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# Application Note NM 1

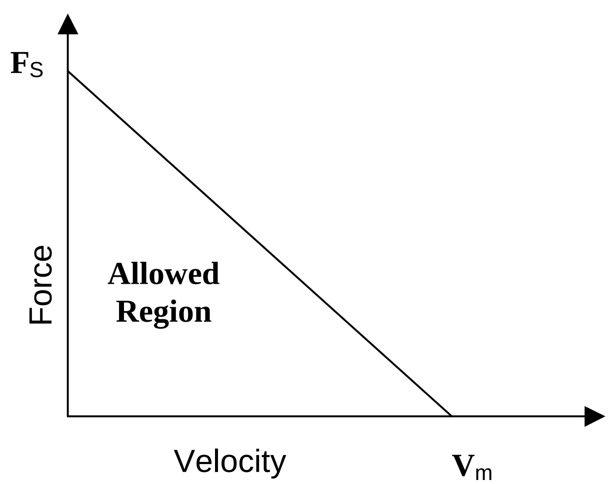
## Selecting a Nanomotion Motor That Best Suits Your Application

### Introduction

This application note highlights the factors to be considered when selecting the Nanomotion motor best suited to your requirements.

### Dynamic Performance

The force versus velocity curve of Nanomotion motors is approximately linear. Every Nanomotion motor is characterized by its maximum no load velocity ($V_m$) and stall force ($F_S$). The Force - Velocity curve appears as seen in the following graph:




It is required that the temporal dynamic force and velocity during the whole motion profile fall, well within the allowed region.

**Load Considerations**

The force in the above scheme is the force available for driving the required mass. This force should exceed the required to overcome gravitational load if its motion is vertical, to overcome system friction and to provide acceleration. These factors must be taken into account when translating the required acceleration into the required motor force:

$$F_m = m \bullet a + f_b$$

or

$$F_m = m \bullet a + m \bullet g + f_b$$ (if a gravitational force is required)

Where:

$F_m$ - required motor force

M - stage moving mass

$f_b$ - system friction force

a - required acceleration

The required force should never exceed the available motor force in the operating velocity.

**Dynamic of Short Steps**

When operating in a close loop, there is a lag between the desired and actual position at the beginning of motion. This will force the system to run at a higher acceleration than specified at a certain part of the travel. This effect will be particularly pronounced in short steps.

It is recommended that for these applications, higher margins be taken in the dynamic performance definitions.

**Duty Cycle**

Nanomotion motors have an Envelope of Performance (EOP) to ensure long-term reliability.

For applications where the dynamic requirements exceed the EOP of a single motor the Nanomotion technique facilitates the use of multiple motors, thus reducing the average command to each motor.

**Resolution**

All Nanomotion motors can operate in high resolution precision applications. However, for applications where positioning in resolutions of less than 0.1 μm is required , and when a very low speed or very fast short steps are required, the Low Speed (LS) series of motors, which are optimized for this purpose are recommended. The LS series of motors are however limited to velocities of 20 mm/sec.

**Settling Time**

The achievable settling time is mainly dictated by the damping of the motor and the natural frequency of the system. A typical number of two to three cycles is required for the motor damping to damp the system vibration along the motion axis. The settling time ($T_S$) is estimated by the following formula:

$T_S = 3/Fr$

Where Fr is the natural frequency of the system calculated according to the following formula:

$$Fr = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

Where:

K – stiffness of the motor in Newton/meter

m – mass of the moving part in kg

If the required natural frequency is higher than the one calculated for a given configuration, adding another motor in parallel or in tandem will increase the system's natural frequency due to the increased stiffness. The combined stiffness of several motors is the algebriac sum of the stiffness of the individual motors. One should recalculate the natural frequency using the combined stiffness of the motors. It is worthwhile noting that the effective motor stiffness increases under close loop operation.

**For further information please consult Nanomotion Customer Support Division.**

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