

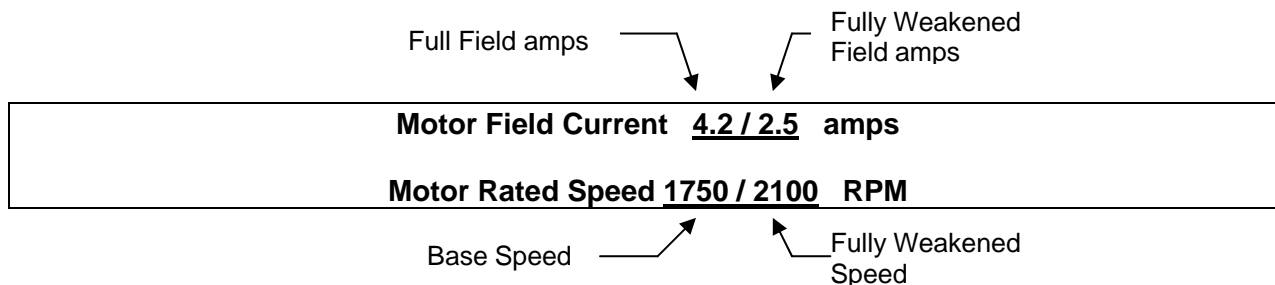
This Technical Note is pertinent to the Quantum III/Mentor II DC Drive Family

Motor Operation above Base Speed Field Weakening

DC motors can be designed for operation above their Base Speed. To accomplish this, the drive will run the motor up to full rated speed (base speed) using full armature voltage and full field current. Then, to obtain greater speeds, the drive will keep the armature voltage constant but reduce the field current thereby achieving higher speeds. This area of operation is often referred to as the:

- Constant HP area
- Extended Speed Range
- Field Weakened zone

As the speed increases, available torque is reduced therefore, delivered horsepower remains the same. Motors that are designed with this capability are known as Field Range Motors and will typically have 2 speeds and 2 Field Currents stamped on the nameplate. See the example below.



The motor will deliver full Torque and Horsepower only at Full Field, Full Armature Voltage and Full Armature amps.

CAUTION

One must never exceed the TOP RPM of the motors designed limits. Motors can self destruct and eject internal components in all directions if RPM's exceed this speed. If the TOP SPEED is not on the Motor Nameplate, we would suggest you contact the Motor Manufacturer for this data.



Quantum III Size 1 Models (9500-8x02 thru -8x06)

To achieve Field Weakened operation the drive needs a Field Controller. Quantum III Size 1 models (9500-8x02 thru -8x06) have a built-in Field Current Regulator capable of supplying up to 8 amps for motor field excitation. This Field Regulator (called MDA3) is controlled via software under Menu 6 within the Quantum III.

Quantum III Size 2 and 3 Models (9500-8x07 and up)

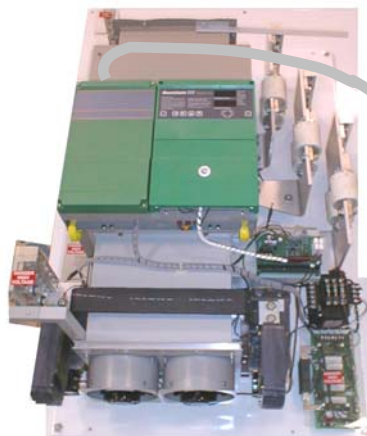
For larger Quantum III models, Size 2 and 3 (9500-8x07 and up), the FXM5 is an available option to provide up to 20A. This Field Controller can be used in a "stand-alone mode" or can be controlled via software under Menu 6 within the Quantum III. If an FXM5 is used in a "stand-alone" mode (not controlled via a ribbon cable), this procedure does not apply.

This guide will outline the basic steps toward Field Weakening. For more specifics on the basic setup of the FXM5 using ribbon cable control click → [CTTN138](#)

For detailed instructions on setting up for Field Weakening using the FXM5 in a Stand Alone mode (without a ribbon connection) click → [CTTN151](#)



Size 2



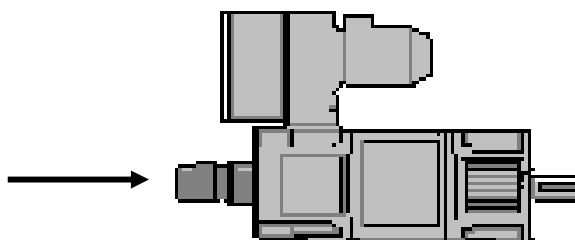
Size 3



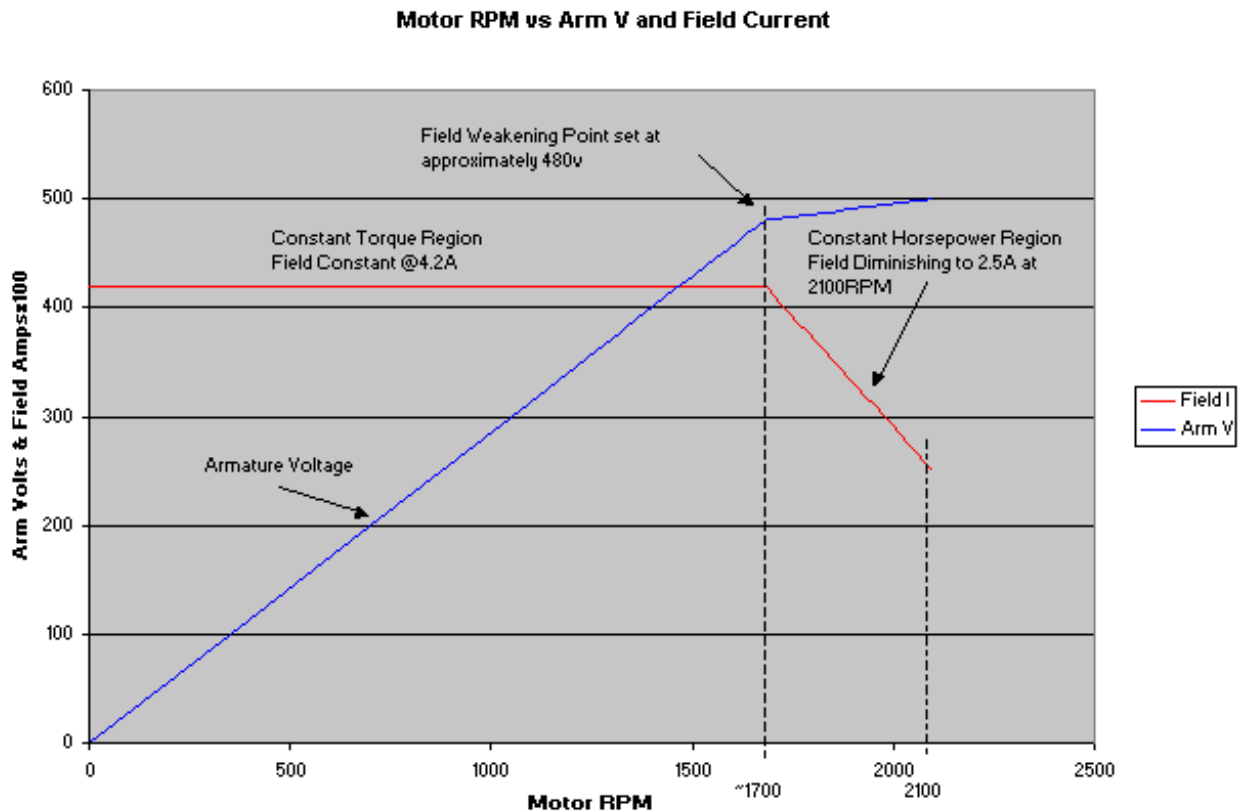
FXM5 External Field Controller

Ribbon control

Note: Your motor will need a speed feedback device such as an AC or DC tach or an Encoder/Pulse Tach to achieve Extended Speed operation.



As stated previously, to accomplish motor speeds above base speed, the Field Current will be weakened but when? The field weakening point is typically set very near the point where the armature CEMF (Counter EMF) becomes near the maximum armature voltage. For a 500v motor, one might set this point at 480v to allow a 20v operating zone for the field weakening area. Secondly, the Field Weakening Regulator must be set to diminish the field at this CEMF point and keep diminishing the field until it reaches the Minimum Field Current setting that is required to achieve the motor speed required for the application (assuming it is below the TOP RPM of course).



The plot above illustrates what will be happening to the field current, armature voltage and the motor speed once the drive crosses over into the Field Weakening Region.


Field Weakening

It is **strongly advised** to perform all the previous steps as outlined in the manual required to commission the Quantum III and motor using a Speed feedback device (AC,DC or Pulse Tachometer) up to the motors' base speed before attempting to achieve operation above in the Field Weakened area. This includes Current Loop & Speed Loop Tuning.

Setting up for Field Weakening

This section will outline the procedure to setup for Field Weakening. It is not the only method but is a rather intuitive “*seat of the pants*” approach. As was mentioned earlier, a motor designed for Extended Speed application will typically have two RPMs and two corresponding Field Current values on the nameplate such as that shown below:

Arm Volts	500vdc
RPM	1750/2500 (The lower number is Base Speed)
Field Amps	4.1/2.2 (The higher number is the Full Field Amount)

 It must be pointed out that just because your motor can spin 2500rpm- it **DOES NOT** mean that your machine was designed to run at that motor speed !!!

Substantial damage to the machine or other hazards could result without consulting the machine manufacturer first in consideration to the maximum machine design limitations.

As indicated previously, your motor must be equipped with a Speed Feedback transducer such as an AC, DC or Pulse Tach to properly utilized Field Weakening. (Keep in mind that AC Tach’s are typically not used with REGEN drive models- Consult Tech Support for advice) Field Weakening can be achieved with any Size 1 Quantum III or any size Quantum III using the FXM5 Field Controller when it is operated via ribbon cable from the main Drive.

This guide will assist with the basic guidance to Field Weaken. For more specific on the basic setup of the FXM5 using ribbon cable control click → [CTTN138](#)

Example

Your motor speed requirements may be less than the upper speed listed on the motor. Suppose your motor nameplate was like the one shown above. If you were applying this drive to an Extruder whose gear-in ratio was 25:1 and you were wished to obtain 85 Screw RPM, what motor RPM would be required.

$$\text{Motor RPM} = \text{Gear-In} \times \text{Machine RPM} = 25 * 85 = 2125 \text{ RPM}$$

Since you need a Tach Feedback signal, we could also calculate what it would be at our full application speed. Suppose our Tach nameplate reads 101vdc/1000rpm

Then our tach voltage at full application speed would be:

$$2125 \text{ rpm} \times \frac{101\text{vdc}}{1000 \text{ rpm}} = 214.625 \text{ vdc} \text{ or roughly } 215\text{vdc}$$

Your motors Top Field Weakened RPM is 2500, but you only need to go to 2125 for your application needs. So, we can obtain the necessary speed by weakening the Field but to what amount? You could calculate a theoretical amount or merely determine the amount experimentally, which turns out to be very intuitive.

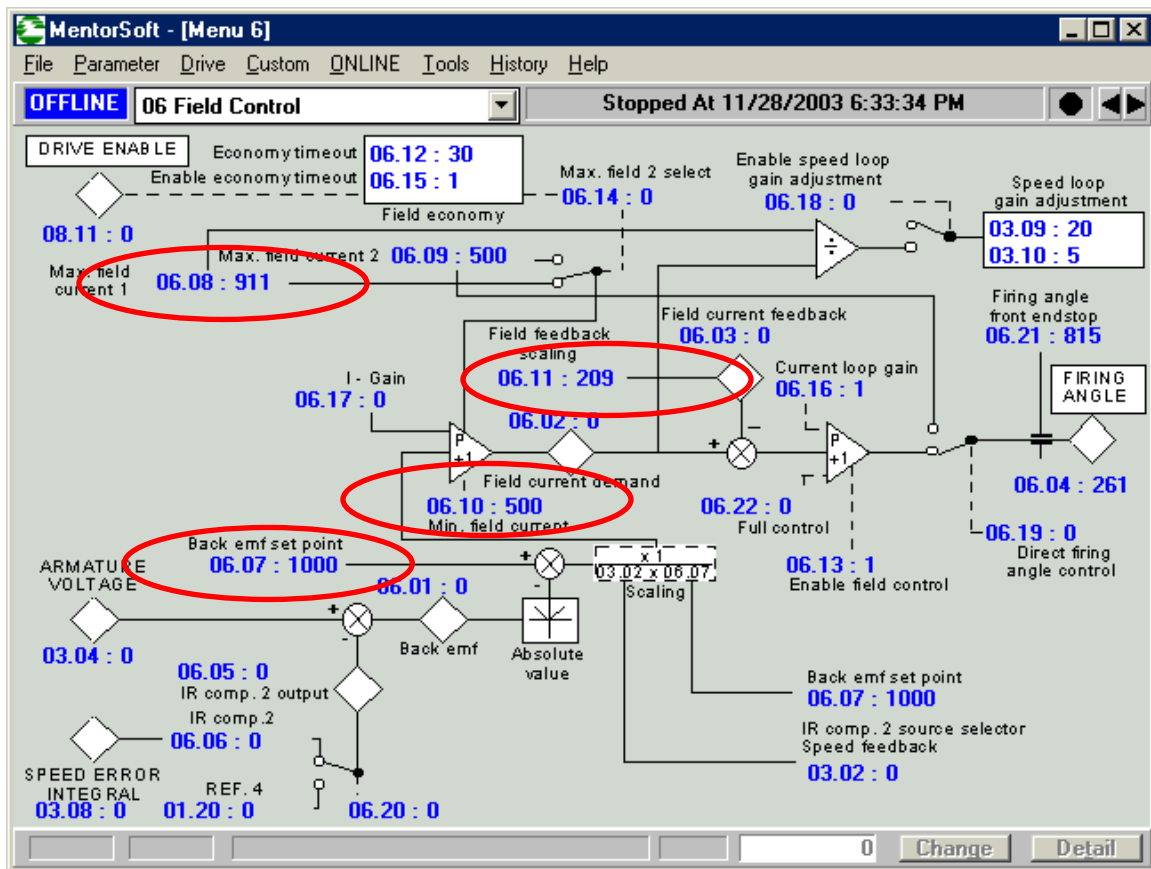
Full Field Settings

Example

Based on the motor nameplate data above, if we are dealing with a Size 1 Quantum III, we would set the Full Field Scaling setting #6.11= 209 to allow us to achieve the 4.1A from the nameplate. (If we were using the FXM5 we would set #6.11= 5). But we don't want 4.5A which the value of 209 would give us. We want :

$$\text{Full Field} = \frac{\#6.08}{\text{Full Field Scaling}} = \frac{\text{Motor Full Field}}{\text{Full Field Scaling}} \times 1000 = \frac{4.1}{4.5} = 0.911 \times 1000 = 911$$

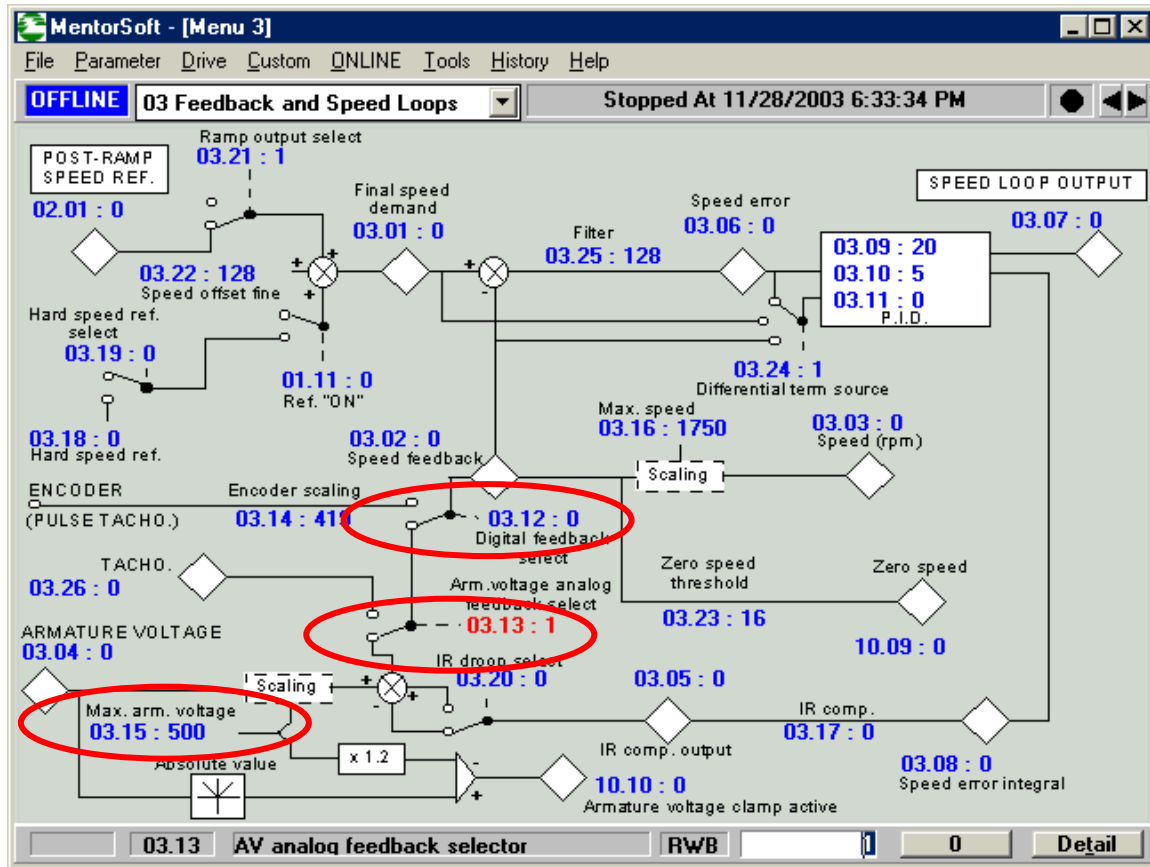
The Field Economy setting and Minimum Field setting , parameters #6.09 and #6.10 respectively, should be at the factory default value of 500. In addition, the Field Weakening Back EMF voltage, parameter #6.07, should be at the factory default of 1000. See the diagram below:



Determination of Field Current Settings


Regardless of whether this is a new drive being set up or a drive being adjusted to obtain additional speed via Field Weakening, we are going to temporarily set the drive up for AVF (Armature Voltage Feedback). This is accomplished by setting parameter #3.13 =1 and ensuring #3.12=0. In addition, we would check parameter #3.15 to ensure that it set to nameplate value for rated Armature Voltage, 500v in this example.

See Diagram below:



Making Parameters Changes

In order to set these parameters, you may need to enter the security code of 200 at any menu xx, parameter 00 or xx.00 (location 0.00 would be valid). Once the security code has been entered, you should be able to get at and change any of the parameters listed.

To see a video on how to do this click here : [CTVI123](#) 

Determination of Minimum Field Current Setting

The following procedure is only to be followed after one has performed the basic drive run-up in the base speed region preferably in Armature Voltage Feedback.

Temporarily reduce the Minimum Field setting #6.10 to say 200. After you've determined your maximum tach voltage based on your required Application RPM and set the Tach Range DIP switch accordingly, attach your voltmeter to the Tach terminals as shown below:

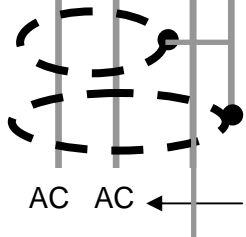
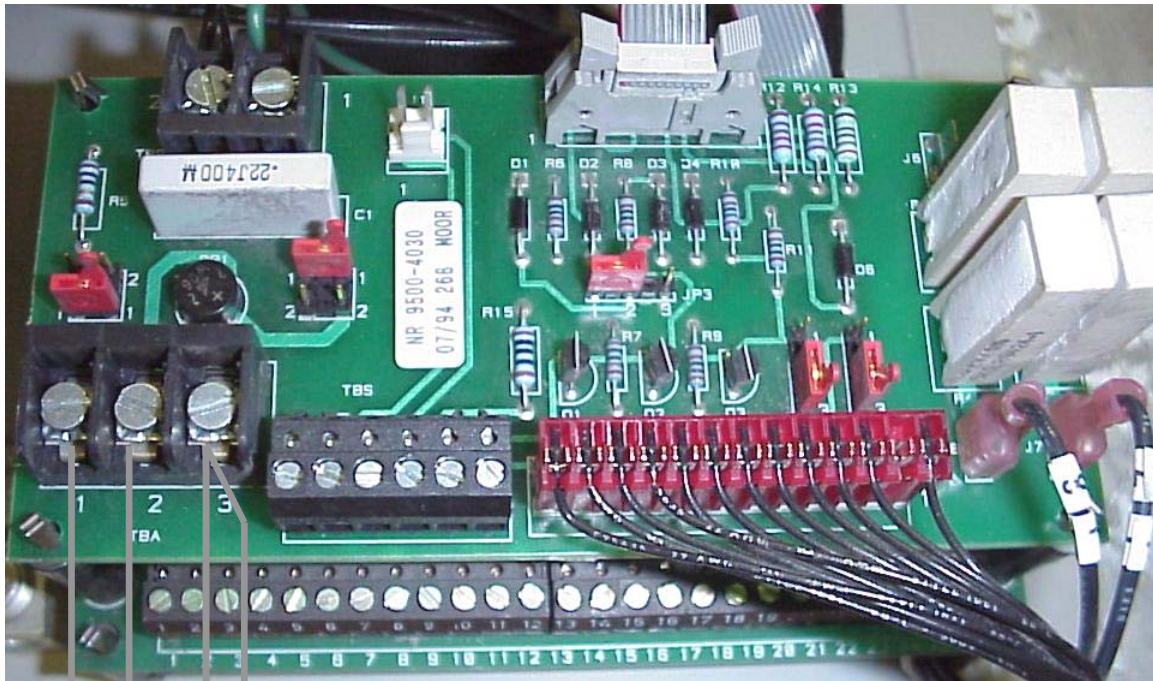


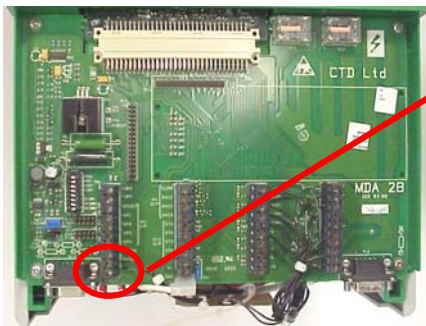
Photo above is for Quantum III Drives only

AC AC ← (if AC Tach used- --- Non-Regen Models only)

DC- DC+ ← (if DC Tach used)

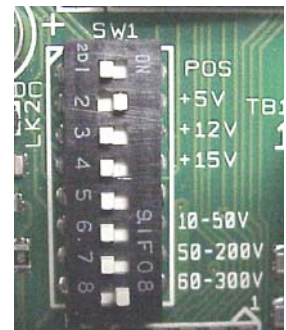
Tachometer Connections

MDA2B Tach Range Setting
(under drive cover)



For Mentor II, DC Tach goes to
MDA2B Board under cover
Terminals 9 and 10

Ranges	
SW 6	= 10 – 50Vdc
SW 7	= 50 – 200Vdc
SW 8	= 60 – 300Vdc



Determination of Minimum Field Current Setting-con't

For the following adjustments - USE THE DRIVE KEYPAD, DO NOT USE MentorSoft TO PERFORM THESE ADJUSTMENTS. The Drive keypad will only change numbers while depressing the UP/DOWN scroll buttons which change at a rate. MentorSoft will permit changes but does not have a scroll function. Therefore changes can occur in steps that are too large and inappropriate for these adjustments. Also a slight mis-entry on a computer keyboard could cause an unwanted step that could result in a bad situation- so for this reason - USE THE DRIVE KEYPAD, DO NOT USE MentorSoft TO PERFORM THESE ADJUSTMENTS.

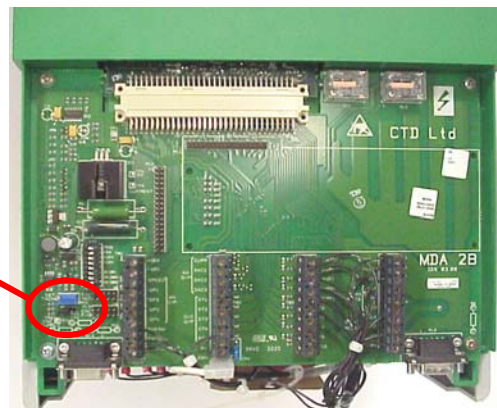
1. Run the motor up again up to full armature voltage (using AVF – Armature Voltage Feedback) using the Full Field Value in #6.08 as determined previously. The motor should be running at Base Speed- verify by measuring your Tach voltage.
2. When you are up to full armature voltage, slowly begin lowering the value in location #6.08 while observing your voltmeter. At first, changes in this location will have little effect (as the Field pulls out of saturation) but suddenly changes will start to have a greater effect.

Keep lowering the value in #6.08 until you attain the required tach voltage per your previous calculations based on your required Application RPM. This will reveal the Weakened Field setting needed to attain your required Application RPM.

Record this as the---- **Weakened Field** value.

If you cannot attain your desired RPM, call Technical Support at 716-774-0093

3. Observe parameter #3.26. Adjust the small blue pot in the lower left of the MDA2B board until #3.26 reads an average of about 999.



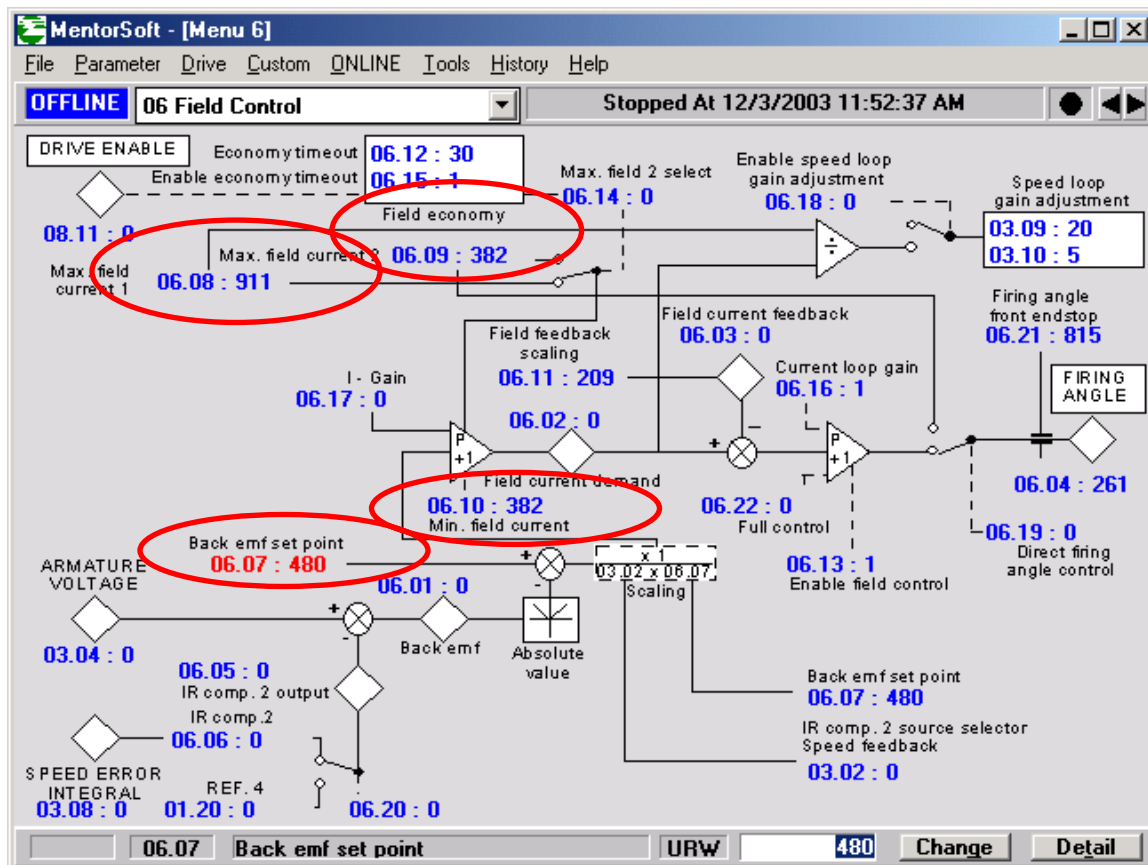
4. It is normal for it to jump around some 10 –20 counts or so. Excessive amounts may indicate Tach problems. After doing this, you have calibrated the Tach Feedback for your required Application RPM.

5. Slowly (very slowly) return the value in #6.08 back up to your Full Field setting (in this example, it was 911). When you've arrived back at Full Field, your motor will once again be at the lower, Base Speed RPM.
6. Reduce the motor RPM and take the drive out of RUN. You are now ready to setup and test for automatic Field Weakening.

Final Field Weakening Settings

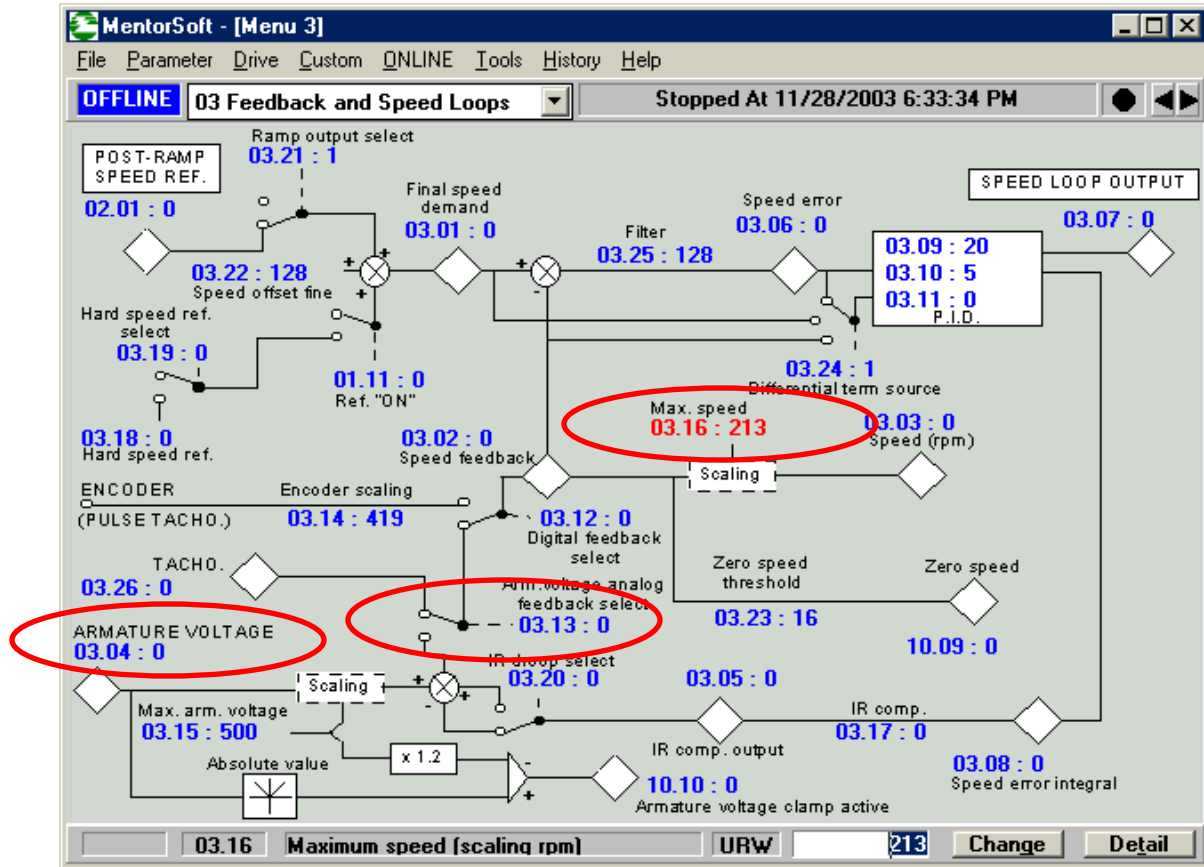
Take your recorded Weakened Field value and set it into parameter #6.09 and #6.10. In addition, set the Cross Over Armature Voltage Setpoint into #6.07 as :

Example: #6.07 = 480 for a 500v armature or
230 for a 240v armature



Test for Automatic Field Weakening

Switch back to Tach Feedback. Set #3.13=0



You are now ready to test for Automatic Field Weakening.

1. With your voltmeter still monitoring the generated Tach Voltage set the drive display to monitor Armature Voltage, parameter #3.04. Start the Drive with 0 reference and slowly take the motor up about 20v below its rated Armature Voltage. As you slowly take your reference up further, your Armature voltage will max out and remain about 10v below its nameplate rating but the speed as indicated by the Tach voltage will continue to climb and you should eventually arrive at your full Application RPM and Tach voltage, with full reference. You can trim if necessary for full speed by adjusting the blue Tacho trim pot on the MDA2B under the cover of the drive.

Full RPM can be read at parameter #3.03 if parameter #3.16 was set at the correct Full RPM calibration value. That value is:

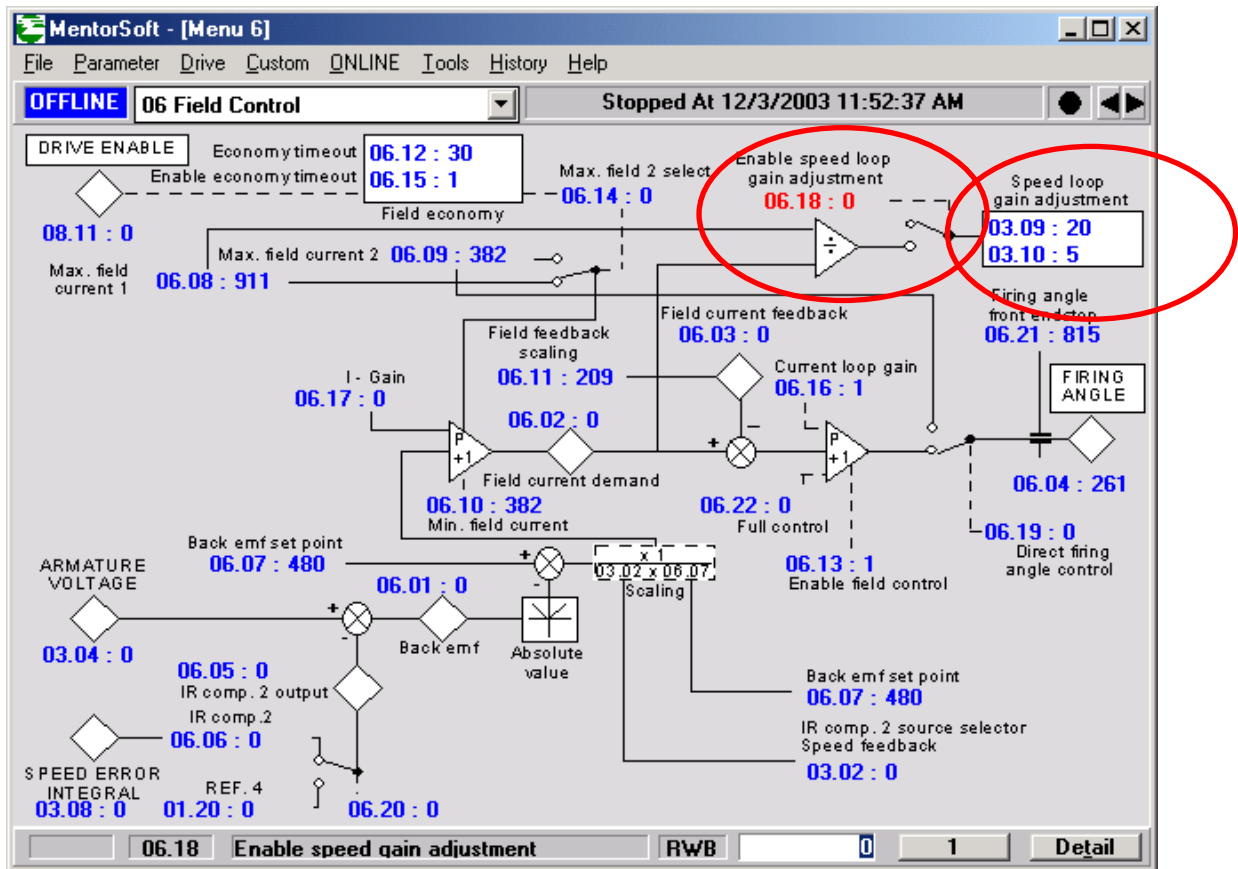
Full RPM Readout calibration value = #3.16 = Motor RPM if less than 2000.
If Full Motor RPM is greater than 2000, divide this speed by 10 and place this rounded value into #3.16.

Final Speed Loop Tuning

Depending on the range or depth of the required Field Weakening (this is the ratio of Full to Weakened Field), Speed Loop tuning can become adversely affected. When the Field is reduced the Torque per Armature amp ratio changes. In addition, the overall Speed Loop gain increases which can make a drive system that was stable at base speed become unstable at weakened speed. In order to compensate for this effect, the software Field Weakening Regulator within Menu 6 of the drive, includes an automatic Speed Loop Gain compensation method.

Setting parameter #6.18=1 will activation this function. This feature reduces the Speed Loop gain as a function of the amount of Field Weakening being requested. This tends to improve the overall Speed Loop stability throughout the speed range.

Note: Proper Speed Loop Tuning (primary accomplished by adjusting parameter #3.09 & #3.10) should be performed in the Base Speed region before setting #6.18=1.



Questions ?? Ask the Author:

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