

Frequency Calibration Is Essential

Summary:

When operating M3 Modules, using only the factory preset frequency setting is not sufficient to ensure consistent performance under all times and all conditions. The factory frequency setting has intrinsic variations due to the drive chip resolution and other temperature and load factors. The result is that not all M3 modules operate reliably at the preset factory setting. If possible, in your application, frequency calibration should be run after every M3 module power-up or more often in environments where the temperature or the load or orientation of module is changing significantly.

Modules Applicable:

Frequency Calibration is essential for all M3 modules that use piezoelectric motors based on Squiggle® technology, which includes:

- M3-F, Smart Focus Module
- M3-FS, Smart Focus Module
- M3-L, Smart Linear Actuator
- M3-LS-1.8-6, Smart Linear Stage
- M3-LS-3.4-15, Smart Linear Stage

Frequency Calibration Is Essential:

New Scale Technologies (NST) has been delivering high performance M3 micro-mechatronics modules to customers for over a decade. These are “all in-one” smart modules, with the controller and position sensor built-in, that respond to SPI, I2C or UART commands. These embedded systems give you the smallest size, fastest and simplest integration into your system, and lowest total cost. M3 modules operate closed-loop using the internal sensors and also open-loop in applications that have an external sensor.

Customers that do not calibrate frequency will not get the best performance from M3 modules. In the worst-case scenario, the M3 modules may not move at all. Therefore, **frequency calibration is essential**. Frequency calibration is available at any time by sending simple ASCII commands to the module as described in the Command and Control Reference Guides and Quick Start Guides provided with each product. The purpose of this Technical Bulletin is to specifically emphasize the importance of Frequency Calibration.

Technical Background:

NST's M3-modules employ piezoelectric ultrasonic motors, operating close to the motor resonant frequency, to deliver the highest force or speed in your application. The motor resonant frequency can be affected by ambient temperature, the load on the module, module orientation, and other factors. Before leaving the factory, M3-modules are calibrated with a preset operating frequency at room temperature with a certain load and module orientation. This factory preset operating frequency represents the best operating

frequency for this scenario and moment only. In addition to being affected by ambient temperature and load/orientation, the resonant frequency of the piezoelectric motor may drift slightly due to material property changes over time, although very small (such as piezoelectric properties, mechanical properties of epoxy and potting material). To give an example, the 1.8 motor used in M3-F/FS, M3-L, M3-LS-1.8-6 increase its resonant frequency ~ 40.8 Hz for every 1°C of temperature decrease.

Example: NSD-2101:

Frequency calibration is also needed to compensate for changes of the base frequency of the driver circuit. For example, the modules M3-F/FS and M3-L use the NSD-2101 ASIC driver together with the SQL-RV-1.8 Squiggle motor. The NSD-2101 internal VCO's uses a 25 MHz clock. The factory calibrated frequency is saved in each module's EEPROM with a period count (of this clock's 40 ns period). The higher the period count, the lower the calibrated frequency. This clock may change over time or change with temperature. Although small, we cannot assume it stays the same. For this example, resolution of the period count represents about 1.2 kHz frequency resolution. This means the factory preset frequency (from the period count) may have an error of ± 0.6 kHz from the best motor operating frequency. This can be a significant deviation from the ideal motor drive frequency.

Greater frequency resolution is available with the NSD-2101 when using on-chip frequency calibration. Frequency calibration is achieved by pressing the frequency calibration button in the Pathway™ application or by sending Command 87. The NSD-2101 driver ASIC uses a higher-resolution internal frequency sweep with resolution to ~ 0.6 KHz. This is two times better resolution than the factory preset. In addition, all external factors that affect frequency are part of this in-situ calibration. The benefits of frequency calibration are essential to achieve best module performance.

To sum up, the factory preset frequency setting is necessary to allow the internal chip calibration to function. However, it is not sufficient to ensure operation under all times and all conditions. The factory frequency setting has intrinsic variations due to the drive chip resolution and other factors.

When and How to Frequency Calibrate:

If possible in your application, frequency calibration should be run after every M3 module power-up or more often in environments where the temperature is changing or the load or orientation of module is changing significantly.

To run the frequency calibration using a command, please refer to the Section “**87: Run Frequency Calibration**” in the **Command and Control Reference Guide** document for the corresponding M3 module. If the stage module is operated using New Scale Pathway software, click the “**Calibrate Frequency**” in the Motor Control Tab (refer to the **Quick Start Guide** document for the corresponding M3 module).