SPEED POSITION CONTROL SYSTEM FOR DC MOTOR

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The system is controlled by a microprocessor, or microcomputer, which determines the optimum speed profile for each movement and passes. The system contains the system' s D/A converter. An optical encoder on the motor shaft provides signals which are processed by converter . So converter produces tacho voltage feedback and position feedback for the control micro.

Keywords motor, microprocessor, maxim speed, frequency

1. Introduction

In this section I will analyze the influence of the offset on the positioning precision. Calculations included : calculation of maximum speed and acceleration, a resistor to set maximum speed

2. Paper contents

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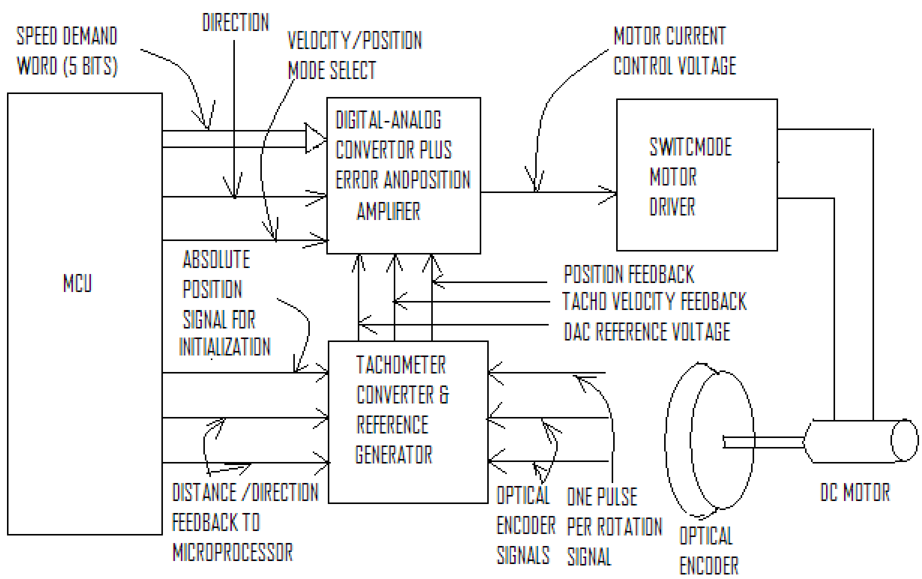

Fig. 1 DC Motor servo positioning System that connects directly to Microcomputers Chips

The system operates in two modes to achieve high speed and accuracy: closed loop speed control and closed loop position control. The combination of these two modes allows the system to travel rapidly towards the target position then stop precisely without ringing.

First the system operates in speed control mode. A movement begins when the microcomputer applies a speed demand word for maxim speed. The motor speed is zero so there is no tacho feedback and the system operates effectively in open loop mode.

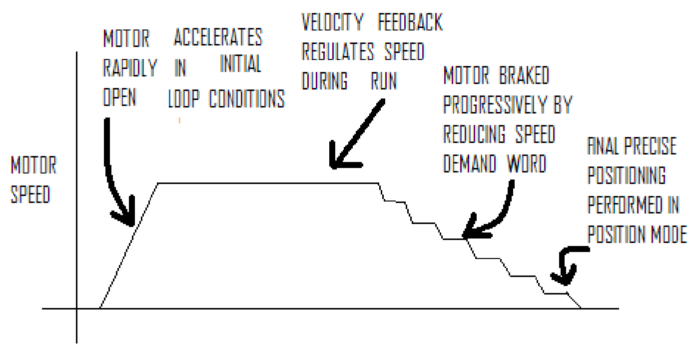

Fig. 2. Two modes to achieve high speed and accurary.

The high current peak – up 2 a acceletates the motor rapidly to ensure a fast start. When the speed code is zero and the target position extremely close, the micro commands the system to switch to position mode. Then the motor stops rapidly at the desired position and is held in an electronic detent.

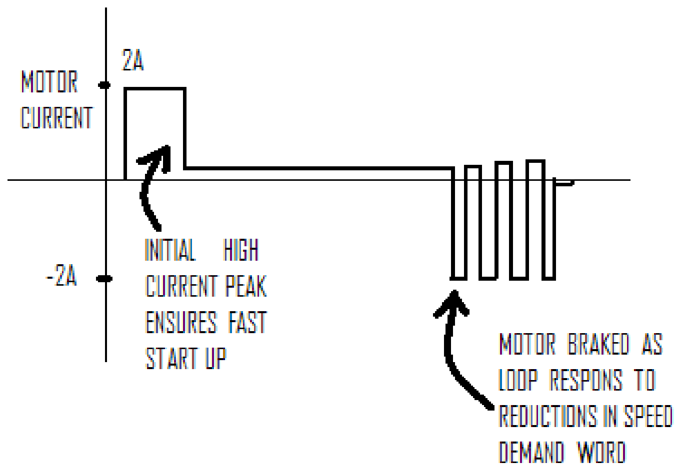

Fig. 3. The motor current diagram

In this situation is possible that the system operates in two modes , first to achieve high speed and second accurary. The speed during a run is regulated by feedback tachometer.

Now the system operates with an optical encorder of the type shown schematically below. It generates two signals 90º C out of Phase plus a one Pulse-per-rotation signal.

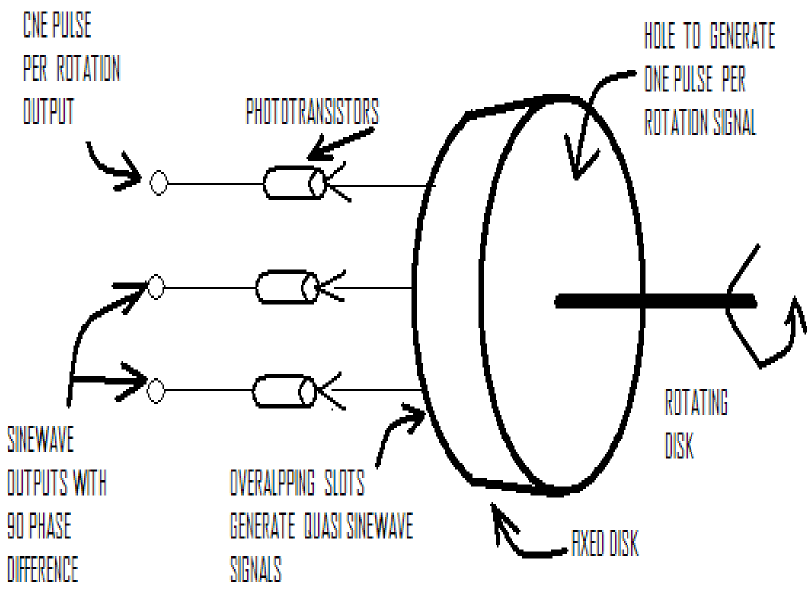

Fig.4. Optical Encoder of the type shown schematically here

The system that are presented consists of a rotating slotted disk and a fixed partial disk, also slotted. The frequency of these signals indicates the speed of rotation and the relative phase difference indicates the direction of rotation. This encoder generates a third signal which consists of one pulse per rotation. This system is used to find the absolute position at initialization.

If tachometer converter processes the three optical encoder signals to generate a tachometer voltage, a position signal and feedback signals for the microprocessor. Finally the multiplier outputs are summed to give the tacho signal. The system presents three important advantages.

- First, since the peaks and nulls tend to cancel out, the ripple is very small.
- Secondly, the ripple frequency is the fourth harmonic of the fundamental so it can be filtered easily without limiting the bandwidth of the speed loop.
- Third it is possible to acquire tacho information much more rapidly, giving a good response time and transient response.

Since the tacho voltage is also derived it follows that the system is self compensating and can tolerate variations in input levels, temperature changes and component ageing with no deterioration of performance.

The tachometer converter processes the three optical signals to generate a tachometer voltage, a position signal and feedback signals for the microprocessor. It also generates a reference voltage for the system's which is converter.

Analytically the tacho generator function can be expressed as:

$$\varphi = \frac{dV_{AB}}{dt} \cdot \frac{\varepsilon_1}{|\varepsilon_2|} - \frac{dV_{AA}}{dt} \frac{\varepsilon_2}{|\varepsilon_2|} \qquad (1)$$

Where ε_1 and ε_2 are two from these three optical signals. The sign $\frac{\varepsilon_1}{|\varepsilon_1|}$ or $\frac{\varepsilon_2}{|\varepsilon_2|}$ is provided by the two comparators. Finally a multiplier outputs are summed and give the tacho signal.

We can be considered as a power tranconductance amplifier- it delivers a motor current proportional to the control voltage. It drives the motor efficiently in switchmode and incorporates an internal current feedback loop to ensure that the motor current is always proportional to the input control signal.

The input control signal is first shifted to produce a unipolar signal and passed to the error amplifier where it is summed with the current feedback signal.

The resulting error signal is used to modulate the switching pulses that drive the output stage. External sense resistors monitor the load current, feedback back motor current information to the error amplifier via the current sensing amplifier.

It is possible, also, to incorporates its voltage reference and all the functions required for closed loop current control of the motor. Further, it features two enable inputs, one of which is useful to implement a power on inhibit function.

The output stage is a bridge configuration capable of handling up to 2A at 36 V. a full bridge stage was chosen because it allows supply voltage to the motor effectively twice the voltage allowed if a half bridge is used.

A single supply was chosen avoid problems associated with pump-back energy.

In a double supply configuration, current flows for most of the time and a certain amount of power is thus taken from one supply and pumped back into the other. Capacitor is charged and its voltage can rise excessively, risking damage to the associated electronics.

In a single supply configuration the single supply capacitor participates in both the conduction and recirculation phases. The average current is such that power is always taken from the supply and the problem of an uncontrolled increase in capacitor voltage does not arise.

A problem associated with the system used is the danger of simultaneous conduction in both legs of output bridge which could destroy the device. To overcome this problem the comparator which drives the final stage consists of two separate comparatos.

A simple push pull output needs a split supply and the device can be damaged by the voltage built up on C1. The bridge output to avoid these problems. Only one supply is needed and the voltage across the single capacitor never rises excessively.

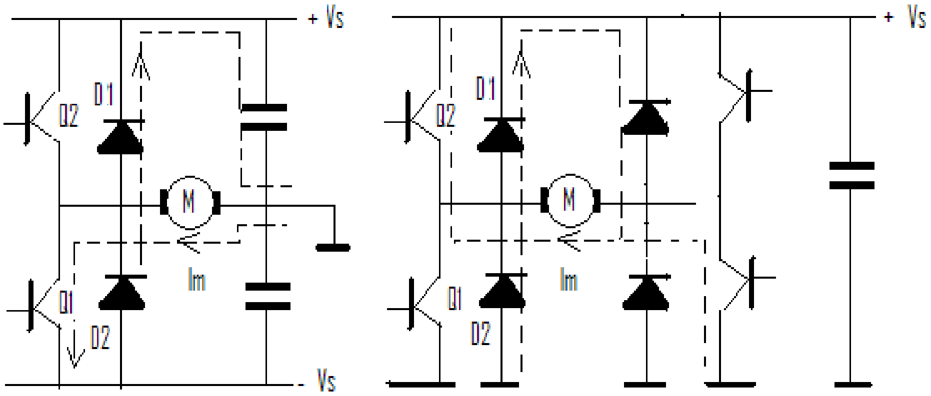

Fig. 5

The motor can be supplied with a voltage up to twice the voltage allowed with a half bridge.

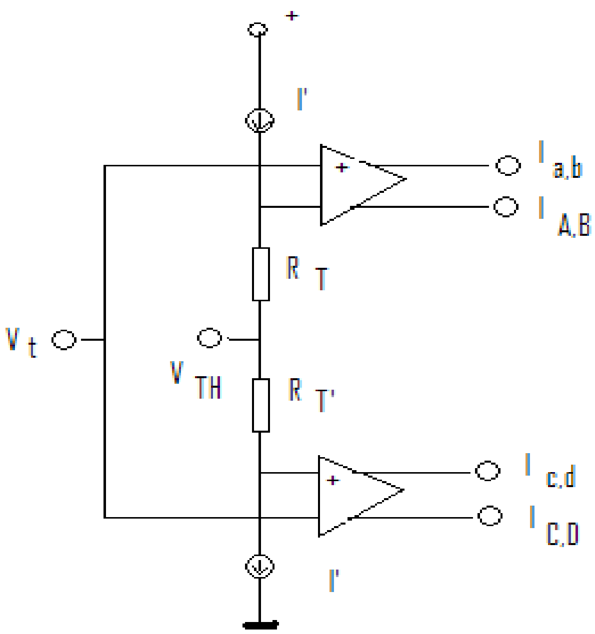

Fig. 6. Comparator consists of two comparators

The other two inputs are driven by the V_{TH} and the error amplifier output, shifted by plus or minus R_T. This voltage shift, when compared with V_t, results in a delay in switching from one comparator to the other.

There will always be a delay between switching off one leg of the bridge and switching on the other. The delay "t" is a function of the integrated resistor R_t and an external capacitor connected which fixes the oscillator frequency. The delay is given by : $t = R_t C$

It is desirable to synchronize the switching frequency to avoid intermodulation. This can be done using the configuration shown in figure below.

A switchmode driver receives a control voltage and delivers a switchmode regulated current to the motor.

A high current peak accelerates motor rapidly to ensure a fast start. The motor accelerates the tacho voltage rises and the system operates in closed loop speed mode moving rapidly forwards the target position. A microcomputer, which is monitoring the optical encoder signals, reduces the speed demand word gradually when the target position is close. Each time the speed demand word is reduced the motor is braked by the speed control loop.

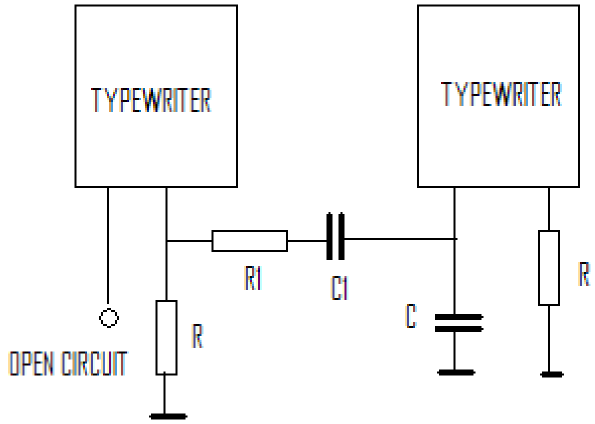

Fig.7. System by synchronizing the chopper rate with the RC Network

The parameters of usually motor which can used is presented in table no.1.

Tabel 1.

The parameters of the motor which we can to consider

Motor-parameter
Voltage U_b
C emf. K_e
N_0 (without load)
I_{om} (without load)
T_f (friction torque)
K_T (motor constant)
Armature moment of inertia
R_M of the motor
L_M of the motor

The main feature of the system is the accurate positioning of the motor. In this section we will analyze the influence of the offset of the positioning precision. When the system is working in position mode, the signal coming from the optical encoder, after suitable amplification, is sent to the summing point of the error amplifier. If there were no offset and no friction, the motor would stop in a position corresponding to the zero crossing of the signal and then at the exact position required. First we will calculate the amount of the offset at the input of the IC.

The maximum speed can be calculated. The calculations include calculation of maximum speed and acceleration and also defining the control algorithm and setting the maximum speed. If we consider the following relation $V_{\min} = 2 \cdot Vc + R_S I_m + K_e \Omega + R_m I_m$ where

E= internally generated voltage
K_e= the motor voltage constant
Ω= the rotation speed of the motor

The $2Vc + R_s I_m$ can be determined of the typewriter datasheet and $R_m I_m$ can be measured. Then is possible to determinate $K_e \Omega$ and again we determine Ω. The chosen maximum speed is obtained by setting the resistors and capacitors values.

We must consider the input offset voltage, we call on input voltage that must be applied to typewriter to keep the motor in rotation, to compensate again the dynamic friction. The motor current necessary to compensate the dynamic friction. We have not considered how the precision coming from the optical encoder, influences the positioning error.

6. Conclusions

The amplitude of the signal is not a linear function and the difference is greater if the product doesn't respect the some condition .

The motor will run at a speed corresponding to the value signal if we don't considerthe motor friction and the offsets.

The amplitude of the signals determines value of the tacho signal. This amplitude must be constant on the whole range of the frequency, otherwise it is not possible to have a linear function between the tacho signal and the frequency. The spread of the amplitudes of the two be compensated. The phase between the two signals should be 90°. If there is a constant difference from this value, a constant factor reduction of the tacho signal results that can be compensated with a potentiometer. If the difference from 90 ° is random, also the reduction of the tacho signals is random in the same way, and it is possible to compensate by a resistor, only the mean value of that reduction.

A system can be controlled by a microprocessor or microcomputer just if we determine the optimum speed profile for each movement and passes commands .

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