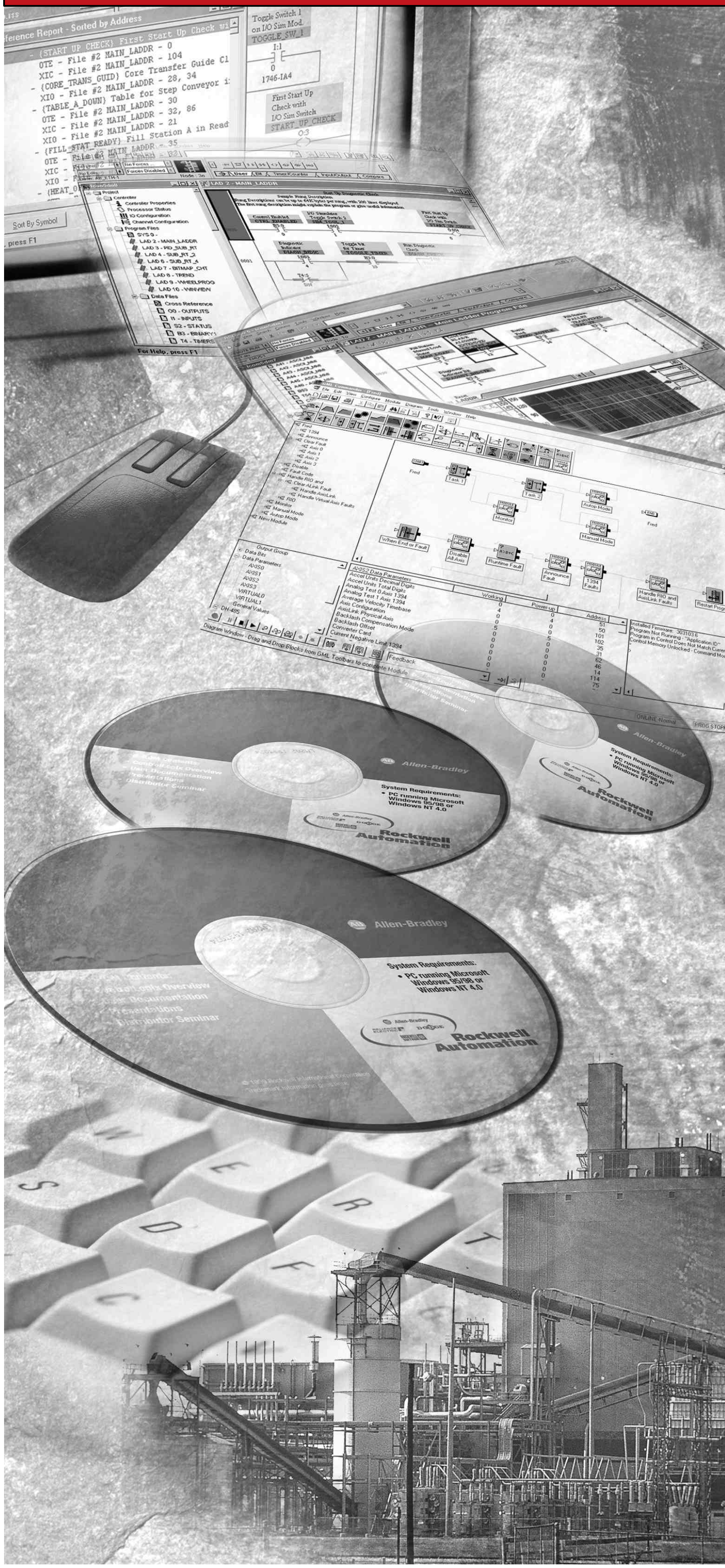


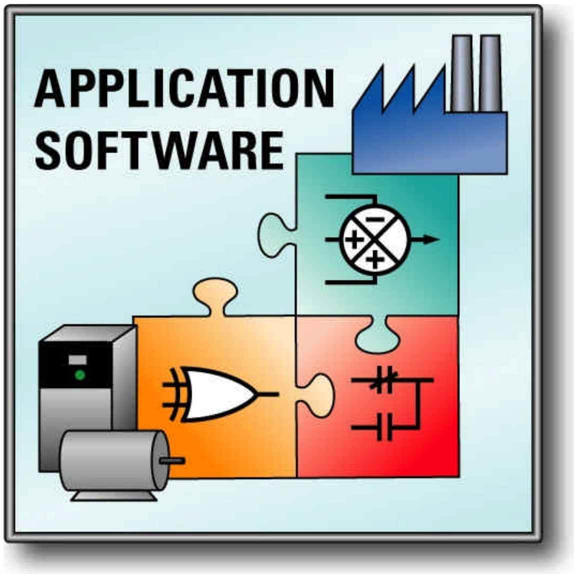
Drive Application Software

Function Module

Inertia Compensation
Imperial Units

Reference Manual

Allen-Bradley
RELIANCE ELECTRIC
DODGE
ROCKWELL SOFTWARE
Rockwell Automation



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

RSLogix5000 is a trademark of Rockwell Automation
PowerFlex is a trademark of Rockwell Automation

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.

1. All FM tags are program scoped.
2. All user connections to the FM are through the Jump to Sub-Routine (JSR) instruction input and return parameters.
3. Users cannot edit Function Modules.
4. 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

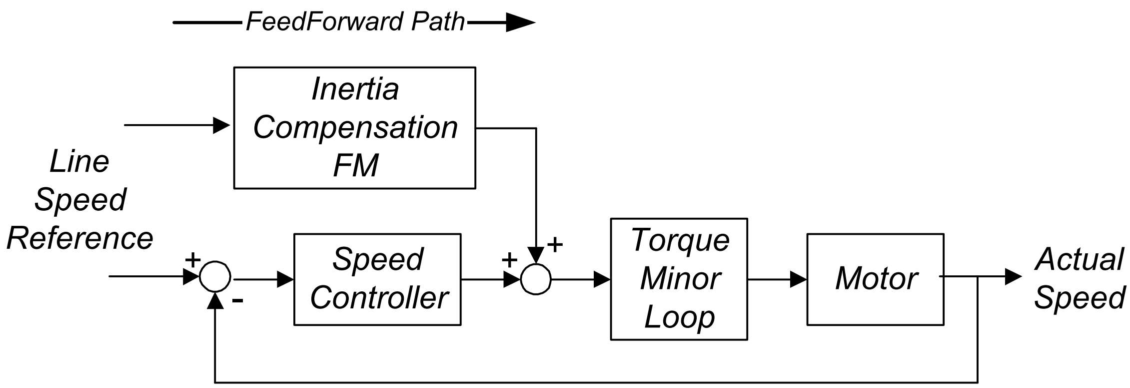
The torque applied by the motor, in a web handling application, can be separated into three torque components:

1. Strip Tension Torque
2. Inertia Torque
3. Losses Torque

The Inertia Compensation Function Module calculates inertia torque and losses torque.

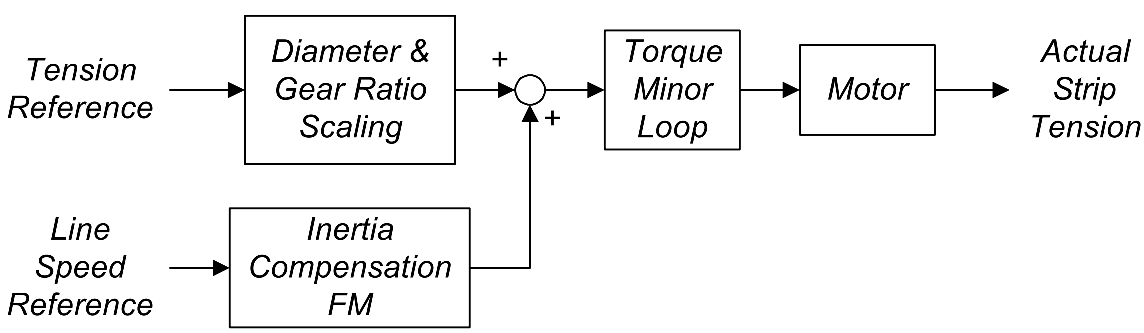
3.1 Feed Forward

Speed regulation, dancer position regulation and strip tension regulation can be improved by feeding inertia and losses torque forward as a torque minor loop reference. The following block diagram demonstrates how the Inertia Compensation Function Module can be used in a feed forward path to improve speed regulation.



3.2 Tension-to-Torque Conversion

When strip tension is controlled indirectly by controlling motor torque, strip tension deviation can be reduced by including inertia and losses torque in tension-to-torque conversion calculations. The following block diagram demonstrates how the Inertia Compensation Function Module can be used to convert tension reference to motor torque reference.



4.0 Functional Description

4.1 Overview

The Inertia Compensation Function Module calculates inertia and losses torque using line speed reference as the primary input. The Inertia Compensation Function Module consists of a program with three routines in RSLogix5000:

1. Main (Ladder)
2. JCalc (Ladder)
3. JLossComp (Function Block)

The Inertia Compensation Function Module is available in imperial units (English) and international units (SI or metric). This reference manual describes the Imperial units version of the Inertia Compensation Function Module.

4.1.1 Main Routine

The Main ladder routine is where the user connects user created controller tags to the input and output program tags of the Function Module. These links are created in the Jump to Sub-Routine (JSR) instructions. One JSR is used to call the JCalc routine and another JSR is used to call the JLossComp routine.

4.1.2 JCalc Routine

The JCalc ladder routine calculates total reflected inertia for a center driven winder by adding the reflected inertia of the roll (material) to the minimum empty core reflected inertia. The strip of material extending from the roll to the adjacent drive section is not included in the calculation.

If the Inertia Compensation Function Module is not used for a center driven winder, the JCalc routine and corresponding JSR instruction can be deleted.

4.1.3 JLossComp Routine

The JLossComp function block routine calculates inertia torque and losses torque. Losses torque is calculated by adding friction and windage torque. Friction torque and windage torque are both functions of angular velocity or motor speed.

4.2 Main routine

The Main routine consists of two rungs of ladder logic programming. A rung comment 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 Function Module into the user application, the user may use the main routine for this programming. Note; any 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.

4.3 JCalc Routine

Material width, material density and diameter are used to calculate the roll inertia. The roll inertia is reflected to the motor shaft by dividing by the gear ratio squared. Total reflected inertia is calculated by adding the reflected roll inertia to the minimum empty core reflected inertia. The total reflected inertia is then normalized two different ways.

The first method of normalization divides total reflected inertia by minimum empty core reflected inertia. This results in a normalized inertia that is 1.0 per-unit at core and greater than 1.0 per-unit as the roll diameter increases.

The second method of normalization multiplies the total reflected inertia by motor base speed and then divides by rated motor torque. This results in inertia with units of seconds. Inertia, normalized this way, represents the time to accelerate the total connected inertia from zero to motor base speed with rated motor torque applied.

Input Parameters

	Name	*Type*	*Range*	*Description*
1	JEC_lbft2	REAL	NA	Minimum Empty Core Reflected Inertia
2	Density_lbft3	REAL	NA	Material Density
3	BuildUpRatio	REAL	NA	Normalized Diameter
4	Constant_RPMperFPM	REAL	NA	Calibration Constant
5	Width_in	REAL	5.0 to 500.0	Material Width
6	GearRatio	REAL	NA	Gear Ratio
7	MtrSpdBase_RPM	REAL	NA	Motor Base Speed
8	MtrTrqRated_lbft	REAL	NA	Motor Rated Torque

Return Parameters

	Name	*Type*	*Range*	*Description*
1	WeightRoll_lb	REAL	NA	Roll Weight
2	Jroll_lbft2	REAL	NA	Roll Reflected Inertia
3	J_lbft2	REAL	NA	Total Reflected Inertia
4	J_sec	REAL	NA	Total Reflected Inertia
5	J_PU	REAL	NA	Total Reflected Inertia

4.3.1 JEC_lbft2

This input parameter is the minimum empty core reflected inertia in pound/feet^2.
Usage – Set equal to the inertia of the machine at empty core in pound/feet2.

4.3.2 Density_lbft3

This input parameter is the material density pound/feet3.
Usage – Set equal to the material density in pound/feet3.

4.3.3 BuildUpRatio

This input parameter is the build-up ratio or normalized roll diameter.
Usage – From the Diameter Calculator Function Module return parameter of the same name.

4.3.4 Constant_RPMperFPM

This input parameter is the translational-to-rotational conversion constant in RPM/FPM.
Usage – From the Diameter Calculator Function Module return parameter of the same name.

4.3.5 Width_in

This input parameter is the material width in inches.
Usage – Set equal to the material width in inches.

4.3.6 GearRatio

This input parameter is the gear ratio expressed as Motor Speed / Roll Speed.
Usage – Set equal to the gear ratio.

4.3.7 MtrSpdBase_RPM

This input parameter is the motor base speed in RPM.
Usage – Set equal to the motor nameplate base speed in RPM.

4.3.8 MtrTrqRated_lbft

This input parameter is the motor rated torque in pound-feet

$$MtrTrqRated\_lbft = \frac{HorsePower \times 5250}{MtrSpdBase\_RPM}$$

Usage – Set equal to the motor rated torque in pound-feet.

4.3.9 WeightRoll_lb

This return parameter is the weight of the roll in pounds.
Usage – Monitor or display only.

4.3.10 JRoll_lbft2

This return parameter is the roll inertia reflected to the motor in Pound-Feet2.
Usage – Monitor or display only.

4.3.11 J_lbft2

This return parameter is the total reflected inertia in Pound-Feet2.
Usage – Monitor or display only.

4.3.12 J_sec

This return parameter is the normalized total reflected inertia in seconds. The value represents the time to accelerate the total connected inertia from zero to motor base speed with rated motor torque applied.
Usage – To the JLossComp routine input parameter of the same name.

4.3.13 J_PU

This return parameter is normalized total reflected inertia. The value represents the ratio of total inertia divided by minimum empty core inertia.
Usage – Monitor or display only.

4.4 JLossComp Routine

Inertia torque is calculated by multiplying total reflected inertia by angular acceleration:

$$T = J \cdot a$$

where: T is torque

J is total inertia

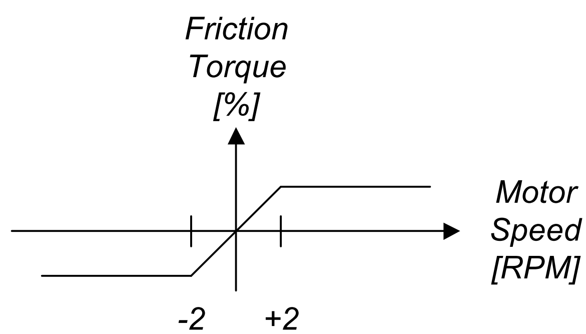
a is angular acceleration

Angular acceleration is calculated from the rate of change of line speed using the translational-to-rotational conversion constant and build-up ratio (normalized diameter). Separate input parameters are provided for line speed reference and line speed reference rate. If necessary, the JLossComp routine can calculate the line speed reference rate from line speed reference by differentiating the line speed reference input.

If the Inertia Compensation Function Module is not used for a center driven winder, the build-up ratio is typically set equal to one.

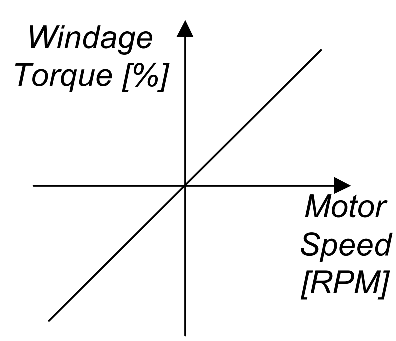
Two inertia compensation gains (JGainQuad1Quad2 and JGainQuad3Quad4) can be used to adjust the calculated inertia torque in two of four operational quadrants. These gains are typically set equal to one, but can be adjusted slightly to reduce strip tension deviations during line speed changes.

Friction torque is calculated using the following curve:



When the rotational speed reference reaches +/- 2 RPM, the output is a fixed torque, representing a kinetic friction torque component. A static friction component is not included.

Windage torque requirements dictate that losses due to rotational speed increase as the square of speed. In practice for typical winding applications, an approximation of windage losses has proved more beneficial and simpler to configure. For these reasons the windage losses compensation has been applied as directly proportional to rotational speed reference and is calculated using the following curve:



The inertia and losses torque return parameter is computed as the sum of inertia torque, friction torque and windage torque.
Two conventions are used to avoid confusion when applying signal polarities to translational speed signals, rotational speed signals, and torque signals.

1. Positive torque produces positive rotational speed
2. Positive rotational speed results in positive line speed

A reverse rotation input parameter, allows the second convention to be reversed. In other words, positive rotational speed results in negative line speed. This function is necessary for center winder applications with over wind and under wind capability. Typically, reverse direction is associated with under wind. With the reverse rotation input parameter set true, the inertia and losses torque resulting from the line speed reference must be negated. It is important to note that this negation is only applied to the per-unit inertia and losses torque return parameter.

Input Parameters

	Name	*Type*	*Range*	*Description*
1	LineSpdRf_FPM	REAL	NA	Line Speed Reference
2	LineSpdRfRate_FPMsec	REAL	NA	Line Speed Reference Rate
3	JDiffEnbl	BOOL	0 to 1	Enable Differentiator
4	JDiffSamples	INT	1 to 20	Number of Differentiator Moving Average Samples
5	BuildUpRatio	REAL	NA	Normalized Diameter
6	Constant_RPMPerFPM	REAL	NA	Translational-to-Rotational Conversion Constant
7	J_sec	REAL	NA	Total Reflected Inertia
8	JGainQuad1Quad2	REAL	0.1 to 3.0	Inertia Compensation Gain Quadrant 1 and 2
9	JGainQuad3Quad4	REAL	0.1 to 3.0	Inertia Compensation Gain Quadrant 3 and 4
10	Friction_Pct	REAL	0.0 to 50.0	Friction Loss
11	Windage_PctRPM	REAL	0.00 to 1.00	Windage Loss
12	MtrTrqRated_lbft	REAL	NA	Rated Motor Torque
13	ReverseRotation	BOOL	0 to 1	Reverse Rotation

Return Parameters

	Name	*Type*	*Range*	*Description*
1	TrqRfJ_Pct	REAL	NA	Torque Reference Inertia Part
2	TrqRfLoss_Pct	REAL	NA	Torque Reference Losses Part
3	TrqRfJLoss_Pct	REAL	NA	Torque Reference Inertia and Losses Part
4	DrvTrqRfJLoss_PU	REAL	NA	Drive Torque Reference Inertia and Losses Part

4.4.1 LineSpdRf_FPM

This input parameter is the line speed reference in FPM.
Usage – Set equal to the line speed reference in FPM.

4.4.2 LineSpdRfRate_FPM

This input parameter is the rate of change of line speed reference in FPM/second.
Usage – If available, set equal to the line speed reference rate, originating in the same routine as LineSpdRf_FPM.

4.4.3 JDiffEnbl

This input parameter enables the internal line speed reference differentiator.
Usage – Set true only if a separate LineSpdRfRate_FPM signal is not available.

4.4.4 JDiffSamples

This input parameter is the number of moving average samples used to filter output of the internal line speed reference differentiator.
Usage – Not used when JDiffEnbl is false. Set to a value between 1 and 20 samples. Similar to a low pass filter, increasing the number of samples increases the filtering effect.

4.4.5 BuildUpRatio

This input parameter is the build-up ratio or normalized roll diameter.
Usage – For center winder applications, from the Diameter Calculator Function Module return parameter of the same name. For constant diameter applications, typically set to 1.0.

4.4.6 Constant_RPMperFPM

This input parameter is the translational-to-rotational conversion constant in RPM/FPM.
Usage – For center winder applications, from the Diameter Calculator Function Module return parameter of the same name. For constant diameter applications, calculate per the following equation:

$$Constant\_RPMperFPM = \frac{GearRatio}{\left(\frac{p}{12}\right) \times RollDiameter[in]}$$

4.4.7 J_sec

This input parameter is the normalized total reflected inertia.
Usage – For center winder applications, use the JCalc routine return parameter of the same name. For constant diameter applications, use the value returned from drive self-tuning function or calculate the value using the following equation:

$$J\_sec = \frac{TotalReflectedInertia \times MtrSpdBase\_RPM}{308 \times MtrTrqRated\_lbft}$$

4.4.8 JGainQuad1Quad2

This input parameter is the inertia compensation gain for operational quadrants 1 & 2. This parameter is entered as a real number where 1.0 = 100% gain.
Quadrant 1 – Positive Speed, Positive Inertia Torque (acceleration forward)
Quadrant 2 – Negative Speed, Positive Inertia Torque (deceleration reverse)
Usage – Typically set to 1.0, however if strip tension deviations occur in quadrant 1 & 2 only, inertia compensation can be adjusted slightly to reduce tension deviations by adjusting slightly above or below a value of 1.0.

4.4.9 JGainQuad3Quad4

This input parameter is the inertia compensation gain for operational quadrants 3 & 4. This parameter is entered as a real number where 1.0 = 100% gain.
Quadrant 3 – Negative Speed, Negative Inertia Torque (acceleration reverse)
Quadrant 4 – Positive Speed, Negative Inertia Torque (deceleration forward)
Usage – Typically set to 1.0, however if strip tension deviations occur in quadrant 3 & 4 only, inertia compensation can be adjusted slightly to reduce tension deviations by adjusting slightly above or below a value of 1.0.

4.4.10 Friction_Pct

This input parameter determines the kinetic friction losses in percent of rated motor torque.
Usage – Tune for best operation (See section 6, Tuning / Start-up).

4.4.11 Windage_PctRPM

This input parameter determines the windage losses in percent of rated motor torque per motor speed in RPM.
Usage – Tune for best operation (See section 6, Tuning / Start-up).

4.4.12 MtrTrqRated_lbft

This input parameter is the motor rated torque in pound-feet

$$MtrTrqRated\_lbft = \frac{HorsePower \times 5250}{MtrSpdBase\_RPM}$$

Usage – Set equal to the motor rated torque in pound-feet.

4.4.13 ReverseRotation

This input parameter negates the DrvTrqRfJLos_PU return parameter below.
Usage – For center winder applications, set false for over wind operation and true for under wind operation. (Assuming positive rotational speed produces positive line speed during over wind operation.) For constant diameter applications, set false.

4.4.14 J_lbft2

This return parameter is the total reflected inertia in Pound-Feet2.
Usage – Monitor or display only.

4.4.15 TrqRfJ_Pct

This return parameter is the inertia torque component in percent of rated motor torque.
Usage – Monitor or display only.

4.4.16 TrqRfLoss_Pct

This return parameter is the friction and windage losses torque component in percent of rated motor torque.

Usage – Monitor or display only.

4.4.17 TrqRfJLoss_Pct

This return parameter is the sum of the inertia and losses torque components in percent of rated motor torque.
Usage – Monitor or display only.

4.4.18 DrvTrqRfJLoss_PU

This return parameter is the sum of the inertia and losses torque components in per-unit rated motor torque with ReverseRotation negate applied.
Usage – Added to the drive torque reference during tension to torque conversion, subtracted from the drive torque feedback during torque to tension conversion, or used as a feed forward signal to the torque minor loop.

5.0 Setup / Configuration

5.1 Overview

All setup and configuration is done in the Main routine. The Inertia Compensation Function Module is connected to the balance of the application software by placing application tag names in the Jump to Sub-Routine (JSR) instructions. One JSR is used to call the JCalc routine and a second JSR is used to call the JLossComp routine. When JSR instruction input parameters are configured with tags, which 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 JCalc JSR Instruction

Note: The JCalc routine and JSR instruction are only used for center winder applications. For constant diameter applications, delete the JCalc routine and JSR instruction. If the JCalc routine is deleted, the Total Reflected Inertia input parameter (JLossComp – In8) must be calculated using the equation shown in the description for this input parameter as described in section 4.

5.2.1 Input Parameters

5.2.1.1 Minimum Empty Core Reflected Inertia

Enter an application tag for the Minimum Empty Core Reflected Inertia input parameter (JCalc – In1). If the application tag values are not in units of pound-feet2, add a rung to the Main routine that will scale the tag value to pound-feet2.

5.2.1.2 Material Density

Enter an application tag for the Material Density input parameter (JCalc – In2). If the application tag value is not in units of pounds per feet3, add a rung to the Main routine that will scale the tag value to pounds per feet3.

5.2.1.3 Normalized Diameter

Enter an application tag for the Normalized Diameter input parameter (JCalc – In3). This tag must be normalized such that the value is equal to 1.0 at minimum empty core diameter. If the Diameter Calculator Function Module is used, enter the tag used as the return parameter in the DiamCalc JSR instruction.

5.2.1.4 Translational-to-Rotational Conversion Constant

Enter an application tag for the Translational-to-Rotational Conversion Constant input parameter (JCalc – In4). This conversion constant must be calculated using the minimum empty core diameter. If the Diameter Calculator Function Module is used, enter the tag used as a return parameter in the DiamCalc JSR instruction.

5.2.1.5 Material Width

Enter an application tag for the Material Width input parameter (JCalc – In5). If the application tag value is not in units of inches, add a rung to the Main routine that will scale the tag value to inches.

5.2.1.6 Gear Ratio

Enter an application tag or immediate value for the Gear Ratio input parameter (JCalc – In6).

5.2.1.7 Motor Base Speed

Enter an application tag or immediate value for the Motor Base Speed input parameter (JCalc – In7).

5.2.1.8 Motor Rated Torque

Enter an application tag or immediate value for the Motor Rated Torque input parameter (JCalc – In8).

5.2.2 Return Parameters

5.2.2.1 Roll Weight and Roll Reflected Inertia
Enter application tags, for the Roll Weight and Roll Reflected Inertia return parameter (JCalc - Ret1, Ret2).

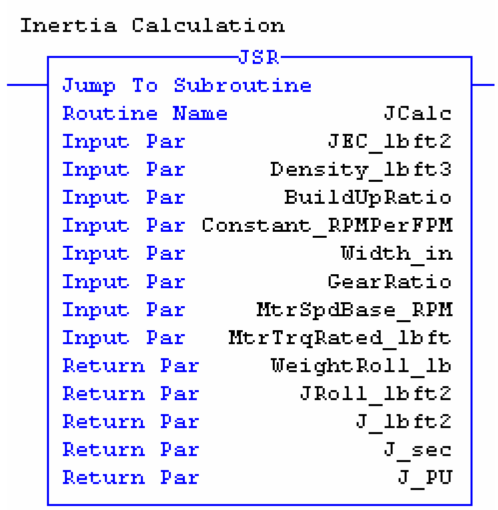
5.2.2.2 Total Reflected Inertia [pound-feet2]
Enter an application tag, for the Total Reflected Inertia return parameter (JCalc – Ret3).

5.2.2.3 Total Reflected Inertia [Seconds]
Enter an application tag, for the Total Reflected Inertia return parameter (JCalc – Ret4). This tag should be used in the JLossComp JSR instruction input parameter (JLossComp – In8).

5.2.2.4 Total Reflected Inertia [Per-Unit]
Enter an application tag, for the Total Reflected Inertia return parameter (JCalc – Ret5).

5.2.3 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Rx.x =JEC_lbft2 - Empty Core Reflected Inertia [Pound-Feet**2]
In2 -Rx.x =Density_lbft3 - Material Density [Pounds/Foot**3]
In3 -Rx.x =BuildUpRatio - Normalized Diameter [1.0 = Empty Core]
In4 -Rx.x =Constant_RPMPerFPM - Calibration Constant [RPM Per FPM]
In5 -Rx.x =Width_in - Material Width [Inches]
In6 -Rx.x =GearRatio - Gear Ratio
In7 -Rx.x =MtrSpdBase_RPM - Motor Base Speed [RPM]
In8 -Rx.x =MtrTrqRated_lbft - Motor Rated Torque [Pound-Feet]
Subroutine Outputs
Ret1-Rx.x =WeightRoll_lb - Roll Weight [Pounds]
Ret2-Rx.x =JRoll_lbft2 - Roll Reflected Inertia [Pound-Feet**2]
Ret3-Rx.x =J_lbft2 - Total Reflected Inertia [Pound-Feet**2]
Ret4-Rx.x =J_sec - Total Reflected Inertia [sec]
Ret5-Rx.x =J_PU - Total Reflected Inertia [Per-Unit]
```



5.3 JLossComp JSR Instruction

5.3.1 Input Parameters

5.3.1.1 Line Speed Reference
Enter an application tag for the Line Speed Reference input parameter (JLossComp – In1). If the application tag value is not in units of FPM, add a rung to the Main routine that will scale the tag value to FPM.

5.3.1.2 Line Speed Reference Rate
If available, enter an application tag for the Line Speed Reference Rate input parameter (JLossComp – In2). If the application tag value is not in units of FPM per second, add a rung to the Main routine that will scale the tag value to FPM per second.

5.3.1.3 Enable Differentiator
Enter an application tag or immediate value for the Enable Differentiator input parameter (JLossComp – In3).

5.3.1.4 Number of Differentiator Moving Average Samples
Enter an application tag for the Number of Differentiator Moving Average Samples input parameter (JLossComp – In4).

5.3.1.5 Normalized Diameter
Enter an application tag for the Normalized Diameter input parameter (JLossComp – In5). This tag must be normalized such that the value is equal to 1.0 at minimum empty core diameter. If the Diameter Calculator Function Module is used, enter the tag used as a return parameter in the DiamCalc JSR instruction. For constant diameter applications, an application tag or an immediate value of 1.0 can be used.

5.3.1.6 Translational-to-Rotational Conversion Constant
Enter an application tag for the Translational-to-Rotational Conversion Constant input parameter (JLossComp – In6). This conversion constant must be calculated using the minimum empty core diameter. If the Diameter Calculator Function Module is used, enter the tag used as a return parameter in the DiamCalc JSR instruction.

5.3.1.7 Motor Base Speed
Enter an application tag or immediate value for the Motor Base Speed input parameter (JLossComp – In7).

5.3.1.8 Total Reflected Inertia [seconds]
Enter an application tag, for the Total Reflected Inertia input parameter (JLossComp – In8). If the JCalc routine is used, enter the tag used as a return parameter in the JCalc JSR instruction (JCalc – Ret4).

5.3.1.9 Inertia Compensation Gain
Enter application tags, for the Inertia Compensation Gain Quadrant 1 and 2 and Inertia Compensation Gain Quadrant 3 and 4 input parameters (JLossComp – In9, In10).

5.3.1.10 Friction Loss
Enter an application tag for the Friction Loss input parameter (JLossComp – In11).

5.3.1.11 Windage Loss
Enter an application tag for the Windage Loss input parameter (JLossComp – In12).

5.3.1.12 MtrTrqRated_lbft
Enter an application tag or immediate value for the Motor Rated Torque input parameter (JLossComp – In2).

5.3.1.13 ReverseRotation

Enter an application tag for the ReverseRotation input parameter (JLossComp – In7). For center winder applications, this tag should be derived from the application program overwind and underwind logic. For constant diameter applications, an application tag or an immediate value of 1 can be used.

5.3.2 Return Parameters

5.3.2.1 Torque Reference Inertia Part, and Torque Reference Losses Part

Enter application tags, for the Torque Reference Inertia Part and the Torque Reference Losses Part return parameters (JLossComp - Ret1, Ret2).

5.3.2.2 Torque Reference Inertia and Losses Part [Percent]

Enter an application tag, for the Torque Reference Inertia and Losses Part return parameter (JLossComp - Ret3).

5.3.2.3 Drive Torque Reference Inertia and Losses Part [Per-Unit]

Enter an application tag, for the Drive Torque Reference Inertia and Losses Part return parameter (JLossComp – Ret4). This tag should be used in the application software feed forward or tension-to-torque conversion function.

5.3.3 Default Tags used in Drive Application Software

```
Subroutine Inputs
In1 -Rx.x =LineSpdRf_FPM - Line Speed Reference [FPM]
In2 -Rx.x =LineSpdRfRate_FPMsec - Line Speed Reference Rate [FPM / second]
In3 -Bx   =JDiffEnbl - Enable Differentiator
In4 -Ixx  =JDiffSamples - Number of Differentiator Moving Average Samples
In5 -Rx.x =BuildUpRatio - Normalized Diameter [1.0 = Empty Core]
In6 -Rx.x =Constant_RPMPerFPM - Calibration Constant [RPM Per FPM]
In7 -Rx.x =J_lbft2 - Total Reflected Inertia [Pound-Feet**2]
In8 -Rx.x =JGainQuad1Quad2 - Inertia Compensation Gain Quadrant 1 and 2
In9 -Rx.x =JGainQuad3Quad4 - Inertia Compensation Gain Quadrant 3 and 4
In10-Rx.x =Friction_Pct - Friction Loss [Percent Load]
In11-Rx.x =Windage_PctRPM - Windage Loss [Percent Load/RPM]
In12-Rx.x =MtrTrqRated_lbft - Motor Rated Torque [Pound-Feet]
In13-Bx   =ReverseRotation - Reverse Rotation
Subroutine Outputs
Ret1-Rx.x =TrqRfJ_Pct - Torque Reference Inertia Part [Percent Motor Rated Torque]
Ret2-Rx.x =TrqRfLoss_Pct - Torque Reference Losses Part [Percent Motor Rated Torque]
Ret3-Rx.x =TrqRfJLoss_Pct - Torque Reference Inertia and Losses Part [Percent Motor Rated Torque]
Ret4-Rx.x =DrvTrqRfJLoss_PU - Drive Torque Reference Inertia and Losses Part [Per-Unit]
```

```
Inertia and Losses
Compensation
JSR
Jump To Subroutine
Routine Name          JLossComp
Input Par             LineSpdRf_FPM
Input Par             LineSpdRfRate_FPMsec
Input Par             JDiffEnbl
Input Par             JDiffSamples
Input Par             BuildUpRatio
Input Par             Constant_RPMPerFPM
Input Par             MtrSpdBase_RPM
Input Par             J_sec
Input Par             JGainQuad1Quad2
Input Par             JGainQuad3Quad4
Input Par             Friction_Pct
Input Par             Windage_PctRPM
Input Par             ReverseRotation
Return Par            TrqRfJ_Pct
Return Par            TrqRfLoss_Pct
Return Par            TrqRfJLoss_Pct
Return Par            DrvTrqRfJLoss_PU
```

6.0 Tuning / Startup

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

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 (param 90) 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

6.3 Offline Tuning / Startup

Verify that the number and order of JSR input parameters and JSR return parameters agree with the JSR rung comment and section 4 of this user manual.
Verify that the data type of all JSR instruction input and return parameters agree with the data type described in the JSR instruction rung comment and section 4 of this user manual. If immediate values are used for input parameters, the immediate value data type can be controlled by using or excluding a decimal point. For example, if the JSR instruction input parameter is designated as type REAL, and the desired value is zero, use "0.0" in the JSR instruction input parameter. An Input entered a "0" is used as an INTEGER value.
Check the value of all JSR instruction input parameter tags. If the tag is calculated by other Logix instructions, verify that the tag will be calculated in the correct engineering units. If the tag is not calculated by other Logix instructions, preset the tag per section 4 of this user manual.

6.4 Online Tuning / Startup

The following JSR inputs can be adjusted online:

1. JCalc In1 - Empty Core Reflected Inertia [Pound-Feet**2]
2. JCalc In2 - Material Density [Pounds/Feet**3]
3. JLossComp In4 - Number of Differentiator Moving Average Samples
4. JLossComp In8 - Total Reflected Inertia [sec]
5. JLossComp In9 - Inertia Compensation Gain Quadrant 1 and 2
6. JLossComp In10 - Inertia Compensation Gain Quadrant 3 and 4
7. JLossComp In11 - Friction Loss [Percent Load]
8. JLossComp In12 - Windage Loss [Percent Load/RPM]

All other JSR inputs will only require offline tuning.

The following steps can be followed when tuning these parameters:

1. Configure drive to run as a speed regulator with the Drive Torque Reference Inertia and Losses Torque Part (JLossComp – Ret4) used as a feed forward signal. See the Tension Regulator Reference Manual for selecting operation as speed mode. Do not change drive configuration parameters to activate speed control.
2. Set Friction Loss (JLossComp - In11) and Windage Loss (JLossComp - In12) to zero.
3. Set Inertia Compensation Gain Quadrant 1 and 2 (JLossComp - In9) and Inertia Compensation Gain Quadrant 3 and 4 (JLossComp – In10) to 1.0.
4. If Enable Differentiator (JLossComp – In3) is true, set the Number of Differentiator Moving Average Samples (JLossComp – In4) to 2.
5. If a center winder application, set up the winder with an empty core or mandrel and preset the diameter calculator to minimum empty core diameter so that the Normalized Diameter is 1.0.
6. Setup a trend with the Line Speed Reference (JLossComp - In11) and speed regulator PI output signal.
7. If a center winder application, accelerate/decelerate the drive and adjust the Empty Core Reflected Inertia (JCalc - In1) until deviations in the speed PI output are minimized. If a constant diameter application, accelerate/decelerate the drive and adjust Total Reflected Inertia (JLossComp - In1) until deviations in the speed PI output are minimized.
8. If Enable Differentiator (JLossComp – In3) is true, add the Torque Reference Inertia Part to the trend, run the drive at a steady speed, and adjust the the Number of Differentiator Moving Average Samples (JLossComp – In4) to minimize signal noise.
9. If a constant diameter application, skip to step 13.
10. Place the largest diameter roll available on the winder and set Material Width (JCalc - In5) to the actual roll width.
11. Accelerate/decelerate the drive and adjust the Material Density (JCalc - In2) until deviations in the speed PI output are minimized.
12. Remove the roll.

13. Run the drive with a steady Line Speed Reference that results in a motor speed of just over 2 RPM.
14. Adjust Friction Loss (JLossComp - In11) until the speed PI output is near zero.
15. Run the drive with a steady Line Speed Reference that results in a motor speed near 75% of full speed.
16. Adjust Windage Loss (JLossComp - In12) until the speed PI output is near zero.
17. After threading the machine, if tension deviates during accleration/deceleration, adjust Inertia Compensation Gain Quadrant 1 and 2 (JLossComp – In9) and Inertia Compensation Gain Quadrant 3 and 4 (JLossComp – In10) as necessary to reduce tension deviations.

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

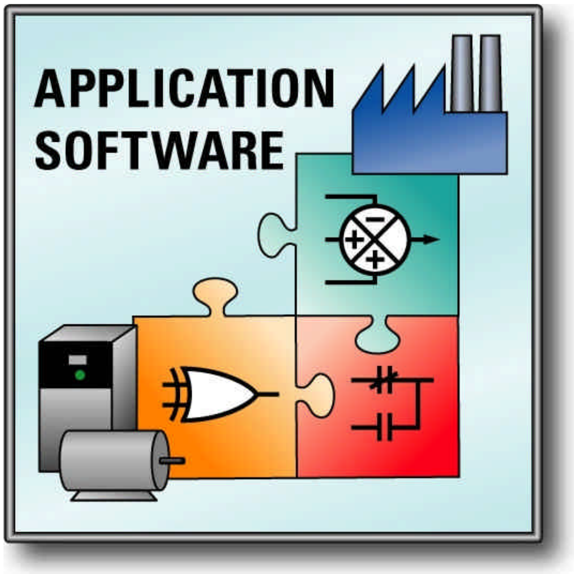
Appendix B - Block Diagram

NA

Appendix C - Parameter (Tag) Table

Input Tags for Inertia Compensation Function Module

Name	***Type***	***Source Tag***	***from Routine***	***Default***	***User Value***
JCalc – Routine					
JEC_lbft2	R x.x	zDLx_JEC_lbft2	NA	5.0	
Density_lbft3	R x.x	zDLx_Density_lbft3	NA	43.2	
BuildUpRatio	R x.x	DLx_BuildUpRatio	DiamCalc	NA	
Constant_RPMperFPM	R x.x	DLx_Constant_RPMperFPM	DiamCalc	NA	
Width_in	R x.x	zDLx_Width_in	NA	24.0	
GearRatio	R x.x	zDLx_GearRatio	NA	5.0	
MtrSpdBase_RPM	R x.x	DLx_MtrSpdBase_RPM	CalcAndDisplay – Main or USER Programming	NA	
MtrTrqRated_lbft	R x.x	DLx_MtrTrqRated_lbft	CalcAndDisplay – Main or USER Programming	NA	
JLossComp – Routine					
LineSpdRf_FPM	R x.x	DLx_LineSpdRf_FPM	RunJogSpdRf	NA	
LineSpdRfRate_FPMsec	R x.x	DLx_LineSpdRfRate_FPMsec	RunJogSpdRf	NA	
JDiffEnbl	B x	zDLx_JDiffEnbl	NA	0	
JDiffSamples	I x	zDLx_JDiffSamples	NA	3	
BuildUpRatio	R x.x	DLx_BuildUpRatio	DiamClac	NA	
Constant_RPMPerFPM	R x.x	DLx_Constant_RPMperFPM	DiamClac	NA	
J_sec	R x.x	DLx_J_lbft2	JCalc or USER	NA	
JGainQuad1Quad2	R x.x	zDLx_JGainQuad1Quad2	NA	1.0	
JGainQuad3Quad4	R x.x	zDLx_JGainQuad3Quad4	NA	1.0	
Friction_Pct	R x.x	zDLx_Friction_Pct	NA	0.0	
Windage_PctRPM	R x.x	zDLx_Windage_PctRPM	NA	0.0	
MtrTrqRated_lbft	R x.x	DLx_MtrTrqRated_lbft	CalcAndDisplay – Main or USER Programming	NA	
ReverseRotation	B x	DLx_DrvStatProcLn.6	LogicAndReference – Logic	NA	



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