



**EUROTHERM  
DRIVES**

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## **590 Digital Section Control**

### **Application Manual**

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## **INTENDED USERS**

This manual is to be made available to all persons who are required to configure, install or service the equipment described herein or any other associated operation.



**WARNING!**

Only qualified personnel who thoroughly understand the operation of this equipment and any associated machinery should install, start-up, or attempt maintenance of this equipment. Non-compliance with this warning may result in serious personal injury and/or equipment damage.

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**WARNING!**

Never work on any control equipment or motors without first removing all power supplies from the equipment.



**Caution**

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This equipment contains **ESD** (Electrostatic Discharge) sensitive parts. Observe static control precautions when handling, installing, and servicing this device.



**Caution**

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This equipment was tested before it left our factory. However, before installation and start up, inspect all equipment for transit damage, loose parts, packing materials, etc.



**Caution**

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Ruptured semiconductor devices may release toxic materials. Contact Eurotherm Drives or the semiconductor manufacturer for proper disposal procedures for semiconductors or other material.

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## Chapter 1 Introduction

### ABOUT THIS MANUAL

This manual describes use of the 590 Digital internal block diagram to implement open and closed loop control of driven web section rolls. The manual is intended to be used as a supplement to the 590 Digital product manual HA387240.

It is important that the user be familiar with setting and configuring the 590 Digital drive, and in particular the following topics:-

- Using the MMI
- Adjusting set-up parameters
- Monitor diagnostic parameters
- Change configuration connections using tags

These topics are thoroughly covered in the 590 Digital product manual.

The special winder blocks use the flexible tag connection scheme within the 590 Digital to allow a variety of different configurations. This manual outlines typical examples of section control configurations. These may be customised to suit individual requirements.

Simple set-up instructions are given.

### SOFTWARE COMPATIBILITY

This manual is written to be compatible with the following software:-

#### 590 Digital drive

Issue 3.2 software.

#### ConfigEd Lite

A graphical programming tool for the 590 Digital drive is available, called ConfigEd Lite. This tool allows block diagrams to be easily constructed in a Windows environment.

ConfigEd Lite template configuration files are available for the 590 Digital internal block diagrams shown in this manual. The filenames are:-

Draw / Ratio Load cell Dancer Torque	SC_DR.590
Digital Draw	SC_DDR.590

Installing a new configuration from the template filename shown above is covered in the ConfigEd Lite user Manual

### APPLICATION

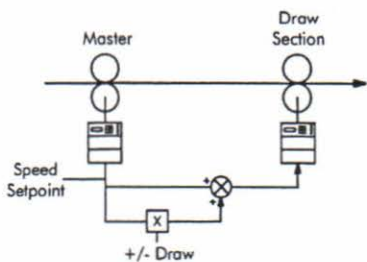
The 590 Digital can be configured for three different types of section control for driven web transport rolls:-

- 1) Open loop draw or ratio control
- 2) Closed loop tension feedback via a dancer or load cell.
- 3) Open loop torque control

The above configurations are designed to provide tension control of web materials.

Speed feedback from the motor must be provided using an analog or digital tachometer. The use of armature voltage feedback is not recommended due to the low accuracy. Commissioning instructions for the 590 Digital drive and its speed loop can be found in the 590 Digital product manual.

## Draw



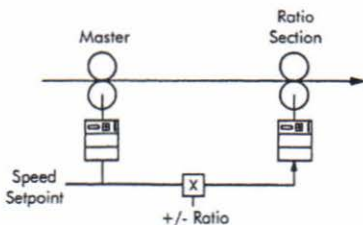
Draw mode is the nearest approximation to an old fashioned line shaft with its mechanical variators. It works well even when the section has little or no grip on the web although this will not control tension. In draw mode, the slave drive is speed controlled with a percentage difference from the lead drive. The speed difference or *draw*, which is usually small, will stretch the web if it is extensible and the speed difference is positive, or permit the web to contract if the speed difference is negative. It is usual to cascade the line speed setpoint of the

master drive, to the draw section drive.

When draw is used with non-extensible webs, very accurate speed control is required to provide acceptable tension control. With these materials, a very small speed difference will either cause the web to be too loose or too tight.

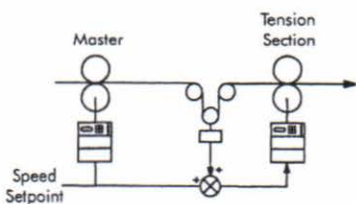
Draw should not be relied upon to give accurate tension control. With certain machine configurations and materials tensions may be unpredictable.

## Ratio



Ratio control is speed control. It is similar to draw except that it is specified as a ratio of the line speed instead of a percentage difference. Ratio control generally varies over a much wider operating range than draw. Ratio is typically used by sections that have no effect on web tension and the ratio is required by the manufacturing process, i.e. coater applicators and metering rolls. It is usual to cascade the line speed setpoint of the master drive, to the ratio section drive.

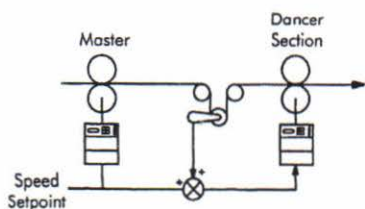
## Load cell Tension



Draw controls speed but does not directly control tension. Tension control uses an outer control loop to adjust the section speed. The load cell provides the feedback signal for the control loop. Speed is adjusted to keep the feedback signal from the load cell at a fixed value, the tension setpoint. It is usual to cascade the line speed setpoint of the master drive, to the load cell section drive.

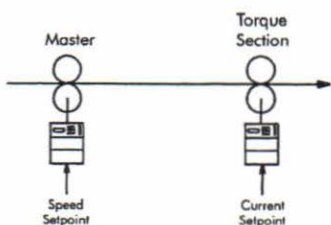


## Dancer Position



It is usual to cascade the line speed setpoint of the master drive, to the dancer section drive.

## Torque



Torque control is an open loop method of controlling tension because there is no direct tension measurement. It assumes that the process losses are small so the web tension will be proportional to torque at the roll. The drive section torque is proportional to motor armature current and the speed is determined by the web speed assuming the drive section does not slip.

Note: To achieve constant tension throughout the speed range, use a constant torque motor. A motor

with a field range will produce less torque as the speed increases above its base speed.

A single 590 Digital configuration is used to implement the above control modes.

## ADDITIONAL FEATURES

Line sections often require additional control features and these are described below.

### Reverse

Reversing is useful for sections such as Coaters and Laminators that may need to reverse directions to accommodate a web path change to coat the other side of the web.

### Anti-reverse

Anti-reverse is required where reversing a section may cause mechanical damage to the machine or be hazardous to the operator.

### Agitate

Agitate or *Sunday drive* is a feature used for coater and printer sections to keep the coater turning at a low speed when the line has stopped to prevent the coating material from solidifying.

### Slack Take-up/Pay-out

A line in draw control, such as a paper machine, will be difficult to get running without the ability to speed up or slow down one section relative to another to remove loops of slack web without disturbing the preset draw. Slack take-up offers this capability. Similarly, it may be necessary to introduce slack web for a splice and this can be achieved with pay-out.

### Jog

Many sections need individual jog for positioning, clearing wrap-ups, or cleaning.

**Ramp**

A section ramp, independent from the main line ramp, allows the individual section to be accelerated smoothly to speed to match the main line and decelerated as required by the process.

**Raise/Lower (Motor Operated Potentiometer Function)**

The Raise/Lower function uses digital inputs to increase and decrease Draw, Ratio, or Tension for interfacing with gauge controls or other automatic systems with logic outputs.



## Chapter 2 Special block description

This section describes each of the special blocks used for section control applications. Refer to the 590 Digital product manual HA387240 for more detail about the internal block diagram and configuration.

### KEY

The numbers within square brackets [ ] indicate 590 Digital tags.

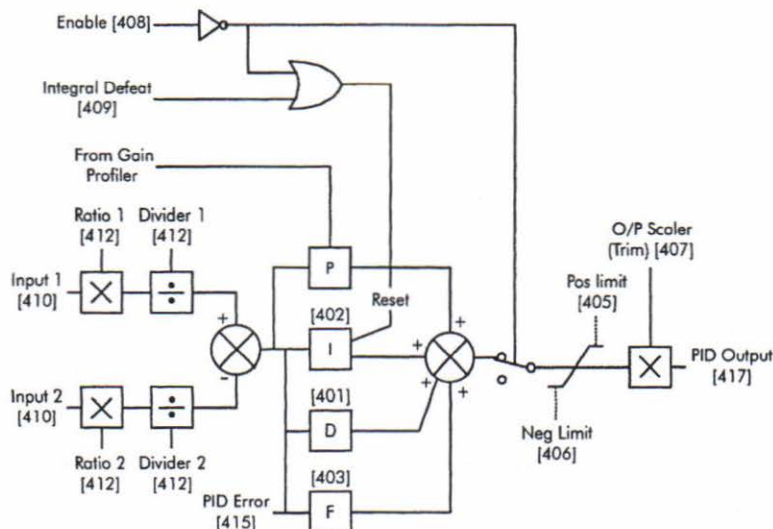
Normal text in CAPITALS refers to MMI parameters or user terminals.

Forward slash characters "/" indicate that the next text is at a lower level of the MMI tree.

### PID BLOCK

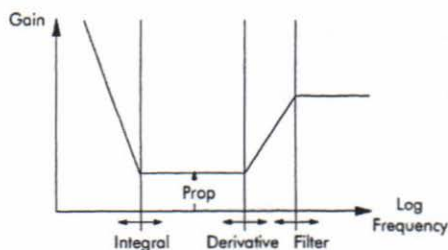
The PID block is designed to allow closed loop control of a feedback variable compared to a setpoint variable. The three control terms (PID) are adjustable to optimise control response. Integral control is used to give zero steady state error.

The following block diagram shows the PID block, which is found in the SPECIAL BLOCKS menu of the drive.



The PID has two inputs which are scaled with independent parameters of RATIO and DIVIDER. The two scaled inputs are subtracted to form an error value and the resultant three term control (PID) operates on this error value.

The following diagram shows the classical PID characteristic.



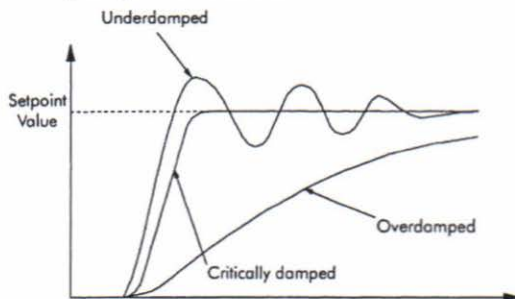
The three main PID variables are described below.

### Proportional gain

The PID error is multiplied by the Proportional gain to produce an output.

The proportional gain is used to adjust the basic response of the closed loop control system. Note that this value does not affect any of the other PID parameters.

Typical responses of a PID controlled system are shown below. The ideal response is the critically damped characteristic.



### Integral

This is used to give zero steady state error between the setpoint and feedback values of the PID. This ensures for example, that the steady state position of a dancer in a controlled drive section, will always be equal to the setpoint.

If the integral is set to a small value, this will cause an under damped or unstable control system.

### Derivative

This is used to correct for certain types of control loop instability, and therefore improve response. It is sometimes used when heavy or large inertia rolls are being controlled.

The derivative term has an associated filter, to suppress high frequency signals.

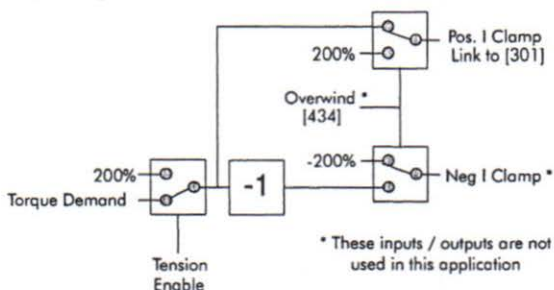
### TORQUE CALCULATOR

The torque controlled section drive uses a saturated speed loop where the motor torque is controlled using the main current limit clamp. Using this scheme also allows simple overspeed protection to be implemented.

The torque calculator block is used to switch the Pos I Clamp (Main Current Limit) between the torque demand input terminal, for torque control, and +200% when jogging etc.

The main current limit is further scaled using the CURRENT LOOP / CUR. LIMIT SCALER.

The Torque calculator parameters are found in the SPECIAL BLOCKS / TORQUE CALC. menu



The TENSION ENABLE input is used to select between the torque demand input and a fixed value of 200%. It can be set, either directly from the MMI or from a digital input. The default for TENSION ENABLE is enabled.

When TENSION ENABLE is enabled

The Pos I Clamp (Main current limit) is controlled from the torque demand input. This is normal torque mode

### When TENSION ENABLE is disabled

The Pos I Clamp is set to +200%. This allows the drive to operate in speed control.

## Chapter 3 Connection and Block diagrams

The following sections describe typical configurations for section control. The block diagrams can be used as shown, or as a starting point for further customisation to suit a particular application.

Drive connection, block diagrams and basic commissioning information is given in the following sections.

The section controlled drive feedback should be derived from the following sources:-

- 1) Analog tach feedback
- 2) Electrical encoder feedback
- 3) Fibre optic Microtach feedback

Armature voltage feedback is not recommended due to the low achievable accuracy.

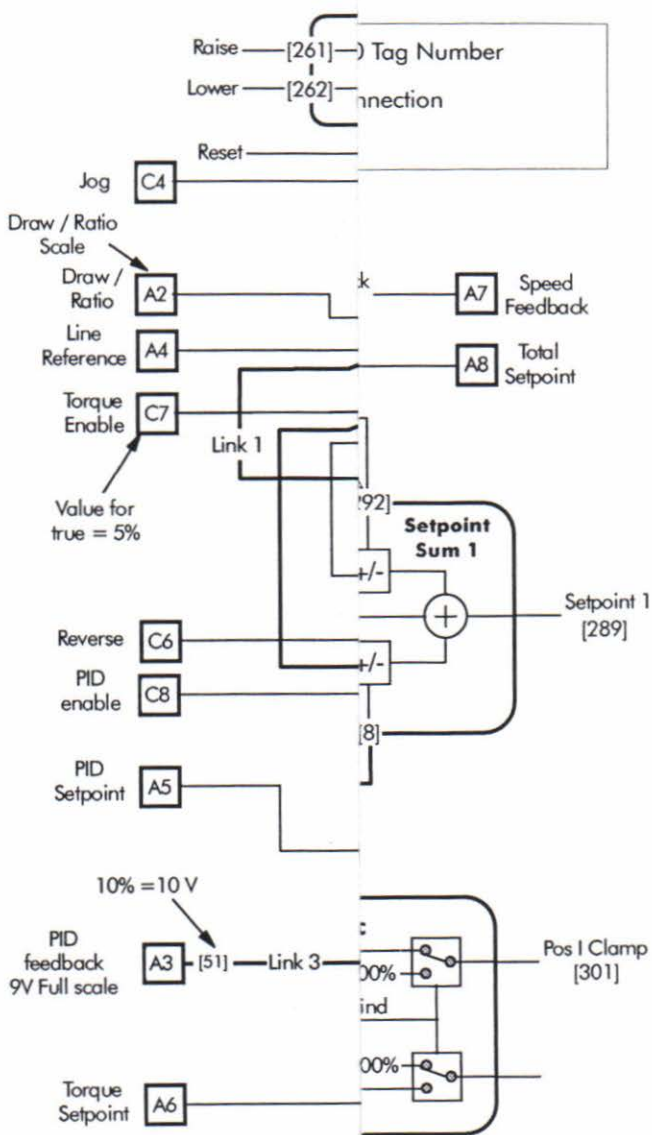
For high accuracy control in Draw or Ratio, digital speed feedback should be used via an electrical encoder or Microtach. Here, the line speed should be cascaded as a digital value using the 5703 products, as outlined elsewhere in this manual.

### CONFIGED LITE USERS

The 590 Digital can be configured using the ConfigEd Lite configuration tool. Refer to the ConfigEd Lite user manual for information about starting a new configuration for analog and digital Line Reference section controls, using the template filenames shown in chapter 1 of this manual.

If ConfigEd Lite is used, the connection and parameter lists shown later in this chapter are included for information only.

590 DIGITAL INTERNAL BLOCK D





**List of connections and parameters**

This section defines the actual connections and set-up parameters shown in the above block diagram.

In general, with regard to parameters, only the changes from the default values are shown.

Note, before any connections can be set, the SYSTEM / CONFIGURE I/O / CONFIGURE ENABLE must be set to ENABLE. This parameter should be set to DISABLE when the configuration is completed.

(Default) indicates that this connection is made by default.

This section is for information only if ConfigEd Lite is used to configure the 590 Digital.

**I/O connections****SYSTEM / CONFIGURE I/O / ANALOG INPUTS**

Input	Destination Tag	Min Value	Max Value	Calibration	Description
ANIN 1 (A2)	447	To suit	To suit	To suit Draw / Ratio range	Draw / Ratio
ANIN 3 (A4)	444	-100%	100%	1.0000	Line Reference
ANIN 4 (A5)	410	-100%	100%	1.0000	PID Setpoint
ANIN 5 (A6)	432	0.00%	100%	1.0000	Torque Setpoint

**SYSTEM / CONFIGURE I/O / ANALOG OUTPUTS**

Output	Source Tag	Description
ANOUT 1 (A7)	207	Speed Feedback
ANOUT 2 (A8)	85	Total Setpoint

**SYSTEM / CONFIGURE I/O / DIGITAL INPUTS**

Output	Destination Tag	Value for true	Value for false	Description
DIGIN 1 (C6)	292	0.00%	0.01%	Reverse
DIGIN 2 (C7)	445	0.01%	0.00%	Torque Enable
DIGIN 3 (C8)	408	0.01%	0.00%	PID Enable

**SYSTEM / CONFIGURE I/O / DIGITAL OUTPUTS**

Output	Source Tag	Description
DIGOUT 1 (B5)	77 (Default)	At Zero Speed
DIGOUT 2 (B6)	122 (Default)	Health
DIGOUT 3 (B7)	125 (Default)	Ready



## Internal links

SYSTEM / CONFIGURE I/O / INTERNAL LINKS		
Link	Source Tag	Destination Tag
Link 1	444	443
Link 2	292	8
Link 3	51	411
Link 4	445	433

## Block Diagram

SYSTEM / CONFIGURE I/O / BLOCK DIAGRAM	
Block	Connected to Tag
RAISE/LOWER DEST	Connect if MOP used
RAMP O/P DEST	309
SPT SUM 1 DEST	289
SETPOINT SUM 2	5
PID O/P DEST	100
POS I CLAMP	301

## Setup Parameters

Set-up parameters are not included for the current and speed loops. These must be determined at commissioning time, as indicated in the 590 Digital product manual.

SETUP PARAMETERS		
Parameter		Value
SPECIAL BLOCKS / PID	O/P SCALER (TRIM)	0.2
	RATIO 1	0.1
	DIVIDER 2	0.9
SPECIAL BLOCKS / SETPOINT SUM 2	LIMIT	105%
	RATIO 1	100% for Draw control 0.00% for Ratio control
SPEED LOOP / SETPOINTS	RATIO 2 (A3)	0.0000
	MIN DEMAND	0.00% if Anti Reverse required
RAMPS	MIN SPEED	Set to agitate speed if required
JOG/SLACK	TAKE UP 1	Set to take up speed if connected
RAISE/LOWER	MAX VALUE	Set to Max value if MOP used
	MIN VALUE	Set to Min value if MOP used

## Serial link

The 590 Main port serial link (P1) can be used with the Section control. Refer to section 17 of the 590 Digital product manual for more information about the serial link.

The following table shows the reconfigurable serial link blocks 14 and 15 which are set up for this application.

SERIAL LINKS / PNO CONFIG					
PNo	ASCII	Source Tag	Serial Link PNO Description	100% Scaling	Access
112	70	444	Line Reference	100.00%	R/W (a)
113	71	447	Draw / Ratio	100.00%	R/W (a)
114	72	432	Torque setpoint	CUR. LIMIT	R/W (a)
115	73	85	Total Setpoint	100%	R/O
116	74	---	Spare	---	---
117	75	---	Spare	---	---
118	76	---	Spare	---	---
119	77	292 (b)	Reverse	0/1	R/W (a)
120	78	404	PID Prop Gain	100.0	R/W
121	79	---	Spare	---	---
122	7A	402	PID Integral TC	100.0 Secs	R/W
123	7B	401	PID Derivative TC	10.00 Secs	R/W
124	7C	411	PID Feedback	9.00%	R/O
125	7D	410	PID setpoint	100.00%	R/W
126	7E	---	Spare	---	---
127	7F	--- (b)	Spare	---	---

Note (a) - Analog / Digital input must be disconnected before write is allowed.

Note (b) - Logic parameter.

To access the above section control parameters from the serial link, address the above Binary PNO or ASCII numbers from the serial link host. Other standard 590 Digital serial link parameters are also available, as described in the product manual.

It is not recommended to use a multi-drop serial link to transfer the Line Reference. This is due to the typically slow data transfer rate.

## WIRING DIAGRAMS

The following diagrams show how to wire to the 590 Digital drive in order to implement the various section control modes

### Draw and Ratio Control

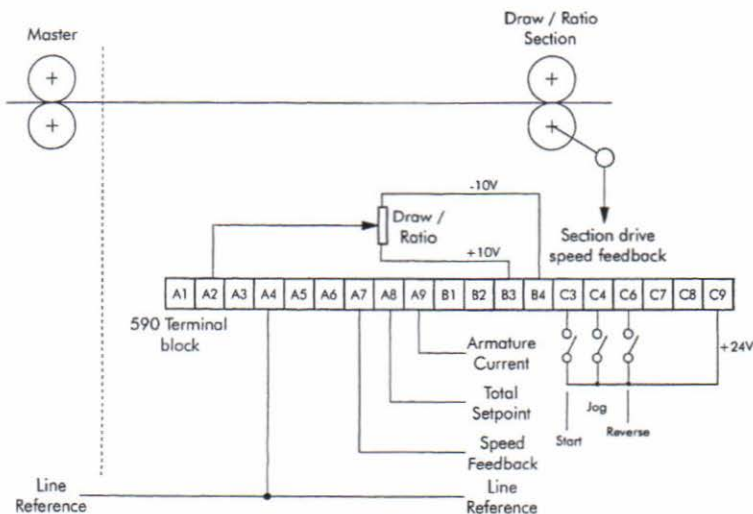
#### Draw Control

Selected by:- SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1 = 100%

Draw mode is line speed plus or minus a percentage of line reference. The line reference input is terminal A4, LINE REFERENCE.

The draw setpoint is connected to terminal A2, DRAW/RATIO, which is multiplied by the line reference and added into the speed demand with the line reference.

The draw range is set by the calibration for the analog input A2 in the CONFIGURE I/O menu. The maximum range is -300 to +300 % but in draw mode this will more typically be -5 to +5%. To set a 5% range, the calibration is set to 0.05, this means that +10 volts on terminal A2 produces +5% draw and -10 volts produces -5% draw.



#### Ratio

Selected by:- SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1 = 0.00%

Ratio mode is line reference multiplied by the ratio input. The line reference input is terminal A4, LINE REFERENCE. This is multiplied by the ratio input on terminal A2, DRAW/RATIO.

The ratio range is set by the calibration for the analog input A2 in the CONFIGURE I/O menu. The maximum range is -300 to +300%.

The overall speed demand is clamped to a maximum of 100% so ratios of more than 100% can only be used at less than full line speed.

### Cascaded draw and ratio

For multi-section draw and ratio systems the line reference must be passed to all cascaded section drives. This is shown in the above wiring diagram. Using this line reference arrangement, each section acts independently from its adjacent drive section.

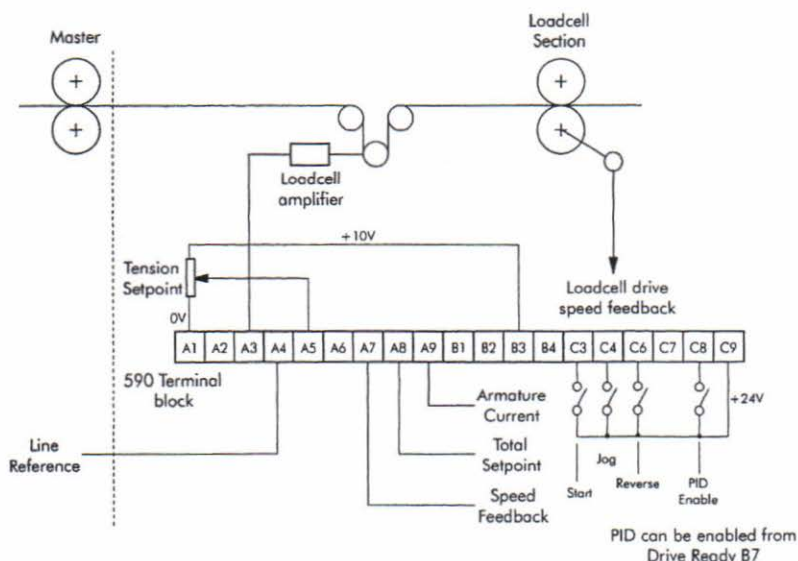
An alternative method is to cascade the total setpoint to the next drive section. Here, each drive section will follow changes in draw or ratio from the previous section. The total setpoint output is supplied from terminal A8 in the above wiring diagram.

### Load cell Control

Selected by:- SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1 = 100% to select draw control  
Terminal C8 enables the PID

The PID can be enabled by wiring the Drive Ready terminal B7 to The PID enable terminal C8. Further hardwired interlocking will have to be done if the section drive is jogged.

The load cell signal must be scaled using a load cell amplifier, such as the Eurotherm Drives 5530, before connecting into terminal A3, PID FEEDBACK, on the 590 series DC motor controller. Full tension should be scaled to be +9 volts to allow 10% over range.



The tension setpoint is applied to terminal A5, scaled as +10 volts = Full tension.

**NOTE, WHEN CASCADING MANY LOAD CELL OR DANCER LOOPS, IT IS STRONGLY RECOMMENDED THAT THE LINE SPEED REFERENCE IS CONNECTED TO TERMINAL A4 OF ALL DRIVES. THE USE OF THE TOTAL SETPOINT IS NOT RECOMMENDED FOR CASCADED SECTIONS, SINCE OVERALL MACHINE STABILITY MAY RESULT.**

Digital transfer of the line reference can be used, see section on Digital Draw / Ratio.

**NOTE, TORQUE ENABLE SHOULD NOT BE USED IN THIS APPLICATION.**

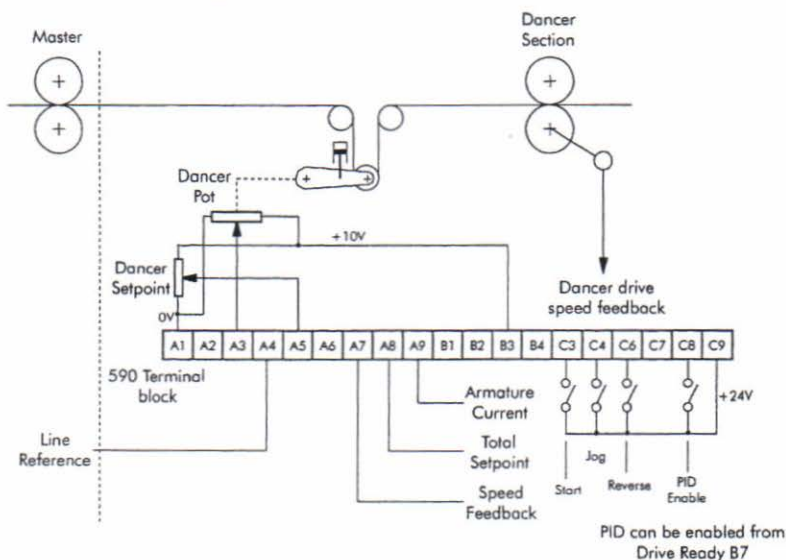


## Dancer Control

Selected by:- SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1 = 100% to select draw control  
Terminal C8 enables the PID

The PID can be enabled by wiring the Drive Ready terminal B7 to The PID enable terminal C8. Further hardwired interlocking will have to be done if the section drive is jogged.

The dancer requires a position transducer that gives out a signal in the range of 0 to +10 volts. The simplest form of transducer is a potentiometer coupled to the dancer shaft and supplied from the drive +10 volts on terminal B3. The optimum mechanical arrangement would provide nearly full potentiometer rotation for the full dancer travel, but less is acceptable down to a minimum of about 30% or 3 volts change.



The dancer position transducer is connected to the PID Feedback terminal A3.

The dancer controlled position is set by connecting a potentiometer to the PID Setpoint terminal A5. Alternatively the dancer position can be set within the 590 Digital by connecting terminal A5 to +10 volts, and adjusting the SPECIAL BLOCKS / PID / RATIO 1 parameter between 0 and 1.000.

**NOTE, WHEN CASCADING MANY LOAD CELL OR DANCER LOOPS, IT IS STRONGLY RECOMMENDED THAT THE LINE SPEED REFERENCE IS CONNECTED TO TERMINAL A4 OF ALL DRIVES. THE USE OF THE TOTAL SETPOINT IS NOT RECOMMENDED FOR CASCADED SECTIONS, SINCE OVERALL MACHINE STABILITY MAY RESULT.**

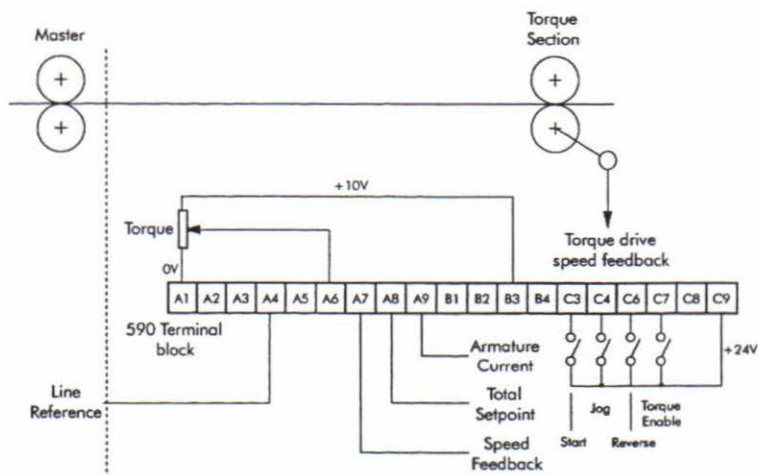
Digital transfer of the line reference can be used, see section on Digital Draw / Ratio.

**NOTE: TORQUE ENABLE SHOULD NOT BE USED IN THIS APPLICATION.**

## Torque Control

Selected by:- SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1 = 100% to select draw control  
Terminal C7 enables Torque control

Torque mode is armature current control. To achieve current control, an overspeed is added to the line reference. Since the actual section speed is held at line speed by the web, the speed loop will saturate causing the current demand to equal the current limit. The current limit is set by terminal A6.



With TORQUE ENABLE terminal C7 set to +24V, a fixed overspeed is added to the line reference. The CURRENT LIMIT is set by the TORQUE SETPOINT terminal A6, and controls the armature current. The overspeed determines how much faster than line reference the section will run if it is not held back by the web, i.e. if the web breaks.

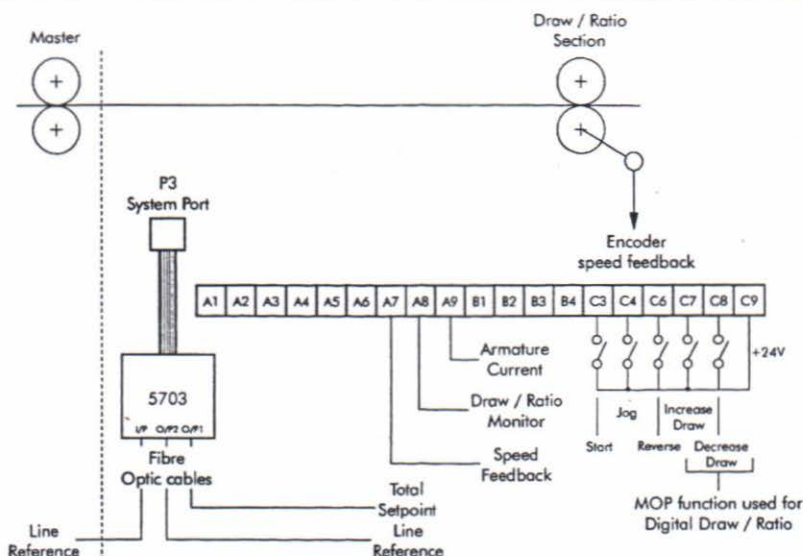
The overspeed level is set by VALUE FOR TRUE of Digital input C7, set in the CONFIGURE I/O / DIGITAL INPUTS menu.

**NOTE: PID ENABLE SHOULD BE DISABLED WHEN TORQUE MODE IS ON.**

## Digital Draw and Ratio Control

Using draw with non-extensible materials requires very small speed differences between line drive sections which, in turn, requires very precise speed control. Analog inputs and outputs may not provide adequate precision and stability. The 590 series DC motor controller is a digital drive and the speed accuracy can be greatly improved by direct, serial connection between drives using the 5703 Peer-to-Peer interface. This interface should be used in conjunction with digital speed feedback from an encoder or the Microtach optical encoder. Refer to the 590 Digital product manual for use of the 5703.





The above wiring diagram differs from the general Draw / Ratio control in that the draw or ratio is set via the Raise / Lower block. This avoids the use of analog inputs, which will introduce a loss of accuracy and drift.

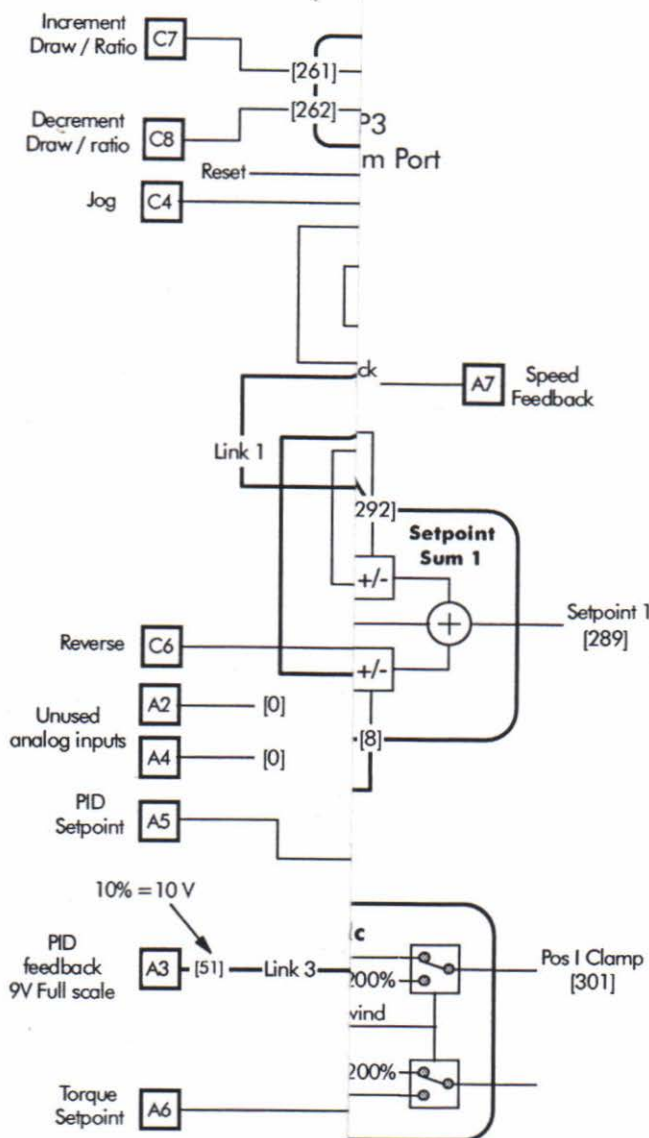
An output is provided to monitor the Raise / Lower block and so indicate the actual draw or ratio set.

Cascaded section applications should use the Line reference or the Total setpoint outputs from the 5703 converter. Refer to the 590 Digital product manual for more details.

**NOTE, THE LINE REFERENCE SHOULD BE CASCADED FOR LOAD CELL AND DANCER SECTIONS AS OUTLINED ABOVE.**

## Chapter 3 Connection and Block

In order to implement digital Dr



## Connection changes for Digital Draw / Ratio

The following changes from the standard section control block diagram should be made to implement the Digital Draw / Ratio block diagram shown above.

This section is for information only if ConfigEd Lite is used to configure the 590 Digital.

## SYSTEM / CONFIGURE I/O / ANALOG INPUTS

Input	Destination Tag	Min Value	Max Value	Calibration	Description
ANIN 1 (A2)	0	---	---	---	Not used
ANIN 3 (A4)	0	---	---	---	Not used

## SYSTEM / CONFIGURE I/O / ANALOG OUTPUTS

Output	Source Tag	% to get 10V	Description
ANOUT 2 (A8)	264	To suit max draw (a)	Draw / Ratio Monitor

Note (a), Max draw set on RAISE/LOWER Max and Min values

## SYSTEM / CONFIGURE I/O / DIGITAL INPUTS

Output	Destination Tag	Value for true	Value for false	Description
DIGIN 1 (C7)	261	0.01%	0.00%	Increment Draw / Ratio
DIGIN 3 (C8)	262	0.01%	0.00%	Decrement Draw / Ratio

## SYSTEM / CONFIGURE I/O / CONFIGURE 5703

Destination Tag	444
Source Tag	85

## SYSTEM / CONFIGURE I/O / BLOCK DIAGRAM

Block	Destination Tag
RAISE/LOWER DEST	447

Set-up parameters are not included for the current and speed loops. These must be determined at commissioning time, as indicated in the 590 Digital product manual.

## SETUP PARAMETERS

Parameter	Value
RAISE/LOWER	MAX VALUE
	Max required Draw / Ratio
	MIN VALUE
	Min required Draw / Ratio
	INCREASE RATE (b)
	Draw Ratio ramp up rate to 100%
	DECREASE RATE (b)
	Draw Ratio ramp down rate to 100%

Note (b), If the required draw is a small value, set the ramp rates to a large value.

**Digital Draw for Load cell and Dancer sections**

If Digital draw is used for Load cell or Dancer sections, the PID must be enabled. Since the PID enable digital input is now used by the Raise / Lower block, this must be enabled when the drive is ready. To do this an internal link should be used as shown below.

SYSTEM / CONFIGURE I/O / INTERNAL LINKS		
Link	Source Tag	Destination Tag
Link 5	84	408

However, the PID will then become enabled if the section drive is jogged.

Alternatively, since adjustment of Draw is not required with tension feedback, terminal C8 can be configured to enable the PID.

**Digital Draw and ConfigEd Lite**

The System port P3 is used for both downloading the ConfigEd Lite configuration and for the 5703 peer to peer interface unit. The P3 serial link is configured differently for these two operations, as shown in the SERIAL LINKS / SYSTEM PORT P3 / P3 SETUP / MODE menu:-

ConfigEd Lite - IPS ASCII  
5703 peer to peer interface - 5703 SLAVE

**GENERAL TERMINAL DESCRIPTION**

The basic terminals used with the section control configuration are described in this section.

**WARNING!**

THE CONTROL TERMINALS OF THE DRIVE ARE FULLY ISOLATED FROM ALL POWER CIRCUITS AND SHOULD NOT BE CONNECTED TO OTHER NON-ISOLATED CIRCUITS. IN THE INTERESTS OF SAFETY AND TO MINIMISE ELECTRICAL NOISE, IT IS RECOMMENDED THAT THE DRIVE 0 VOLTS COMMON TERMINAL BE CONNECTED TO GROUND EITHER DIRECTLY AT THE DRIVE OR AT ONE POINT IN THE SYSTEM.

**Draw / Ratio (A2)**

Range:  $\pm 10V$ .  
Scaling: Dependant on calibration of analog input A2.  
Used for: Draw or Ratio control.  
Restrictions: None.

This input sets the Draw or Ratio between the Line and the section drive speeds. The input range is  $\pm 10V$  which corresponds to:-

Ratio of  $\pm 1.000$ .  
Draw of  $\pm 100\%$ .

These values are for an analog input calibration value of 1.0000

Draw or Ratio control is selected by the set-up parameter SPECIAL BLOCKS / SETPOINT SUM 2 / RATIO 1.

If this parameter is set to 0.00% Ratio control is selected.  
If this parameter is set to 100.00%, Draw is selected.

**PID Feedback (A3)**

Range:  $\pm 10V$ .



Scaling:  $\pm 9V = \text{Maximum feedback.}$   
Used for: Load cell, Dancer closed loop tension control.  
Restrictions: PID ENABLE C8 must be at +24V.

Typically this signal could come from tension or position feedback transducers such as a load cell or Dancer.

Note, this input is scaled at  $\pm 9$  volts for full scale to allow control with maximum feedback. This is necessary since the analog inputs have a maximum value of  $\pm 10V$ . Load cell amplifiers must be suitably scaled to give 9 volts for full scale tension.

#### **Line reference (A4)**

Range:  $\pm 10V$ .  
Scaling:  $\pm 10V = \pm \text{Maximum line reference.}$   
Used for: Section drive main speed reference.  
Restrictions: None.

A line speed reference is required. If this signal comes from a source other than a Eurotherm Drives motor controller, it may need to be scaled and isolated.

It is recommended that the line setpoint is used for section control applications, and not line speed feedback. The line setpoint is likely to be a cleaner electrical signal.

(For digital peer-to-peer transfer of the line reference, see the Digital Draw / Ratio section.)

For machine with a line direction in one direction only, A4 should normally range from 0 to +10V. This input must be used with all forms of section control.

#### **PID Setpoint (A5)**

Range:  $\pm 10V$ .  
Scaling:  $\pm 10V = \text{Maximum setpoint.}$   
Used for: Load cell, Dancer closed loop tension control.  
Restrictions: PID ENABLE C8 must be at +24V.

Typically this signal could come from a potentiometer supplied from the drive +10 volt terminal, B3. This input is used with Load cell and Dancer feedback systems, where the PID setpoint is the load cell tension or dancer position setpoint respectively.

#### **Torque Setpoint (A6)**

Range:  $\pm 10V$ .  
Scaling:  $\pm 10V$  gives % armature current = CUR. LIMIT SCALER.  
Used for: Torque control.  
Restrictions: TORQUE ENABLE C7 must be at +24V.

This input will control the motor current between 0 and the value of the CURRENT LOOP / CUR. LIMIT SCALER parameter.

#### **Analog Tach Feedback (B2)**

Range: To suit calibration board components. See 590 Digital manual.  
Scaling: To suit calibration.  
Used for: General analog input.  
Restrictions: Analog tach must not be in use.

The analog tach is fed into this input for local drive feedback. Scaling is performed on the plug in calibration board, as outlined in the 590 Digital product manual.

If an encoder is used for local drive feedback, this terminal can be used as an additional analog input.

The analog tach input should be scaled to suit the range of the signal being used. The minimum scaling value is  $\pm 10V$  which is the same as a standard analog input. Scaling is performed on the plug in calibration board.

Connections are made to the Analog Tach input using a link. Here the link source is Tag 58.

### Ready (B7)

When at 0V: Drive not ready.  
 When at +24V: Drive ready to pass armature current.  
 Note, this output is not affected by the drive enable C5. See 590 Digital manual.  
 Used for: Enabling the load cell or dancer PID at the correct time.  
 Switching mechanical parking brakes at the correct time.  
 Restrictions: None.

This terminal is not shown in the connection diagrams but is set up by default.

### Speed Feedback (A7)

Range:  $\pm 10V$ .  
 Scaling:  $\pm 10V = \text{Maximum speed feedback}$ .  
 Used for: Monitoring the section motor speed.  
 Restrictions: None.

This is the actual speed of the section drive motor.

### Total Setpoint (A8)

Range:  $\pm 10V$ .  
 Scaling:  $\pm 10V = \text{Maximum setpoint}$ .  
 Used for: Cascaded Draw / Ratio control  
 Restrictions: None.

This is the total setpoint of the Draw / Ratio calculation. It does not include any PID trim, but does include Torque control speed offset.

### Torque Enable (C7)

Actions at 0V: Torque control disabled.  
 Actions at +24V: Pos 1 Clamp connected to TORQUE SETPOINT A6.  
 Value for True value added to speed demand to saturate speed loop.  
 Used for: Selects Torque control mode.  
 Restrictions: PID Enable must be at 0V.  
 Must be at 0V for proper operation of Program Stop

This logic input enables Torque control and has the following actions:-

### Reverse (C6)

Actions at 0V: No effect on the speed demand.  
 Actions at +24V: Speed demand is inverted in sign.  
 Used for: Reversing the section drive.  
 Restrictions: None.

This input reverses the total setpoint to the section drive. The direction change is not ramped and the total setpoint output is not affected.



### **PID Enable (C8)**

Actions at 0V	PID disabled and it's output is set to zero.
Actions at +24V	PID enabled for closed loop control.
Used for:	Load cell and Dancer control.
Restrictions	Torque Enable C7 must be at 0V

This is a logic input which is used to enable the PID for closed loop load cell and dancer control.

### **Jog (C4)**

Actions at 0V:	Normal running.
Actions at +24V:	Jog.
Used for:	Draw / Ratio mode.
Restrictions:	PID and Torque Enables must be at 0V.

JOG is selected by digital input C4. The jog direction can be selected by terminal C6, REVERSE.

### **Start (C3)**

This input starts the drive as described in the 590 Digital product manual.

Actions at 0V:	Drive stop.
Actions at +24V:	Drive start.
Used for:	Drive Start / Stop.
Restrictions:	None.

### **USING OTHER SECTION CONTROL FEATURES**

Additional section control features are described in this section.

#### **Anti-reverse**

If it is necessary to ensure that a section does not reverse, even if reversing would be required to maintain tension or dancer position, then the Anti-reverse function should be used.

Anti-reverse is achieved by setting **SETUP PARAMETERS / SPEED LOOP / SETPOINTS / MIN DEMAND** to zero.

Anti-reverse will cause the tension control loop integral to saturate if the control loop is asking for reverse speed. Anti-reverse will only operate with a unidirectional section. If terminal C8, REVERSE, is selected, the setpoint will be clamped to zero.

#### **Agitate**

A minimum speed can be set to provide an agitate function. This is implemented by setting **SETUP PARAMETERS / RAMPS / MIN SPEED** to the required agitate speed.

MIN SPEED should be set to about 5%. When the drive section is started, the speed will ramp up to MIN SPEED. When the line reference exceeds this agitate speed, the section will follow the line. MIN SPEED will only have an effect if the line reference is reduced again below the agitate value.

**NOTE, THE NIP MUST BE OPENED AND THE PID OR TORQUE DISABLED WHEN THE LINE REFERENCE IS BELOW THE AGITATE SPEED.**

#### **Ramp**

The line reference signal sent to the drive goes through a ramp. This ramp controls the acceleration to agitate speed, if used, and allows the section to be started and stopped while the line is running. The ramp parameters are located in **SETUP PARAMETERS / RAMPS**.

NOTE, THE RAMP ACCELERATE AND DECELERATE TIMES SHOULD BE SET FASTER THAN THE LINE RAMP SO THAT THE SECTION CAN ALWAYS KEEP UP WITH THE LINE.

### **Slack Take-up/Pay-out**

Slack Take-up/pay-out is a speed increase while running to take up slack web. If the drive is running and the jog terminal, C4, is energised, the drive speed will increase by an amount set in parameter TAKE-UP 1. The parameters are located in SETUP PARAMETERS / JOG/SLACK.

The speed increase is ramped to provide smooth control of the section and any cascaded sections. TAKE-UP 2 can be set negative to pay-out slack and is selected by MODE in the JOG/SLACK menu. This function can be controlled by an unused terminal by re-configuring a digital input to tag 228. See the 590 Digital product manual for full details of the jog /slack functions.

NOTE: TAKE UP SLACK IS ONLY USEFUL WHEN DRAW OR RATIO CONTROL IS IN USE.

## Chapter 4 Basic set-up instruction

This section describes the operations required to set up drives containing the section control blocks.

The different types of section control are described above, but the basic steps required to set up the drive are very similar in all cases.

The fundamental steps to be taken throughout the set-up procedure are indicated with ♦.

If the drive is configured using the display and keys, it is important to ensure that the parameters of the drive are saved on a regular basis. If this is not done, parameters adjusted during the following set-up may be lost if the auxiliary supply to the drive fails. Refer to the 590 Digital product manual for information about saving parameters.

### INFORMATION REQUIRED

The following information is required from the winding machine manufacturer in order to set up the section control blocks:-

- ♦ Absolute maximum line speed.
- ♦ Motor maximum speed at smallest section roll diameter and maximum line speed.

### WITH NO WEB CONNECTED TO THE SECTION ROLLS

The majority of the drive set up should be performed without web connected to the section rolls. This allows the rolls to rotate freely, without being restrained by the web.

Before configuring the section control from the drive MMI, it is assumed that the 590 Digital contains the default parameter set. This can be ensured by:-

- 1) Switching on the auxiliary power with the 4 MMI keys pressed.
- 2) Saving the parameters.

It is assumed that the appropriate centre winder block diagram has been configured according to the above block diagram and tables, or by downloading the ConfigEd Lite software file detailed in chapter 1.

### Initial set-up

Basic drive commissioning is covered adequately in the 590 Digital product manual, and only the steps are outlined below:-

- ♦ Check the motor voltage and current ratings of armature and field windings.
- ♦ Calibrate the drive to suit these ratings.
- ♦ Ensure that field current control, and field weakening is enabled if required.
- ♦ Calibrate the speed feedback, either analog tach, encoder or Microtach.
- ♦ Autotune current loop.

At this stage the drive is ready to run the section rolls.

- ♦ Set the PID and TORQUE ENABLES

Initial commissioning of the drive and winder blocks should be done with the TENSION and TORQUE ENABLES C8 OFF. This ensures that the drive setpoint is only derived from the LINE REFERENCE terminal A4.

- ◆ Ensure that the various set-up parameters shown in the above tables are set.
- ◆ Set the DRAW input terminal A2 to 0V.
- ◆ Ensure that Draw is selected by setting SETPOINT SUM 2 / RATIO 1 to 100%..

### Commission drive control loops

- ◆ Check the motor direction

Set the LINE REFERENCE terminal A4 to 1V.

At this point the drive can be started, the direction of rotation and speed feedback sign checked as outlined in the 590 Digital product manual.

If the REVERSE terminal C6 is at 0V, the drive should rotate forward, in control at approximately 10% of line reference. The roll direction should be such that the web would run in the normal direction.

- ◆ Check any normal and fast stop options

With the drive started.

Ensure that any normal section drive stop systems operate correctly. It is important to be able to quickly stop the section rolls, at any time during the commissioning process.

Ensure that any emergency stop systems connected to the section control drive, operate correctly. These often use the 590 Digital PROGRAM and COAST stop inputs. See the 590 Digital product manual for more information on these functions.

Note, the PROGRAM STOP input may not work if torque mode is active.

- ◆ Set up drive speed loop

With the drive started.

The drive speed loop should be tuned as outlined in the 590 Digital product manual.

- ◆ Set up the field weakener

If the field weakener is to be used, this should be set up as outlined in the 590 Digital product manual.

- ◆ Set drive maximum speed

The drive top speed should now be set, such that with the maximum line reference input to terminal A4 (+10V), the surface speed of the rolls are equal to the maximum line reference. This should ideally be checked with a hand held surface tachometer.

- ◆ Check REVERSE operation

With the drive started.

The REVERSE terminal C6 should be checked where the section roll direction should be reversed, with the same line reference.

This completes the basic drive set-up. Set-up associated with the various section control modes is now described.

### Draw and Ratio set-up

The above tests are performed with the section drive in Draw mode. Set the LINE REFERENCE terminal A4 to 50%.



◆ Check operation and calibration of the Draw

With the drive started, change the value of the DRAW / RATIO terminal A2. Ensure that the section roll speed changes as expected. The surface speed of the section rolls should be 50% with A2 at 0V.

◆ Check operation and calibration of the Ratio

Select Ratio mode by setting SETPOINT SUM 2 / RATIO 1 to 0%

With the drive started, change the value of the DRAW / RATIO terminal A2. Ensure that the section roll speed changes as expected. The surface speed of the section rolls should be 50% with A2 at 10V.

The calibration and range of the Draw or Ratio is set by adjusting the calibration parameters of CONFIGURE I/O / ANALOG INPUTS / ANIN 1 (A2).

### **Dancer and Load cell set-up**

Select Draw mode by setting SETPOINT SUM 2 / RATIO 1 to 100% and ensure that analog input A2 is not connected.

#### **Dancer feedback**

When a dancer is used, the feedback signal is usually derived from a potentiometer or LVDT transducer mechanically connected to the dancing arm.

◆ Check dancer feedback signal

With the drive stopped, the dancing arm should be moved manually and the signal observed on terminal A3. Ideally this signal should swing between 0 and +9V as the dancer is moved between it's end stops. A smaller range is acceptable however, for example between 5 volts and 8 volts. This signal should be also observed on SPECIAL BLOCKS / PID / INPUT 2.

◆ Set dancer setpoint

The dancer setpoint (SPECIAL BLOCKS / PID / INPUT 1) should be set to give zero DIAGNOSTICS / PID ERROR, when the dancer is at the mid-point position. This can be trimmed when the section drive is operating if necessary.

◆ Check dancer PID loop sign

The loop sign should be checked to ensure that the drive rotates in the correct direction when the dancer is moved. Set the REVERSE terminal C6 to 0V.

Set the LINE REFERENCE A4 to zero.

Assert the PID ENABLE terminal C8. This will enable the PID.

Move the dancer down to the "Full" position. Ensure that the SPEED DEMAND diagnostic drifts to +20%.

Move the dancer up to the "Empty" position. Ensure that the SPEED DEMAND diagnostic drifts to -20%.

If this is not the case, the loop sign can be set using the PID / OUTPUT SCALER parameter. The sign of this can be changed to set the correct loop sign.

◆ Check the dancer pressure signal

In order to apply tension, the mechanical dancer loading system should be checked. This often a low friction rolling diaphragm air cylinder with a quick vent air regulator.

#### ◆ Set PID parameters

The PID parameters should now be set, in preparation for the first running trials. A good starting point for dancer control using the above configuration would be:-

PID Parameter	Value
PROP GAIN	5.0
INT. TIME CONST	5.0 Sec
DERIVATIVE TC	0.0

The PID parameters are to be found in the SPECIAL BLOCKS / PID menu.

#### Load cell feedback

When a load cell is used, the feedback signal is usually derived from the load cell via a dedicated amplifier.

#### ◆ Check and calibrate the load cell amplifier

The load cell amplifier should be calibrated to give a feedback voltage of +9 volts with full tension applied to the sensing roller. Calibration is usually implemented by passing a rope around the sensing roller, following the normal web path of the machine. Known mass weights are then hung on the rope to simulate loading due to the web tension. For good accuracy, sufficient weights should be added, to load the sensing roller to near maximum tension. The load cell amplifier span control should then be adjusted to yield an output voltage in proportion to the applied weight. The amplifier zero control should be adjusted to give no output with the weights not attached.

The load cell amplifier operating instructions should be consulted for further information on calibration.

The load cell amplifier signal should be also observed on SPECIAL BLOCKS / PID / INPUT 2.

#### ◆ Check load cell setpoint

The load cell setpoint (SPECIAL BLOCKS / PID / INPUT 1) should be checked. This should range between 0 and +10 volts.

#### ◆ Check load cell PID loop sign

The loop sign should be checked to ensure that the drive rotates in the correct direction when the load cell is loaded. Set the REVERSE terminal C6 to 0V.

Set the line reference to zero.

Assert the PID ENABLE terminal C8. This will enable the PID.

Set a low tension setpoint on PID SETPOINT terminal A5.

Apply load less than the setpoint value. Ensure that the SPEED DEMAND diagnostic drifts to +20%.

Apply load greater than the setpoint value. Ensure that the SPEED DEMAND diagnostic drifts to -20%.

If this is not the case, the loop sign can be set using the PID / OUTPUT SCALER parameter. The sign of this can be changed to set the correct loop sign.



◆ Set PID parameters

The PID parameters should now be set, in preparation for the first running trials. A good starting point for load cell control using the above configuration would be:-

PID Parameter	Value
PROP GAIN	1.0
INT. TIME CONST	5.0 Sec
DERIVATIVE TC	0.0

The PID parameters are to be found in the SPECIAL BLOCKS / PID menu.

### Torque set-up

Select Draw mode by setting SETPOINT SUM 2 / RATIO 1 to 100% and ensure that analog input A2 is not connected.

◆ Check the Torque setpoint

Monitor the DIAGNOSTICS / POS I CLAMP. This should read a value equal to the SETUP PARAMETERS / CURRENT LOOP / CUR. LIMIT SCALER.

Set the TORQUE SETPOINT A6 to +5V and the TORQUE ENABLE C7 to +24V.

The POS I LIMIT diagnostic should read 50% of the CUR. LIMIT SCALER. Adjustment of the TORQUE SETPOINT should adjust the POS I CLAMP between 0 and the CUR. LIMIT SCALER.

◆ Check the overspeed

Set the LINE REFERENCE and TORQUE SETPOINT to 50%.

Start the drive and monitor the SPEED DEMAND diagnostic.

Set the TORQUE ENABLE to +24V. The SPEED DEMAND should increase by the VALUE FOR TRUE of DIGIN 1 (C7).

### WITH WEB CONNECTED TO THE SECTION ROLLS

The winder can now be webbed up, in preparation for the first running trials.

Ensure that any signal cables removed during the above commissioning, are re-connected.

### Draw and Ratio set-up

◆ Select an initial DRAW / RATIO

Ensure that Draw or Ratio mode is selected as described before. Set the DRAW / RATIO input to provide equal surface speeds between the master and section rolls.

◆ Ensure that REVERSE C6 is set for the correct section roll direction

◆ Check machine operation

Start the machine and ensure that the web is transported correctly between the section rolls. Ensure that the DRAW / RATIO terminal A2 provides the necessary function throughout the full speed range.

### Dancer and Load cell set-up

◆ Check that the REVERSE terminal C6 is correctly set for the section rolls, and PID ENABLE is set.

- ◆ Set a small tension setpoint or dancer pressure
- ◆ Set SPECIAL BLOCKS / PID / INTEGRAL DEFEAT to ON

This will give proportional only control for the first tests.

- ◆ Set the line reference to zero
- ◆ Turn down the drive current limit

To eliminate the possibility of excessive tensions during the first start-up, the SET-UP PARAMETERS / CURRENT LOOP / CUR. LIMIT SCALER should be reduced to say 20%.

- ◆ Start the section drive

If possible, manually take up any slack web and start the section drive.

Web tension or dancer position should increase, and stabilise at the setpoint value. If the tension does not increase, check the DIAGNOSTICS / CURRENT FEEDBACK. If this is approximately the same as the CUR. LIMIT SCALER, increase this parameter until the tension or dancer position feedback equals the setpoint value.

If the section rolls are unstable, the SPECIAL BLOCKS / PID / PROP GAIN may have to be adjusted.

If the section rolls rotates in the wrong direction, either the REVERSE terminal C6 is incorrectly set, or the loop sign is incorrect.

- ◆ Restore the drive current limit

Once the winder is under tension in a stable manner, set the CUR. LIMIT SCALER to 100%.

#### Tuning the tension loop

- ◆ Initial set up the PID parameters

These parameters are found within the SPECIAL BLOCKS / PID menu

Apply a small disturbance to the section drive. This can be done by disconnecting the LINE REFERENCE terminal A4, and applying a small voltage step of about 0.2 volts to this input. The RAMP ACCEL and DECEL times must be set to 0.1sec for this test to operate.

Observe the recovery characteristic of the PID loop, and adjust PROP GAIN to give a satisfactory response. Increasing this parameter will improve the response time, but the section drive will eventually become unstable. It should be the aim to achieve the critical damping response as outlined in the PID description above.

A small amount of DERIVATIVE TC may be required for dancer feedback and large high speed section rolls.

Set INTEGRAL DEFEAT to OFF. This will ensure zero steady state error of the PID loop. Repeat the above step response tests and reduce the INT. TIME CONST parameter if necessary to improve the response. If the winder is unstable with INTEGRAL DEFEAT set to OFF, increase the INT. TIME CONST.

- ◆ First running trials

Restore any wiring removed during the above set-up

Start the machine and monitor the DIAGNOSTICS / PID OUTPUT which should be around zero. If the PID output is large (5 to 20%) do not proceed to higher line speeds, but recheck the calibration and sign of the LINE REFERENCE terminal A4.

If any of the above two values are not as expected, stop the machine, and recheck the above drive calibration steps.

### **Torque set-up**

- ◆ Select DRAW mode as described above.
- ◆ Ensure that REVERSE C6 is set for the correct section roll direction
- ◆ Check machine operation

Set TORQUE ENABLE C7 to +24V.

Set a small value of TORQUE SETPOINT, start the machine and ensure that the web tension increases.

Run the machine and ensure that the section tension is controlled from the TORQUE SETPOINT.

### **Final checks**

The machine should now be run over the full speed and Draw / Ratio / Tension / Torque range to check stability and performance.

In the case of dancer and load cell control, the DIAGNOSTICS / PID output should be checked at various line speeds to ensure that this remains close to zero.

### **Saving the configuration**

It is most important that the final drive configuration and parameters are saved. The configuration and parameters can be saved in two ways:-

Drive internal PARAMETER SAVE - This is absolutely essential to prevent data loss on power off

ConfigEd Lite - Parameter save to a computer. This is optional, but will allow restoration of the configuration, in the case of drive failure.

Refer to the 590 Digital and ConfigEd Lite manuals for more information on these two methods of saving the drive configuration and parameters.

## Chapter 5 Appendices

### APPENDIX A EQUATIONS

The following shows some equations, used to determine motor torque and power requirements. General equations for centre winders are shown, which are equally applicable to fixed diameter section rolls.

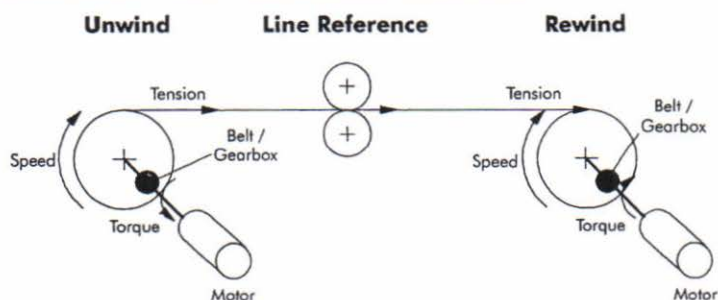
For section rolls the following modifications are required:-

- There may be more than one roll compared to a centre winder, e.g. a nipped combination.
- The net tension will be the differential between input and output tensions of the section rolls.
- The diameter build up parameter is 1 for section rolls.

### Simple centre winder equations

The following section shows some simple equations for centre winders.

It is assumed that the winders operate in constant tension mode.



### Metric units

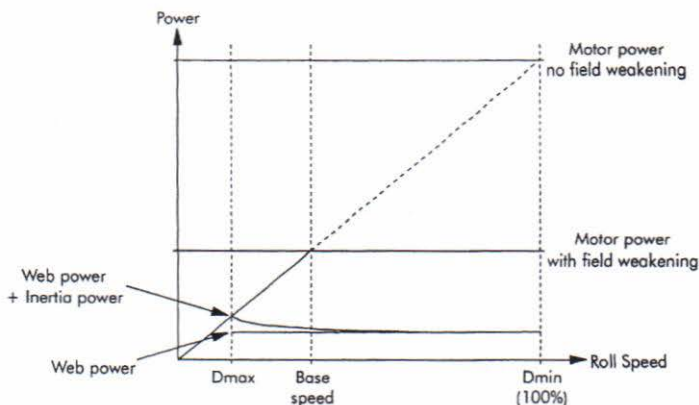
The following SI units are used to produce the equations shown below.

- Tension - Kilograms force (kgf)
- Torque - Newton Metres (Nm)
- Line Speed - Metres/Sec ( $MS^{-1}$ )
- Line accel - Metres/Sec<sup>2</sup> ( $MS^{-2}$ )
- Rotation speed - RPM (RPM)
- Roll Diameter - Metres (M)
- Power - KWatt (kW)
- Mass - kg (kg)

### Motor Power

The following diagram shows the motor and roll powers at maximum line speed compared to roll speed.





The above graph is for the case of constant tension and friction is ignored.

$$\text{Power}_{\text{Web}} = \frac{\text{Tension} \times \text{Max Line Speed}}{101.94} \text{ kW}$$

$$\text{Power}_{\text{Inertia}} = \frac{\text{Roll Mass} \times \text{Max Line Accel} \times \text{Max Line Speed}}{2000} \text{ kW}$$

$$\text{Power}_{\text{Friction}} = \frac{\text{Motor Max Speed}}{9549} \times \text{Motor Torque}_{\text{Friction}} \text{ kW}$$

Using the above individual roll powers

$$\text{Power}_{\text{Roll}} = \text{Power}_{\text{Web}} + \text{Power}_{\text{Inertia}} + \text{Power}_{\text{Friction}} \text{ kW}$$

Referring to a motor with field weakening

$$\therefore \text{Power}_{\text{Motor}} = \left\{ (\text{Power}_{\text{Web}} + \text{Power}_{\text{Inertia}}) \times \frac{\text{Diameter Build Up}}{\text{Constant Power Range}} \right\} + \text{Power}_{\text{Friction}} \text{ kW}$$

Here, the Constant Power Range is the motor field weakening range.

This parameter is 1 if no field weakening.

### Motor Torque

The worst case motor torque will exist for the following conditions:-

- 1) Maximum roll diameter
- 2) Maximum acceleration rate
- 3) Maximum roll width
- 4) Maximum material tension
- 5) Maximum roll mass

$$\text{Torque}_{\text{Tension}} = \text{Tension} \times \text{Roll Diameter} \times 4.905$$

Assuming the roll is a solid cylinder

$$\text{Torque}_{\text{Inertia}} = \frac{\text{Roll Mass} \times \text{Line Accel} \times \text{Roll Diameter}}{4}$$

$$\text{Torque}_{\text{Roll}} = \text{Torque}_{\text{Tension}} + \text{Torque}_{\text{Inertia}}$$

$$\therefore \text{Torque}_{\text{Motor}} = \frac{\text{Torque}_{\text{Roll}}}{\text{Ratio}_{\text{Gearbox}}} + \text{Torque}_{\text{Friction}}$$

### Motor Speed

The maximum motor speed will exist under the following conditions:-

- 1) Maximum line speed
- 2) Smallest core diameter
- 3) Maximum gearbox ratio

$$\text{Speed}_{\text{Roll}} = \frac{\text{Speed}_{\text{Line}}}{\text{Diameter}} \times 19.1 \text{ RPM}$$

$$\therefore \text{Speed}_{\text{Motor}} = \text{Speed}_{\text{Roll}} \times \text{Ratio}_{\text{Gearbox}} \text{ RPM}$$

## Imperial units

The following units are used to produce the equations shown below.

Tension - Pounds Force (lbs)

Torque - Pounds Foot (lbs ft)

Line Speed - Feet/Sec (ft S<sup>-1</sup>)

Line accel - Feet/Sec<sup>2</sup> (ft S<sup>-2</sup>)

Rotation speed - RPM (RPM)

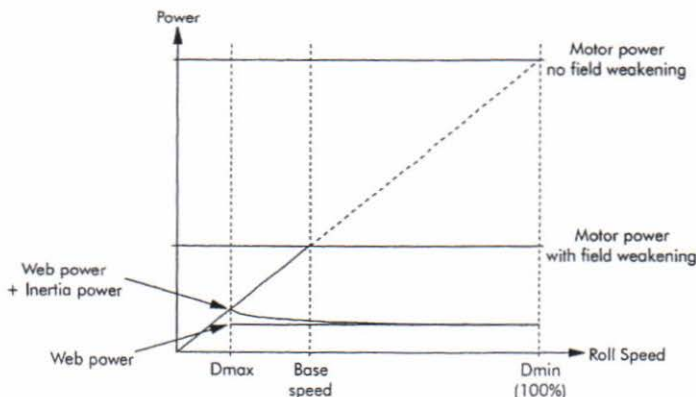
Roll Diameter - Feet (ft)

Power - Horsepower (hp)

Weight - Pounds (lbs)

## Motor Power

The following diagram shows the motor and roll powers at maximum line speed compared to roll speed.



The above graph is for the case of constant tension and friction is ignored.

$$\text{Power}_{\text{Web}} = \frac{\text{Tension} \times \text{Max Line Speed}}{549.8} \text{ hp}$$

$$\text{Power}_{\text{Inertia}} = \frac{\text{Roll Mass} \times \text{Max Line Accel} \times \text{Max Line Speed}}{35391} \text{ hp}$$

$$\text{Power}_{\text{Friction}} = \frac{\text{Motor Max Speed}}{5250} \times \text{Motor Torque}_{\text{Friction}} \text{ hp}$$

Using the above individual roll powers

$$\text{Power}_{\text{Roll}} = \text{Power}_{\text{Web}} + \text{Power}_{\text{Inertia}} + \text{Power}_{\text{Friction}} \text{ hp}$$

Referring to a motor with field weakening

$$\therefore \text{Power}_{\text{Motor}} = \left\{ (\text{Power}_{\text{Web}} + \text{Power}_{\text{Inertia}}) \times \frac{\text{Diameter Build Up}}{\text{Constant Power Range}} \right\} + \text{Power}_{\text{Friction}} \text{ hp}$$

Here, the Constant Power Range is the motor field weakening range.

This parameter is 1 if no field weakening.

**Motor Torque**

The worst case motor torque will exist for the following conditions:-

- 1) Maximum roll diameter
- 2) Maximum acceleration rate
- 3) Maximum roll width
- 4) Maximum material tension
- 5) Maximum roll mass

$$\text{Torque}_{\text{Tension}} = \frac{\text{Tension} \times \text{Roll Diameter}}{2} \text{ lbs ft}$$

Assuming the roll is a solid cylinder

$$\text{Torque}_{\text{Inertia}} = \frac{\text{Roll Mass} \times \text{Line Accel} \times \text{Roll Diameter}}{129} \text{ lbs ft}$$

$$\text{Torque}_{\text{Roll}} = \text{Torque}_{\text{Tension}} + \text{Torque}_{\text{Inertia}} \text{ lbs ft}$$

$$\therefore \text{Torque}_{\text{Motor}} = \frac{\text{Torque}_{\text{Roll}}}{\text{Ratio}_{\text{Gearbox}}} + \text{Torque}_{\text{Friction}} \text{ lbs ft}$$

**Motor Speed**

The maximum motor speed will exist under the following conditions:-

- 1) Maximum line speed
- 2) Smallest core diameter
- 3) Maximum gearbox ratio

$$\text{Speed}_{\text{Roll}} = \frac{\text{Speed}_{\text{Line}}}{\text{Diameter}} \times 19.1 \text{ RPM}$$

$$\therefore \text{Speed}_{\text{Motor}} = \text{Speed}_{\text{Roll}} \times \text{Ratio}_{\text{Gearbox}} \text{ RPM}$$



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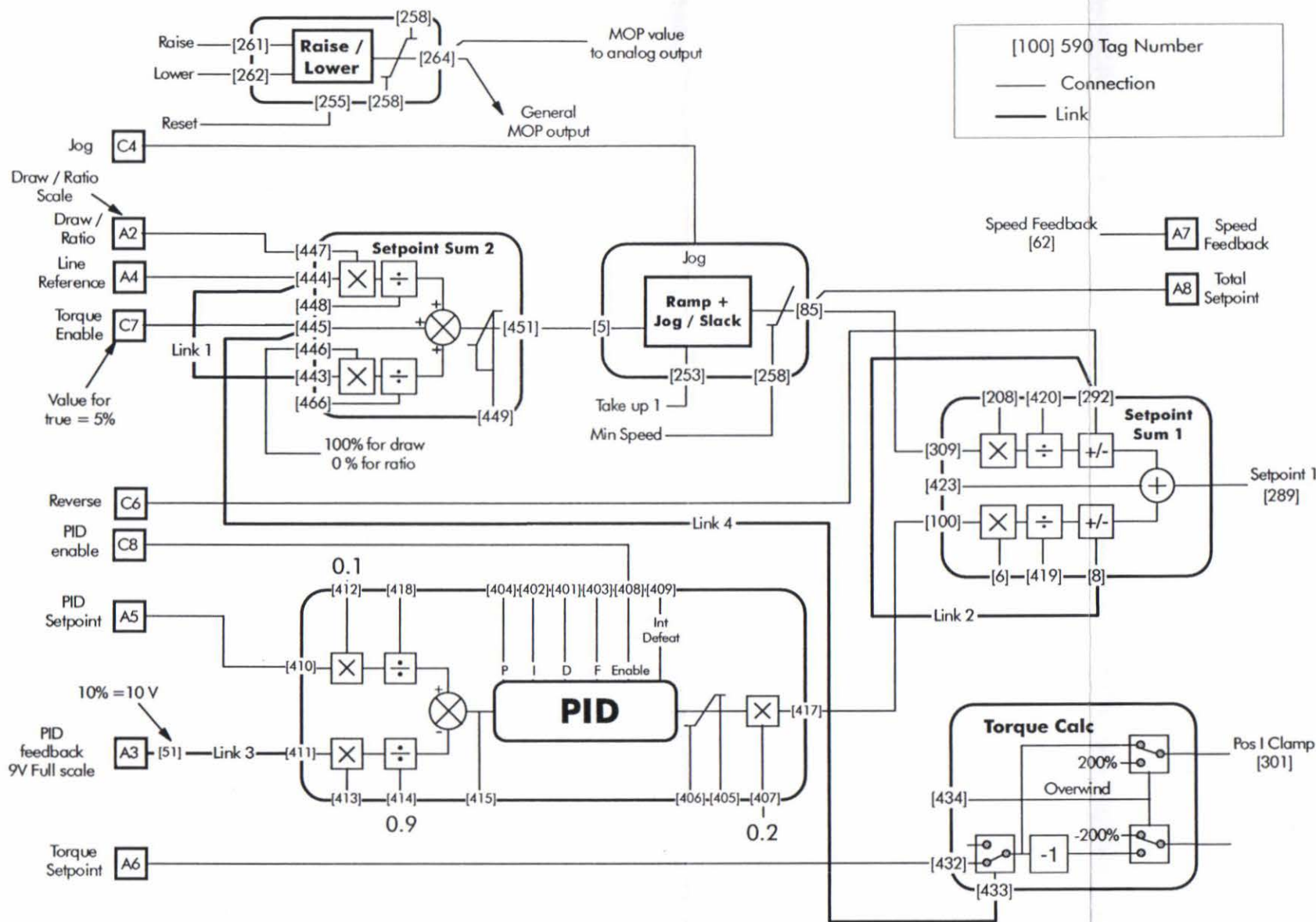
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A 1	Initial Issue of HA388664 First released issue	9516	22-9-94	
FIRST USED ON		MODIFICATION RECORD 590 Digital Section Control		
 <b>EUROTHERM DRIVES</b>		DRAWING NUMBER  ZZ388664	SHT. 1 OF 1	

590 DIGITAL INTERNAL BLOCK DIAGRAM





In order to implement digital Draw / Ratio, the Block diagram must be modified as shown below.

