# Motor Tuning – Theory

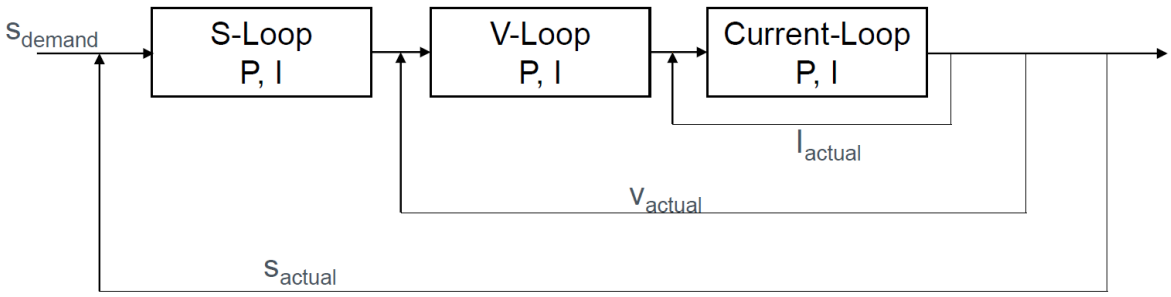
Application Note

## 1 Introduction

In drive technology, the precise adjustment of control parameters is crucial for the dynamic behavior and stability of electric drives. Controller optimization – known as tuning – aims to improve the interaction between current, speed, and position control under real operating conditions. By systematically adjusting the P and I components, overshoot, settling times, and control deviations can be minimized. Nanotec motors with integrated controllers are delivered with preset control parameters that have been determined for an average load case. Presets can also be provided for external motors. These presets already work very well for the majority of applications. Tuning offers the opportunity to further optimize control behavior, particularly for variable loads or demanding travel profiles, to achieve higher efficiency, better performance, and reduced thermal stress on the drive components.

## 2 The controller structure at Nanotec

At Nanotec, the control loop consists of three cascaded proportional-integral controllers: the current controller, the speed controller, and the position controller. The current controller is active in all operating modes. The speed controller is also active in all modes except the “Real Torque” modes, in which it can be deactivated in torque mode via bit 5 in 0x3202. The position controller is active in Profile Position, Homing, Interpolated Position Mode, Cyclic Synchronous Position Mode, and Clock Direction Mode. In Velocity, Profile Velocity, and Cyclic Synchronous Velocity modes, the position controller can optionally be activated via bit 1 in 0x3202. This can improve the control behavior, especially at low speeds.



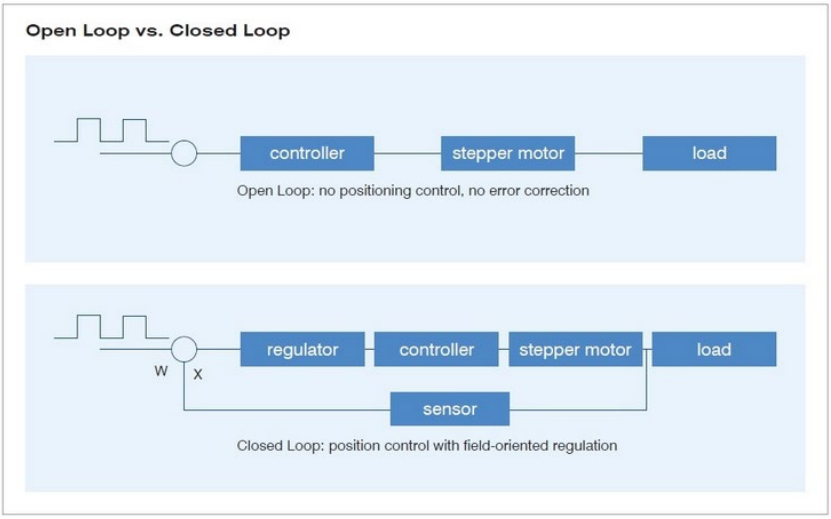

A new controller structure applies to firmware versions FIR-v22xx and later. For compatibility reasons, the old control parameters in 0x3210 are still active by default. To activate the new control parameters, 0x3212:04=1 must be set. The old values are automatically converted and transferred to the new objects 0x321A to 0x321E. Our practical videos on motor tuning will use the new control parameters.

Each control loop consists of a proportional component with the gain factor Kp and an integral component with the integration time Ti. The manipulated variable is the controller output and serves as the input to the next controller. It is limited by the maximum speed for the position controller, the maximum current for the speed controller, and the maximum PWM signal for the current controller.

The gain factor Kp directly influences the manipulated variable: for a given deviation, the manipulated variable is proportional to the gain factor. Each controller also has an integral component, which is determined by the integration time Ti. The shorter the integration time, the faster the control variable

increases. If the integration time is 0, the integral component is internally set to “0” and the controller operates with the proportional component only.

In Closed Loop mode, the actual value is constantly compared with the reference value. If there is a deviation between the two, the controller responds based on the specified control parameters. The aim of optimizing the control parameters is to achieve smooth motor operation, high accuracy, and a fast, dynamic response to disturbances.




All control deviations should be eliminated as quickly as possible. Due to the cascaded control structure, optimization should start with the innermost control loop – the current controller – before moving on to the speed controller and, if necessary, the position controller.

The current control parameters depend solely on the motor itself and are independent of the load. Our motors with integrated controller are delivered with preset control parameters, so no adjustment is required. The speed and position control parameters can be adapted to the load to further optimize the control behavior.