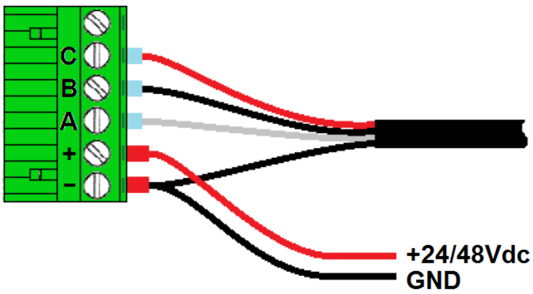
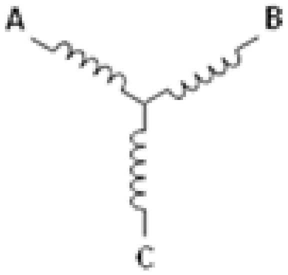
Technical Note

Pole Period Determination

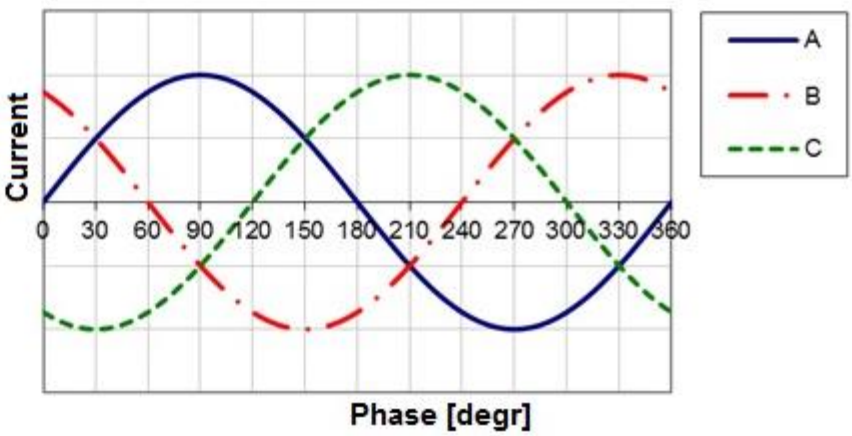
Multipole concept

A SMAC actuator with 3 motor wires (see image→) is a multipole (also the term 3-phase actuator is used). The 3 phases are connected to the green connector at A, B and C.
The 3 phases connect to the motor coils which are in star configuration (see image below).





3 sinusoidal shaped voltages are applied to the 3 phases to make the actuator move. One full sine wave (360 ^{o}) is equal to one electrical revolution. The sine waves have a phase difference of 120 degrees as shown in the plot below. One electrical revolution is also called the pole period.



For a linear motor the pole period can be smaller, equal or longer than the actual stroke of the actuator. This pole period distance is important for the phasing of the actuator. This pole period can be measured using a ruler by measuring the north pole to north pole distance inside the actuator. Since this is not easy for an already assembled actuator, the electrical method that this technical note describes is more convenient and it is the pole period that the controller actually experiences.

Recording phasing position related to encoder position

The most accurate method is to record the phasing position and encoder position for an open loop moving phase vector. The relationship between encoder position and phase position provide the pole period. Since this method constructs the pole period using lots of measured points, the accuracy/repeatability will be good.

The program to create the open loop movement is shown below.

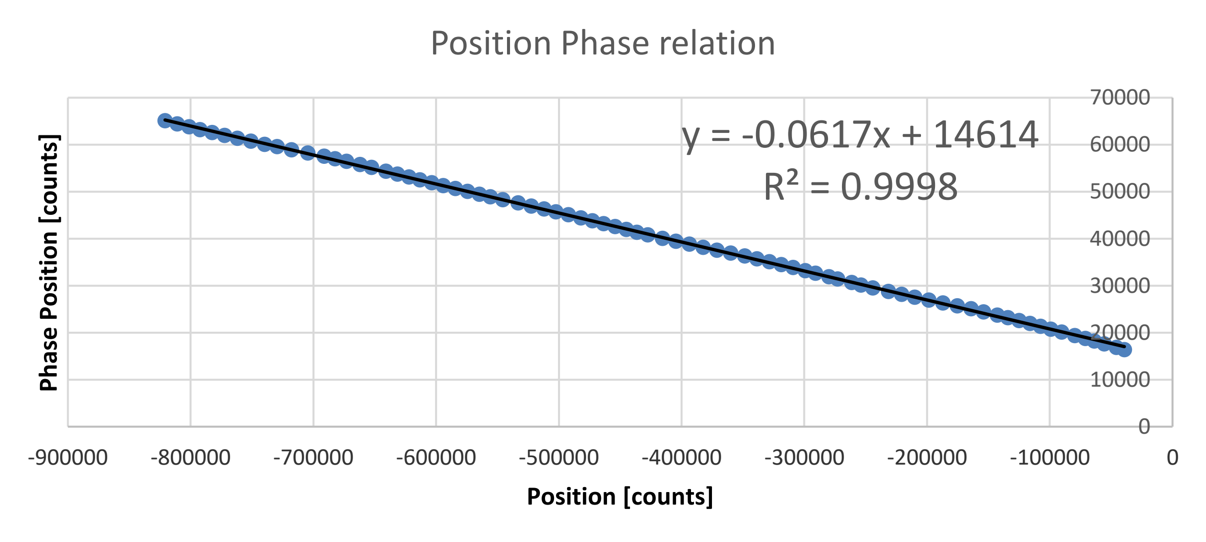
0		MacroNumber	1	Start open loop motion
4	1-1	Homing	Use_current_position,Offset=0	
11	1-2	PhaseDetect	Initial_position_allways_known,Rotorpos=0	
1	1-3	SetVariable	Var=Modes_of_operation(0x006060),Constant,Const=-1	open loop vector mode
1	1-4	SetVariable	Var=Target_duty(0x002F01),Constant,Const=7000	7000/32767 times the supply voltage used
1	1-5	SetVariable	Var=Controlword(0x006040),Constant,Const=6	
1	1-6	SetVariable	Var=Controlword(0x006040),Constant,Const=7	
1	1-7	SetVariable	Var=Controlword(0x006040),Constant,Const=15	
1	1-8	Wait	Time,Timeout=10000	wait 10 seconds
2	1-9	Motor	Off	
1	1-10	Macro	End_program	

This macro will make the actuator move according a phase vector for about 10 seconds after which the actuator is switched off. This mode applies voltage to the actuator and does not control the current. The voltage applied in this example is 7000/32767 times the supply voltage. Using 24V this would result in approx. 5V phase to phase voltage.

Before starting this macro, place the actuator in the most extended position, start logging of Actual position and Phasing-Phasing actual rotor position.

The logging can be stopped and stored in a CSV file after the motion stops after 10 seconds.

The CSV-file then must be opened into Excel. Create a plot with the Actual position on the X axis and the Phasing actual rotor position on the Y axis. Reduce the data selected in a way that the plot represents a linear behaviour between the two parameters.



When you have the data selected that shows the proper linear behaviour a linear fit can be made in excel. Do this by selecting the data in the graph, click the right mouse button and select “Add Trendline”. In the popup window select type = linear and check the boxes with “Display equation on chart” and “Display R squared value on chart”. The equation in the graph shows the directional coefficient (value 0.0617) plus an offset. The offset is not relevant. The R^2 represents the deviations between the data and the fitted equation. If it is 1 the correlation between the data and the fitted line is 100% if it is 0 it is totally uncorrelated. When performing this test the R^2 should be higher than 0.95 and aim for 0.999 or better.

Calculate Pole Period

You can calculate the pole period as follows:
Pole Period [mm] = 65535 x (1/Coeff) x (1/EncCpmm [counts/mm])

With:
65535 being the phase vector value for one electrical revolution of the LCC controller
Coeff. being the directional Coefficient. In the example being 0.0617 [-]
EncCpmm being the Encoder resolution [counts/mm]. In the example being 10000 (=0.1 micron)

In this example the Pole Period is 65535 x (1/0.0617) x (1/10000) =106.216 mm.

The used actuator (LCA50-100-52) has a specified pole period of approx. 105 mm.