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Identification and Compensation of Resonance in Hybrid Stepper Motor

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ABSTRACT

Hybrid Stepper motor suffers with skipped steps due to the occurrence of resonance and instability, under different loading conditions. Estimation of rotor position and speed is important to avoid skipped step and reduced resonance in Hybrid Stepper Motor (HSM). Different existing methods to tackle resonance conditions are discussed. In this paper, identification of resonance is done by observing variations in actual and synchronous speed of the motor. Hence the speed based measurement by tachometer can be used to identify the resonance.

Keywords: **Resonance, Skipped step, Synchronous speed, Tachometer.**

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I. INTRODUCTION

Hybrid Stepper Motor (HSM) are used in positioning applications due to their high efficiency and small step angle. In these motors, the stepping rate normally follows the excitation rate. Resonance is the oscillatory phenomena which disturbs the normal operation of the stepper motor. In some cases the magnitude of oscillation increases with time and eventually the motor loses synchronism. Resonance and instability may be classified into three categories, namely the low frequency, medium range instability, and higher range oscillation .The oscillation that occurs below 200 Hz is called low frequency resonance. Medium range instability occurs between 500 Hz to 1500 Hz. The higher range oscillation occurs in the range of 2500 Hz to 4000 Hz. When resonance and instability are noted at certain speeds the behaviour of the machine varies with loading condition and needs to be addressed. Full step, half step and micro-stepping excitation schemes can be used.. Resonance conditions are created in the motor, under various excitation schemes Resonance can be identified experimentally, through mechanical measurements. Mechanical measurements include rotor position, speed, torque and vibration. The approach is to replace the tackling method of resonance by identifying resonance by mechanical measurements.[4]

Stepper motor makes a move from one step to the next and the rotor doesn't stop immediately. The rotor actually moves back (undershoots) and forth (overshoots) until it comes to rest. This is known as ringing and it occurs every time due to the commanded move of the motor to the next step before it comes to rest. When motor under no load condition exhibits a fair amount of ringing, it gets converted into motor vibration. The motor will often stall due to the high vibration and cause the motor to lose its synchronism if loaded heavily.[3] Stepper motor will exhibit much stronger vibrations when the input pulse frequency matches the natural frequency of the motor. This is called resonance. During resonance conditions, oscillations will be more and there is chance of skipped steps. The resonance range may change slightly due to the damping effect of the load inertia.

The paper is organized as follows. Section II presents existing methods to tackle resonance .Section III presents Identification of resonance (with mechanical parameters). In Section IV conclusions are summarized.

II. EXISTING TECHNIQUES TO TACKLE RESONANCE

1. Micro step mode of excitation.
2. Change in phase current.
3. Shifting the step frequency
4. Increasing the friction.
5. Dampers.

Above techniques are available to reduce resonance and vibration as discussed by Kenjo[1] (1984) and Acarnely[2](2002). Each technique has its advantages and disadvantages. The key to eliminate its effects lies in either controlling where the resonant point falls or in reducing its severity.

1. Micro step mode of excitation.

Due to the smaller step angle, the oscillation is reduced and the system has less resonance points. The major disadvantage of the mini-step drive motor windings is the cost of implementation due to the need for partial excitation of the motor windings at many current levels, using a chopper drive circuit in which the reference current level for each phase is changed every mini-step. If no current compensation is provided in the micro step driver, a torque reduction of the motor may occur which is disadvantages in some applications. However, even if the motor is driven with sinusoidal pulse, vibration and resonance still exist due to the motor inherent characteristics.

2. Change in Phase Current

Resonance excitation is strongest during no-load operation and therefore, brings problems during testing. The phase current reduction also minimizes the stiffness and must be taken into account while positioning accuracy.

3. Shifting the Step Frequency

Resonance occurs during no-load operation using full step mode at approximate 70-100 Hz and appears at multiples or harmonics of the resonance. It is easier to avoid the resonant frequency by choosing a frequency that is somewhat higher or lower. Small deviations from the critical step frequencies reduce the resonance.

4. Increasing the friction

Friction generally has a damping effect on the system and oscillation becomes smaller. However, the torque is reduced by this and the motor efficiency also reduces.

5. Dampers

Damper reduces the oscillation and absorbs the vibration energy. The resonant frequencies are very much reduced because of the speed difference between the oscillating rotor and the external mass. Although this results in the significant reduction of overshoot, the use of dampers is unsatisfactory during high frequencies as it is limited by the friction torque.

Above techniques are either for reducing the resonance or for avoiding the resonant frequency. The solution to operate the motor during resonance conditions is left undiscussed.

III. . IDENTIFICATION OF RESONANCE

Resonance can be identified experimentally, through mechanical measurements like speed. Fig 1 shows steps to follow to identify resonance condition.

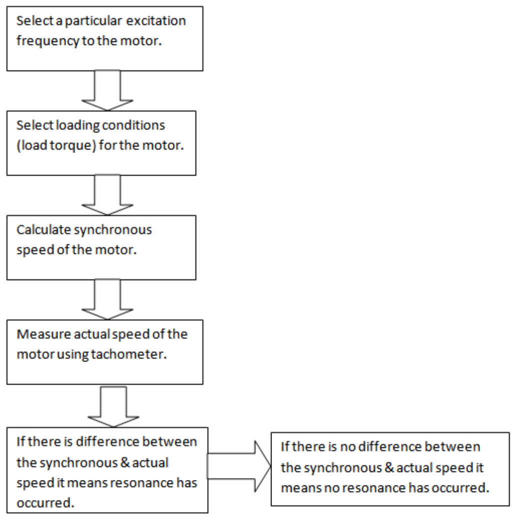

Fig1: Flowchart for identifying resonance.

Experimental investigations can be carried out on basis of above mentioned flowchart for different excitation scheme of the hybrid stepper motor as shown in the Fig 2 below.

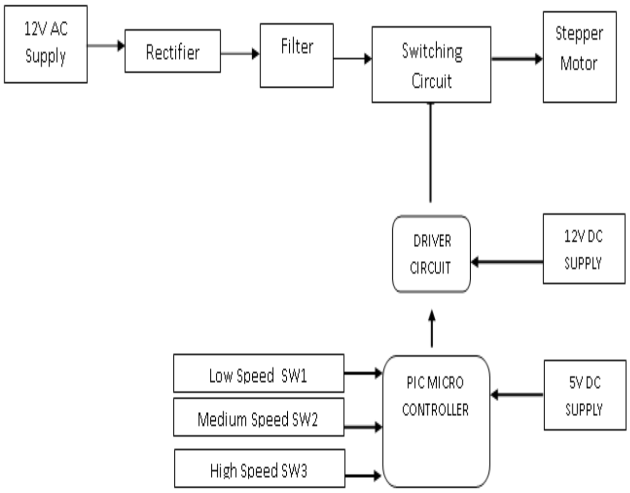

Fig 2: Hardware set-up for driving the stepper motor

RESONANCE AND NON RESONANCE OBSERVATIONS IN FULL STEP MODE

Current (A)	Excitation Clock Frequency (Hz)	Synchronous Speed (RPM)	Actual Speed (RPM)	Difference in speed (RPM)	Load Torque (Nm)
0.32	17	5.1	5.3	**+0.2**	0
0.32			5.1	0	0.07
0.32			5.1	0	0.14
0.31			5.1	0	0.18
0.31	23	6.9	6.9	0	0
0.30			6.9	0	0.03
0.30			6.9	0	0.16
0.28	44	13.2	13.7	**+0.5**	0
0.26			13.2	0	0.07
0.26			13.2	0	0.11
0.25	56	16.8	16.8	0	0
0.24			16.8	0	0.07
0.23			16.8	0	0.12
0.21	85	25.6	25.7	**+0.1**	0
0.20			25.6	0	0.07
0.20			25.6	0	0.09
0.11	130	39	39	0	0
0.10			39	0	0.07

Table 1: Experimental data for identifying resonance [4].

The above work carried out in [4] clearly delineates the difference in actual and synchronous speed at full step excitation scheme and can be carried out in the same way for half and micro step excitations.

IV.CONCLUSION

In this paper identification of resonance is done by clearly delineating the difference between actual and synchronous speed of the stepper motor, suggesting the motor has skipped step, by mechanical measurement of speed using tachometer.

REFERENCES

[1] Kenjo T., “Stepping motors and their microprocessor controls”, oxford university press, Oxford, 1984.

[2] P. P. Acarnely, stepping motors: A guide to modern theory and practice, London, U. K. peter petegrinus, 1999.

[3] Athani V. V., “Stepper motors: fundamentals, applications and design, new age international publisher, reprint 2005.

[4] K. Balakrishnan, B. Umamaheswari, and K. Latha, “Estimation of rotor position and speed for hybrid stepper motor under various phase excitation schemes and compensated resonance,” in Proc. (POWERENG) Int. Conf. Power Eng., Energy Elect. Drives, May 2011, pp. 1–6 & 2013.

