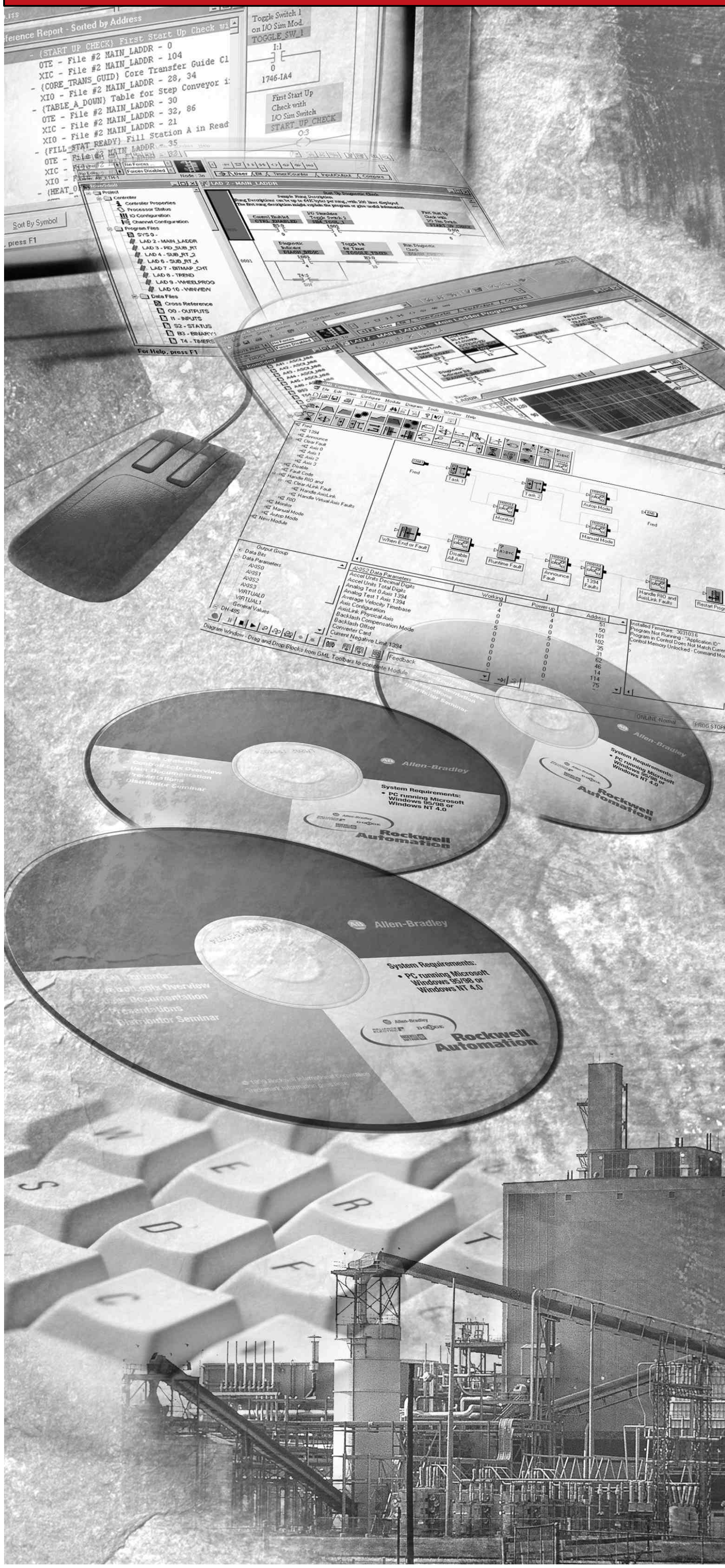
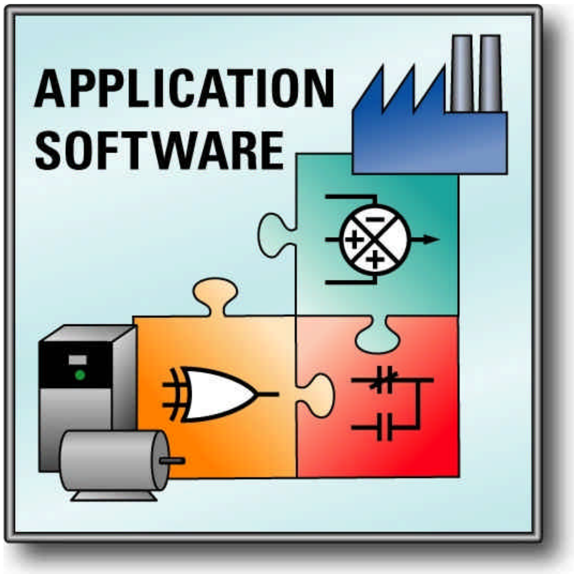


Drive Application Software

Function Module

Tension Control Generic Units

Reference Manual



Important User Information

Users of this Reference Manual must be familiar with the application this Function Module is intended to support and its usage. Function Modules intended usage are as a building blocks for a created application. The user must be familiar with the programming tools used to implement this module, the program platform to be used in the application, and the Rockwell Automation drive products to be controlled in the application.

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Rockwell Automation publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Rockwell Automation office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Trademarks

Table of Contents

1.0 Precautions

Class 1 LED Product

ATTENTION: Hazard of permanent eye damage exists when using optical transmission equipment. This product emits intense light and invisible radiation. Do not look into module ports or fiber optic cable connectors.

General Precautions

ATTENTION: This drive contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference Allen Bradley publication 8000-4.5.2, "Guarding Against Electrostatic Damage" or any other applicable ESD protection handbook.

ATTENTION: An incorrectly applied or installed drive can result in component damage or a reduction in product life. Wiring or application errors such as under sizing the motor, incorrect or inadequate AC supply, or excessive surrounding air temperatures may result in malfunction of the system.

ATTENTION: Only qualified personnel familiar with the PowerFlex 700S AC Drive and associated machinery the products control should plan, program, configure, or implement the installation, start-up and subsequent maintenance of the system / product. Failure to comply may result in personal injury and/or equipment damage.

ATTENTION: To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the +DC & –DC terminals of the Power Terminal Block (refer to Chapter 1 in the PowerFlex 700S User Manual for location). The voltage must be zero.

ATTENTION: Risk of injury or equipment damage exists. DPI or SCANport host products must not be directly connected together via 1202 cables. Unpredictable behavior can result if two or more devices are connected in this manner.

ATTENTION: Risk of injury or equipment damage exists. Parameters 365 [Encdr0 Loss Cnfg] - 394 [VoltFdbkLossCnfg] let you determine the action of the drive in response to operating anomalies. Precautions should be taken to ensure that the settings of these parameters do not create hazards of injury or equipment damage.

ATTENTION: Risk of injury or equipment damage exists. Parameters 383 [SL CommLoss Data] - 392 [NetLoss DPI Cnfg] let you determine the action of the drive if communications are disrupted. You can set these parameters so the drive continues to run. Precautions should be taken to ensure the settings of these parameters do not create hazards of injury or equipment damage.

2.0 Definitions

A Function Module [FM] is a base program designed to perform a specific function (operation) in an application. Function Modules are not complete applications and will require additional programming to control a machine section. The additional programming required for the application and configuration of the overall application is the responsibility of the user.

An Application Module [AM] is a complete program designed to perform a specific machine sections application (task). Application Modules are complete programs and only require configuration and integration in order to perform the designated tasks.

2.1 Conventions

The conventions described below are used in programming and documentation of Function Modules and Application Modules.

All FM tags are program scoped.
All user connections to the FM are through the Jump to Sub-Routine (JSR) instruction input and return parameters.
Users cannot edit Function Modules.
Data format

Data Type	RSLogix Type	Format	Range	Example
B = Boolean	BOOL	x	0 to 1	0 or 1
I = Integer	INT	x	+/- 32767	8947
D = Double INT	DINT	x	+/- 2097151	74364
R = Real (Float)	REAL	x.x	+/-16777215*	3.4 / 13.0

* = Applies to single precision accuracy.

2.2 Normalized Quantities

Often a physical quantity is normalized by dividing the physical quantity by a base quantity with the same engineering units as the physical quantity. As a result, the normalized quantity does not have units, but is ‘expressed per-unit’. The normalized quantity has a value of 1.0 [per-unit] when the physical quantity has a value equal to the base quantity.

A good example of this is the physical quantity of motor current. The information that the motor is drawing 40 amps has little significance. The motor nameplate states that the rated motor current is 30 amps. The motor is drawing 133% current is significant information. In the previous illustration the quantity of motor amps was normalized to 133%. In per unit, the quantity is normalized to 1.33.

2.3 Terminology

2.3.1 Web

A web is defined as the material that is being transported through the machine. A web is sometimes referred to as “sheet” or “strip”.

2.3.2 Strip

The strip is defined as the material that is being transported through the machine. A web is sometimes referred to as “sheet” or “web”. The term “strip tension” is referencing the tension of the material in the machine.

2.3.3 Drive

The drive is the power device that is transmitting power to the motor. The motor is connected to a mechanical device that is propelling the material. This manual is specific to the PowerFlex 700S drive.

2.3.4 Motor Torque

A D.C. Motor has two currents flowing through it. The first current is the flux, also known as the field current. This is the magnetizing current that allows the motor to produce torque. The second current is the armature current. This is the actual torque producing current of the motor.

An A.C. motor has only one current physically flowing through the machine. However, this current is a combination of both magnetizing and torque producing current. Motor Torque on an AC motor is the torque producing portion of the total current flowing through the motor.

2.3.5 Section

A Web Handling Machine is broken up into sections. A section consists of one or more drives used to propel the material through the line.

An Unwind Section could consist of one drive, one motor, and one spindle

A lead Section could consist of more than one drive and one motor combination. This could consist of line pacer and then several helper drives. The helper drives “help” in transporting the strip through the machine.

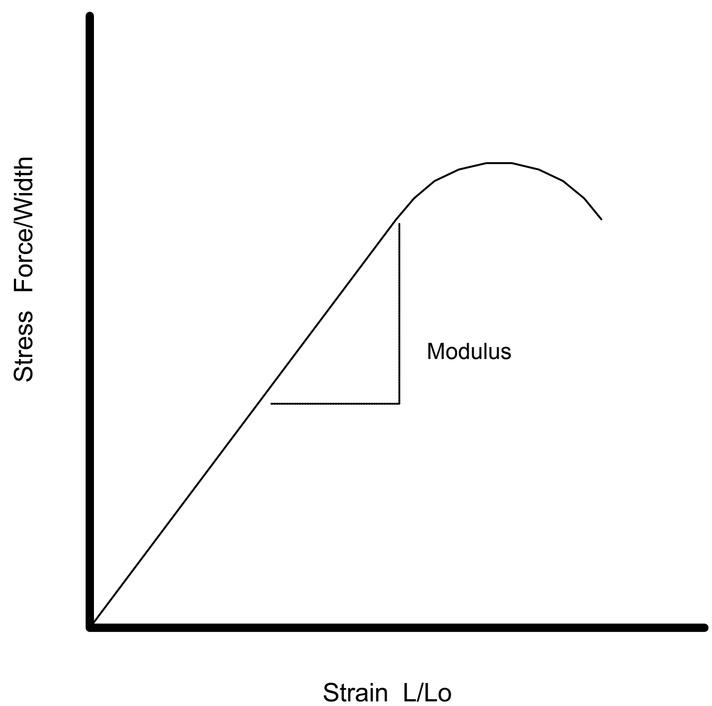
Typically when more than one drive is in a section, one drive is the leader and the other drive is the follower. The follower typically follows the leader’s torque reference.

3.0 Overview

There are several methods of controlling the tension of the web (draw, mechanical dancer, load cell feedback and open loop torque). The Tension Control Module allows the user to configure the module for the various applications.

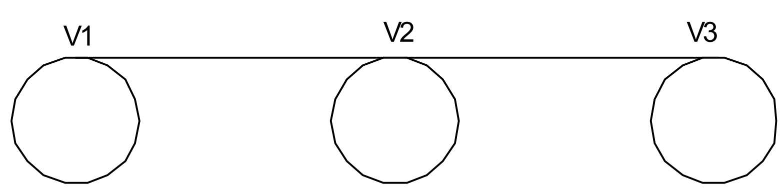
3.1 Web Mechanics

All material follows a stress versus strain relationship. When the material is stretched a force will be generated. The slope of the stress versus strain curve shown below is known as the modulus and is commonly referred to as Young's Modulus. As the strain on the material increases, a point is reached where the material begins to stretch. At some point the strain will become to great and the material will break. The modules is different for each material.



3.2 Draw Control

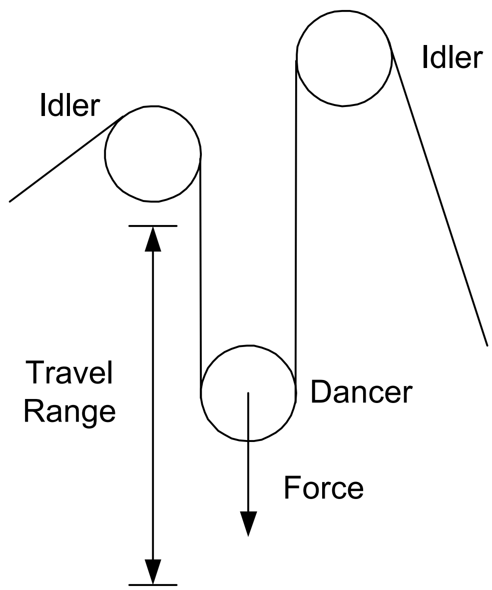
Draw Control is the control of difference in line speed between two sections. One roller on the machine is a master speed reference. The other roll's speed is adjusted to maintain a draw to the master section. The speed differential between the two sections is the draw. Tension Control using Draw is a manual operation. The machine operator adjusts the Draw set point to maintain the desired tension in the web.



$$\%Draw_{12} = \frac{V1 - V2}{V2} x100 \qquad \%Draw_{23} = \frac{V2 - V3}{V3} x100$$

3.3 Mechanical Dancer

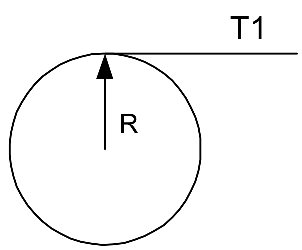
A dancer is a mechanical device that applies force to the web. The force could be a weight, air pressure, or hydraulic pressure. If there is any difference in speed between the two sections, the dancer will move. If the speed of the out going section is greater than the speed of the incoming section the Dancer will move up and have less stored web. If the speed of the out going section is less than the incoming section the Dancer will move down and will store more web. The Tension Control Function Module monitors the dancer position and adjusts the driven section to maintain the dancer at a user specific position (typically 50% travel).



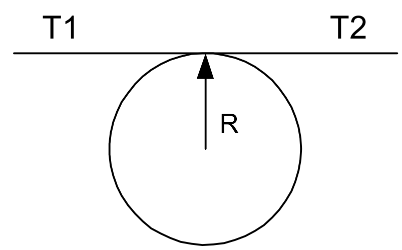
3.4 Open Loop Torque

Open loop torque does not require a tension or position feedback device. The amount of torque required to change the tension between rolls may be calculated. The difference in tension between sections plus losses is converted into percent motor torque. For Unwind and Rewinds, the amount torque required is the tension required plus losses converted into percent motor torque.

Winder / Unwind



Inline Tensioning



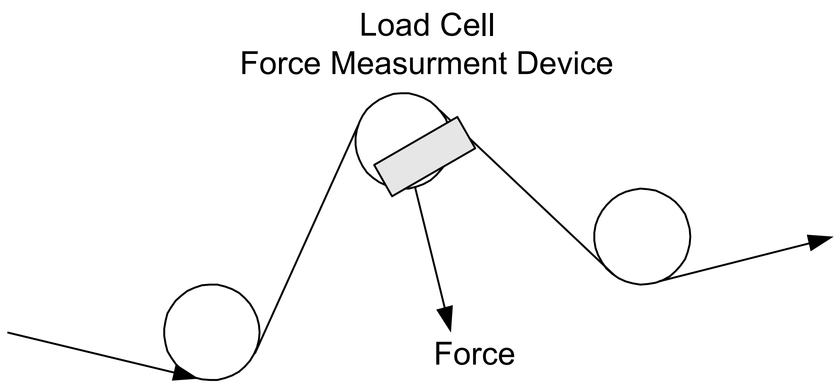
R = Radius in feet
G = Gear Ratio
T_{mr} = Torque Motor Rated

$$\% \text{ Torque} = \frac{T1}{R * G * T_{mr}} * 100$$

$$\% \text{ Torque} = \frac{(T1 - T2)}{R * G * T_{mr}} * 100$$

3.5 Tension Feedback

The Tension Control Function Module may be configured to use actual force tension feedback to perform closed loop tension regulation. A force measurement device (typically referred to as a Load Cell) is used to measure the actual force applied to the web. The load cell does not apply a force to the web, as in the case of the dancer. The controlling section applies the force to the web by pulling harder or by holding back. The load cell simply measures the force on the web and provides the information to the controlling section.



4.0 Functional Description

4.1 Overview

The Tension Control Function Module calculates tension torque requirements and supports web tension control with dancer position feedback, load cell feedback, and without tension feedback. The Tension Control Function Module consists of a program with five routines in RSLogix 5000. These routines are dependent on one another and typically should not be separated.

1. Main (Ladder)
2. Logic (Ladder)
3. Regulator (Function Block)
4. TenRfTaper (Function Block)
5. TrqMem (Function Block)

The user may edit the Main routine to connect signals (tags) and configure the FM. The user cannot edit the remaining routines. The Tension Control Function Module is unit less in design. The modules outputs will reflect the inputs applied to module. The units applied to the module must be consistent. DO NOT mix imperial and metric units.

4.1.1 Main routine

The Main routine is where the user connects user created controller tags to the input and output program tags of the FM. These links are created in the Jump to Sub-Routine (JSR) instructions. A unique JSR is used for each subroutine (Logic, Regulator, TenRfTaper, & TrqMem).

4.1.2 Logic routine

The Logic routine is used to configure and control the tension regulator. The user configures the Function Module based on what type of control (load cell, dancer, or open loop torque). The user enters machine specific information such as gear ratio, rated motor torque, etc.

4.1.3 Regulator routine

The Regulator routine controls either the position of the dancer; the tension utilizing a load cell for feedback, or the open torque. This routine is also responsible for selecting either run tension reference or stall tension reference and ramping the selected reference to the final value.

4.1.4 TenRfTaper routine

The TenRfTaper routine adjusts the tension reference based on roll diameter. As the material builds up on a winder, the tension reference is reduced to prevent material damage. This routine performs linear taper. If a profiled taper circuit is required, the user may delete this routine and generate their own control circuit.

4.1.5 TrqMem routine

The TrqMem routine is used to hold torque reference when transferring tension control between two Center Winders. Once the web is cut from the expiring roll, the incoming roll transfers into tension control.

4.2 Supported Modes of Tension Regulation

4.2.1 Typical Tension Regulation Modes

The following modes of tension regulation are the most commonly employed. These are not the only modes of tension regulation available, but are straight forward to implement and commonly used in many industries.

4.2.1.1 Draw

Draw is the simplest form of tension control. The Draw control in the Process Line Application Modules is supported through the RunJogSpdRf routine of the LogixAndReference program. This type of tension regulation is typically used without the tension regulator, but is sometimes used for speed offset in machines that stretch the web. Variable diameter applications cannot be controlled with only draw for tension regulation.

4.2.1.2 Dancer Position Control with Speed Trim

In this mode of tension control the tension (force) applied to the web is dependant on the mechanical load applied to the dancer. The tension applied to the web is independent of the regulating sections speed or torque as long as the mechanical dancer has not reach it's minimum or maximum travel limits. Typically, the controlling section does not know the tension desired on the web. The controlling section varies it's speed to maintain the dancers position at typically 50% total travel. The position feedback of the dancer is required by the controlling section.

4.2.1.3 Tension Feedback with Speed Trim

In this mode of tension regulation, the actual web tension is measured by a force measurement device (load cell / transducer). The controlling section requires a set point of web tension and the feedback of actual web tension. Based on the values of these inputs the section will adjust (trim) it's speed to maintain the feedback tension equal to the set point tension.

4.2.1.4 Tension Feedback with Torque Trim (for Center Winder/Unwind)

This mode of tension regulation is recommended for Center Winder and Unwind applications only. The actual web tension is measured by a force measurement device (load cell / transducer). The controlling section requires a set point of web tension and the feedback of actual web tension. The tension set point is used to generate a base torque requirement. Based on the values of these inputs the section will adjust (trim) it's torque to maintain the feedback tension equal to the set point tension.

4.2.1.5 Open Loop Torque Control (for Center Winder/Unwind)

This mode of tension regulation is recommended for Center Winder and Unwind applications only. The actual web tension is not measured in this mode. As there is not feedback device to "regulate" the tension, this mode of operation is called "Open Loop". The set point tension is used to calculate the required torque for tension. If the losses for the machine change, the resultant tension on the web will change as a result. The user can make adjustments to correct for losses.

4.2.1.6 Torque Follower

Torque follower is a special form of the "Open Loop Torque Control". In this mode the drive acts as in open loop torque control, but the torque set point is enter as torque and typically communication from a master section. The torque set point in the open loop torque control mode is entered as a tension set point.

4.2.2 Special Requirements Tension Regulation Modes

The following modes of tension regulation are specialized to particular industries or require additional machine and mechanical data beyond what is typically available. These additional requirements and sometimes the need of higher mathematics for configuration, makes these modes of tension regulation more demanding on the user, commissioning engineer, and may require additional maintenance. Therefore, we recommend application of these modes of tension regulation for only the most experience engineers.

4.2.2.1 Dancer Position Control with Torque Trim

This mode of dancer position control requires accurate tension set point information from the mechanical loading system. The method of loading and the mechanical construction of the dancer direct effect the amount of tension applied to the web. Without accurate web tension information from the loading device, this mode of tension regulation will not function.

4.2.2.2 Dancer Position Control with Speed Trim & Torque Feed Forward

In this mode of tension control the tension (force) applied to the web is dependant on the mechanical load applied to the dancer. The tension applied to the web is independent of the regulating sections speed or torque as long as the mechanical dancer has not reach it's minimum or maximum travel limits. The controlling section varies it's speed to maintain the dancers position at typically 50% total travel. The position feedback of the dancer is required by the controlling section. In this mode of dancer position control, the required torque for tension is calculated from the mechanical loading information and fed forward to the drive. This requires accurate tension set point information from the mechanical loading system. The method of loading and the mechanical construction of the dancer direct effect the amount of tension applied to the web. Without accurate web tension information from the loading device, this mode of tension regulation will not function.

4.2.2.3 Tension Feedback with Torque Trim (for Inline Tensioning)

When applying this mode of tension regulation on an inline section, additional information is required regarding the tension on the web of the adjacent section. The dynamic information required from the adjacent sections tension makes this mode more complicated to implement and is there for not recommended for retro fits and systems with limited engineering resources. See section 3.4

4.2.2.4 Tension Feedback with Speed Trim & Torque Feed Forward

In this mode of tension regulation, the actual web tension is measured by a force measurement device (load cell / transducer). The controlling section requires a set point of web tension and the feedback of actual web tension. Based on the values of these inputs the section will adjust (trim) it's speed to maintain the feedback tension equal to the set point tension. In addition, the torque required due to tension is feed forward to the drive. In this configuration the drives speed regulator is only trying to maintain the tension, not also generate the total required torque. This causes the speed regulator to typically operate around zero independent of the total torque required.

4.2.2.5 Open Loop Torque Control (for Inline Tensioning)

When applying this mode of tension regulation on an inline section, additional information is required regarding the tension on the web of the adjacent section. The dynamic information required from the adjacent sections tension makes this mode more complicated to implement and is there for not recommended for retro fits and systems with limited engineering resources. See section 3.4

4.2.2.6 Open Loop Torque Control with Speed Trim

This mode of tension regulation trims the speed reference of the section based on the torque tension set point and torque actual feedback. This type of control can be beneficial for torque applications with webs of very high spring coefficients like steel. This configuration requires the "master" section (speed regulated) adjacent to the torque section be coordinated with the same speed reference. The tuning for this mode is sometimes very difficult and should be left for only the most experienced engineers. This is not a typical (conventional) form of torque control.

4.2.2.7 Open Loop Torque Control with Speed Trim & Torque Feed Forward
This mode of tension regulation trims the speed reference of the section based on the torque tension set point and torque actual feedback. In addition to trimming the speed, the torque per tension component is also feed forward to the drive. This type of control can be beneficial for torque applications with webs of very high spring coefficients like steel. This configuration requires the "master" section (speed regulated) adjacent to the torque section be coordinated with the same speed reference. The tuning for this mode is sometimes very difficult and should be left for only the most experienced engineers. This is not a typical (conventional) form of torque control.

4.2.2.8 Torque Follower Control Modes
The Torque Follower Control Modes operate exactly the same as the Open Loop Torque control modes except the reference input is torque, not tension.

4.2.3 Tension Regulation Mode Selection

The following table indicates the command word settings to activate the listed modes of tension regulation. The Process line command word is [wDLx_DrvCmmdProcLn]. The selected mode of thension control is activated and deactivated with bit 7 [Tension Control Enable] of the command word. If this is low, the selected mode of tension regulation will be off and the drive will operate in speed mode.

[X] indicates high blank indicates low *Tension Control Mode*	Tension Control Enable Bit 07	Tension Control Bit 09	Torque Control Bit 10	Dancer Control Bit 11	Torque Trim Bit 12	Speed Trim Bit 13	Torque Follow Bit 15
Draw trim – no Tension Regulator		NA	NA	NA	NA	NA	NA
Dancer Control with Speed Trim	X			X		X	
Dancer Control with Torque Trim	X			X	X		
Dancer Ctrl w Speed Trim & Trq FF	X			X	X	X	
Tension Control with Speed Trim	X	X				X	
Tension Control with Torque Trim	X	X			X		
Tension Ctrl w Speed Trim & Trq FF	X	X			X	X	
Open Loop Torque	X		X		X		
Open Loop Torque with Speed Trim	X		X			X	
Open Loop Trq w Spd Trim & Trq FF	X		X		X	X	
Torque Follower Control	X				X		X
Torque Follower w Speed Trim	X					X	X
Torque Follower w Spd Trim & Trq FF	X				X	X	X

4.3 Main routine

The Main routine consists of four rungs of ladder logic programming. A rung description briefly describes the Input and Return (output) parameters of the JSR instructions for each routine called. Temporary tags have been entered for each input parameter and each return parameter. The tag names entered in the JSR's are not declared. The user must replace these tag names with existing project tags or create new tags. The routine will show an error until all input and return parameters are satisfied. The input parameters may also be entered as actual values. If an input parameter is set to a value and not a tag, the value cannot be edited in run mode. Values entered directly in the JSR should be constants that do not change during machine operation. Specific formatting is required for values entered directly in the JSR.
NOTE: For Application Module users, the tags in the JSR's are predefined and configured for operation. No additional integration is necessary.

Data Type	Format	Example
B = Boolean	x	0 or 1
I = Integer	x	123
R = Real (Float)	x.x	3.4 / 13.0

If any signal scaling is required to interface the FM into the user application, the user may use the main routine for this programming. Note; Scaling for **inputs** to the routines should be done before the JSR and any scaling applied to the **return** values from the routines should be done after the JSR.

4.4 Logic Routine

The Logic Routine is used to configure the Tension Control Function Module. In this routine the selected tension mode is tested, constants for speed and torque scaling are generated, and sections of code are enabled or disable depending on the tension mode selected.

Input Parameters

	Name	*Type*	*Range*	*Description*
1	CtrlEnbl	BOOL	0 to 1	Enables the Tension Control Module
2	Running	BOOL	0 to 1	Releases the tension regulator when the machine is running
3	TenCtrl	BOOL	0 to 1	Select Tension Control
4	TrqCtrl	BOOL	0 to 1	Select Torque Control
5	DanCtrl	BOOL	0 to 1	Select Dancer Control
6	TrqTrim	BOOL	0 to 1	Regulator adjust Trq Reference
7	SpdTrim	BOOL	0 to 1	Regulator adjust Speed Reference
8	TenZoneDwStream	BOOL	0 to 1	Location of the Tension Zone with respect to the controlling section
9	ReverseRotation	BOOL	0 to 1	selects the sign of the Torque signal
10	TrimHoldHigh	BOOL	0 to 1	Trim Regulator Hold High
11	TrimHoldLow	BOOL	0 to 1	Trim Regulator Hold Low
12	TenRfStall	BOOL	0 to 1	Stall Tension Reference Selected
13	TrqFbJLoss	BOOL	0 to 1	Torque Fdbk includes Inertia & Friction
14	TrqMemEnbl	BOOL	0 to 1	Torque Memory Enable
15	TrqFolwCtrl	BOOL	0 to 1	Torque Follower Control
16	TenMax_EU	REAL	NA	Tension Maximum [Engineering Units]
17	RadiusCalc_EU	REAL	NA	Calculated Radius
18	GearRatio	REAL	NA	Gear Ratio [Motor Speed/Roll Speed]

19	MtrTrqRated_EU	REAL	NA	Motor Rated Torque [Engineering Units]
20	LineSpdMax_EU	REAL	NA	Max Line Speed [Engineering Units
21	J_sec	REAL	0 to 500	Total Reflected Inertia [Sec]

Return Parameters

	Name	*Type*	*Range*	*Description*
1	LogicStat	DINT	NA	Logic Status
2	TrqPerTen	REAL	NA	Torque Per Tension Conversion
3	TrqPerLineSpd_sec	REAL	NA	Torque [% of Motor Rated] Per Speed [% of Maximum Line Speed]

4.4.1 CtrlEnbl

The CtrlEnbl input enables the regulator. When false the regulator output will ramp to zero. This input must be high to activate the selected mode of tension regulation.
Usage – Use this input to activate the regulator.

4.4.2 Running

This input indicates that the drive is running. It is used to release the tension regulator when running and to disable the tension regulator when the section is commanded to stop.
Usage – Connect this input to the drive running bit in the Process line status word.

4.4.3 TenCtrl

This input configures the controller to regulate tension. Tension set point and tension feedback signals are for the regulation in this mode.
Usage – Use this input to configure the controller to regulate tension.

4.4.4 TrqCtrl

This input configures the controller to regulate torque. The torque reference is calculated based on the desired tension.
Usage – Use this input to configure the controller to regulate torque.

4.4.5 DanCtrl

This input configures the controller to regulate dancer position. The dancer's position reference is set with DanStpt_Pct (typically 50%). The feedback for the regulator is the actual dancer position.
Usage – Use this input to configure the controller to regulate dancer position...

4.4.6 TrqTrim

This input configures the regulator's output to adjust (trim) the torque signal to the drive.
Usage – Use this input to have the controller adjust the torque signal to the drive.

4.4.7 SpdTrim

This input configures the regulator's output to adjust (trim) the speed signal to the drive.
Usage – Use this input to have the controller adjust the speed signal to the drive.

4.4.8 TenZoneDwStream

This input configures the regulator's output based on the drive's position in the web path. If the tension zone controlled by the section is up stream (before) the section, set this input low. If the tension zone controlled by the section is down stream (after) the section, set this input high.
Usage – Set this input based on section position relationship to the master section

4.4.9 ReverseRotation

This input reverses the Rotation of the drive. It is used for Over/Under Wind Operation. Setting this input high indicates an Under Wind operation. If the winder / unwind is only operated in the under wind mode, configure the machine for positive direction equals under wind and set this bit low
Usage – Set this input to change the polarity of the rotation based on machine parameters.

4.4.10 TrimHoldHigh

This input holds the positive output of the PI Regulator.
Usage – Use this input to hold the PI regulator from increasing in value.

4.4.11 TrimHoldLow

This input holds the negative output of the PI Regulator.
Usage – Use this input to hold the PI regulator from decreasing in value.

4.4.12 TenRfStall

The tension reference typically is set to a lower value while the machine is at rest and the tension regulator remains activated. This input activates the stall tension reference. When activated, the tension reference is switched to the stall tension reference.
Usage – Use this input to set the tension reference to a lower value while the machine is at or near zero speed.

4.4.13 TrqFbJLoss

This parameter is set depending on the components of the torque feedback used in the application program. If the torque feedback from the drive contains the inertia and losses torque components, this value should be set to 1.
Usage – Use this input if the torque feedback (torque producing current) includes the losses compensation.

4.4.14 TrqMemEnbl

The Torque Memory Enable feature is used when transferring rolls on a turret winder stand. When torque memory is enabled, the tension control mode is change to Torque Open Loop. There is a separate subroutine to handle Torque Memory.
Usage – Use this input if the Torque Memory Subroutine is present.

4.4.15 TrqFolwCtrl

The Torque Follower Controller is used when the drive is following a torque signal from another drive. The tension control mode is Torque control but he reference is entered as PU torque and not tension. This mode sometimes is referred to as load sharing.
Usage – Use this input if the drive is following a torque reference signal from another drive.

4.4.16 TenMax_EU

This is the maximum tension for the section. Maximum tension is usually determined by the machine builder and/or motor rating and gear ratio. Pounds and ounces are typical units for the Imperial System. Newtons are typical units for the metric system.
Usage - Connect to the Maximum Tension tag or set the value of Maximum Tension in the JSR instruction

4.4.17 RadiusCalc_EU

This is the Radius of the roll controlling tension. For a variable diameter section, this value will be calculated from the diameter calculator. The units need to match the same units as Line Speed Max (see below). Typical units are feet (Imperial) or meters (Metric).
Usage - Connect to the Calculated Radius tag or set the value of Radius in the JSR instruction.

4.4.18 GearRatio

The gear ratio of the machine section.

$$GearRatio = \frac{MotorRevolutions}{RollRevolutions}$$

Usage – Connect to the gear ratio tag or set the value of gear ratio in the JSR instruction.

4.4.19 MtrTrqRated_EU

This is motor rated torque in engineering units. The engineering units for this term must match with the engineering units for TenMax_EU and RadiusCalc_EU. For example if the tag TenMax_EU has units of pounds and the RadiusCalc_EU has units of feet, than the units for motor rated torque would be foot-pounds.
The Motor Rated torque can be calculated using the motor's nameplate data. For Imperial Units (Foot-Lbs), the equation is the following:

$$MtrTrqRated(foot - pounds) = \frac{MotorHorsePower * 5252}{MotorRatedSpeed}$$

For Metric Units (Newton-Meters), the equation is the following:

$$MtrTrqRated(newton - meters) = \frac{MotorKiloWatts * 9.55}{1000 * MotorRatedSpeed}$$

Note: Application Module users, The rated motor torque is calculated by the program.
Usage – Connect to the Rated Motor Torque tag or set the value of Rated Motor Torque in the JSR instruction.

4.4.20 LineSpdMax_EU

This is the Line Speed Maximum in engineering units.
Usage – Connect to the Line Speed Max tag or set the value of Line Speed Max in the JSR instruction.

4.4.21 J_sec

J_sec is the total inertia reflected back to the motor. For variable diameter rolls, the inertia comp routine will calculate this value. For constant diameter rolls, the drive calculates this value. For the PowerFlex 700S, parameter 9 is the total system inertia reflected back to the motor in seconds. Inertia in seconds is define as the Time to reach base motor speed at rated motor torque.
Usage – Connect to the J_sec tag or set the value of J_sec in the JSR Instruction.

4.4.22 LogicStat

This is the logic status from the tension control routine. The logic status tag is used by other routines in the Tension Control Function Module.

Bit 00	Control On: The tension control regulator is active.
Bit 01	Tension Control: The tension control regulator is controlling tension.
Bit 02	Torque Control: The tension control regulator is controlling torque.
Bit 03	Dancer Control: The tension control regulator is controlling dancer position.
Bit 04	Torque Follower Control: The drive is following the torque reference from another drive.
Bit 05	Torque Trim: The tension control regulators output is summing with the drive torque reference.
Bit 06	Speed Trim: The tension control regulator's output is summing with drive's velocity reference.
Bit 07	
Bit 08	PI Integral Hold High: The PI Regulator is inhibited in increasing its output.
Bit 09	PI Integral Hold Low: The PI Regulator is inhibited form decreasing its output.
Bit 10	Stall Tension: The Tension Control's Reference is the stall tension reference.
Bit 11	TrqFbJloss: The Torque feedback from the drive includes the inertia and losses
Bit 12	Torque Memory On: The Torque Memory is enabled.
Bit 13	
Bit 14	
Bit 15	
Bit 16	Tension Reference Off: The tension control regulator is not active
Bit 17	Dancer Reference Off: The tension control regulator is not controlling position of a dancer.
Bit 18	Min/Max Torque: The tension control regulator is set up for Min/Max Torque.
Bit 19	Min/Max Torque On. The tension control regulator is actively controlling torque.
Bit 20	Regulator On: The tension control regulator is on.
Bit 21	Regulator Off: The tension control regulator is off.
Bit 22	FeedForwardOn: The tension control algorithm is feed forwarding a torque signal.
Bit 23	TorqueFeedForwardNegage: The feed forward term is negated.
Bit 24	TorqeFeedbackNegate: The Torque feedback is negated.
Bit 25	TrimOutputNegate: The output of the tension control regulator is negated
Bit 26	TorqueReferenceOn: The drive is following a torque follower
Bit 27 - 31	Not used

4.5 Regulator routine

The regulator routine is responsible for closing the tension, position or torque loop. This routine is also responsible for switching between stall and run reference. When enabled, the regulator will ramp the reference set point from the feedback value to the set point.
This routine accepts the feedback directly from the analog input module. The routine will then scale the feedback from minimum tension reference to a maximum tension reference. This routine also generates a feed forward torque reference based on the tension set point, roll radius, gear ratio and motor rated torque.

The closed loop system consists of a lead-lag filter and a PI regulator. This has the ability to close all three types of tension regulation loops (tension, position or torque). When the regulator is configured for tension, the feedback is actual tension from a load cell. When the regulator is configured for position, the feedback is the actual position feedback of a dancer. There is a signal generated in the routine that may be optionally used to apply loading pressure to the dancer. When the regulator is configured for torque, the feedback is the torque feedback from the drive.

Input Parameters

	Name	*Type*	*Range*	*Description*
1	TenStp_DC	REAL	NA	Tension set point [Data Counts](RAW)
2	TenStpMin_DC	REAL	NA	Min Tension set point [Data Counts]
3	TenStpMax_DC	REAL	NA	Max Tension set point [Data Counts]
4	TenRfStall_Pct	REAL	0 to 100	Tension Reference Stall Percent
5	TenRfStallMin_Pct	REAL	0 to 100	Tension Reference Stall Min Percent
6	TenRfTaper_Pct	REAL	0 to 100	Tension Reference Taper %
7	DanStpt_Pct	REAL	0 to 100	Dancer Set point [% of Full Storage]
8	RfRate_PctSec	REAL	0 to 100	Reference Rate [% per Second]
9	TenDanFb_DC	REAL	NA	Tension/Dancer Fdbk [Data Counts]
10	TenDanFbMin_DC	REAL	NA	Minimum Tension/Dancer Feedback
11	TenDanFbMax_DC	REAL	NA	Maximum Tension/Dancer Feedback
12	TrqFb_PU	REAL	-2.0 to 2.0	Torque Feedback [Per Unit]
13	TrimKP	REAL	0 to 50	Trim Regulator Proportional Gain
14	TrimWld_Rad	REAL	0 to 5	Trim Regulator Lead Frequency
15	TrimLimSpd_Pct	REAL	0 to 100	Speed Trim Limit [% Max Line Speed]
16	TrimLimSpdZero_Pct	REAL	0 to 100	Speed Trim Limit at Zero Speed
17	LineSpdTrimLimSpd_Pct	REAL	0 to 100	Line Speed where full speed trim will be available
18	TrimLimTrq_Pct	REAL	0 to 100	Torque Trim Limit [% of Max Tension]
19	TrimRate_PctSec	REAL	0 to 100	Trim Rate [% Unit/Second]
20	TrimFbWLead_Rad	REAL	0 to 10	Feedback Lead Frequency [Rad/Sec]
21	TrimFbWLag_Rad	REAL	0 to 200	Feedback Lag Frequency [Rad/Sec]
22	DrvTrqRfJLoss_PU	REAL	-2.0 to 2.0	Inertia & Losses Torque Ref to Drive
23	LineSpd_EU	REAL	NA	Line Speed [Engineering Units]
24	LineSpdMax_EU	REAL	NA	Line Speed Maximum
25	MtrSpdBase_RPM	REAL	NA	Base Speed from Motor Name Plate
26	Constant_RPMperEU	REAL	XXX	Converstion Constant
27	BuildUpRate	REAL	XXX	Build Up Ratio
28	TrqRf_Pct	REAL	-100 to 100	Torque Reference [% Rated Torque]

Return Parameters

	Name	*Type*	*Range*	*Description*
1	DrvSpdTrimRf_EU	REAL	NA	Drive Speed Trim Reference [Engineering Units]
2	DrvSpdTrimRf_PU	REAL	-1.0 to 1.0	Drive Speed Trim reference [Per Unit]
3	DrvTrqTrimRf_PU	REAL	-1.0 to 1.0	Drive Torque Trim Reference [Per Unit]
4	DrvTrqMode	INT	0 to 5	Drive Torque Mode Selection
5	TenRf_Pct	REAL	0 to 100	Tension Reference [Percent of Maximum]
6	RegRf_Pct	REAL	0 to 100	Regulator Reference (Input)
7	RegFb_Pct	REAL	0 to 100	Regulator Feedback (Input)
8	RegErr_Pct	REAL	-100 to 100	Regulator Error

4.5.1 TenStpt_DC

This is the tension set point in raw “Data Counts”. The Tension set point will be scaled from 0 to 100 percent based on TenStptMin_DC and TenStptMax_DC.
Usage – Connect to the tag that is the tension set point of the section.

4.5.2 TenStptMin_DC

This is the tension reference value that will equate to 0 percent.
Usage - Connect to the Tension Set point Minimum value tag or set the constant value in the JSR.

4.5.3 TenStptMax_DC

This is the tension reference value that will equate to 100 percent.
Usage - Connect to the Tension Set point Maximum value tag or set the constant value in the JSR.

4.5.4 TenRfStall_Pct

This is stall tension reference set point. This value is express in terms of percent of Tension Set point. If TenRfStall_Pct is set to 10% and the Tension Set point is 100 pounds, than in stall the tension reference would be 10 pounds.
Usage - Connect to the Tension Reference Stall Set point value tag or set the constant value in the JSR.

4.5.5 TenRfStallMin_Pct

The Tension Reference Stall Minimum Percent is used to maintain a minimum tension on the web during stall. This value is in percent of maximum tension. In the above description, during stall the tension reference would be 10 pounds. However, in this example the machine must maintain a minimum 25 pounds. If the maximum tension (TenStpMax_DC) is 1000 pounds, then TenRfStallMin_Pct would be set to 2.5%.

$$\frac{25}{1000}\,x\,100 = 2.5\%$$

4.5.6 TenRfTaper_Pct

This is the taper tension reference in percent. The value is calculated in the TenRfTaper routine.
Usage - The tag entered in the TenRfTaper JSR instruction for this return parameter should be entered as an input parameter to the Regulator JSR instruction.

4.5.7 DanStpt_Pct

This is the Dancer Set point in percent.
Usage - Connect to the Dancer Set Point value tag or set the constant value in the JSR. (Typical usage is setting to a constant, approximately 50%)

4.5.8 RfRate_PctSec

This is the rate limit of the reference set point. The reference set point in percent is incremented or decremented by this value. For example, if RfRate_PctSec were set to 1, than it would take 100 seconds for the reference to ramp from zero to 100 percent. If RfRate_PctSec were 100, then it would take one second for the reference to ramp from zero to 100 percent. This is used for “bump less” transfers in and out of tension control.
Usage - Connect to the Reference Rate value tag or set the constant value in the JSR

4.5.9 TenDanFb_DC

This is the Tension or Dancer Feedback in data counts. In the Application Module, this signal is set up to come directly from an analog input 2 of the PowerFlex 700S.
Usage – Connect to the tag that is the tension or dancer feedback of the drive section

4.5.10 .TenDanFbMin_DC

This is the value of TenDanFb_DC that equates to 0 percent.
Usage - Connect to the Tension or Dancer Feedback Minimum value tag or set the constant value in the JSR.

4.5.11 TenDanFbMax_DC

This is the value of TenDanFb_DC that equates to 100 percent.
Usage - Connect to the Tension or dancer feedback maximum value tag or set the constant value in the JSR.

4.5.12 TrqFb_PU

This is the torque feedback for “Closed Loop” torque control when trimming speed.
Usage – Connect to the tag that is the actual torque feedback (PU) of the drive section.

4.5.13 TrimKp

This is the proportional gain of the trim PI regulator. This affects both the calculated value of the integral and proportional control algorithm.
Usage - Connect to the Trim Kp value tag or set the constant value in the JSR

4.5.14 TrimWld

This is the lead frequency of the PI regulator in radians/second. This affects the calculated value of the integral control algorithm.
Usage - Connect to the Trim Wld value tag or set the constant value in the JSR

4.5.15 TrimLimSpd_Pct

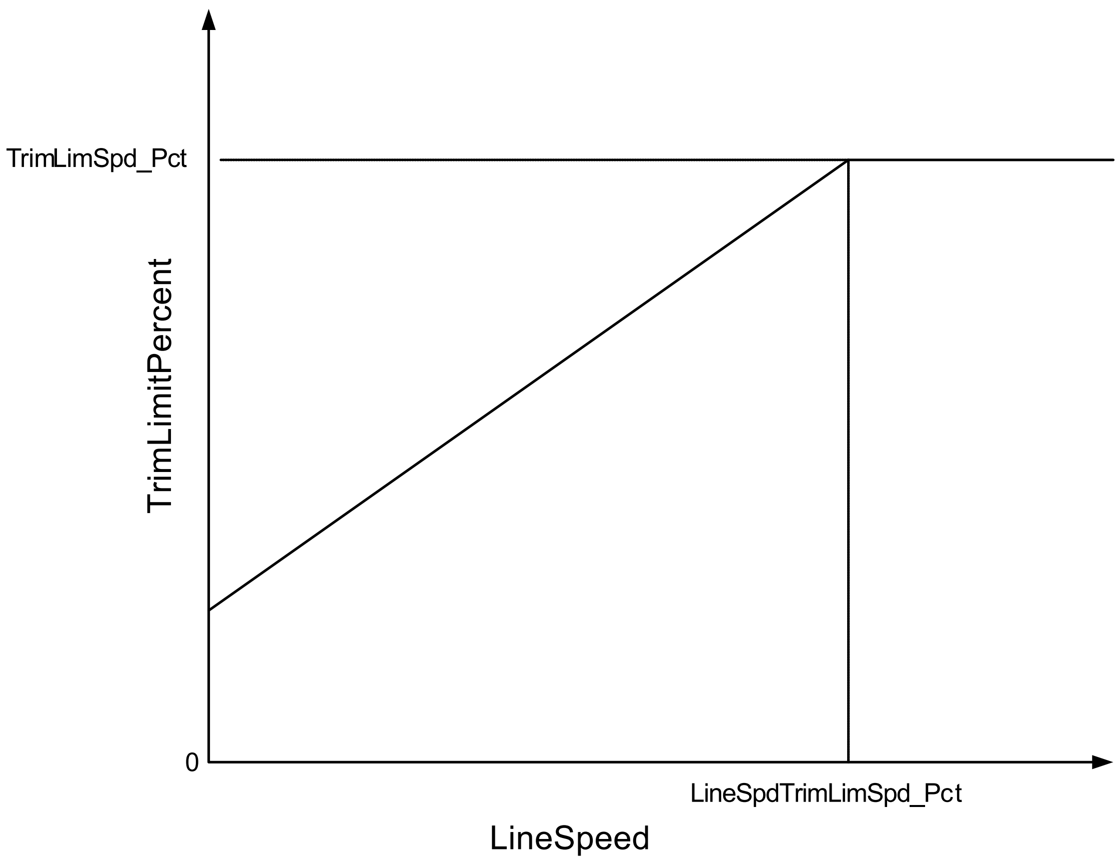
This is the maximum amount of speed trim the regulator will output. This value is in percent of Maximum Line Speed.
Usage - This value is typically set to 10%. Connect to the Trim Limit value tag or set the constant value in the JSR.

4.5.16 TrimLimSpdZero_Pct

This is the amount of speed trim the regulator will output at zero speed. This value is in percent of Maximum Line Speed.
Usage – This value is typically 1 to 2 %. Connect to the Trim Limit at Zero speed value tag. Or set the constant value in the JSR.

4.5.17 LineSpdTrimLimSpd_Pct

This is the line speed where the trim limit output will be equal to TrimLimSpd_Pct. As the line speed is increased from zero to this value, the trim limit output is incrementing from TrimLimSPdZero_Pct to TrimLimSpd_Pct. This value is entered as a percent of maximum line speed.
Usage – Connect to the Line Speed Maximum for trim reference tag or set the constant value in the JSR.



4.5.18 TrimLimTrq_Pct

This is the trim limit when the trim regulator is acting in torque control. It is entered as percent of maximum tension for the section.
Usage – This value is typically 20 to 30%. Connect to the Trim Limit Torque tag or set the constant value in the JSR.

4.5.19 TrimRate_PctSec

When the trim regulator is turned off, the output is ramped from the current value to zero. The decrement rate is determined by TrimRate_PctSec. This is part of "bump less" transfer for the tension control circuit.
Usage - Set this value to avoid sudden changes in tension when the regulator is switched off. This is used when the system is changed to sensor less mode.

4.5.20 TrimFbWLead_Rad

This is the regulator feedback signal's Lead / Lag filter lead term in Radians/Second.
Usage – Set this value as appropriate. See specific tuning guidelines.

4.5.21 TrimFbLag_Rad

This is the regulator feedback signal's Lead / Lag filter lag term in Radians/Second.
Usage – Set this value as appropriate. See specific tuning guidelines.

4.5.22 DrvTrqRfJLoss_Pu

This is the inertia and losses compensation value for the drive section. This value is calculated in the inertia & losses routine. It includes both inertia compensation, windage, and friction losses.
Usage - The tag entered in the losses JSR instruction for this return parameter should be entered as an input parameter to Regulator JSR instruction.

4.5.23 LineSpd_EU

This is the linear line speed reference in engineering units.
Usage – Enter the tag that represents line speed in engineering units.

4.5.24 LineSpdMax_EU

This is the maximum line speed for the section in engineering units.
Usage – Enter the value in the JSR Instruction.

4.5.25 MtrSpdBase_RPM

This is the motor base speed in rpm. This value can be found on the motor name plate and must equal the value set in the drive's parameter base.
Usage – Enter the motors base speed into the JSR instruction.

4.5.26 Constant_RPMperEU

This is the constant that converts the linear line speed to RPM at core diameter.
Usage – Enter the tag for RPM to Engineering Unit Conversion or the value into the JSR Instruction.

4.5.27 BuildUpRatio

This is the build up ratio. It is calculated by the diameter calculation subroutine. A build up ratio of 1 = Min Empty Core.
Usage – The tag entered in the DiamCalc JSR instruction for this return parameter should be entered as an input parameter to the Regulator JSR instruction

4.5.28 TrqRf_Pct

This is the torque reference in percent of rated motor torque. This torque reference is used when in Torque Follower Control and/or when torque memory is activated.
Usage – Enter the tag for torque reference percent or the value to the JSR instruction.

4.5.29 DrvSpdTrimRf_EU

This is the output of the regulator in speed trim mode. This value is in engineering units.
Usage- Use this value if the speed reference to the drive is in engineering units. This value is summed the feed forward term.

4.5.30 DrvSpdTrimRf_PU

This is the output of the regulator in speed trim mode. This value is in Per Unit and can be summed with the feed forward speed reference to the drive.
Usage- Use this value if the speed reference to the drive is in per unit. This value is summed the feed forward term.

4.5.31 DrvTrqTrimRf_PU

This is the output of the regulator in torque trim mode. This value is in Per Unit and can be summed with the feed forward torque reference to the drive.
Usage- Sum this value with the torque reference of the drive.

4.5.32 DrvTrqMode

This is the request torque mode to the drive.

0 = Zero Torque
1 = Speed Mode (Torque Reference is output of the speed regulator)
2 = Torque Mode (Torque Reference is the external torque reference).
3 = Min Mode (Torque Reference is the minimum value of either the speed regulator or torque reference).
4 = Max Mode (Torque Reference is the minimum value of either the speed regulator or the torque reference).
5 = Sum Mode (Torque Reference is the sum of the speed regulator and external torque reference).

Usage – This value needs to be linked to the torque mode select of the drive.

4.5.33 TenRf_Pct

This is the Tension Reference as a percentage of maximum tension.
Usage – Can be used for display purposes.

4.5.34 RegRf_Pct

This is the Regulator Reference in percentage of rated reference. If the Trim Regulator is regulating tension then this value is the percentage of maximum tension. If the trim regulator is regulating dancer position, then this value is the percentage of maximum storage. If the trim regulator is regulating torque, then this value is the percentage of motor rated torque. The value will include adjustment from the Tension Taper routine for Tension Control mode and Torque Control mode
Usage – This value can be used for display purposes.

4.5.35 RegFb_Pct

This value is the regulator feedback in percentage of rated reference. If the Trim Regulator is regulating tension then this value is the percentage of maximum tension. If the trim regulator is regulating dancer position, then this value is the percentage of maximum storage. If the trim regulator is regulating torque, then this value is the percentage of motor rated torque.
Usage – This value can be used for display purposes.

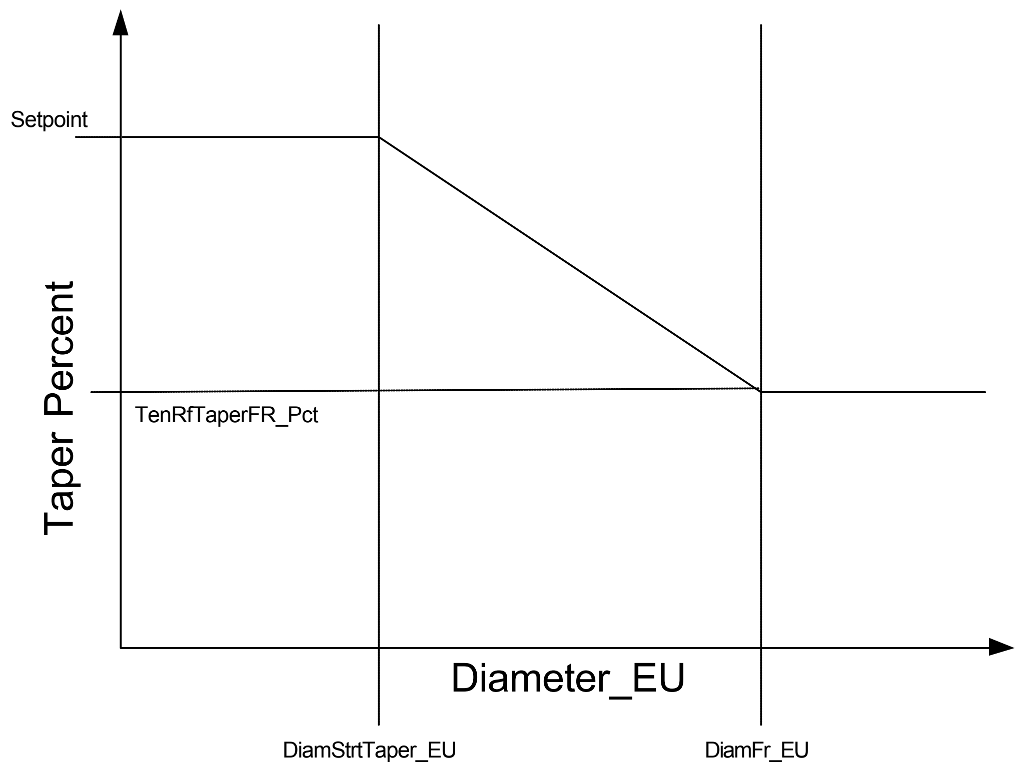
4.5.36 RegErr_Pct

This value is the regulator error in percentage of rated reference.
Usage – This value can be used for display purposes.

4.6 TenRfTaper routine

The routine is for use in Center Winder applications only.
As material is wound on to the roll, the tension reference is reduced to prevent crushine (damage) to the material all ready wound on the core. The web chariastics and finished roll diameter dictate if and how much taper is required. The taper percentage is adjusted as a function of roll diameter. At core the actual tension will be the setpoint tension. As diameter increases the actual tension will be decreased until full roll diameter is reached. The percent taper is the percent of the setpont tension to be applied at full roll.

The TenRfTaper reduces the tension reference as the roll diameter builds. The user inputs the diameter at which taper tension begins and the amount of taper tension in percent.



Input Parameters

	Name	Type	Range	Description
1	DiamCalc_EU	REAL	NA	Diameter Engineering Units
2	DiamFR_EU	REAL	NA	Diameter Full Roll
3	DiamStrtTaper_EU	REAL	NA	Diameter Start Taper
4	TenRfTaperFR_Pct	REAL	0 to 100	Tension Reference Full Row %

Return Parameters

	Name	Type	Range	Description
1	TenRfTaper_Pct	REAL	0 to 100	Taper Tension Reference Pct

4.6.1 DiamCalc_EU

The DiamCalc_EU is the actual diameter of the center drive roll. This comes from the Diameter Calculator Routine.
Usage – Connect the DiamCalc_In tag to the JSR instruction

4.6.2 DiamFr_EU

This is the Diameter where the taper tension stops decreasing. When the DiamCalc_EU is equal to DiamFR_EU, then the actual web tension will equal Set point Tension * TenRfTaper_Pct.
Usage – Input the Diameter value at which the taper tension stops decreasing. In the Application Module, this is set to the full roll diameter value.

4.6.3 DiamStrtTaper_EU

This is the Diameter where the actual tension starts decreasing s set by the taper tension percent. If the DiamCalc_EU is below this value the taper tension percent will remain at 100%. When the DiamCalc_EU is greater than DiamStrtTaper_EU, then the taper tension will decrease toward the TenRfTaperFR_Pct.
Usage – Input the Diameter value at which the taper tension starts decreasing.

4.6.4 TenRfTaperFR_Pct

This is the final value of the taper tension. The Taper Tension Output will equal this value whenever the DiamCalc_EU is equal or greater to DiamFR_EU.
Usage – Input the Taper Tension Reference final value in percent.

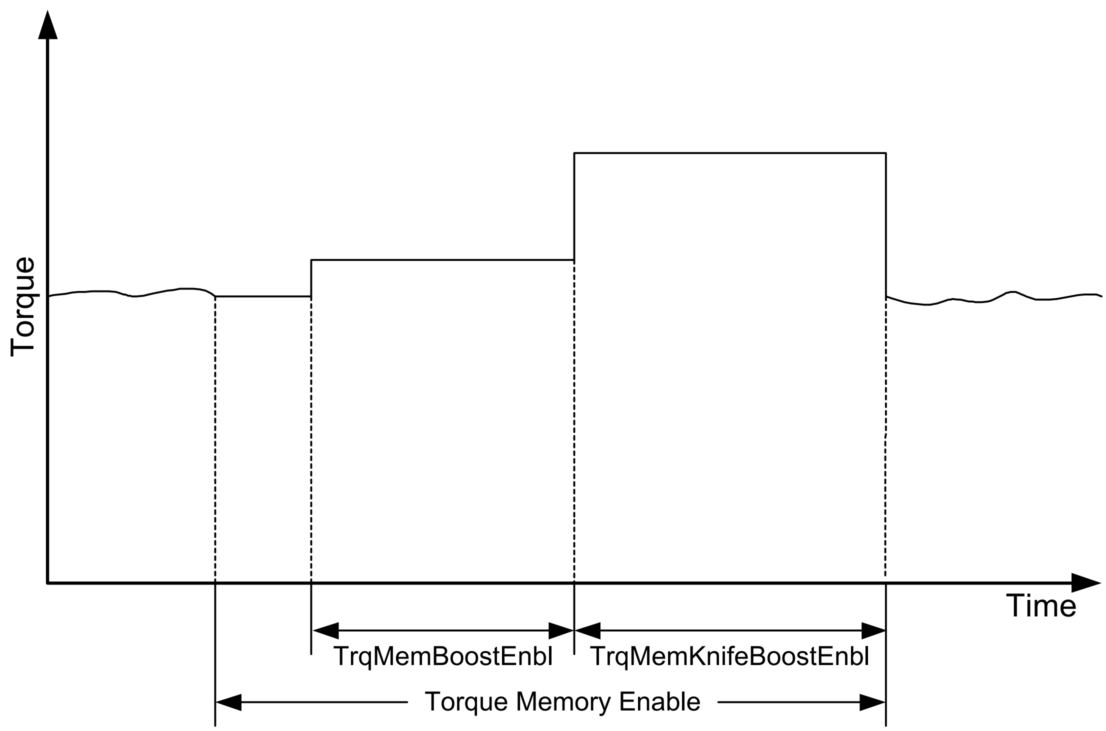
4.6.5 TenRfTaper_Pct

This is the output of the taper tension reference routine. The output remains at 100% until the diameter is equal to or greater than DiamStrtTaper_EU. When the diameter is between the start diameter and full row diameter, the tension reference is reduced on a linear basis between 100 percent and the value of full roll tension reference. This output is multiplied by the Tension set point to generate a final tension reference based on taper.

4.7 TrqMem routine

The torque memory subroutine is used to hold the drive's torque reference at a constant value when a roll change is performed on a Center Winder with automatic roll change support. The base torque memory value is the torque feedback prior to enabling torque memory. The Torque Memory Routine has two Boost commands. The first is a TrqMemBoostEnbl and the other is a TrqMemKnifeBoostEnbl. Both of these boosts have individual settings. Both settings are a percentage multiplier to the base memorized torque from the drive.

For example, the drive's torque feedback was varying between 49 to 51 percent. When the torque memory is enabled the Torque Feedback was 50 percent. The Torque Memory base value is now set to 50 percent. The TrqMemBoostRf_Pct is set for 10% and the TrqMemKnifeBoostRf_Pct is set for 50%. When the TrqMemBoostEnbl is set, the Torque Memory Reference is set to 55% (1.10 * 50% = 55%). When the TqMemKnifeBoostEnbl is set, the Torque Memory Reference is set to 75% (1.50 * 50% = 75%). Once Torque memory is disabled the Torque Memory Reference is set equal to the Torque Feedback of the drive.



Input Parameters

	Name	*Type*	*Range*	*Description*
1	TrqFb_PU	REAL	NA	Torque Feedback Per Unit
2	DrvTrqRfJLoss_PU	REAL	NA	Torque Reference for inertia & Losses
3	TrqMemBoostEnbl	BOOL	0 to 1	Torque Memory Boost Enable
4	TrqMemBoostRf_Pct	REAL	10 to 300	Torque Memory Boost Reference
5	TrqMemKnifeBoostEnbl	BOOL	0 to 1	Torque Memory Knife Boost Enable
6	TrqMemKnifeBoostRf_Pct	REAL	10 to 300	Torque Memory Knife Boost Reference

Return Parameters

	Name	*Type*	*Range*	*Description*
1	TrqRf_Pct	REAL	0 to 200	Torque Reference Percent

4.7.1 TrqFb_Pu

The drive torque feedback is in per unit. A value of one (1) is equal to 100% torque rating of the motor. This is the torque producing current of the motor. This value is monitored and captured when the torque memory enable is set true.
Usage – This is the torque feedback from the drive.

4.7.2 DrvTrqRfJLoss_PU

All mechanical systems have losses. These consist of friction and windage. Along with losses additional torque is required to accelerate the section. This is known has inertia compensation. Both of these components are added together to produce DrvTrqRfJLoss_PU. This value is in per unit. A value of one (1) is equal to 100% torque rating to the motor. The Torque Memory Routine will subtract this value from torque feedback if the torque feedback includes the losses compensation.
Usage – Connect to Drive Torque Reference J Loss in the JSR instruction.

4.7.3 TrqMemBoostEnbl

When the torque memory boost enable is set the captured Torque Feedback is increased by the Torque Memory Boost Reference %. When the torque memory boost is reset, the output is set back to the captured Torque Feedback.
Usage – Use this when the Captured Torque value needs to be increased.

4.7.4 TrqMemBoostRf_Pct

When the Torque Memory Boost is enabled, the captured Torque Feedback is increased by the Torque Memory Boost Reference Percent. This reference is a percentage increase. For example, if TrqMemBoostRf_Pct is set to 10%, the Torque Memory Reference will be 10% more than the Torque Feedback of the drive.
Usage - Connect to the TrqMemBoostRf_Pct tag or set the value of Memory Boost in the JSR instruction.

4.7.5 TrqMemKnifeBoostEnbl

When this tag is enabled, the Torque Memory Reference is increased by TrqMemKnifeBoostRf_Pct.
Usage - Use this bit when an increase in the Torque Memory is needed. For example, when the knife is firing to sever the web.

4.7.6 TrqMemKnifeBoostRf_Pct

When the Knife Torque Memory Boost is enabled, the captured Torque Feedback is increased by the Knife Torque Memory Boost Reference Percent. This reference is a percentage increase. For example, if TrqMemKnifeBoostRf_Pct is set to 10%, the Torque Memory Reference will be 10% more than the Torque Feedback of the drive.
Usage - Connect to the TrqMemKnifeBoostRf_Pct tag or set the value of Memory Boost in the JSR instruction.

5.0 Setup/Configuration

5.1 Overview

All setup and configuration is done in the Main routine. The Tension Control Function Module has five routines. The Function Module is connected to the balance of the application module software by placing application tag names in the Jump to Sub-Routine (JSR) instructions of the Main routine.

The JSR input parameter is looking for a specific type of tag for each input and return. It is important that the application tag is the correct data type for the input. The most common data types used by the function module are as follows:

1. Boolean (BOOL)
2. Floating point (REAL)
3. Integer (DINT)

If the user is entering a value instead of an application tag, the value needs to be of the same type as the tag input. REAL input must be configured (entered) as x.x (1.0 = 1). If they are not entered in this format the JSR will attempt to convert the value from and integer, this will lead to errors in the program.
When the JSR instruction input parameters are configured with tags that are intended to be tuned by the user at commissioning, it is recommended that the (z prefix) naming convention be used for tags of this type.

5.2 Logic JSR Instruction

The Logic routine has two functions. The first function is to configure and setup the Function Module for the application. To configure the Function Module place a 0 or 1 in the configuration place holder of the JSR. To setup the function module place an appropriate tag for the value requested in the JSR. The second function is to control the Function Module. This is done by placing the appropriate tags into the JSR.

5.2.1 Input Parameters

5.2.1.1 CtrlEnbl – In 1

Enter a boolean tag for Control Enabled. This tag is set true to enable the trim regulator. When set false, the trim regulator will ramp the output to zero.

5.2.1.2 Running – In 2

Enter a boolean tag for Drive Running. This tag is true when the drive is running with the run velocity reference.

5.2.1.3 TenCntrl – In 3, DanCntrl – In 4, TrqCntrl – In 5

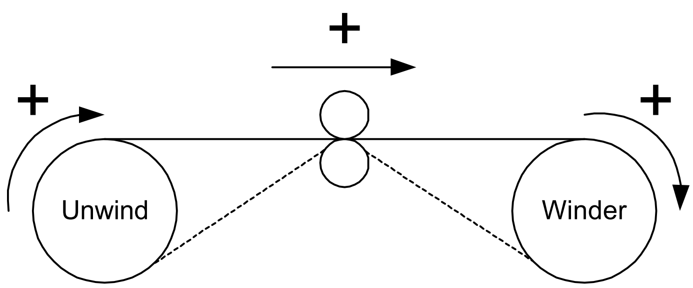
These three inputs determine the type of control regulator (Tension, Dancer, and Torque). Only one of the three inputs should be on at a time. Enter a boolean tag for the bits if they can dynamically change. If these are static values, then enter a 1 into the desired control type and a 0 for the other two.

5.2.1.4 TrqTrim – In 6, SpdTrim – In 7

These two inputs determine where the output of the trim loop is sent. Set one of the inputs true. Set input 6 to a 1 for torque trim. Set input 7 to a 1 for speed trim. Do not set both trim selections simultaneously.

5.2.1.5 TenZoneDwStream – In 8

Set high if the regulated tension zone is after the controlling section in the web path. The following figure shows the tension zone for unwinds is always down stream (set High) and the tension zone for winders is always upstream (set Low).



	Unwind		Winder	
	Over	Under	Over	Under
TenZoneDwStream	1	1	0	0
ReverseRotation	0	1	0	1
Velocity Feedback	+	-	+	-

5.2.1.6 ReverseRotation – In 9 (Under Wind)
Set based on the material and machine configuration. Typically ReverseRotation is the under wind selection. If the only mode of operation is under wind this may be set low and the machine configured for positive rotation in under wind. See the figure above for more information.

5.2.1.7 TrimHoldHigh – In 10
Typical applications will enter a zero (0). If an external hold is needed enter a boolean tag for Logic-In10.

5.2.1.8 TrimHoldLow – In 11
Typical applications will enter a zero (0). If an external hold is needed enter a boolean tag for Logic-In11.

5.2.1.9 TenRfStall – In 12
Enter a boolean tag for TenRfStall input parameter (Logic-I12). This tag switches the tension reference to a reduced (stall) tension reference.

5.2.1.10 TrqFbJLoss – In 13
Set to 0 if the torque feedback from the drive does not include inertia and losses torque components. Set to 1 if the torque feedback includes the inertia and losses components. For the application module set this input to 1.

5.2.1.11 TrqMemEnbl – In 14
Enter a boolean tag to enable Torque Memory.

5.2.1.12 TrqFolwCtrl – In 15
Set to a 1 when the drive section follows the torque reference from another drive (load share). Otherwise set this input to zero.

5.2.1.13 TenMax_EU – In 16
Enter a real tag that contains the maximum tension value. If the maximum tension value is entered directly make sure to enter at least one digital after the decimal point. (i.e. xxx.x)

5.2.1.14 RadiusCalculated_EU – In 17
Enter a real tag that contains the Radius of the driven roll in engineering units. For winder/unwind applications this value typically comes from the diameter calculator routine.

5.2.1.15 GearRatio – In 18
Enter a real tag that contains the gear ratio. If the gear ratio is entered directly, make sure to enter at least one digit after the decimal point.

5.2.1.16 MtrTorqRated_EU – In 19
Enter a real application tag that contains the Rated Motor Torque. If the rated motor torque is entered directly, make sure to enter at least one digit after the decimal point.

5.2.1.17 LineSpeedMax_EU – In 20
Enter a real tag that contains the Maximum Line Speed value. If the maximum line speed is entered directly, make sure to enter at least one digit after the decimal point.

5.2.1.18 J_sec – In 21
Enter a real tag that contains the system inertia in seconds. This typically is produced by the JCalc routine.

5.2.2 Output Parameters

5.2.2.1 TenCtrlLogicStat – Ret 1
This output verifies that the Tension Control Logic Routine has accepted the control inputs properly and is used to control the remaining Tension Control Function Module routines.

5.2.2.2 TrqPerTen – Ret 2
This output is used for scaling the tension values to torque.

5.2.2.3 TrqPerLineSpdSec – Ret 3
This output is the amount of torque required to accelerate the present load one percent (1%) of maximum speed.

5.2.3 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Bx   =CtrlEnbl - Control Enable
In2 -Bx   =Running - Drive Running
In3 -Bx   =TenCtrl - Tension Outer Loop Control
In4 -Bx   =TrqCtrl - Torque Outer Loop Control
In5 -Bx   =DanCtrl - Dancer Outer Loop Control
In6 -Bx   =TrqTrim - Torque Trim
In7 -Bx   =SpdTrim - Speed Trim
In8 -Bx   =TenZoneDwStream - Tension Zone Down Stream
In9 -Bx   =ReverseRotation - Reverse Rotation
In10-Bx   =TrimHoldHigh - Trim Regulator Hold High
In11-Bx   =TrimHoldLow - Trim Regulator Hold Low
In12-Bx   =TenRfStall - Stall Tension Reference
In13-Bx   =TrqFbJLoss - Torque Feedback Includes Inertia and Loss Torque
In14-Bx   =TrqMemEnbl - Torque Memory Enable
In15-Bx   =TrqFolwCtrl - Torque Follower Control
In16-Rx.x =TenMax_EU - Tension Maximum [Engineering Units]
In17-Rx.x =RadiusCalc_EU - Calculated Radius [Engineering Units]
In18-Rx.x =GearRatio - Gear Ratio [Motor Speed / Roll Speed]
In19-Rx.x =MtrTrqRated_EU - Motor Rated Torque [Engineering Units]
In20-Rx.x =LineSpdMax_EU - Maximum Line Speed [Engineering Units]
In21-Rx.x =J_sec - Total Reflected Inertia [seconds]
Subroutine Outputs
Ret1-Ix   =LogicStat - Logic Status
Ret2-Rx.x =TrqPerTen - Torque Per Tension Conversion
Ret3-Rx.x =TrqPerLineSpd_sec - Torque [Percent of Motor Rated] Per Speed [Percent of Maximum
Line Speed per Second]
```

```
         Tension Control
              Logic
 ------------JSR-----------
 Jump To Subroutine
 Routine Name                Logic
 Input Par   wDLx_DrvCmmdProcLn.7
 Input Par    DLx_DrvStatProcLn.1
 Input Par   wDLx_DrvCmmdProcLn.9
 Input Par  wDLx_DrvCmmdProcLn.10
 Input Par  wDLx_DrvCmmdProcLn.11
 Input Par  wDLx_DrvCmmdProcLn.12
 Input Par  wDLx_DrvCmmdProcLn.13
 Input Par   zDLx_TenZoneDwStream
 Input Par    DLx_DrvStatProcLn.6
 Input Par                      0
 Input Par                      0
 Input Par   wDLx_DrvCmmdProcLn.8
 Input Par                      1
 Input Par  wDLx_DrvCmmdProcLn.29
 Input Par  wDLx_DrvCmmdProcLn.15
 Input Par         zDLx_TenMax_lb
 Input Par      DLx_RadiusCalc_ft
 Input Par         zDLx_GearRatio
 Input Par   DLx_MtrTrqRated_lbft
 Input Par    zDLx_LineSpdMax_FPM
 Input Par              DLx_J_sec
 Return Par DLx_TenCtrlLogicStat
 Return Par             TrqPerTen
 Return Par      TrqPerLineSpd_sec
```

5.3 Regulator JSR Instruction

5.3.1 Overview

The Tension Regulator is configured in the Setup/Logic Routine. This Subroutine is responsible for the closed loop regulation of tension control.

5.3.2 Input Parameters

5.3.2.1 TenStpt_DC – In 1

Enter a real application tag that is used for tension reference. This input can be referenced from any digital (panelview …) or analog source available. The value will be internally scaled based on the TenStptMin_DC and TenStptMax_DC parameters.

5.3.2.2 TenStptMin_DC – In 2, TenStptMax_DC – In 3

For TenStptMin_DC enter a real application tag that reflects the tension reference zero percent (0%) value. Typically this value would be zero. For TenStptMax_DC Enter a real application tag that stores tension reference 100% value.
See section 5.3.2.8

5.3.2.3 TenRfStall_Pct – In 4

Enter a real application tag for the stall tension reference value. If entering this value directly into the JSR instruction, ensure that there is one significant digit after the decimal point.

5.3.2.4 TenRfStallMin_Pct – In 5

Enter a real application tag for the minimum stall tension reference value. If entering this value directly into the JSR instruction ensure that there is one significant digit after the decimal point.

5.3.2.5 TenRTaper_Pct – In 6

Enter the real application tag from the Taper Tension Reference JSR Instruction.

5.3.2.6 DanStpt_Pct – In 7

Enter a real application tag for the Dancer Set point reference. If entering this value directly into the JSR instruction ensure that there is one significant digit after the decimal point.

5.3.2.7 TenDanRfRate_PctSec – In 8

Enter a real application tag for the Reference Ramp Rate. If entering this value directly into the JSR instruction ensure that there is one significant digit after the decimal point.

5.3.2.8 TenDanFb_DC – In 9, TenDanFbMin_DC – In 10, TenDanFbMax_DC – In 11

These parameters configure/scale the feedback. The feedback is scaled internally from engineering units or counts to percent. The TedDanFbMin sets the zero percent value of the feedback. The TenDanFbMax sets the one hundered percent value of the feedback. The feedback and reference need to be scaled such that they are equal.

Example: This example is for the trim regulator trimming tension with a load cell feedback. The load cell generates a signal such that 0 lbs tension is equal to 1v and 50lbs is equal to 10v. Set the drive's analog input two, such that ten volts (10V) is equal to one hundred (100%), with this setting 1v will equal 10%. The TenDanFbMin_DC value should be set to 10. The TenDanFb_max value should be set to 100. With this configuration the tension reference needs to be scaled such that one hundred percent is equal to 50 pounds of tension. If the tension reference was sent to the routine as a number between zero and 50, than TenRefStpt_Min_DC is set to 0 and TenREfStp_Max_DC is set to 50.

5.3.2.9 DrvTrqFb_PU – In 12

Enter a real application tag that aliases the Motor Torque Feedback

5.3.2.10 Trim_KP – In 13

Enter a real application tag that stores the Proportional Gain Value. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.11 TrimWld_Rad – In 14

Enter a real application tag that stores the Lead Value of the trim regulator. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.12 TrimLimSpd_Pct – In 15

Enter a real application tag that stores the Trim Limit Speed Pct. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.13 TrimLimSpdZero_Pct – In 16

Enter a real application tag that stores the Trim Limit Speed Zero. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.14 LineSpdTrimLimSpd_EU – In 17

Enter a real application tag that stores the Line Speed Trim Limit Speed in EU. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.15 TrimLimTrq_Pct – In 18

Enter a real application tag that stores the Trim Limit Torque Pct. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.16 TrimRate_PctSec – In 19
Enter a real application tag that stores the Ramp Rate of the trim regulator. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.17 TrimFbWLead_Rad – In 20
Enter a real application tag that stores the Trim Feedback Lead frequency. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.18 TrimFbWLag_Rad – In 21
Enter a real application tag that stores the Trim Feedback Lag frequency. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.19 DrvTrqRfJLoss_PU – In 22
Enter the real application tag that stores the Inertia and Friction Compensation. This tag usually is from the output of the JLossComp JSR Instruction.

5.3.2.20 LineSpd_EU – In 23
Enter a real application tag that contains the value of the line speed. This value can come from a reference routine or from some other section.

5.3.2.21 LineSpeedMax_EU – In 24
Enter a real application tag that stores the Maximum Line Speed value. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.22 MtrSpdBase_RPM – In 25
Enter a real application tag that stores the Motor Base Speed. This value must be the same value that is in parameter 4; Motor RPM. It is recommended that this be an application tag rather than a direct entry into the JSR instruction.

5.3.2.23 Constant_RPMperEU – In 26
Enter the real application tag that contains the Rotary to Velcotiy Reference. This tag is usually the tag from the DiamCalc.

5.3.2.24 BuildUpRatio – In 27
Enter the real application tag that contains the build up ratio. This tag is usually the tag from the DiamCalc.

5.3.2.25 TrqRef_Pct – In 28
Enter the real application tag that contains Torque Reference.
If not used enter 0.0

5.3.3 Output Parameters

5.3.3.1 DrvSpdTrimRf_EU – Ret 1
Enter a real application tag to store the value of the taper tension percent. This signal my be summed with the feed forward speed reference in engineering units.

5.3.3.2 DrvSpdTrimRf_PU – Ret 2
Enter a real application tag to store the value of the taper tension percent. This signal is used to trim the speed reference at the drive. The value is in Per Unit.

5.3.3.3 DrvTrq_trimRf_PU – Ret 3
Enter a real application tag to store the value of the taper tension percent. This signal is used to trim the torque reference at the drive. The value is in Per Unit.

5.3.3.4 DrvTrq_Mode – Ret 4
Enter a real application tag to store the value of the taper tension percent. This value is used to configure the drives speed / torque mode. It is required for proper operation of the tension control program. Write this value to the drives speed torque mode selection parameter.

5.3.3.5 TenRf_Pct – Ret 5

Enter a real application tag to store the value of the taper tension percent. This is the scaled tension reference. May be used for display.

5.3.3.6 RegRf_Pct – Ret 6

Enter a real application tag to store the value of the taper tension percent. This is the final tension / dancer / torque reference to the regulator.

5.3.3.7 RegFb_Pct – Ret 7

Enter a real application tag to store the value of the taper tension percent. This is the actual feedback value used by the regulator

5.3.3.8 RegErr_Pct – Ret 8

Enter a real application tag to store the value of the taper tension percent. This is the actual error of RegRf_Pct to RefFb_Pct as seen by the regulator.

5.3.4 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Rx.x =TenStpt_DC - Tension Setpoint [Data Counts]
In2 -Rx.x =TenStptMin_DC - Minimum Tension Setpoint [Data Counts]
In3 -Rx.x =TenStptMax_DC - Maximum Tension Setpoint [Data Counts]
In4 -Rx.x =TenRfStall_Pct - Stall Tension Reference [Percent of Setpoint]
In5 -Rx.x =TenRfStallMin_Pct - Stall Tension Reference Minimum [Percent of Maximum]
In6 -Rx.x =TenRfTaper_Pct - Tension Reference Taper [Percent of Setpoint]
In7 -Rx.x =DanStpt_Pct - Dancer Setpoint [Percent Full Storage]
In8 -Rx.x =RfRate_PctSec - Reference Rate [Percent per Second]
In9 -Rx.x =TenDanFb_DC - Tension/Dancer Feedback [Data Counts]
In10-Rx.x =TenDanFbMin_DC - Minimum Tension/Dancer Feedback [Data Counts]
In11-Rx.x =TenDanFbMax_DC - Maximum Tension/Dancer Feedback [Data Counts]
In12-Rx.x =TrqFb_PU - Torque Feedback [Per Unit]
In13-Rx.x =TrimKp - Trim Regulator Proportional Gain
In14-Rx.x =TrimWld_Rad - Trim Regulator Integral Time [Seconds]
In15-Rx.x =TrimLimSpd_Pct - Speed Trim Limit [Percent of Maximum Line Speed]
In16-Rx.x =TrimLimSpdZero_Pct - Speed Trim Limit at Zero Line Speed [Percent of Maximum
Line Speed]
In17-Rx.x =LineSpdTrimLimSpd_EU - Line Speed Where Full Speed Trim Limit Will Be Applied
[Engineering Units]
In18-Rx.x =TrimLimTrq_Pct - Torque Trim Limit [Percent of Maximum Tension]
In19-Rx.x =TrimRate_PctSec - Trim Rate [Per-Unit / Second]
In20-Rx.x =TrimFbWLead_Rad - Feedback Lead Frequency [Radians/Second]
In21-Rx.x =TrimFbWLag_Rad - Feedback Lag Frequency [Radians/Second]
In22-Rx.x =DrvTrqRfJLoss_PU - Drive Torque Reference Inertia and Losses Part [Per-Unit]
In23-Rx.x =LineSpd_EU - Line Speed [Engineering Units]
In24-Rx.x =LineSpdMax_EU - Maximum Line Speed [Engineering Units]
In25-Rx.x =MtrSpdBase_RPM - Motor Base Speed [RPM]
In26-Rx.x =Constant_RPMperEU - Conversion Constant [RPM per Engineering Unit]
In27-Rx.x =BuildUpRatio - Build Up Ratio
In28-Rx.x =TrqRf_Pct - Torque Reference [Percent of Motor Rated Torque]
```

```
Subroutine Outputs
Ret1-Rx.x =DrvSpdTrimRf_EU - Drive Speed Trim Reference [Engineering Units]
Ret2-Rx.x =DrvSpdTrimRf_PU - Drive Speed Trim Reference [Per-Unit]
Ret3-Rx.x =DrvTrqTrimRf_PU - Drive Torque Trim Reference [Per Unit]
Ret4-Ix   =DrvTrqMode - Drive Torque Mode [1=Spd, 3=Min, 4=Max, 5=Sum]
Ret5-Rx.x =TenRf_Pct - Tension Reference [Percent of Maximum Tension]
Ret6-Rx.x =RegRf_Pct - Regulator Ref [%of Max Tension/%of Rated Torque/%of Storage]
Ret7-Rx.x =RegFb_Pct - Regulator Fdbk [%of Max Tension/%of Rated Torque/%of Storage]
Ret8-Rx.x =RegErr_Pct - Regulator Error [%of Max Ten/%of Rated Torque/%of Storage]
```

```
            Tension Control
               Regulator
 ------------------JSR-----------------
 Jump To Subroutine
 Routine Name                 Regulator
 Input Par              wDLx_TenStpt_DC
 Input Par           zDLx_TenStptMin_DC
 Input Par           zDLx_TenStptMax_DC
 Input Par          zDLx_TenRfStall_Pct
 Input Par       zDLx_TenRfStallMin_Pct
 Input Par               TenRfTaper_Pct
 Input Par               zDLx_DanStpt_Pct
 Input Par     zDLx_TenDanRfRate_PctSec
 Input Par              wDLx_TenDanFb_DC
     <Drive:I.UserDefinedRealData[2]>
 Input Par          zDLx_TenDanFbMin_DC
 Input Par          zDLx_TenDanFbMax_DC
 Input Par              DLx_DrvTrqFb_PU
             <Drive:I.MotorTorqueRef>
 Input Par                  zDLx_TrimKp
 Input Par              zDLx_TrimWld_rad
 Input Par          zDLx_TrimLimSpd_Pct
 Input Par      zDLx_TrimLimSpdZero_Pct
 Input Par zDLx_LineSpdTrimLimSpd_FPM
 Input Par          zDLx_TrimLimTrq_Pct
 Input Par         zDLx_TrimRate_PctSec
 Input Par            zDLx_TrimWldFb_rad
 Input Par            zDLx_TrimWlgFb_rad
 Input Par          DLx_DrvTrqRfJLoss_PU
                 <Drive:O.TorqueRef1>
 Input Par             DLx_LineSpdRf_FPM
 Input Par            zDLx_LineSpdMax_FPM
 Input Par             DLx_MtrSpdBase_RPM
 Input Par        DLx_Constant_RPMperFPM
 Input Par              DLx_BuildUpRatio
 Input Par                     TrqRf_Pct
 Return Par         DrvLineSpdTrimRf_FPM
 Return Par            DLx_DrvSpdTrimRf_PU
     <Drive:O.UserDefinedRealData[1]>
 Return Par            DLx_DrvTrqTrimRf_PU
     <Drive:O.UserDefinedRealData[2]>
 Return Par                DLx_DrvTrqMode
             <Drive:O.SpdTorqModeSel>
 Return Par                     TenRf_Pct
 Return Par                     RegRf_Pct
 Return Par                  DLx_RegFb_Pct
 Return Par                    RegErr_Pct
```

5.4 TenRfTaper JSR Instruction

5.4.1 Input Parameters

5.4.1.1 DiamCalc_EU – In 1

Enter the Diameter Calculated tag from the Diameter Calculator Routine. This is the first returned tag from the Diameter Calculator JSR instruction.

5.4.1.2 DiamFR_EU – In 2

Enter a real application tag that will store the value of Diameter Full Roll.

5.4.1.3 DiamStrtTaper_EU – In 3
Enter a real application tag that will store the value of the diameter for taper tension to begin.

5.4.1.4 TenRfTaperFR_Pct – In 4
Enter a real application tag that will store the value of the final taper tension percentage.

5.4.2 Output Parameters

5.4.2.1 TenRFTaper_Pct – Ret 1
Enter a real application tag to store the value of the taper tension percent. This is used in the tension regulator subroutine.

5.4.3 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Rx.x =DiamCalc_EU - Calculated Diameter [Engineering Units]
In2 -Rx.x =DiamFR_EU - Diameter Full Roll [Engineering Units]
In3 -Rx.x =DiamStrtTaper_EU - Diameter Where Tension Taper Starts [Engineering Units]
In4 -Rx.x =TenRfTaperFR_Pct - Tension Reference Taper at Full Roll [Percent of Setpoint
Tension]
Subroutine Outputs
Ret1-Rx.x =TenRfTaper_Pct - Tension Reference Taper [Percent of Setpoint]
```

```
          Tension Control
         Tension Reference
               Taper
 ---------------JSR---------------
 Jump To Subroutine
 Routine Name            TenRfTaper
 Input Par          DLx_DiamCalc_in
 Input Par            zDLx_DiamFR_in
 Input Par  zDLx_DiamStrtTaper_in
 Input Par  zDLx_TenRfTaperFR_Pct
 Return Par           TenRfTaper_Pct
```

5.5 TrqMem JSR Instruction

5.5.1 Input Parameters

5.5.1.1 TrqFB_PU – In 1
Enter a real application tag for the Torque Feedback from the drive. This application tag should alias Drive: I.MotorTorqueRef.

5.5.1.2 DrvTrqRfJLoss_PU – In 2
Enter the real application tag associated with inertia and friction compensation. Typically this tag is the output from the JLossComp JSR Instruction.

5.5.1.3 TrqMemBoostEnbl – In 3
Enter a Boolean application tag that is programmed to boost the torque reference to the drive.

5.5.1.4 TrqMemBoosRf_Pct – In 4
Enter a real application tag that stores the Boost Reference value. When entering this value directly at least one digit after the decimal is required i.e. RRR.R

5.5.1.5 TrqMemKnifeBoostEnbl – In 5

Enter a Boolean application tag that is programmed to boost the torque reference to the drive.

5.5.1.6 TrqMemKnifeBoostRf_Pct – In 6

Enter a real application tag that stores the Knife Boost Refereference. When entering this value directly at least one digit after the decimal is required i.e. RRR.R

5.5.2 Output Parameters

5.5.2.1 TrqRef_Pct – Ret 1

TrqRef_Pct is used in the Regulator routine when the section's Torque Memory is enabled.

5.5.3 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Rx.x =TrqFb_PU - Torque Feedback [Per-Unit]
In2 -Rx.x =DrvTrqRfJLoss_PU - Drive Torque Reference Inertia and Losses Part [Per-Unit]
In3 -Bx   =TrqMemBoostEnbl - Torque Memory Boost Enable
In4 -Rx.x =TrqMemBoostRf_Pct - Torque Memory Boost Reference [Percent]
In5 -Bx   =TrqMemKnifeBoostEnbl - Torque Memory Knife Cut Boost Enable
In6 -Rx.x =TrqMemKnifeBoostRf_Pct - Torque Memory Knife Cut Boost Reference [Percent]
Subroutine Outputs
Ret1-Rx.x =TrqRf_Pct - Torque Reference [Percent Motor Rated Torque]
```

```
                Tension Control
                 Torque Memory
                     JSR
Jump To Subroutine
Routine Name                        TrqMem
Input Par                   DLx_DrvTrqFb_PU
               <Drive:I.MotorTorqueRef>
Input Par              DLx_DrvTrqRfJLoss_PU
                     <Drive:O.TorqueRef1>
Input Par             wDLx_DrvCmmdProcLn.30
Input Par            zDLx_TrqMemBoostRf_Pct
Input Par             wDLx_DrvCmmdProcLn.31
Input Par zDLx_TrqMemKnifeBoostRf_Pct
Return Par                        TrqRf_Pct
```

6.0 Tuning / Start Up

6.1 Installing the Application Module

Perform the following operations in the order listed to ensure proper signal connections between the DriveLogix controller and the PowerFlex 700S firmware.

1. Download the RSLogix 5000 [.acd] file to the DriveLogix controller
2. Download the DriveExecutive [.dno] file to the PowerFlex 700S

   Note, order of these events are critical as the DriveLogix controller must send the Peer Communication format to the PowerFlex 700S firmware before the PowerFlex 700S will accept all the configuration settings provided in the DriveExecutive file. Manually setting the Peer Communication format in the drive will not be effective until configured in DriveLogix. If this sequence of operation is not followed, the DriveLogix controller may not communicate with the PowerFlex 700S.

6.2 Drive Tuning & Configuration

6.2.1 Drive Tuning

For basic commissioning of the application, the drive must first be tuned to regulate the motor. The following steps will guide you through the basic requirements of drive tuning when using an application module.

1. Set param 153 bit 8 high. This will set the start/stop control to 3 wire for operation via the HIM. When the start up is complete this **must** be set to low for 2 wire operation from DriveLogix.
2. From the HIM, select the "Start-Up" function and follow the directions. In this section you will perform the following steps.
   a. Motor Control
      i. FOC – for Induction Motor
      ii. PMag – for Permanent Magnet Motor
   b. Motor Data – Enter all motor data for the attached motor, check # poles
   c. Feedback Config – Select feedback type
   d. Pwr Circuit Diag
   e. Direction Test – (NOTE, the motor will run) recommend always changing wires and not software, this is for maintenance purposes, if the program is restored it will default to the standard direction setting.
   f. Motor Tests – (NOTE, the motor will run)
   g. Inertia Measure – (NOTE, the motor will run)
   h. Speed Limits
      i. Select "+/- Speed Ref"
      ii. Fwd Speed Limit
      iii. Rev Speed Limit
      iv. Abs Overspd Lim – Max over speed past the Fwd and Rev Speed Limit. This is where the drive will fault
   i. **Do not** complete the remainder of the Start-Up procedure in the drive
   j. Scroll down to "Done/Exit"
3. Tune the speed regulator. Depending on the inertia of the machine and other factors, the speed regulator bandwidth (p90) should be set for 15 to 50 radians.
4. Set param 153 bit 8 Low. This will set the start/stop control to 2 wire for operation via DriveLogix

6.2.2 Analog Input 2 (Default Config for AM)

After finishing the assisted start, the next step is to configure analog inputs. Analog Input two is default aliased to the DanTenFB_DC tag in the the drivelogix controller. The feedback is scaled such that ten volts equates to 100 percent.

Tension Feedback Example: This example is for the trim regulator trimming tension with a load cell feedback. The load cell generates a signal such that fifty pounds (50lbs) is equal to ten volts (10V).
Follow the Load cell manufacture's guidelines for setting up the load cell. The following is typical start up procedure.

For a PowerFlex 700S

1. With no external force on the load cell (just the deadweight of the roll), zero the load cell output and verity that p806 [Analog In2 Data] is zero. Adjust p809 [Analog 2 Offset] accordingly.
2. Apply the maximum line running weight in the machine path. Adjust the load cell's output to get 10 volts. Adjust p808 [Analog 2 Scale] such that p806 [Analog 2 Data] is equal to 100.
3. Remove the known weight and verify the load cell is sending 0 volts.

With the drive's analog input scaled such that ten volts (10V) is equal to one hundred (100%). TenDanFbMin_DC is set to zero (0). TenDanFb_max is set to one hundred (100). Therefore the tension reference needs to be scaled such that one hundred percent is equal to fifty pounds. If the tension reference was sent to the routine as a number between zero and fifty, then TenRefStpt_Min_DC is set to zero (0) and TenREfStp_Max_DC is set to fifty (50).

Dancer Feedback Example: This example is for the trim regulator trimming dancer position. The Dancer Feedback is wired to the drive's analog input two. The zero storage position is when the material would be tight. The full storage position is when the material would be slack.

For a PowerFlex 700S

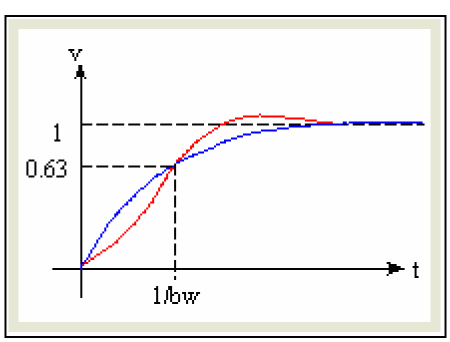
1. Move the dancer to the zero storage position. Verify that p806 [Analog In2 Data] is zero. Adjust p809 [Analog 2 Offset] accordingly.
2. Move the dancer to the full storage position. Verify that p806 {Analog In2 Data} is one hundred (100). Adjust p808 accordingly.

6.3 Trim Regulator Gains

The trim regulator consists of a simple Proportional – Integral (PI) regulator with a lead-lag filter in the feedback path. The values for integral, proportional, lead and lag are entered through the application tags.

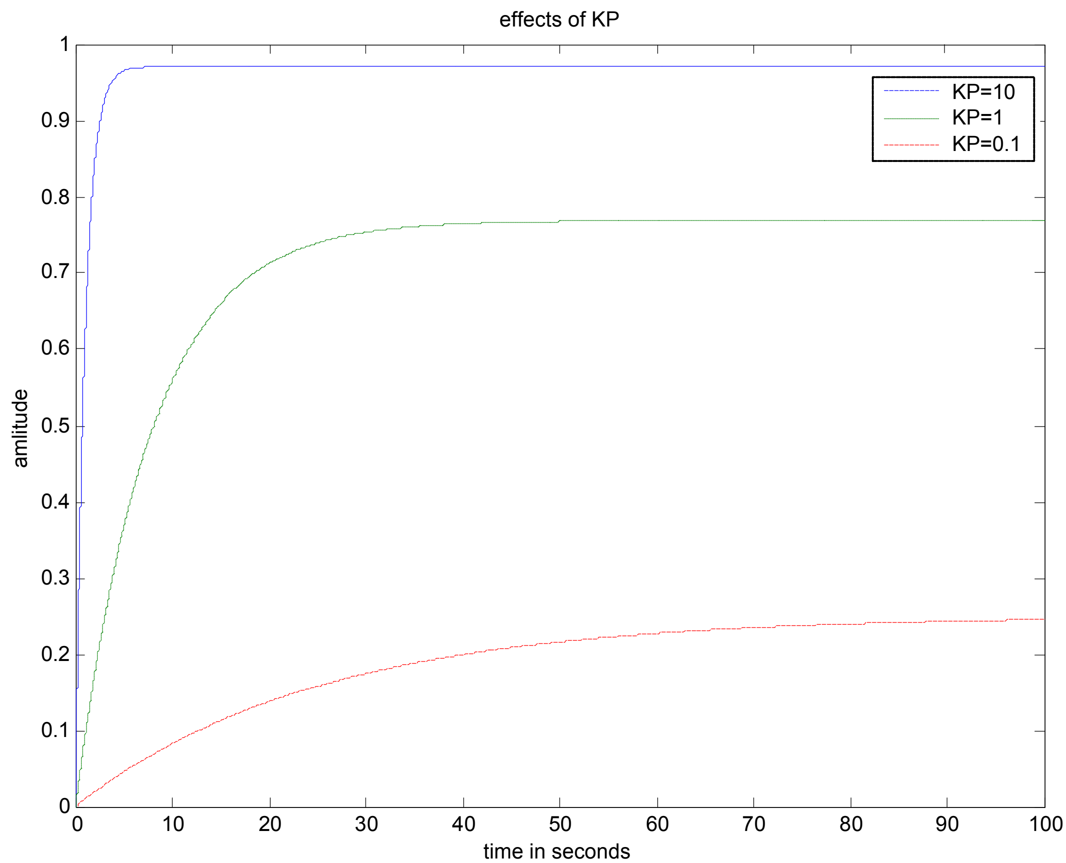
6.3.1 Bandwidth

There are many definitions of Bandwidth. The definition that this manual follows is the time response to reach 63% of the final value.



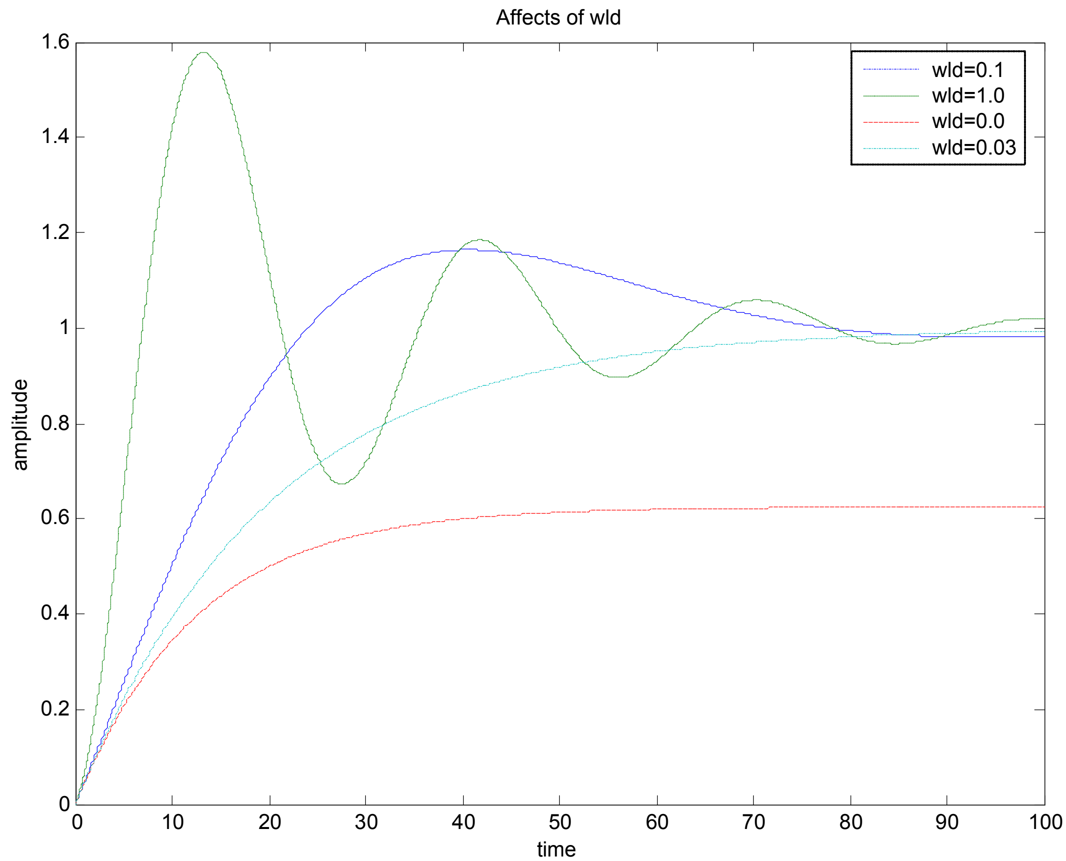
6.3.2 Trim_KP

The Trim_KP is the proportional term of the PI. The PI Regulator Error is multiplied by tis value. It is scaled such that a value of one, would produce 100% output of the regulator when there is 100% error. If the reference was 100% and the feedback was 0%, than the error would be 100%.
Notice that the step response does not reach its final value. This is known as steady state error.
Typically this value is increased until the trim regulator appears to be unstable and then is backed off 30%.



6.3.3 Trim_wld

The Trim_wld term is the lead frequency for the PI regulator. The term wld is (integral Gain/proportional gain). This term affects the steady state error of the regulator. The above plot only has KP, therefore there is a steady state error. Typically after the KP term is set, than the wld term is increased untill the desired steady state response is achieved.

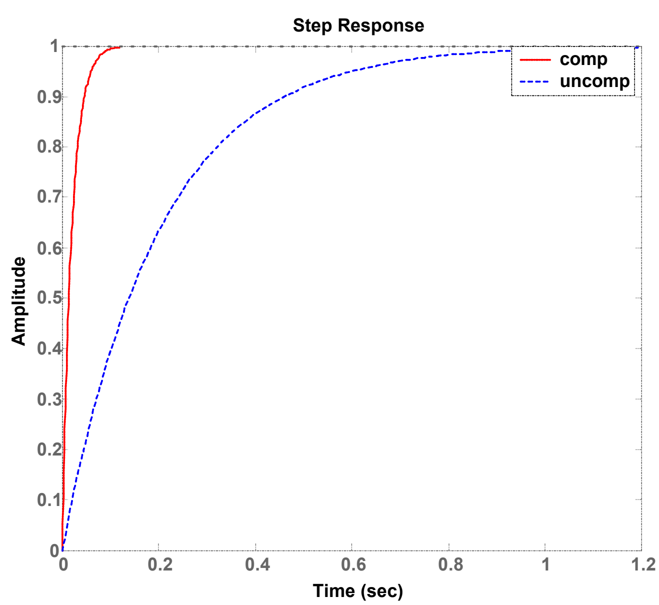


6.3.4 TrimFbWLead_Rad

This the Lead frequency in rad/second of the feedback filter. It is typically set to the speed loop bandwidth (p97 in the PowerFlex 700S) to cancel the lag effect of the velocity loop.

6.3.5 TrimFbWLag_Rad

This is the Lag frequency in rad/second of the feedback filter. It is typically set to five times the lead frequency set above.



6.4 Dancer Regulation

6.4.1 Trimming Speed:

The TrimLimSpd_Pct is the maximum output of the trim regulator when the line speed is at maximum. This value should typically be ten percent. When the line speed is zero the TrimLimSpdZero_Pct is the maximum output of the trim regulator. This value is typically set to one percent. This allows the trim regulator to operate even though the line velocity is at zero.
When the Trim Regulator is trimming speed, the following calculations will give the user a starting point for the various gains. The output of the trim regulator should be limited to about ten percent.
There are some specific starting points for dancer regulation. To calculate these gains there are some specific information that is required. The first piece of information required is the amount of material that the dancer can store. The user can usually determine this information from the mechanical drawings. An empirical method, is to measure the distance traveled by the "swing roll" and multiply by two. All data for the following calculations must be entered in like units (Imperial or Metric).

A. Amount of material stored in linear measurement:-______________
   Units must be the same as the linear measurement in line "B"

Convert the tag value of LineSpeedMax_EU into the units of linear measurement/second. Example: If the tag units are feet/min then divide by 60 to get feet/second.

B. Linear Speed/Second:_________________________

C. Dived line "A" by "B", Pbar = _____________ in seconds

D. Enter the desired Bandwidth for the Dancer Regulator, BW = _________rad/sec
   This is typically 1/5th the bandwidth of the speed regulator.

E. Multiply line "C" by "D" (Pbar*BW) to Solve for TrimKP = ___________

F. Trim_wld=TrimKP/zeta
   (zeta) is typically set for 1, a setting less than 1 will cause more overshoot, and a value greater than 1 will have less overshoot (increased dampening).

G. TrimFB_wld=p97 system bandwidth from the PowerFlex 700S

H. TrimFB_wlg=5*TrimFB_wld

After the initial values are set, the user may have to adjust (tune) these initial values for desired performance.

6.4.2 Trimming Torque

When the regulator is trimming torque, the TrimTorqueLimit is typically set to 10%.

The user will need to begin by setting the TrimFB_wld and TrimFB_lag to 10. The Trim_wld term is set to zero. The user should increase the TrimKP term until the system appears to oscillate and then reduce the TrimKP by 50%. At this point, there will be a steady state error. Adjust Trim_wld to decrease the steady state error. Begin decreasing the TrimFB_wld from 10 to 5 to 1 until the desired response is achieved.

6.5 Tension Regulator

6.5.1 Trimming Speed:

The TrimLimSpd_Pct is the maximum output of the trim regulator and is based on the maximum line speed. This value should typically be 5 to 10 percent. When the line speed is zero the TrimLimSpdZero_Pct is the maximum output of the trim regulator. This value is typically set for 1 to 2 percent. This allows the trim regulator to operate even though the line velocity is at zero.

There is not a simple formula for calculating the starting gains for tension regulation. The user should start by setting the TrimFB_wld and TrimFb_wlg equal to each other. This will cancel the effect of the feedback lead lag filter.

Begin the tuning process by increasing TrimKP until the system becomes oscillatory. Once the system becomes oscillatory, you will need to reduce TrimKP to 70% of the value. After TrimKP is set adjust Trim_Wld until the steady state performance is satisfactory.

6.5.2 Trimming Torque

When the tension regulator is trimming torque, the TrimLimTrq_Pct is set typically for 10 to 20 percent.

The user should start by setting the TrimFB_wld and TrimFb_wlg equal to each other. This will cancel the effect of the feedback lead lag filter.

Begin the tuning process by setting the Trim_wld term to zero. Increase the TrimKP term until the system appears to oscillate and then reduce the TrimKP by 50%. At this point, there will be a steady state error. Adjust Trim_wld to decrease the steady state error. Begin decreasing the TrimFB_wld from 10 to 5 to 1 until the desired response is achieved.

Appendix A - Process Line Command & Status Words

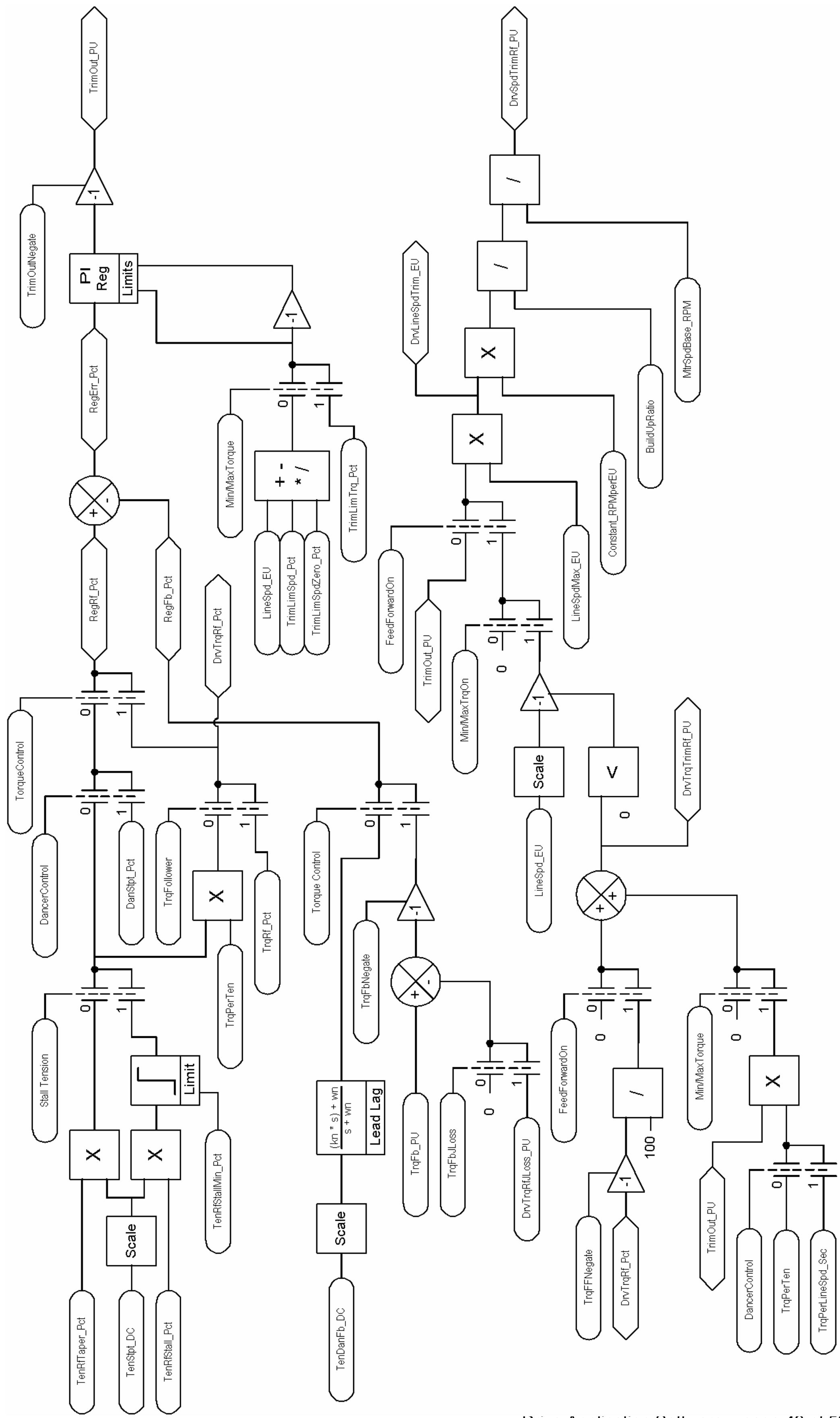
The following table is a functional list of the Process Line command word [wDLx_DrvCmmdProcLn]

Bit	*Input Signal*	*Description*
00	Clear Fault	Clear all Faults
01	Run (2 Wire)	1 = Start, transition to 0 = Stop
02	Reserved	
03	Coast Stop	not supported in rev 110101
04	Jog Forward	Jog in Forward direction
05	Jog Reverse	Jog in Reverse direction
06	Reverse Rotation (Under Wind)	Under wind selection
07	Tension Control Enable	Activates selected mode of Tension Control
08	Stall Tension	User determines how and when to activate Stall Tension
09	Tension Control	Selects Tension Control Mode - Tension
10	Torque Control	Selects Tension Control Mode - Torque
11	Dancer Control	Selects Tension Control Mode - Dancer
12	Torque Trim	Selects Trim type – Torque is trimmed
13	Speed Trim	Selects Trim type – Speed is trimmed
14	Draw Trim Off	Zeros the Draw trim signal
15	Torque Follower Control	Special Control mode for torque follower
16	Diam Preset 1	Commands preset 1 for Diam Calc
17	Diam Preset 2	Commands preset 2 for Diam Calc
18	Diam Preset 3	Commands preset 3 for Diam Calc
19	Diam Preset Increase	Manual increase for Diameter Calc
20	Diam Preset Decrease	Manual decrease for Diameter Calc
21	Diam Calc Increase Enable	Releases Diameter Clac for Increase
22	Diam Calc Decrease Enable	Releases Diameter Calc for Decrease
23	Reserved	
24	Reserved	
25	Reserved	
26	Reserved	
27	Reserved	
28	Reserved	
29	Torque Mem Enable	Memorizes running torque
30	Torque Mem Boost Enable	Boosts the memorized torque by user set percentage.
31	Torque Mem Knife Cut	Boosts the memorized torque by user set percentage.

The following table is a functional list of the Process Line status word [DLx_DrvStatProcLn]

Bit	*Output Signal*	*Description*
00	Fault	Drive Fault or a System Fault
01	Running	Drive is Running / not stopping
02	Reserved	
03	Motor Ctrl On	Motor is being control (Motor POWER)
04	Reserved	
05	Jogging	section Jogging
06	Rotational Reverse	Under Wind
07	Tension Control On	Selected mode of Tension control is enabled
08	Zero Speed	Below Zero Line speed set point
09	Diameter Calculation Active	*Future*
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	
16	Enable Loss Fault	Drive Enable lost
17	Fail to Run fault	Drive failed to start
18	Communication fault	NA – not support
19	Message fault	NA – not support
20	Motor Overload Fault	Overload alarm from drive
21	Motor Overtemperature Flt	Over temperature alarm from drive
22	Motor Blower Loss Fault	Motor blower has stopped or tripped off
23	Reserved	
24	Reserved	
25	Reserved	
26	Reserved	
27	Reserved	
28	Reserved	
29	Reserved	
30	Operate Permissive	Use in line control logic to command a coordinated line ramp stop.
31	On Permissive	Loss of permissive resets start command. The drive will coast stop or ramp stop depending on configuration

Appendix B - Block Diagram

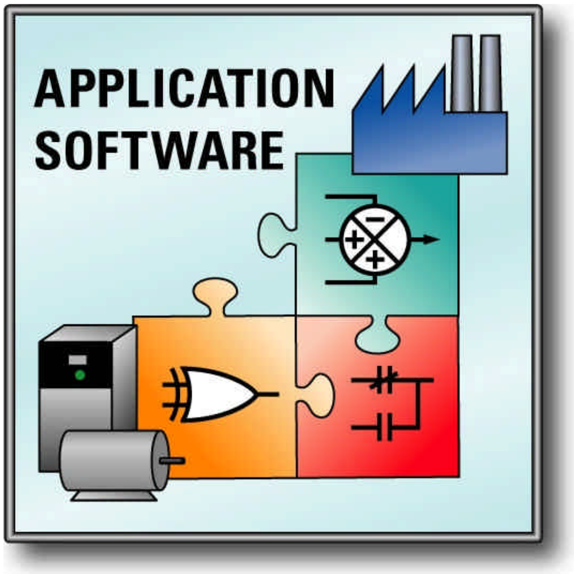


Appendix C - Parameter (Tag) Table

Input Tags for Tension Control Function Module

Name	***Type***	***Source Tag***	***from Routine***	***Default***	***User Value***
Logic – Routine					
CtrilEnbl	B x	wDLx_DrvCmmdProcLn.7	NA	0	
Running	B x	wDLx_DrvCmmdProcLn.1	NA	0	
TenCtrl	B x	wDLx_DrvCmmdProcLn.9	NA	0	
TrqCtrl	B x	wDLx_DrvCmmdProcLn.10	NA	0	
DanCtrl	B x	wDLx_DrvCmmdProcLn.11	NA	0	
TrqTri,	B x	wDLx_DrvCmmdProcLn.12	NA	0	
SpdTrim	B x	wDLx_DrvCmmdProcLn.13	NA	0	
TenZoneDwStream	B x	zDLx_TenZoneDwStream	NA	0	
ReverseRotation	B x	DLx_DrvStatProcLn.6	LogicAndReference – Logic	0	
TrimHoldHigh	B x	constant	NA	0	
TrimHoldLow	B x	constant	NA	0	
TenRfStall	B x	wDLx_DrvCmmdProcLn.8	NA	0	
TrqFbJLoss	B x	constant	NA	1	
TrqMemEnbl	B x	wDLx_DrvCmmdProcLn.29	NA	0	
TrqFolwCtrl	B x	wDLx_DrvCmmdProcLn.15	NA	0	
TenMax_EU	R x.x	zDLx_TenMax_lb	NA	50.0	
RaduisCalc_EU	R x.x	DLx_RadiusCalc_ft	DiamCalc	NA	
GearRatio	R x.x	zDLx_GearRatio	NA	5.0	
MtrTrqRated_EU	R x.x	DLx_MtrTrqRated_lbft	CalcAndDisplay – Main or User Programming	NA	
LineSpdMax_EU	R x.x	zDLx_LineSpdMaxFPM	NA	500.0	
J_Sec	R x.x	DLx_J_Sec	JLossComp	NA	
Regulator – Routine					
TenStpt_DC	R x.x	wDLx_TenStpt_DC	NA	0.0	
TenStptMin_DC	R x.x	zDLx_TenStptMin_DC	NA	0.0	
TenStptMax_DC	R x.x	zDLx_TenStptMax_DC	NA	100.0	
TenRfStall_Pct	R x.x	zDLx_TenRfStall_Pct	NA	10.0	
TenRfStallMin_Pct	R x.x	zDLx_TenRfStallMin_Pct	NA	5.0	
TenRfTaper_Pct	R x.x	TenRfTaper_Pct	TenRfTaper – Routine	NA	
DanStpt_Pct	R x.x	zDLx_DanStpt_Pct	NA	50.0	
TenDanRfRate_PctSec	R x.x	zDLx_TenDanRfRate_PctSec	NA	10.0	
TenDanFb_DC	R x.x	wDLx_TenDanFb_DC	NA	0.0	
TenDanFbMin_DC	R x.x	zDLx_TenDanFbMin_DC	NA	0.0	
TenDanFbMax_DC	R x.x	zDLx_TenDanFbMax_DC	NA	100.0	
DrvTrqFb_PU	R x.x	DLx_DrvTrqFb_PU	p303 – Motor Torque Ref	NA	
TrimKp	R x.x	zDLx_TrimKp	NA	1.0	
TrimWld_Rad	R x.x	zDLx_TrimWld_Rad	NA	10.0	
TrimLimSpd_Pct	R x.x	zDLx_TrimLimSpd_Pct	NA	5.0	
TrimLimSpdZero_Pct	R x.x	zDLx_TrimLimSpdZero_Pct	NA	2.0	
LineSpdTrimLimSpd_EU	R x.x	zDLx_LineSpdTrimLimSpd_FPM	NA	1.0	

Name	Type	Source Tag	from Routine	Default	User Value
Regulator – Routine (continued)					
TrimLimTrq_Pct	R x.x	zDLx_TrimLimTrq_Pct	NA	15.0	
TrimRate_PctSec	R x.x	zDLx_TrimRate_PctSec	NA	10.0	
TrimFbWLead_Rad	R x.x	zDLx_TrimWldFb_Rad	NA	60.0	
TrimFbWLag_Rad	R x.x	zDLx_TrimWlgFb_Rad	NA	50.0	
DrvTrqRfJLoss_PU	R x.x	DLx_DrvTrqRfJLoss_PU	JLossComp_Imp_FM – Main (JLossComp)	0.0	
LineSpd_EU	R x.x	DLx_LineSpdRf_FPM	LogicAndReference – RunJogSpdRf	NA	
LineSpdMax_EU	R x.x	zDLx_LineSpdMax_FPM	NA	500.0	
MtrSpdBase_RPM	R x.x	DLx_MtrSpdBase_RPM	CalcAndDisplay – Main	NA	
Constant_RPMperEU	R x.x	DLx_Constant_RPMperFPM	CalcAndDisplay – Main	NA	
BuildUpRatio	R x.x	DLx_BuildUpRatio	DiamCalc_Imp_FM – Main (DiamCalc)	NA	
TrqRf_Pct	R x.x	TrqRf_Pct	TenCtrl_FM – Main (TrqMem)	NA	
TenRfTaper – Routine					
DiamCalc_EU	R x.x	DLx_DiamCalc_in	DiamCalc_Imp_FM – Main (DiamCalc)	NA	
DiamFR_EU	R x.x	zDLx_DiamFR_in	NA	30.0	
DiamStrtTaper_EU	R x.x	zDLx_DiamStrtTaper_in	NA	6.0	
TenRfTaperFR_Pct	R x.x	zDLxTenRfTaperFR_Pct	NA	50.0	
TrqMem – Routine					
TrqFb_PU	R x.x	DLx_DrvTrqFb_PU	p303 – Motor Torque Ref	NA	
DrvTrqRfJLoss_PU	R x.x	DLx_DrvTrqRfJLoss_PU	JLossComp_Imp_FM – Main (JLossComp)	NA	
TrqMemBoostEnbl	B x	wDLx_DrvCmmdProcLn.30	NA	0	
TrqMemBoostRf_Pct	R x.x	zDLx_TrqMemBoostRf_Pct	NA	0.0	
TrqMemKnifeBoostEnbl	B x	wDLx_DrvCmmdProcLn.31	NA	0	
TrqMemKnifeBoostRf_Pct	R x.x	zDLx_TrqMemKnifeBoostRf_Pct	NA	0.0	



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