Automatic winder slitter positioning using a programmable logic controller

Ronald J. Mortenson

The use of a PLC for automatic control of slitter setup positioning typifies its expanding capabilities and brings with it many advantages over previous control systems.

To improve the serviceability, reliability, and simplicity of a new winder, our engineering staff decided to use a programmable logic controller (PLC) for the total winder control, including automatic slitter positioning. This installation involved interfacing the PLC with 37 position feedback encoders, a color graphics display, an intelligent keypad, and motor control for 37 positioning gearmotors, all of which replaced the vendor's dedicated system. The benefits have proven to be well worth the task of interfacing and the additional programming involved.

Interfacing the winder with the PLC

Winder configuration

The winder is a single-drum winder, with six pairs of rewind stations located along either side of the drum and thirteen slitters located over the drum, for a total of 37 devices (**Fig. 1**). A rewind station pair has two halves, each supporting one side of the roll. Not all stations are used for setups of less than 12 rolls, so there is space on either end of the drum to park the ones that are not used. Station pairs are packed by moving them off the drum to reserved positions on either side of the winder. Each of these devices has an ac positioning gearmotor that drives it into position and a position feedback encoder that indicates the absolute position of the device.

The operator's benchboard is centrally located on the operator's side of the winder. In addition to the usual operator controls, there is an operator's video display and a keypad for selecting the display screen and entering the setup data.

The winder control room is located directly behind the drive's side of the winder. It contains the PLC master rack, the positioning gearmotor contractor panel, the position encoder interface module rack, the operator's display controller, the dc drive, input/output (I/O), and the motor control for the rest of the winder.

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Electrical connections

All devices are wired to the control room via festooning in the machine frame.

Figure 2 shows the electrical connections. Each positioning gearmotor is wired to a reversing contactor which is tied to a common bus that can be powered from the 480-V ac line for course positioning or from one of three ac variable-frequency drives for fine positioning. All contactors are controlled and interlocked via the PLC.

Each position encoder is wired to an encoder interface module, which in turn is connected to a data/address bus going to a register input and a register output card in the PLC's master rack.

The operator's display controller and keypad are each connected to two of three RS232 communications ports in the PLC. The third port is connected to the dc drive and accommodates all communications between the two.

Operator's display controller

This device is basically a color graphics terminal with the capability to store predefined displays. Once a display is called to the screen, fields of data and messages are positioned and displayed using the appropriate control codes.

Keypad

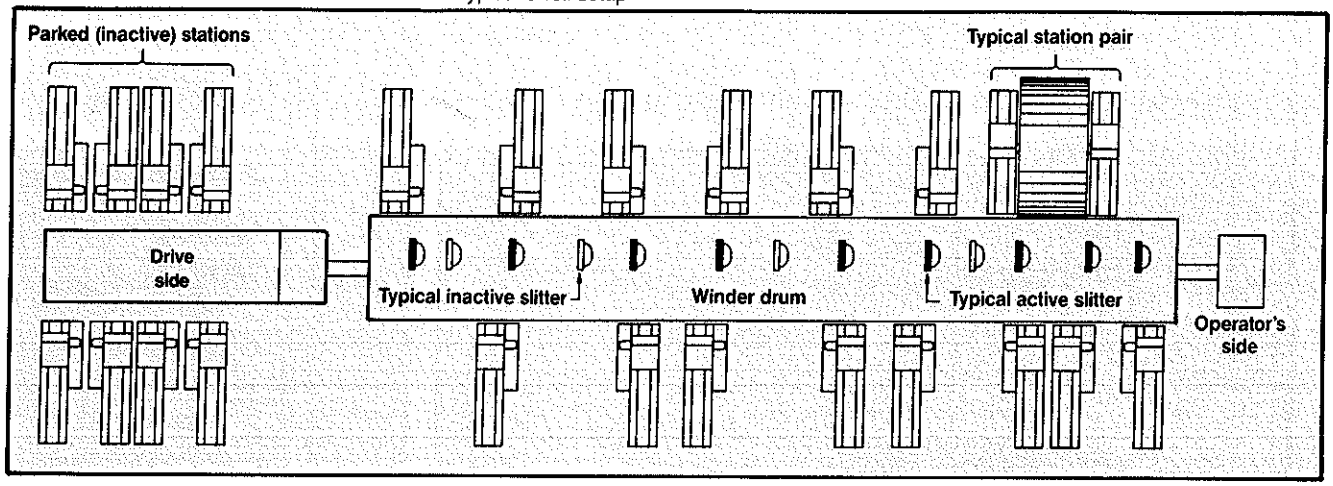
The keypad is an intelligent device that communicates via an RS232 link, using the PLC's native protocol. It has two sections—a 14-key numeric pad and a 12-key function pad.

Four registers in the PLC are used to hold the keypad data. The first register holds the status of special function keys. The second and third hold numeric values, and 12 bits of the fourth register are used to reflect the status of the 12 function keys.

Absolute position encoder

This device is actually a system with two components. The first is a multiturn encoder containing two resolvers geared together, producing a 64-turn, 1024-count/revolution resolution, and a 0.25 mm/count gear in. The encoder is coupled onto a bearing housing that has a pinion

1. Scheme of the slitter and station devices in a typical 8-roll setup



gear meshed with a rack on the machine frame. The housing also acts as a suspension which pivots from one side and is spring loaded against the rack on the other, eliminating any backlash.

The second component is an encoder interface module. It supplies the encoder with the properly phased sinuosity reference signals and converts the feedback signals into a 16-bit transistor-transistor logic (TTL) binary number that represents absolute position. The modules are mounted in a rack, organized in three columns such that their relative positions are the same as the encoder to which they are connected on the machine. A resolver-based encoder was chosen over the winder vendor's optical encoders because of its passive nature, which makes it inherently reliable.

PLC interface card

This integrated circuit card was custom designed in-house to allow a clean means of interfacing the encoder interface module to the PLC. The card serves two functions. First, it allows the module's data, address, and power lines to be tied together on a common bus that is connected to the register input card, register output card, and power supplies, respectively.

Second, it provides address decoding logic so that each module has a unique address, which the PLC uses to enable the data output for subsequent reading. The card plugs onto the back of the encoder interface module using three D-style connectors. A 26-pin ribbon bus cable plugs into each interface card, taking all TTL-level signals to the PLC. A special power bus cable supplies the dc current at +15 V, -15 V, and +5 V to all the modules.

Operator's displays

There are two operator's displays, the "setup data entry" and the "drive status" displays. Each is called up by the appropriate function key on the keypad.

Setup data entry display

The display for "setup data entry" shows an illustration of the winder drum and a table of allowable setup values.

When the display is called up, the operator is first prompted for the number of rolls in the setup. On entering this value, he is prompted for the individual roll widths. Each roll width is entered in millimeters, and each value is displayed in the approximate position that the roll will be located along its respective side of the drum.

This arrangement gives the operator a representation of the location of each roll in the setup. When the last roll width has been entered, the total width is displayed. A message indicates that the permissible widths have been met and that the operator is to proceed with setup positioning.

The operator enters a code to begin positioning. If a device stalls during positioning, the fault is enunciated on the display, at which point the operator can choose to manually assist the device into position or terminate the setup. On completion, a "positioning complete" message is displayed, and the winder is ready to run the new setup.

Throughout the data entry process, all values entered are validated before they are accepted by the system. As a backup, in the event the keypad or the operator's display fails, the PLC is programmed to allow the electrical maintenance personnel to enter and initiate a setup via the PLC's programming terminal.

Drive status display

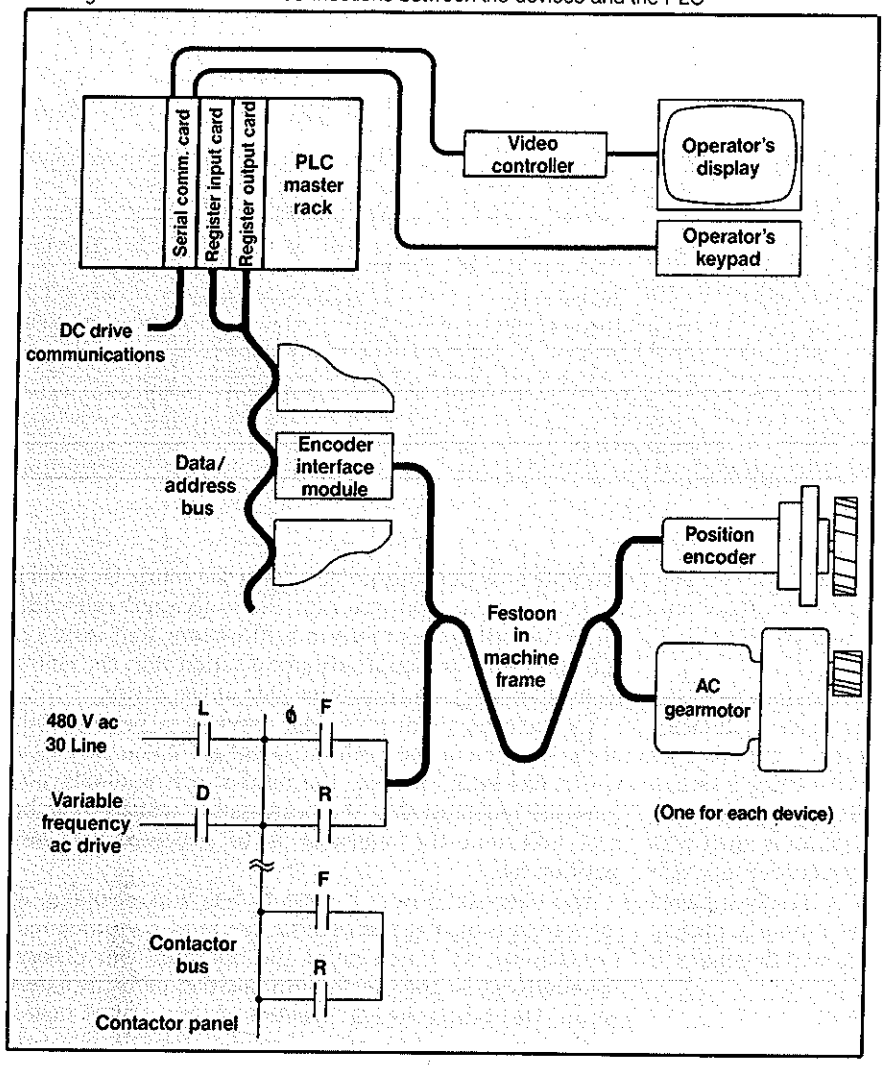
This display is presently a status display only. It contains four dynamic bar graphs, indicating unwind current, tension, drum current, and web speed. The number of inches of paper on the unwind is also displayed in digital form.

Drive status and drive fault messages are displayed to indicate the drive status at any particular time.

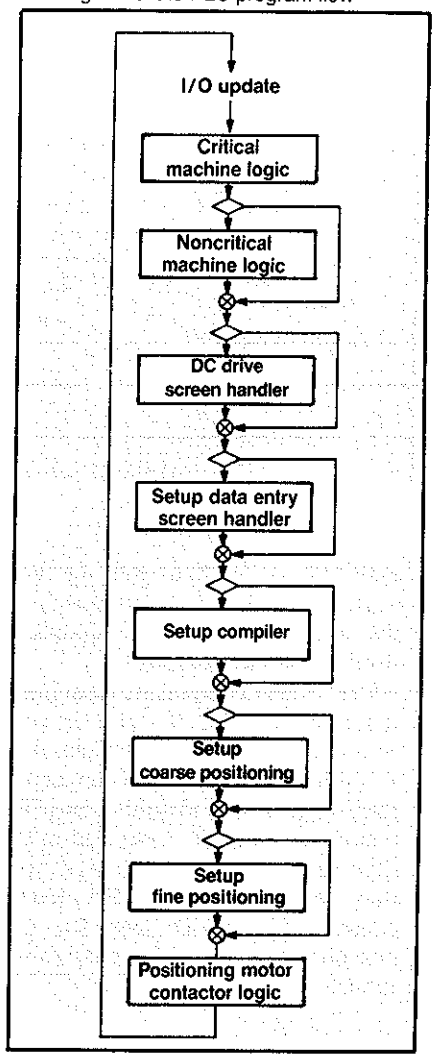
Programming

The program is broken down into eight sections, as shown in **Fig. 3.** The machine logic is organized into two groups according to whether or not the logic needs to be scanned during setup positioning. The noncritical logic is bypassed during positioning to save scan time. The remainder of the program is dedicated to the screen handling and the setup positioning routines.

2. Diagram of the electrical connections between the devices and the PLC



3. Diagram of the PLC program flow



DC drive screen handler routine

This routine is called up by the appropriate function key on the key pad. Once called, it simply updates the bar graphs and the data fields as described in the operator's display section.

Setup data entry routine

This routine inputs the setup data and initiates positioning as described in the operator's display section.

Setup compiler routine

This routine takes the roll widths entered in the "setup data entry routine" and performs an algorithm that calculates the target positions of each of the 37 devices. Also, it determines the active devices for use in the machine logic. This routine is executed only once per setup during a single scan.

Coarse positioning routine

This routine reads the positions of all the devices and causes them to move via reversing contactors across the ac line toward their respective target positions. When the device gets to within ±10 mm of its target, it is dropped off the line. When all devices have been positioned, coarse positioning is complete and fine positioning begins. The scan update time during coarse positioning is 62 ms.

Fine positioning routine

In this routine, as many as three devices are positioned simultaneously, one from each group of devices. These groups are the 13 slitters, the 12 stations on the front side of the drum, and the 12 stations on the back side of the drum. The routine begins by checking successive active devices of each group to see if they require positioning.

When as many as three devices are found, they are moved in the appropriate direction via three variable-frequency ac drives at 12 Hz. As each device reaches its target position within ±0.5 mm), it stops. When all three devices have reached their positions, the process repeats itself until all active devices of each group have been positioned. At this point, a "positioning complete" message is displayed.

As with the coarse positioning routine, if a device stalls while positioning, a fault is enunciated on the display. The scan time for fine positioning is 38 ms.

Advantages to using a PLC

Performance

This PLC positioning system is basically a functional replacement of the vendor's dedicated system and matches its performance in accuracy and speed. With the exception of a keypad, we have not had a single failure of the system to date.

Simplicity

The only additional PLC hardware required to accommodate the positioning system were three Multibus® cards in the PLC master rack and the contactor panel I/O (86 points). The PLC, display controller, and the encoder interface module rack are all on one panel. The vendor's original system had three, full-height, 19-in. rack enclosures, consisting of mostly dedicated hardware, plus six multiplexing boxes. Consequently, hardware was reduced by approximately 50%, which in itself makes the system more reliable and easier and less costly to maintain.

Serviceability

Our mill presently has over forty PLC systems installed, most of which are from the same vendor. From the maintenance standpoint, this means there is a continuity of hardware and troubleshooting techniques between PLC systems, and there is minimal training as new systems are brought on-line. Because the positioning system is simplified and the environment is familiar to us, the learning curve is less difficult to overcome in troubleshooting than with the vendor's dedicated system, where there may be only one system from which to draw experience.

The PLC hardware is common to many other systems, reducing our spare parts inventory and allowing us to swap parts between PLCs. All the components were domestically supplied, "off the shelf" items, making replacement parts easier and less expensive to obtain.

The generic nature of the PLC has allowed third parties to develop documentation software, which we use extensively to provide fast, accurate, and easy-to-maintain program documentation. This documentation has become essential because of the dynamic nature of PLC programs, and the software has allowed us to tailor the documentation for our maintenance staff.

Conclusions

We have seen control technology change drastically in the last ten years. With it, the capabilities of the PLC have expanded from simple logic control to that of its being a versatile control tool. The application of the PLC to automatic slitter positioning typifies this versatility and allows users to develop systems that have a consistent environment and are easier and less expensive to maintain.

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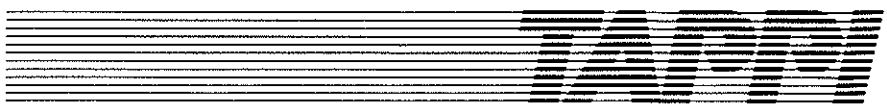
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