

A method for determining the initial rotor position of a synchronous motor

The invention concerns a method for determining the initial position of a rotor or runner of a multi-phase synchronous motor or reluctance motor designed in a linear or rotary constructional manner, which is fed by a frequency converter, wherein the motor is impressed with a test current with a predetermined current vector phase position and the resulting torque or force from this is determined. Furthermore the invention relates to a device for carrying out the method.

In positioning means with electronically controlled servo drives increasingly synchronous motors are applied. Also reluctance motors are applied. This applies to the same degree for rotary and linear constructional forms. With synchronous motors, in contrast to direct current motors and asynchronous motors, there is a certain relationship between the position of the runner with respect to the stator and the phase position of the electromagnetic travelling field or rotating field. On switching on the servo drive the runner located in an undefined position under certain conditions is brought in a jolted manner into the position predetermined by the electromagnetic travelling field or rotating field ("phase matched"), wherein the mechanical jolt in the handling means may lead to the damage of machines or objects.

From US 47 46 850 there is known a method for acquiring the runner rest position of a synchronous motor with which a high frequency test current is fed into the exciter winding, and the voltages induced by this in the stator phase windings are measured. From their ratios the rest position of the runner is determined.

With a similar method which is known from EP 228 535 A1, the high frequency test signal is impressed to the stator current or the stator voltage.

From the article of Backhouse, Reinold, Kalker: "A Procedure to Estimate the Absolute Position..." in : EPE Conference report, Florence, 1991, Volume 3, pages 659 to 663, there is known a method with which a test current whose size increases is impressed to a predetermined phase position. If the torque caused by this current exceeds the counter-moment which is composed of the frictional moment and load moment, then the test current is registered and switched off. In order to eliminate the unknown but constant counter-moment, mostly two measurements with differing phase

angles are required. Then from these measurements, with the help of a microcomputer the rest position may be determined. This procedure may last up to five seconds.

It is the object of the invention, to improve a method of the previously mentioned type so that with a smaller effort than with the known methods a fast as possible determining of the initial position can be achieved. A further object of the invention lies in providing a device for carrying out the method.

The object is achieved with respect to the method in that on determining a torque or a force the vector phase position of the test current is rotated in that direction in which the torque or the force is reduced.

In practice this procedure may for example proceed so that the control electronics are displaced into a defined basic condition which corresponds to a defined basic setting of the phase position of the vector of travelling field or rotating field vector, that the rotary current windings, according to the mentioned basic setting, are supplied with test currents which are weak in ratio to the normal current strength, preferably increasing from zero, wherein the forces or torques occurring on the runner are acquired, and that the phase position of the travelling or rotating field is changed until the force or the torque essentially disappears.

With this the currents provided for the supply of the rotary current windings are firstly brought by the control electronics into certain ratios to one another, which define a first phase position of the field vector. If subsequently the test currents increase to one another in the defined ratio there occurs an increase of the forces or torques on the runner. As soon as these are measurable, the next method step, the changing of the phase position in the direction of a reduction of the forces or torques can be carried out.

With the method according to the invention the phase position of the travelling field vector or rotating field vector is adjusted with respect to the mechanical position of the motor, before significant forces or torques are produced. A jolt-like pivoting in of the runner is advantageously avoided. After the adjusting, the synchronous motor may be started smoothly. At the same time the effort with regard to the apparatus or technical circuits is advantageously much less than in the state of the art. For example the preparation of high frequency test currents or a certain microcomputer for evaluation and the necessary software may be done away with. The method according to the

invention also does not use complicated algorithms, but obtains from a signal which serves for determining the torque, in the simplest manner - almost directly - a control variable for rotating the vector phase position. With this, in contrast to the state of the art, the load angle is made to zero by changing the current phase position.

The method can be still further improved in that from the ratio of the strength of the force or the torque to the strength of the test current, the load angle is determined and the phase position of the travelling or rotating field is adapted more quickly with a large load angle and more slowly with a small load angle. This measure makes use of the condition that the force or the moment is roughly proportional to the current strength multiplied by the sine of the load angle. It follows therefrom that the quotient of the strength of the force or of the torque divided by the current strength is roughly proportional to the sine of the load angle, with small load angles is thus roughly proportional to the load angle itself. If then the mentioned quotient is large then this means a large load angle which is quickly reduced by a quick shifting of the travelling field or a quick rotation of the rotating field. In contrast, with a small load angle the phase position of the travelling field or rotating field is adapted more slowly. By way of this strategy one obtains as a whole a relatively quick regulation with a high accuracy.

The accuracy of the regulation may be yet further improved in that the current strength of the test currents with the phase difference becoming smaller, are increased preferably until reaching the normal current strength. By way of this measure the current strength becomes dependent on the load angle so that on the one hand with large load angles too large a force or a too large a torque and thus a jolting of the motor is not to be feared, whilst on the other hand with small load angles constantly a measurable force or a measurable torque is present with which a more exact adjustment is possible until the load angle disappears. With a load angle almost disappeared the test currents may be increased until reaching the normal current strength without danger.

In a further development of the method according to the invention it is provided that the control electronics subsequently to a first adjustment are displaced to a second basic condition which corresponds to a second basic setting deviating from the first basic setting of the phase position of the travelling or rotating field vector, and that thereafter all further method steps are repeated. By way of this measure it is ensured that also in the case of an original load angle of 180° a safe and essentially smooth starting up is ensured.

counter 11 of the control electronics 2. The reduction counter 11 adapts the step width of the incremental transducer 9 to the step width of an incremental counter 12 which is connected to the reduction counter 11 via count leads 13. The incremental counter 12 counts the impulses delivered by the reduction counter 11 and therefrom forms digital rotational direction information which is inputted via a data lead 14 into the function generator 6. On operation of the synchronous motor 1 in the function generator 6 the constantly changing angle position is now taken into account. Furthermore the function generator 6 takes into account a current setting and a load angle setting for the synchronous motor 1, which via a current setting lead 15 and a load angle setting lead 16 are inputted into the function generator 6.

The control electronics 2 comprise componentry 17 which is provided for the control of the phase matching of the rotating field. The componentry 17 consists of a digital/analog converter 18 which is connected to the reduction counter 11 via a data lead 19. The output of the digital/analog converter 18 is connected to a servo amplifier 21 via a signal lead 20, and at the output of the servo amplifier there is present a control signal which reaches the impulse generator 23 via a control lead 22.

For the synchronisation of the rotating field with the position of the runner, the control electronics 2 are displaced into a particular operating condition. For this purpose the control electronics 2 comprise a sequencing control unit 24 which serves the operation of three change-over switches. With a first change-over switch 25 the current setting lead 15 is switched from the external current setting to an internal current setting lead 28 which is connected to the componentry 17. Via the second change-over switch 26 the load angle setting lead 16 leading to the function generator 6 is connected to an internal load angle setting lead 29 which leads to the sequencing control unit 24. The third change-over switch 27 connects the incremental counter 12 in normal operation via the counter leads 13 to the reduction counter 11 and in phase matching operations via phase matching leads 30 to the impulse generator 23. The operation of the change-over switches 25, 26, 27 is effected via change-over leads.

On activation of the control electronics these are switched to the phase matching mode and the sequencing control unit 24 brings the change-over switches 25, 26, 27 into the positions shown in the picture. Simultaneously the sequencing control unit 24 inputs an angle setting for the rotating field vector into the function generator 6 via the load angle setting lead 29. If a torque is produced on the runner of the synchronous

motor 1, impulses go from the incremental transducer 9 via the reduction counter 11 into the digital/analog converter 18 and from here into the servo amplifier 21 which via a control signal 22 causes the impulse generator 23 to deliver impulses to the incremental counter 12. The incremental counter 12 produces at its output digital directional data which via the data lead 14 reach the function generator 6 which on account of this directional data changes the rotary current settings R, S, T according to a rotation of the rotating field vector. The so rotated magnetic rotating field now gives rise to a smaller torque on the runner so that via the incremental transducer 9 and the reduction counter 11 a smaller deflection is inputted into the digital/analog converter 18 by way of the data lead 19. The servo amplifier 21 reacts to the changed deflection information in that via the control lead 22 it increases the current setting in the current setting lead 28 as well as delivering a lower number of count impulses to the incremental counter 12 via the phase matching leads 30.

After the measured torque has finally disappeared, where appropriate up to a negligible residue, the first procedure is completed. In a second procedure the control is once again repeated with a different angle setting for the basic setting of the rotating field vector. Afterwards the sequencing control unit 24 switches the change-over switches 25, 26, 27 into their normal operating position and the synchronous motor 1 may be started with a setting of the current and of the load angle.

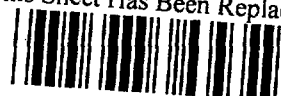
A correspondingly adapted servo drive device with control methods may also be used for a smooth or low jolt starting up or starting operation of a linear motor. The only precondition for this is that there is a permanent relationship (synchronisation) between the exciter field, for example a periodic dipolar field of a stationary stator, and a travelling field which can be shifted by multi-phase currents, for example a rotating current field of a linear moving runner. In this case the terms with respect to the rotating rotary motor are to be exchanged with corresponding terms of the linear motor.

List of reference numerals

1	synchronous motor
2	control electronics
3	lead
4	lead
5	lead
6	function generator
7	power unit
8	mechanical connection
9	incremental transducer
10	impulse lead
11	reduction counter
12	incremental counter
13	count leads
14	data leads
15	current setting lead
16	load angle setting lead
17	componentry
18	digital/analog converter
19	data lead
20	signal lead
21	servo amplifier
22	control lead
23	impulse generator
24	sequencing control unit
25	first change-over switch
26	second change-over switch
27	third change-over switch
28	current setting lead
29	load angle lead
30	phase matching leads
31	change-over lead
32	change-over lead



1. A method for determining the initial position of a rotor or runner of a multi-phase synchronous motor or reluctance motor designed in a linear or rotary constructional manner, which is fed by a frequency converter, wherein a test current with a predetermined current vector phase position is impressed on the motor and the resulting torque or force from this is determined, characterised in that on determining a torque or a force the vector phase position of the test current is rotated in that direction in which the torque or the force is reduced.
2. A method according to claim 1, characterised in that from the ratio of the strength of the force or the torque to the strength of the test current, the load angle is determined and the phase position of the travelling or rotating field is adapted more quickly with a large load angle and more slowly with a small load angle.
3. A method according to claim 2, characterised in that the current strength of the test currents with the phase difference becoming smaller are increased, preferably until reaching the normal current strength.
4. A method according to one of claims 1 to 3, characterised in that control electronics (2) subsequent to a first running are displaced to a second basic condition which corresponds to a second basic setting deviating from the first basic setting of the phase position of the travelling or rotating field vector, and that thereafter all further method steps are repeated.
5. A device for carrying out the method according to one of the preceding claims, characterised by a torque sensor (9) or force sensor and an additional control (17) connected after this for the frequency converter for delivering the test current with the predetermined vector phase position.
6. A device according to claim 5, characterised in that with an elastic drive connection, a distance transducer or rotation transducer (9) of a present position measuring system serves as a force or torque sensor in that a deviation from the rest position serves for acquiring the force or the torque on the runner.
7. A device according to claim 6, characterised in that the distance transducer or





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rotation transducer is formed as an incremental transducer (9) which supplies impulses to the control electronics (2).

8. A device according to claim 7, characterised in that the control electronics (2) comprises an incremental counter (12) which from the impulses of the incremental transducer (9), where appropriate adapted by way of a reduction counter (11), forms digital phase position information which in a connected function generator (6) is converted into a two or multi-phase rotary current setting (R, S, T) for the synchronous motor (1).

9. A device according to claim 8, characterised in that the the additional control (17) comprises a digital/analog converter (18), connected to the incremental transducer or reduction counter (11), with a subsequent analog servo amplifier (21), and an impulse generator (23) controlled by the servo amplifier (21), which delivers counter impulses to the incremental counter (21) for setting the test current phase position.

10. A device according to claim 9, characterised in that the servo amplifier (21) yields a current setting (28) to the function generator (6) for producing the force or the torque on the runner.

11. A device according to claim 10, characterised in that the servo amplifier (21) lets the motor currents increase with a reducing force or torque and the lets the repetition frequency of the impulse generator (23) decrease.

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