

This Application Note is pertinent to the Quantum MP / Mentor MP Family

Field Weakening Feedback Loss and the Speed Estimator

This application note will discuss how to properly set up the Mentor MP / Quantum MP for field weakening applications. In an attempt to keep this document as brief as possible the basic drive set up will not be discussed. If the basic setup is not complete at this point, it is highly recommended that the reader follow the Quick Start Guide for Mentor MP, [CTAN #350](#), before proceeding with this set up. Also, [CTAN #351](#), adding a DC Loop Contactor to a Mentor MP may also prove useful.

Since the drive has been set up already using [CTAN #350](#), our motor field current regulator and speed feedback (either tachometer or encoder) are already complete and both the static and rotating auto tunes have been performed. The advantage to this is that a majority of the required parameters have been setup automatically. A little “tweaking” may be required but not much.

A few initial hints

The drive includes a feedback loss protective function. This is a good thing but there a few aspects one needs to be aware of.

The parameters of interest are;

#3.55 – Select estimated speed feedback upon Feedback Loss (default = Off)

#3.56 – Speed feedback loss window (default = 20%)

Parameter **#3.55** sets the feedback loss mode. By default it is set to OFF which means that if the drive detects a feedback loss it will trip with **FbL** and (shut down) the drive. If it is set to 1, the drive will automatically switch to estimated speed feedback (armature feedback). The way the drive detects feedback loss is by comparing the actual speed feedback parameter (**#3.52 for tachometer of #3.27 for encoder**) to the estimated speed feedback **#5.04**. If they are off by the percentage as set by parameter **#3.56**, the drive will either trip or automatically switch to estimated speed feedback.

If the absolute value of (#3.52 or #3.27) - #5.04 is greater than the percentage set in parameter #3.56 times the motor base speed, the feedback loss trip will be initiated.

i.e Based on default values of parameters #3.55 and #3.56, for a 1750 rpm base speed motor, if the difference between the actual speed (as read by the feedback device) is greater than $0.2 \times 1750 = 350$ rpm, the feedback loss trip will be initiated.

The problem here is that if the “Flux Estimator” is not correctly set (this subject to be addressed later on in this document) the drive can either trip or switch to estimated feedback (parameter #3.57 will be “On” if it switched to estimated speed). The confusing part is that even though the tachometer (or encoder) feedback is present and functioning correctly -- the drive trips or the drive switches to estimated speed feedback (which causes the drive to run erratically). Both these events can cause misleading results.

To Avoid all this: set parameter **#3.55 to 0** and **#3.56 to 50%** or greater (the higher the speed range, the higher the percentage). These parameters can be changed once the drive is correctly running and the “Flux Calculator” is tweaked. If the drive does lose the tachometer or encoder feedback, the drive will trip on feedback loss (**FbL**).

Field Weakening Setup

Initial Parameter Settings

Set the following parameters before running the motor

Parameter	Setting	Comments
#3.11	0.033	Speed Loop Integral Gain; Increases the speed loop integral time constant (for tachometer/encoder feedback)
#5.28	1	Field Weakening Compensation Disable; Reduces the speed loop gain in constant hp operation
#5.64	1	Enable field weakening
#5.59	480 / 220	Back EMF Set Point; 480 vdc for 500 vdc motors, 220 for 240vdc motors. Normally set to rated armature voltage minus the IR drop (rated armature current times armature resistance)
#5.69	20% default	Minimum Flux; This amount is good for about a 50% increase in speed over base speed. For wider speed ranges, i.e 2:1 or 3:1, 50 – 60% will probably be required.
#1.06	2250 rpm (ex.1750 base)	Maximum Reference Clamp; Set to the maximum motor speed required above the Motor's base speed rating (as set in parameter #5.08).

Running the Drive

The drive is now set up to run up into the field weakened range.

Once again, this procedure is based on the fact that CTAN350 has been completed successfully.

1. Connect a digital voltage meter to the A+ and A- connections to monitor the motor voltage.
2. Set the display to parameter #0.40, Speed Feedback (rpm)
3. Start the drive and slowly bring it up to the motors base speed (set in parameter #0.29)
4. Note that the armature voltage is approximately equal to the voltage level set into parameter #5.59 (=/- 2 vdc).
5. Check parameter # 5.04, Estimated Motor Speed. It should be approximately equal to the actual motor speed, parameter # 0.40.
6. Slowly bring the motor speed halfway up the full field weakened speed range while watching the armature voltage. It should not change more than a volt or two.

7. Check the estimated motor speed, parameter #5.04, it will not exactly match the actual speed as shown in parameter # 0.40 but within ~20% of the motor base speed in rpm (i.e. if the motor base speed is 1750, 20% = **350rpm**).
8. Slowly bring the speed up to maximum while monitoring the armature voltage. As before, it should not change more than +/- 2vdc. If you see it to begin to increase, stop increasing the speed and reduce the minimum flux setting slowly (parameter #5.69) by another 10% but do not go below 15%.
9. Continue increasing the speed until reaching the full field weakened speed (monitor armature voltage and repeat step #9 if required).
10. While operating at maximum speed, check and record the following;
 - #5.55 – Flux Demand
 - #5.04 – Estimated speed

The value in parameter #5.55 is the flux value required to reach field weakened speed. Parameter # 5.69 should be set to slightly less than this value. This will limit the maximum allowable speed to slightly higher than the maximum reference clamp.

The value in parameter #5.04 is the Estimated Speed based on the flux estimator algorithm in the drive. The accuracy of this value will be based on the settings in parameters #5.74, “Rated Field Compensation Factor”, #5.29, “Motor Saturation break point 1” and #5.30, “Motor Saturation break point 2” .

Below is an analytical description of what the settings are;

Note, that the rotating auto tune does a good job in determining these values.

#5.74, “Rated Field Compensation Factor”

This parameter is used to “Tweak” the rated field current value (which was entered in parameter #5.70 from the motor nameplate information) such that at rated **motor no-load voltage** (Rated armature voltage – IR drop → motor back Emf) the motor runs at **rated motor speed**. In most cases, the value may need to be decreased (estimated motor speed greater than actual motor rpm). If motor estimated speed (#5.04) is less than the actual speed (#3.52 for tachometer #3.27 for encoder) this parameter should be left at 100% and the motor rated field current, #5.70, should be increased until the speeds do match.

#5.29, “Motor Saturation break point 1”

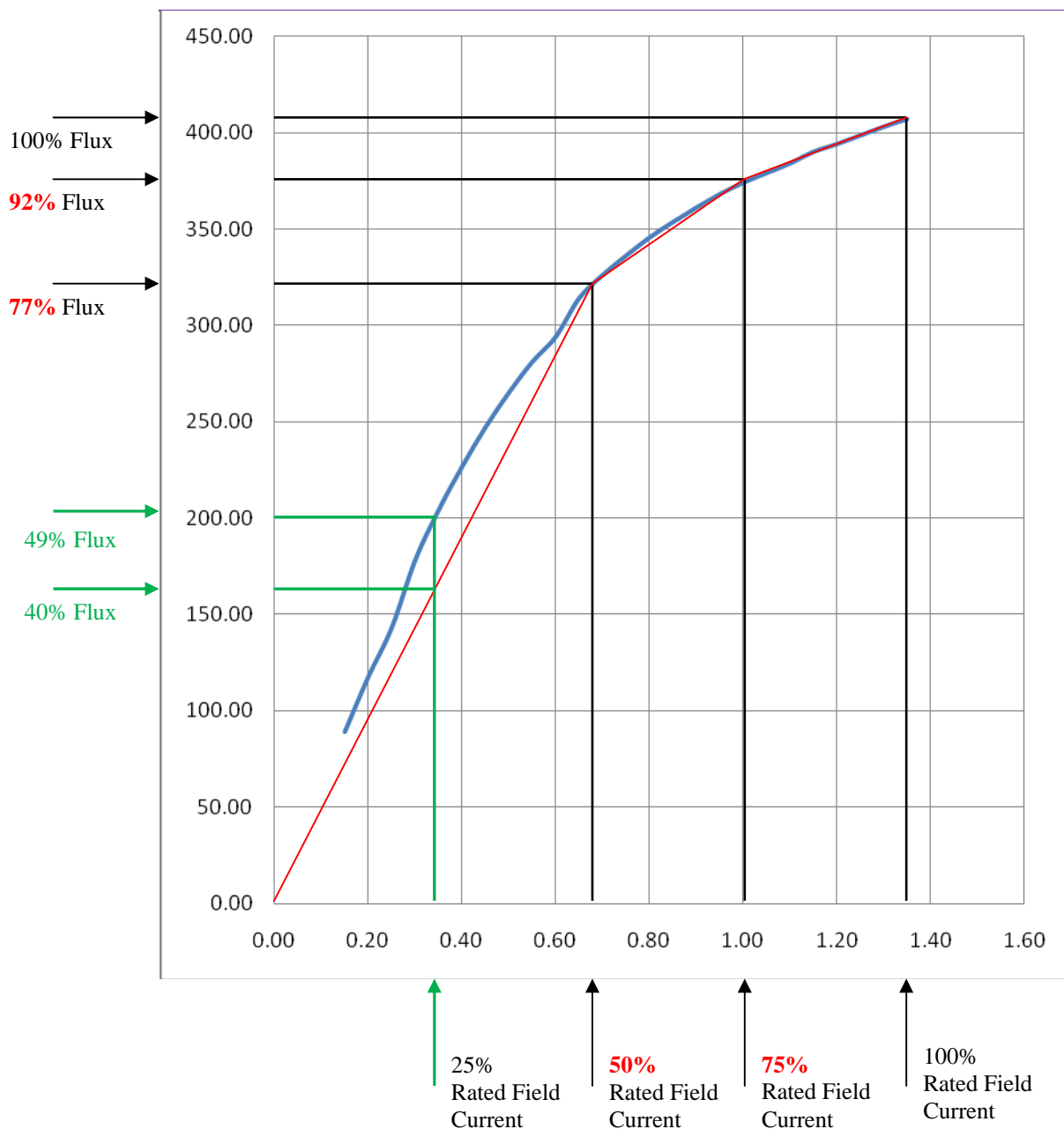
This parameter sets the motor field flux level produced by 50% of rated field current. The default level of 50% would give rise to a linear relationship between field current and field flux. This is typically not the case due to field flux saturation and residual flux effects in the motor. A value 80% would be more typical than 50% in your “run of the mill” US made motors.

#5.30, “Motor Saturation break point 2”

This parameter sets the motor field flux level produced by 75% of rated field current. The default level of 75% would give rise to a linear relationship between field current and field flux. This is typically not the case due to field flux saturation and residual flux effects in the motor. A value 92% would be more typical than 75% in your “run of the mill” US made motors.

Field Current vs Field Flux Graph

This is a typical graph of field current versus field flux (**blue curve**) produced by measuring the motor's no load back emf at various decreasing field current values. The motor was driven by a Mentor MP set up for tachometer running at 1500 rpm which would correspond to the 100% flux level shown at the left (approximately 407 vdc back emf). The curve in **red** shows the field current versus field flux estimated by the Mentor MP using the two break points at 50% and 75% field current. One can see that from 100% down to 77% flux, the two graphs (**blue** and **red**) follow each other. From 77% flux to 49% the two graphs deviate from one another. The net result is that when the drive is running at 200% base speed, (1500 rpm / 0.49 =) 3061rpm, the speed estimator will calculate (1500 rpm / 0.4 =) 3750 rpm which is off by (3750 – 3061 =) 689 rpm. This accounts for a (689/1500 =) 46% error in estimated motor speed, percentage set in parameter #3.56. From the graph, you can clearly see that a third break point (at 25% field current) would greatly reduce the difference between the actual and estimated speed.



Tweaking the Field Flux Estimator

As mentioned previously, the rotating auto tune normally does a pretty good job of setting parameters #5.29 and #5.30. To verify that the settings are correct check the following;

1. Take the motor base speed (#5.08) divided by the percentage in parameter #5.29 (i.e. 75% = 0.75). Set your speed reference to that speed.
Compare parameter #5.04 to the actual speed feedback (#3.52 for tachometer or #3.27 for Encoder) they should be very close, say +/- 20rpm. If it is greater than that you could adjust #5.29 slightly up or down to get a better match.
2. Take the motor base speed (#5.08) divided by the percentage in parameter #5.30 (i.e. 50% = 0.50). Set your speed reference to that speed.
Compare parameter #5.04 to the actual speed feedback (#3.52 for tachometer or #3.27 for Encoder) they should be very close, say +/- 20rpm. If it is greater than that you could adjust #5.30 slightly up or down to get a better match.
3. You could also re-run the rotating auto tune (#2) again but you would need to set the following parameters;
#5.29 = 50, #5.30 = 75 and #5.74 = 100
4. When you run higher in speed than the level in step #2 above (if you will be running greater than 130 to 150% base speed) all you can do is to plot (in a table) parameter #5.04 verses either #3.52 for tachometer or #3.27 for Encoder and find the speed where the difference is greatest. This rpm difference should be used to set # 3.56 as follows;

$$(\text{RPM Difference} \times 1.1) / \text{Motor base speed} = \text{speed feedback loss window}$$



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