

Application note

Applying a known torque

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In many applications there is a requirement to apply a known torque to a component. Whilst this can be achieved using an air tool or motor, a servo system offers the advantages of flexibility, repeatability and accuracy.



Introduction

In some applications (e.g. tightening wheel nuts) it is sometimes necessary to not only apply a known torque but to subsequently rotate the fixture a known angle. Again a servo system makes this easily achievable.

It is important to size the servo system based on Continuous Torque ratings to avoid overloading the motor or amplifier as it is usually not known how long the operation will take to achieve final torque.

Applying a Known Torque

One of the characteristics of an AC Servo motor is its ability to produce a known amount of torque for a given stator current (this is known as the motor's Torque Constant – K_t – and is expressed in units of Nm/A or Lb-In/A).

For example, a Baldor BSM80N-275AA servo motor has a torque constant of 0.904 Nm/amp so if the amplifier was to supply 3 amps to this motor it would develop 2.712 Nm of torque at the shaft.

By controlling the amount of current supplied to the motor we are able to vary the amount of torque produced by the motor. The maximum torque produced can be limited by setting a current limit on the amplifier/drive. To increase this torque a special type of gearbox known as a 'torque multiplier' is often fitted to the motor shaft.

A torque multiplier is designed to provide a known (i.e. exact) multiplication factor of the input torque (e.g. 125:1) by taking into account the losses in the gearbox. The result of this design is that the speed (and hence position) ratio of the gearbox is always greater than the torque multiplication factor (the difference in ratio depends on the design of the gearbox and may vary from manufacturer to manufacturer).

As an example a torque multiplier providing a 125:1 torque multiplication may actually provide a 162.28:1 speed ratio. This must be considered if the application requires precise positioning as well as application of a known torque.

When applying a known torque it is usually not sufficient to just demand a known current as this will result in the servo motor running away at high speed if the load is initially low (e.g. imagine using the servo tool to tighten a nut onto a threaded stud. Initially the load is low until the nut starts to bite against the material being fastened).

Instead it is more common to limit the maximum available current from the amplifier (thereby limiting the maximum torque that can be applied) using the Mint CURRENTLIMIT keyword and to operate the servo motor in speed control (i.e. the Mint VELREF command or equivalent depending on product being used). This therefore allows control of speed whilst ensuring the required torque is not exceeded.

In addition the TORQUELIMITPOS and TORQUELIMITNEG keywords can be used instead of CURRENTLIMIT to provide additional directional limits. For example, if the tightening process is rotating the axis in a forward direction then it is usual to set TORQUELIMITNEG to zero to prevent any torque being produced in the reverse direction and therefore limit 'kickback' whenever the tightening operation is stopped.

The Mint JOG command is a positional type move and as such the intelligent drive will monitor following error (i.e. the difference between demand and measured positions). As the fixture (e.g. nut or bottle cap) is tightened the positional following error will increase. It is therefore usual to avoid using JOG, but in some applications there is a requirement to first apply a known torque and then rotate the fixing a known angle (e.g. using MOVER). In these cases it is typical to turn off following error mode (FOLERRORMODE = _emIgnore) so that the inevitable increase in following error does not result in the amplifier being disabled.

To detect that the required torque has been applied the Mint program must monitor two conditions:

- the measured current has reached the programmed limit
- the motor has stopped moving

These conditions are often performed sequentially (i.e. the measured current is compared against a percentage of the programmed limit – often known as the 'Preset Torque' – and then the axis is monitored for detection of zero speed). The zero speed detection usually ensures a number of consecutive zero speed results are achieved before allowing program flow to continue. This is to cater for instances where the fixture may appear to have been fully tightened but then something breaks loose (e.g. there may be some debris or loose paint on the part being fixed).

Very often a high speed is used to tighten to the preset torque and then the axis is run at a slower speed when producing the final torque. This approach leads to a more accurate and consistent result in the shortest possible time.

Tuning

When tuning the amplifier for these sorts of applications it is important to ensure that the current loop response does not produce any overshoots in the measured current. If the current loop overshoots then this can result in excessive torque being applied to the fixture.

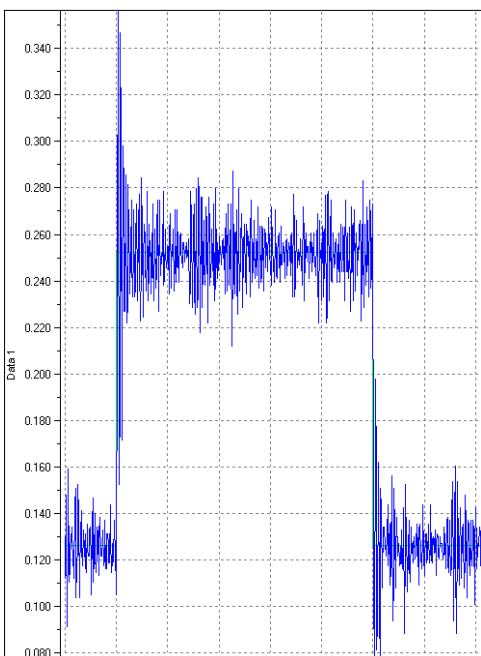


Figure 1. Excessive Current Loop Overshoot

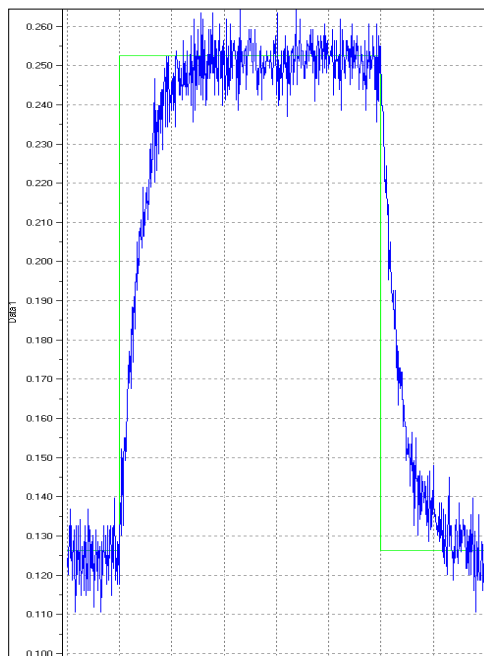


Figure 2. Ideal Current Loop Response

The amplifier speed loop gains and motion controller position loop gains should be tuned in the normal way (refer to the appropriate product installation manual for guidelines) with the exception that the position loop proportional gain should be kept as low as possible whilst still allowing accurate positioning.

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