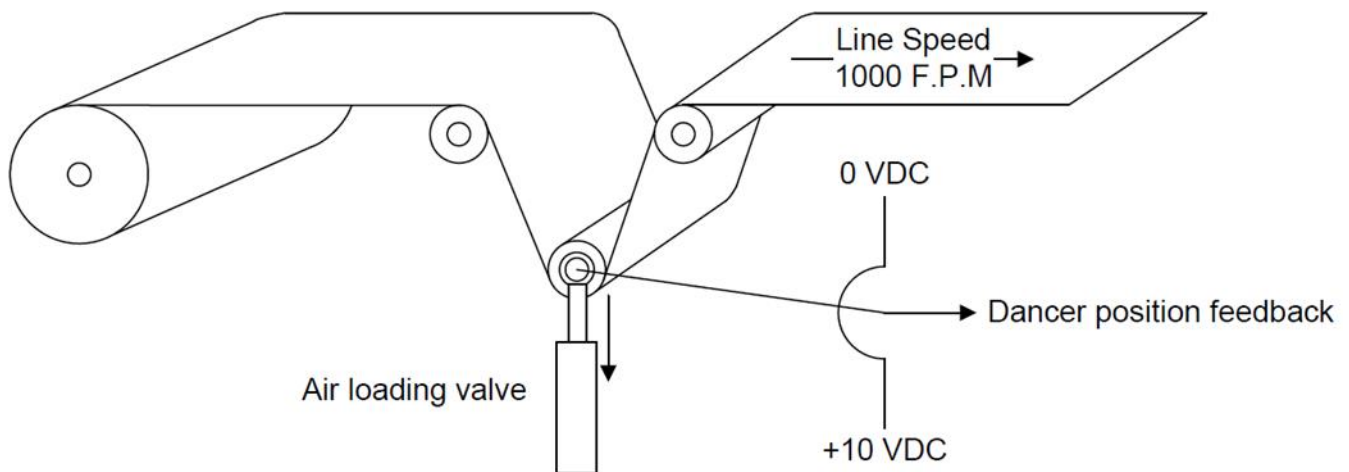


Simple PID Controlled Dancer Un-winder Setup

This application note will describe the basic set up and programming required for a simple dancer controlled un-winder. This system must also work in reverse as a re-winder.

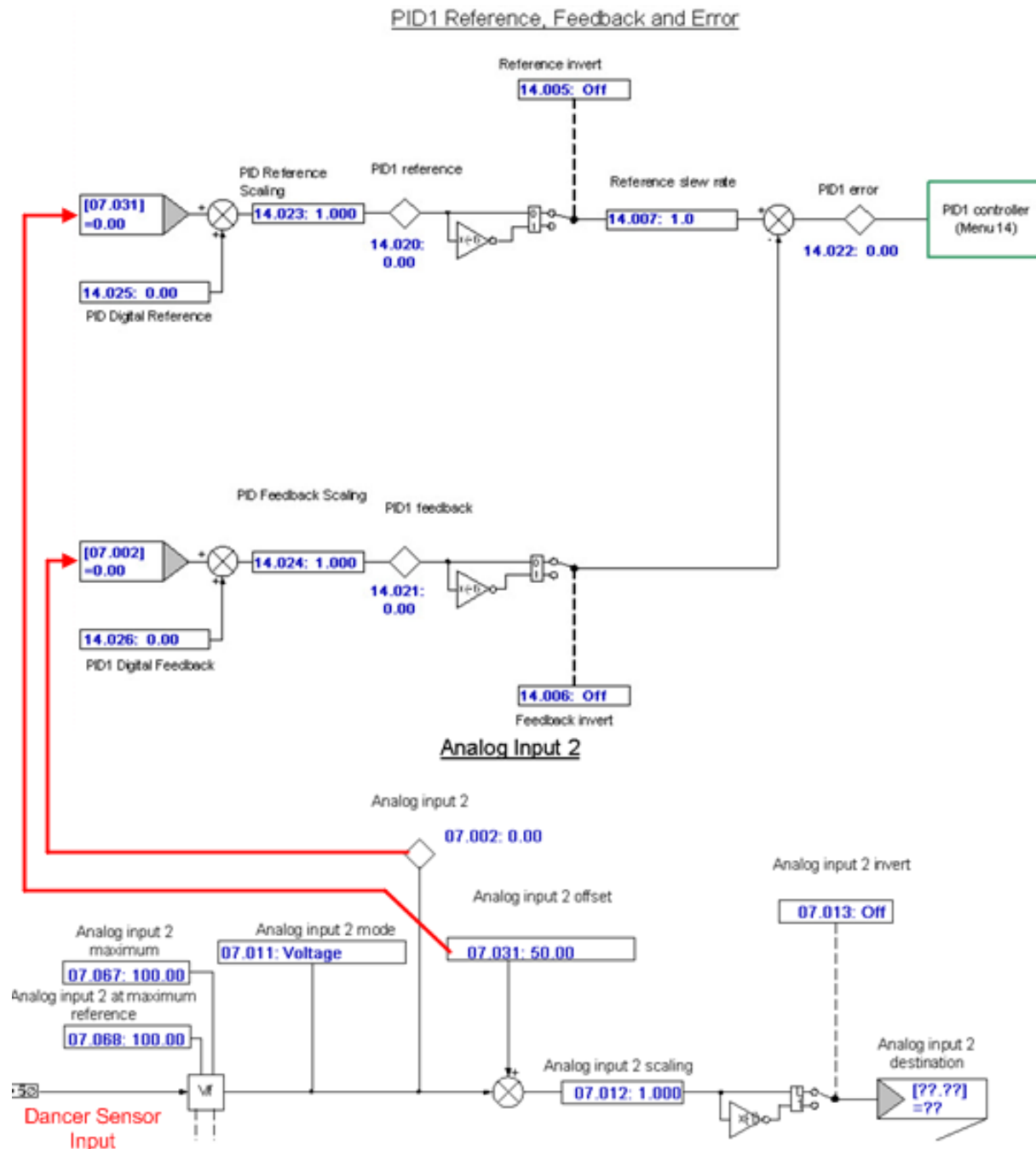


Machine Data

Core Diameter: 6 inches
Full Roll Diameter: 18 inches
Web width: 12 inches
Tension: 1pli

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 1800 rpm 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. In general, materials with lower tensile strength such as tissues, lights foils & films should be avoided with this implementation

The drive will be set up to use analog input #2 for the dancer feedback. Note that the voltage across the dancer potentiometer is such that if it drops, the feedback voltage will increase causing the unwind to rotate counterclockwise in order to “pull” the dancer back to center (or set-point) position. A digital set point will be used for dancer position. This set up applies to the Commander C200/ 300 and the Unidrive M. The terminal strip connections shown are for the Commander C200/ 300. Block diagrams are taken from Connect software.



Parameter	Setting	Notes
07.031	50%	P.I.D. Setpoint
07.015	0.0	Un-maps Analog Input 2 destination
14.003	07.031	P.I.D. Setpoint
14.004	07.002	P.I.D. Dancer Feedback
14.008	On	P.I.D Enable
14.009	14.008	P.I.D Enable
14.027	14.008	P.I.D Enable
14.010	1.000	These are the P.I.D. function tuning parameters. They are set "analytically" per the application. See P.I.D. Tuning Notes on Page 6.
14.011	0.500	
14.012	0.000	
14.014	-20.0	Limits the maximum reverse speed of the motor and should be set based on the application requirements/ limitations
14.016	01.036	This directs the output of the P.I.D. function to a standard speed register.

Note: Parameter 07.031, used as the P.I.D. setpoint, and the P.I.D. gains 14.010, 14.011 and 14.012 can be "mapped" to menu 0.0 (keypad display) in menu 20.xxx.

In this type application, the motor base speed will be selected based on the maximum line speed and the core diameter. From the machine data above the relationship between motor rpm and line speed in feet per minute is:

$$\begin{aligned}
 \text{FPM} &= \text{RPM} \times \text{Pi} \times \text{core diameter (ft)} \\
 &= \text{RPM} \times 3.14 \times 0.5 \text{ (6 in core diameter)} \\
 &= \text{RPM} \times 1.57
 \end{aligned}$$

The motor horsepower will be determined by this RPM, the web tension and the gear ratio if there is a gear box involved.

To keep things simple, we will assume a line speed of 1000 FPM, the motor RPM at this line speed would be 636 RPM. The maximum torque required will be 12 lbs times the radius at full roll which is .75 ft. The required motor torque would then be 9 ft-lbs. If a standard 4 pole (1750 rpm) motor were to be used, the motor horsepower would be:

$$\text{HP} = \frac{\text{Torque} \times \text{Speed}}{5250} = \frac{9 \times 1750}{5250} = 3 \text{ HP}$$

A three horsepower motor may be cutting it too close in this example due to losses (windage, friction and possibly a slightly higher material tension requirement) so we may need to go up to the next integral horsepower, being 5 HP. Since at 1000FPM the motor rpm is only 636 we are throwing out almost two thirds of the motor horsepower. The addition of a gearbox is probably the best solution in this case. Let's see what happens with a 4: 1 gear box and a 1 HP motor as opposed to a 5 HP motor directly driving the load. Assuming the gear box is 80 % efficient, the torque available on the output shaft would be:

$$\begin{aligned}
 T(\text{out}) &= \frac{5250 \times \text{HP}}{(\text{Motor Base Speed} / \text{Gear Ratio})} = \frac{(5250 \times 1)}{(1750 / 4)} = 12 \text{ ft-lbs.}
 \end{aligned}$$



With an efficiency of 80%, this would give us a useable torque of $0.8 \times 12 = 9.6$ ft-lbs between the speed range of say 65 to 650 RPM (output of gear box). Above the 650 RPM we would be in “field weakening” range which would result in a reduction in available torque but since this is a un-winder / re-winder the torque required at the higher speeds will be less anyway.

The equation for motor torque above base speed is:

$$T = \frac{\text{Motor rated torque @ base speed}}{(\% \text{ Motor Speed} / 100\%)^2}$$

In this example, at core the motor would be running at **~2547 rpm** (at 1000 fpm with the 4:1 gear box). Therefore, the available motor torque would be:

$$T(\text{at Core speed}) = \frac{3 \text{ ft-lbs (at base speed)}}{(2547 / 1800)^2} = 1.49 \text{ ft-lbs.}$$

The output shaft of the gear box would have 4 times this amount; therefore **4.8 ft-lbs** (assuming 80% efficient gear box) would be available at the output shaft of the gear box.

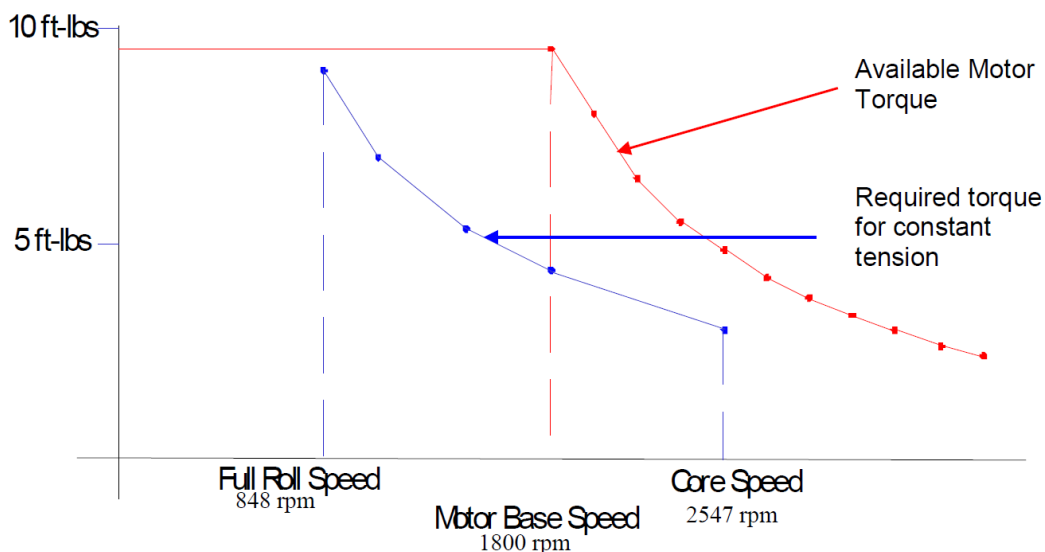
The required motor torque to produce the material tension at core is:

$$\begin{aligned} T(\text{core torque}) &= \text{Web Tension} \times \text{core radius} \\ &= 12 \text{ lbs} \times (3" / 12") = \mathbf{3 \text{ ft-lbs}} \end{aligned}$$

The required motor torque to produce the material tension at full roll is:

$$\begin{aligned} T(\text{full roll torque}) &= \text{Web Tension} \times \text{full roll radius} \\ &= 12 \text{ lbs} \times (9" / 12") = \mathbf{9 \text{ ft-lbs}} \end{aligned}$$

The graph below will show the approximate motor torque vs. the load torque at various points. The required torque for constant tension is within the available motor torque so a 1 HP motor should be OK to use:





Additional Programming Notes

As with any application, the drive should be set up and tuned as well as possible **BEFORE** trying to set up the PID loop. For this set up, the drive should be set up for open loop vector control (or better yet, RFC mode) and a rotating auto tune performed. This will provide the best torque / current control allowing for good dynamic control with **minimal** acceleration / deceleration times. **A dynamic braking resistor is highly recommended especially for larger rolls.** Since the system operates in the extended speed range (above base speed) the maximum frequency setting should be determined based on the equation below:

$$\text{Max Frequency} = \frac{\text{Core speed (rpm)} \times 1.05 \times 60 \text{ (Hz)}}{\text{Motor Base Speed}} = \frac{2547 \times 1.05 \times 60}{1800} = \mathbf{89.1 \text{ Hz}}$$

Refer to AN0296 for information on RFC Control Mode