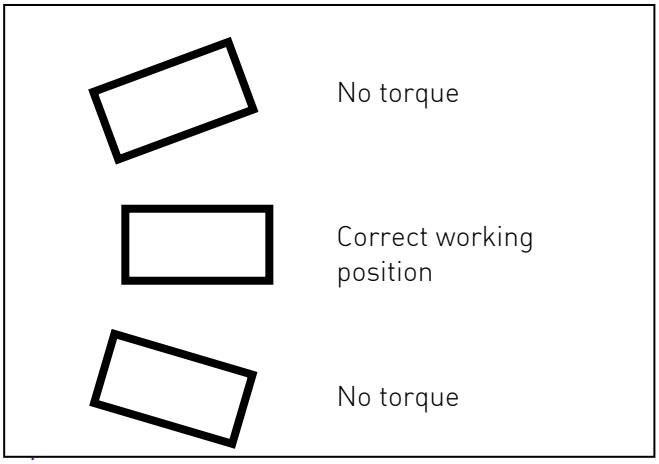
Motor Data

Feature	Specification
Type	Servo planar motor (air bearing hybrid stepper motor)
Weight	7 kg
Numbers of motors	Three motors (1x X / 2x Y)
Force per motor	Maximum 40 N (at 3 A continuous current)
Special	Y-motor in Master-Slave working mode (position control) to protect the motor against rotation
Air valve	Onboard
Amplifier for addition application	Onboard
Supply voltage	48 VDC, 24 VDC
Communication	CANopen
Inductive encoders	Encoder system AMO, resolution 0.00025 mm
Encoder measurement system	Stator of the motors

The Challenge

How to commutate a system when the measurement system is moving

In contrast to other planar systems, the moving part of this planar motor includes the measurement mechanism. This mechanism makes the planar motor cheaper and provides more options for different measurement systems.



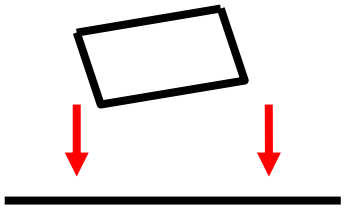
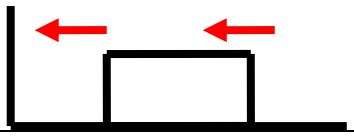
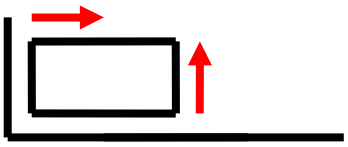
No angle allowed

The challenge of planar motor design is that it must be position-stabilized at all times: The motor can only provide the full force if it is oriented correctly.

Even a small angle results in a huge loss of potential force. In the worst case scenario, the angle deviates so much from the required position that the planar motor is not able to move and loses all commutation.

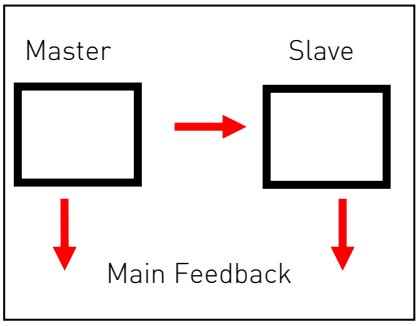
The Elmo Solution

How the commutation works

Movements	Description
	At start-up, the location and orientation of the planar motor is unknown. The planar motor can only acquire force if it is positioned correctly. All feedbacks must be inactive and all the Y-axis SimplIQ-Whistle drives must move with the same speed relative to the frame,
	The planar motor moves to the outer frame in the "Stepper" mode (not using the feedback), to arrive at the correct starting position. The twist is corrected and the SimplIQ-Whistle drives on the Y-axis are commutated.
	The planar motor must move to a corner to define its second position. While moving, the motor must continually verify that it is always correctly positioned with respect to the frame.
	From the corner, the motor can commutate the X-axis. With all the axes commutating, the planar motor is able to move in position mode and the Master-Slave protection is activated.

How does the anti-angle work?

Because the communication is not sufficiently fast to handle the synchronization, Elmo Motion Control recommends that both devices be set up in a Position-Follower configuration. The YA[N]command for the SimplIQ-Whistle defines the behavior and direction of the auxiliary position sensor signals. YA[4] is used to specify that the auxiliary encoder pins shall be outputs, and shall repeat the pulses of the main position incremental or analog sensors. This mode is used to enable other drives to follow, without electrically overloading the main position sensor.



The main position incremental encoder is direct on every controller. The Master is controlled in position or velocity mode and sends its position over the auxiliary encoder. YA[4] = 4 specifies that there are no auxiliary encoder inputs and that the auxiliary encoder pin output repeats the main encoder input (or produces an emulated encoder signal for drives with analog encoder or resolver feedback options).

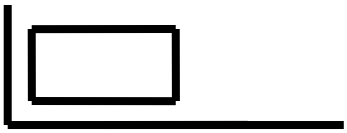
The situation is similar for the Slave. YA[4] = 2 sets up an auxiliary encoder entry that is used as input for external quadrate incremental encoder signals.

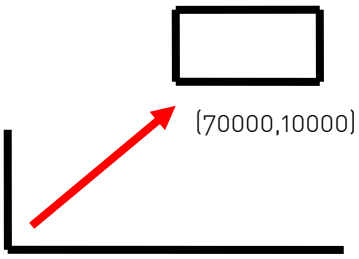
Program example:

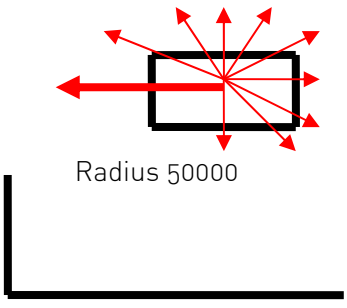
```
#@AUTOEXEC
YA[4]=2 // Set AUX feedback as quadrate incremental encoder command input.
FR[3]=1 // Set follower ratio to 100%
AG[2]=0 // Disable influence of analog input
RM=1 // Enable reference mode
UM=5 // Set position mode
MO=1 // Motor on
BG    // Begin motion
```

Advantages of using the Maestro as a control unit

Movement	Description

	The Maestro controls only the Master Axis for the planar motor.
	Setting up the movement parameters. Both axes are controlled as vectors. At the beginning, after each movement, we want the motor to wait for new commands:
	v1.attach()
	v1.vsp=70000 // max velocity
	v1.vse=0 //* end velocity*/

	**Achieving point-to-point movement**. Initially, we want the motor to start at 0 and move to a position in the field.
	v1.line(70000, 100000) //go to position (7000,10000)
	v1.bg //action!

start angle 180°
 
	Achieving more interesting motion. It is more useful to work as a vector from this location.
	What we want:
	Radius 50000,
	Start angle 180°
	3/4 turn=270°
	v1.circle(50000, 180, 270) // create circle
	v1.bg // start motion

Important considerations

- Standard voltage is 48 V DC. It is possible to work with up to 85 V DC for high speed applications.
- Reduce the amount of cabling to greatly improve performance.
- Plug and Play functionality simplifies the motion system.
- Closed loop functionality provides very high resolution and better control.
- Smoother movement is possible because all the axes have one feedback system.
- Control at a low level is enabled: The Master-Slave control needs to be extremely fast and precise.
- Mass is important because all the devices are moving.

PASIM®

PASIM Direktantriebe GmbH was founded in 1991 by Dr. Günter Dreifke, based on the know-how of the Technical University of Ilmenau. This expertise, coupled with knowledgeable, experienced staff and patented solutions is, to this day, the foundation and guarantee of sound, steady technical and corporate development.

The core business of PASIM is the development, manufacture, distribution and servicing of the company's air-mounted direct drives and systems. The advanced mechatronic products are produced by the company's personnel in close cooperation with regional partners. The company employs seventeen staff members.

Why Elmo:

- Advanced motion and servo control
- Distributed networking
- High density coupled with high power
- High reliability
- High efficiency
- Easy to use: Reduction of complexity
- Compact Size

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