2. POSITIONING TYPE APPLICATION

A computer peripheral type serial character printer is a typical positioning application. The stepper motor is used to advance the paper for line feed.

The printer prints either six or eight lines per inch.

A 4.5:1 gear ratio is used between the paper roller and the motor. A 7.5° stepper motor taking eight steps per incremental movement will advance the paper at six lines per inch. A simple control logic change makes the motor take six steps per movement giving eight lines per inch.

The reflected frictional load to the motor is 22% of the frictional load of the roller and paper and only 5% of the inertial load because of the gear ratio.

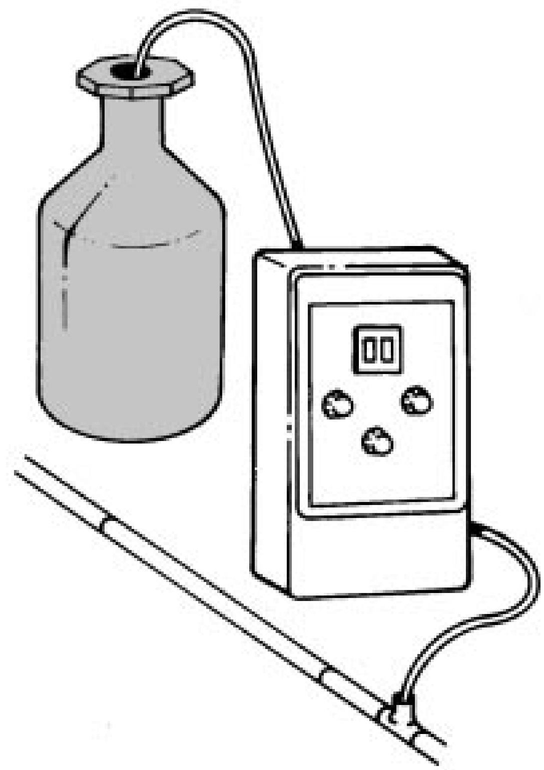
Since the motor always takes at least six pulses to move a line, the timing of the pulses is spaced or ramped so as to accelerate and decelerate the motor in the fastest time with minimum ringing.

In order to get the maximum line feed rate, the motor is driven by a a bi-level supply which puts five times rated voltage on the motor when stepping and drops down to 25% rated voltage when not being stepped. This allows maximum input power during stepping and minimum dissipation during standstill.

Additionally, the accuracy of the spacing between lines is optimum, since the motor is stepped in multiples of four or two.

3. VARIABLE SPEED APPLICATION

Many variable speed applications use DC motors with the speed of the motor being controlled by velocity feedback devices. Since problems of life, noise and complexity of feedback servo make the use of a DC motor unsatisfactory, it is more advantageous to use stepper motors in applications such as a reagent pump.



Reagent pumps are used to dispense various solutions at preselected rates. A crystal oscillator is used as the base frequency. Sub-multiples of this frequency are obtained by dividing the base frequency to get the desired feed rates.

A 4:1 ratio pulley and belt couple the 7.5° stepper motor to the pump. The stepper motor was selected on the basis of the maximum running rate torque required with a 50% safety factor. Since the feed rates are fixed by the crystal, torque load variations within the range have no effect on the rate the fluid is dispensed.

The relative low shaft speed of the motor and the absence of brushes provide the long motor life required of the pump. Also, the stepper motor has the ability to be pulsed from very low rates to very high rates, thus giving the pump a possible flow rate range of 1000:1. A practical open loop DC system speed range is only about 10:1.

Primary units in this guide are metric (SI – the International System of units):

Length - m - (meter)
Mass - g - (gram)
Force - mN - (millinewton)
Torque - mN•m - (millinewton meter)
Inertia - g•m^2 - (gram meter^2)

In this system, mass is always in kilograms or grams. Force, or weight, is always in newtons or millinewtons.

Force (or weight) = Mass x Acceleration

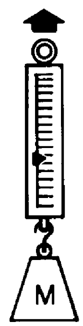
$$F = ma$$

when a = 9.81 m/sec^2 (acceleration due to gravity), then F would be the weight in newtons.

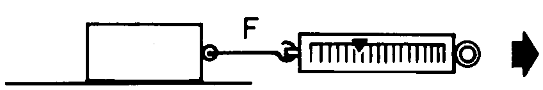
How to measure Mass or Force.

A spring scale reading of 1 kg means that you are measuring a mass of 1 kg.

A spring scale reading of 2.2 lb also is measuring a mass of 1 kg.



If you use that same spring scale to measure a force, the 1 kg reading must be multiplied by 9.8 to give a force of 9.8 newtons.



The reading of 2.2 lb is a force and is equal to 9.8 newtons.

If the same scale is used to measure torque (T = FR) at a one meter radius, the reading of

1 kilogram x 1 meter = 1 kgm

must be multiplied by 9.8 to give a torque of 9.8 newton meters (N•m).

	Given Unit				**Units Used in this Manual (Metric SI)**
Length	1 inch	=	2.54 cm	=	2.54 X 10^{-2}m
Force	1 oz	=		=	278 mN
	1 lb	=	4.45 N	=	4,450 mN
	1 g•cm	=		=	9.8 mN
Mass	1 lb	=		=	454g
	1oz	=		=	28.4g
	1kg	=		=	1,000g
	1 slug	=	14.6 kg	=	14,600g
Inertia	1 g•cm^2	=		=	10^{-4} g•m^2
	1 oz-in-sec^2	=		=	7.06 g•m^2
	1 slug ft^2	=		=	.29 g•m^2
Torque	1 oz-in	=	72.01 g•cm	=	7.06 mN•m
	1 lb-ft	=		=	1.356 x N•m
	1 g•cm	=		=	9.8 x 10^{-2} mN•m
			10.2 g•cm	=	1 mN•m
			141.6 oz-in	=	1 N•m

1. Torque (mN•m) = Force (mN) x Radius (m)

Torque = FR

2. Torque required to accelerate inertial load

$$\mathbf{T\ (mN{\bullet}m) = J\ \alpha}$$

J = Inertia in g•m^2

α = Acceleration in radians/sec^2

EXAMPLE:
If a rotor inertia plus load inertia = J = 2 x 10^{-3} g•m^2, and the motor is to be accelerated at 6,000 radians per sec, what torque is required?

$T = J\alpha = 2 \times 10^{-3} \times 6000$
$T = 12$ mN•m

For stepper motors, α can be converted to radians/sec^2 from steps/sec^2.

$$\alpha\ \text{(radians/sec)} = \frac{\Delta v\ \text{(steps/sec)}}{\Delta t\ \text{(accel. time)}} \times \frac{2\pi}{\text{steps/rev}}$$

$$\mathbf{TORQUE = J\ \frac{\Delta v}{\Delta t} \times \frac{2\pi}{steps/rev}}$$

EXAMPLE:
For a 48-step per revolution motor accelerating from zero to steps/sec running rate v in Δt seconds.

$$\text{TORQUE} = J\ \frac{v}{\Delta t} \times \frac{\pi}{24}$$