Emerson Drive Solutions
CONTROL TECHNIQUES | EMERSON MOTION CONTROL

Application Note CTAN #146

The application note is pertinent to Unidrive in Servo Mode.

Unidrive Servo Motor Thermal Protection

Pertinent Servo Motor Data :

1. Torque Constant (Kt):
The relationship between current and torque (from stall to rated speed) of a servo is known as the torque constant.

2. Continuous Stall current (#5.07):
The continuous stall current of a servo motor is the maximum permitted continuous current with the motor holding zero speed. This is the current at which the motor generates continuous stall torque.

3. Rated current:
The rated or continuous current of a servomotor is that current which causes the winding temperature to stabilize at the maximum permitted value with the motor running at its rated speed. Although this may vary depending on wire material and motor design a typical value would be 135 degrees Celsius. The rated torque is the torque produced at rated current.

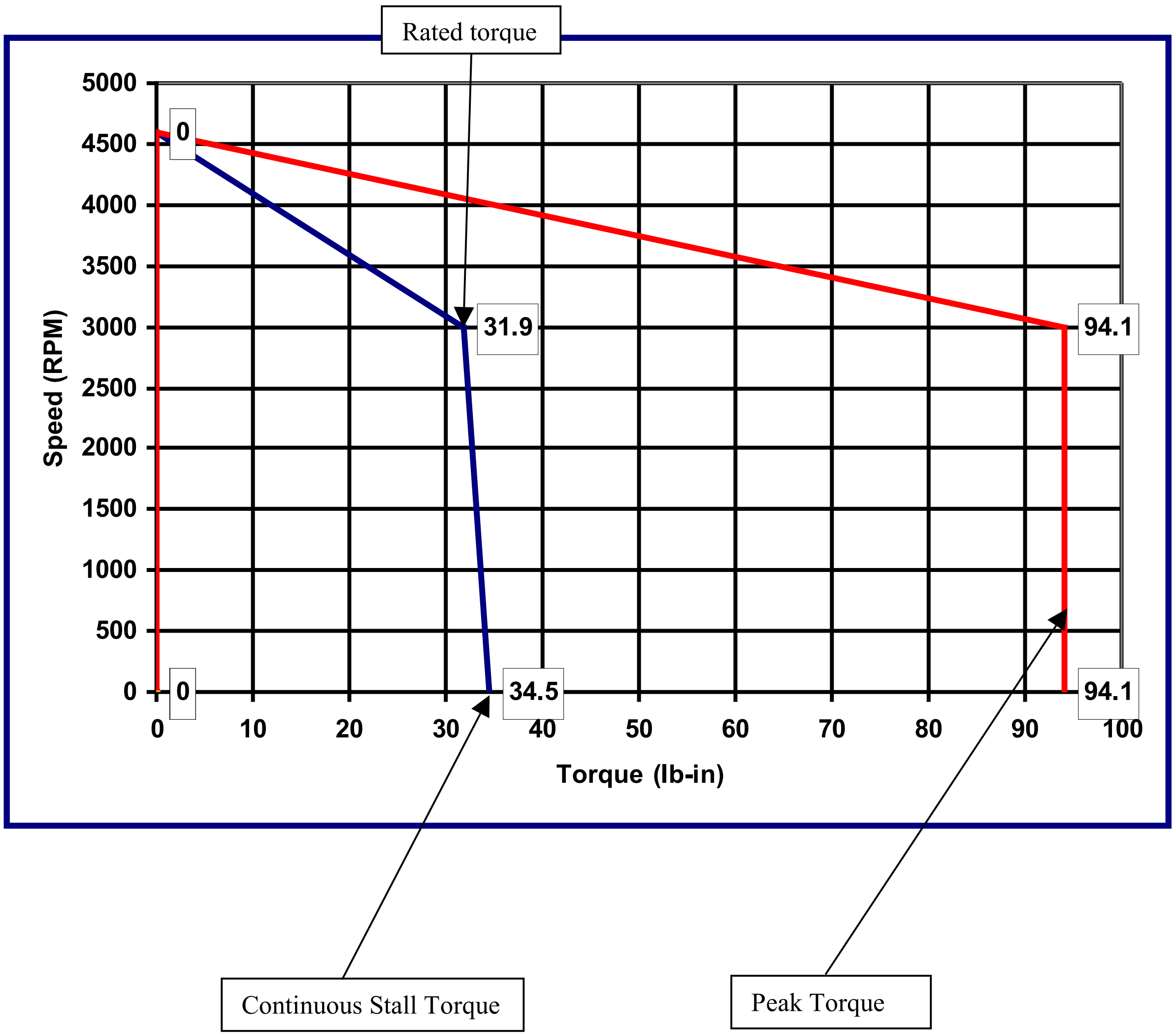
4. Peak Current of a servo motor:
This is the absolute maximum current which can be drawn by a servo motor for a short time period. In most servo motors this is 3 times stall current.

5. Peak Current requirement of an application:
This is the current needed to produce the peak torque required by the application. It is normally only required during acceleration and deceleration and is calculated during the sizing phase probably using software such as Emersize. This must always be less than the peak current rating of the motor. This value should be loaded into parameters #4.05, #4.06 and #4.07 expressed as a percentage of the continuous stall current (#5.07). It should be noted that this cannot exceed 175% of the **Unidrive rated current.**

6. Effects of Application Duty Cycle:
Any application will have a duty cycle which will affect the size of the motor and drive required. For example if the application is always accelerating and decelerating with no dwells between moves the motor and drive continuous stall rating will need to be equal to peak current of the application as described in paragraph 5.
Note that stall and rated torque for a given motor may be increased by use of a manufacturer supplied blower kit. Contact Control Techniques sales for details of these.

Speed torque curves:

These are graphs produced for a given motor and drive combination which show the relationship between speed and continuous and peak torque output. The example below shows the curve for the 95UMB300 motor used with a Unidrive model UNI1403 set at 6Khz switching frequency.



The motor documentation for the 95UMB300 gives the torque constant (Kt) as 14.16 lb-in / A. Therefore the peak current for the above curve is = 94.1 / 14.16 = 6.645A and the stall current = 34.5 / 14.16 = 2.44A.

Undrive parameter #5.07 would therefore be set to 2.44. The **maximum** value for parameters #4.05, #4.06 and #4.07 would be 272%.

Checking the rated current for a UNI1403 at 6Khz switch frequency gives 3.8A therefore its peak current rating would be 3.8 * 1.75 = 6.65A. This confirms the data given in the above curve.

Overcurrent Protection Features of the Unidrive.

Introduction:
If the load on the motor causes current to be drawn in excess of the motor continuous values the following will occur assuming no drive motor protection parameters had been set:

1. The motor winding temperature will rise more quickly dependent on the actual excess of current draw over the continuous rating.
2. If the current excess is permitted to continue the temperature will eventually stabilize at some value beyond the maximum permissible allowed (in our example 135 degrees). This would either burn out the windings or if the installation is correctly implemented the motor thermal protection device (thermostat or thermistor) would operate and trip the drive.

3. The following Unidrive parameters therefore need to be correctly set up in order for the drive to provide motor protection before the last resort thermistor trip occurs.

Thermal Time Constant #4.15
The motor manufacturer often has derived a thermal time constant for the motor windings. One time constant is the time in seconds taken for the winding temperature to reach 63.2% of the maximum temperature with rated current flowing. This data may not always be published by the motor manufacturer. The values for the Unimotor range are tabulated in appendix A of this document For Magna and NT motors use of the value for a similar sized Unimotor is suggested.

Motor Continuous Stall Current #5.07
Application required peak current limits #4.05, #4.06 and #4.07

Operation of the Unidrive Protection Scheme.

1. Instantaneous over current trip **OI.AC** will occur if current draw exceeds 215% of the drive rated value. This is primarily to protect the Unidrive not the motor.
2. The **"It"** accumulator overload **It.AC.** This will occur when the thermal overload accumulator, parameter **#4.19** Reaches 100%. The effect of this depends on the setting of parameter **#4.16.** If #4.16 is set to its default value of 0 the drive will trip but if #4.16 = 1 then the drive output current will fold back to the motor stall current set in parameter **#5.07.** The way in which the overload accumulator functions is explained in the following section of this document.
3. Peak current limits. These are the values loaded into parameters **#4.05, #4.06** and **#4.07.** The drive will limit its maximum output current to these values. A typical servo application will use the symmetrical limit in parameter **#4.07.**

Thermal Accumulator (parameter #4.19).

If the motor rated current (**#5.07)** and the motor thermal time constant (**#4.15)** have been correctly set the accumulator will model the winding temperature of the motor. This is scaled such that the trip or fold back point of 100% equates to a motor winding temperature = 105% of the maximum. The time to trip (or fold back) for a given maintained overload can be calculated using the following formula.

$$T = -(\#4.15) * \ln(1-(105^2 / (\text{current as \% of } \#5.07)^2))$$

As an example assume the following :

1. Rated current (#5.07) = 10 amps
2. Actual current draw = 15 amps = 150%
3. Thermal time constant (#4.15) = 89 secs.

Therefore:

$T = -89 * \ln(1-(105^2 / 150^2)) = 60$ seconds

In reality this is an oversimplification since a servo motor will usually be performing a more or less complex motion profile. This should be be taken into account by using the current draw in the acceleration, steady motion, deceleration and dwell phases of the profile to calculate the RMS current. Input the calculated RMS current as a percentage of motor rated current (#5.07) to the above formula to calculate the trip or current fold back time.

In a correctly sized application the RMS current will be less than the rated current of the motor so that a trip or fold back should not occur during normal operation.

Notes:

1. Assuming all the relevant parameters are correctly set and with a running motor the accumulator will always display a value equal to the motor winding temperature expressed as a percentage of the trip point temperature.
2. If the motor has been running at its rated current for sufficient time for the winding temperature to reach and stabilize at maximum, **any** over current will **(and should)** cause a trip or fold back to occur after a very short time.

Appendix A.

Unimotor winding thermal time constants.

The values in the following table should be directly input to parameter #4.15

Motor	75A	75B	75C	75D	95A	95B	95C	95D	95E
#4.15	90	102	120	131	91	116	129	145	166

Motor	115A	115B	115C	115D	115E	142A	142B	142C	142D
#4.15	52	77	86	97	102	75	98	119	133

Motor	142E	190A	190B	190C	190D
#4.15	139	112	149	188	195

Note: Unidrive software versions 3 and later have a maximum value for parameter #4.15 of 400 secs. In earlier versions of software the maximum was 89 secs. Unidrive software earlier than Version 3 was therefore unable to correctly model the thermal characteristics of all these motors and premature trips may occur.

Questions ?? Ask the Author:

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