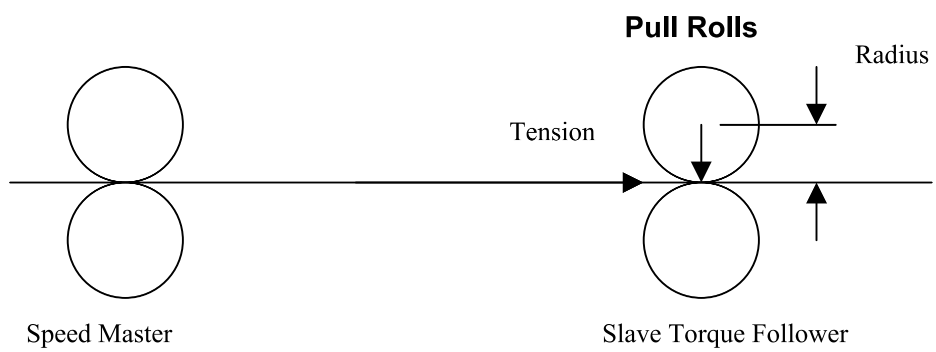
The Application Note is pertinent to the Mentor II/ Quantum III Family

Tension Follower

A common drive application need is for a slave drive to follow a master drive in a Tension mode. Typical applications include Pull Rolls, Scrap Winders and similar tugging followers. In these type of applications, the slave follower merely needs to tug on the product to create a tension perhaps to keep out wrinkles for example. A basic Speed Follower (ratioed) typically would not be able to control Tension well (unless the material is extensible). It would make the Slave be either a little too fast or a little too slow. Being too slow would be obvious (material would begin to sag) but a little too fast would cause the drive to go toward current limit and it would eventually trip on a Timed Overcurrent shutdown. If the Master speeds up so does the follower but the Tension remains relatively constant. The amount of tension typically needs to be adjustable by an Operator.



In the example above, the Pull Rolls have a constant radius, therefore by controlling the amount of Torque the motor can produce, can in turn control the amount of Tension because:

$$\text{Tension} = \text{Torque/ Radius}$$

For example, if we had a roll with 6 inch diameter (3 in radius) and our motor could supply up to 50 ft-lbs of Torque, we could pull on the strip material to produce up to:

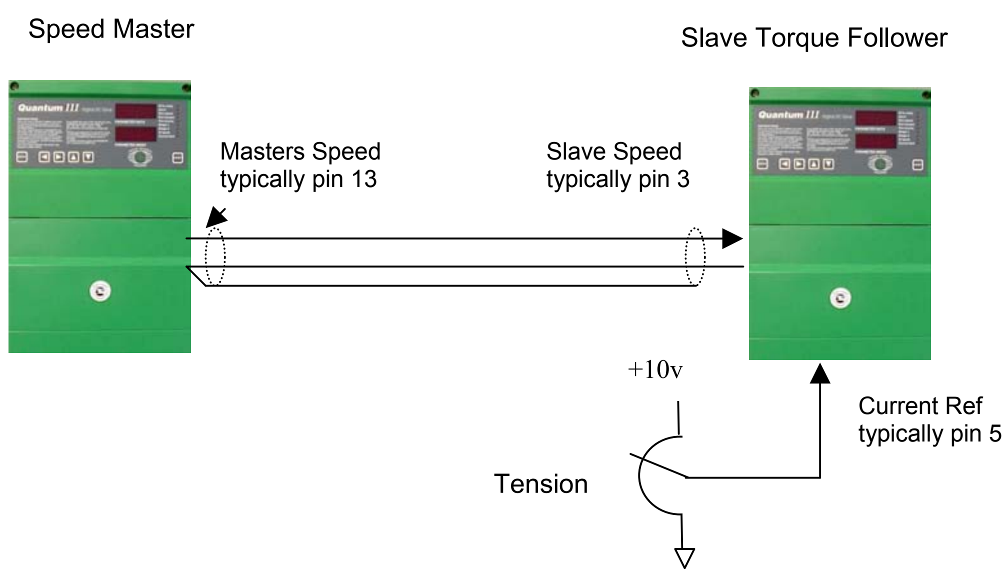
$$\text{Tension} = \frac{50\ \text{ft-lbs}}{0.25\ \text{ft}} = 200\ \text{lbs}$$

Assuming a gear-in of 1:1 otherwise the available Torque would be multiplied by the gear ratio. Of course there are always losses but for general purposes this is a good approximation.

The Mentor II or Quantum III Drives can be configured as a Current regulator which in turn allow them to control Tension per the example above. To be able to regulate tension, the radius must remain constant and the acceleration and deceleration of the line must be slow, otherwise during acceleration the Tension would be reduced because some of the Torque would end up being used to accelerate the inertia and not become tension. But for many modest applications this type of control would be acceptable. For absolute control of Tension, one would need to run the drive as a Speed Regulator with Tension Trim which would require genuine Tension Feedback from a Force Transducer (Load Cell).

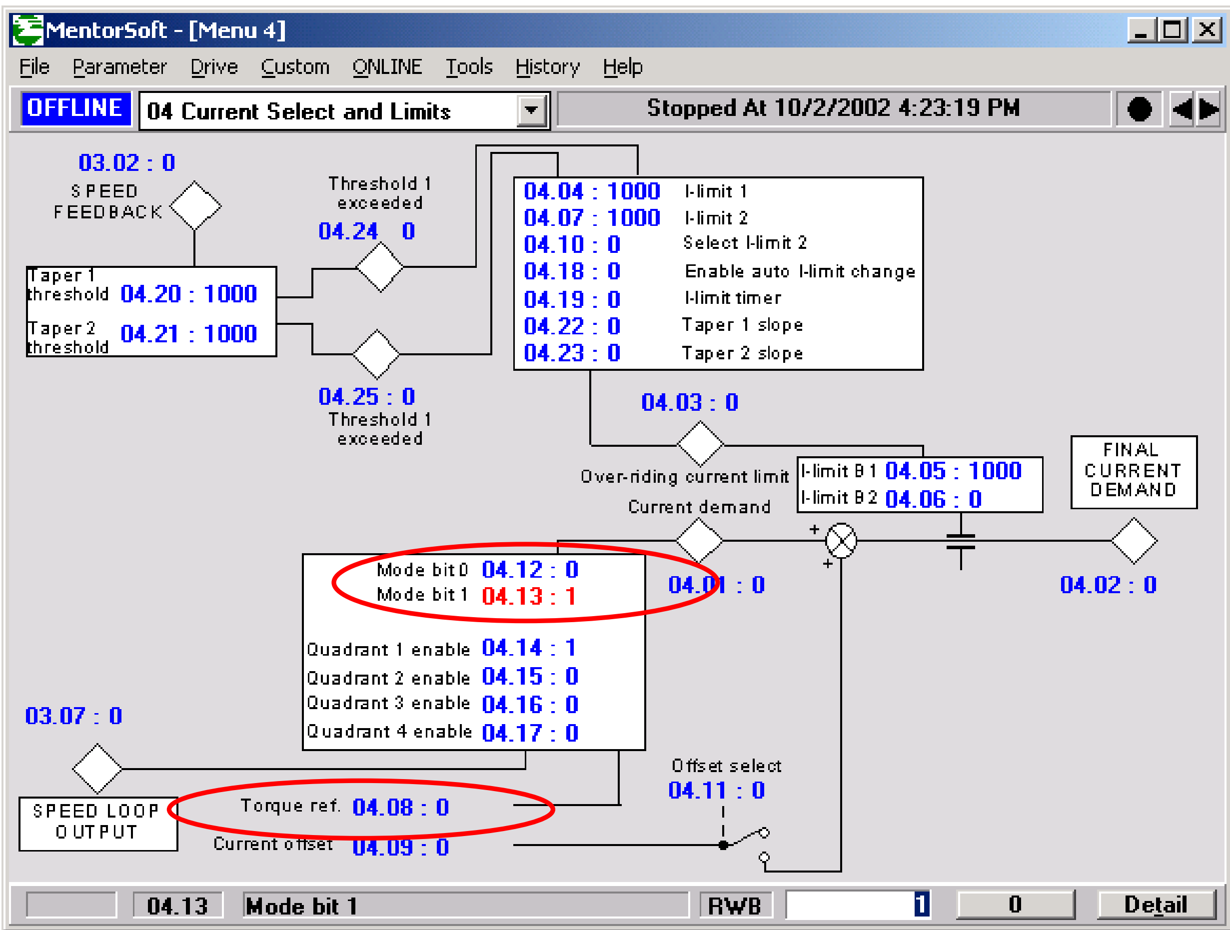
One problem with a Current Regulated Drive is that the current being regulated makes torque that will cause the motor to accelerate. If there is no shaft load (ie the Material Web Breaks or hasn't yet been threaded thru or the Pull Rolls not yet closed) the motor continues to accelerate and can attain unsafe speeds in a very short time.

To help prevent such situations, the Mentor II/Quantum III have another mode called Torque w/Speed Override. When this mode is used, the same scenario would hold true except the motor speed would be clamped at a level set by an incoming speed reference. This speed reference could be a fixed number preset into the drive so as to produce no more than the maximum speed of the motor. But a better method is to take the speed of the Master drive and feed it to the slave for this clamping purpose. However, when this mode is used, the speed reference must exceed the speed that would be developed during it's "Tension" control. To accomplish this, one could multiply the incoming Speed Reference by an amount of 5-10%. This provides enough reference to insure the Speed Loop output is saturated so that the current regulator would be in control. Should the material break at say 50% Line Speed, the followers Torque would cause its' motor to accelerate but its' Speed would be clamped at 5-10% above the Masters incoming speed.



Configuring for Torque w/Speed Override

When parameter #4.12 and #4.13 =0 (the factory default) , the drive operates as a Speed Regulator. To invoke the Torque w/Speed Override mode, you would make #4.13=1. This could be a permanent setting or be controlled by an external input. For instance, you might want to have a contact called Tandem that would throw the Slave into the Torque w/Speed Override mode. If the Tandem switch is not on, the Slave could be made to remain in the Speed mode and the Tension pot could be the Speed reference (to save installing another pot- but this could cause operator problems however as he might forget to reset the pot before he changes modes).



The Torque (Tension) reference is normally directed to #4.08 from terminal 5 from A/D #2.

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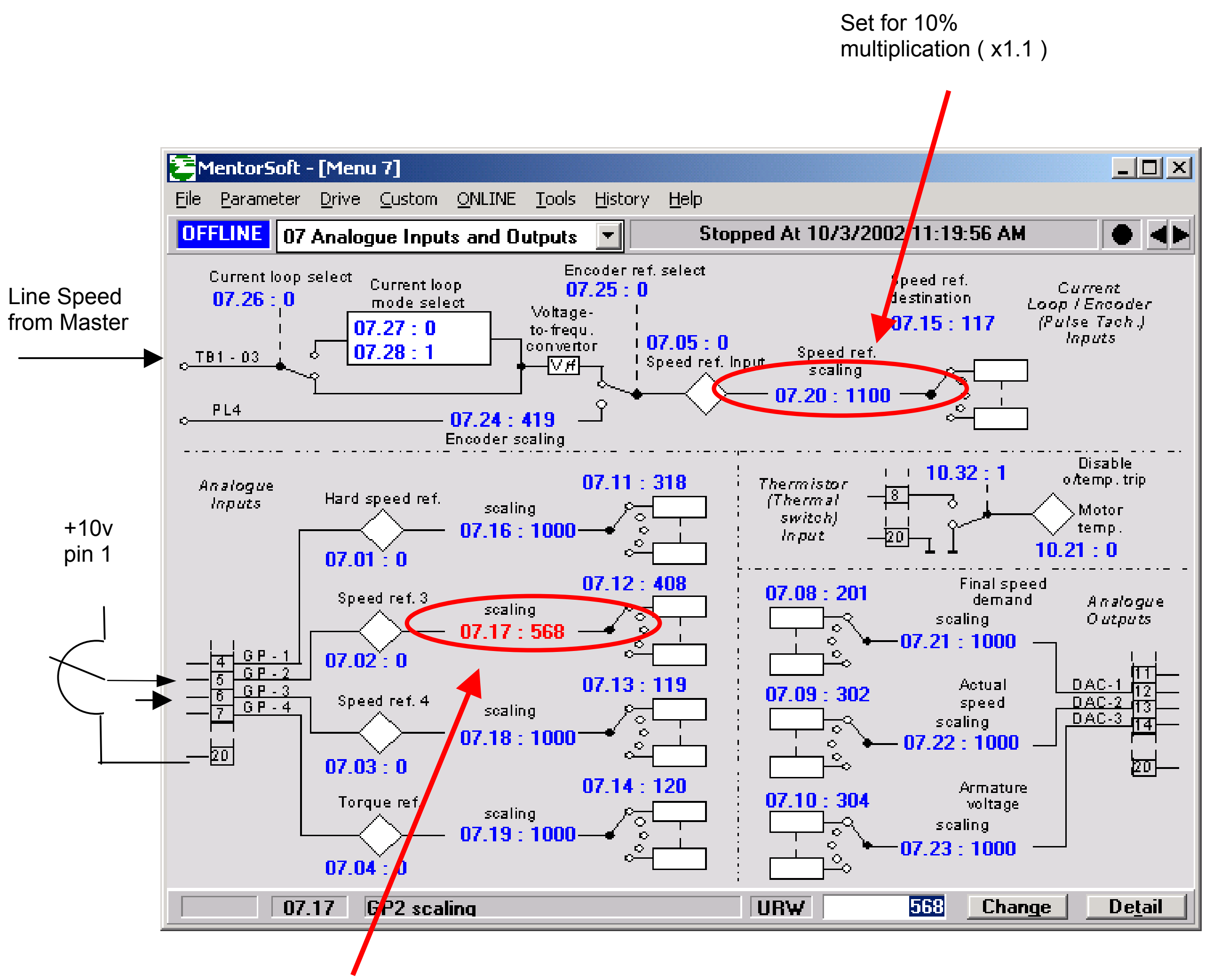
Tension Reference



The scaling register #7.17 would need adjusted so that +10v would request no more than 100% of your motors FLA. For example, suppose your motors nameplate FLA was 25A and you were using a Quantum III model 9500-8602. You would have installed the 14 ohm current scaling resistor that scales the drive for 29.3A = 100%. In Mentor/Quantum current units, 1000=150% current, therefore 666 =100% or in this case 29.3A. We don't want 100% of the drive but rather 100% of the motor which is 25/29.3 = 0.853 or 85% of the drive which becomes 85% of 666 or 568. So for this example we would place 568 into #7.17 so that when the Tension pot is set to full +10v, 1000 appears at #7.02 but gets multiplied by 0.568 becoming 568 directed to #4.08 for Current Reference.

Mentor II Example

A similar example for a Mentor II might be where the motor FLA is 57A being driven with an M75 Drive. An M75 Mentor II can deliver 75A at 100% or 666 in current units (#4.08). We do not want 100% of the drive but rather 100% of the motor, which is 57/75 or 0.76 or 76% of the drive rating. Since 100% = 666 current units, we wants 0.76 * 666 or 506. So for this example we would place 506 into #7.17 so that when the Tension pot is set to full +10v, 1000 appears at #7.02 but gets multiplied by 0.506 becoming 506 directed to #4.08 for Current Reference.

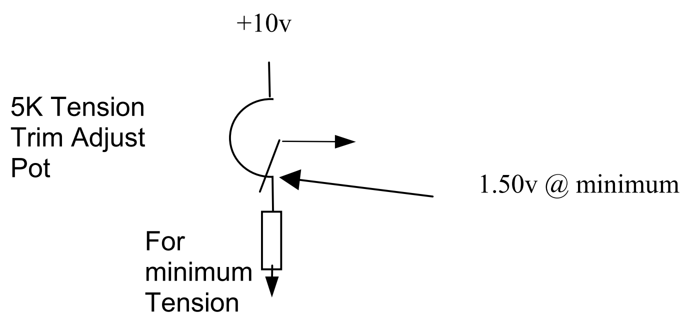
Minimum Tension

As far as the minimum Tension, one method might be for one to place a fixed resistor on the low end (counter clockwise CCW) of the pot (or put a trim pot there also).

If the minimum tension is to be 15% , this would mean the :

$$\text{Minimum Voltage} = \frac{\text{Min Tension}}{\text{Max Tension}} = \frac{15\%}{100\%} = 0.15 * 10v = \underline{1.5 volts}$$

If we were to use a 5K Operator pot for the adjustable Tension what value of resistor would we need ?



Using Kirchoff's law, and knowing that we want the wiper of the pot to see 1.5 volts when it is rotated fully CCW , the voltage across the pot would be 10v-1.5 or 8.5v. Using Ohm's Laws, this voltage of 8.5v across a 5K pot would mean there is 8.5v/5000 or 1.7mA flowing. Therefore, the minimum Tension resistor would be 1.5v/1.7mA or about 880 ohms. This would keep the Tension bounded between 15%-100%.

Alternate Method of Achieving an Adjustable Minimum Tension

The previous method of using a fixed resistor to develop a voltage division is simple but would not be easily adjustable (unless we were to use a trim pot). By placing 1.5v on the CCW end of the pot and connecting the CW end to 10v, we can see how we could span between our desired Tension limits.

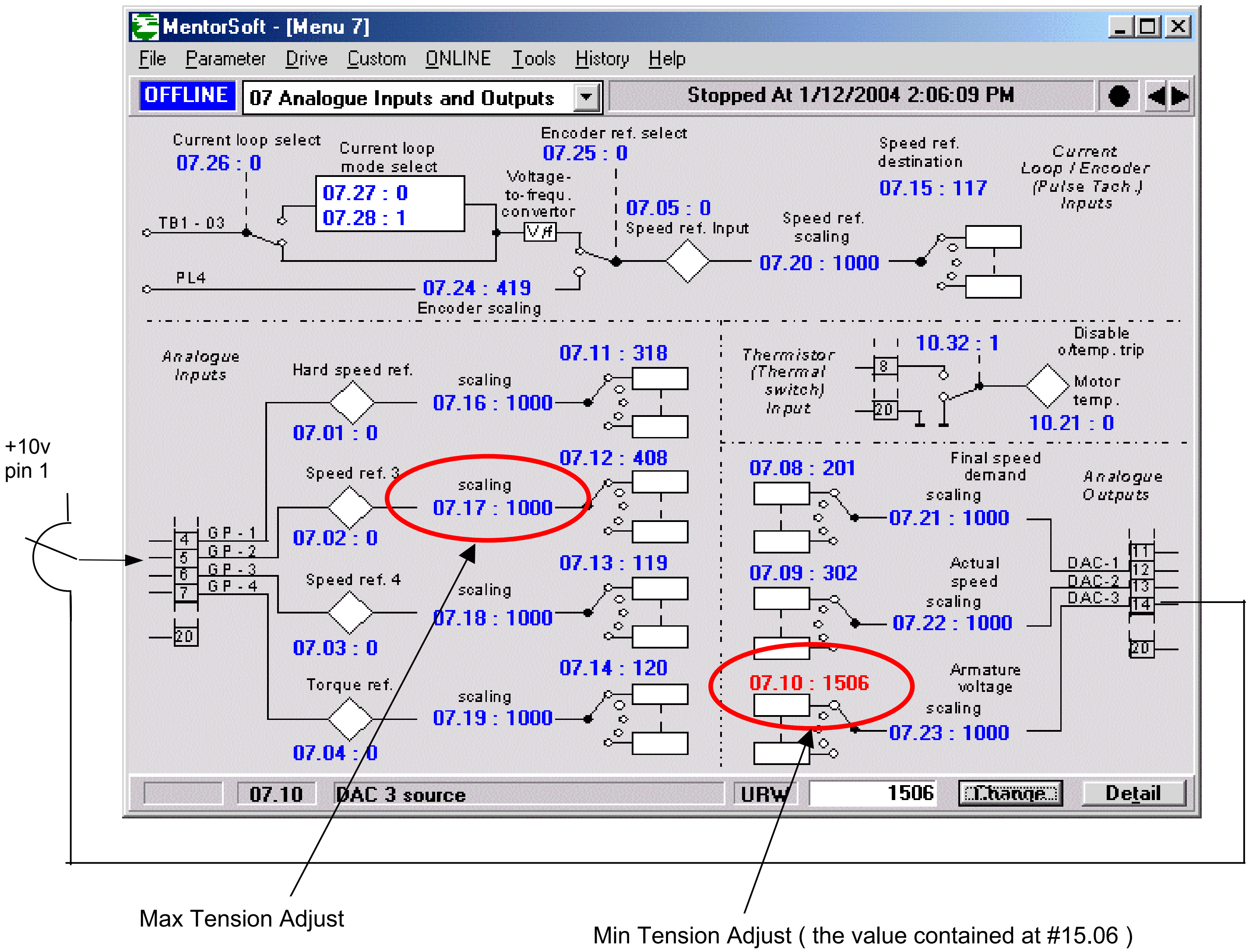
A more clever method would use one of the programmable analog outputs to develop 1.5v for the CCW end of the pot instead of using voltage division. To accomplish this, we could use one of the free registers residing up in menu 15 and 16- specifically 15.06 – 15.10 or 16.06 – 16.10. These registers hold a number from 0-1999.

By attaching one of the free D/A converters to one of these registers, one could adjust the D/A output to span between 0 to 10v. In our case for the above minimum Tension example, we want 1.5v. To accomplish this we would place the following number in one of these free registers:

$$\frac{\text{Desired Voltage}}{10\text{v}} \times 1999 = \underline{1.5 \times 200} = \underline{\mathbf{300}}$$

Since any register within the range mentioned above can be used I'll pick #15.06 in which to place this number. With the Tension pot at minimum, one could adjust this value for the appropriate desired minimum. Don't forget to store !

Note: Any of the analog outputs on Pins 12,13 or 14 could be used for this purpose – (as long as they weren't already in use.

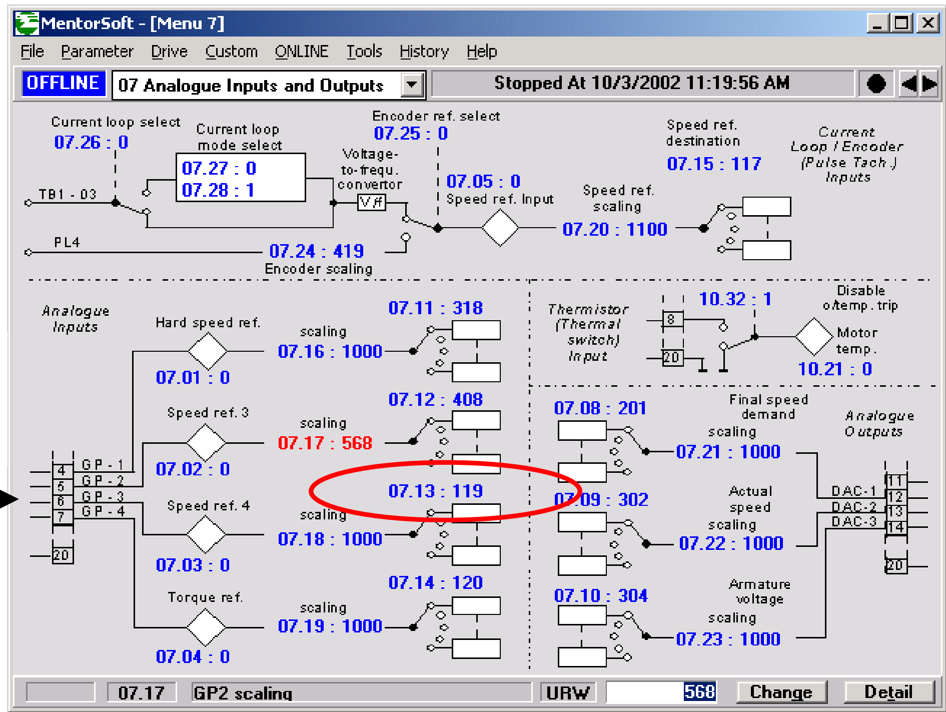


TANDEM OPERATION

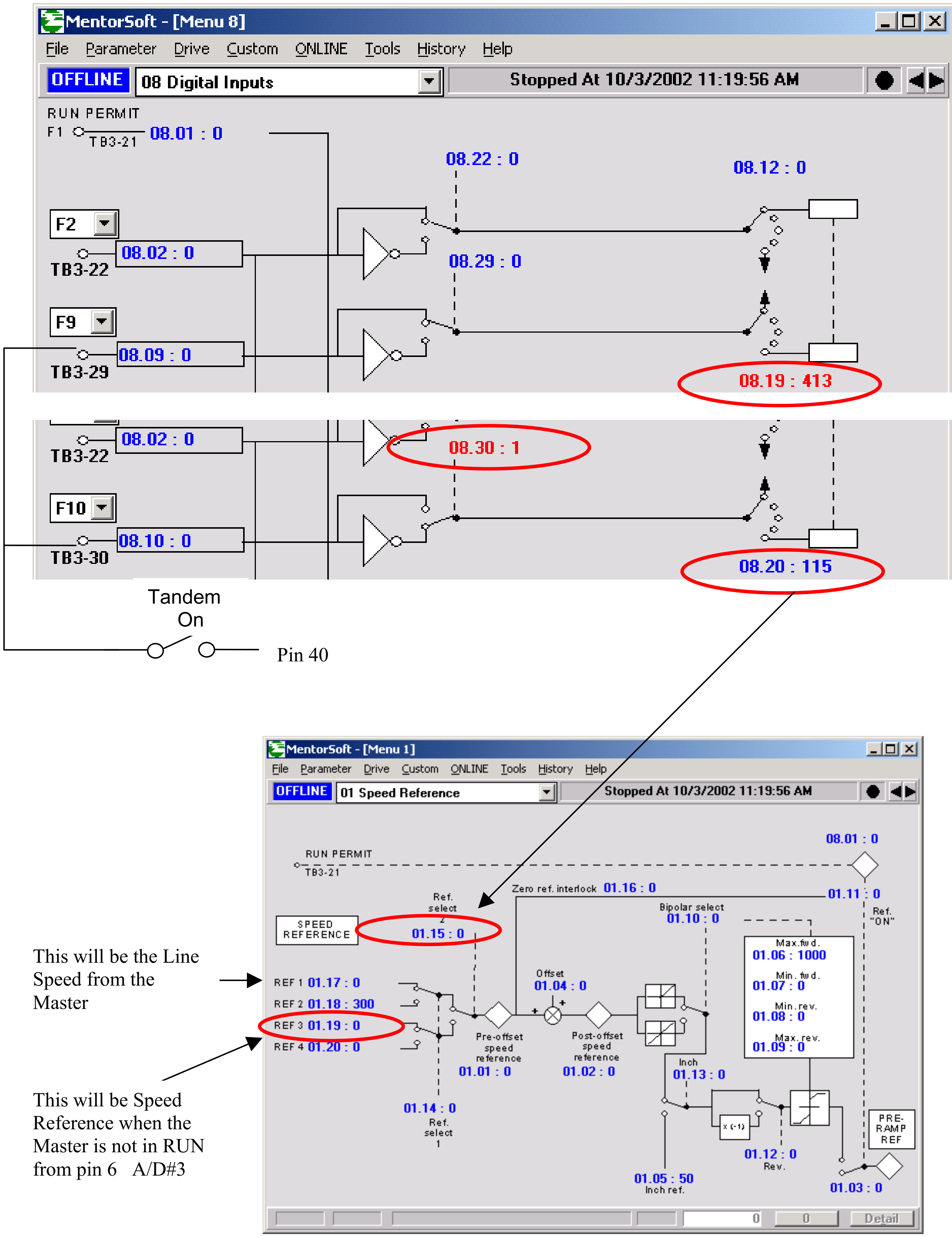
If one would wish to implement that scheme where this pot would control Tension if the Master was on but control speed of the slave when the Tandem switch was not ON, we could do the following:

We need a contact from the Tandem switch. This will go to the Slave and place it into the Torque Mode and de-select Pin 3 as the Speed Reference when the switch is ON (closed). When the Tandem is not ON, the Slave would go to the Speed Mode and the Speed Reference would be from the Tension/Speed pot (5 & 6) or another independent pot which would be wired to pin 6 or A/D #3.

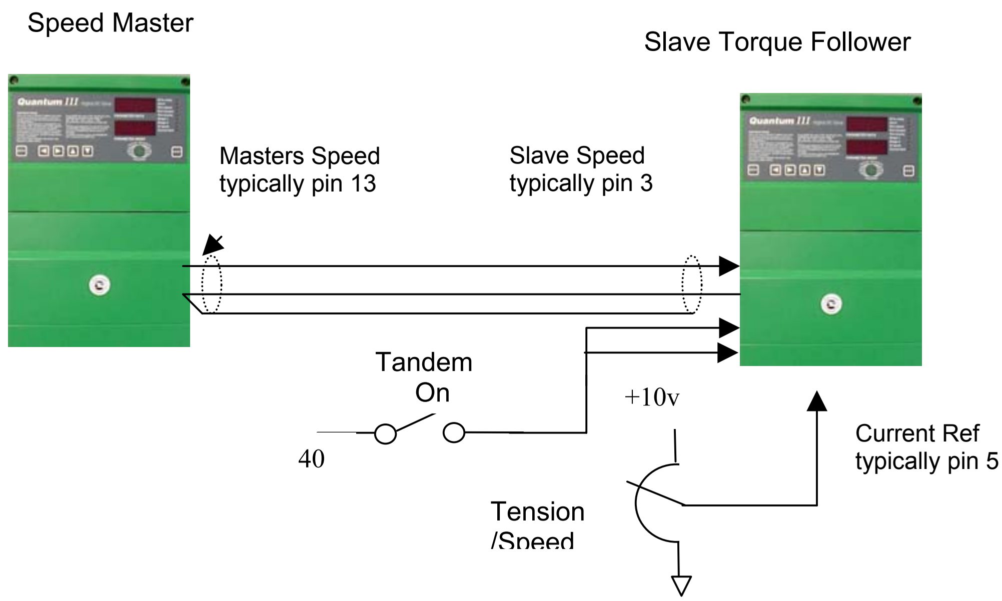
Independent Speed of Slave when Master is not in RUN



The analog input on pin 6 is already being directed to one of the selectable speeds- #1.19. We just need the TANDEM contact perform this selection and the Speed vs. Torque Mode. On a Quantum III we have several free inputs F7-F10.   We could use F9 and F10 which are pins 29 & 30 respectively for this switching.   We would jumper pins 29 & 30 and connect it to the Tandem switch.


MentorSoft - [Menu 8]
File Parameter Drive Custom ONLINE Tools History Help
OFFLINE
08 Digital Inputs
Stopped At 10/3/2002 11:19:56 AM
RUN PERMIT
F1
TB3-21
08.01 : 0
08.22 : 0
08.12 : 0
F2
08.02 : 0
TB3-22
08.29 : 0
F9
08.09 : 0
TB3-29
08.19 : 413
08.02 : 0
TB3-22
08.30 : 1
F10
08.10 : 0
TB3-30
08.20 : 115
Tandem
On
Pin 40
MentorSoft - [Menu 1]
File Parameter Drive Custom ONLINE Tools History Help
OFFLINE
01 Speed Reference
Stopped At 10/3/2002 11:19:56 AM
08.01 : 0
RUN PERMIT
TB3-21
Zero ref. interlock 01.16 : 0
01.11 : 0
Ref. "ON"
Ref. select 2
Bipolar select 01.10 : 0
SPEED REFERENCE
01.15 : 0
Max.fwd. 01.06 : 1000
Min. fwd. 01.07 : 0
Min.rev. 01.08 : 0
Max. rev. 01.09 : 0
REF 1 01.17 : 0
REF 2 01.18 : 300
REF 3 01.19 : 0
REF 4 01.20 : 0
Offset 01.04 : 0
Pre-offset speed reference 01.01 : 0
Post-offset speed reference 01.02 : 0
Inch 01.13 : 0
01.14 : 0
Ref. select 1
x (-1)
01.12 : 0
Rev.
PRE-RAMP REF
01.05 : 50
Inch ref.
01.03 : 0
Detail
This will be the Line Speed from the Master
This will be Speed Reference when the Master is not in RUN from pin 6 A/D#3

Resultant Layout



Questions ?? Ask the Author:

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