The Application Note is pertinent to the Quantum III / Mentor II Regenerative drives

Adjustable Brake / Dynamometer Applications

This application note will discuss the use and setup of Mentor II / Quantum III Regenerative drives in “loading” type applications such as “brakes” for unwind stands and motor test stands.

Unwinder

On unwind stands, braking torque is often created through the use of friction brakes and eddy current type brakes. Friction brakes wear out over time (need to be replaced) and usually need to be re-adjusted as they wear and even heat up. Eddy current brakes offer better control of the braking torque but is not very energy efficient.

Dynamometer Test Stand

Dynamometer applications in many cases use a water dynamometer to load down a motor for test purposes. These units do not use any electrical energy but do create heat. They also require water supply and drain connections.
AC motor/drive solutions can be used with multi-drive "common bus" configurations but for single motor/drive situations, a AC Regenerative Drive solution is usually quite expensive. A non-regenerative AC motor drive solution could be applied but would require the application of a continuously rated DB (dynamic braking) resistor. This method would be quite inefficient as the braking energy has to be continuously dissipated into heat.

The DC motor (being used as a generator) approach employing a Quantum III / Mentor II Regenerative Drives offers a high degree of energy efficient operation since the mechanical braking energy is converted to electrical energy and regenerated back to the power line thereby recovering most all of the energy used plus the braking levels are precisely controlled and ultimately more repeatable. This Application Note will discuss how one can use the Quantum III / Mentor II drives to provide adjustable braking torque for applications such as:

Product Unwinding applications
V-Belt, Chain Testing machines
Motor Test Stands
or any machine needing hold back torque

In both of these applications, the motor current (torque) needs to be controlled independent of motor speed. Many might think that the drive should be set up as a current regulator, but this is, in most cases the wrong approach. Take the unwind application for instance, when the material runs out, there is no load on the motor. If the drive is set as a current regulator, the drive still "forces' current into the armature causing the motor to accelerate to whatever speed the motor can get to, sometimes as much as twice base speed. This would be a dangerous situation. In the case of the motor dynamometer test stand if the motor being tested trips out (or shuts down for any reason), again the load motor will run away to high speed.

What is the best approach? Set the drive as a speed regulator with a zero speed reference and use the current limit of the drive to control the amount of torque that will be used to enforce the zero speed demand. In this approach, the drive tries to hold zero speed with only as much current (or torque) as the current limit setting will allow. If the external load on the motor decreases or goes to zero the motor will simply stop.
The figure 1 shows a basic diagram of the drives speed and current loop as configured for the brake control. When speed feedback is zero (motor is at zero speed) the output of the speed loop will be zero and there will be no voltage across the remote current / torque potentiometer. The current reference would be zero and thus command no armature current. When the material starts to pull and cause the motor to turn, the speed feedback signal will start to increase in value causing the output of the speed loop to supply a voltage across the remote current / torque potentiometer. This voltage will then create a current reference based on the setting of the potentiometer causing current to flow into the armature generating braking torque in the motor. Since the pulling force of the material is stronger than the braking torque of the motor, the motor would accelerate to an rpm where the surface speed of the unwind equals the line speed of the material being pulled off. If for some reason the material breaks or stops pulling, the current in the motor will cause the motor to slow down to zero speed. The speed loop output will go to zero and the motor current will then go to zero. A similar situation as described above occurs in the dynamometer application.
Implementation

The first thing that needs to be done is to set the speed reference to zero. Since the default speed reference register is #1.17 (this is where the standard speed pot input writes to), we will use it for a zero speed reference by “disconnecting” the speed pot from controlling it and setting its value to zero. To disconnect the analog input from register #1.17, the analog input destination register #7.15 would normally be set to zero (do nothing value). Since we are going to need a torque / current limit input we might as well change the destination of the standard speed potentiometer input to write to #4.04, the overriding current limit register, which will give us our external torque / current limit control. To make this change, you must first change parameter #7.10 to 404, press the reset button (for the change to take effect) and then set parameter #1.17 to 0 (see next page).
Limiting the range of Current/Torque Limit

In many applications, it is desirable to limit the range of adjustment of the remote current limit / torque potentiometer. By placing a resistor in series with the potentiometer, as shown below, this limiting can be achieved. Calculation of the resistor values will be demonstrated in the example below.
Example #1 -- Unwinder

Suppose you have an Unwinder, as shown below, and the process requires the “hold back” torque to decrease as the roll builds down in order to maintain constant tension. Suppose that at full roll the motor needs 80% current (torque) and since the “build down” is 4:1, the current at core would be 20%. In order to do this, a “lay-on” roll would be required. To make things easy, the span of the potentiometer is such that at full roll, the potentiometer is fully clockwise and at min, or empty roll, the potentiometer is fully counter clockwise.

Motor Data: 10HP, 1750 RPM, 500VDC, 18 Amp Armature current.
Drive Data; Quantum III Regenerative Drive, 20 HP max, 9500-8602

The Quantum III Drive when programmed for 10 Hp at 500vdc armature is capable of supplying 30.6 amps (150% armature current) when the current limit is set fully clockwise (#4.04 = 1000). In this application we need to limit the current to a range of 3.6 amps to 14.4 amps. Based on the above, we need to select resistors such that;

If the current limit pot (connected to the “lay-on” roll) is fully counter clockwise the voltage at the wiper is:

\[ V_{\text{min}} = \frac{\text{desired current}}{\text{Max current}} \times \text{Voltage at max current demand} \]

\[ V_{\text{min}} = \frac{3.6 \times 10}{30.6} = 1.17 \text{ vdc} \]
If the current limit pot (connected to the “lay-on” roll) is fully clockwise the voltage at the wiper is:

\[
V_{\text{max}} = \frac{\text{desired current} \times \text{Voltage at max current demand}}{\text{Max current}}
\]

\[
V_{\text{max}} = \frac{14.4 \times 10}{30.6} = 4.7 \text{ vdc}
\]

The drawing above shows the voltage levels needed across the lay-on roll potentiometer to achieve proper motor current levels at core and full roll. The values of the resistors, \(R_{\text{max}}\) and \(R_{\text{min}}\) can now be calculated.

In order to calculate the resistor values, \(R_{\text{min}}\) and \(R_{\text{max}}\), we need to determine the current flowing through the network. Since we know the voltage drop across the potentiometer and its resistance, the current can easily be calculated.

\[
I_r = \frac{\text{Voltage across potentiometer}}{\text{potentiometer resistance}} = \frac{4.7 - 1.17}{5000} = 3.53 \text{ vdc}
\]

\[
= 0.706 \text{ milliamps (ma)}
\]
Rmin can now be calculated:

\[
R_{\text{min}} = \frac{\text{Voltage across } R_{\text{min}}}{\text{Current through } R_{\text{min}}} = \frac{1.17 \text{ vdc}}{0.706 \text{ ma}} = 1657 \text{ ohms}
\]

Use 1.6K 5%

Rmax can now be calculated:

\[
R_{\text{max}} = \frac{\text{Voltage across } R_{\text{max}}}{\text{Current through } R_{\text{max}}} = \frac{10 - 4.7}{0.706 \text{ ma}} = 7507 \text{ ohms}
\]

Use 7.5K 5%

**Alternative Potentiometer Connection**

The above example shows how to calculate the resistor values in the circuit. The resistors, Rmin and Rmax may be eliminated by using the flexibility of the Quantum III / Mentor II drive with its analog outputs and the ability to scale the analog inputs and outputs. This simplifies the overall circuit since all that is needed is the external 5000 ohm potentiometer.

To accomplish this task we need to adjust the gain of the analog input such that with 10vdc input we get a current demand of 14.4 amps (when the potentiometer is fully clockwise) and “create” a voltage at the bottom, or counter clockwise side, of the potentiometer to get the 3.6 amps (when the potentiometer is fully counter clockwise). To do this we must calculate the values of register #4.04 that correspond to 14.4 amps and 3.6 amps.

\[
\text{Desired Current} \times 1000 = #4.04
\]

**MAX Drive Current**

\[
\begin{align*}
14.4 \times 1000 &= 470 \\
3.6 \times 1000 &= 117 \\
\frac{30.6}{30.6} &= \frac{117}{470}
\end{align*}
\]

To set the maximum current demand, (10 vdc = 470 in register #4.04) all we need to do is set the scaling parameter for analog input #7.20 to 470.

To set the minimum current demand, we need to calculate the required voltage at the counter clockwise end of the potentiometer. Since 10 vdc now equals 470, 2.49 vdc would equal 117.

\[
\begin{align*}
117 \times 10 \text{ vdc} &= 2.49 \text{ vdc} \\
\frac{470}{470} &= \frac{117}{470}
\end{align*}
\]

To create this voltage at the counter clockwise side to the potentiometer, we will connect the counter clockwise side to the potentiometer to an analog output, then control its magnitude by setting its source register to an application parameter in menu #15 (#1506 for example) and then adjust its value to give the correct output voltage.

\[
\text{Output voltage} = \frac{\text{register Value} \times 10 \text{ vdc}}{\text{Max allowable value of register}} = \frac{\text{register Value} \times 10 \text{ vdc}}{1999} = 2.49
\]

register Value = 498
Example #2 -- Dynamometer Test Stand

The dynamometer test stand is much simpler to set up. Normally there is only a “torque” potentiometer which adjusts from 0 to 100% motor torque. The “digital” zero speed reference is the same as for the Unwinder, the “torque” potentiometer is simpler.

Scaling parameter #7.20 = motor full load \times 1000 = \frac{18 \times 1000}{30.6} = 588

Adjust parameter #15.06 (in menu #15) so that terminal #14 on TB#2 of the MDA-2B board reads ~ 2.49 volts and parameter #4.04 reads 117 with potentiometer fully counter clockwise.
Enhancements

In both examples, it may be desirable to read out motor torque in ft-lbs. This is easily accomplished by changing the scale factor for the drive current readout register #5.02. Normally parameter #5.05 is set to the drive maximum current based on the selected burden resistor. In these examples, the drive was programmed for 10 HP. The motor rated current was 18 amps. For a 10 horsepower motor, the rated motor torque would be:

\[
\text{Torque} = \frac{\text{HP} \times 5250}{\text{Rated Speed}} = \frac{10 \times 5250}{1750} = 30 \text{ ft-lbs}
\]

Since the drive can output 30.6 amps max, the maximum torque would be:

\[
\text{Max Torque} = \frac{30.6 \times 30 \text{ ft-lbs}}{18 \text{ (motor rated current)}} = 51 \text{ ft-lbs}
\]

Therefore parameter #5.05 would be set to 51, and the readout @ #5.02 would read motor torque in ft-lbs

Questions: Ask the author ??
Steve Zaleski Email: mailto:steve.zaleski@emersonct.com Tel: 716-774-1193