Rockwell Automation Application Content

Machine Builder Libraries

Reference Manual

Tension Zone
Variable Diameter with Load Cell

raM_Opr_TensionZoneVD_LC v2.x

Rockwell Automation

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Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://literature.rockwellautomation.com) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
ATTENTION	Identifies information about practices or circumstances or death, property damage, or economic loss. Attentions avoid a hazard, and recognize the consequence.
SHOCK HAZARD	Labels may be on or inside the equipment, that dangerous voltage may be present.
BURN HAZARD	Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

Table of Contents

1 Overview

raM_Opr_TensionZoneVD_LC:

- Instruction uses Speed Trim Regulator and Diameter Calculator to control web tension in center driven winder or unwinder applications with variable diameter spindle based on tension feedback from a load cell. Tension Taper Reference option is available for winder applications.

Use when:

- Controlling web tension in a center driven (un)winder and
  - Speed Trim Regulator is preferable over Torque Trim Control to control web tension
  - Tension feedback device is a load cell
  - Application requires a diameter calculation algorithm
  - Decreasing winding tension based on diameter value is a desired option (tension taper reference).

Do NOT use when:

- Torque Trim Regulator is preferable over Speed Trim Regulator to control web tension.
- Diameter measured by sensor (use the fixed diameter instruction in this case).
- Controlling tension in a nip roll section (use the fixed diameter instruction in this case).

1.1 Prerequisites

- Axis Handler v1.x.xx
- Load Cell Feedback Device
- Valid Axis Configuration are Position Loop or Velocity Loop
- Studio 5000 - Logix Designer
  - v30.0 →
- Studio 5000 - Application Code Manager
  - v2.0 →

1.2 Functional Description

Instruction uses Diameter Calculator, Tension Taper Reference, Tension Reference, and Speed Reference Technology Blocks to achieve correct tension at line speed.

1.2.1 Axis Handler Interface

Instruction will register itself against an axis handler, otherwise instruction will generate Error 1000.

Handler needs to be in run state, otherwise instruction will generate Error 1001.

Handler needs to be in a supported mode, otherwise instruction will generate Error 1002.

- ➢ Virtualized and Physicalized are supported handler modes.

Handler Path Axis needs to match instruction axis, otherwise instruction will generate Error 1006.

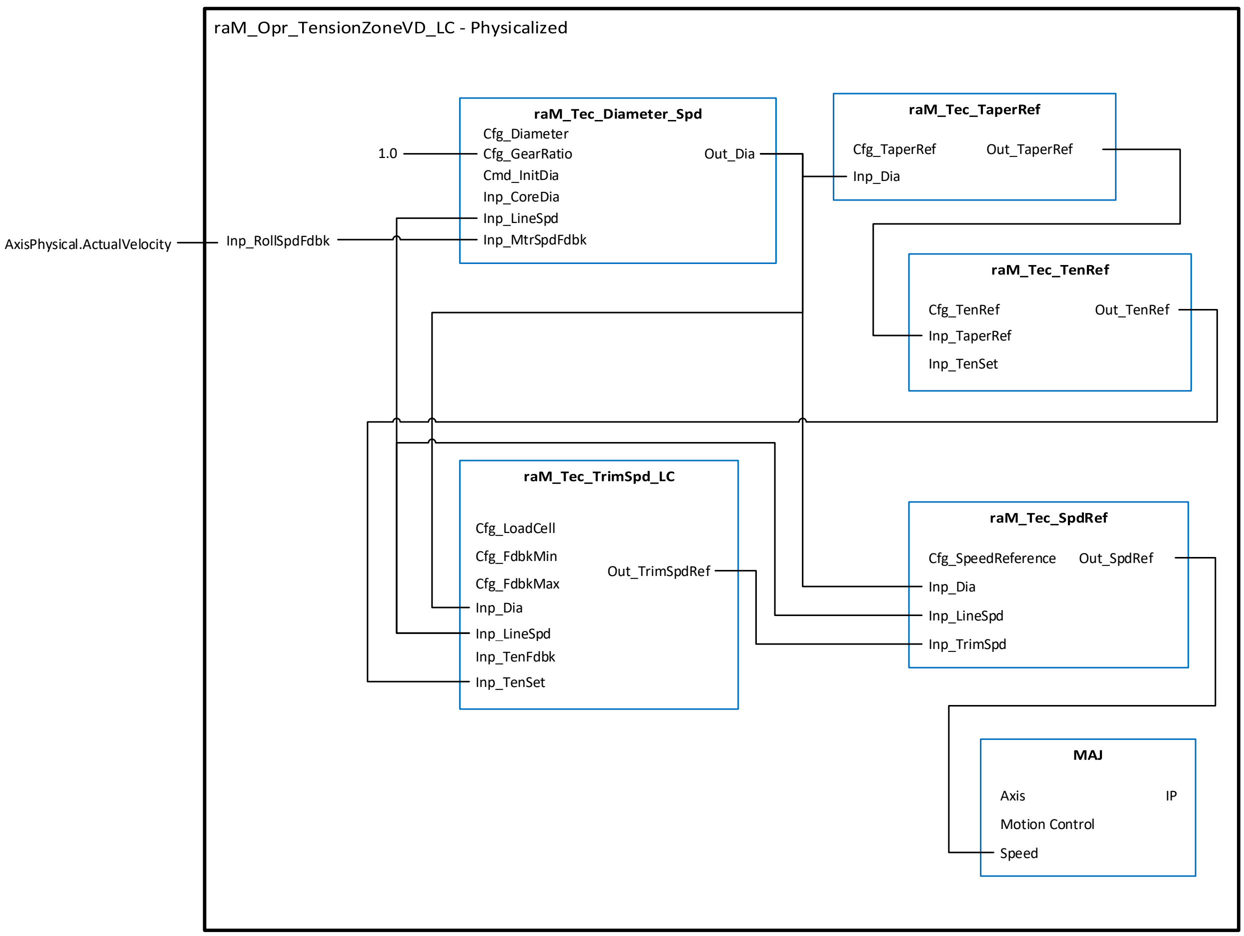
Axis Control Mode needs to be in a valid mode, otherwise instruction will generate Error 1008.

- ➢ Position and velocity are valid axis control modes.

1.2.2 Internal Interconnection Diagram with Handler in Physicalized Mode

The diagram below shows the connection between the technology blocks used by the instruction. The diagram does not show all parameters of internal instructions in order to emphasize connections between instructions.

The parameter Cfg_GearRatio of the raM_Tec_Diameter_Spd is set to 1.0 inside of raM_Opr_TensionZoneVD. User must configure the gear ratio between motor and roll in the axis physical proprieties. AxisPhysical.ActualVelocity should be used as Inp_RollSpdFdbk of raM_Opr_TensionZoneVD_LC instruction.



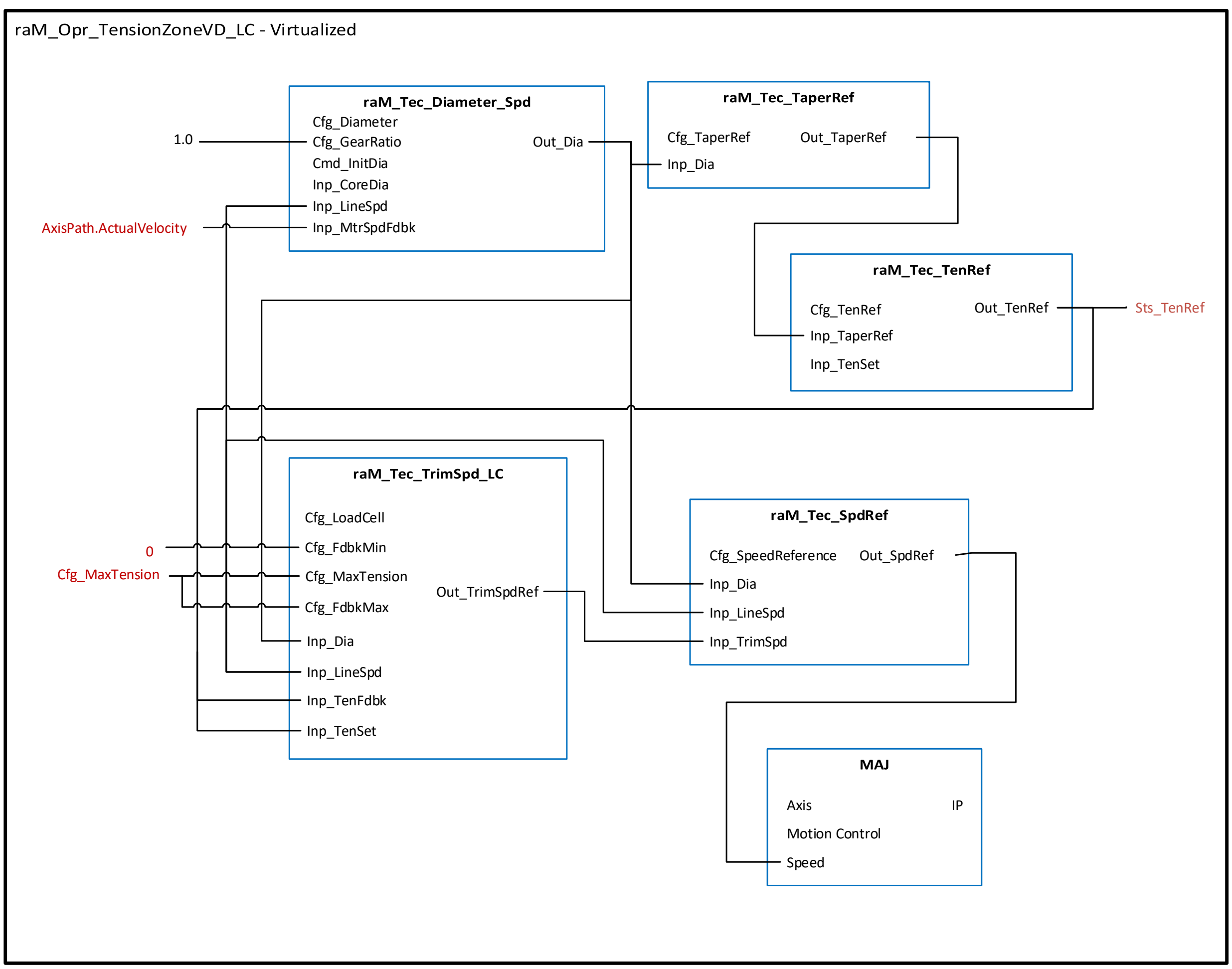
1.2.3 Interconnection Diagram with Handler in Virtualized Mode

The diagram below shows the connections among internal instructions inside the tension zone instruction. The diagram does not show all parameters of internal instructions in order to emphasize the connections. The arrows inside instructions indicate internal modifications to parameters values when handler is in virtualize mode.

Inside raM_Opr_TensionZoneVD_LC, Cfg_GearRatio of instruction raM_Tec_Diameter_Spd is set to 1.0. User must configure the gear ratio between motor and roll in the axis physical proprieties.

When in Virtualize Mode:

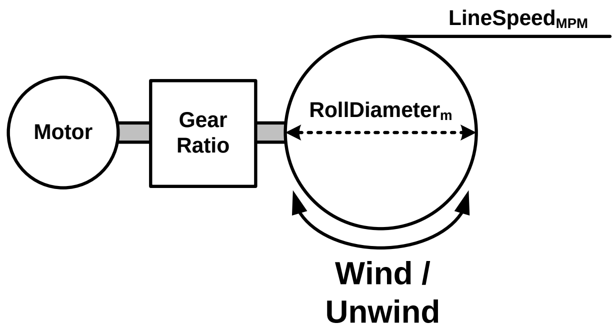
- Instruction will use AxisPath.ActualVelocity instead of Inp_RollSpdFdbk as the roll speed feedback used to calculate the roll diameter.
- Instruction will use Inp_TenSet instead of the Inp_TenFdbk as feedback from the load cell. Inp_TenFdbk still influenced by Cfg_FdbkWLag.
- Instruction will change Cfg_FdbkMin to 0 and Cfg_FdbkMax to the Cfg_MaxTension value internally to ensure that Inp_TenFdbk and Inp_TenSet have the same scaling.



1.2.4 Diameter Calculator – raM_Tec_Diameter_Spd

Calculates roll diameter using Line Speed Reference and Roll Speed Feedback (revs/sec) during winding or rewinding process.

If the rotational speed of the driven section is kept constant, the surface speed (or line speed) will increase as the diameter of the section increases. To maintain constant surface speed, the rotational speed must decrease proportional to the increase in roll diameter. For example, if the roll diameter doubles, the rotational speed must be reduced by half to maintain constant surface speed.



The equation below represents the calculation performed by the instruction.

$$MotorSpeed_{RPS} = \frac{LineSpeed_{MPS} \cdot GearRatio}{\pi \cdot RollDiameter_m}$$

Limit Diameter Rate of Change

To prevent rapid changes in roll diameter, the diameter rate of change (in meters) per revolution is the material thickness multiplied by a factor of 2. To avoid unwanted limitation, the rate of the change setpoint (Cfg_DiaChangeRate) should be increased by 5-10%.

Max Diameter Rate of Change [meters/rev]

Web thickness in mm:

$$Cfg\_DiamChangeRate = \frac{\text{MaxWebThickness}_{\text{mm}}}{500}$$

Web thickness in mils:

$$Cfg\_DiamChangeRate = 5.08 \cdot 10^{-5} \text{MaxWebThickness}_{\text{mils}}$$

The actual diameter rate of change setpoint should be increased by at least 5% to avoid **unwanted limitation of the diameter calculator.**

1.2.5 Tension Taper Reference - raM_Tec_TaperRef

Calculates tension taper reference (%) from diameter input value (meters).

Tension taper is the process by which the applied tension to a center driven winding roll is reduced as diameter increases to reduce roll damage. Applications which are sensitive to high internal roll pressure or where roll telescoping is a risk will demand taper tension. Material characteristics and finished roll diameter dictates if, and how much, taper is required. Tension taper is not applicable for unwinding or surface driven applications.

The Tension Reference Taper instruction calculates the % the tension will be reduced or tapered based on the roll diameter.

The tension reference taper can be adjusted based on start diameter, full roll tension taper % and the taper profile.

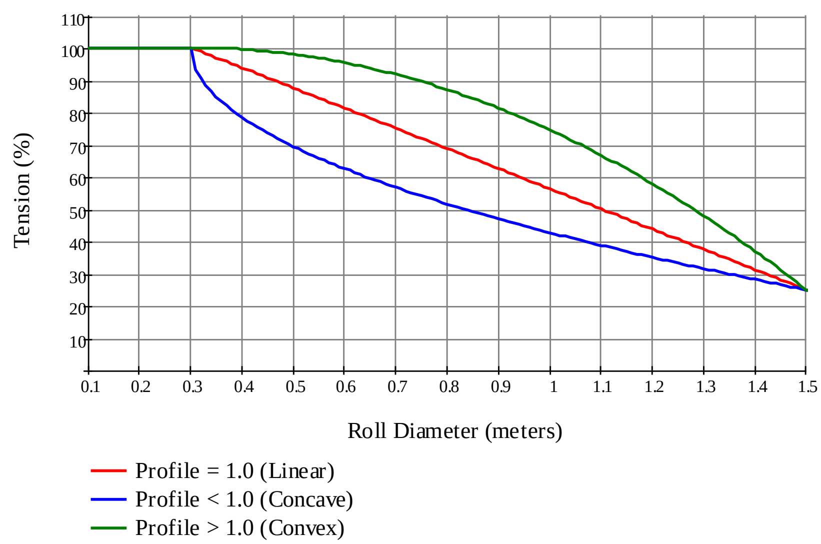
Equation 1 – Tension Taper Reference

$$\mathrm{TaperRef}_{\%}(\mathrm{Diam}_m) := \begin{cases} 100 & \text{if } \mathrm{ECDiam}_m \le \mathrm{Diam}_m < \mathrm{StartDiam}_m \\ 100 - (100 - \mathrm{FRTaper}_{\%}) \bullet \left(\dfrac{1}{\mathrm{FRDiam}_m - \mathrm{StartDiam}_m} \mathrm{Diam}_m - \dfrac{\mathrm{StartDiam}_m}{\mathrm{FRDiam}_m - \mathrm{StartDiam}_m} \right)^{\mathrm{Prof}} & \text{if } \mathrm{StartDiam}_m \le \mathrm{Diam}_m < \mathrm{FRDiam}_m \\ \mathrm{FRTaper}_{\%} & \text{if } \mathrm{Diam}_m \ge \mathrm{FRDiam}_m \end{cases}$$

The tension reference taper profile will depend on the winding application requirements. Profiles equal to 1 result in a linear slope, less than 1 result in a “concave” slope and greater than 1 result in a “convex” slope.

Figure 1 – Relationship between the tension reference taper slope and profile.

Example: Empty core diameter = 0.1m
Full roll diameter = 1.5m
Start diameter = 0.3m
Full roll taper % = 25%



1.2.6 Tension Reference – raM_Tec_TenRef

Calculates tension reference (Newtons) from tension setpoint (Newtons) and tension taper reference (%).

The Tension Reference instruction calculates the tension reference based on the taper reference percentage and tension setpoint. If maximum tension, tension setpoint, or taper reference is changed, the instruction will calculate a new tension reference value and control the rate of change according to the tension reference rate.

Out_TenRef (Newtons) = Inp_TenSet (Newtons) *Inp_TaperRef (%)

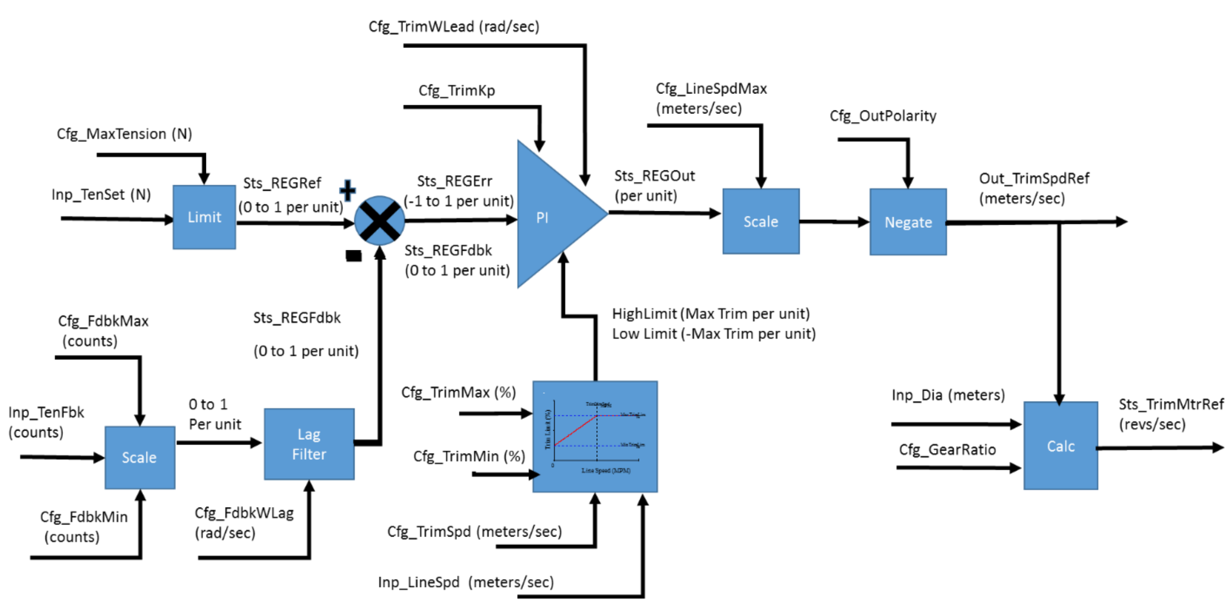
1.2.7 Speed Trim Regulator with Load Cell – raM_Tec_TrimSpd_LC

Calculates the speed trim reference (meters/second) by multiplying normalized output of Tension PI Regulator by Maximum Speed Reference (meters/sec). Tension reference (Newtons) is subtracted from scaled Tension feedback (user units) to obtain tension error that enters the PI Regulator. The PI Regulator limits are calculated based on a function determined by parameters: Maximum Trim(%), Minimum Trim(%), Speed Trim (meters/sec) and Line speed reference (meters/sec).

A trim regulator is used to provide precise material tension closed loop control. Dancer position feedback or tension feedback devices are used to correct the error between the measured value and the desired setpoint. The error between the reference and the feedback is connected to a PI (Proportional+Integral) instruction, which generates a corrective action or output trim. The output trim is then used to adjust the torque / speed reference accordingly.

The diagram below gives an overview of the tension control speed trim regulator using a tension feedback device (load cell):

Tension Control Speed Trim Regulator



Tension control is typically performed by using a feedback device, which can directly measure the force applied to the material. This feedback device is commonly referred to a load cell. The load cell does not apply a force to the web, but the controlling section applies force by pulling harder (winding) or holding back (unwinding).

The output trim polarity depends on whether the load cell is downstream or upstream. The load cell is downstream in unwinding applications and upstream in winding applications.

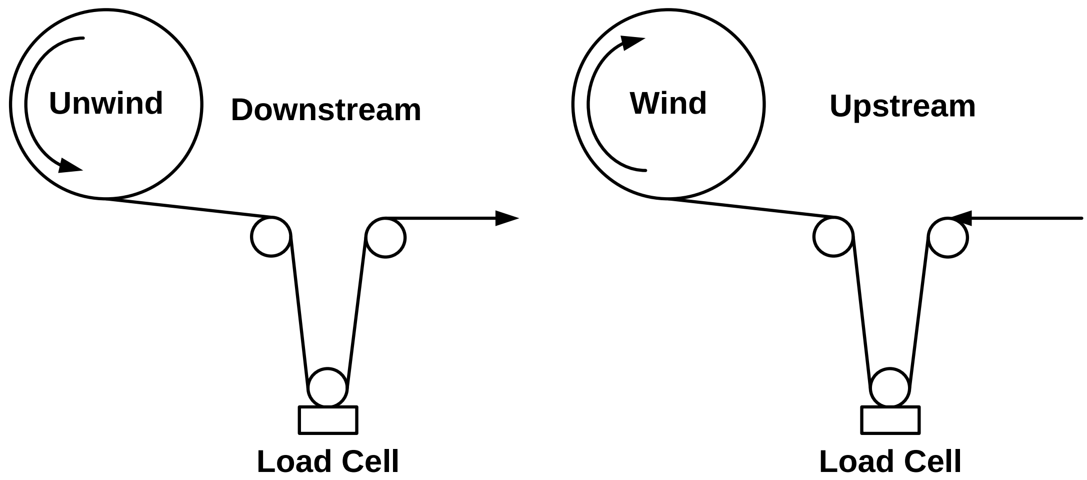


Figure 1 – Relationship between unwind / wind mode and the location of the load cell.

Mode – Load Cell Location	*Cfg_OutPolarity* (Negate Trim Output)
Unwind – Downstream	**1**
Wind – Upstream	**0**

Table 1 – Tension Control Speed / Torque Trim Instruction Negate Select (Reference Figure 1)

The speed trim regulator varies the amount of applied trim based on the line speed. At zero speed, there is a minimum allowed trim limit. As speed increases, the applied trim increases until it reaches its maximum trim limit. The speed at the maximum trim limit is determined by the trim limit speed. Typically, the trim limit speed is a fixed percentage (10-50%) of max line speed.

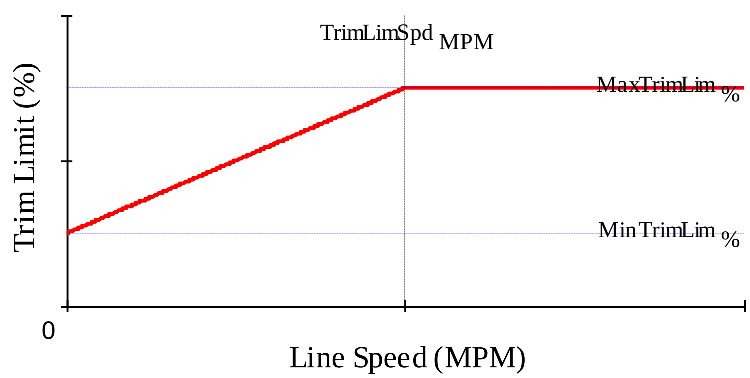


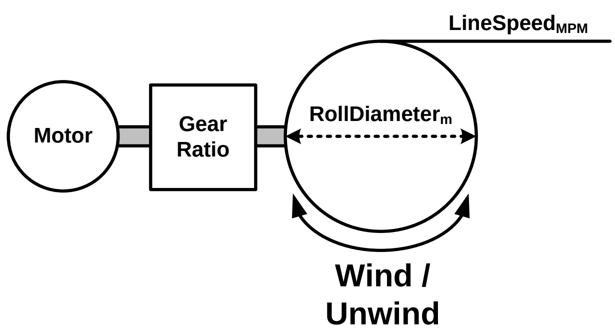
Figure 2 – Relationship between speed trim limit and line speed.

1.2.8 Speed Reference – raM_Tec_SpdRef

Calculates Roll Speed Reference (revs/sec) using calculated diameter (meters), Line Speed Reference (meters/second) and Speed Trim Regulator Output (meters/sec). Line Speed Reference is added to Speed Trim Regulator Output (meters/sec) and divided by (π * Diameter) to obtain roll speed reference in revs/sec.

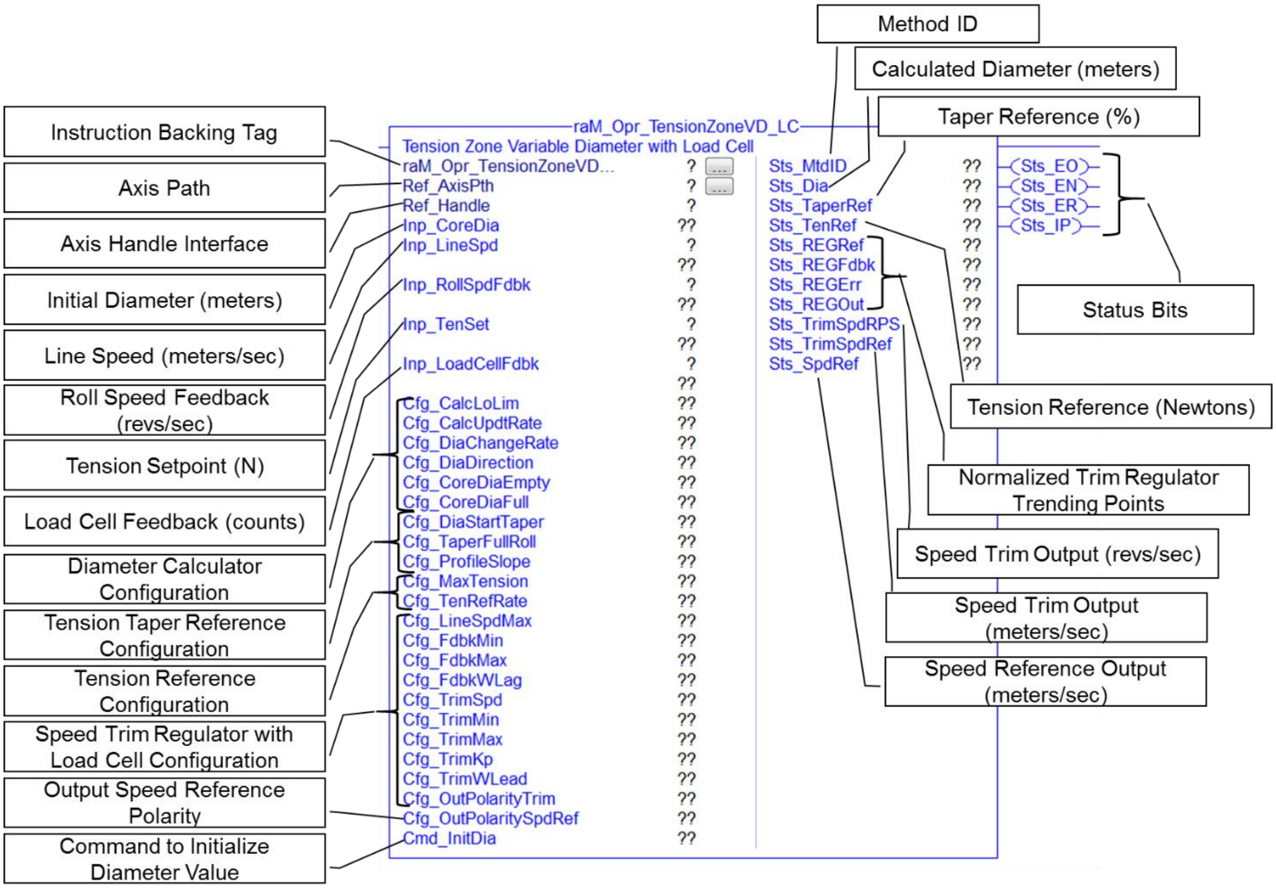
Calculates Roll speed Reference (revs/sec) using calculated diameter (meters), Line Speed Reference (meters/second) and Speed Trim Regulator Output (meters/sec). Line Speed Reference is added to Speed Trim Regulator Output (meters/sec) and divided by (π * Diameter) to obtain roll speed reference in revs/sec.

The figure below illustrate the relationship between roll diameter, surface speed and gear ratio when calculating motor speed.



The equation below represents the calculation performed by the instruction.

$$Out_{SpdRef}RPS = \frac{\left(Inp_{LineSpd}MPS + Inp_{TrimSpd}MPS\right)}{\pi * Inp_{Dia}Meters} * Cfg\_GearRatio$$



General Status Bit Behavior:

Note: Status bit not shown on the output side of the instruction are not used and will not exist in the instruction backing tag.

Status Bit	Description / Behavior
*.Sts_EO	• Enable Out indicated the status of the output line of the instruction. • If false (logically LO) any instruction on the ladder rung between the instruction and the neutral rail will not be energized. • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.
*.Sts_EN	• The rung-in condition of the ladder rung is true and the instruction is being evaluated. • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.
*.Sts_ER	• If the instruction experiences an internal error, the *. Sts_ER bit will be set. Error codes / Extended codes can be found by monitoring the backing tag *.Sts_ERR / *.Sts_EXERR members respectively. • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.
*.Sts_DN	• Used when the execution of the instruction completes within a single scan. • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.
*.Sts_IP	• Used to identify the instruction is in the process • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.
*.Sts_PC	• Used when the execution of the instruction requires more than a single scan to complete, and indicates the 'process' carried out by the instruction has successfully completed. • If the instruction is removed from ladder scan either in a conditional subroutine, MCR zone, JMP/LBL etc., the bit will remain in its last evaluated state.

1.3 Execution

- Level

1.3.1 Overview

Prior to object execution:

1. Set the current diameter
2. Energize the axis

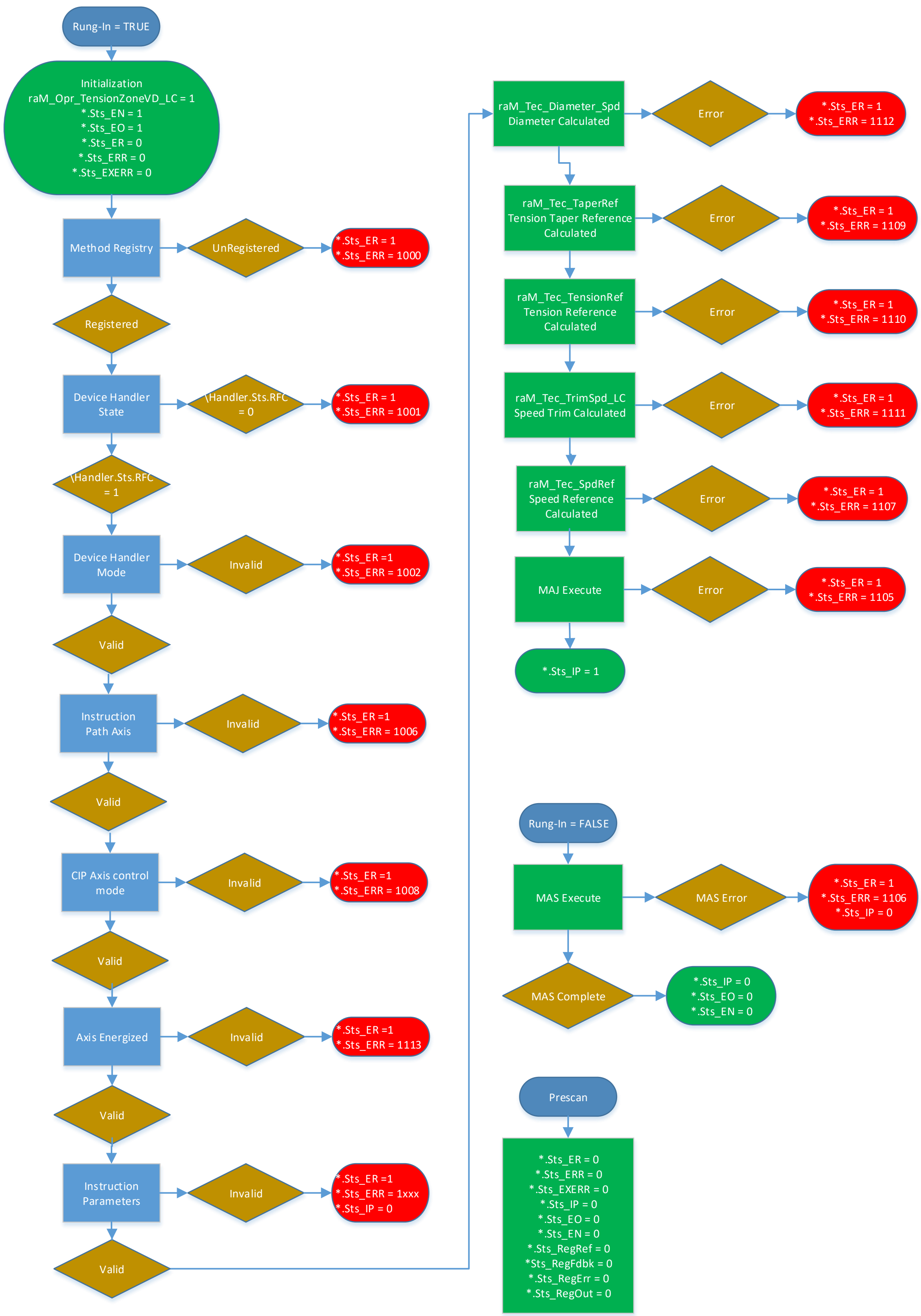
- Instruction Initialization
    - *.Sts_EO = 0
    - *.Sts_EN = 0
    - *.Sts_IP = 0
    - *.Sts_ER = 0

- Instruction being executed
    - *.Sts_EO = 1
    - *.Sts_EN = 1
    - *.Sts_ER = 0
        - IF: Error -> Sts_ER = 1 and Sts_IP = 0
        - IF Not Error -> Sts_IP = 1

1.3.2 Affected Axis Handler Status

Status	Description	Value
\[ProgramName].AxisHandlerTagName_Sts.Standstill	Axis is not Moving. Velocity is 0 +/- Zero Velocity Window	0
\[ProgramName]. AxisHandlerTagName_Sts Sts.NoMotion	Axis is at Standstill, and no Motion Instructions are Active	0
\[ProgramName]. AxisHandlerTagName_Sts Sts.FirstFault	Axis Handler First-Out Fault	
\[ProgramName]. AxisHandlerTagName_Sts Sts.EventLog	Axis Handler Event Log	
\[ProgramName]. AxisHandlerTagName_Sts Sts.FaultLog	Axis Handler Fault Log	

1.3.3 Execution Table



2 Instruction

2.1 Footprint

Characteristic	Description	Value	Unit
Definition	Estimated memory required to store the object definition, including all dependents.	26.4	kB
Instance	Estimated memory required per object instantiated. This includes the object instance and all datatypes required to verify the project. In the case of user configurable arrays, an application relevant array length will be used for estimation.	2.1	kB
Execution L7x	Estimated execution time / scan footprint evaluated in 1756-L7x PAC	925	us

2.2 Input Data

Input	Function / Description	DataType
Ref_AxisPth	Path Axis	AXIS_VIRTUAL
Ref_Handle	Axis Handler Data Structure	raM_UDT_Dvc_xADH_DataHndl
Inp_CoreDia	Sets the diameter calculator to the preset diameter value; typically used following roll changes, prior to running the roll [meters]. To set the diameter calculator to its preset value: Cmd_InitDia is toggled TRUE. Sts_Dia will then be set to Inp_CoreDia.	REAL
Inp_LineSpd	Line speed reference [meters/sec]. Input used to integrate web distance in meters.	REAL
Inp_RollSpdFdbk	Roll speed feedback [revs/sec]. Input used to integrate spindle distance in revs.	REAL
Inp_TenSet	Tension setpoint [Newtons].	REAL
Inp_TenFdbk	Tension feedback in counts [User Units].	REAL
Cfg_CalcLoLim	Adjusts min line speed in meters/min that the diameter calculator will be active [meters/sec]. The diameter calculator will be disabled if the line speed is below the calc enable threshold. The diameter calculator should be disabled at low line speeds to prevent errors in the calculation. Typically, a setting of 1-10% of max line speed produce favorable results.	REAL
Cfg_CalcUpdtRate	Adjusts the number of roll revolutions per diameter calculation [revs]. The calculator will measure the length of the web accumulated at the set number of revolutions. A greater number of revolutions will naturally average the roll diameter. A lower number of revolutions will generate faster updates to the diameter calculator. Typically, a setting of 1-8 revs will produce favorable results. Thicker web materials (>62mils or >1.57mm) should be set lower, and thinner webs (<62mils or <1.57mm) should be set higher. Using a whole number of revolutions will help reduce diameter calculation variations due to roll eccentricity.	REAL

Input	Function / Description	DataType
Cfg_DiaChangeRate	Controls the max rate of change for the diameter calculator, entered in meters per revolution of the roll (spindle) [meters/rev]. The change in diameter per revolution is the material thickness multiplied by 2. This setpoint is used for limitation of the diameter calculator. Calculated set point should be increased by 5-10% to avoid unwanted limitation	REAL
Cfg_DiaDirection	Allows the diameter calculator to increase, decrease or change in both directions. 0 - Bidirectional 1 - Increment only (typical for winders) 2 - Decrement only (typical for unwinders)	DINT
Cfg_CoreDiaEmpty	Empty core (min) diameter [meters].	REAL
Cfg_CoreDiaFull	Full roll (max) diameter [meters].	REAL
Cfg_DiaStartTaper	The diameter where the tension will start to taper or decrease [meters]. Tension reference taper: If Sts_Dia ≤ Cfg_DiaStartTaper, then Taper Reference = 100% If Sts_Dia > Cfg_DiaStartTaper, then Cfg_TaperFullRoll <= Taper Reference <= 100%	REAL
Cfg_TaperFullRoll	Final tension reference for reference taper [% at full roll diameter]. Slope is calculated to reduce tension from 100% to this setpoint. If Diameter ≤ Cfg_DiaStartTaper, then Taper Reference = 100% If Diameter ≥ Cfg_CoreDiaFull, then Taper Reference = Cfg_TaperFullRoll	REAL
Cfg_ProfileSlope	Determines the desired taper slope profile. Slope profile: <1 “Concave” slope =1 Linear slope >1 “Convex” slope Typical values range from 0.5-2.0.	REAL
Cfg_MaxTension	Maximal tension [Newtons]	REAL
Cfg_TenRefRate	Tension reference rate of change [% of max line tension per sec]. A larger reference rate setpoint will allow for more rapid changes in tension reference. Used for “bump less” transfers in and out of tension control. Typically, a setting of 10..-25%/sec will produce favorable results.	REAL
Cfg_LineSpdMax	Max line speed [meters/sec].	REAL
Cfg_FdbkMin	Min feedback position in counts [User Units], equates to 0%. Used to scale the load cell feedback from counts → per unit. Example: If the load cell feedback is 0-10counts, set the min feedback to 0.	REAL
Cfg_FdbkMax	Max feedback position in counts [User Units], equates to 100%. Used to scale the load cell feedback from counts → per unit. Example: If the load cell feedback is 0-10 counts, set the max feedback to 10.	REAL
Cfg_FdbkWLag	Feedback filter lag frequency [rad/sec].	REAL
Cfg_TrimSpd	Line speed [meters/sec] where max trim limit will be applied. Typically set to 10-50% of max line speed.	REAL
Cfg_TrimMin	The allowed regulator trim at zero speed [%] Typically set to 1-2%.	REAL
Cfg_TrimMax	The max allowed regulator trim [%]. Line speed must be equal to or greater than the Cfg_TrimSpd, before max trim limit is applied. Typically set to 10-20%. Refer to Figure 2 of section 1.2.7 (Speed Trim Regulator).	REAL

Input	Function / Description	DataType
Cfg_TrimKp	Proportional gain for the PI instruction. The regulator error is multiplied by this value. It is scaled such that a value of one would produce 100% output of the regulator when there is 100% error. (default value is 1) Typically, the gain is increased until the trim regulator appears to be unstable and then is reduced by 30%.	REAL
Cfg_TrimWLead	Lead frequency for the PI instruction [rad/sec]. This value is the integral gain / proportional gain. The lead frequency affects the steady state error of the regulator. Typically after the proportional gain (Kp) is set, the lead frequency is adjusted until the desired steady state response is achieved.	REAL
Cfg_OutPolarityTrim	This will be set based on the application. Refer to Table 1 of section 1.2.7 (Speed Trim Regulator) to determine if the trim output should be negated. 0 = Normal - Load Cell is located after (according to the direction where material is moving) the section where tension speed trim regulator is acting (uwinder Applications and optional for nip rolls). 1 = Inverted - Load Cell is located before (according to the direction where material is moving) the section where tension speed trim regulator is acting (winder applications and optional for nip rolls). Default = 0	DINT
Cfg_OutPolaritySpdRef	Negates the motor speed reference. This will be set based on the application. 0 = Normal 1 = Inverted Default = 0	DINT
Cmd_InitDia	Sets the diameter calculator to the preset diameter value; typically used following roll changes, prior to running the roll. Sts_Dia will then be set to Inp_CoreDia.	BOOL

2.3 Output Data

Output	Function / Description	Data Type
raM_Opr_TensionZone_VD_LC	Object Identifier	BOOL
Sts_EO	Provides a visible indicator of the EnableOut system parameter.	BOOL
Sts_EN	Identify object is or has been in scan	BOOL
Sts_ER	Instruction has experienced an internal error	BOOL
Sts_ERR	Instruction Error Code	DINT
Sts_EXERR	Instruction Extended Error Code	DINT
Sts_MtdID	Instruction ID	DINT
Sts_Dia	empty core to full roll [meters] Actual calculated diameter. When instruction not enabled or the error bit is TRUE, this output will be held at its last value.	REAL
Sts_REGRef	Reference input into the regulator loop [per unit]. Primary function is a display value. Useful in tuning the trim regulator.	REAL
Sts_REGFdbk	Feedback input into the regulator loop [per unit]. Primary function is a display value. Useful in tuning the trim regulator.	REAL
Sts_REGErr	Error input into the PI instruction [per unit]. Primary function is a display value. Useful in tuning the trim regulator. Error = Reference – Feedback	REAL
Sts_REGOut	Output trim from the PI instruction [per unit]. Primary function is a display value. Useful in tuning the trim regulator. When the EnableIn bit is FALSE or the error bit is TRUE, the trim regulator holds last value	REAL
Sts_TrimSpdRPS	Speed trim reference [revs/sec]. Primary function is a display value in revs/sec.	REAL
Sts_TrimSpdRef	Speed trim reference [meters/sec]. Influence of tension regulator in the speed reference of the spindle axis. The Sts_REGOut (limited by Minimum and Maximum Trim) is multiplied by Cfg_LineSpdMax to calculate the speed trim reference in meters/sec. When the EnableIn bit is FALSE or the error bit is TRUE, the trim regulator holds last value.	REAL
Sts_SpdRef	Speed reference [revs/sec]. The output from the trim regulator in meters/sec is added to line speed reference. The result is divided by the roll diameter multiply by PI to determine the speed reference to the increase / decrease the spindle axis. When the EnableIn bit is FALSE or the error bit is TRUE, the trim regulator holds last value	REAL
Sts_TaperRef	Taper reference [%]. The output of taper reference instruction.	
Sts_TenRef	Tension Reference [Newtons]. The output of tension reference instruction. Tension Setpoint multiplied by the taper reference.	
Sts_IP	Instruction in process	BOOL

2.4 Error Codes

Sts_ERR	Description
0	No errors present
1000	Method Failed to register. Method will not execute until registered. Method Registry Array must be larger.
1001	Axis Handler is not in a running state. Commands to the device cannot be processed.

Sts_ERR	Description
1002	Axis Handler is not in a supported mode.
1003	Axis Handler OnPath Status is not available. For AxisHandler_AV execute Energize method. For AxisHandler_CD execute Energize and SyncPthPhyAx methods.
1005	Path and Physical Axes referenced by instruction do not match Axes associated with the Handler.
1006	Path axis referenced by instruction does not match Path Axis associated with the Axis Handler.
1007	Physical Axis referenced by instruction does not match Physical Axis associated with the Handler.
1008	Invalid Axis Control Mode. Axis must be configured for Velocity or Position.
1013	Invalid Inp_LineSpd value. Value must be greater than or equal to zero (≥0).
1020	Invalid Cfg_CalcLoLim value. Value must be greater than or equal to zero (≥0).
1021	Invalid Cfg_CalcUpdtRate value. Value must be greater than zero (>0).
1022	Invalid Cfg_CoreDiaEmpty value. Value must be greater than zero (>0).
1023	Invalid Cfg_CoreDiaFull value. Value must be greater than Cfg_CoreDiaEmpty (>Cfg_CoreDiaEmpty).
1024	Invalid Cfg_DiaChangeRate value. Value must be greater than or equal to zero (≥0).
1025	Invalid Cfg_DiaDirection value. Value must be 0, 1 or 2.
1026	Invalid Inp_CoreDia value. Value must be greater than or equal to Cfg_CoreDiaEmpty (≥Cfg_CoreDiaEmpty) and less than or equal to Cfg_CoreDiaFull (≤Cfg_CoreDiaFull).
1060	Invalid Cfg_DiaStartTaper value. Value must be greater than Cfg_CoreDiaEmpty (> Cfg_CoreDiaEmpty) and less than Cfg_CoreDiaFull (< Cfg_CoreDiaFull).
1061	Invalid Cfg_MaxTension value. Value must be greater than zero (>0).
1062	Invalid Cfg_ProfileSlope value. Value must be greater than zero (>0).
1063	Invalid Cfg_TaperFullRoll value. Value must be greater than or equal to zero and less than or equal to hundred (≥0 AND ≤100).
1064	Invalid Cfg_TenRefRate value. Value must be greater than zero (>0).
1067	Invalid Inp_TenSet value. Value must be greater than or equal to zero and less than or equal to Cfg_MaxTension (≥0 AND ≤Cfg_MaxTension).
1081	Invalid Cfg_FdbkMax value. Value must be greater than zero (>0).
1082	Invalid Cfg_FdbkWLag value. Value must be greater than zero (>0).
1084	Invalid Cfg_LineSpdMax value. Value must be greater than zero (>0).
1085	Invalid Cfg_TrimKp value. Value must be greater than or equal to zero (≥0).
1087	Invalid Cfg_TrimMax value. Value must be greater than or equal to Cfg_TrimMin (≥Cfg_TrimMin).
1088	Invalid Cfg_TrimMin value. Value must be greater than or equal to zero (≥0).
1089	Invalid Cfg_TrimSpd value. Value must be greater than zero (>0).
1090	Invalid Cfg_TrimWLead value. Value must be greater than or equal to zero (≥0).
1101	Invalid Cfg_OutPolaritySpdRef value. Value must be either zero or one (0 OR 1).
1102	Invalid Cfg_OutPolarityTrim value. Value must be either zero or one (0 OR 1).
1105	Motion Axis Jog (MAJ) instruction error. Check Extended Error Code to see MAJ error.
1106	Motion Axis Jog (MAS) instruction error. Check Extended Error Code to see MAS error.
1107	Speed Reference instruction error. Check Extended Error Code to see raM_Tec_SpdRef error.
1109	Tension Taper Reference instruction error. Check Extended Error Code to see raM_Tec_TaperRef error.
1110	Tension Reference instruction error. Check Extended Error Code to see raM_Tec_TenRef error.
1111	Load Cell Speed Trim instruction error. Check Extended Error Code to see raM_Tec_TrimSpd_LC instruction error.
1112	Diameter Calculator instruction error. Check Extended Error Code to see raM_Tec_Diameter_Spd error.
1113	Axis not energized.

Sts_EXERR	Description
< Number >	If native instruction error occurs internally (MAJ or MAS), the value of the instruction*.ERR DINT will be placed in Sts_EXERR

3 Application Code Manager

3.1 Definition Object: raM_Opr_TensionZoneVD_LC

This object contains the AOI definition and used as linked library to implement object. This gives flexibility to choose to instantiate only definition and create custom implement code. User may also create their own implement library and link with this definition library object.

3.2 Implement Object: raM_LD_TensionZoneVD_LC

Implement Language: Ladder Diagram

Parameter Name	Default Value	Instance Name	Definition	Description
ObjectName	raM_LD_TensionZoneVD_LC			Object Name
RoutineName	{ObjectName}	{RoutineName}	Routine	Name of the routine where the object will be placed
TagName	_{ObjectName}		Local Tag	Instruction Backing Tag
StartBitTagName	Cmd_Start{ObjectName}		Local Tag	Start bit Tag Name
LineSpdName	_LineSpd	{LineSpdName}	--	Line Speed Tag Name
RollSpdFdbkName	_RollSpdFdbk	{RollSpdFdbkName}	--	Roll Speed Feedback Tag Name
TenSetName	_TenSet	{TenSetName}	Local Tag	Tension Set Point Tag Name
LoadCellFdbkName	_LoadCellFdbk	{LoadCellFdbkName}	--	Tension Feedback Tag Name

Linked Library

Link Name	Catalog Number	Revision	Solution	Category
raM_LD_AxisHandler_CD	raM_LD_AxisHandler_CD	>=2.0	(RA-LIB) Machine	DvcHdlr – CIP Motion
raM_Opr_TensionZoneVD_LC	raM_Opr_TensionZoneVD_LC	>=2.0	(RA-LIB) Machine	Tension Control

3.3 Attachments

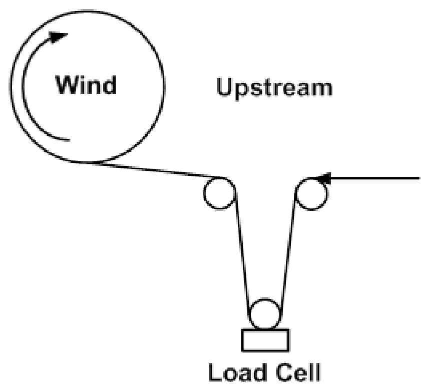
Name	Description	File Name	Extraction path
V2_{LibraryName}	Reference Manual	RM-{LibraryName}.pdf	{ProjectName}\Documentation

4 Application

4.1 Scenario Description

- In this application example, user will configure instruction raM_Opr_TensionZoneVD_LC to control tension in a winder section of a machine as seen in the picture below. The material thickness measured was 2 mm.

Tension Zone with Load Cell – Winder Application



Relationship between unwind / wind mode and the location of the load cell.

Mode – Load Cell Location	*Cfg_OutPolarityTrim*
Unwind – Downstream	**1**
Wind – Upstream	**0**

Figure 1: Relation between tension reference taper slope and profile.

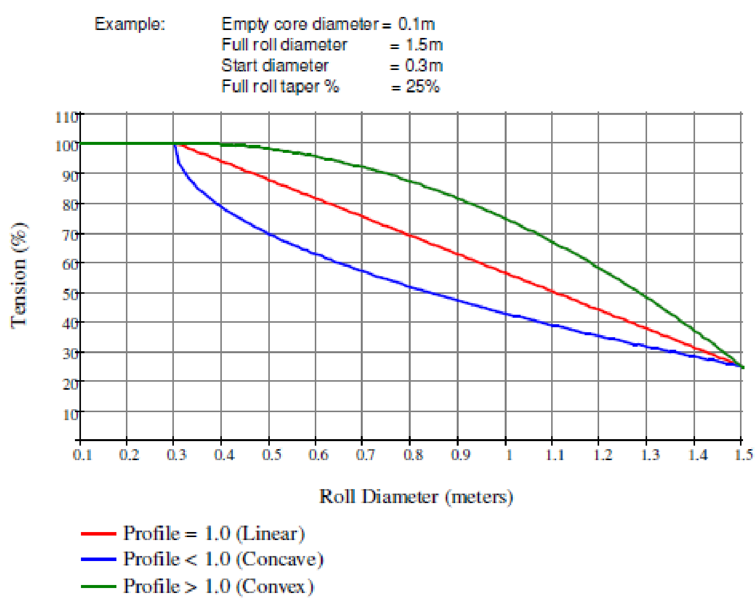
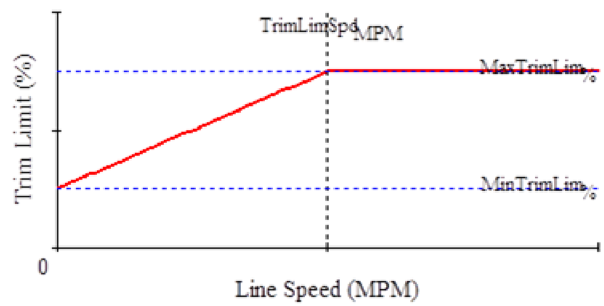
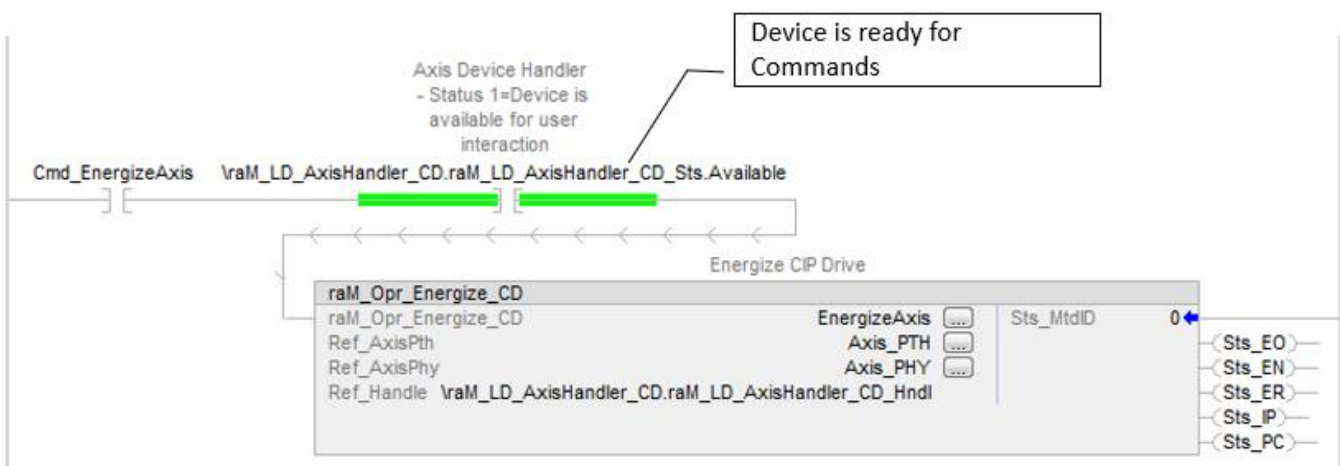


Figure 2: Trim Speed and Minimum and Maximum Trim Relationship.



4.2 Axis Handler Mode and Axis Status

- In this example, instruction is being used only in physicalize mode
- Place Axis Handler in Program and Physicalize Mode
- Energize Axis



4.3 Instruction Parametrization

4.3.1 Instruction References:

- Axis Path which is being referenced by the instruction
  - Ref_AxisPth = Axis_PTH
- Axis Handle Interface which is being referenced by the instruction
  - Ref_Handle = \raM_LD_AxisHandler_CD.raM_LD_AxisHandler_CD_Hndl

4.3.2 Instruction Configuration Parameters:

- Minimum Line Speed where diameter is calculated is 5% of Maximum Line Speed
  - Cfg_CalcLoLim = 0.2 meters/sec (5% of 4 meters/sec)
- Diameter will be calculated at each revolution of the roll

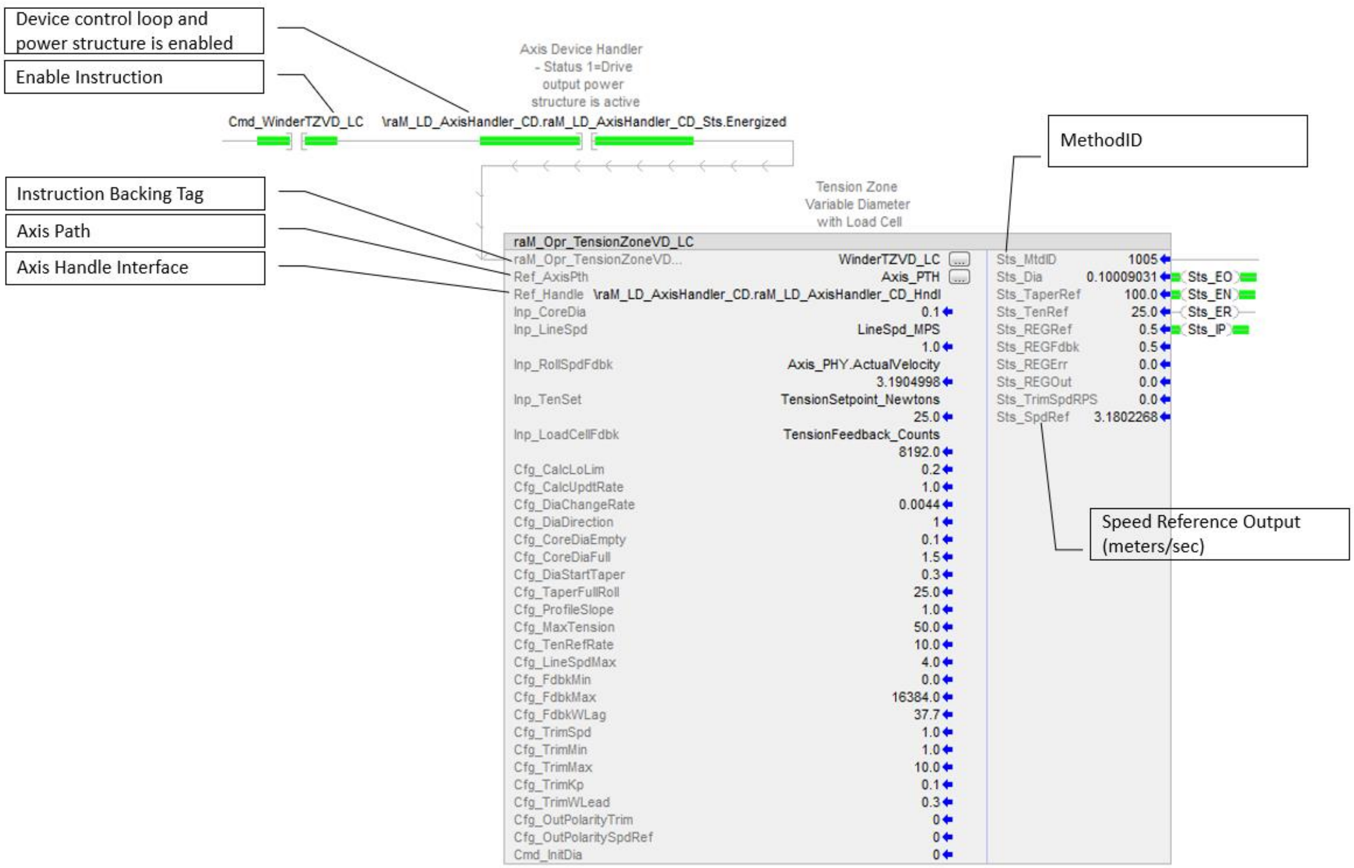
  - Cfg_CalcUpdtRate = 1 revolution
- Maximum rate of change allowed for the calculated diameter will be meters/rev
  - Cfg_DiaChangeRate = 0.0044 meters/rev
  - Material Thickness (2 mm) multiplied by 2 with 10% increase.
- Diameter Direction
  - Cfg_DiaDirection = 1 (incremental only since it is a winder)
- Empty Core Diameter
  - Cfg_CoreDiaEmpty = 0.1 meters
- Full Roll Diameter
  - Cfg_CoreDiaFull = 1.5 meters
- Diameter where tension taper starts
  - Cfg_DiaStartTaper = 0.3 meters
- Final taper reference at Full Roll Diameter
  - Cfg_TaperFullRoll = 25 % (% of max tension)
- Taper Profile is Linear
  - Cfg_ProfileSlope = 1.0 (Linear – red line in the Figure 2)
- Maximum Tension
  - Cfg_MaxTension = 50 Newtons
- Maximum rate of change allowed for the tension reference
  - Cfg_TenRefRate = 10% of maximum tension per second
- Maximum Line Speed
  - Cfg_LineSpdMax = 4 meters/sec
- Minimum Feedback value coming from load cell
  - Cfg_FdbkMin = 0 counts
- Maximum Feedback value coming from load cell
  - Cfg_FdbkMax = 16384 counts
- Feedback filter lag frequency
  - Cfg_FdbkWLag = 37.7 rad/sec (approximately 6 Hz)
- Line Speed Reference where max trim limit is applied
  - Cfg_TrimSpd = 1 meter/sec
- Minimum Trim (applied at zero line speed reference)
  - Cfg_TrimMin = 1% of Maximum Line Speed
  - Tension trim still regulating tension at zero speed
- Maximum Trim (applied if line speed greater than or equal to Cfg_TrimSpd)
  - Cfg_TrimMax = 10% of Maximum Line Speed
- Tension Trim Regulator Proportional gain
  - Cfg_TrimKp = 0.1
- Tension Trim Regulator Lead Frequency
  - Cfg_TrimWLead = 0.3 rad/sec
- Tension Trim Regulator Output Polarity
  - Cfg_OutPolarityTrim = 0 (Normal – winder application)
- Speed Reference Output Polarity
  - Cfg_OutPolaritySpdRef = 0 (Normal)

4.3.3 Sequence to Initialize Diameter

- Disable Instruction
- Inp_CoreDia = 0.1 (Initial Diameter value)
- Cmd_InitDia = 1 (Sts_Dia will assume Initial Diameter Value)
- Cmd_InitDia = 0

4.3.4 Input Required Parameters:

- Line Speed Reference
  - Inp_LineSpd = 1.0 meters/second
- Roll Speed Feedback
  - Inp_RollSpdFdbk = 3.1830988 revs/second (Inp_LineSpd/ (π * Sts_Dia))
  - This value was entered so the calculated diameter would be 0.1 meters
- Tension Setpoint
  - Inp_TenSet = 25.0 Newtons
  - This value was chosen so Tension Setpoint = 50%
- Load Cell Feedback
  - Inp_TenFdbk = 8192 counts
  - This value was chosen so Tension Feedback = 50%



4.3.5 Output Value Parameters (after Enable Rung):

- Method ID Acquired by Instruction
  - Sts_MtdID = 1005
- Value of Calculated Diameter
  - Sts_Dia (calculated diameter) is 0.1 meters
  - Sts_Dia = Inp_LineSpd/ (π* Inp_RollSpdFdbk))
- Value of Taper Reference
  - Sts_TaperRef = 100.0%
- Value of Tension Reference
  - Sts_TensionRef = 25.0 Newtons
- Value of Regulator (Inputs and Outputs)

  - Sts_REGRef = 0.5 (50%)
  - Sts_REGFdbk = 0.5 (50%)
  - Sts_REGErr = 0.0 (REGRef – REGFdbk)
  - Sts_REGOut = 0.0 since REGErr is zero
- Value of TRIM Speed Outputs
  - Sts_TrimSpdRPS = 0.0 since REGErr is zero
  - Sts_TrimSpdRef = 0.0 since REGErr is zero
  - Sts_SpdRef = 3.18 revs/second
    - Same value as Inp_RollSpdFdbk
    - Roll Speed when LineSpd = 1.0 meters/sec and Diam = 0.1 meters

4.4 Verify the Diameter Calculation:

4.4.1 Set the configuration parameters.

- *Cfg_CalcLoLim* → Recommended starting value: 5% max line speed.
- *Cfg_CalcUpdtRate* → Recommended starting value: 1-4revs for thicker material, 5-8revs for thinner material. Use a whole number of revs
- *Cfg_DiaChangeRate* → Refer to equation based on material thickness
- *Cfg_DiaDirection* → Application specific. To determine if the Sts_Dia is updated during increment (typically winders), decrement (typically unwinders), or in both directions.
- *Cfg_CoreDiaEmpty* → Empty core diameter in meters.
- *Cfg_CoreDiaFull* → Full roll diameter in meters.

4.4.2 Clear any instruction errors.

- Check *Sts_ER*.
- If the error bit is set, correct any instruction error conditions that may exist (refer to Sts_ERR for error details) and then toggle instruction execution.

4.4.3 Preset the Diameter Calculator instruction to the actual diameter.

- Measure the starting roll diameter.
- Disable instruction input condition.
- Set *Inp_CoreDia* to the initial roll diameter.
- Toggle *Cmd_InitDia*.
- Verify that *Sts_Dia* equals *Inp_CoreDia*, which should equal the initial roll diameter.
- Enable instruction input condition.

4.4.4 Verify the calculated roll diameter.

- Run the spindle at a line speed greater than *Cfg_CalcLoLim*.
- Verify that *Sts_Dia* matches the actual diameter of the roll.
- If the calculated roll diameter does not change:
  - Verify the rung-in condition for the instruction is TRUE and *Cmd_InitDia* is FALSE.
  - Verify the instruction has not detected an error (*Sts_ER*).
  - Verify the values of *Cfg_DiaDirection, Cfg_CoreDiaEmpty,* and *Cfg_CoreDiaFull* will allow the diameter to ramp to the measured value.

- If the calculated roll diameter is not accurate:
  - Hand tach the roll surface and verify the line speed reference.
  - Verify that *Inp_RollSpdFdbk* matches the actual feedback of the axis.
  - Verify gear ratio is set correctly (check physical axis configuration in your axis scaling).
- If the calculated roll diameter is accurate, but fluctuates:
  - Increase the *Cfg_CalcUpdtRate* and use a whole number of revs. Avoid using a fractional revs, as whole numbers help reduce fluctuations due to roll eccentricity.
  - Verify the accuracy of the inputs.

4.5 <u>Verify the Taper Reference:</u>

Taper Reference is intended to be used only in winding applications.

4.5.1 Set the configuration parameters.

- *Cfg_CoreDiaEmpty* → Empty core diameter (meters).
- *Cfg_CoreDiaFull* → Full roll diameter (meters).
- *Cfg_DiaStartTaper* → Application specific.
  - Recommended setting for initial startup: Start with a setting less than the full roll diameter.
- *Cfg_TaperFullRollt* → Application specific.
  - Recommended setting for initial startup: Start with a setting less than 100%.
- *Cfg_ProfileSlope* → Application specific.
  - Recommended setting for initial startup: 1 – Linear slope.

4.5.2 Clear any instruction errors.

- Check *Sts_ER*.
- If the error bit is set, correct any instruction error conditions that may exist (refer to Sts_ERR for error details) and then toggle AOI execution to reset *Sts_ER* and *Sts_ERR*.

4.5.3 Verify the tension reference taper % calculation.

- Set the roll diameter to several valid non-zero roll diameters (empty core to full roll). Try to span the entire range of the taper (i.e. empty core to full roll).
- Verify that *Sts_TaperRef* matches the expected tension reference taper % at each roll diameter according to Equation 2.

Equation 2 – Tension Taper Reference

$$\mathrm{TaperRef}_{\%}(\mathrm{Diam}_m) := \begin{cases} 100 \quad \text{if} \quad \mathrm{ECDiam}_m \le \mathrm{Diam}_m < \mathrm{StartDiam}_m \\ 100 - (100 - \mathrm{FRTaper}_{\%}) \cdot \left(\dfrac{1}{\mathrm{FRDiam}_m - \mathrm{StartDiam}_m} \mathrm{Diam}_m - \dfrac{\mathrm{StartDiam}_m}{\mathrm{FRDiam}_m - \mathrm{StartDiam}_m} \right)^{\mathrm{Prof}} \quad \text{if} \quad \mathrm{StartDiam}_m \le \mathrm{Diam}_m < \mathrm{FRDiam}_m \\ \mathrm{FRTaper}_{\%} \quad \text{if} \quad \mathrm{Diam}_m \ge \mathrm{FRDiam}_m \end{cases}$$

- If the calculated tension reference taper % is held at 0:
  - Verify the rung-in condition for the instruction is true.
  - If *Cfg_TaperFullRoll* is set to 0, verify that *Sts_Dia* is not equal to or greater than *Cfg_CoreDiaFullRoll*.
- If the calculated tension reference taper % is held at 100:
  - Verify the rung-in condition for the instruction is true.
  - Verify *Cfg_TaperFullRoll* is not set to 100.

  - Verify *Cfg_DiaStartTaper* is not set equal to *Cfg_CoreDiaFull*.

- If the calculated tension reference taper % is not accurate:
  - Verify the rung-in condition for the instruction is true.
  - Verify the accuracy of the inputs and that the configuration parameters have been set correctly.

4.6 Verify the Tension Reference:

4.6.1 Set the configuration parameters.

- Cfg_TenRefRate → Recommended starting value: 5…10%
- Cfg_MaxTension → Max tension (Newtons).

4.6.2 Clear any instruction errors.

- Check Sts_ER.
- If the error bit is set, correct any instruction error conditions that may exist (refer to Sts_ERR for error details) and then toggle instruction execution to reset Sts_ER and Sts_ERR.

4.6.3 Verify the tension reference calculation.

- For unwinding applications or when the Tension Reference Taper instruction is not used, set Cfg_TaperFullRoll to 100%.
- If the Tension Reference Taper instruction is used, set the roll diameter to a valid non-zero roll diameters (empty core to full roll).
- Set the Inp_TenSet to a valid non-zero tension setpoint (≤Cfg_MaxTension).
- Verify that Sts_TenRef matches the expected tension reference.
- If the calculated tension reference is 0:
  - Verify the rung-condition-in for the instruction is true.
  - If *Cfg_TaperFullRoll* is set to zero, verify that *Sts_Dia* is not equal to or greater than C*fg_CoreDiaFullRoll*.
- If the calculated tension reference is not accurate:
  - Verify the accuracy of the inputs and that the configuration parameters have been set correctly.

4.7 Verify the Load Cell Trim Speed:

4.7.1 Set the configuration parameters.

- Verify gear ratio in physical axis properties (motor RPS / roll RPS).
- *Cfg_LineSpdMax* → Max line speed (meters/second).
- *Cfg_DanRefRate* → Application specific. Recommended setting for initial startup 10-25%.
- *Cfg_FdbkMin* → Application specific.
- *Cfg_FdbkMax* → Application specific.
- *Cfg_TrimSpd* → Recommended setting: 10-50% max line speed
- *Cfg_TrimMin* → Recommended setting: 1%
- *Cfg_TrimMax* → Recommended setting: 10-20%
- *Cfg_FdbkWLag* → Feedback low pass filter lag frequency. 5-10rad/sec

4.7.2 Clear any instruction errors.

- Check *Sts_ER*.
- If the error bit is set, correct any instruction error conditions that may exist (refer to Sts_ERR for error details) and then toggle instruction execution to reset *Sts_ER* and *Sts_ERR*.

4.7.3 Verify the tension feedback.

- Setup and trend:
  - *Sts_REGFdbk*
- Ensure the load cell has been properly calibrated.
- Apply a no-load condition to load cell (i.e. remove any material). Verify *Sts_REGFdbk* is approximately equal to zero.
- Apply a known load to the load. Verify *Sts_REGFdbk* equates to the applied load in per unit (i.e. applied load [N] / Cfg_MaxTension[N] → per unit).
- If the *Sts_REGFdbk* is held at 0 or not updating:
  - Verify the rung-in condition for the instruction is true.
  - Verify the instruction has not detected an error (*Sts_ER*)
  - Verify *Inp_TenFdbk* is non-zero. If zero, check the wiring for dancer and/or analog input. Ensure the analog input tag has been mapped correctly.
- If *Sts_REGFdbk* is updating, but not accurate:
  - Verify *Inp_TenFdbk* is accurate. If not, check the wiring for load cell and/or analog input. Ensure the analog input tag has been mapped correctly.
  - Verify *Cfg_FdbkMin* and *Cfg_FdbkMax* are set correctly based on the feedback from *Inp_TenFdbk* and value set in *Cfg_MaxTension.*
  - Verify *Cfg_FdbkWLag* parameter based on the feedback from *Inp_TenFdbk*.

4.7.4 Tune the trim regulator KP & WLD parameters.

- Initially start with *Cfg_TrimWlead* set to 0.
- Thread the machine.
- Setup and trend:
  - *Sts_REGRef*
  - *Sts_REGFdbk*
  - *Sts_REGErr*
  - Sts_*REGOut*
- Operate the spindle at a line speed reference where the full trim will be applied (>*Cfg_TrimSpd*).

- Execute 5-10% step changes to the *Inp_TenSet* and observe regulator responses on the trend.
- Increase *Cfg_TrimKp* until the system becomes oscillatory. When this occurs, reduce *Cfg_TrimKp* by 30%.
- Adjust *Cfg_TrimWLead* to decrease the steady state error. Begin decreasing *Cfg_TrimWLead* from 10 to 5 to 1rad /sec until the desired steady state performance is achieved.

4.8 Verify the Speed Reference:

4.8.1 Set the configuration parameters.

- Make sure Physical Axis Configuration is accurate and reflects correct Gear ratio (motor RPS / roll RPS).
- Cfg_OutPolaritySpdRef → Application specific to determine if the motor speed reference should be negated.

4.8.2 Clear any instruction errors.

- Check *Sts_ER*.
- If the error bit is set, correct any instruction error conditions that may exist (refer to Sts_ERR for error details) and then toggle instruction execution to reset *Sts_ER* and *Sts_ERR*.

4.8.3 Verify the speed reference output

- Setup and trend:
  - *Sts_SpdRef*
  - *Axis Speed Feedback*
- Operate the spindle at various line speed references.
- If the speed reference output is 0:
  - Verify the rung-in condition for the instruction is true.
  - Verify the instruction has not detected an error (*Sts_ER*).
  - Verify that the Inp_LineSpd, Sts_TrimSpdRef and Sts_Dia are not set to zero.
- If the speed reference output is not accurate:
  - Verify the rung-in condition for the instruction is true.
  - Verify the accuracy of the inputs and instructions parameters.

5 Appendix

General

This document provides a programmer with details on this instruction for a Logix-based controller, its Application Code Manager library content, and visualization content, if applicable. This document assumes that the programmer is already familiar with how the Logix-based controller stores and processes data.

Novice programmers should read all the details about an instruction before using the instruction. Experienced programmers can refer to the instruction information to verify details.

IMPORTANT This object includes a Logix Designer Asset for use with Version 30 or later of Studio 5000 Logix Designer.

Common Information for All Instructions

Rockwell Automation Application Content may contain many common attributes or objects. Refer to the following reference materials for more information:

- Foundations of Modular Programming, **IA-RM001C-EN-P**

Conventions and Related Terms

Data - Set and Clear

This manual uses set and clear to define the status of bits (Booleans) and values (non-Booleans):

This Term:	Means:
Set	The bit is set to 1 (ON) A value is set to any non-zero number
Clear	The bit is cleared to 0 (OFF) All the bits in a value are cleared to 0

Signal Processing - Edge and Level

This manual uses Edge and Level to describe how bit (BOOL) Commands, Settings, Configurations and Inputs to this instruction are sent by other logic and processed by this instruction.

Send/Receive Method:	Description:
Edge	• Action is triggered by "rising edge" transition of input (0-1) • Separate inputs are provided for complementary functions (such as "enable" and "disable") • Sending logic SETS the bit (writes a 1) to initiate the action; this instruction CLEARS the bit (to 0) immediately, then acts on the request if possible • LD: use conditioned OTL (Latch) to send • ST: use conditional assignment [if (condition) then bit:=1;] to send • FBD: OREF writes a 1 or 0 every scan, should use Level, not Edge. Edge triggering allows multiple senders per Command, Setting, Configuration or Input (many-to-one relationship)
Level	• Action ("enable") is triggered by input being at a level (in a state, usually 1) • Opposite action ("disable") is triggered by input being in opposite state (0) • Sending logic SETS the bit (writes a 1) or CLEARS the bit (writes a 0); this instruction does not change the bit • LD: use OTE (Energize) to send • ST: use unconditional assignment [bit:= expression_resulting_in_1_or_0;] or "if-then-else" logic [if (condition) then bit:= 1; else bit:= 0;] • FBD: use OREF to the input bit Level triggering allows only one sender can drive each Level

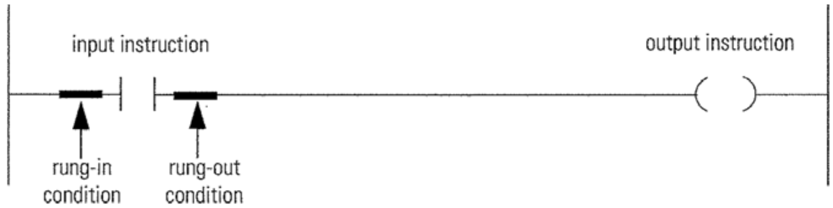
Instruction Execution - Edge and Continuous

This manual uses Edge and Continuous to describe how an instruction is designed to be executed.

Method:	Description:
Edge	• Instruction Action is triggered by "rising edge" transition of the rung-in-condition
Continuous	• Instruction Action is triggered by input being at a level (in a state, usually 1) • Opposite action is triggered by input being in opposite state (0) • Instructions designed for continuous execution should typically be used on rungs without input conditions present allowing the instruction to be continuously scanned

Relay Ladder Rung Condition

The controller evaluates ladder instructions based on the rung condition preceding the instruction (rung-in condition). Based on the rung-in condition and the instruction, the controller sets the rung condition following the instruction (rung-out condition), which in turn, affects any subsequent instruction.



If the rung-in condition to an input instruction is true, the controller evaluates the instruction and sets the rung-out condition based on the results of the instruction. If the instruction evaluates to true, the rung-out condition is true; if the instruction evaluates to false, the rung-out condition is false.

IMPORTANT	The rung-in condition is reflected in the EnableIn parameter and determines how the system performs each Add-On Instruction. If the EnableIn signal is TRUE, the system performs the instruction's main logic routine. Conversely, if the EnableIn signal is FALSE, the system performs the instruction's EnableInFalse routine. The instruction's main logic routine sets/clears the EnableOut parameter, which then determines the rung-out condition. The EnableInFalse routine cannot set the EnableOut parameter. If the rung-in condition is FALSE, then the EnableOut parameter and the rung-out condition will also be FALSE.

Pre-scan

On transition into RUN, the controller performs a pre-scan before the first scan. Pre-scan is a special scan of all routines in the controller. The controller scans all main routines and subroutines during pre-scan, but ignores jumps that could skip the execution of instructions. The controller performs all FOR loops and subroutine calls. If a subroutine is called more than once, it is performed each time it is called. The controller uses pre-scan of relay ladder instructions to reset non-retentive I/O and internal values.

During pre-scan, input values are not current and outputs are not written. The following conditions generate pre-scan:

- Transition from Program to Run mode.
- Automatically enter Run mode from a power-up condition.

Pre-scan does not occur for a program when:

- Program becomes scheduled while the controller is running.
- Program is unscheduled when the controller enters Run mode.

IMPORTANT The Pre-scan process performs the Process Add-On Instruction's logic routine as FALSE and then performs its Pre-scan routine as TRUE.