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METHODS OF AUTOMATIC CONTROL OF STEPPER MOTORS

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Annotation. This in the article step motors management three main method — wavy sequence (wave drive), complete step mode (full step) and half step mode (half step) — analysis Every of the method work principle , advantages and disadvantages seeing is released . Experience results based on half step mode the most many optimal method to use that is based on . Article step from motors user engineers and researchers for intended.

Key words : stepper motor , commutation **,** wave mode , half step , torque, rotor, stator.

Аннотация. В этой статье представлены три основных метода управления шаговыми двигателями — волнообразная последовательность (wave drive), режим полного шага (full step) и режим полушага (halfstep mode) — с анализом принципа работы каждого из методов, рассмотрением преимуществ и недостатков. Результаты тестирования, основанные на использовании режима полушага, являются наиболее оптимальным методом, на котором основано использование. Статья step от инженеров-пользователей и исследователей двигателей для intended.

Ключевые слова: шаговый двигатель, коммутация, волновой режим, полушаг, крутящий момент, ротор, статор.

Annotatsiya. Ushbu maqolada pog‘onali motorlarni boshqarishning uchta asosiy usuli - to‘lqinli ketma-ketlik (to‘lqinli haydovchi), to‘liq qadam rejimi (to‘liq qadam) va yarim qadam rejimi (yarim qadam) - har bir usulning ishlash printsipi, afzalliklari va kamchiliklari tahlil qilinadi. Yarim qadam rejimiga asoslangan tajriba natijalari foydalanish uchun eng maqbul usul . Mo‘ljallangan uchun motors foydalanuvchi muhandislar va tadqiqotchilar maqola qadam.

Kalit so‘zlar: Step vosita , kommutatsiya , to‘lqin rejimi , yarim qadam , moment, rotor, stator.

1. INTRODUCTION.

Step by step stepper motors are modern automation and robotics in systems wide applicable electricity mechanic from devices They are one . digital management signals using clear angular shifts provide to the feature has that was because of , digital systems with directly mutual under the influence be takes [1].

Step by step of motors main advantage — opposite communication even without a system positioning provide to take This feature is They can be used in

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3D printers , CNC machines , medical in tools and in robotic manipulators wide application opportunity gives [2].

Step by step motors management different methods there is they are motor operation efficiency , yield torque and resonance to the problems directly impact shows . Therefore , optimal control method choice engineering in practice important importance profession will reach .

This of the article goal — step by step motors management three main method analysis so that they technician features from comparison consists of . Research following issues cover takes : every one of the method phases commutation mechanism ; yield of the torque force amount ; resonance to the event tendency level and application sectors .

2. METHODS AND MATERIALS.

In the study step of motors three kind management method theoretical and experimental analysis made . Each method for phases commutation sequence , rotor position and harvest amount of torque to be applied studied . Analysis bipolar and unipolar type for step from motors used . Moment- angle dependencies vector diagrams and mathematician models using expressed .

2.1 . Wavy sequence Wave Drive Mode

First method — phase one by one commutation through is executed . In this phases time according to each other does not cover ; certain one at the time only one phase connected (Fig. 1, a). This method ***"one phase on" full step*** or is called " ***wave drive mode"*** . Each in step rotor balance point rotor ***" natural "*** balance point with suitable falls .

Disadvantage : in bipolar motors of time certain one during 50% of the current is used , in unipolar motors and only 25%. This is full torque output as to be absent take is coming .

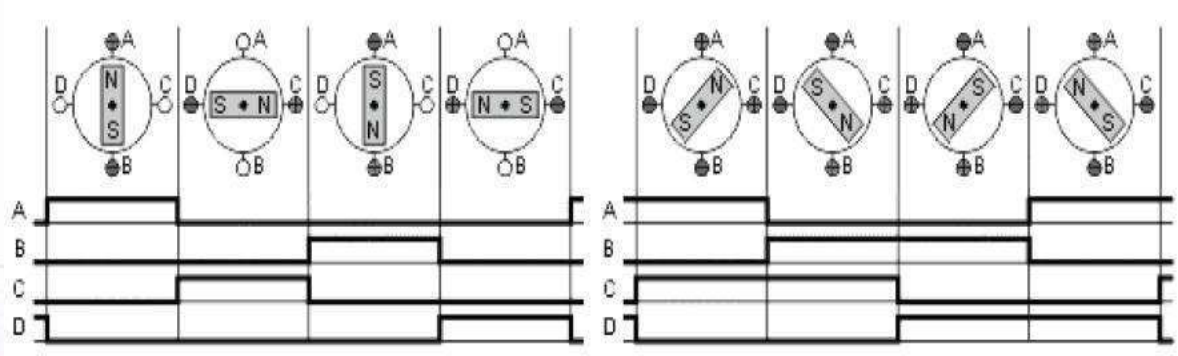


Figure 1. Phases commutation sequence : a) wavy , b) stepped

2.2 . Complete step mode (Full Step Mode)

Second method — phases time according to on top of each other agreement with is to manage . In this two phase of time one at the moment This method ***"two phase on" full step*** or This is called " ***full step mode"*** . In this method, the rotor

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poles are The space in the middle is halved (Figure 1, b), and one phase connected to the point 40% more torque is provided.

Complete step in mode two phase connected without rotor clean point half step by step moves . That's it . record to grow it is necessary that stationary rotor motor manufacturer standing without occupied and rotor this status in the bushes vine no without It will not remain. for the engine to the source connect or rotor half- turn step by step moves.

Stopped without rotor moving not leaving for to my heart's content hold standing vine to give necessary . Hold on stand current from rated current small to be possible , because immovable rotor in the engine No large torque is required. However rotor stopped engine in full working order torque to provide necessary when This issue is complicated. vines corrector modern drivers through solution This issue is only manager microcontrollers management to programs related.

2.3. Half step Half Step Mode

Third method — *half step This* method is called a *sequence* . above record done two of the method from the combination consists of . English in the language ***"one and two phase on" half step*** or This is called " ***half step mode"*** . In this case, the motor is the main step half turns.

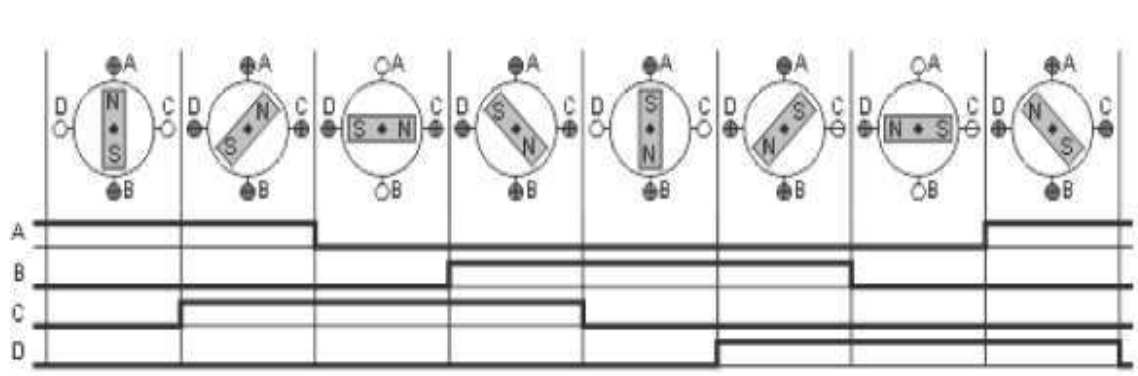


Figure 2. Half step sequence

This management method the most many widespread is a method , because small step motors price expensive and for example 100 step 200 steps on the motor harvest to do — scientific in terms of much interesting issue . This in a way every one step one phase with cover is taken , other at the time and two phase together Both are connected. start in a way rotor corner shift step half turn organization does.

Step size reduce outside this method partially resonance also eliminate the incident Half step regime power in terms of complete torque harvest to do does not improve. But the current time improved drivers half step regime harvest does and the engine is complete torque provides.

3. RESULTS.

3.1. Moment- angle description

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One phase is signaled in motors of the moment to the rotor connection balance approximately is sinusoidal . Two busy motors for , N steps has (α = 2 π /N) torque- angle for the motor dependency with the following formula is expressed as :

$$M = Mh \sin(\varphi / \varphi) \qquad (1.3)$$

this M is the moment, Mh is the hold stand moment , φ — step angle , φ — brake turn angle .

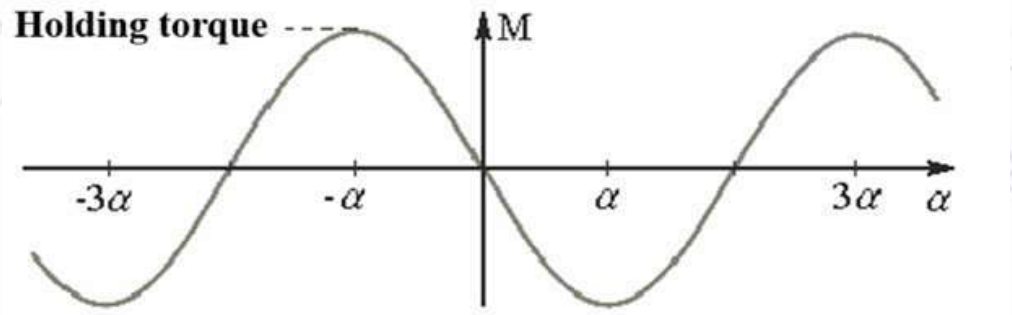


Figure 3. One my heart to the source connected rotor turn of the situation to the moment dependency graph

Real life in the picture location tired difference to do possible , because the rotor and stator geometric The structure is not ideal . The moment maximum value hold stand moment If the rotor hold stand from the moment big the moment that is outside If given , the rotor will rotate to the corner If an external torque is applied , stand from the moment big if not , then the rotor is unbalanced in the case of will be.

This record to grow necessarily , the chulkams from the source separated hold on even if stand moment to zero equal not because permanent magnet area This torque is available in the motor . maximum of the moment about 10 % organization will reach.

3.2. Two my heart torque at connection

If time one at the moment two my heart source with if provided , then total torque per one my friend harvest did moments from the sum (Figure 4). In this case , if the vines values one kind if , the moment maximum value half step by step moved will be , physical rotor balanced the point is also half step by step moves.

Peak torque value (hold) stand moment) one my heart to the source connected relatively $\sqrt{2}$ times is large :

$$Mh2 = \sqrt{2}Mh1 \qquad (1.4)$$

This on the ground Mh2 — two my heart to the source when connected hold stand moment , Mh1 — one my friend to the source when connected hold

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stand moment . Just like this moment is moving of motors passport descriptions is brought.

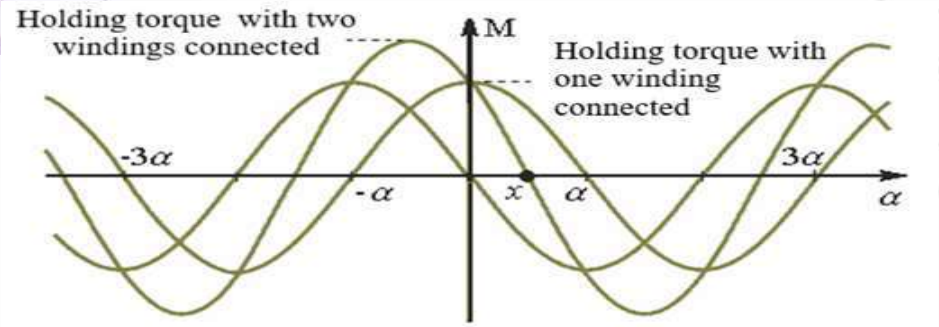


Figure 4. Two my heart connected torque-rotor relationship features

3.3. Magnetic field vector analysis

Magnetic field direction and value vector diagram (Figure 5) of this analysis completes .

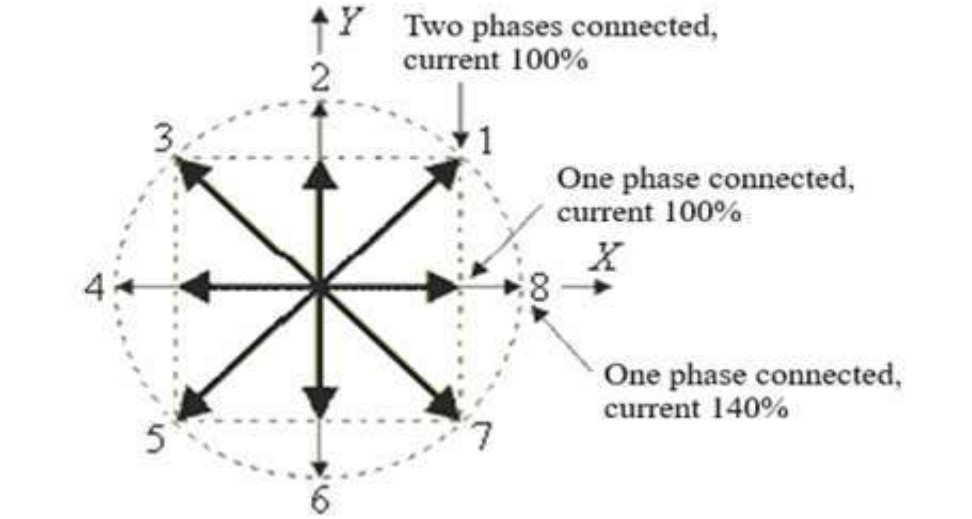


Figure 5. Phases every kind in modes to the source magnetic field when connected value and direction

This vector X and Y axes in a diagram directions of the engine first and second slurs harvest did magnet of the area directions with suitable If the motor is one ami to the source connected without If it works , then the rotor will move to positions 1, 3, 5, 7. If the motor has two ami to the source connected without If it works , then the rotor will move to positions 2, 4, 6, 8. occupies.

In this case, the torque value large , because the torque value in the picture vector to the length proportional . These two The method is also complete . step provide , but the rotor position half step by step moved . If this two the method double and to the scumbags suitable in sequence impulses If given , then the rotor will rotate in sequence 1, 2, 3, 4, 5, 6, 7, 8 the situation possesses — this and half step the regime provides.

4. DISCUSSION.

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Received to the results see , all three management method advantages and disadvantages as follows described:

4.1 . Wavy regime

This method main disadvantage — electricity low efficiency of the machine at the level In bipolar motors same at the time only 50%, in unipolar motors and 25% of the active will be . Therefore harvest The moment to be done is complete. it won't be possible and this method high torque required in applications not applicable.

4.2 . Complete step mode

Complete step in mode two my friend one at the time connection because of one phased to the regime 40% more torque generation compared to However , the rotor has stopped . in case hold stand for to my heart's content permanent vine giving stand necessary . Modern drivers this problem vine to adjust through solution will reach.

4.3. Half step mode

Half step mode following to the advantages has :

–grass expensive motors unused without big permission resolution value achieve possibility there is ;

–resonance event with related problems much less occurs — resonance and partial loss of torque take is coming .

Disadvantage: step step by step when passing of the moment vibration This vibration is observed when the engine is running . vibration and noise harvest does.

All three method between half step mode the most wide widespread It is clear that and to resonance stability between balance For example , using a 100-step motor to produce 200 steps harvest to do opportunity is of the method important scientific and practical It is expensive.

4.4. Methods comparative analysis

Table 1.

Management methods comparative description

Criterion	Wavy regime	Complete step	Half step
Moment power	Low (50/25%)	Large (+40%)	Average
Resolution	Standard	Standard	2x higher
Resonance danger	Medium	Medium	Less
Vibration	Less	Medium	Medium

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Criterion	Wavy regime	Complete step	Half step
Usage	Simple systems	Heavy load	Most people cases

5. CONCLUSION.

This research step motors management three main method analysis done . Taken from the results following conclusions release possible :

– Wavy sequence method the most simple and convenient , but my friend only one part active that was because of harvest The torque is low.

– Complete step mode one at the time two phase connect Provides 40% more torque through and in case of heavy loads preferably choice is considered .

– Half step mode accuracy two even increases and resonance problems reduces — that so he is in practice the most wide widespread method is considered .

In the future in microdevices tools vines thin corrector modern drivers with together half step and microstepping methods study to the goal according to .

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