論文の要約

論文題目: Microcomputer-based Position Control Strategies of Ultrasonic Motors
(マイクロコンピューターによる超音波モータの位置制御)

In recent years, Ultrasonic Motors (USMs) have been gaining much attention as owning excellent characteristics and operating performances: high torque at low speed, high torque to weight ratio, fast and accurate speed response, holding torque without power supply, good start-stop dynamics, simple mechanical design, compact in size and no electromagnetic noise. The USMs are therefore much expecting to be applied in robot actuators, high precision positioning devices and medical equipment's.

The USMs use ultrasonic vibrations from a piezoelectric material to produce a rotating motion. They are powered by two-phase high-frequency sinusoidal voltage and their control signals are generally the voltage amplitude, frequency and the phase difference of the two phase voltage applied. The operating principle of USMs have complicated speed characteristics compared to the one of conventional electromagnetic motors which makes it very difficult to control motor speed as well as motor position. Hence, applications of the USMs are significantly restricted with those drawbacks.

This research is focused on developing position controllers of traveling-wave ultrasonic motors to overcome the above-mentioned drawbacks. The main concentration is on position control method using frequency and phase difference between the two-phase voltages supplied to the motor.

On the other hand, when applying a load torque to an USM, a dead-zone occurs in the control input. Position controllers, which consider dead-zone, are consequently proposed for the motor. To implement the proposed control schemes, a SH7125 microcomputer with an embedded system are employed. The state quantities, such as acceleration, speed and position are required to apply the digital implementation. However, a RP-442Z rotary encoder, which is used to measure the system output for feedback, causes quantization errors in the speed information. To overcome these problems, Variable Structure System observer with the possibility of decreasing quantization error is also presented.

In chapter 4, in addition to a nonlinear position controller, a nonlinear adaptive position controller is also suggested. Those proposals will help performance of the control system maintaining stable when the motor parameters, as one of its typical characteristics, changing value significantly. Effectiveness and reliability of the proposed method is experimentally verified and compared to a conventional PI position controller. According to the experimental results, the proposed position controllers provide a good position control. The proposed variable structure system observer reduces the quantization errors and gives good position estimation. The dead zone effect is reduced by using the observer. The experimental results also demonstrate good tracking performances.

In chapter 5, a digital position controller is proposed to control the USMs. This new approach is expected to deal with the unstable problem of the nonlinear position controller

when the sampling time is shortened. The new proposed position controller is also digitally implemented by a SH7125 microcomputer and an embedded system named high-performance embedded workshop. From the experimental results, it is concluded that the proposed position controller provides a good position control for USMs and is quite stable with the shortening of the control period. The quantization errors have been reduced by the proposed digital variable structure system observer. The observer also gives good position estimation.

In summary, as the goal from very first step of this research work, small, low cost and fast responsive position controllers have been achieved as followings:

1. Nonlinear Position Controller,
2. Nonlinear Adaptive Position Controller,
3. Digital Position Controller.

The effectiveness reliability of the proposed position controllers have been experimentally verified, showing good results. The controllers are expectedly expanded for the motor application in the industrial world.

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