Installation & Operation Manual

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Introduction

Round Saw-ADD turns the arbor into a force sensor. This means it can measure the forces on the saw that steer it into deviation, allowing for a corrective action to stop it. The earlier detection allows for a substantially higher chance of corrective action. Keep in mind, SawADD measures the force that drives deviation, before actual deviation occurs.

Round Saw-ADD uses two force sensors per arbor. One measuring sawing forces and one measuring guide friction forces. This allows the differential of the two sensors to provide a normalizing of the deviation force measurements or common mode rejection. This also allows a gain to be applied for an even faster response.

This new SawADD technology is fast enough to close the quality control loop. It is the only technology that has achieved this goal of real time control for increased lumber recovery and grade.

Lagging signals like arbor motor current are inadequate for closed loop control of velocity, particularly at higher feed speed where incipient deviation occurs in microseconds. Thus, supporting a rigorous lumber size control program for optimal yields. Only SawADD will react in time to save deviation from occurring and thus is the only Anti Deviation system available today.

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Preparation

Saw ADD LLC will provide:

1. Modifications to customer supplied new or re-conditioned arbor(s).
2. Sensors and mounting hardware.
3. Sensor drivers with 0 to 10-volt output.
4. SawADD PLC program installation and startup assistance.

SawADD customer will provide:

1. New or reconditioned arbor(s) for SawADD modifications.
2. Sufficient saw feed system drive horsepower and braking capacity (braking resistors or regen to decelerate the log feed speed at a rate of 150 inches per second squared or 750 ft/min/sec, is recommended).
3. Two or four high speed analog input channels with RTS of 1 ms (to the PLC that is controlling the cant feed speed and in a highspeed task of 5ms update).
4. Three twisted pair shielded signal wires in conduit from the PLC analog inputs to each J-box to be mounted on the gang within eight feet of each arbor.
5. J-boxes large enough to hold the 2, 5x4.5x1 inch din rail mounting sensor driver modules, mounted on machine adjacent to arbor door.
6. Half inch flexible conduit (max 8 ft. length) to arbor from the J-boxes and pulling in the sensor cable with prewired connector to the sensor driver.
7. Installation of sensor mounting hardware.

The installation can be done in one weekend. It will require removal of existing arbor, installation of SawADD ready arbor and sensor mounting hardware, mounting J-boxes and electrical termination. Modifications to arbor(s) and mounting the electrical J-boxes and conduit should be accomplished in advance.

Arbor Modifications

The modifications to make the arbor SawADD Ready will include the installation of a target ring. This will require some precision machining and assembly which is provided by the equipment manufacture or Saw ADD LLC's machine shop.

The specifications and assemble details are as follows:

1. Choose a tapered bearing adaptor that is closest to but less than the arbor shaft diameter where the target ring will be located for maximum deflection outside of the saw box.
2. Turn the arbor to the adaptor inside dia.
3. Machine target ring with the following specs:
   a. Material 6061 aluminum.
   b. Tapered bore to match the taper of the bearing adaptor.
   c. Thickness of at least 0.25 inches but can be larger if clearance allows.
   d. Concentrical tolerance of 0.0002 or better.
   e. Width should be 2 inches.
   f. Surface finish of 16 Ra micro-inches
4. Assemble the target ring with the bearing adaptor on the arbor at specified location and tighten to expand the target ring 0.0035 inches. On vertical arbors install the bearing adaptor with the nut on the bottom.
5. On vertical arbors, install a thin-walled sleeve under the bearing adaptor reaching to the lower bearing to provide a shoulder.
6. Machine four sensor port holes for #10 ORB, THREAD 7/8-14 NF, in the cartridge shell 90 degrees apart indexed with one sensor closest to centerline of machine.

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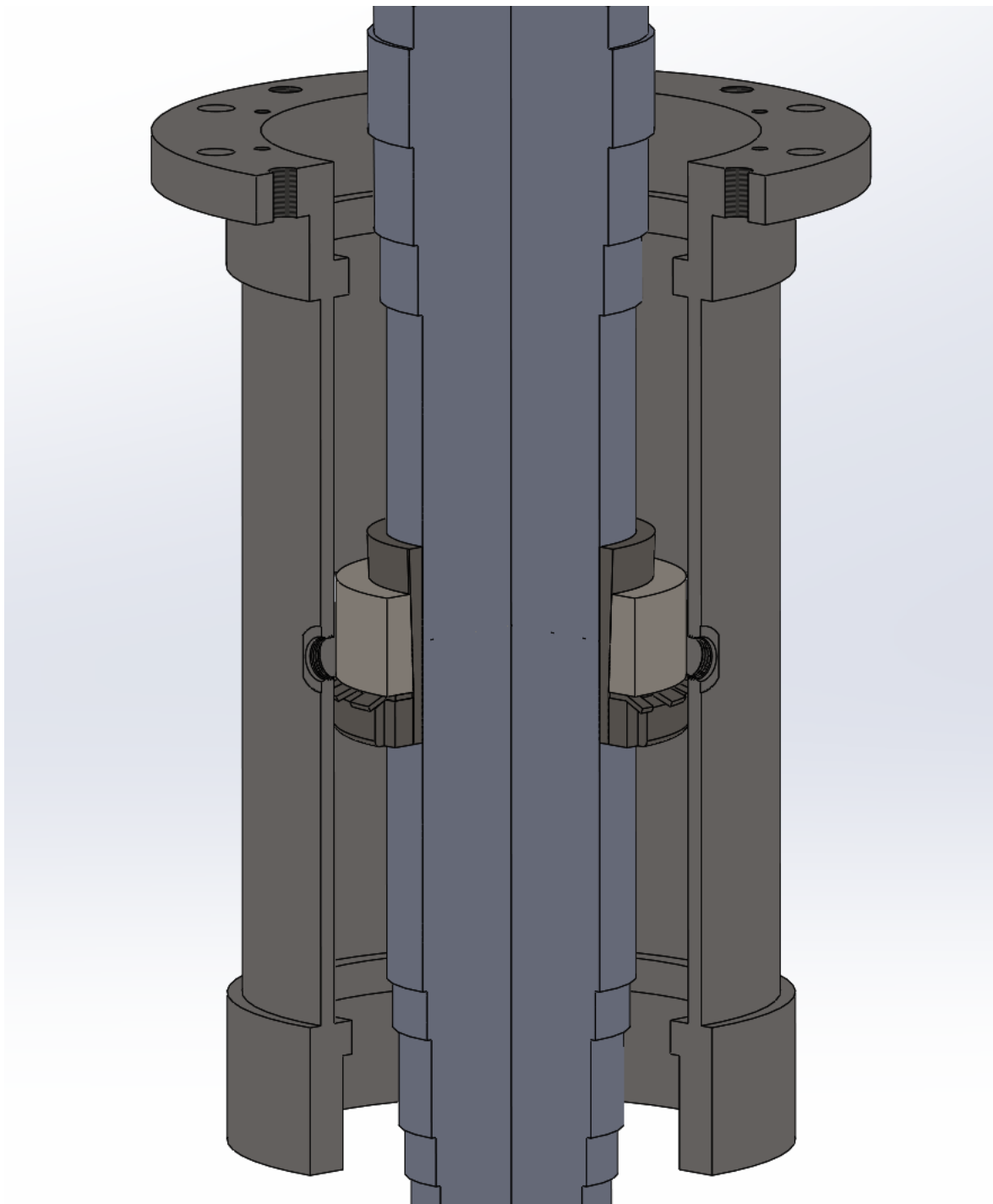
Arbor Installation

The installation of the SawADD ready arbor will vary with the type of machine. The two major types are the cartridge Arbor and the Cone type that are supported with bearings at each end of the sawbox and have a cone assembly on the door for saw changes.

Cartridge Arbor

1. The installation of the cartridge type arbor will require cutting access holes in the arbor mounting shell, if not manufactured SawADD ready, typically done on sight with a torch. These holes need to line up with the sensor mounting holes in the arbor shell that are sealed with oring plugs.
2. Saddle nipples should be welded over the access holes so that a plug can be used to cover the hole to protect the sensor assembly and keep debris out.
3. Before inserting the arbor cartridge, pull strings in from the junction box to the sensor access holes.
4. Mount the arbor cartridge into the mounting shell as normal. Take care not to pinch the strings to pull in the sensor cable.

Arbor installed in door shell with strings left between shells to pull in SawADD sensor cables. Boss plugs will be removed and replaced with sensor assemblies where openings are put for that arbor.

Cone Arbor

1. Cone type arbors will have a special bearing cap on the drive end that is extended to provide mounting holes for the sensors.
2. A new arbor steady rest bracket will need to be installed that will extend out to the coupling for the jack bolts.
3. Install the arbor assembly as normal supporting the cone end until the coupling is installed or use the steady rest jack bolts to hold the arbor.

PLC Interface

The PLC interface requires an analog input module that will accept 0 - 10 volt or 0 – 20 ma. The analog input module should have 4 channels, be capable of an RTS (Real Time Sample rate) of 2 milliseconds or less, and an RTI (Real Time Interval) communications with the Processor of 5 milliseconds or less. The ControlLogix 1756-IF4FXOF2F or the Flex module 1794-IF4I will provide the fast analog update. The 1756-IF4FXOF2F is preferred.

The J-boxes should be pre-mounted within 8 feet of conduit to the lower guide, and DIN rail mounted in it for two 5" deep by 4.5" high by 1" wide sensor drivers. The sensor cable plugs into the front of the module, requiring a total of 5 inches of depth. The sensor cable will be pulled from the sensor to the J-box.

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If the distance from the J-box to the PLC analog input is more than 200 feet or not in its own conduit, then a voltage to current converter is recommended but will cause a considerable delay and should not be used if not necessary.

A very convenient converter that is DIN mounted, 24 volts, and about the same size as the driver module, is the Phoenix Contact model MCR-C-UI-UI-DCI, however it will have a lag time of 10ms. The part number for pre-configuration is 2810913/IN03/OUT01/NONE.

A twisted shielded signal pair will be connected from the driver modules (2 per arbor) or the converter modules to each PLC analog input. The shield should be grounded at the PLC. A third pair will be used for 24 volt DC to power the modules.

Wiring on the analog modules may be different for current than voltage signal as it is with the ControlLogix 1756-IF4FXOF2F fast analog module.

Sensor Mounting & Adjustment

1. Unscrew plugs in arbor cartridge through access holes in mounting shell or in bearing cap on Cone Arbor. Use holes that are 90 degrees apart. Use the 6 and 9 o'clock positions, if possible, on a climb cutting horizontal bottom arbor. Other options can be use if required because of mechanical restrictions but a direct acting sensor is preferred.
2. Screw sensor assembly with Boss O-ring adaptor into the mounting hole and tighten (with deep socket on cartridge arbors).
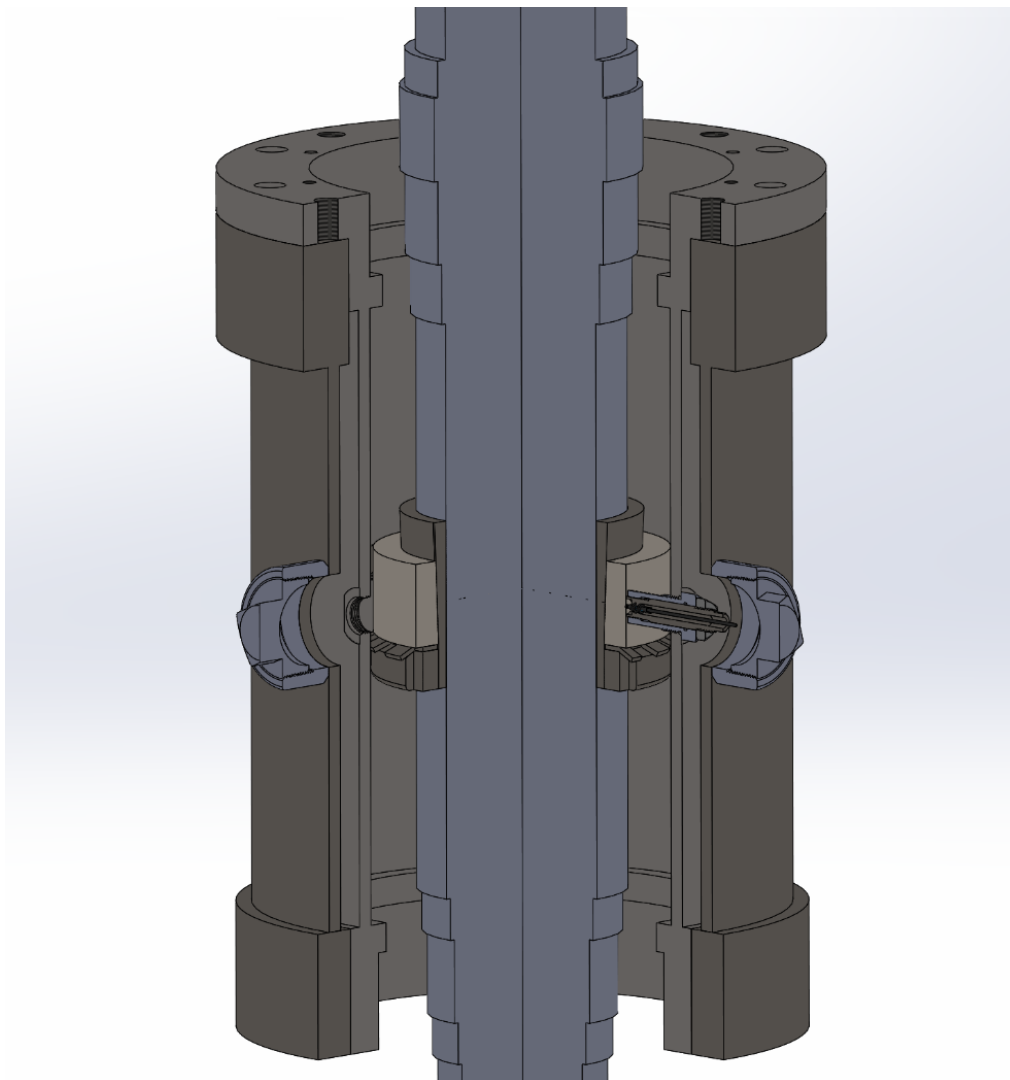
Cartridge Arbor
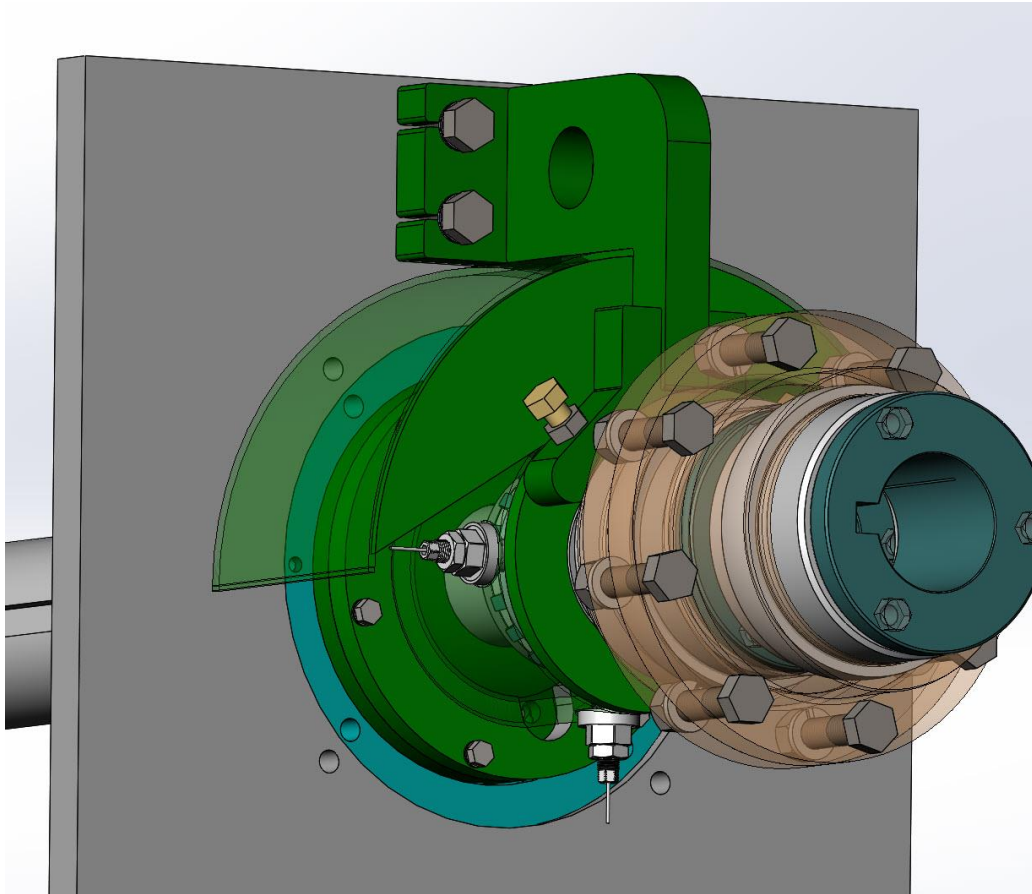
Cone Arbor

3. Pull the extension cable in from the junction box. On a cartridge arbor use the strings left in the cartridge shell to pull the sensor cables in from the junction box.
4. Connect power to the sensor driver modules in the junction box and plug sensor cables into drivers.
5. Plug cables into sensors (through the special tee sockets that will be used for cartridge arbors) to adjust the sensor while monitoring output signal voltage on the driver module. For cartridge arbors, 2 tee sockets are provided, one to adjust the

sensor and one to tighten the locking nut.
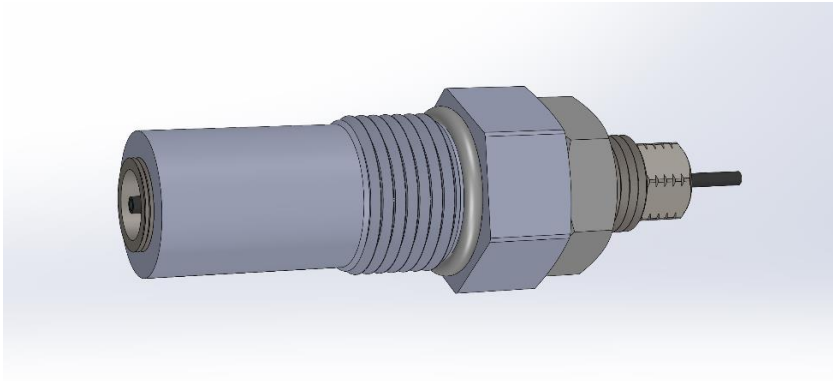
6. Adjust the sensor inward until it bottoms on the target ring previously installed on the arbor.
7. Adjust the sensor outward while watching the voltage on the driver module output signal. Preset the voltage at about 5 volts, if arbor will move away from sensor during operation, and at about 8 volts if movement will be toward sensor. Thermal expansion of the target at operating temperatures will decrease the voltage. If this brings the percent of range too close to 100% or 0% during operation, then increase the preset voltage so that it is always in range during operation.
8. Tighten the locking nut while holding the sensor adjustment and watching the voltage. (On Cartridge Arbors this will require the supplied special Tee sockets by threading the connection cable through the sockets) The desired voltage will change because of stretch in sensor body and will need to be readjusted while tightening. This will be a little difficult because it is like trying to hit a moving target.

9. Replace sensor cover or conduit adaptor with O-ring that will slide over the sensor and Boss port fitting and lock in place with a setscrew. The O-ring should be compressed against the housing by the conduit adaptor before tightening the setscrew to prevent liquid from weeping into the conduit.
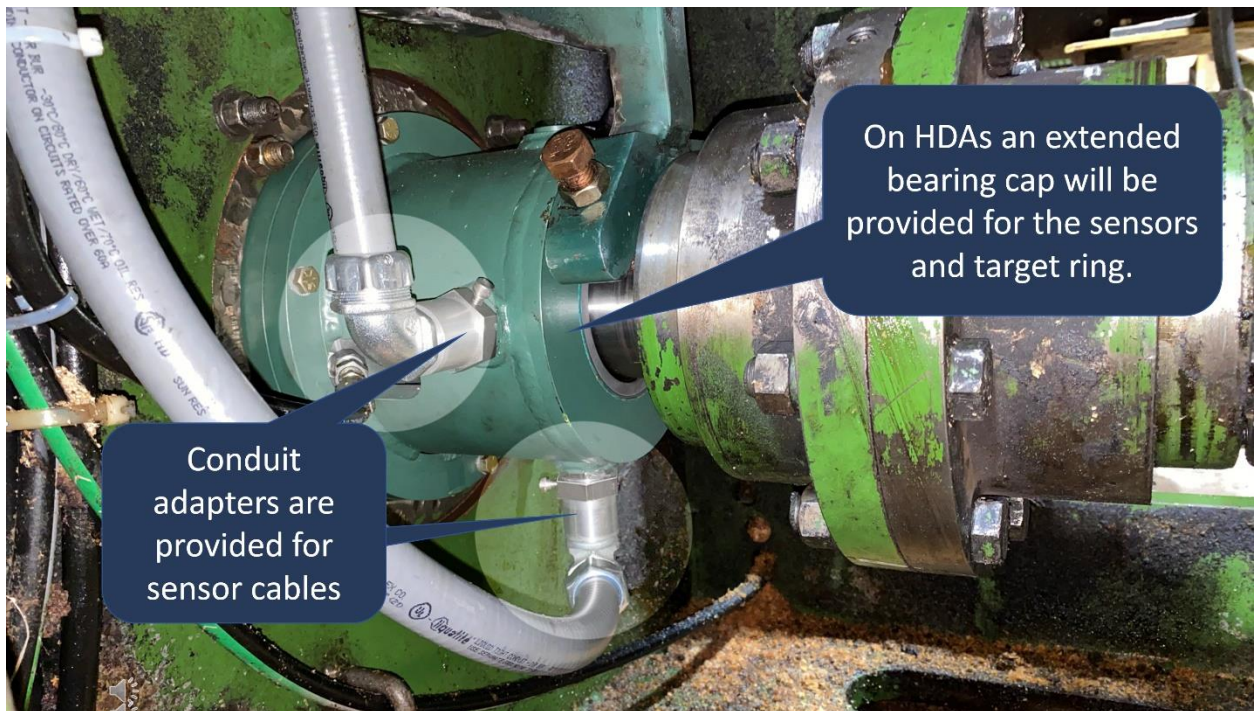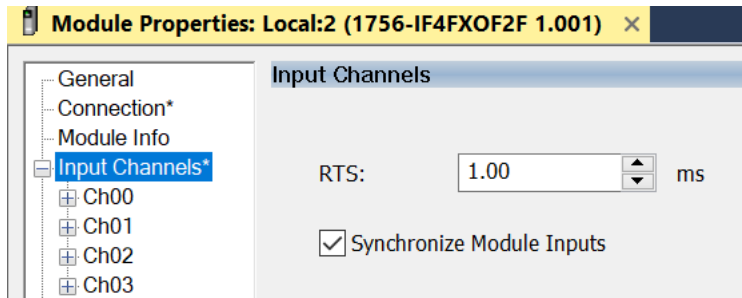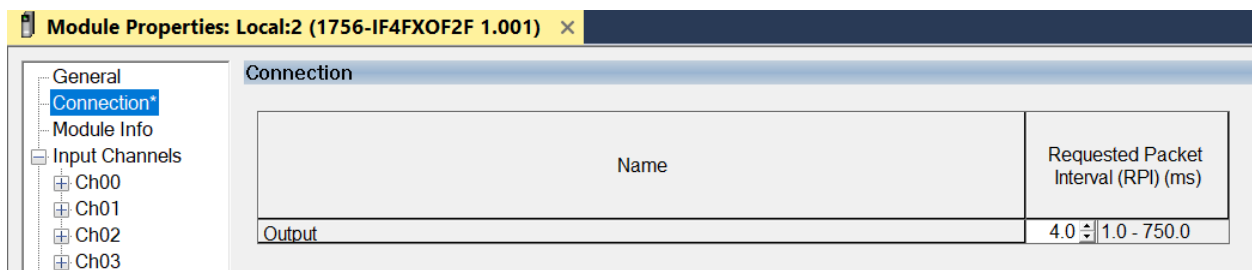
Configuration & Scaling

The scaling of the analog input can be done by the PLC module properties input configuration if using the ControlLogix 1756 module. A window from RSLogix 5000, Input Configuration is shown below.
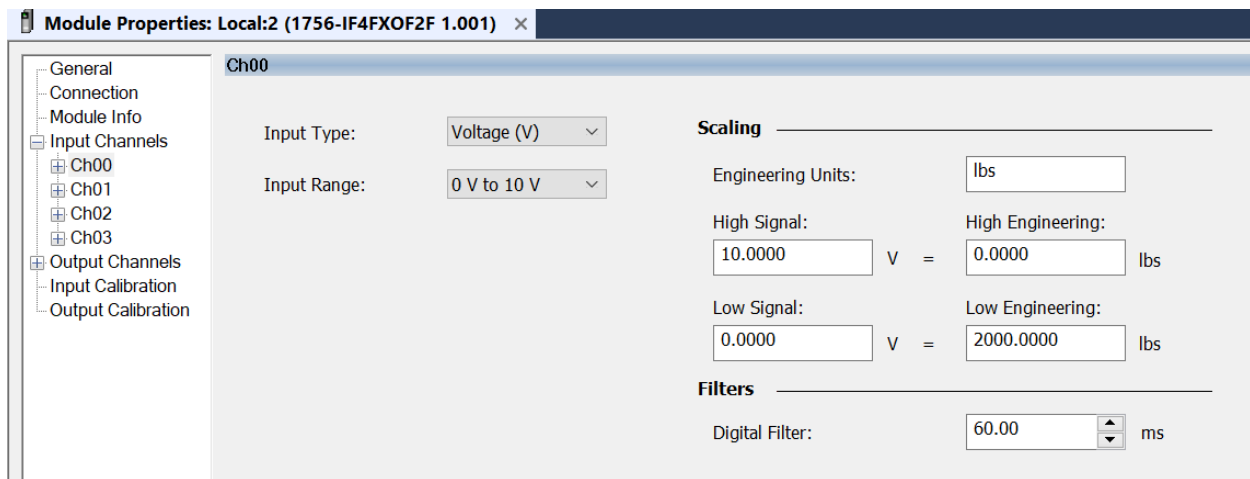
- The input type should normally be volts, but in some cases the distance to the controller will require the voltage to current converter, and the input range, be set for 0 ma to 20 ma, but be aware that it will cause a 10ms delay and should be avoided if at all possible especially on Round saws.
- The Scaling of the input range to engineering units of pound force on the saws can be inverted by the High Engineering units set to 0.0, and the Low set to a number that is determined by the design and factory calibration of the arbor spring constant and should not be changed after startup. In the screen shot above it was set to 1200.0 but could be as low as 600 or as high as 2000.
- The Digital Filter provides smoothing of the input but should be run as low as it can for faster response.
- The RTS should be set as low as the module will achieve. This will allow the Digital Filter to provide some smoothing.

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Module Properties: Local:2 (1756-IF4FXOF2F 1.001) ×

- General
- Connection*
- Module Info
- Input Channels*
  - Ch00
  - Ch01
  - Ch02
  - Ch03

Input Channels

RTS: 1.00 ms

☑ Synchronize Module Inputs

In the Connection tab of the configuration, the RTI should be set at least as fast as the periodic task that the SawADD program is running in. That way, the data is fresh each time the program is executed.

Module Properties: Local:2 (1756-IF4FXOF2F 1.001) ×

- General
- Connection*
- Module Info
- Input Channels
  - Ch00
  - Ch01
  - Ch02
  - Ch03

Connection

| Name	Requested Packet Interval (RPI) (ms)
Output	4.0 1.0 - 750.0

PLC Program

A PLC program for SawADD is provided in ControlLogix Ladder library LK5 format. The Round Saw-ADD program needs to be put in a Periodic Task with an update equal to the rotation period divided by 4 which is 5ms for a 3000 RPM arbor and with a high priority for accuracy.
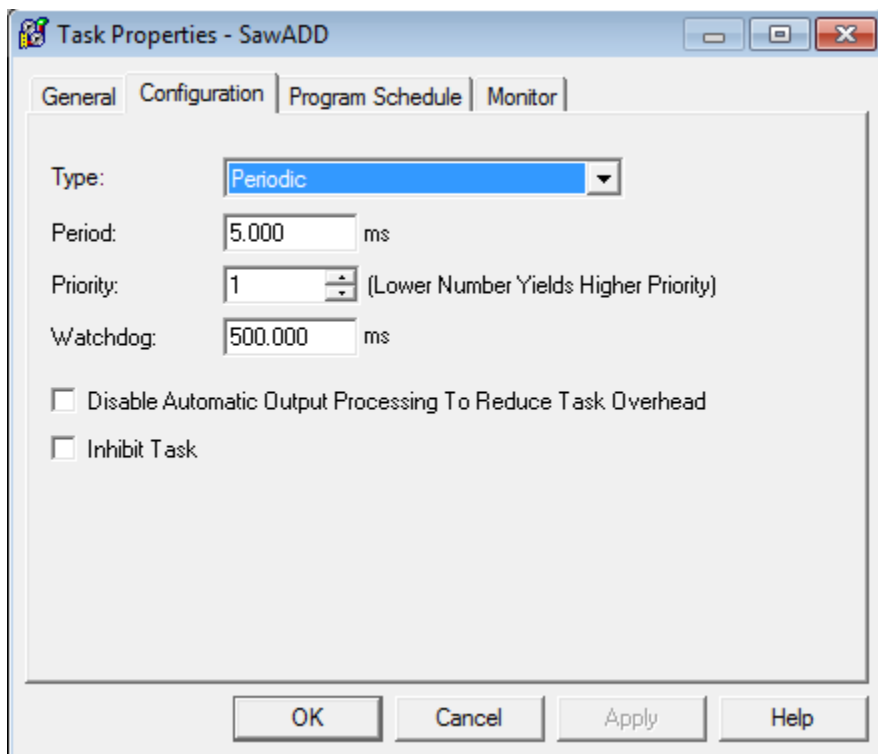

Synchronizing the of rotation to the update allows the arbor shaft runout (out of roundness) to be zeroed out. A delay of one scan for the downstream sensor in the direction of the rotation allows common mode rejection in the sensor differential by measuring the same point on the shaft. This compensates for change in runout position on the shaft caused by change in RPM during motor loading.

The SawADD program supplied in an .LK5 format to be imported into the SawADD Periodic task as shown below.
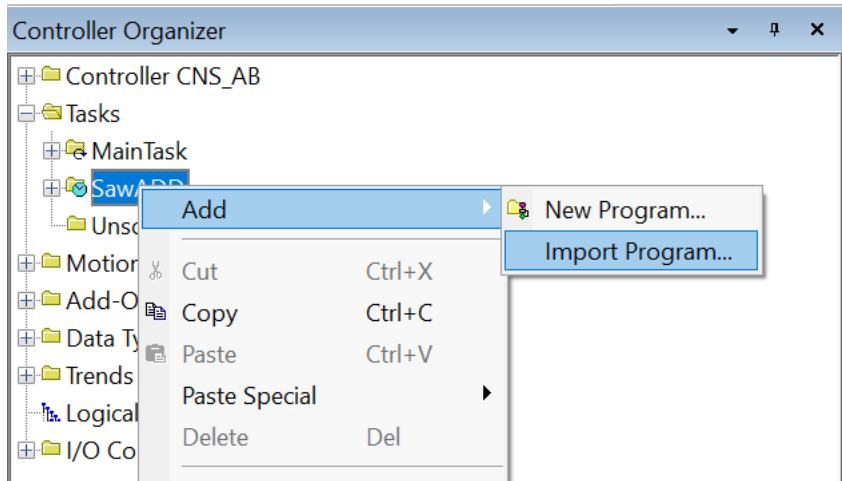
The file called Arbor.LK5 should be imported for each Arbor to be monitored. A routine called Inputs, in each of the programs, is where the physical inputs associated with each of the Arbors will have controller tags needed to resolve inputs unique to the Arbor.
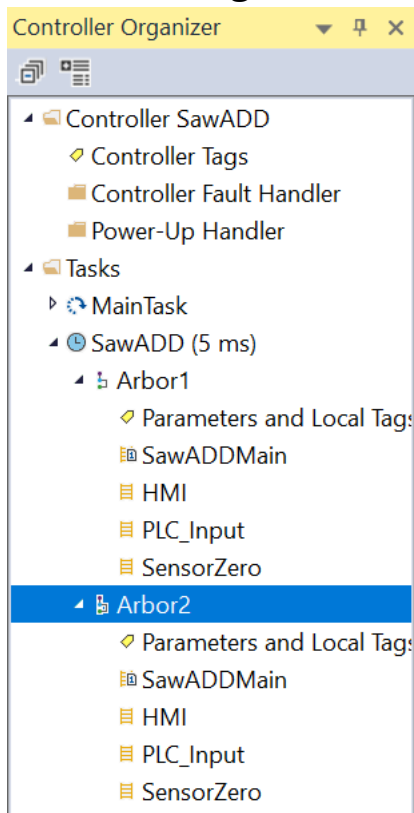
In this example the Arbor1 and Arbor2 have separate Input routines.

The input tags unique to the arbor should be addressed in the Input program to reference PLC controller tags. That way the other routines can remain the same between arbors or saws with local tags and more easily updated.

The SawADD programs will read the analog inputs for the SawADD sensors, along with limits provided from an HMI, to produce a proportional multiplier for each program and the **lowest** should be used to reduce feed speed when exceeding limits. The limit

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adjustments and reduction maximums will be described in the following sections on the HMI Display and Limit Setup. All tag values that should be in the HMI will have HMI_ at the beginning of the tag.

An important consideration for the PLC program is the placement of the sensors relative to arbor movement under radial loading of the saws for scaling the input as direct or reverse acting. To display the percent of range in the HMI routine the scale and input direction must be entered in the input routine.

The sawing speed that is generated by the optimizer and fed to the saw line drives during sawing must be multiplied by the SawADD Reduction every scan. This value will also increase the line speed to the HMI requested Speed Adjust percent. The drive output Task must be as fast as the SawADD Task or SawADD's effectiveness is reduced.

HMI Display

An HMI Displays for adjustments, meters and trends are supplied in a FactoryTalk RSView SE importable .xml format. The import files use a PLC shortcut name of "SC" to link to the PLC tags. This shortcut will need to be added to the FactoryTalk Linx Communications Setup. The xml files are imported by creating a new display page in the existing RSView project for each xml file and then importing into the display. This combined HMI, SawADD Trend display and Report Trend display requires a large display screen and should be added to your Production HMI, Filing Room HMI and the Operators HMI.
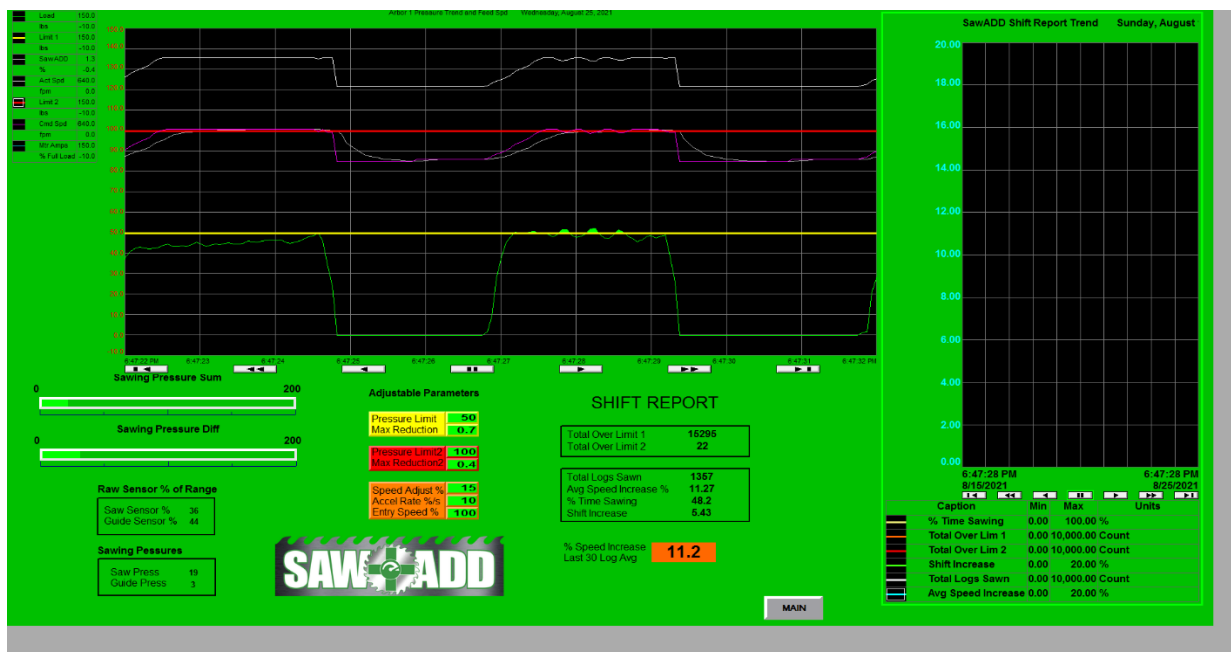
The display shown above is for a single arbor. It would be repeated for additional arbors. The Speed Settings could be common or not. The slowest speed from the two should be used when a cant is in the associated saws.

The Sawing Pressure Sum and Sawing Pressure Diff bar meters and SawADD trend will be zero when no log in the cut. The bars will change color when the sawing pressure reaches the limit settings.

The HMI above can be broken down into components like the parameters for better visibility and entry, as shown below.
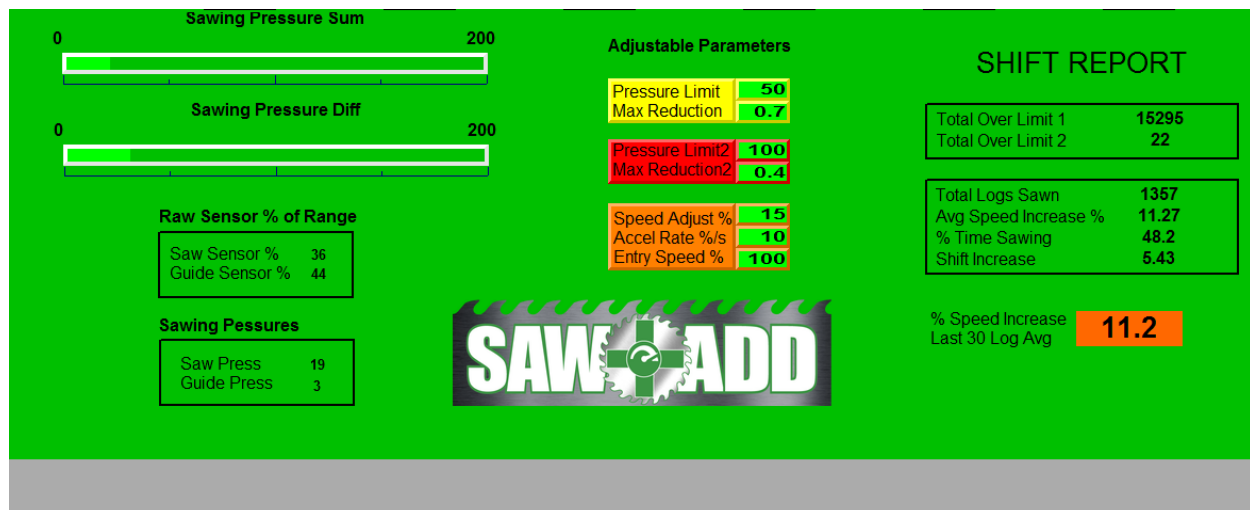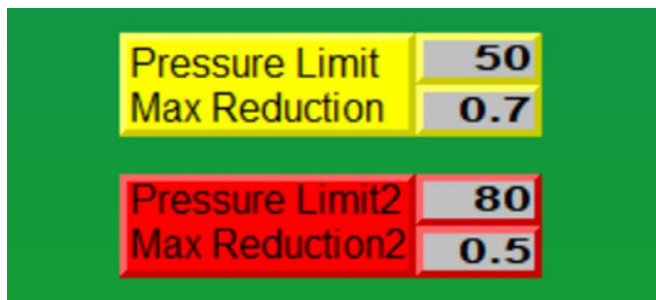
1. Saw Pressure Limits

The Pressure Limit 1 is in a yellow box on the RSView HMI and the bar meter will turn yellow when the pressure on the saws exceeds the Limit 1. The speed reduction begins when this limit is exceeded and is limited to the Max Reduction box value in the box of the same color below it.

The purpose of the Max Reduction with Limit 1 is to allow a quick response to excessive pressure but not overcompensate. It should be set to reduce only to a very conservative speed that will minimize deviation.

A Pres Limit 2 is in a red box on the RSView HMI and the bar meters will turn red when the pressure exceeds Limit 2. The Max Reduction for Limit 2 will need to be lower than for Limit 1. This will allow a greater reduction to save a saw in an extreme pressure without coming to a stop to allow sawing out of the cant.

Pressure Limit	50
Max Reduction	0.7
Pressure Limit2	80
Max Reduction2	0.5

2. Sensor Readings

The display for each SawADD sensor reading is scaled in the analog input card to pounds between 0 and around 2000. These values are converted to a percent of range for the HMI display by entering the scale value into the SensorScale tag in the Input program Local Tags. For reverse acting sensors the increasing direction can be flipped for the HMI display by toggling on the corresponding DirectActSensor or ReverseActSensor local tag, to have the display increasing with pressure or following the sensor voltage. The former seems the most intuitive and is recommended.

When the sensors are within range the HMI % values should be between 5% and 80% (direct acting, DA) or 20% and 95% (reverse acting, RA).

If the value becomes greater than 80% or less than 5% then the label will flash red and SawADD will not attempt to get the Speed Adjust percent increase but will still slow the feed speed to save saws and deviation. If this happens, then the sensor should be readjusted as described in the Sensor Mounting and Adjustment section. It is not necessary and not advisable to adjust them to recommended setting more often as this will wear out the fine adjustment thread.

Raw Sensor % of Range

Saw Sensor %	4
Guide Sensor %	63

Sawing Pessures

Saw Press	0
Guide Press	0

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1. **Speed Control Settings**

SawADD's HMI allows your production personnel to easily make changes to the feed-speed on the fly, without having to change complex tables. With SawADD you simply type a single number into **Speed Adjust** % for the desired percentage speed increase above optimizer feed speed, across the board.

|	
Speed Adjust %	15
Accel Rate %/s	10
Entry Speed %	100
% Speed Increase for Last 30 Logs	10.2
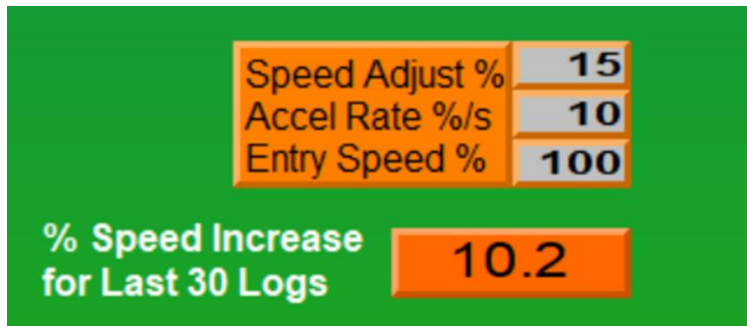
The **Accel Rate %/s** is the rate of increase of the feed speed, (if not being reduced by excess pressure) to the Speed Adjust increase setting or to the speed before being reduced by excess pressure. It should be run as high as possible without causing oscillation in the feed speed.

The **Entry Speed** % is available for those that want to reduce the entry speed. The number entered will be the percent of the optimizer feed speed and will begin increasing to the Speed Adjust percent increase after entering the cut.

SawADD's HMI also has an **Avg Speed Increase** % meter, for the last 30 logs, to gage your saw performance above the optimizer speed table. When the average goes below a predetermined level or negative (less than before SawADD) then you are losing potential production to keep the saws running and an alarm can be set to change a saw.

A SawADD HMI trend is provided using the SawAvg program which takes an average of the last 5 samples providing some smoothing but not missing any data at the HMI slower update of 50ms. It also takes the highest of the saw pressure and sensor differential. With RSView the trends can also light up the area over the limit for visual alert.
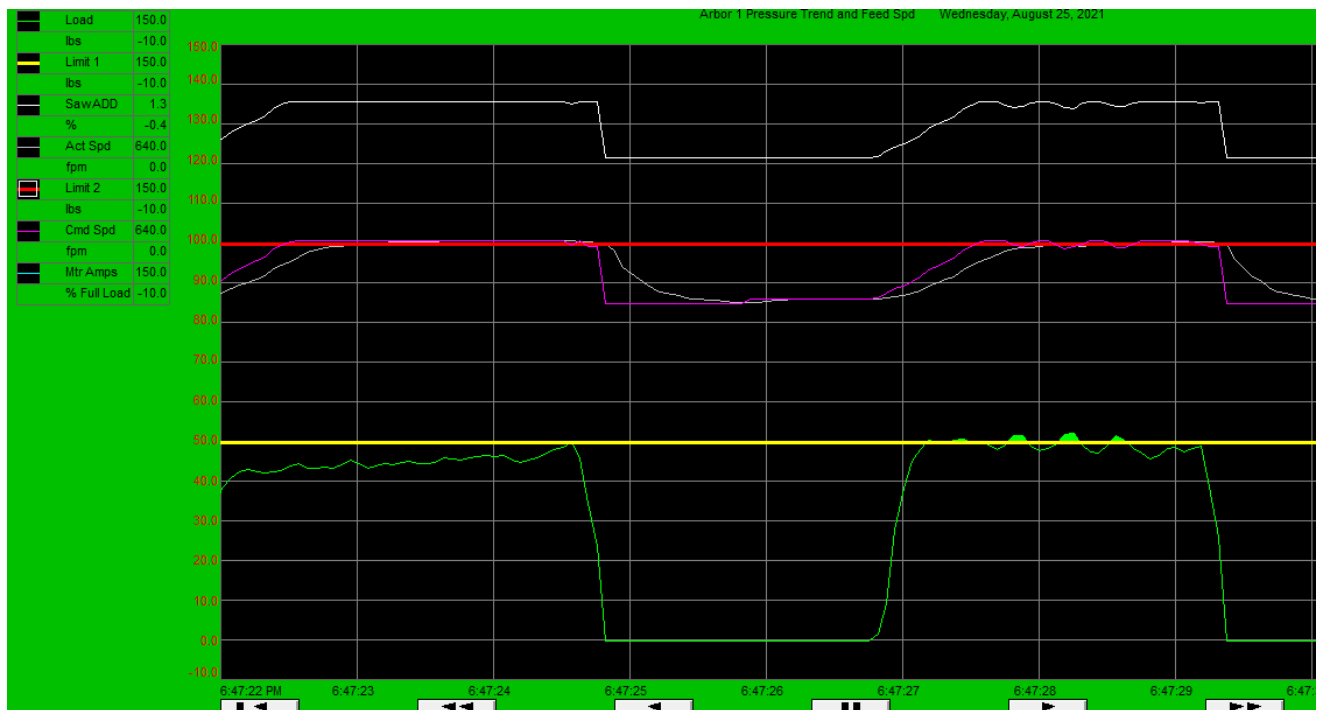
Feed Speed

The feed speed multiplier program tag, SawADD_Reduction, is a real number from 1.0 plus **Speed Adjust** % to a reduction limit (i.e. 0.8). It must be used in your existing program to multiply times the feed speed before it is output to the drives. It is important to multiply this reduction with all the drives that will be affecting the log motion while in the saws. If the multiplier is used on the sawing speed for the log in the saws, then the gap control logic should handle the drives that are in contact with the log.

The program tag, SawADD_Reduction, is moved into a controller tag SawADD_SpeedMultiplier in the PLC_Inputs program so it can be used in the speed control programs. In the case of two arbors a second controller tag is needed and logic to use the lowest.

The feed speeds can generally be increased by as much as 15%, with SawADD feedback to slow down to the conservative speed when necessary to preserve lumber sizes. If the reduction in speed is too much and affecting production, then a saw change should be considered.

The deceleration rate for the drive should be set as high as possible without being too aggressive, at least 150 in/sec/sec. A controller tag is provided in the HMI program, SawADD_Reducing_Speed, to be used if needed for the feed drive to switch to a higher decel rate. The higher the decel rate the more deviation that will be prevented. Since switching takes time it is best to leave the drive in a high decel mode.

The acceleration rate while in the cut should be limited to a much lower rate (25 in/sec/sec or 125fpm/sec) as a method of providing

some damping to prevent repeated decel and accel oscillation. The Accel Rate is handled in the SawADD program and should be a parameter in the HMI. The decel rate must be set in the drive control and may be a ramp time for decel from max drive speed to zero speed.

Limit Setup

The guide pressure limits for accurate sawing, good size control, and reducing target size is typically set to around 50 pounds and 100 pounds. Increase the limits when pushing for more production, allowing for a larger variation or standard deviation, and hence larger target size. Tougher sawing species like Douglas Fir may require a high limit.

A speed limit max reduction is used to prevent over correcting. We will typically use two sets of pressure limits and two sets of reduction limits. That way the primary Limit 1 (50 to 100) can be associated with a conservative Limit 1 Max Reduction to about 80% (down to speeds that would be run without SawADD). A second limit may be set higher than normal operation, to provide a safety net for extremes… Which may save a saw. For example, the sawing pressure Limit 2 can be 100 pound and Max Reduction limit to 30%, but never to 0% which would stop the feed without the ability to recover.

Diagnostics and Trending

The SawADD program also provides diagnostic data on the saws. These tag names are preceded with RPT_ and they are in the HMI screen for report purpose. Counts are kept of each time a saw pressure exceed a limit to help diagnose problems with individual saws. The Average Speed Increase % multiplied be the % Time Sawing will produce the Shift Increase.

Shift Reporting

The Shift Report data shown below is collected in tags that are preceded by RPT_ and are reset when the system log count is reset or the Shift_Run_Reset tag is cycled.

SHIFT REPORT	
Total Over Limit 1	15295
Total Over Limit 2	22
Total Logs Sawn	1357
Avg Speed Increase %	11.27
% Time Sawing	48.2
Shift Increase	5.43

The "AvgSpd Increase" is the increase achieved by SawADD above the preselected speed. This average of the SawADD speed command multiplier is done for the entire shift, averaged every 5 ms execution of the periodic task. SawADD will attempt to increase the speed by the requested "Speed Adjust" and decrease the speed when the sawblade forces exceed the limit. A controller tag, SawADD_Speed_Used, is provided in the HMI program that should be used to provide feedback when another machine section is

controlling speed lower than SawADD, in order to keep the AvgSpd Increase accurate.

The counts of over limit positive and negative will give an indication of the performance of the saws and point to the one that is reducing the average increase.

Each time the Shift report is reset the RPT_ tag data is moved into tags preceded by LOG_. These tags are then logged as described in Shift Data Logging.

Shift Data Logging

To create data logging for the tags from the Shift Report, a Data Log Model must be created in the FactoryTalk View Studio, Data Log branch of the Project Explorer. To create a model right click on Data Log Models and selecting "New". The Data Log Model names shown here must be used to match those used for the pens in the HMI Trends supplied.
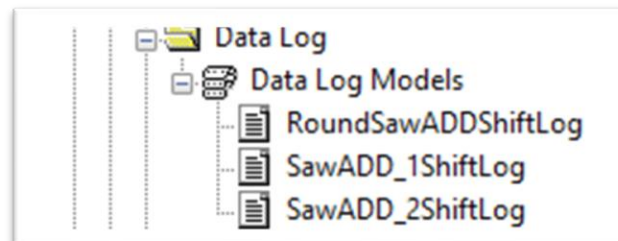
Select the tags to log by selecting the tab "Tags in Model". The Tag Browser can be invoked (button with 3 dots), then the PLC Short Cut selected and then the PLC program selected. All the tags beginning with LOG_ can be selected, then click the "Add Tags to List" button, then the "Add" button and finally the "OK" button.
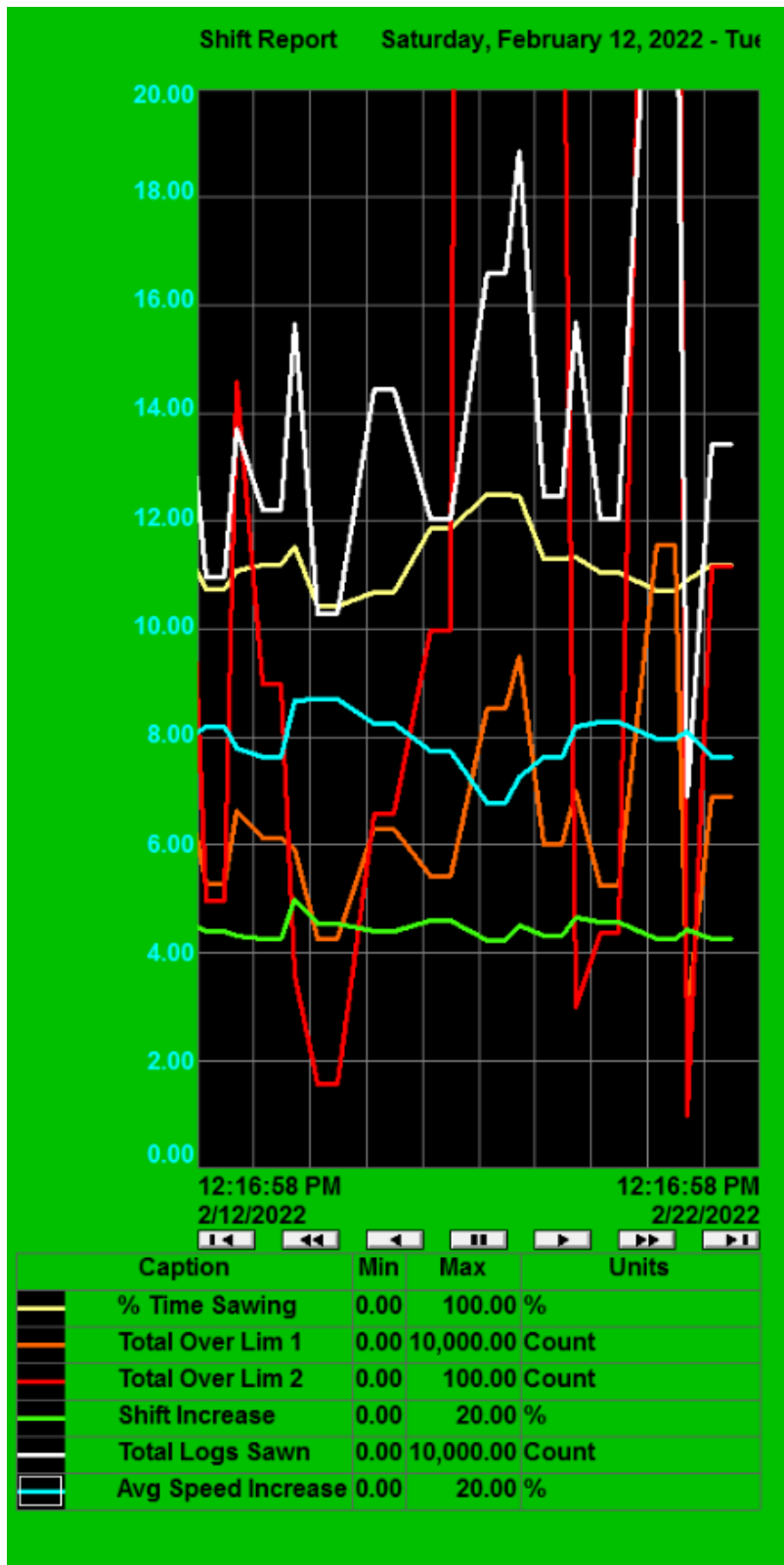
The Shift Data Log Trend shown below appears on the main SawADD HMI display. The pens shown on a trend are selected by turning them on from the chart properties by right clicking on the trend and selecting Pens.

This trend is setup with 10-day span which should have a data change only twice a day. A longer span can be set in the trend properties. A line cursor can be put on the trend by clicking anywhere on the data and the date and time the data was captured will be shown above the cursor line. This will allow tracking the shift and the saws run on that shift if kept in a logbook.

Clicking on a pen in the legend will change the left scale to the one for that pen. The trend can be scrolled back for as long as the trend has been kept.

To start data logging in Factory Talk View Studio do the following:

- In the **Display Settings** dialog box, in the **Behavior** tab, specify the **DataLogOn** command as the startup command or the **DataLogOff** command as the shutdown command.

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Shift Report   Saturday, February 12, 2022 - Tue

Caption	Min	Max	Units
% Time Sawing	0.00	100.00	%
Total Over Lim 1	0.00	10,000.00	Count
Total Over Lim 2	0.00	100.00	Count
Shift Increase	0.00	20.00	%
Total Logs Sawn	0.00	10,000.00	Count
Avg Speed Increase	0.00	20.00	%

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Advanced Tuning

The SawADD PLC program provides some advanced tuning adjustments that should only be attempted by someone experience in closed loop control.

The proportional gain algorithm is reverse acting, in order to provide a speed reduction multiplier. It uses the saw pressure error compared to the saw pressure setpoint and scaled by the setpoint times a P-Gain parameter. The default value for the P-Gain is 0.3 to provide a minimal over correction.

The two sensor differential pressure is multiplied by a D-Gain parameter to provide a faster reacting process variable that can also be used with the same limits and P-Gain. The default value of the D-Gain is 2.0.

The highest value of the sum and differential of the sensors is used to compare with the limits and produce the speed reduction multiplier.