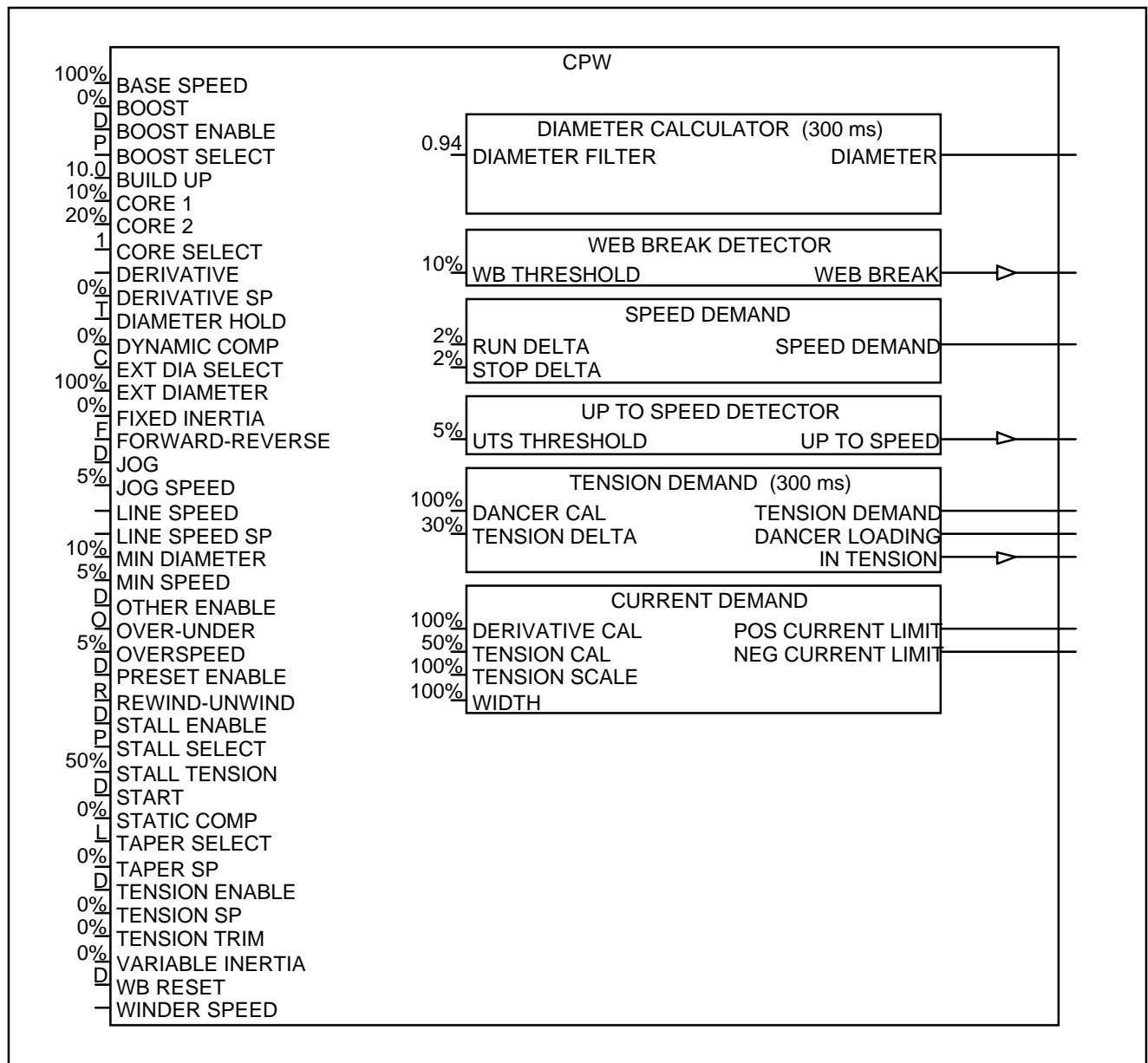## Winders/CPW

This function block implements a Current Programmed Winder. It is intended to perform the current limit calculations and associated logic for an open loop winder. A simplified block diagram is shown below; detailed drawings can be found in the appendix.

This function block is made up of five sub-function blocks: "Diameter Calculator & Web Break Detector", "Up to Speed Detector", "Tension Demand", "Speed Demand", and "Current Demand". Each of these are described below. Unless otherwise noted, all parameters are persistent, can be preset, and have set and get methods. All logic

outputs have built in Logic Senders.

Diameter Calculator & Web Break Detector

This block performs the Diameter calculation used by the other sub-function blocks. Simply, the diameter is calculated by dividing the absolute value of the **Line Speed** by the absolute value of the **Winder Speed**. This result is scaled by the Build Up parameter[1]. This result goes to a filter block who's output can be held and is then clamped giving the final diameter output. **Diameter Filter** is used to set the filter rate and the diameter input to the filter is held when **Preset Enable** is false and **Diameter Hold** is true, or when **Preset Enable** is false and **Tension Enable** is false or **Line Speed** is less than **Min Speed**. Note that only the input diameter is held, the filter output may continue to change in the held state until it matches the held diameter. **Min Diameter** is the minimum diameter value for the the clamp. The **Diameter** output will not go below this value.

It is also possible to use a Diameter Preset (**Core 1**, **Core2** and **Ext**ernal **Diameter**, selected by **Core Select** and **Ext Dia Select**). The Diameter Preset is used as both the input and output of the filter if **Preset Enable** is true and **Tension Enable** is false or **Line Speed** is less than **Min Speed**. The Diameter Preset is also loaded into the filter whenever the module is restarted.

The Web Break Detector takes the difference between the computed diameter and the previously computed diameter and based on **Rewind**-**Unwind** and **Forward**-**Reverse**, adds or subtracts it to an internal accumulator[2] . When the internal accumulator is greater than **WB Threshold**, the **Web Break** output becomes true, otherwise it is false. The internal accumulator can be reset to zero by either **WB Reset** going true or **Tension Enable** going false.

Diameter Tick Time can only be preset and specifies the rate at which the diameter is calculated.

Up to Speed Detector

This block compares a computed line speed (uses **Winder Speed, Diameter** and **Build Up**) with **Line Speed SP**. If the absolute value of the difference is is less than **UTS Threshold**, the **Up to Speed** output is set true.

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[1] The *Link* system uses a normalized numbering system. All values are represented as numbers between -1 and 1. When the result of a calculation would be a value outside this range, the result is saturated to -1 or 1 so that it will be a legal value. Thus, many intermediate calculations need to be scaled to prevent saturation.

[2] The accumulator is clamped so that it never goes below 0. The sum added in is clamped to **WB Threshold**/4.

Tension Demand

This block computes a tension demand. The first part of the tension demand calculation involves computing a taper term. This term is based on **Diameter**, **Taper SP**, the selected core (**Core 1** or **Core 2**), and the type of **Taper Select**ed (see drawings for details). The taper term is multiplied by **Tension SP**, and if **Stall Enable** and **Boost Enable** are false, is the input to the ramp. If **Stall Enable** is true, this term is multiplied by **Stall Tension** and input into the ramp if **Stall Select** is proportional, otherwise, just the **Stall Tension** term is presented to the ramp. If **Boost Enable** is true and **Stall Enable** is false, a boost is added before the value is input to the ramp. The amount of boost is based on **Boost Select**. If it is fixed, the amount of boost will be **Boost**. If it is proportional, the amount will **Boost** multiplied by the tension term.   **Tension Delta** controls the ramp rate and specifies the amount the ramp may change each **Tension Tick Time** (the rate at which tension demand is calculated). The ramp output is also the **Tension Demand** output. The tension demand can be multiplied by **Dancer Cal** to compute the **Dancer Loading** output. This message is sent only when **Tension Enable** is true and **Other Enable** is false. This condition also sets the **In Tension** output.

Speed Demand

This block calculates the **Speed Demand** output. The **Start** and **Jog** select wether the **Line Speed** or the **Jog Speed** is input into the ramp. If either **Start** or **Jog** is true, **Run Delta** is use as the ramp rate, otherwise, **Stop Delta** is used for the stop rate and the ramp input is zero. If **Tension Enable** is true, **Overspeed** is add or subtracted to the output from the ramp depending on the state of **Rewind**-**Unwind**. That value is divided by **Build Up** (see Diameter Calculator) and then divided by **Diameter**. That result is finally passed thru a clamp that limits the **Speed Demand** output to ±100%.

Current Demand

This block calculates the **Pos Current Limit** and **Neg Current Limit** outputs.   The Current Demand is computed by combining Inertia Comp, S&D Comp, scaled tension demand, Scaled Derivative and **Base Speed** terms, see drawings for details. The inertia compensation, static & dynamic compensation, and scaled tension demand term are straight forward.   The Scaled Derivative term is computed by either dividing the **Derivative** input by **Derivative Cal**, or calculating the derivative from **Derivative SP** and then dividing it by **Derivative Cal**. Only one of either **Derivative** or **Derivative SP** should be connected since both act as triggers to this block. The **Derivative** input normal comes from the master ramp block if it is used and the **Derivative SP** normal is **Line Speed SP** if it is used. When **Tension Enable** is false, the **Pos Current Limit** will be 200% and the **Neg Current Limit** will be -200% (after a 200ms delay if it remains false). If **Tension Enable** is true, the current limit outputs will depend on Current Limit and the values of **Rewind**-**Unwind** and **Over**-**Under** which determine if the positive or negative current limit is being controlled.

Parameter	Description	Default
	Diameter Calculator - Main Parameters	
Min Diameter	Minimum value of Diameter Calculator output. Full diameter = 100% Min = 100%/Build Up	10%
Diameter Filter	Diameter Filter value = $e^{-\text{Tick Time}/\text{Filter Time}}$ (if Tick Time = 300ms and Filter Time = 5 seconds, then Filter value = 0.94).	0.94
Diameter Hold	Initial condition of Diameter Filter.	Track
Preset Enable	Initial condition of Diameter Preset. Preset loads value of Core or External Diameter into Diameter Filter.	Disabled
Min Speed	Line Speed value below which Diameter is held.	5%
Build Up	Ratio of Full Roll Diameter to Core Diameter.	10
Diameter Tick Time	Clock period for Diameter calculation. Filter Time is proportional to Tick Time.	300 ms
	Diameter Calculator - Web Break Parameters	
WB Threshold	Internal accumulator threshold value to detect a web break. Represented as a % of full roll diameter.	10%
Rewind-Unwind	Selects application for Rewinding or Unwinding. Rewind = true, Unwind = false. See Forward-Reverse.	Rewind
Forward-Reverse	Initial condition of line Direction. Only used in reversing lines. In Reverse, unwind becomes rewind and rewind becomes unwind. Forward = true, Reverse = false.	Forward
WB Reset	Initial condition of Web Break Counter Reset.	Disabled
Tension Enable	Initial condition of Tension Enable.	Disabled
	Diameter Calculator - Core Parameters	
Ext Diameter	Initial value of External Diameter input (% Full roll).	100%
Ext Dia Select	Selects source of Diameter Preset (see Preset Enable).	Core

Core 1	Value of Core 1 (% Full roll).	10%
Core 2	Value of Core 2 (% Full roll).	20%
Core Select	Initial core selection (Core 1 = false, Core 2 = true).	Core 1
	Speed Demand - Main Parameters	
Run Delta	Run Ramp increment per Tick Time (Speed Demand Tick determined by update rate of Line Speed SP input, typically 100ms). 2% in 100ms = Ramp time to 100% of 5 seconds.	2%
Stop Delta	Stop Ramp increment, when Start and Jog are Disabled (see Run Delta above).	2%
Jog Speed	Value of Jog Speed	5%
Start	Initial condition of Start input	Disabled
Jog	Initial condition of Jog input	Disabled
Overspeed	Overspeed value added to Speed Demand in Tension mode.	5%
	Tension Demand - Main Parameters	
Tension Tick Time	Clock period for Tension Demand calculation.	300 ms
Stall Tension	Tension value when Stall Enabled.	50%
Stall Select	Stall value - "Fixed" = Stall Tension, "Proportional" = Stall Tension * Set Tension.	Proportional
Stall Enable	Initial condition of Stall Enable	Disabled
Boost	Boost value when Boost Enabled.	0%
Boost Select	Boost value - "Fixed" = Boost, "Proportional" = Boost * Set Tension.	Proportional
Boost Enable	Initial condition of Boost Enable.	Disabled
Tension SP	Initial value of Tension Setpoint.	0%
Taper SP	Initial value of Taper Setpoint.	0%

Taper Select	Selects "Linear" or "Hyperbolic" Taper profile.	Linear

	Tension Demand - **Output Parameters**	
Dancer Cal	Scaling of output for Dancer Loading (note: not normally used in CPW with no dancer).	100%
Tension Delta	Tension Ramp increment per Tension Tick Time. For Tension Tick Time of 300 ms and Tension Delta of 33.3%, 100% ramp time = 1 second.	30%
	Current Demand - **Main Parameters**	
Over-Under	Selects Winding Direction. Also used for direction of Jog for payout and takeup.	Over
Derivative Cal	Calibration of the Derivative input signal to provide the scaled derivative for Inertia Compensation. Where the rate signal from the Master Ramp function block is used as the derivative input, the Derivative Cal should be set at 0.2/Ramp Time in seconds to provide a scaled derivative of 50% (see Inertia Parameters below).	100%
	Current Demand - **Inertia Parameters**	
Fixed Inertia	This parameter calibrates the torque required to accelerate and decelerate the Fixed Inertia of the motor and mechanics. With the derivative Cal set as above, the Fixed Inertia value should be set to the % Full Load Current required to accelerate the empty core at the specified ramp rate.	0%
Variable Inertia	This parameter calibrates the torque required to accelerate and decelerate the roll. With the derivative Cal set as above, the Variable Inertia value should be set to the % Full Load Current required to accelerate the full roll at the specified ramp rate.	0%
Width	Initial value of Roll Width	100%

	Current Demand - Winder Parameters	
Base Speed	This parameter compensates for a field weakening range. Base Speed is % of Full Speed.	100%
Static Comp	Parameter for Static or Stiction Compensation. Compensation is Constant. Value is % motor Full Load Current.	0%
Dynamic Comp	Parameter for Dynamic or Friction Compensation. Compensation is proportional to speed. Value is % motor Full Load Current at full speed.	0%
	Current Demand - Tension Parameters	
Tension Scale	Divisor to permit Tension Calibration of greater then 100%.	100%
Tension Trim	Initial value for Trim input.	0%
Tension Cal	Tension Calibration - normally 50% to provide 100% motor Full Load Current for 100% tension demand at full roll.	50%
	Miscellaneous Parameters	
UTS Threshold	Up to Speed Threshold. Up to Speed Output is true when Winder Surface Speed is within Threshold of Line Speed.	5%
Other Enable	Disconnects Dancer Loading output when other spindle Tension is Enabled (note: not normally used in CPW with no dancer).	Disabled

Operation	Description
Base Speed	Current Demand input. Expects a value between -100% and 100%.
Boost	Tension Demand input. Expects a value between -100% and 100%.
Boost Enable	Tension Demand input. Expects Proportional (true) or Fixed (false).
Boost Select	Tension Demand input. Expects Enabled (true) or Disabled (false).
Build Up	General Input. Expects a value between 1 and 20.
Core 1	Diameter Calc. input. Expects a value 0.1% to 100% Full Roll.
Core 2	Diameter Calc. input. Expects a value 0.1% to 100% Full Roll.
Core Select	Diameter Calc. input. Expects Core 2 (true) or Core 1 (false).
Dancer Cal	Tension Demand input. Expects a value between -100% and 100%.
Derivative Cal	Current Demand input. Expects a value between -100% and 100%.
Derivative SP	Current Demand input. Expects a value between -120% and 120%.
Derivative	Current Demand input. Expects a value between -1.0 and 1.0.
Diameter Filter	Diameter Calc. input. Expects a value between 0 and 1.0.
Diameter Hold	Diameter Calc. input. Expects Hold (true) or Track (false).
Dynamic Comp	Current Demand input. Expects a value between -100% and 100%.
Ext Dia Select	Diameter Calc. input. Expects External (true) or Core (false).
Ext Diameter	Diameter Calc. input. Expects a value 0.1% to 100% Full Roll.
Fixed Inertia	Current Demand input. Expects a value between -100% and 100%.
Forward-Reverse	Diameter Calc. input. Expects Forward (true) or Reverse (false).
Jog	Speed Demand input. Expects Enabled (true) or Disabled (false).
Jog Speed	Speed Demand input. Expects a value between -120% and 120%.
Line Speed	Diameter Calc. input. Expects a value between -120% and 120%.
Line Speed SP	Speed Demand input. Expects a value between -120% and 120%.
Min Diameter	Diameter Calc. input. Expects a value 0.1% to 100% Full Roll.
Min Speed	Diameter Calc. input. Expects a value between -120% and 120%.
Other Enable	Tension Demand input. Expects Enabled (true) or Disabled (false).
Over-Under	Tension Demand input. Expects Over (true) or Under (false).

Overspeed	Speed Demand input. Expects a value between -120% and 120%.
Preset Enable	Diameter Calc. input. Expects Enabled (true) or Disabled (false).
Rewind-Unwind	Tension Demand input. Expects Rewind (true) or Unwind (false).
Run Delta	Speed Demand input. Expects a value between 0 and 100%.
Stall Enable	Tension Demand input. Expects Enabled (true) or Disabled (false).
Stall Select	Tension Demand input. Expects Proportional (true) or Fixed (false).
Stall Tension	Tension Demand input. Expects a value between -100% and 100%.
Start	Speed Demand input. Expects Enabled (true) or Disabled (false).
Stop Delta	Speed Demand input. Expects a value between 0 and 100%.
Taper SP	Tension Demand input. Expects a value between -100% and 100%.
Taper Select	Tension Demand input. Expects Hyperbolic (true) or Linear (false).
Tension Cal	Current Demand input. Expects a value between -100% and 100%.
Tension Delta	Tension Demand input. Expects a value between 0 and 1.0.
Tension Enable	Tension Demand input. Expects Enabled (true) or Disabled (false).
Tension SP	Tension Demand input. Expects a value between -100% and 100%.
Tension Scale	Current Demand input. Expects a value between -100% and 100%.
Tension Trim	Current Demand input. Expects a value between -200% and 200%.
UTS Threshold	Up to Speed input. Expects a value between -120% and 120%.
Variable Inertia	Current Demand input. Expects a value between -100% and 100%.
WB Threshold	Diameter Calc. input. Expects a value between 0 and 100%.
WB Reset	Diameter Calc. input. Expects Enabled (true) or Disabled (false).
Width	Current Demand input. Expects a value between -100% and 100%.
Winder Speed	General input. Expects a value between -120% and 120%.
Get Base Speed	Returns the current state: Value between -100% and 100%.
Get Boost	Returns the current state: Value between -100% and 100%.
Get Boost Enable	Returns the current state: Enabled (true) or Disabled (false).
Get Boost Select	Returns the current state: Proportional (true) or Fixed (false).
Get Build Up	Returns the current state: Value between 1 and 20.

Get Core	Returns the current state: % (Full Roll = 100%).
Get Core 1	Returns the current state: % (Full Roll = 100%).
Get Core 2	Returns the current state: % (Full Roll = 100%).
Get Core Select	Returns the current state: Core 2 (true) or Core 1 (false).
Get Current Demand	Returns the current state: Value between -200% and 200%.
Get Dancer Cal	Returns the current state: Value between -100% and 100%.
Get Derivative Cal	Returns the current state: Value between -100% and 100%.
Get Derivative SP	Returns the current state: Value between -120% and 120%.
Get Diameter	Returns the current state: % (Full Roll = 100%).
Get Diameter Filter	Returns the current state: Value between -1.0 and 1.0.
Get Diameter Hold	Returns the current state: Holding (true) or Tracking (false).
Get Diameter Preset	Returns the current state: % (Full Roll = 100%).
Get Dynamic Comp	Returns the current state: Value between -100% and 100%.
Get Ext Dia Select	Returns the current state: Enabled (true) or Disabled (false).
Get Ext Diameter	Returns the current state: % (Full Roll = 100%).
Get Fixed Inertia	Returns the current state: Value between -100% and 100%.
Get Forward-Reverse	Returns the current state: Forward (true) or Reverse (false).
Get Jog	Returns the current state: Enabled (true) or Disabled (false).
Get Jog Speed	Returns the current state: Value between -120% and 120%.
Get Line Speed	Returns the current state: Value between -120% and 120%.
Get Line Speed SP	Returns the current state: Value between -120% and 120%.
Get Min Diameter	Returns the current state: % (Full Roll = 100%).
Get Min Speed	Returns the current state: Value between -120% and 120%.
Get Other Enable	Returns the current state: Enabled (true) or Disabled (false).
Get Over-Under	Returns the current state: Over (true) or Under (false).
Get Overspeed	Returns the current state: Value between -120% and 120%.

Get Preset Enable	Returns the current state: Enabled (true) or Disabled (false).
Get Ramped Speed	Returns the current state: Value between -120% and 120%.
Get Rewind-Unwind	Returns the current state: Rewind (true) or Unwind (false).
Get Run Delta	Returns the current state: Value between 0% and 100%.
Get Speed Delta	Returns the current state: Value between 0% and 100%.
Get Speed Demand	Returns the current state: Value between -120% and 120%.
Get Stall Enable	Returns the current state: Enabled (true) or Disabled (false).
Get Stall Select	Returns the current state: Proportional (true) or Fixed (false).
Get Stall Tension	Returns the current state: Value between -100% and 100%.
Get Start	Returns the current state: Started (true) or Off (false).
Get Stop Delta	Returns the current state: Value between 0% and 100%.
Get Taper SP	Returns the current state: Value between -100% and 100%.
Get Taper Select	Returns the current state: Hyperbolic (true) or Linear (false).
Get Tension Cal	Returns the current state: Value between -100% and 100%.
Get Tension Delta	Returns the current state: Value between -100% and 100%.
Get Tension Demand	Returns the current state: Value between -100% and 100%.
Get Tension Enable	Returns the current state: Enabled (true) or Disabled (false).
Get Tension Scale	Returns the current state: Value between -100% and 100%.
Get Tension SP	Returns the current state: Value between -100% and 100%.
Get Tension Trim	Returns the current state: Value between -200% and 200%.
Get UTS Threshold	Returns the current state: Value between -120% and 120%.
Get Up to Speed	Returns the current state: true or false.
Get Variable Inertia	Returns the current state: Value between -100% and 100%.
Get WB Threshold	Returns the current state: Value between 0% and 100%.
Get WB Reset	Returns the current state: Enabled (true) or Disabled (false).
Get Web Break	Returns the current state: Enabled (true) or Disabled (false).

Get Width	Returns the current state: Value between -100% and 100%.
Get Winder Speed	Returns the current state: Value between -120% and 120%.