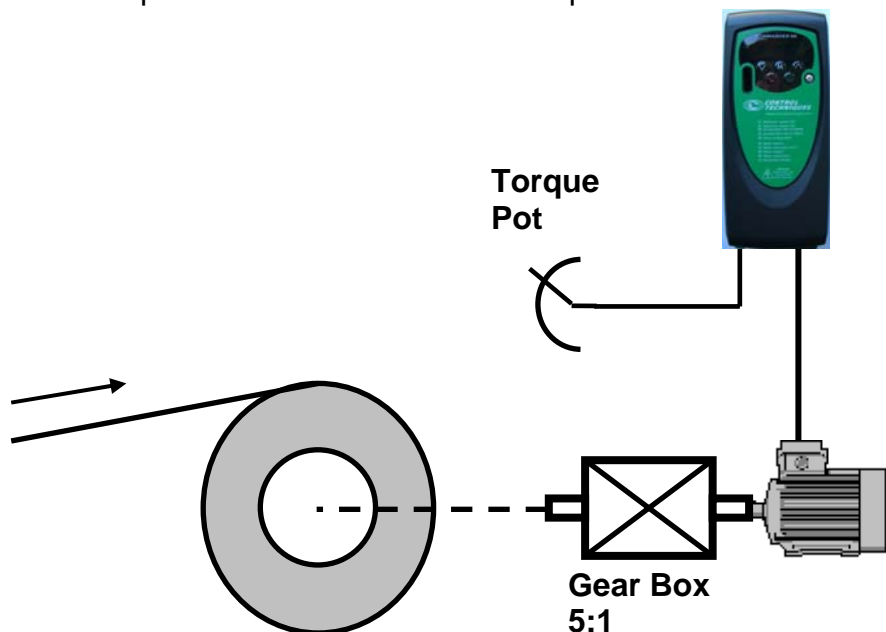


This Application Note is pertinent to the Commander SK Family

### Simple Commander SK Torque Winder

The Commander SK AC drive may be used in simple open loop torque winding applications. The drive may be set up as a simple torque control. This method of control does have some limitations since it is not closed loop (i.e. it does not have a true inner current loop) and therefore the torque producing current is calculated based on measured (and entered) motor parameters. In essence, this means that the ability to control motor torque is limited to approximately a 5:1 range with reasonable accuracy. The useable speed range should also be kept in the range of 6 to 60 Hz (180 to 1800rpm on a 4-pole motor) with a typical build up ratio of no more than approximately 4:1. For best results, the motor should be geared in such that at core and maximum line speed the motor runs at rated speed.



**Questions:** Ask the author ??

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## Typical Example:

Core Diameter: 6"  
Full Roll Diameter: 24"  
Buildup: 4:1  
Web Width: 60"  
Tension: 2 PLI @ core ( Pounds per linear inch )  
Line Speed: 500fpm  
Taper: Hyperbolic

## Motor Sizing

$$\text{Maximum Motor RPM} = \frac{\text{fpm (feet per minute)}}{\text{fpr (feet per revolution i.e. Roll circumference)}} \times \text{Gear Ratio}$$

Note: Roll circumference =  $\pi \times$  core diameter = 3.14 x Core Diameter

$$= \frac{\text{Feet}}{\text{Minute}} \times \text{Gear Ratio} = \frac{1}{\frac{\text{Minute}}{\text{Feet}}} \times \text{Gear Ratio}$$
$$= \frac{\text{Revolution}}{\text{Minute}} \times \text{Gear Ratio} = \text{rpm}$$

$$= \frac{\text{Revolution}}{\text{Minute}} \times \text{Gear Ratio} = \text{rpm}$$

$$= [500\text{fpm} / (\pi \times \text{core diameter})] \times \text{gear ratio}$$

$$= \frac{500 \times 5}{\pi (6^{\text{in}}/12^{\text{in/ft}})} = \frac{500 \times 5}{1.57} = \mathbf{1592 \text{ rpm}}$$

## Motor Torque (for web tension)

$$= \frac{\text{PLI (pounds per linear inch)} \times \text{Web width (inches)} \times \text{Core radius (inches)}}{\text{Gear Ratio}}$$

$$= \frac{\text{pounds}}{\text{inches}} \times \text{inches} \times \text{inches} = \text{pounds - inches}$$
$$\frac{\text{pounds - inches}}{\text{gear ratio}}$$

$$\frac{\text{pounds - inches}}{12 \text{ inches}} = \text{pounds - feet} = \mathbf{lb - ft}$$
$$\frac{12 \text{ inches}}{1 \text{ foot}}$$

$$= \frac{(2^{\text{lb/in}} \times 60^{\text{in}}) \times (\text{core radius})}{\text{gear ratio}}$$

$$= \frac{(2^{\text{lb/in}} \times 60^{\text{in}}) \times (3^{\text{in}}/12^{\text{in/ft}})}{5} = \mathbf{6 \text{ lb-ft}}$$

$$\text{Motor HP (for web tension)} = \frac{\text{Motor Torque} \times \text{Motor Base Speed}}{5250}$$

$$= \frac{6^{\text{lb-ft}} \times 1800^{\text{RPM}}}{5252}$$

$$= \mathbf{2.06 \text{ Hp}}$$

**Recommended Motor Hp = 3.0Hp ( to include machine losses)**  
**Suggests Drive Model: SKC3400220**

## Drive Programming and Setup

The system is to be setup in the following manner:

1. Analog input #1 is the torque reference 0 to 10vdc = 0 to 100% motor torque.  
In this example, the torque reference would be set to ~66 % (6 Ft-Lbs), not counting machine losses.
2. Menu 0 (keypad menu) Setup

Menu 0 Parameter	Actual Menu	Function	Setting / Comment
01	1.07	Minimum Speed	Set to 0
02	1.06	Maximum Speed	Set to 60 Hz
03	2.11	Acceleration Time	33 (20 sec to 60 Hz)
04	2.21	Deceleration Time	33 (20 sec from 60 Hz)
05	11.27	Drive Configuration	Pr (preset speeds)
06	5.07	Motor Current	Per motor
07	5.08	Motor Full Load RPM	0
08	5.09	Motor Voltage	Per motor
09	5.10	Motor Power Factor	Per motor
10	11.44	Security	L3
18	1.21	Preset Speed 1	Core speed
19	1.22	Start Torque Level	60 = 150%
20	1.23	Analog Torque Reference	From remote analog signal
40	5.11	Motor Poles	Per motor
41	5.14	Voltage mode	UrA

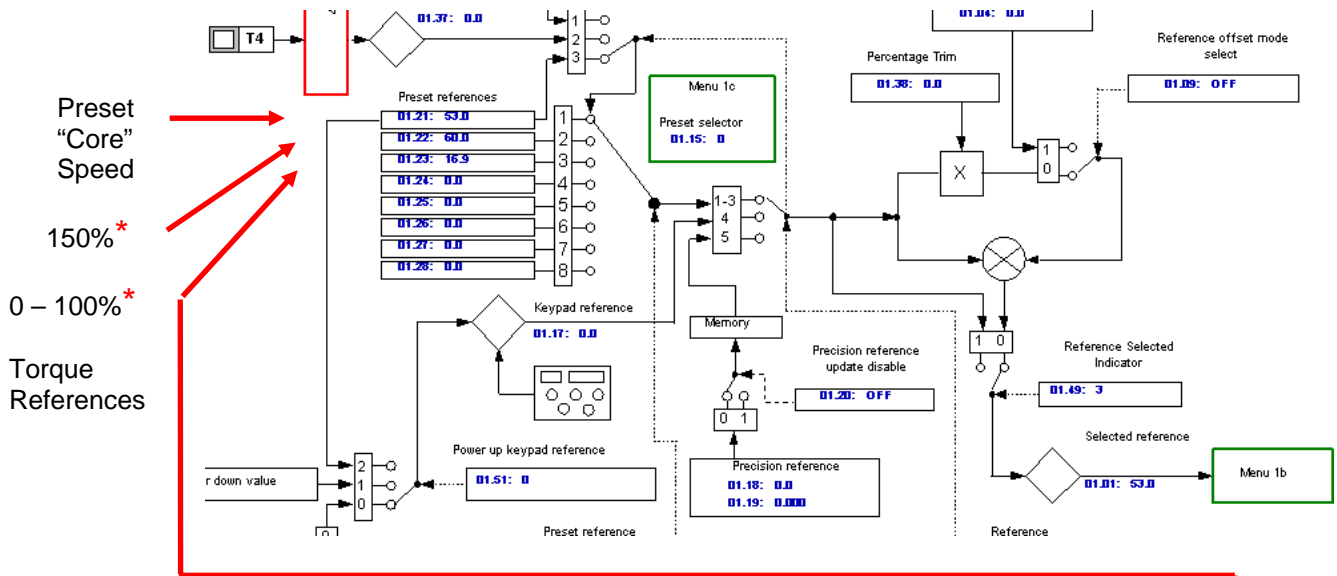
3. The rotating auto tune should be used for best results (set parameter # 38 to 2) before running the motor (motor must be uncoupled from the load).

To see how to perform the **AutoTune** you could click the link below:

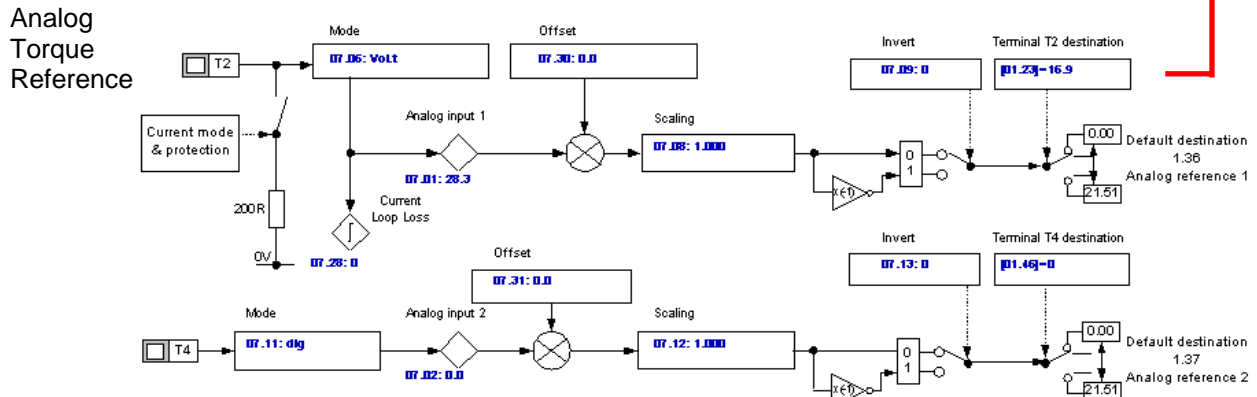
[CTVI102](#)



## Speed Reference



## Analog Torque



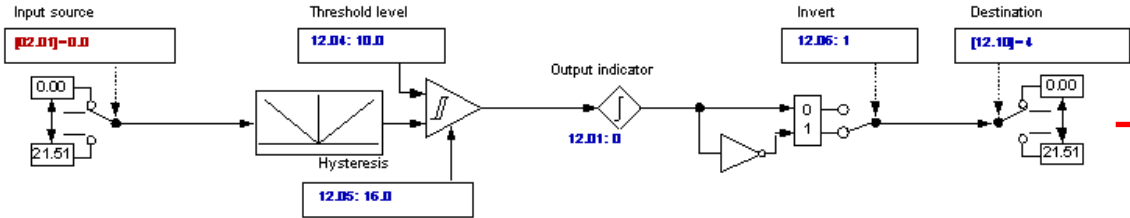
150%\* -- 0 to 60 equals 0 to 150% Torque

### Note:

Parameter #7.08 above (scaling) may be used to scale the maximum external torque reference. With it being set to 1.000, the max torque would be 0 to 150%. Change #7.08 to 0.67 for 0 to 10 vdc = 0 to 150%. Parameter #4.24, User current maximum scaling, should also be set to 150%.

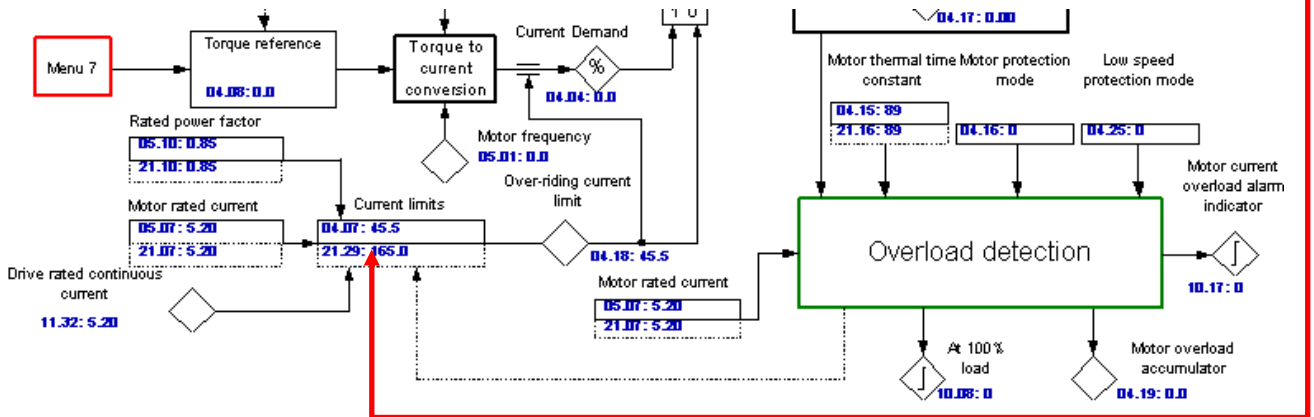
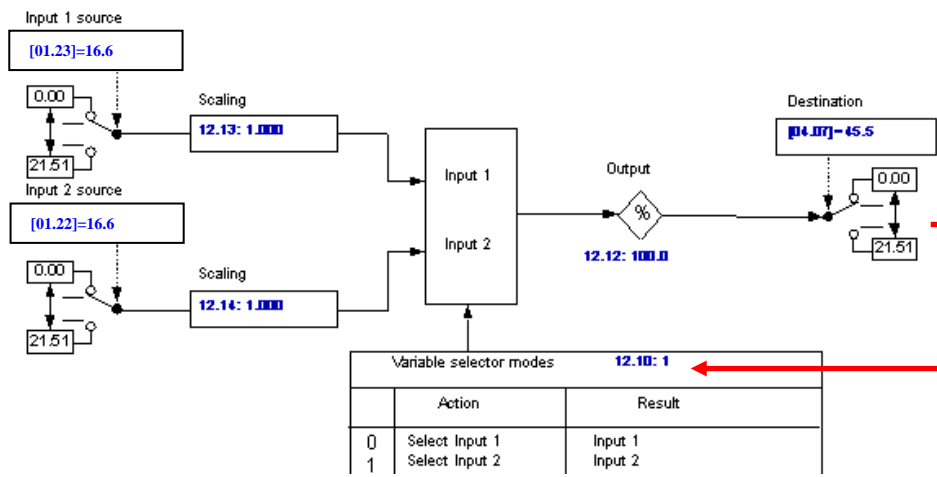
# Torque Reference Selection

## Threshold detector 1



## Variable selector 1

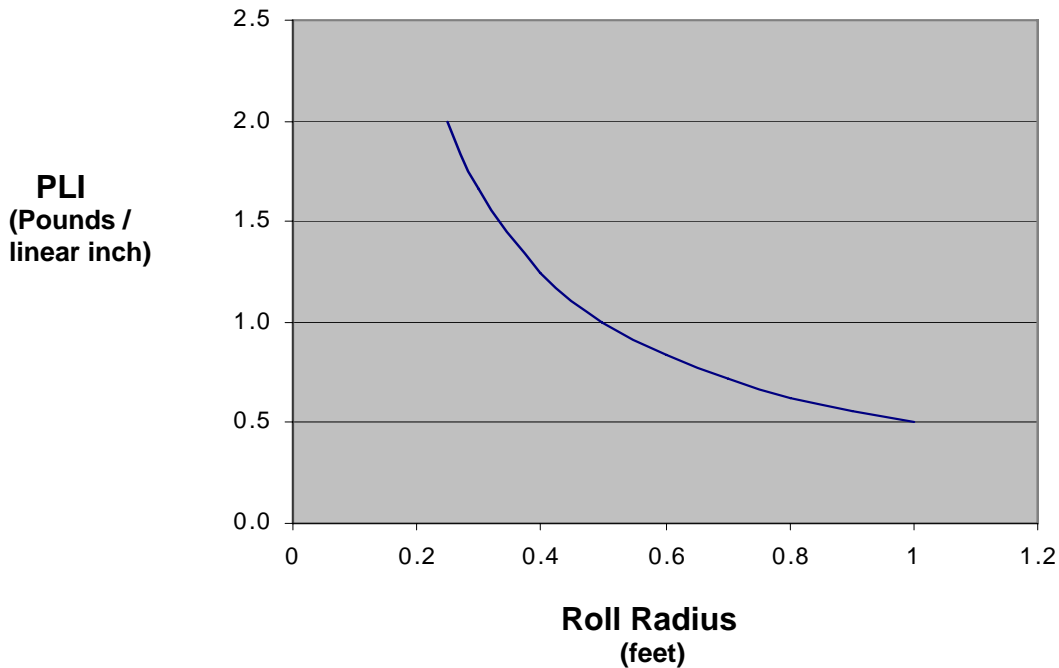
Preset speed registers holding Torque values



This circuit selects a 150% torque setting if the speed is less than 10% for jogging and initial starting purposes. The full roll motor speed should always be greater than 10% motor speed. Once 10% speed is exceeded, the drive switches to the torque reference set by the reference potentiometer. Current loop gains (#4.13 and #4.14) may need to be adjusted for good dynamic response.

The tension verses build up radius is shown in the graph below. Keep in mind that machine losses are not taken into account and therefore the actual results may vary. Note that the full roll tension is down to 0.5 pli vs. 2.0 at core. This is typical of a constant torque rewind which exhibits a hyperbolic tension profile.

### Roll Build-up chacteristics



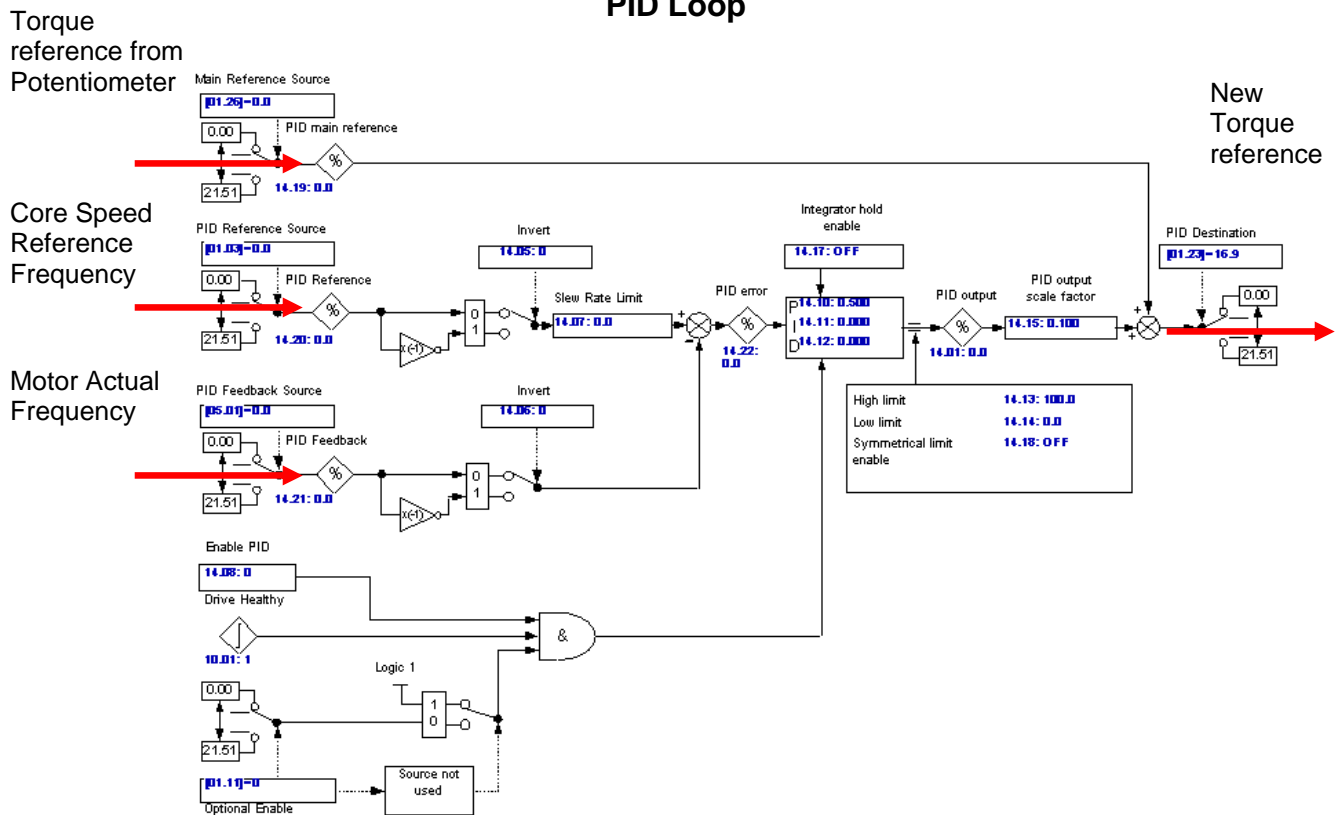
### Parameter Settings (other than menu 0)

Parameter #	Setting	Comments
#1.21	53	Core speed per example 53Hz = 1590rpm
#1.22	60	Start / Jog Torque setting, typically 150% (60 = 150%)
#1.23	---	Torque reference set by the analog input
#4.24	150	User current maximum scaling
#7.10	1.23	Analog input destination (Torque reference)
#7.08	0.67	Scale factor to scale analog input to 0 to 100%
#12.03	2.01	Comparator input – Core speed reference
#12.04	10	Comparator threshold, 10% speed
#12.05	5	Comparator hysteresis level – 5%
#12.06	1	Comparator output invert
#12.07	12.10	Comparator destination (control bit, variable selector 1)
#12.08	1.23	Variable selector source 1, analog torque reference
#12.09	1.22	Variable selector source 2, 150% torque reference
#12.11	4.07	Variable selector output destination, drive current limit

## System Enhancements

Suppose that a hyperbolic taper produced too light a tension at full roll. In a more complicated system, perhaps a system capable of calculating or measuring the radius of the roll, a constant tension profile would be achieved. With the goal of keeping costs to a minimum (i.e. drive only) the goal will be to produce some profile which provides something better than a hyperbolic taper. In order to do this, the PID menu will be used. The basic idea is to come up with a signal related to core vs. actual motor rpm and use it to provide an additional torque reference as the roll builds up. This will provide a higher tension as the roll builds. created by the difference between the core speed (frequency) minus the actual motor frequency times the proportional gain (#14.10).

### Additions / Changes to original programming PID Loop



**Note:** #14.08 is set to 1 to enable the PID and #14.09 is set to 1.11 to hold the PID reset until the drive is placed in run.

The PID circuit shown above is used to add an additional torque signal to the “core” torque level as set by the external torque potentiometer. The additional reference is created by the difference between the core speed (frequency) minus the actual motor frequency times the proportional gain (#14.10) and the scale factor (#14.15).

As an example, let's try setting up the system such that we produce a motor torque of 6 ft-lbs at core and 12 ft-lbs at full roll.

**What values would we set in the gain parameter #14.10 and the core torque level? What would the build-up PLI profile look like?**

We will we need to recalculate the motor horsepower for full roll tension and the full roll rpm.

**Motor HP @ Full Roll (for web tension)**

$$= \frac{12^{\text{lb-ft}} \times 1800^{\text{RPM}}}{5252}$$

$$= 4.12 \text{ Hp} \text{ ---- Use 5 Hp motor and SKC3400400}$$

**Full Roll Motor RPM** = [500fpm / (π x core diameter)] x gear ratio

$$= \frac{500 \times 5}{\pi (24^{\text{in}}/12^{\text{in/ft}})} = \frac{500 \times 5}{6.28} = 398 \text{ rpm}$$

The rated torque of a 5 Hp motor is :

$$\text{Torque}_{\text{motor}} = \frac{\text{HP} \times 5250}{1800} = 14.58 \text{ ft-lbs} , 150\% = 21.87$$

Since the torque required at core is 6 ft-lbs, the external torque pot needs to be set such that register #1.26 is equal to :

$$\#1.26 = \frac{6 \text{ ft-lbs}}{21.87 \text{ ft-lbs}} \times 100\% = 27.4 \text{ (\% of 5Hp motor torque)}$$

Since the torque required at full roll is 12 ft-lbs, the torque reference needs to be:

$$\#1.23 = \frac{12 \text{ ft-lbs}}{21.87 \text{ ft-lbs}} \times 100\% = 54.8 \text{ (\% of 5Hp motor torque)}$$

at Full roll speed of 398 rpm.

The output of the pid (#14.01) must equal the difference between the required torque reference (#1.28) at full roll and the fixed core speed torque reference (#1.26) which in this example is # 14.01 = 54.8(#1.28) – 27.4(#1.26) = 27.4.

The gain factor would be calculated bases on the following equation:

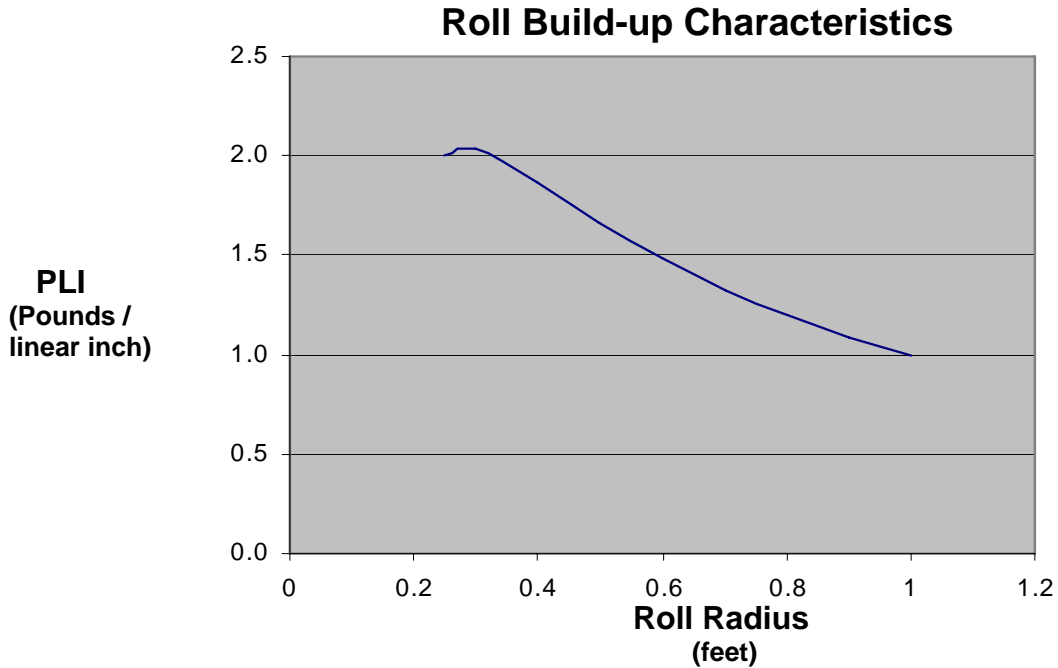
Since the PID error ( #14.22) at full roll speed is:

$$\#14.22 = \frac{\text{Core speed} - \text{full roll speed}}{\text{Motor Base Speed}} \times 100\% = \frac{1592 - 398}{1800} \times 100\% = 66.3\%$$

The gain factor, #14.10 is then the ratio of #14.01 / #14.22

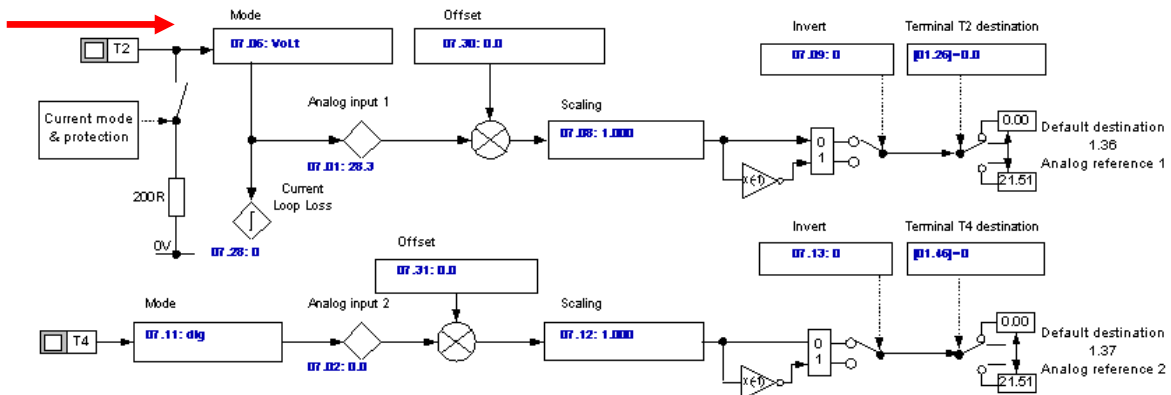
$$\#14.10 = \frac{\#14.01}{\#14.22} = \frac{27.4}{66.3} = 0.431$$

The graph below shows the new roll build-up characteristics. It is approximately a linear taper of 2:1 with a 4:1 roll build up.



**NOTE:** As described above, the external “core” torque reference input must write to register #1.26 for the enhanced example.

Analog Torque Reference



### Enhanced Parameter Settings

Parameter #	Setting	Comments
#14.02	1.26	Analog torque reference input
#14.03	1.03	Core speed reference
#14.04	5.01	Motor speed
#14.08	1	Enable PID
#14.09	1.11	Optional PID enable (only enable while in run)
#14.10	0.431	Gain setting per application
#14.14	0	No negative values
#14.16	1.23	Motor torque reference