

# DEVELOPMENT OF INDUSTRIAL GRADE HORIZONTAL POLARGRAPH

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## Abstract

This article describes the basis for a horizontal compact drawing robot, its use in the industry, constituent parts and how these parts and methods – drawn from electronics, mechanics and informatics – combine to make up the entirety of this machine.

**Keywords:** *horizontal polargraph, drawing robot, Arduino.*

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## 1. Introduction

In the industry, much emphasis is necessarily placed on maximizing reliability and, above all, performance. Simplifying certain tasks can be the difference between profit or loss.

Many processes can be performed quickly with experienced and skilled workers, but skilled labour is often too expensive or simply unattainable if there is not enough interest in the industry. Untrained or less skilled workers are often unable to work at the same speed and precision, or in case of complex problems may be unable to find a solution in these situations.

Because of this, in many places we replace the role of humans with robots, so we can mathematically guarantee the solution of most problems.

One such problem can appear in the manufacture of curved sheet parts. The component design engineer often designs the piece and passes it to a specialist at the plasma machine to be cut down. However, when it reaches the specialist, whose understanding may be different from that of the designer, one by one he has to walk through the piece and record the bending lines by hand. This is a very time-consuming job and the more inexperienced the specialist, the higher the frequency of errors, even to the point that the part can be ruined. Furthermore, it often does not help if

the manufacturer of the part and the person performing the bending are one and the same, since he does not know exactly the bending lines from memory every time.

This problem requires an automatic system that eliminates the human factor, for example, a drawing robot.

So our machine has to meet a few criteria in order to make industrial and practical sense of its use:

- has to have a large workspace;
- installing it on the work area and starting it cannot take more than 5 minutes;
- It should be easy to manage and intuitive.

On the market, the various drawing machines have huge support structures, which increases precision, but this precision is not necessary for us to this extent, and in the case of constant and larger plates in their field of work, due to the size of these machines, their installation in the work area requires up to 3-4 people and occupies a huge area.

The so-called polar graph [1] is suitable for the task of adjusting the variable work space, but the biggest problem is that gravity is used to move on the x axis and the engines direct the working point in only one direction.

For this reason, a new solution to this task should be found, since the existing possibilities are unsatisfactory. This is where a new solution comes into play, a rethinking of an existing idea or technology.

What we are looking for is a tape that can hold its weight against gravity, exert force in an axis direction and, in the event of unscrewing, it is able to fold and bend. With this, we are able to create a compact polar graph with two motors, two storage wrists and two tapes that can work on the horizontal plane, thus making it substantially easier to install and practical in the production process.

## 2. Parameters and geometric design

### 2.1. The geometric working space of the machine and its calculation

First of all, we need to get the distance between the two wrists, which is given by the formula (1).

Then we can calculate the active length of the tapes and determine the direct geometry in which the endpoint of the drawing device and the equipment is determined by the formula (3) to calculate the position of the working point. (Figure 2)

$$b = l1 * \cos \theta 1 + l2 * \cos \theta 2 \tag{1}$$

$$l1 = \left( \frac{l2 * \cos \theta 2}{b} \right) \tag{2}$$

$$x = \left( \frac{(l1^2 - l2^2)}{b} \right) \tag{3'}$$

$$y = \left( \frac{1}{\sqrt{2}} * \sqrt{l1^2 + l2^2 - \frac{b^2}{2} - \frac{(l1^2 - l2^2)}{2 * b^2}} \right) \tag{3''}$$

### 2.2. Practical workspace

The machine is controlled from both sides, with the help of the two engines we can reach any point within the working area. (Figure 3)

The area consists of 3 priority zones, the first zone is the primary work space, which is the sum of a rectangle and a polynomial triangle, this area can be reached by both wrists so that it can be worked on.

Only one wrist has access to the secondary area, so although the length of each tape would be enough to reach the entire area, the entire area is inaccessible to the finished machine.

The last area is the area outside the primary and secondary areas that the machine cannot reach.

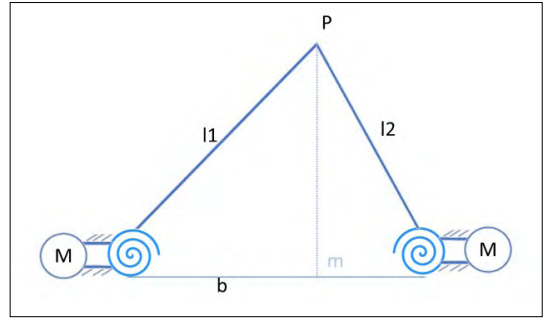


Figure 1. Machine parameters - top view.

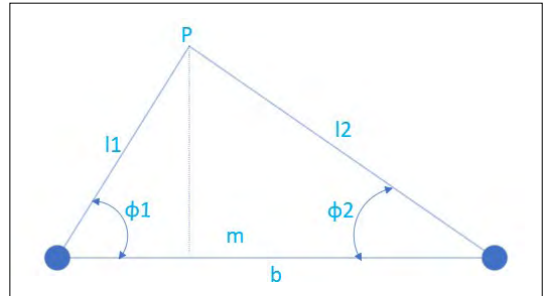


Figure 2. Geometrical parameters from top view.

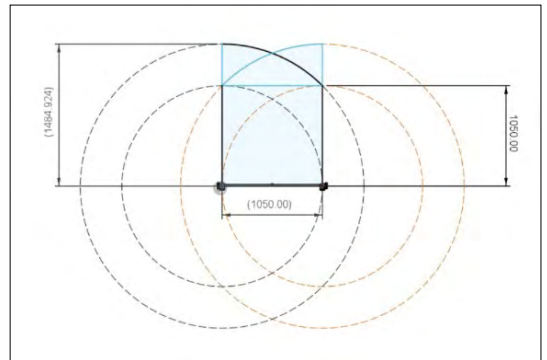


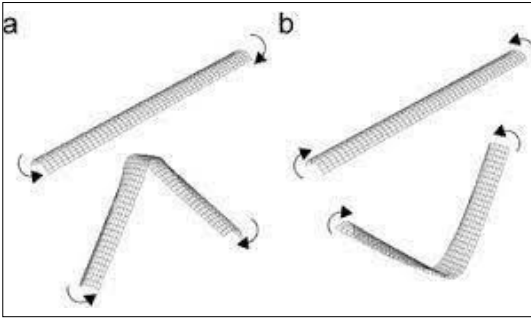
Figure 3. The entire machine workspace from above.

## 3. Implementation

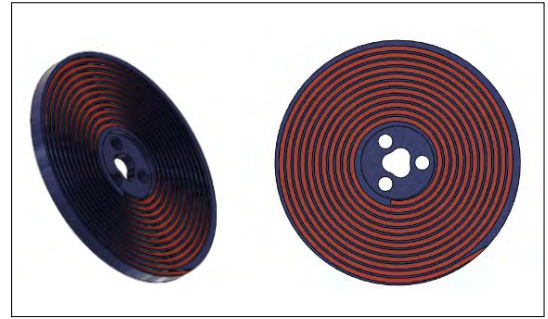
### 3.1. Tape spring

These tapes hold their shape in one direction and bend into the other (Figure 4). this is a special mechanical property in robotics that can create compact low-load moving arms. [2, 3]

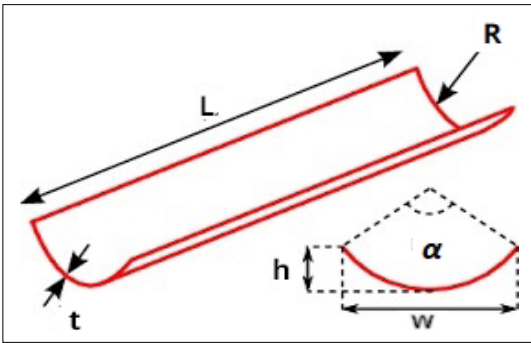
If the force does not exceed the critical value, the arm is able to exert a force in one direction with the axis, this is unsuitable for high-performance tasks, but our light drawing pencils can be moved without any problems [4]. (Figure 5)



**Figure 4.** Tape springs and types of movement.



**Figure 6.** Geometric structure of the wrist disc.



**Figure 5.** Construction of a strip spring.



**Figure 7.** Before and after assembly of the entire wrist.

### 3.2. Wrist

Our machine's wrist has given up storing and then successfully compressing the tape into its convex configuration and using two plates with spiral indentation. (Figure 6)

The folding discs are made of metal for a higher sturdiness and for better sliding, they are connected by a plastic reel whose height precisely follows the width of the tape. [5] (Figure 7)

Due to its design, when the wrists are turned, the force acting on the tape forces the spiral wall to force it into a convex shape. Because of this, the plate is able to exert more force along its axis, as well as its side.

### 3.3. Stepper motor

Its role is to rotate the wrist thereby moving the plates out so that it reaches a sufficiently large linear force that moves the pencil.

For this role, we use a NEMA17 bipolar motor with a step of  $1.8^\circ$ , (Figure 8) for high accuracy and ease of handling.

The stepper motor is controlled by an A4988 2A-force engine controller, as this controller is easily accessible and easily replaced in the event



**Figure 8.** A NEMA17 stepper motor.

of a problem. The advantages also include the fact that the controller can control the engine at sufficient speed and accuracy.

### 3.4 Drawing structure

There is a structure located at the end of the tapes, the first part consists of the 2-cylinder joint, which receives the tapes and allows them to rotate, the second part holds the frame of the SR 90



Figure 9. Design of the drawing structure.

servo motor, at the end of which it can move up a cylindrical platform with a gear and rack, which may contain drawing tools of different sizes and shapes. (Figure 9)

### 3.5 Arduino and control

We use an Arduino Uno (Figure 10) to control the machine and, to reach the more compact contractor, we use a CNC shield, which establishes a direct connection with the Arduino.

Then the engine controllers and the associated stepper motors are added to them.

## 4. Conclusions

In order for the industry to develop, new technologists need to enable easier and faster production in order to keep up with market demand. The drawing machine can fulfil a small task in this chain, but this need cannot be fully supported without tests.

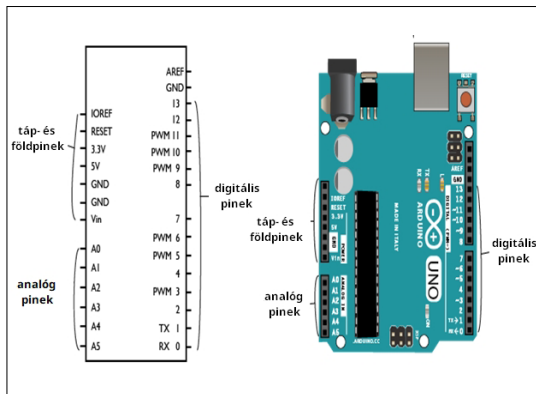


Figure 10. Cable layout and graphic presentation of an ARDUINO UNO.

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