Walla Walla University

Automated 3D Filament Spooling System

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Introduction

A local company called ProtoParadigm based out of Milton-Freewater approached Professor Stirling with a problem. ProtoParadigm makes 3D printer filament and had recently acquired a client who wanted filament spooled onto custom spools for a small 3D printer. These small spools, however, were being loaded manually onto a spinning machine to be spooled. This process is time consuming and the workers who are operating this machine could be working elsewhere. The problem that we were posed with was how to automate this process.

The automation process would require starting with a master spool of filament, and ending with the small spools wound and their filament constrained. This process involves guiding the filament off of the master spool, through a distance counter, and to the spool while maintaining reasonable tension. The filament first leaves the master spool and is passed under a dancer, or dynamic tensioner, and through rollers to pass through a rotary encoder to count distance of filament passed through the system. Past the encoder, the filament enters a driving motor connected to a one-way bearing roller. This allows the filament to be pushed forward during the initial attachment phase but still run freely during spooling. After the driving motor, the filament is run through a tungsten tube connected to a stepper motor that oscillates back and forth, guiding the filament evenly across the spool. The spool is spun with a motor and simple drive system until the proper length is reached, upon which time the filament is clipped to the side of the spool and then cut, freeing the filled spool to be ejected from the process.

Instructions

Below are instructions for loading the machine, starting the machine, and clearing jams.

Loading the Machine

- Remove any spool currently loaded in the system. This is most conveniently and reliably done by: 1.) putting the system in switches mode and engaging the brake, making sure that the system is on 2.) cutting any excess filament loaded into the system, making sure to have a firm grip on the filament on the spool 3.) feeding the remaining end of the filament into the holes in the side of the master spool such that the filament won’t unravel

from the spool when untended 4.) Disengaging the brake and 5.) while pulling up on the

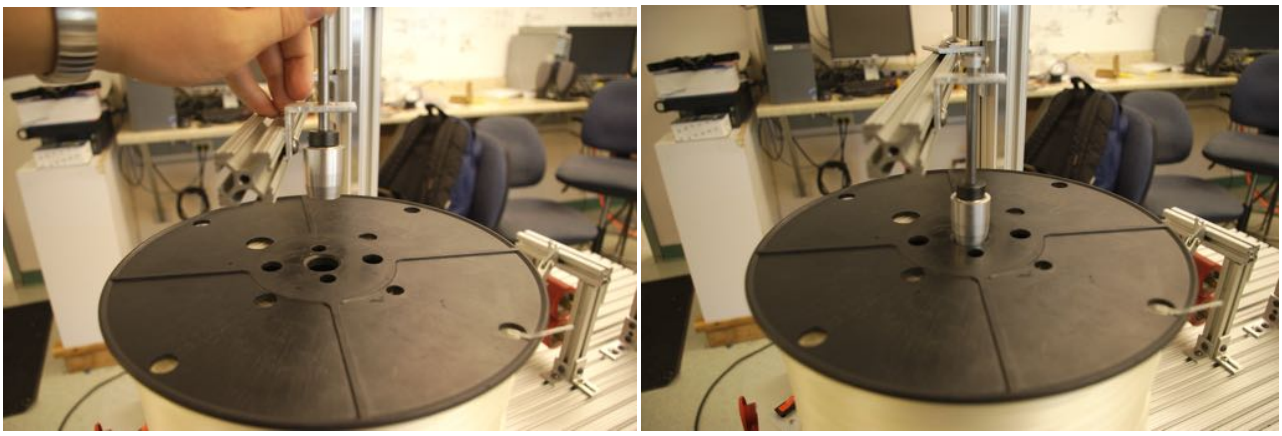


Figure 1. Disengaging the spindle.

spindle on the top the spool, lift the spool up and out of place.

- Remove any filament currently threaded in the system. This can be done by pulling on one end, making sure not to break the rotary encoder or drive motor.

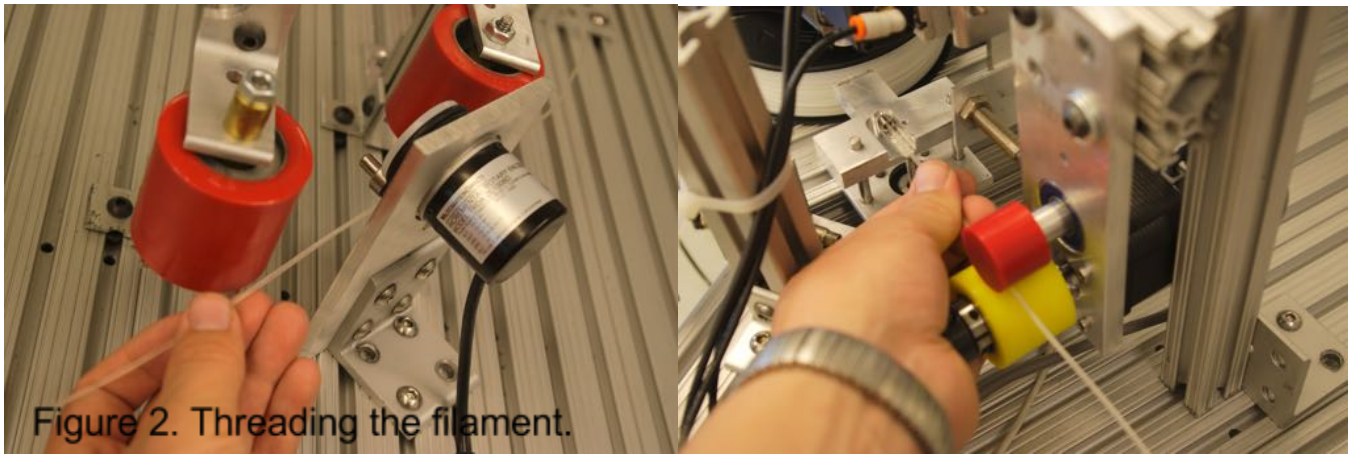


Figure 2. Threading the filament.

- Loading the spool and threading the filament into the system. This is best done by: 1.) placing the spool next to the bearing it would normally sit on, 2.) pulling up on the spindle, and sliding the spool onto the bearing, making sure to not slide the bearing out of place, 3.) releasing the spindle, making sure it loosely fits into the center of the spool, 4.) engaging the brake (make sure the system is on and in switches mode), 5.) taking up three loops of filament, making sure to keep tension on the spool at all times, 6.) clamping the filament leaving the spool onto the side of the spool such that it won't move, 7.) feeding the loose end of the filament through the rollers, rotary encoder, and drive motor all the way through the end of the tungsten tube, 8.) releasing the clamp that

was holding the filament onto the spool, 9.) pulling on the end of the filament coming out of the tungsten tube, 10.) making sure the filament is threaded correctly through the system, and 11.) cutting off the remaining filament directly in front of the tungsten tube (on the side feeding into the spool)

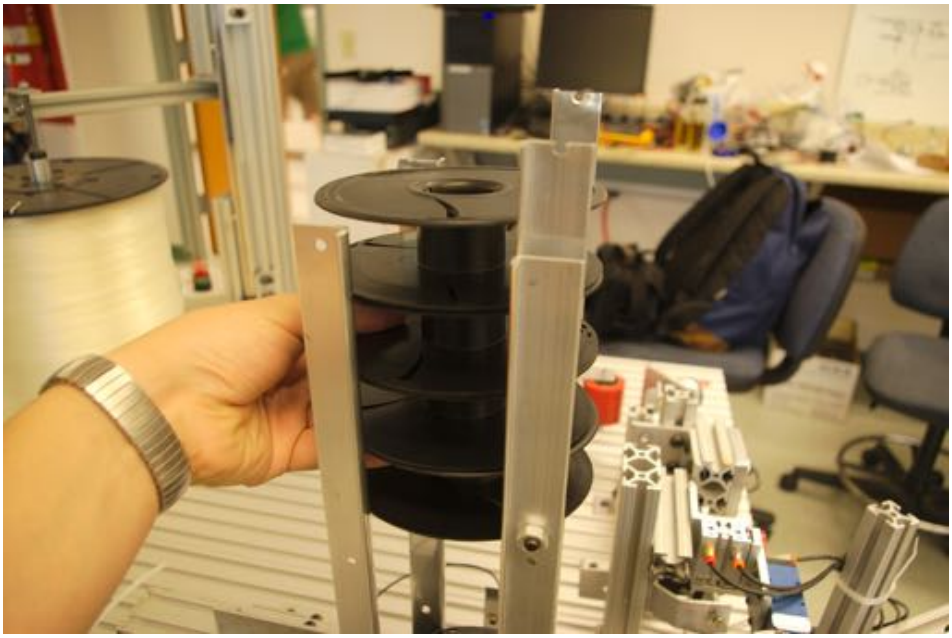


Figure 3. Putting spools in the feeder.

- Making sure there are enough spools loaded into the machine, and clearing any loaded spools or obstructions from the spooling area. When loading the spools, make sure all of the spools are loaded with the threading hole on top, otherwise the filament will not be threaded into the spool and the machine will jam.
- Feed a clip into the clipper. This is done by turning off the system, placing a clip into the jaws of the clipper, and then turning the system back on. (a feed system for clips may be added in future versions)

Starting the Machine - Pre-operational Checks

Before running the machine, a few checks need to be made.

- Make sure the filament is correctly threaded through the system such that it centered inside each of the rollers, the rotary encoder, and the drive roller, the tensioner rests on top of the filament, and that it extends right through the tungsten tube up to the end.
- Make sure all of the spools are loaded with the threading hole on top, otherwise the filament will not be threaded into the spool and the machine will jam.
- Make sure no spools or obstructions are in the threading area.

- Check to make sure there are no obstructions in the way of the pneumatic cylinders, and that nothing is blocking any of the sensors.

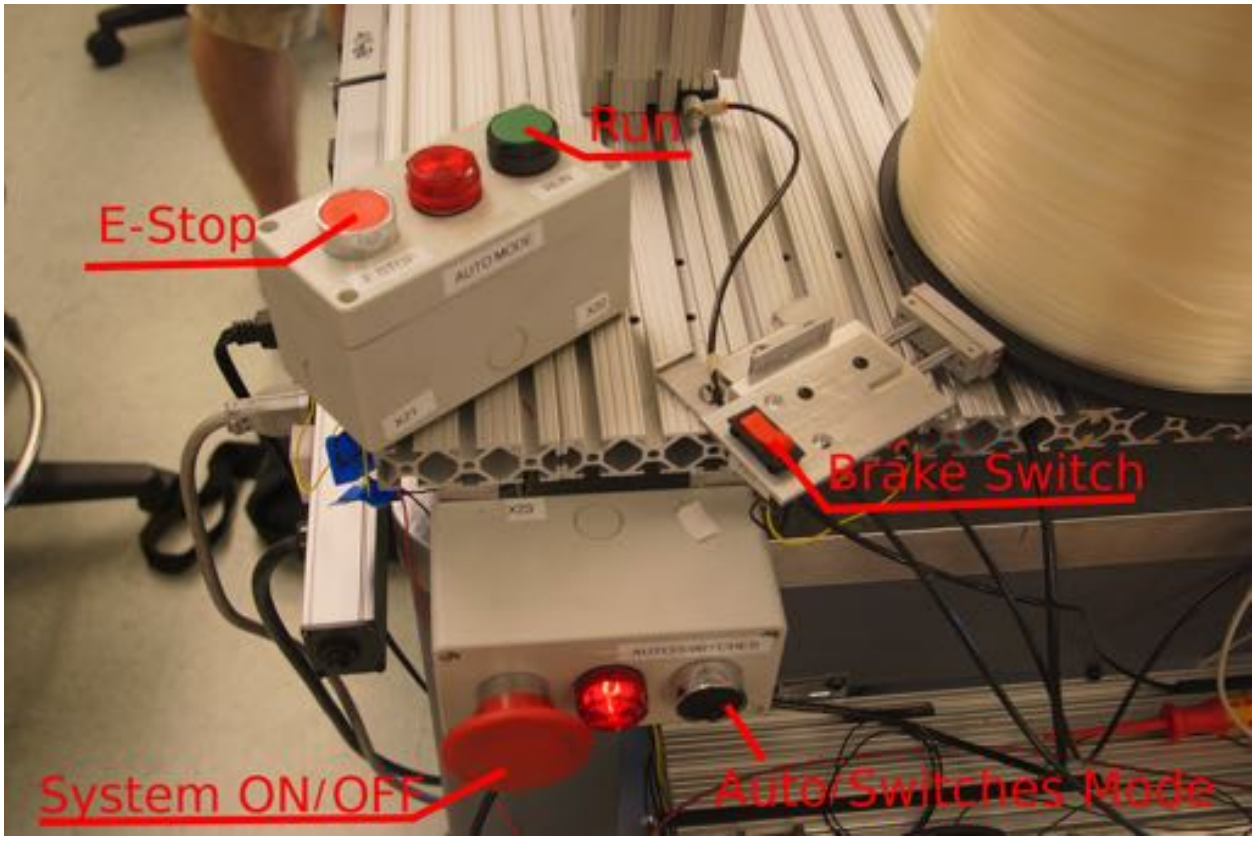


Figure 4. Operation switches.

Then the system can be run.

- Turn the system on by twisting the big red system on/off button.
- Turn on the PLC with the white switch..
- With the system and PLC on, press the green run button to start the machine.
- Monitor the first few spools to ensure all of the processes are working correctly.
- If something goes wrong, press the red e-stop button to pause the machine at any point in the operation. (make sure to clear any resulting obstructions)
- When the system is done, press the red e-stop button to stop the operation of the machine. (again make sure to clear any resulting obstructions)

Clearing Jams

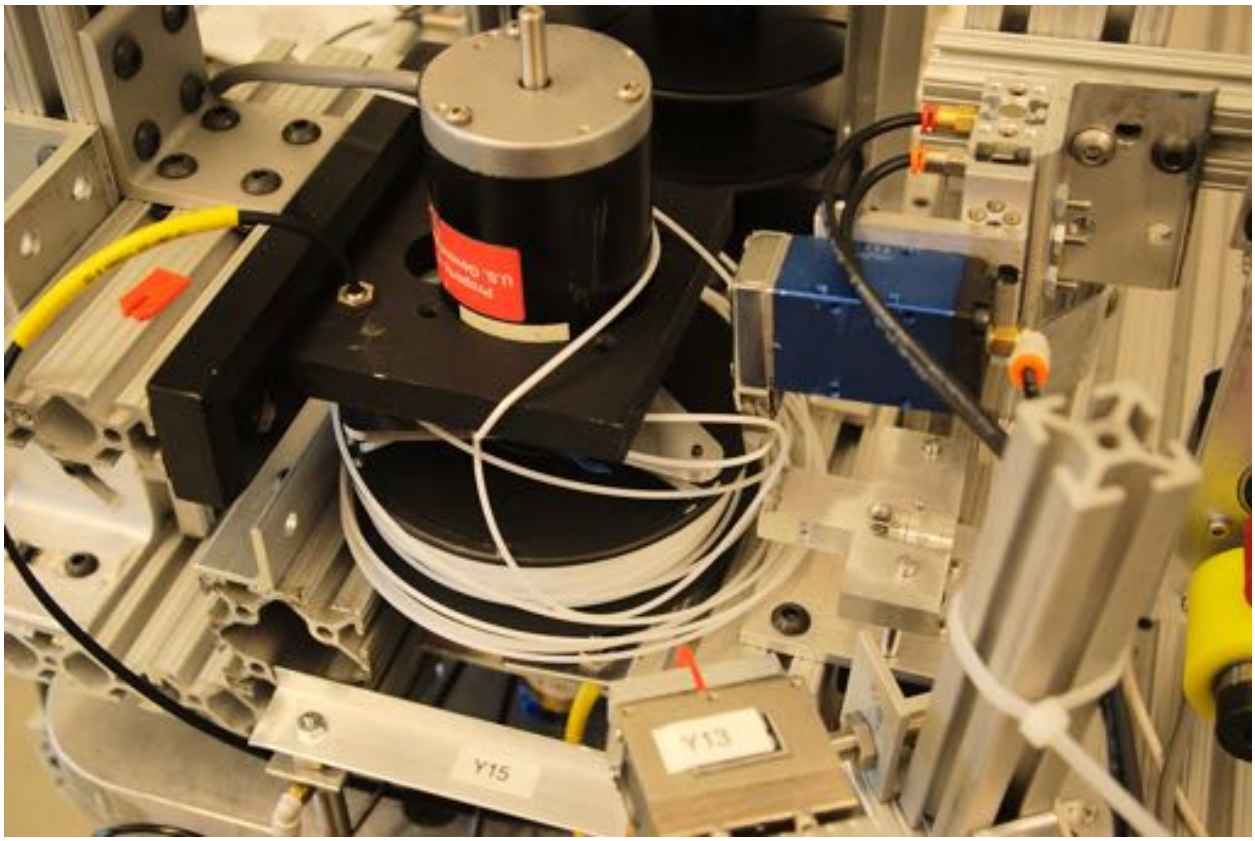


Figure 5. An example of a jam.

- If the filament winder develops a jam, first turn the machine off and check where the jam occurred. The most common places a jam will occur are near the small spool winding section or near where the filament is being unwound off of the large spool.

- Check if the filament is damaged by looking for tight bends and breaks. If the filament is damaged, cut the damaged section out by snipping the filament at a point before the area where the damage occurred.

- Remove the section of filament that was cut off and inspect the machine to ensure everything is still aligned and no damage occurred.

- After the machine has been inspected, thread the filament back through the rollers as described in the loading section. Use wire cutters to cut any extra filament off as close to the pneumatic cutters as possible so that the filament looks as it would when the spool is being changed.

Machine Processes

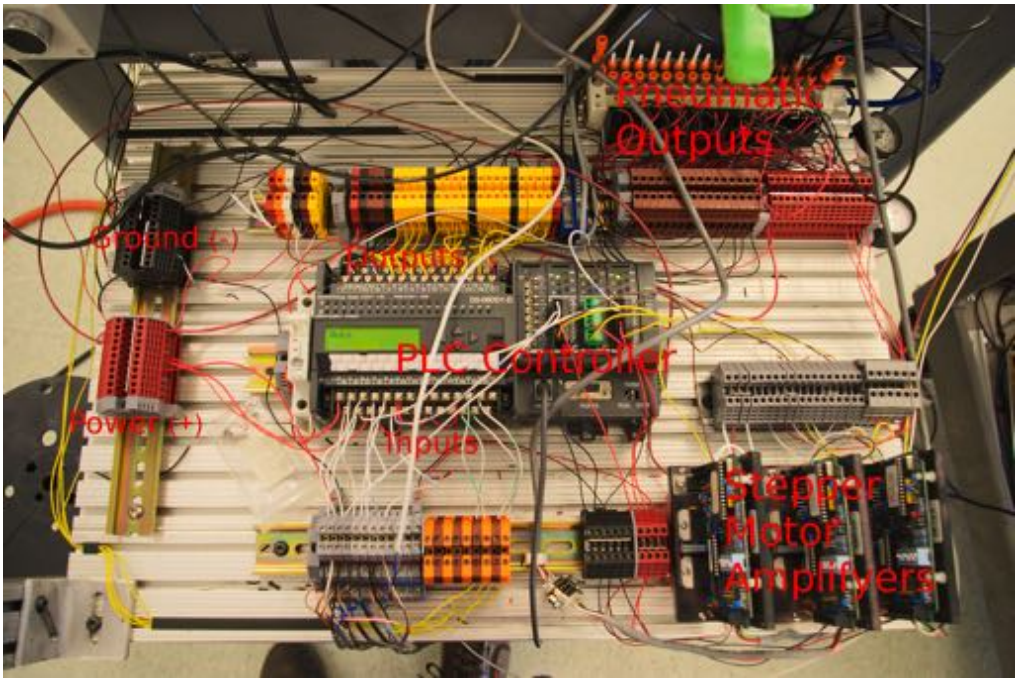


Figure 6. PLC wiring board.

Wiring and Controllers

This part of the system controls the motion and operations of the entire system. The PLC controller is programmed to control the entire system through its outputs. It outputs to to the pneumatic cylinders used by the various pushers and jaws in the system using a pneumatic valve manifold. It also controls the motors throughout the system using stepper motor amplifiers. Finally, it takes electrical inputs from different sensors which sense the locations of the various components so that they can be controlled based on actual data about their position.

Master De-spooling System

The large spool is supported by a bearing on the bottom and a holder containing a bearing on top. The top holder is made so that it can be retracted to replace the spool. A brake is mounted on the table at the bottom of the spool and actuated by a pneumatic cylinder to press against the bottom rim of the spool. This provides a way for us to control the rotational speed of the spool as well as a way to stop it when changing small spools.

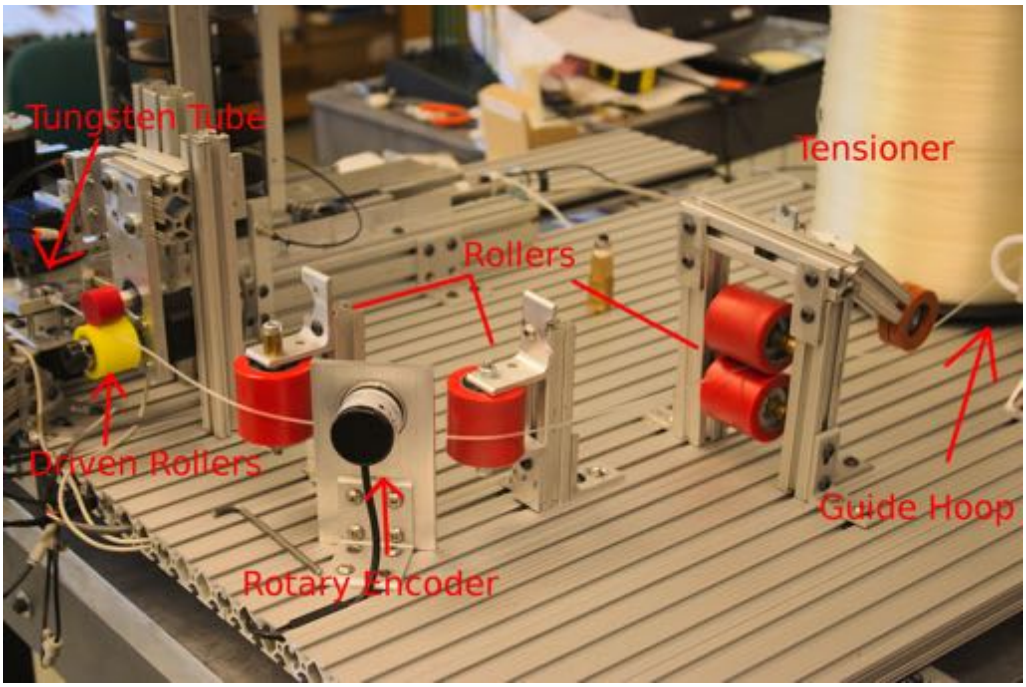


Figure 7. Filament transport system

Filament Transport System

The filament is guided from the big spool to the winding device by traveling through an aligning hoop, a weighted tensioner, free spinning rollers, and a counter. The counter measures the length of filament that has passed through it in feet by using an incremental rotary encoder that measures the change in angle of a roller of a known diameter. The filament is then fed to the small spool through a pair of driven rollers containing a one way pin bearing. This bearing allows the rollers to spin freely in one direction and locking to the shaft when it is turned the opposite way. The rollers will only be used to drive the filament when it is being inserted into a new spool. Once the filament is started in the spool the drive motor on the rollers will be turned off and the rollers will freely spin as the filament is pulled through. The last guiding mechanism the filament will pass through before the spool is a polished tungsten tube connected to a stepper motor with an assembly to move it vertically. The vertical motion will be used to both direct the filament for initial attachment to the spool as well as control the filament so that it winds evenly on the spool.

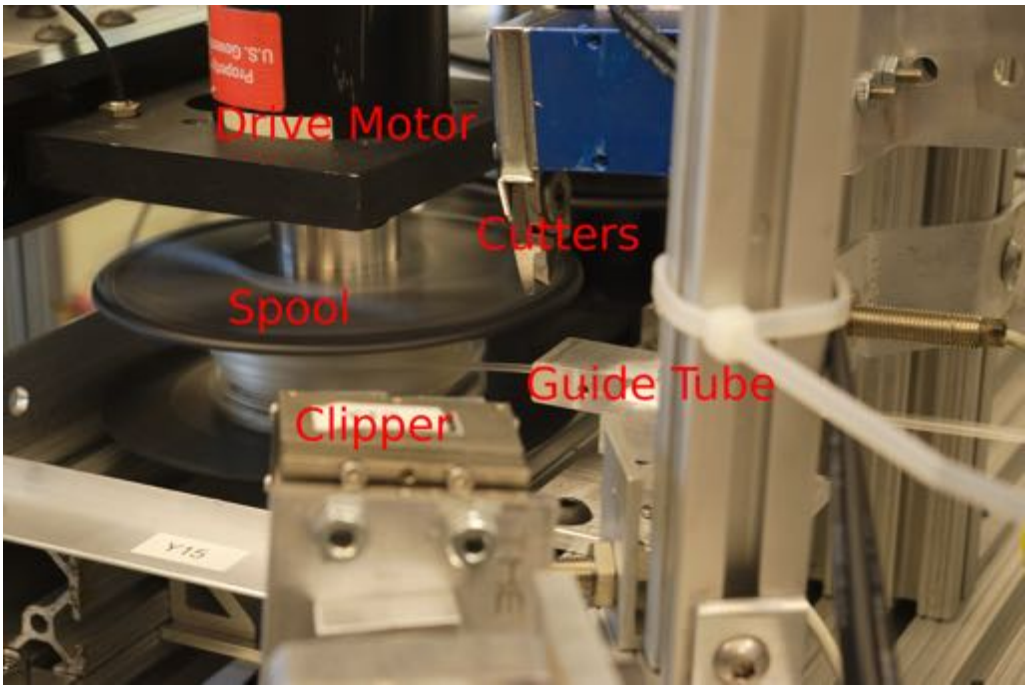


Figure 8. Spooling system.

Switching Spools

When the spool is full the tungsten tube will be lifted to its highest location so that a pneumatic device can push a clip that holds the filament to the rim of the spool so that it will not unwind. A

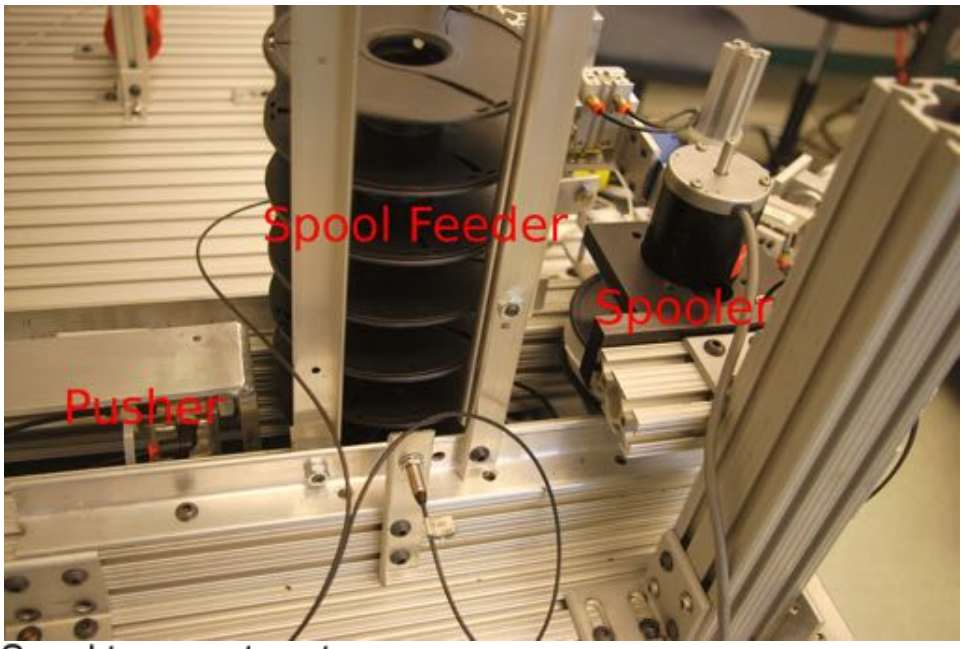


Figure 9. Spool transport system.

pneumatic wire cutter connected to a pneumatic cylinder is then moved into position to cut the filament. The wire cutter is then moved vertically out of the way
once the filament is cut. The spools are loaded in a stack so that they sit flat on top of each other. The stack consists of four vertical bars, two of which are wider apart at the bottom to allow a spool to be removed from that side. Once the spool is full, a ram connected to a pneumatic cylinder pushes a new spool against the full one.

The full spool drops into a box, the new spool is put in position, a stop is lifted to keep the new spool in place, and the ram has a flat plate on top to hold the stack of fresh spools in place while it is extended.

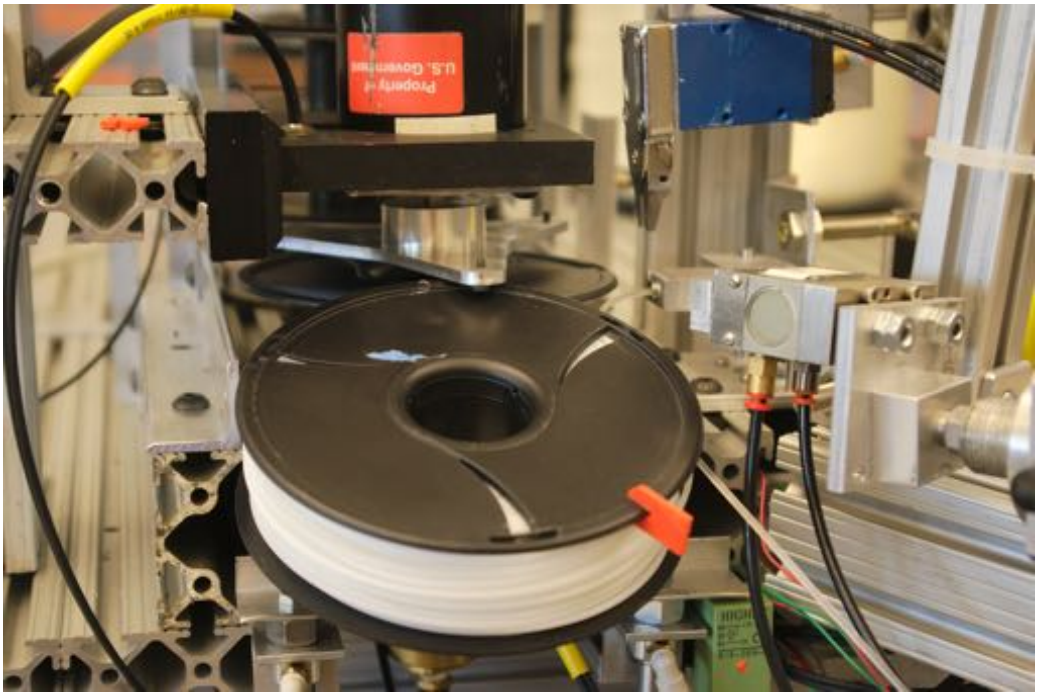


Figure 10. Finished spool dropping out of the machine.

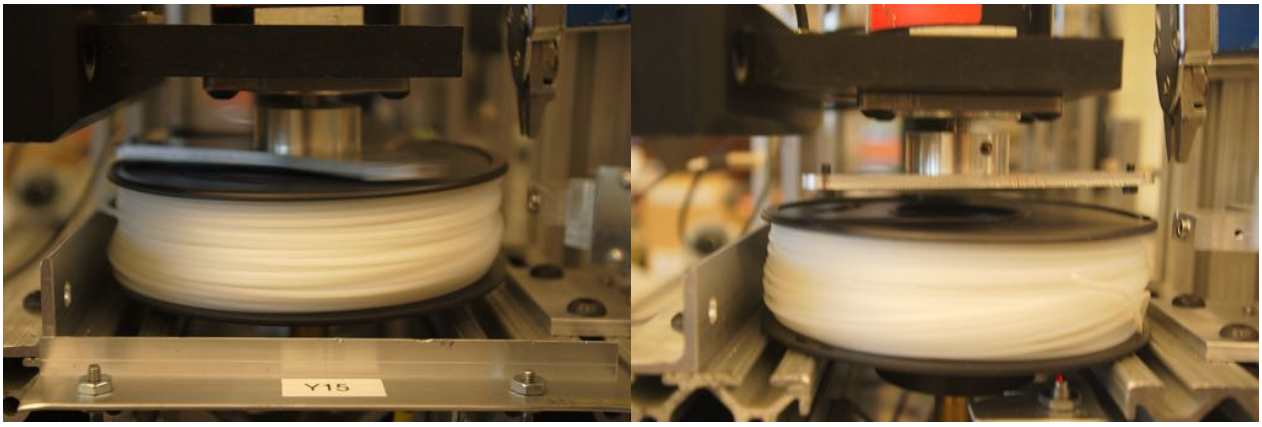


Figure 11. Spool engaged in the motor (left) and disengaged (right).

Winding the spool

A pneumatic cylinder pushes a tapered bearing attachment from the bottom of the spool to lift it up against a plate attached to a stepper motor above. The plate is fitted with studs that align to drop into slots on the top of the spool to provide grip to spin it. The motor is spun 1/3 revolution slowly to ensure the plate is lined up. The tungsten tube then lines the filament up with a hole drilled in the core tube of the spool and the driven rollers push the filament until it is in. The spool then begins to slowly begin spinning until the filament is firmly connected. At this point the spool will be spun at 250 ft/min while the tungsten tube is moved up and down to guide the filament.

Maintenance

To maintain the machine, the master spool, spool stack, and clip feeder should be checked every 4 hours to see if they need to be refilled/replaced. After changing the master spool, watch the machine operate as it loads the next couple of spools to make sure it is working properly. At the end of each day of operation the sensors should be tested to ensure they are still working correctly. In order to do this, activate each sensor one by one and watch the lights on the PLC that correspond to the sensors to make sure they light up. The brake pad should also be inspected after every week of operation to determine if it needs to be replaced after too much wear. While checking the brake pad the alignment of all components should also be inspected in case some fasteners have loosened.

States and Logic

Initialization State Machine

This state is run one time on PLC boot-up. This state machine determines whether or not a spool is currently loaded or not. If no spool is loaded, the pusher will engage, however, if a spool is already in place, this state machine will jump to a “Done” state.

Main State Machine

This state machine is in charge of which mode the PLC is in, initializing a run sequence, and handling the “Switches” mode.
The default startup mode is “Auto”, however, you may press the black button next to the power button to change to “Switches” mode.

Auto Mode

Auto mode is simply a wait state for user input. The two options are to run a spooling sequence by hitting the green “Run” button, or pressing the black “Auto/Switches” button. After a run sequence is initiated, the state machine will jump into wait mode where it will stay until all of the later processes output “done” or “ready” coils.

Switches Mode

In switches mode, the user is able to individually toggle the switches on the PLC module to run specific tasks. These tasks are each limited by logic to prevent jamming or crashes. If any operation is to be called that could cause a crash, the PLC will jump to an error state. in this error state, an error read out will appear on the screen with a resolution to the problem.

Spooling State Machine

This state machine is called by a coil in “Auto” mode. Once this coil has been called, the process of spooling will continue without any further user input.

This state begins by checking for a loaded spool. If there is no loaded spool, one will be loaded. Immediately after the spool is loaded, a stop gate is raised and the aligning center pneumatic is raised; the motor is now engaged. The feeder state machine is then called and the spooling state waits for a “done” coil output. Once this has been completed, the state machine resets the digital encoder, is given a velocity command, and the output is activated. the motor will then spool up and continue until the encoder reads greater than or equal to a predetermined count (245 ft. or 61,250 counts). This number is relayed in hex from the digital encoder through the module loaded in slot 4.

Just prior to spooling the state machine calls the bouncer coil. The bouncer is then suspended when the encoder outputs its predetermined count (245 ft. or 61,250 counts).

Once this output has been reached, a velocity of “0” is sent to the motor and it decelerates until stop. At this point the output is reset and the motor is sent a K2 command. This is the homing sequence for the motor. By homing the motor, we are able to avoid any snags caused by spools hitting the motor attachment upon exit.

After homing, this state machine then calls the Clipper coil and waits for a “done” output from both the Clipper and the Cutter. Once these commands are completed the aligning pneumatic is lowered along with the safety gate. the spool is ejected and a new one is loaded. This state machine will now wait in the “done” state until a command in the main state machine’s wait state is active.

Every state in this state machine has an emergency stop rung built in. This emergency stop is an immediate jump to the initial state and will kill all other processes. In retrospect, it would have been much easier to use a method similar to the damper switch by using “SET” and “RST” commands.

Bouncer State Machine

(Oscillating Motor for evenly distributing filament on the spool)
This state machine was never fully completed. Due to some restrictions with live time outputting, the true nature of the bouncer was never achieved. In its current mode, the bouncer will run a very slow trapezoidal motor profile in the downward direction until being suspended by the spooling state machine. Once the motor has been suspended, it is homed upward to a position that can allow for clipping and cutting of the filament. It will then wait in its “done” state until notified by the spool state machine.

Clipper State Machine

This state machine relied on an inductive sensor output. the pneumatic cylinder extended until the sensor was high. Once this sensor was high, the jaws were opened and the cylinder returned. After this operation the “done” state sent a coil to begin the Cutter state machine.

Cutter State Machine

This state machine is very similar to the one above, Once being called, the sliding pneumatic is lowered and the clippers engaged, Both states output a done command and wait until the spooling state has returned to “ready”

Spool Damper State Machine

This state machine is simply an on/off command for the spool damper. The operator can toggle the switch on the damper to engage or disengage the the brake. The state machine does check for a “ready” command from the spooling state. If the spooling state does not output the “ready” command, the switch will not work.

Performance Data

Many improvements could be made to the system before we are able to have consistent spooling. Our current configuration of a sideways master spool causes tension problems throughout the system. The tensioner is not ideal and needs to be redesigned to adequately hold the filament as it passes through. Our filament guidance system, from the master spool to the driving motor, is adequate and works at high speed. The high speed encoder module is consistent and accurate when measuring filament. Our drive motor and one way bearing work well, except the filament has the tendency to jump out of the gear. The method used for feeding spools into the system works reliably and simply, allowing for easy spool loading with only two moving parts. Severing the filament at the end of spooling with the pneumatic cutters is efficient and reliable. Clipping the filament to the spool will need to be updated as it currently only works about 20% of the time. Our programming is efficient, barring the bugs we discovered when programming the PLC.

All in all, our system performs well and efficiently. With some basic improvements, the system could be a reliable, efficient, and time-saving device for ProtoParadigm.

Future Improvements

A number of improvements need to be made before our system can be considered fully-functioning. While the current prototype effectively demonstrates the concept of the system, and most of the components and systems do work, it will need further tweaks and adjustment to work as intended. Some of the output commands for the motors in the system work in the programmed logic, but are not reaching their destinations, which can cause problems like the spooling motor not homing the spool, the tungsten tube not moving up or down, the tungsten tube not moving and the filament drive not driving. This could be fixed done by programming and running the motors separately in LinuxCNC rather than running stepper motor amplifiers from the PLC. Additionally, the filament is difficult to mount in the rollers without it coming out, and it may sometimes come out during operation. Cutting grooves in the rollers could improve the ease-of-threading and reliability of that system. Finally, there is no clip feeder, which means that the system can only be run once, with a technician manually turning off the system and replacing the clip each time.

Other improvements on the concept itself could also yield better productivity from the system. Placing the master spool in its place and threading the filament through the system is difficult to do without it the spool dropping loops of filament underneath it, which are extremely difficult to dislodge without perpetuating the problem. A good fix for this would be to mount the spool horizontally instead. Finally, while attaching the filament on with the clip at the end has been shown to work with no filament on the pusher and with filament by hand, placing the filament in the right spot with the tungsten tool such that it is lined up with the tube may be too challenging to do reliably. Because of this, other methods such as wrapping the spool in plastic just after cutting the filament could be used to attach the filament instead.

Appendix A - Ladder Logic

(Visual Ladder follows document)

```
PLC 06

// Rung 1
// Address 0
ISG S1000

// Rung 2
// Address 2
STR SP1
LCD K2 """Initializing..."""

// Rung 3
// Address 14
STRN X1
ANDN X0
OUT Y17

// Rung 4
// Address 17
STR X4
AND X0
STR X3
AND X0
ORSTR
JMP S1001

// Rung 5
// Address 23
SG S1001

// Rung 6
// Address 25
STR SP1
TMR T10 K10

// Rung 7
// Address 29
STR T10
LCD K2 """" """"
TMR T11 K3

// Rung 8
// Address 37
STR T11
JMP S1002

// Rung 9
// Address 39
SG S1002

// Rung 10
// Address 41
```

```
STR SP1
OUT C1000

// Rung 11
// Address 43
ISG S0

// Rung 12
// Address 45
STR SP1
TMR T0 K3

// Rung 13
// Address 49
STR X23
AND T0
AND C1000
JMP S1

// Rung 14
// Address 53
STR X22
AND C1000
JMP S5

// Rung 15
// Address 56
STRN X21
SET C77

// Rung 16
// Address 58
STR X21
RST C77

// Rung 17
// Address 60
STR SP1
LCD K1 """Auto"""

// Rung 18
// Address 66
SG S1

// Rung 19
// Address 68
STR SP1
TMR T1 K3

// Rung 20
// Address 72
STR T1
AND X23
JMP S0

// Rung 21
// Address 75
```

```
STR X104
OUT Y14
TMR T2 K5

// Rung 22
// Address 80
STR T2
OUT Y13

// Rung 23
// Address 82
STR X100
OUT Y16

// Rung 24
// Address 84
STR X101
ANDN X102
ANDN X100
OUT Y17

// Rung 25
// Address 88
STR X101
AND X102
STR X101
AND X100
ORSTR
JMP S4

// Rung 26
// Address 94
STR X1
STRN X0
ANDN X100
ORSTR
ANDN X107
JMP S2

// Rung 27
// Address 100
STR SP1
LCD K1 """Switches"""

// Rung 28
// Address 108
STR X102
OUT Y15

// Rung 29
// Address 110
STR X105
TMR T3 K3
OUT Y10

// Rung 30
// Address 115
```

```
STR T3
OUT Y11

// Rung 31
// Address 117
STR X106
OUT Y12

// Rung 32
// Address 119
SG S4

// Rung 33
// Address 121
STR X102
LCD K1 """Error: Flip X102"""
OUT Y15

// Rung 34
// Address 134
STRN X102
LCD K1 """ """

// Rung 35
// Address 139
STR X100
LCD K2 """Error: Flip X100"""
OUT Y16

// Rung 36
// Address 152
STRN X100
LCD K2 """ """

// Rung 37
// Address 157
STRN X100
ANDN X102
AND X101
LCD K1 """Error: Flip X101"""

// Rung 38
// Address 171
STRN X100
ANDN X101
ANDN X102
AND X3
JMP S1

// Rung 39
// Address 176
SG S2

// Rung 40
// Address 178
STR X1
LCD K1 """No spools"""
```

```
LCD K2 """ """

// Rung 41
// Address 191
STRN X0
LCD K2 """No spool loaded"""
LCD K1 """ """

// Rung 42
// Address 207
STR X101
OUT Y17

// Rung 43
// Address 209
STRN X1
AND X0
OR X107
JMP S1

// Rung 44
// Address 213
SG S3

// Rung 45
// Address 215
STRN X21
SET C77

// Rung 46
// Address 217
STR X21
RST C77

// Rung 47
// Address 219
STR X100
OUT Y16

// Rung 48
// Address 221
STR X102
OUT Y15

// Rung 49
// Address 223
STRN X100
ANDN X101
ANDN X102
ANDN X103
ANDN X104
ANDN X105
ANDN X106
AND C11
AND C21
JMP S0
```

```
// Rung 50
// Address 233
STR SP1
LCD K1 """Running:"""
OUT C12
OUT C22
OUT C32
OUT C42

// Rung 51
// Address 245
SG S5

// Rung 52
// Address 247
STR SP1
OUT C1

// Rung 53
// Address 249
STRN C11
JMP S3

// Rung 54
// Address 251
ISG S100

// Rung 55
// Address 253
STR SP1
LD K10
OUT V2040
RST B2056.0
OUT B2154.1

// Rung 56
// Address 260
STR C1
AND X0
JMP S102

// Rung 57
// Address 263
STR C1
ANDN X0
JMP S101

// Rung 58
// Address 266
STR SP1
OUT C11
RST Y7
RST Y12

// Rung 59
// Address 270
SG S101
```

```
// Rung 60
// Address 272
STR C77
JMP S100

// Rung 61
// Address 274
STRN X0
ANDN X1
OUT Y17

// Rung 62
// Address 277
STR X4
JMP S102

// Rung 63
// Address 279
SG S102

// Rung 64
// Address 281
STR C77
JMP S100

// Rung 65
// Address 283
STR SP1
TMR T102 K5
SET Y7
SET Y12

// Rung 66
// Address 289
STR T102
OUT Y15

// Rung 67
// Address 291
STRN X5
JMP S103

// Rung 68
// Address 293
SG S103

// Rung 69
// Address 295
STR C77
JMP S100

// Rung 70
// Address 297
STR SP1
OUT Y16
OUT Y15
```

```
// Rung 71
// Address 300
STRN X0
TMR T103 K10

// Rung 72
// Address 304
STR T103
OUT C5

// Rung 73
// Address 306
STR C52
JMP S104

// Rung 74
// Address 308
SG S104

// Rung 75
// Address 310
STR C77
JMP S100

// Rung 76
// Address 312
STR SP1
OUT Y15
OUT Y16
RST Y12

// Rung 77
// Address 316
STR SP1
LD K1
OUT V2041
OUT B2056.7

// Rung 78
// Address 321
STR B2022.7
JMP S105

// Rung 79
// Address 324
SG S105

// Rung 80
// Address 326
STR C77
JMP S100

// Rung 81
// Address 328
STR SP1
OUT Y15
```

```
OUT Y16
LCD K2 """Spooling"""

// Rung 82
// Address 338
STR SP1
SET B2056.0
RST B2056.4

// Rung 83
// Address 343
STR B2056.0
LDD K1000
OUTD V2030
OUT C15
OUT B2154.1

// Rung 84
// Address 351
STR C15
OUT B2056.7

// Rung 85
// Address 354
STR V2102 K61a8
OUT C14

// Rung 86
// Address 357
STR C14
LDD K0
OUTD V2030
OUT C15

// Rung 87
// Address 362
STR C15
OUT B2056.7

// Rung 88
// Address 365
STR C15
TMR T107 K50

// Rung 89
// Address 369
STR T107
OUT B2056.2

// Rung 90
// Address 372
STR B2022.2
TMR T106 K10
OUT C27

// Rung 91
// Address 378
```

```
STR T106
JMP S107
SET Y12
OUT B2154.1
RST B2056.0

// Rung 92
// Address 385
SG S107

// Rung 93
// Address 387
STR C77
JMP S100

// Rung 94
// Address 389
STR SP1
OUT Y15
OUT Y16

// Rung 95
// Address 392
STR SP1
LD K2
OUT V2041
TMR T107 K5

// Rung 96
// Address 398
STR T107
OUT B2056.7
OUT C16
TMR T115 K30

// Rung 97
// Address 405
STR C22
AND B2022.7
AND C16
AND T115
JMP S110

// Rung 98
// Address 411
STR B2022.6
LCD K2 """CMD ERROR"""

// Rung 99
// Address 421
SG S110

// Rung 100
// Address 423
STR C77
JMP S100
```

```
// Rung 101
// Address 425
STR SP1
OUT Y15
OUT Y16
LCD K2 """Homing"""

// Rung 102
// Address 434
STR SP1
OUT B2056.0
SET B2056.4

// Rung 103
// Address 439
STRN B2022.4
OUT C4

// Rung 104
// Address 442
STR C33
AND C43
JMP S111

// Rung 105
// Address 445
SG S111

// Rung 106
// Address 447
STR C77
JMP S100

// Rung 107
// Address 449
STR SP1
LCD K2 """Waiting"""

// Rung 108
// Address 457
STR C31
AND C41
JMP S112

// Rung 109
// Address 460
SG S112

// Rung 110
// Address 462
STR C77
JMP S100

// Rung 111
// Address 464
STR SP1
OUT Y17
```

```
// Rung 112
// Address 466
STR X4
TMR T112 K5

// Rung 113
// Address 470
STR T112
JMP S113

// Rung 114
// Address 472
SG S113

// Rung 115
// Address 474
STR C77
JMP S100

// Rung 116
// Address 476
STR SP1
LCD K2 """" """"

// Rung 117
// Address 481
STRN C1
AND C12
JMP S100

// Rung 118
// Address 484
ISG S200

// Rung 119
// Address 486
STR C77
JMP S200

// Rung 120
// Address 488
STR SP1
LD K10
OUT V2140

// Rung 121
// Address 491
STR C2
JMP S201

// Rung 122
// Address 493
STR SP1
OUT C21

// Rung 123
```

```
// Address 495
SG S201

// Rung 124
// Address 497
STR C77
JMP S200

// Rung 125
// Address 499
STR SP1
LD K1
OUT V2141
OUT B2156.7

// Rung 126
// Address 504
STR B2122.7
JMP S202

// Rung 127
// Address 507
SG S202

// Rung 128
// Address 509
STR C77
JMP S200

// Rung 129
// Address 511
STR SP1
OUT B2156.0
OUT B2156.4

// Rung 130
// Address 516
STR C27
OUT B2156.2
TMR T202 K3

// Rung 131
// Address 522
STRN B2122.4
AND T202
JMP S203

// Rung 132
// Address 526
SG S203

// Rung 133
// Address 528
STR C77
JMP S200

// Rung 134
```

```
// Address 530
STR SP1
LD K2
OUT V2141
OUT B2156.7

// Rung 135
// Address 535
STR B2122.7
JMP S204

// Rung 136
// Address 538
SG S204

// Rung 137
// Address 540
STR C77
JMP S200

// Rung 138
// Address 542
STR SP1
OUT B2156.0

// Rung 139
// Address 545
STR SP1
TMR T204 K5

// Rung 140
// Address 549
STRN B2022.4
JMP S205

// Rung 141
// Address 552
SG S205

// Rung 142
// Address 554
STR C77
JMP S200

// Rung 143
// Address 556
STR SP1
OUT C22

// Rung 144
// Address 558
STRN C2
AND C11
JMP S200

// Rung 145
// Address 561
```

```
ISG S300

// Rung 146
// Address 563
STR C77
JMP S300

// Rung 147
// Address 565
STR C3
JMP S301

// Rung 148
// Address 567
STR SP1
OUT C31

// Rung 149
// Address 569
SG S301

// Rung 150
// Address 571
STR C77
JMP S300

// Rung 151
// Address 573
STR SP1
TMR T301 K3
OUT Y10
LCD K2 """Cutting"""

// Rung 152
// Address 585
STR T301
TMR T302 K3
OUT Y11

// Rung 153
// Address 590
STR T302
JMP S302

// Rung 154
// Address 592
SG S302

// Rung 155
// Address 594
STR C77
JMP S300

// Rung 156
// Address 596
STR SP1
OUT C33
```

```
// Rung 157
// Address 598
STRN C3
AND C32
ANDN C41
JMP S300

// Rung 158
// Address 602
ISG S400

// Rung 159
// Address 604
STR C77
JMP S400

// Rung 160
// Address 606
STR C4
JMP S401

// Rung 161
// Address 608
STR SP1
OUT C41

// Rung 162
// Address 610
SG S401

// Rung 163
// Address 612
STR C77
JMP S400

// Rung 164
// Address 614
STR SP1
OUT Y14
TMR T41 K5
LCD K2 """Clipping"""

// Rung 165
// Address 626
STR T41
OUT Y13
TMR T42 K5

// Rung 166
// Address 631
STR T42
JMP S402
OUT C3

// Rung 167
// Address 634
```

```
SG S402

// Rung 168
// Address 636
STR C77
JMP S400

// Rung 169
// Address 638
STR SP1
OUT C43

// Rung 170
// Address 640
STRN C4
AND C33
JMP S400

// Rung 171
// Address 643
ISG S500

// Rung 172
// Address 645
STR C77
JMP S500

// Rung 173
// Address 647
STR SP1
LD K10
OUT V2240

// Rung 174
// Address 650
STR C5
JMP S501

// Rung 175
// Address 652
STR SP1
OUT C51

// Rung 176
// Address 654
STR C5
JMP S501

// Rung 177
// Address 656
SG S501

// Rung 178
// Address 658
STR C77
JMP S500
```

```
// Rung 179
// Address 660
STR SP1
LD K1
OUT V2241
OUT B2256.7

// Rung 180
// Address 665
STR B2222.7
JMP S502

// Rung 181
// Address 668
SG S502

// Rung 182
// Address 670
STR C77
JMP S500

// Rung 183
// Address 672
STR SP1
OUT B2256.0
LCD K2 """Feeding"""

// Rung 184
// Address 682
STR SP1
TMR T52 K10

// Rung 185
// Address 686
STRN B2222.4
AND T52
JMP S503

// Rung 186
// Address 690
SG S503

// Rung 187
// Address 692
STR C77
JMP S500

// Rung 188
// Address 694
STR SP1
OUT C52

// Rung 189
// Address 696
STRN C5
AND C52
AND C11
```

```
JMP S500

// Rung 190
// Address 700
ISG S1100

// Rung 191
// Address 702
STR X20
AND C11
OUT Y12

// Rung 195
// Address 708
END


#BEGIN ELEMENT_DOC
"X0","Spool Loaded","",""
"X1","SpoolStandEmpty","",""
"X2","Motor Home","",""
"X3","Pusher Home","",""
"X4","Pusher Away","",""
"X5","Stopper Home","",""
"X23","Switches","",""
"X100","Center0","","Y16"
"X101","Pusher0","","Y17"
"X102","Stopper0","","Y15"
"X104","Clip0","","Y13-14"
"X105","Cutter0","","Y10-11"
"X106","Spool_Damper0","","Y12"
"X107","Error Override","",""
"Y10","Cutter_Pneum","","X105"
"Y11","Cutter_Jaws","","X105"
"Y12","Spool_Damper","","X106"
"Y13","Clip_Jaws","","X104"
"Y14","Clip_Pneum","","X104"
"Y15","Stopper","","X102"
"Y16","Center","","X100"
"Y17","Pusher","","X101"
"C1","S100Spool","",""
"C2","S200Bouncer","",""
"C3","S300Cutter","",""
"C4","S400Clipper","",""
"C5","S500Feeder","",""
"C11","S100ConfirmReady","",""
"C12","S100ConfirmDone","",""
"C21","S200ConfirmReady","",""
"C22","S200ConfirmDone","",""
"C27","S200STOP","",""
"C31","S300ConfirmReady","",""
"C32","S300COnfirmDone","",""
"C33","S300Done","",""
"C41","S400ConfirmReady","",""
"C42","S400ConfirmDone","",""
"C43","S400Done","",""
"C51","S500ConfirmReady","",""
```

"C52","S500ConfirmDone","",""
"C77","EMER_STOP","",""
"S0","Ready","",""
"S1","Switch_Board","",""
"S2","Sensor Error","",""
"S3","Wait","",""
"S4","Gate_Error","",""
"S5","Sub1","",""
"S11","Send_Spool1","",""
"S12","Spool1","",""
"S13","Send_Home1","",""
"S14","Home1","",""
"S100","Eject_Spool_Home","",""
"S102","Stop","",""
"S103","Raise","",""
"S104","Send_Spool","",""
"S105","Spool","",""
"S107","Send_Home","",""
"S110","Home","",""
"S111","S100Wait","",""
"S112","Eject","",""
"S113","Done","",""
"S200","Bouncer_Ready","",""
"S201","Send_Bouncer","",""
"S202","Bounce","",""
"S203","Bouncer_Send_Hom","",""
"S204","Bouncer_Home","",""
"S205","Bouncer_Done","",""
"S300","Cutter_Ready","",""
"S301","Cutter_Go","",""
"S302","Cutter_Done","",""
"S400","Clipper_Ready","",""
"S401","Clipper_Go","",""
"S402","Clipper_Done","",""
"S500","Feeder_Ready","",""
"S501","Send_Feeder","",""
"S502","Feed","",""
"S503","Feeder_Done","",""
"S1000","Initialize","",""
"T1","TSwithces","",""
"T2","TClip","",""
"T3","TCutter","",""
"B2022.2","1Output_Suspende","",""
"B2022.4","1Output_Active","",""
"B2022.7","1Cmd_Complete","",""
"B2056.0","1Enable_Output","",""
"B2056.2","1Suspend_Output","",""
"B2056.4","1Direction","",""
"B2056.7","1Process_Command","",""
"B2122.2","2Output_Suspende","",""
"B2122.4","2Output_Active","",""
"B2122.7","2Cmd_Complete","",""
"B2154.1","3Reset_Count","",""
"B2156.0","2Enable_Output","",""
"B2156.2","2Suspend_Output","",""
"B2156.4","2Direction","",""
"B2156.7","2Process_Cmd","",""

"B2222.4","3Output_Active","",""
"B2222.7","3Cmd_Complete","",""
"B2256.0","3Enable_Output","",""
"B2256.4","3Direction","",""
"B2256.7","3Process_Cmd","",""

#END

Appendix B - Stepper Motor Configuration

Feeding Motor

This motor profile was a simple trapezoid shape profile that ran the filament a predetermined length. This length corresponded with the distance from the cutter's jaws to the center of the spool. This was obtained by trial and error testing of profile lengths.

Bouncer Motor

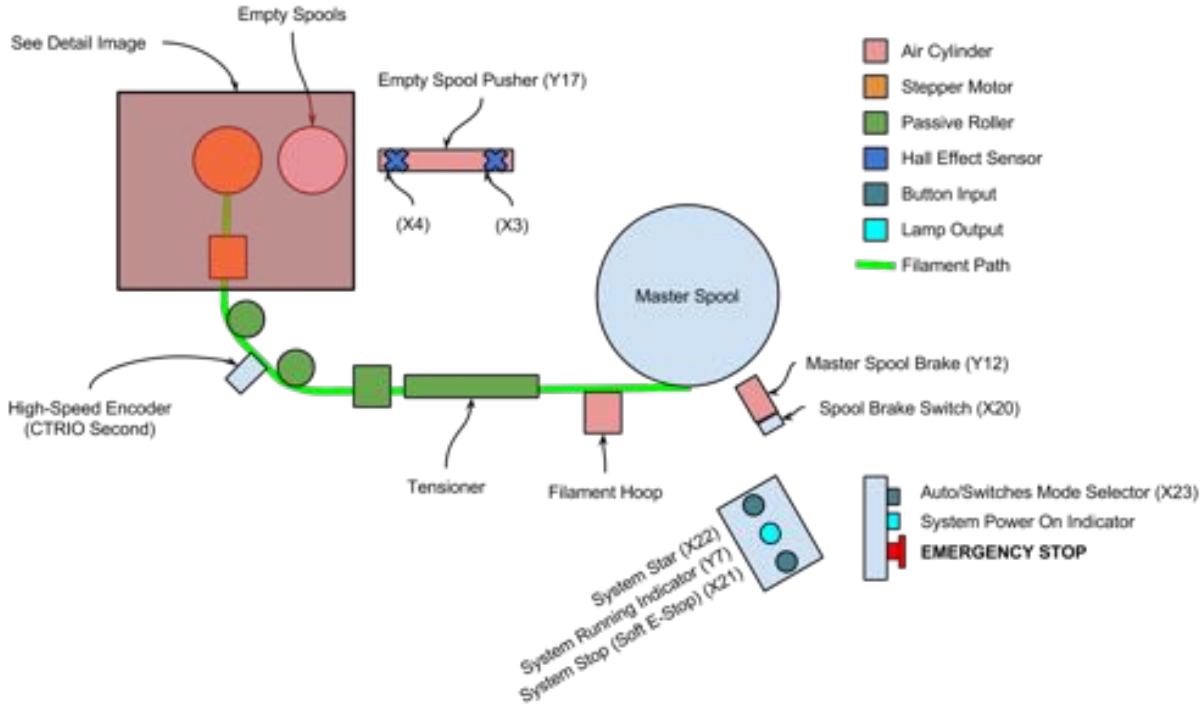
The Bouncing motor profile was never properly completed due to rapid feedback limitations. The current motor profile is a short, trapezoidal profile that is to be run in a downward direction.

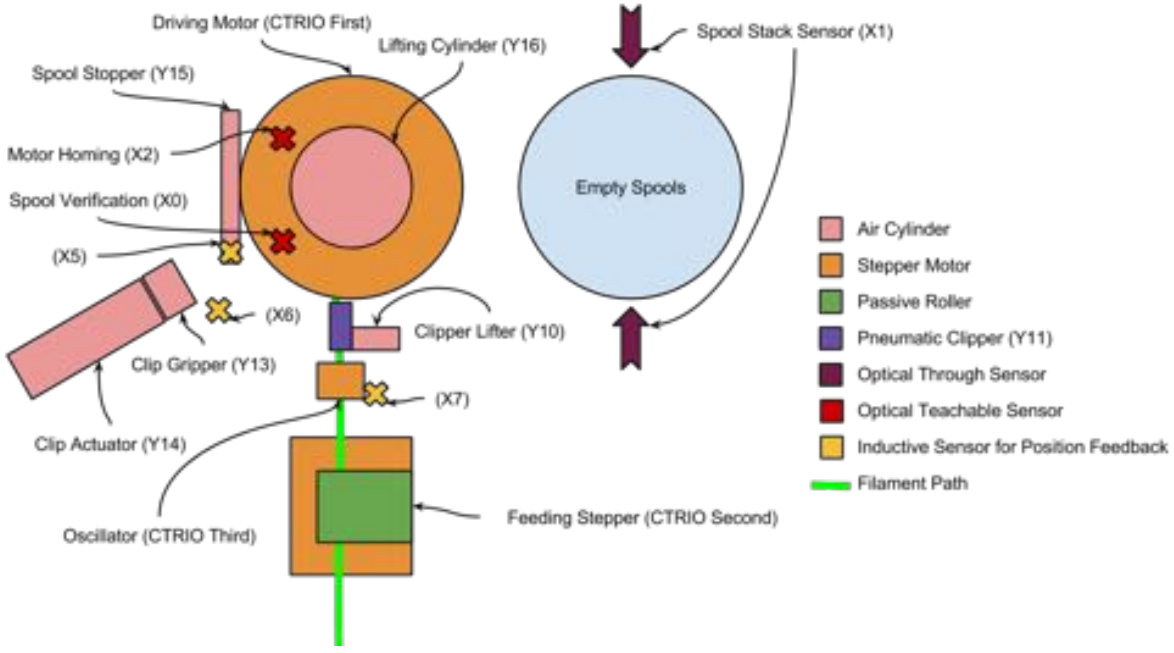
A second homing profile is also set to run after the above profile is suspended. This homing profile is called in ladder logic to be in an upward direction. This profile relies on an inductive sensor that reads high when the motor is home.

Spooling motor

The spooling motor contains two motor profiles. The first profile is a dynamic velocity profile. This allows the programmer to determine a velocity without having to rewrite the module. The motor is set to have a 3000ms accel and deccel rate.
The second profile is a homing profile similar to the bouncer. This sensor, however, is a teachable distance sensor. Once the sensor goes low, the motor will stop.

Appendix C - Wiring Diagram

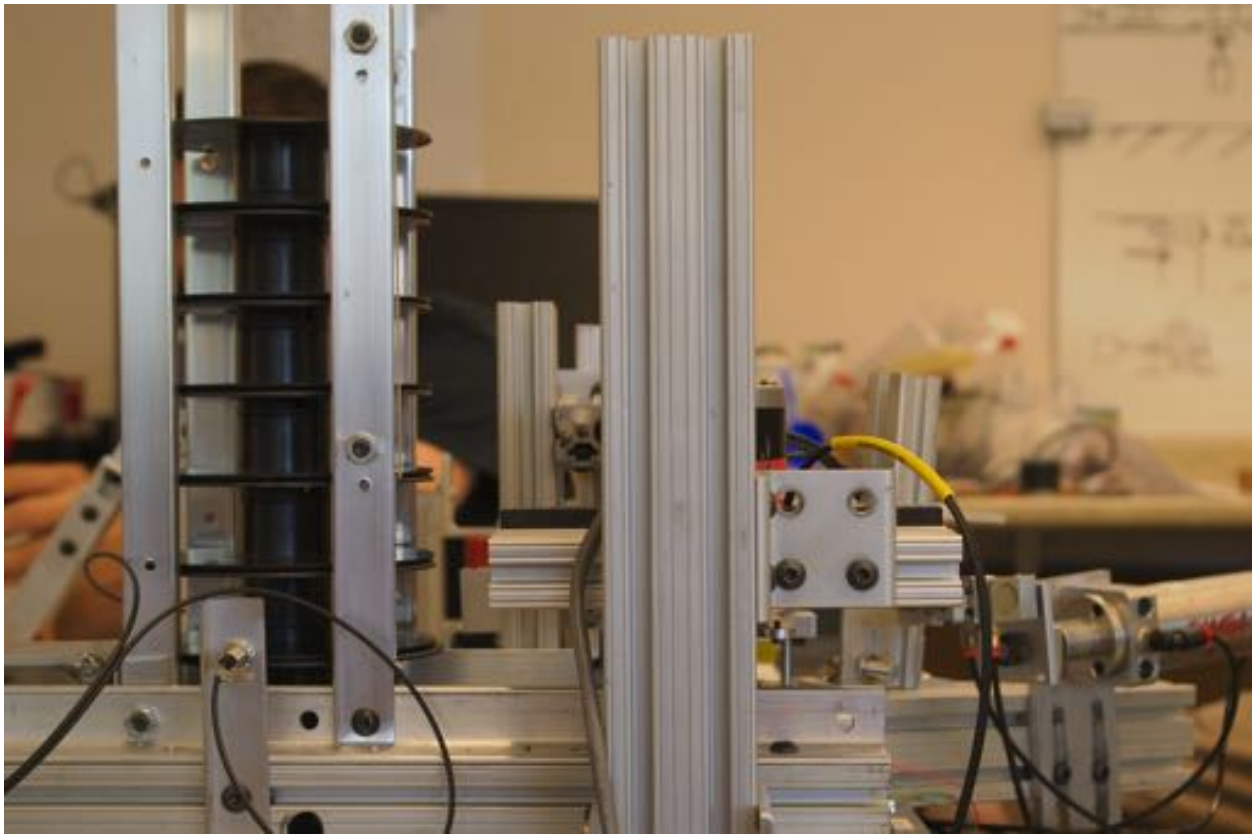


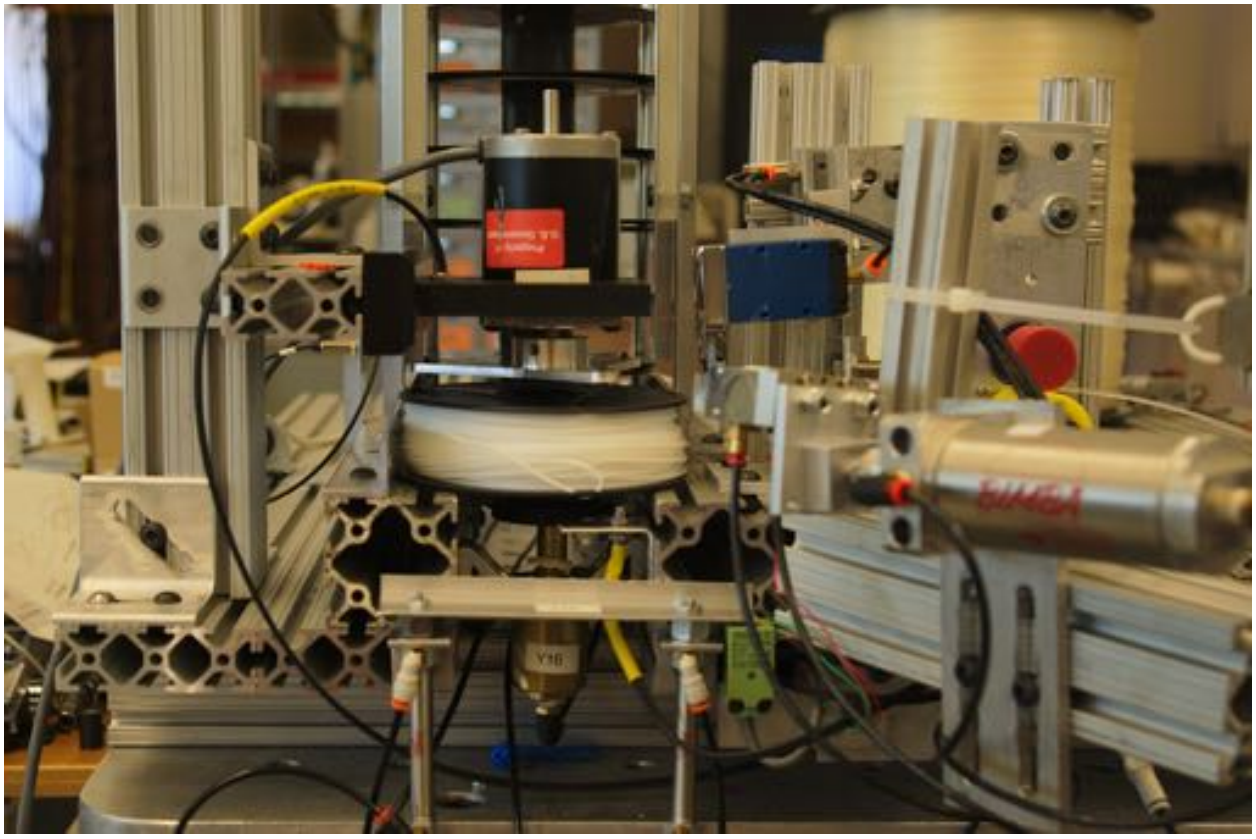


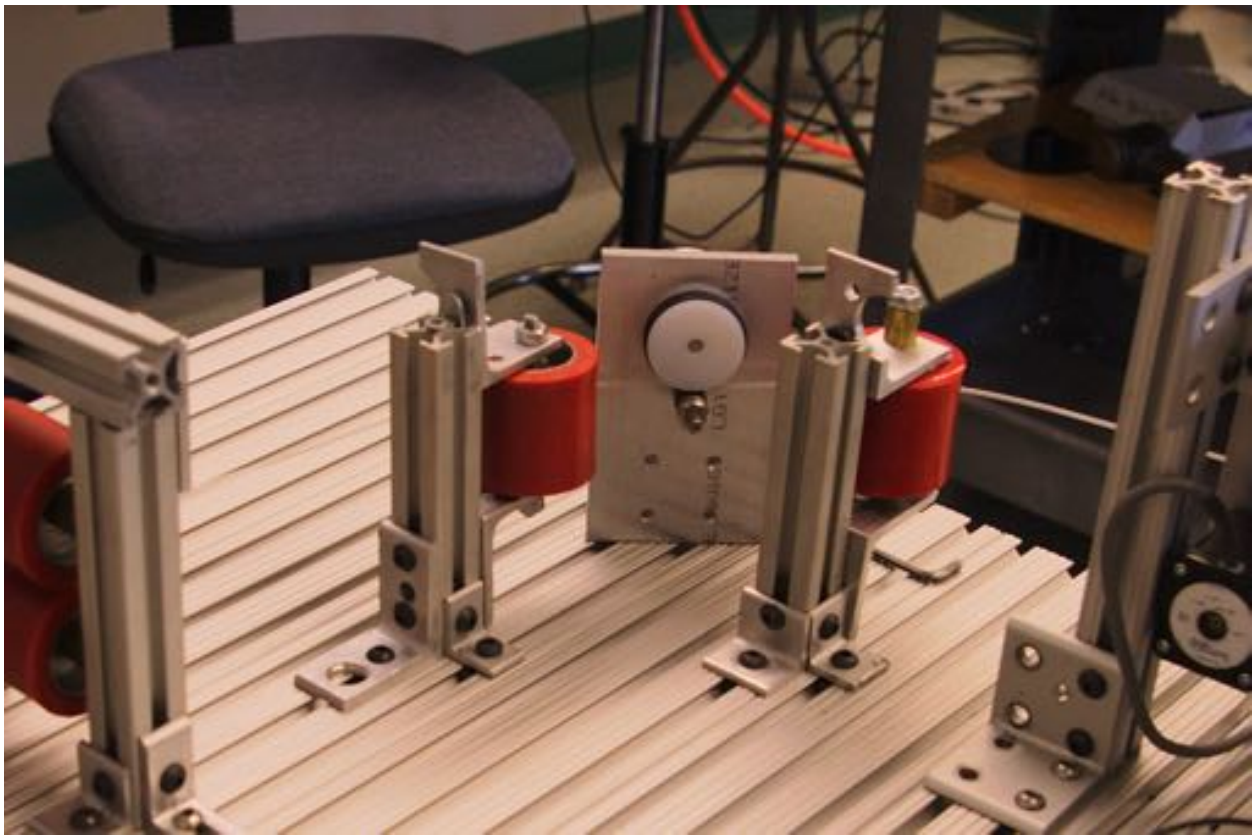
Device	Port	Description	
Inputs			
PLC	X0	Spool Loaded	
	X1	Spool Stack Sensor	
	X2	Motor Homing	Also wired to A and C ports on first CTRIO Module for motor homing
	X3	Pusher Home	
	X4	Pusher Out	
	X5	Stopper Home	
	X6	Clip Actuator Out	
	X7	Oscillator Up (Home)	Also wired to third CTRIO Module port C for motor homing
	X20	Master Spool Brake	
	X21	System Stop (Soft E-stop)	
	X22	System Start	
	X23	Switches/Auto Mode Selector	
CTRIO	A	Quadrature Encoder input from high speed encoder	
	B	Connected to third CTRIO module	
Outputs			
PLC	Y7	System Running Indicator	
	Y10	Clipper Lifter	
	Y11	Clipper Jaws	
	Y12	Master Spool Brake	
	Y13	Clip Gripper	
	Y14	Clip Actuator	
	Y15	Stopper	
	Y16	Lifter	
	Y17	Pusher	

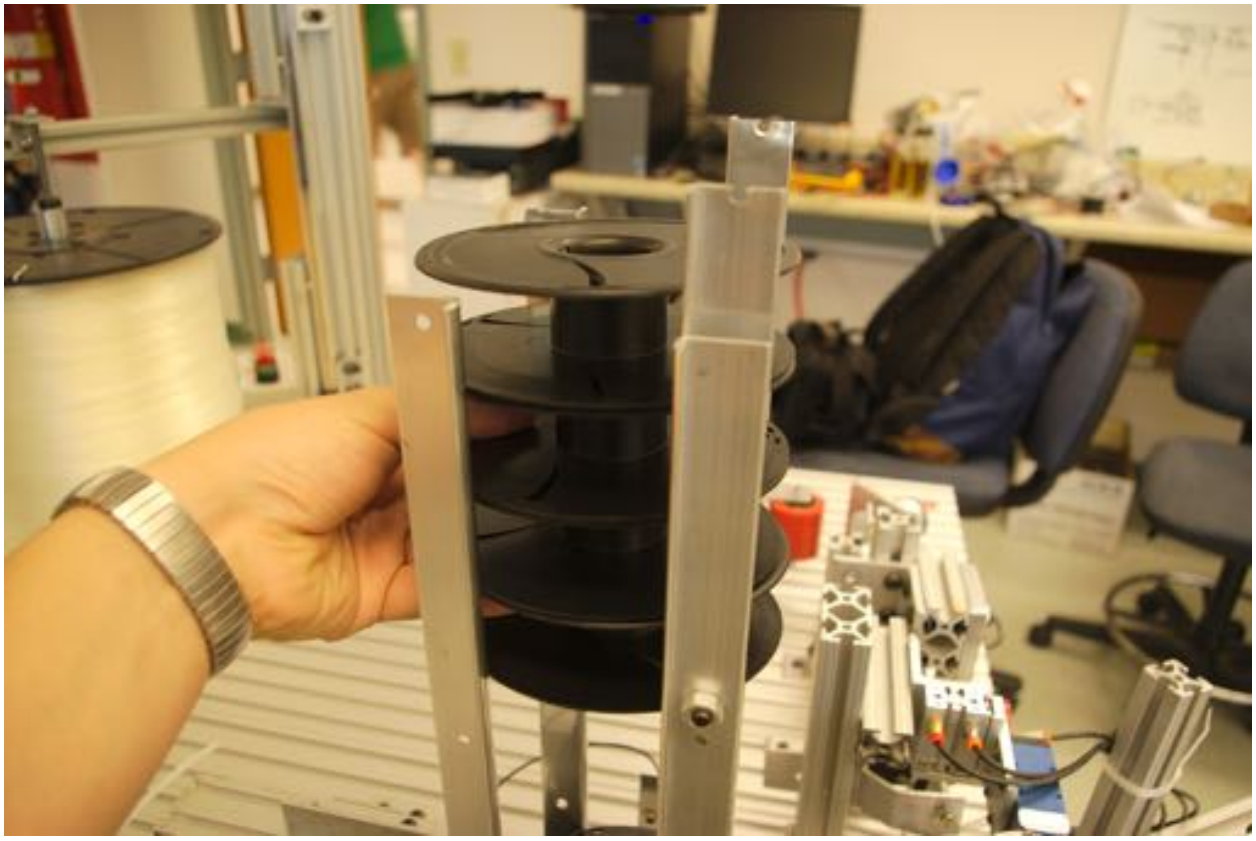
CTRIO First	YC	Common	
	Y0	Step-	Stepper Motor control for Driving Motor
	Y1	Dir-	
CTRIO Second	YC	Common	
	Y0	Step-	Stepper Motor control for Feeding Stepper
	Y1	Dir-	
CTRIO Third	YC	Common	
	Y0	Step-	Stepper Motor control for Oscillator
	Y1	Dir-	

Appendix D - Other Diagrams or Images

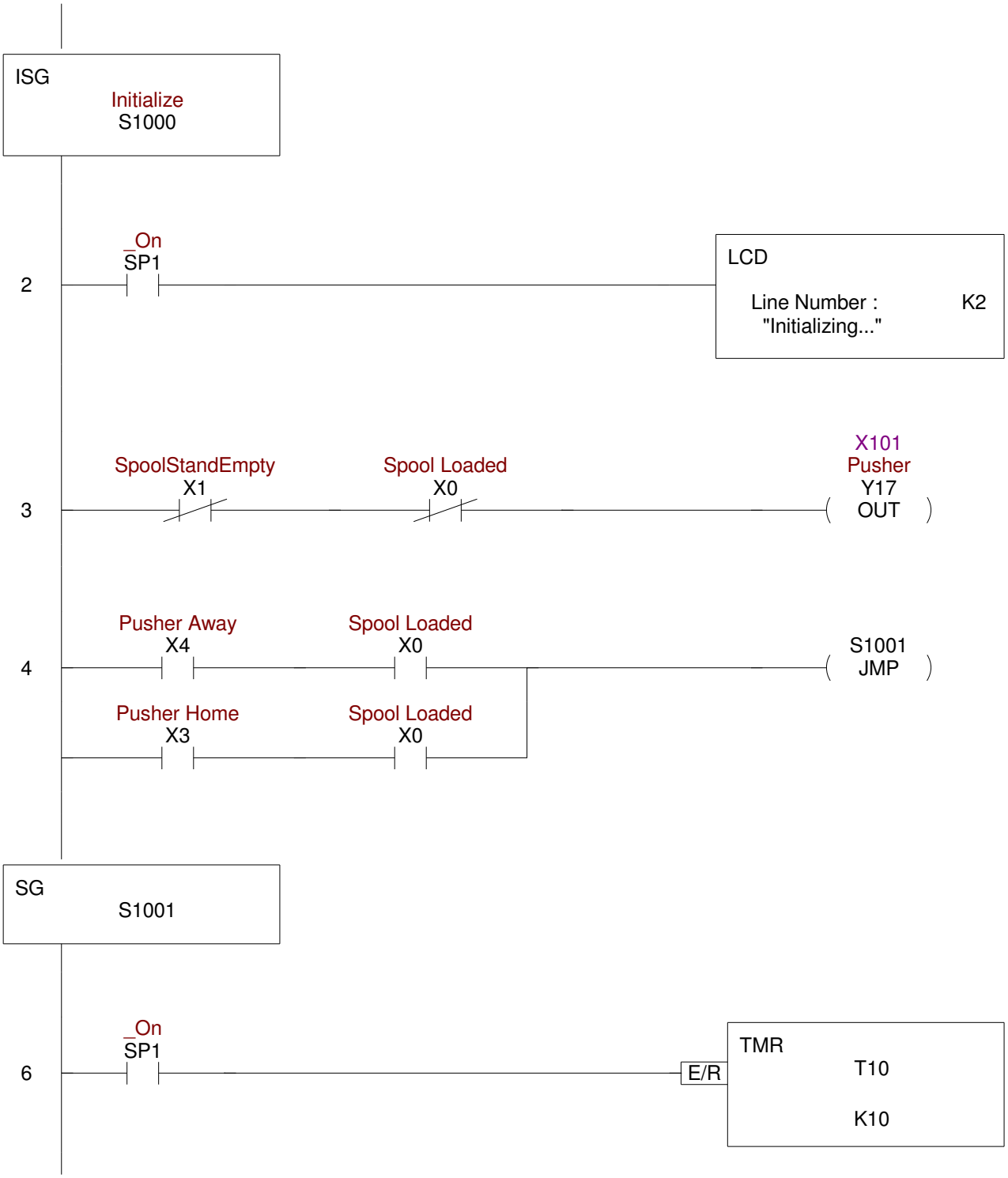


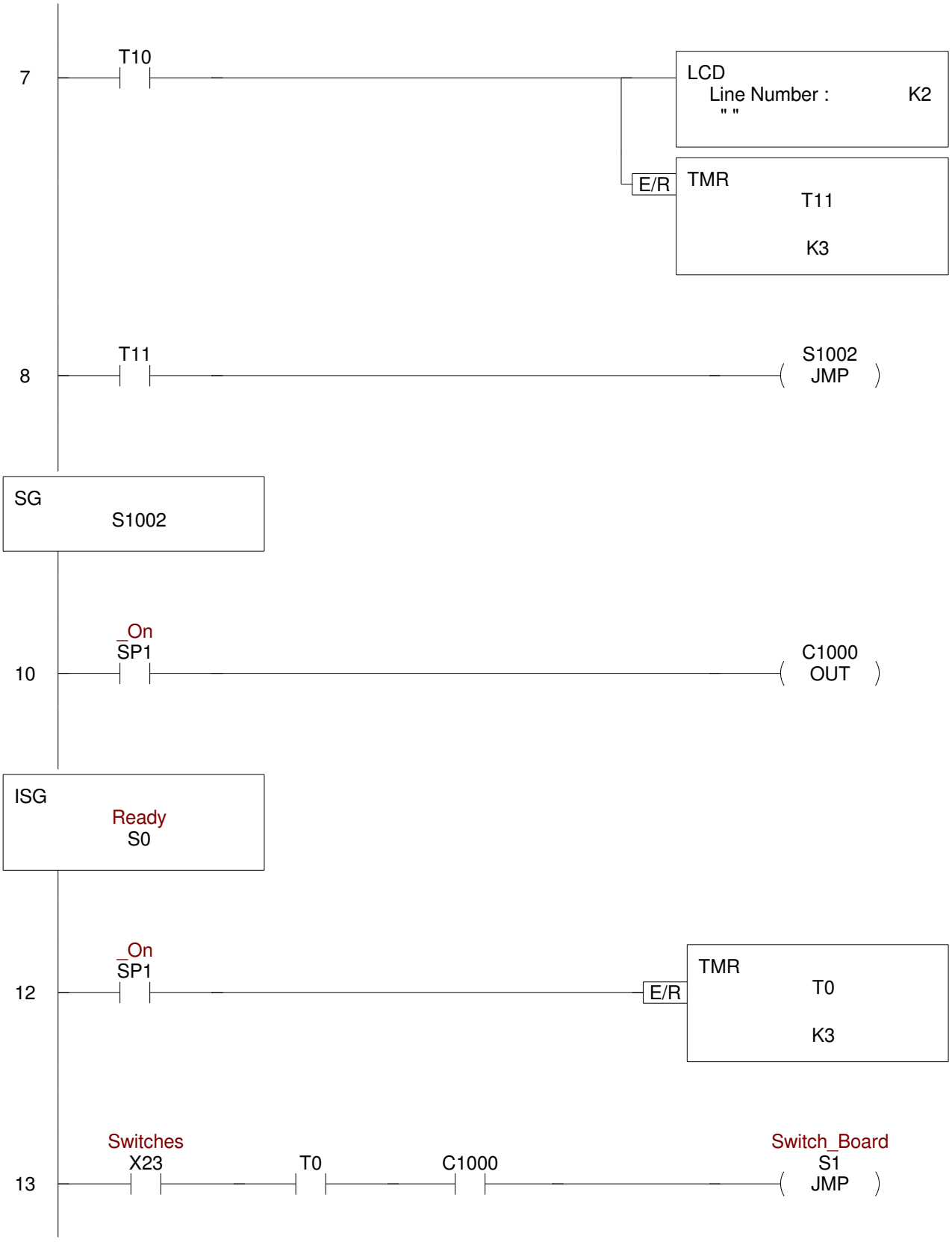


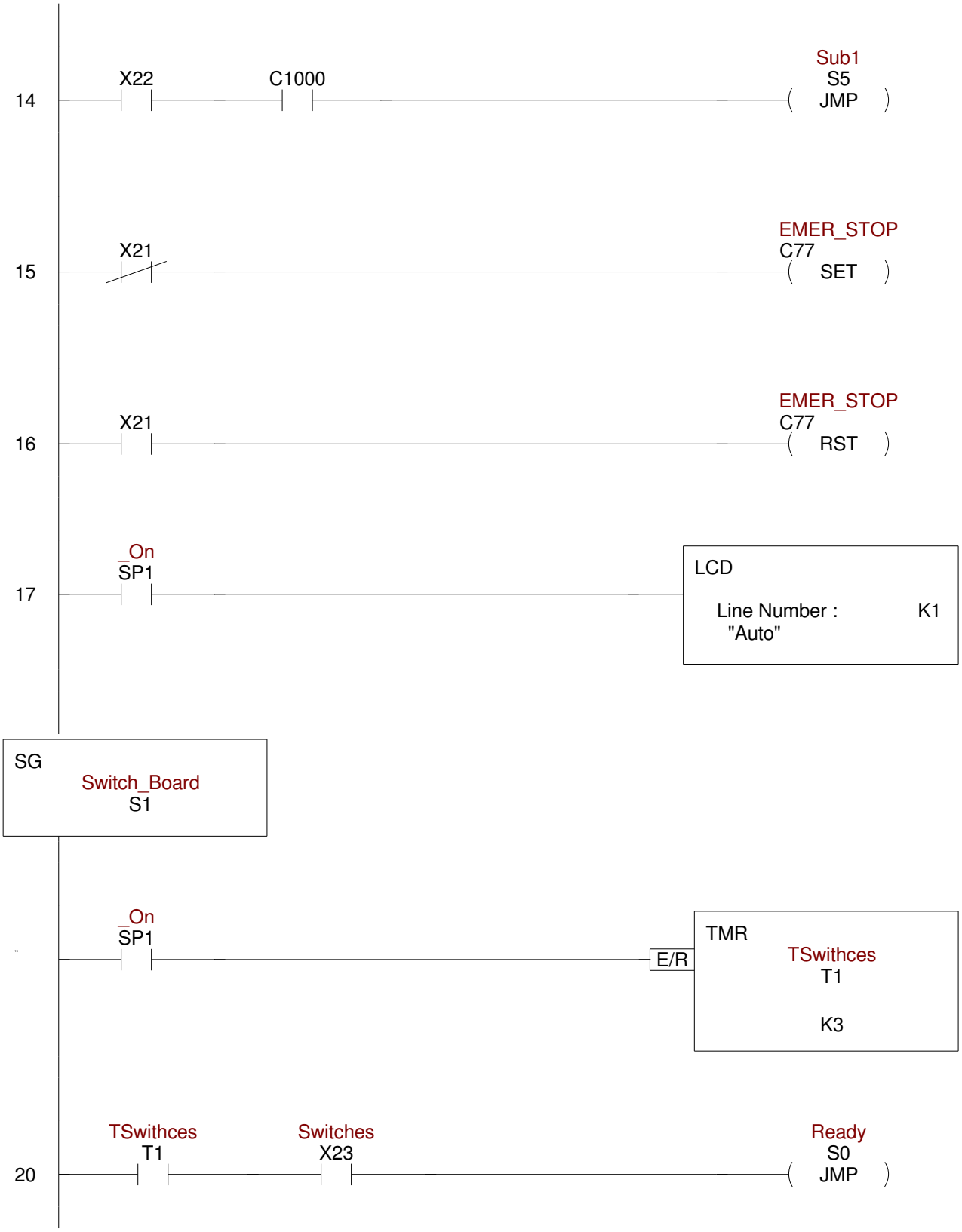


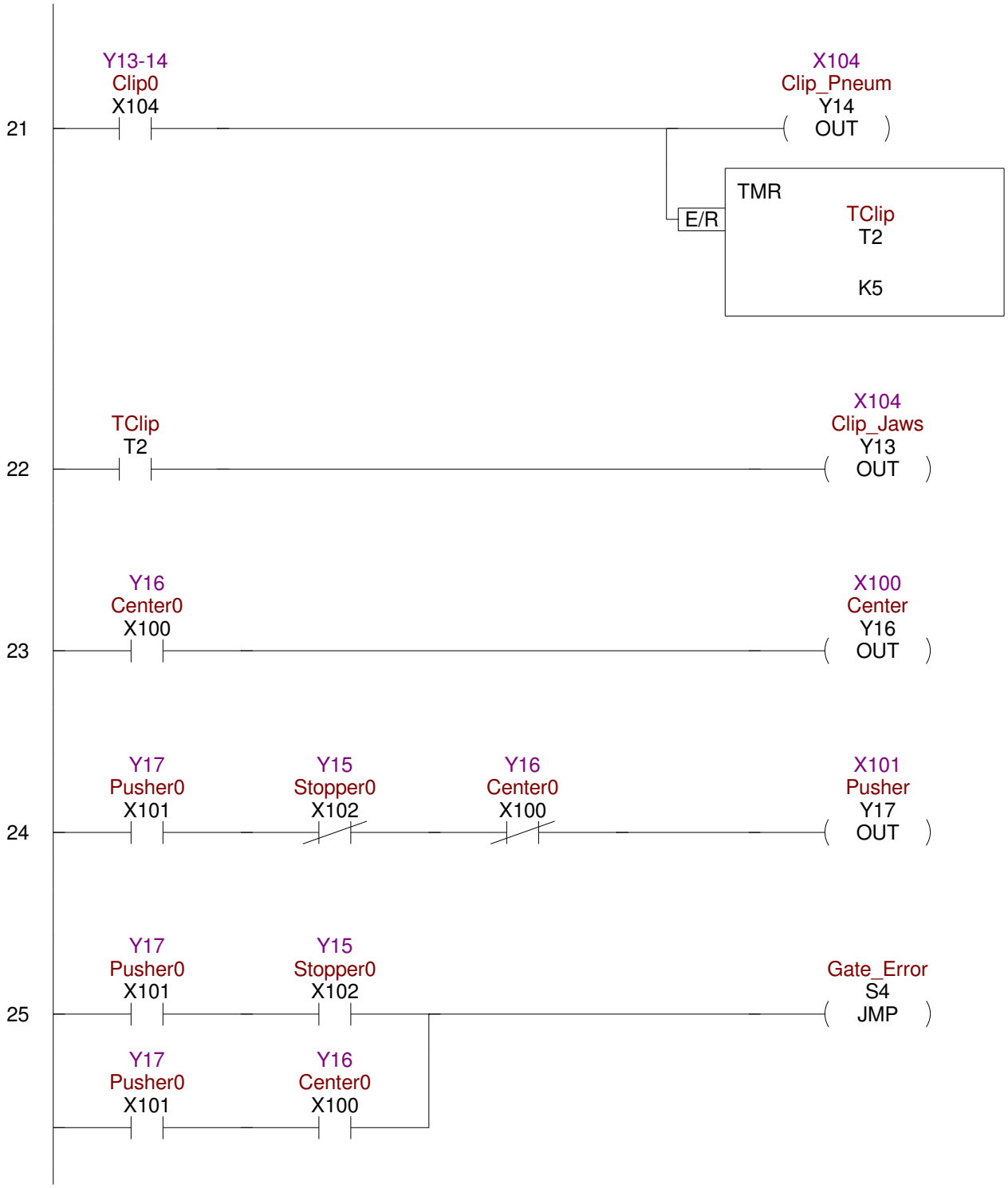


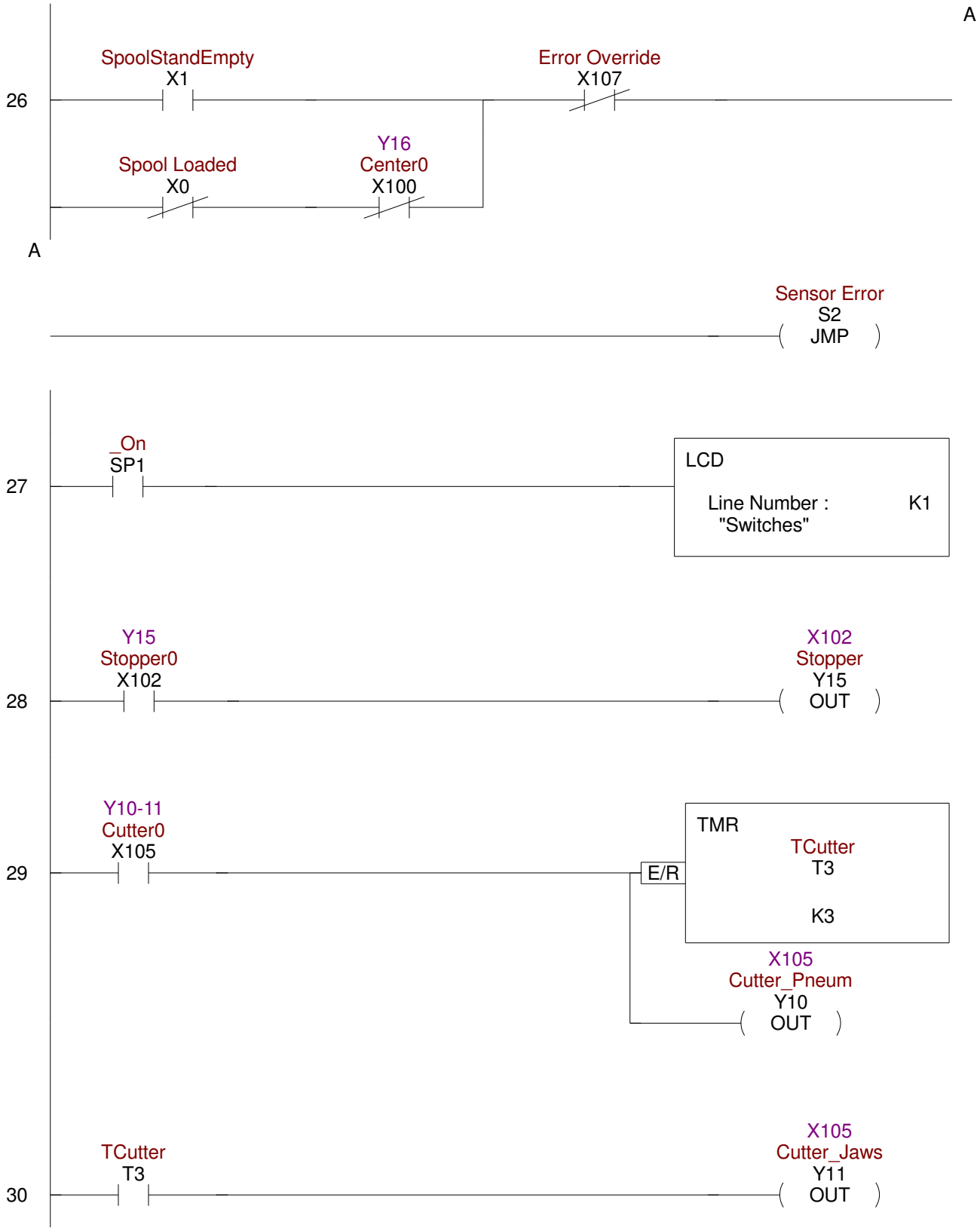
Path: c:\users\engrtech\desktop\team 4\plc input_output.prj
Save Date: 06/09/15 09:39:00
Creation Date: 05/28/15 17:45:04
PLC Type: 06
Class ID: DirectLogic 06 Series
Link Name: K Seq COM 4

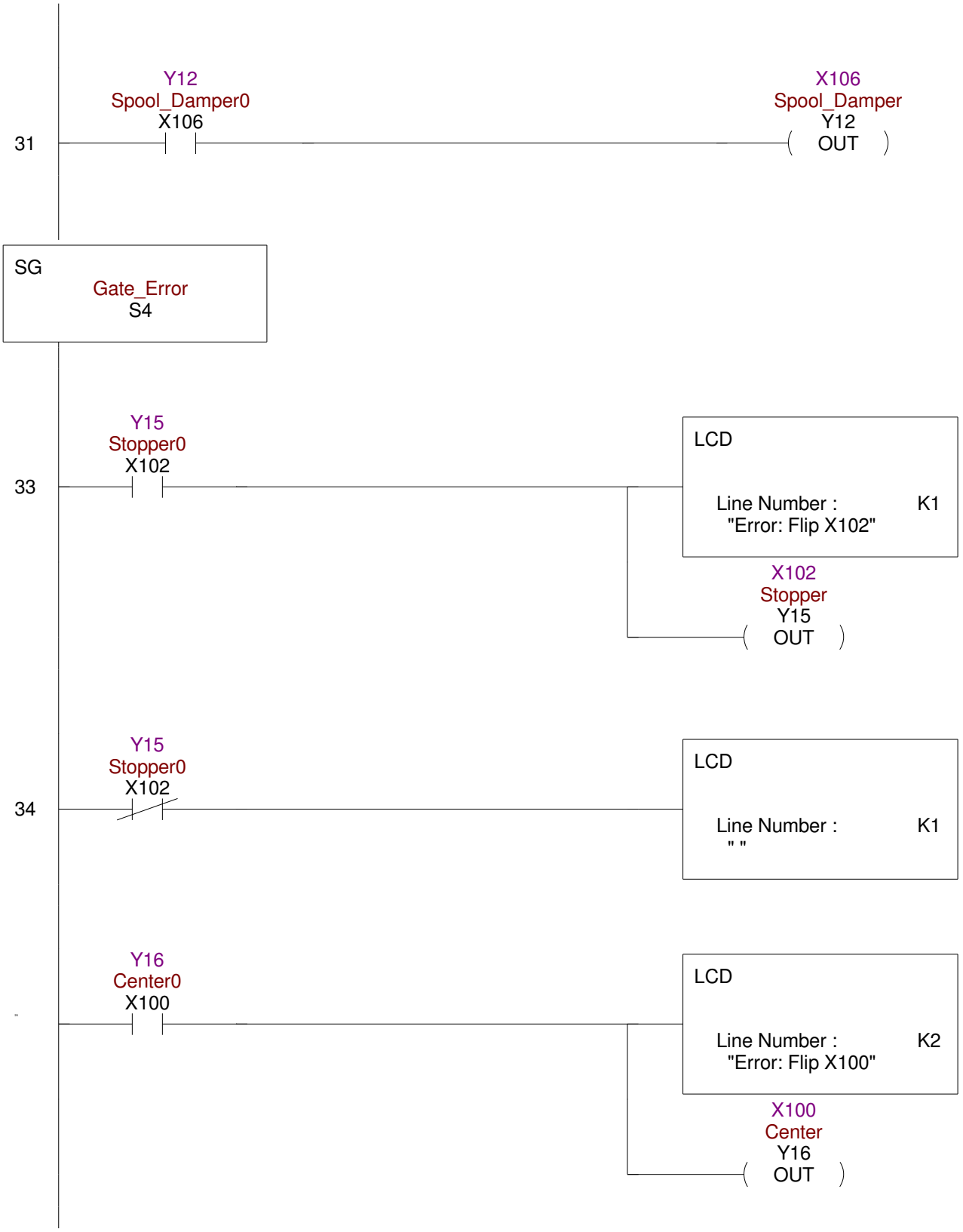

ISG
Initialize
S1000
2
_On
SP1
LCD
Line Number : K2
"Initializing..."
3
SpoolStandEmpty
X1
Spool Loaded
X0
X101
Pusher
Y17
OUT
4
Pusher Away
X4
Spool Loaded
X0
S1001
JMP
Pusher Home
X3
Spool Loaded
X0
SG
S1001
6
_On
SP1
E/R
TMR
T10
K10

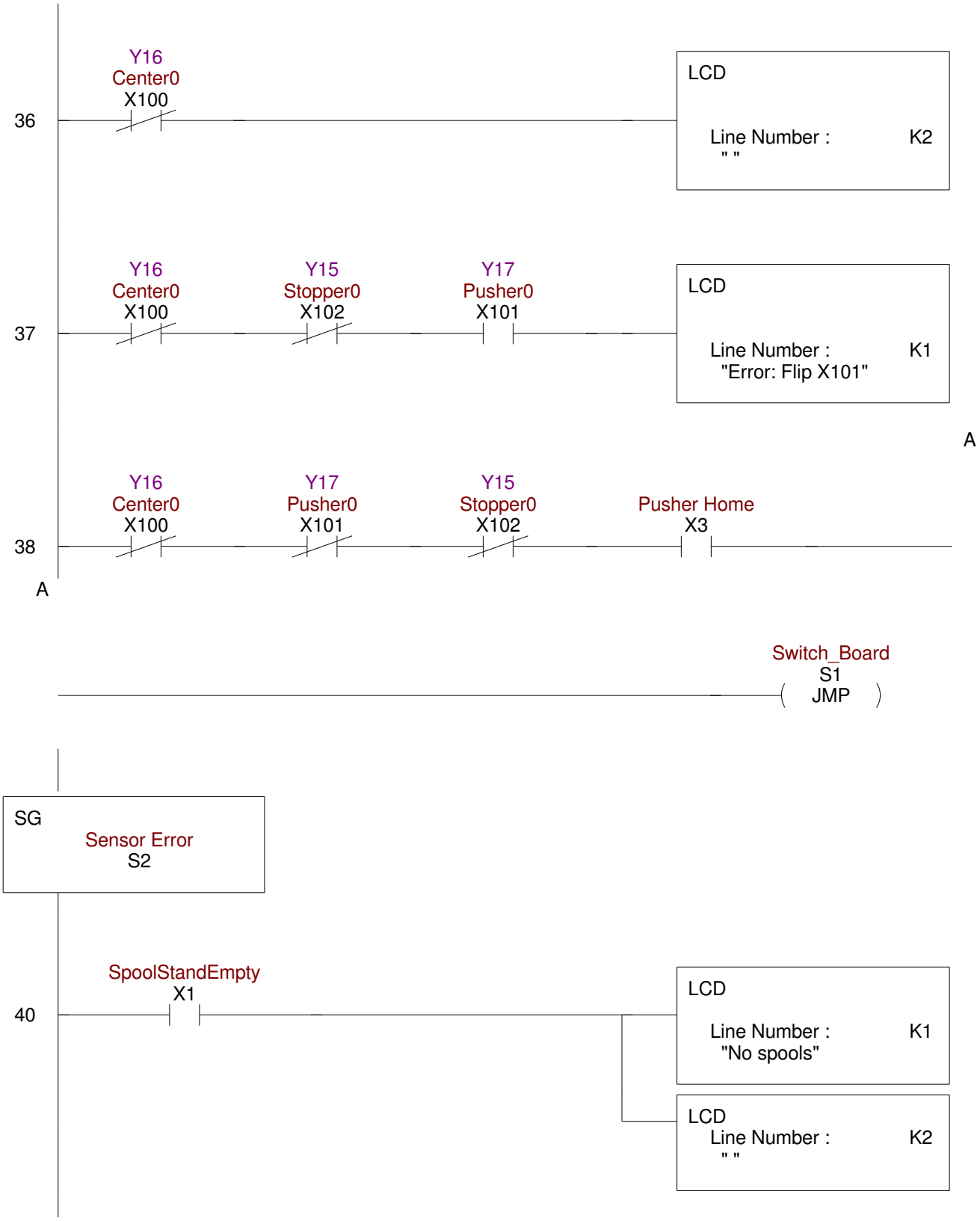

7
T10
LCD
Line Number :
K2
" "
E/R
TMR
T11
K3
8
T11
S1002
JMP
SG
S1002
10
_On
SP1
C1000
OUT
ISG
Ready
S0
12
_On
SP1
E/R
TMR
T0
K3
13
Switches
X23
T0
C1000
Switch_Board
S1
JMP

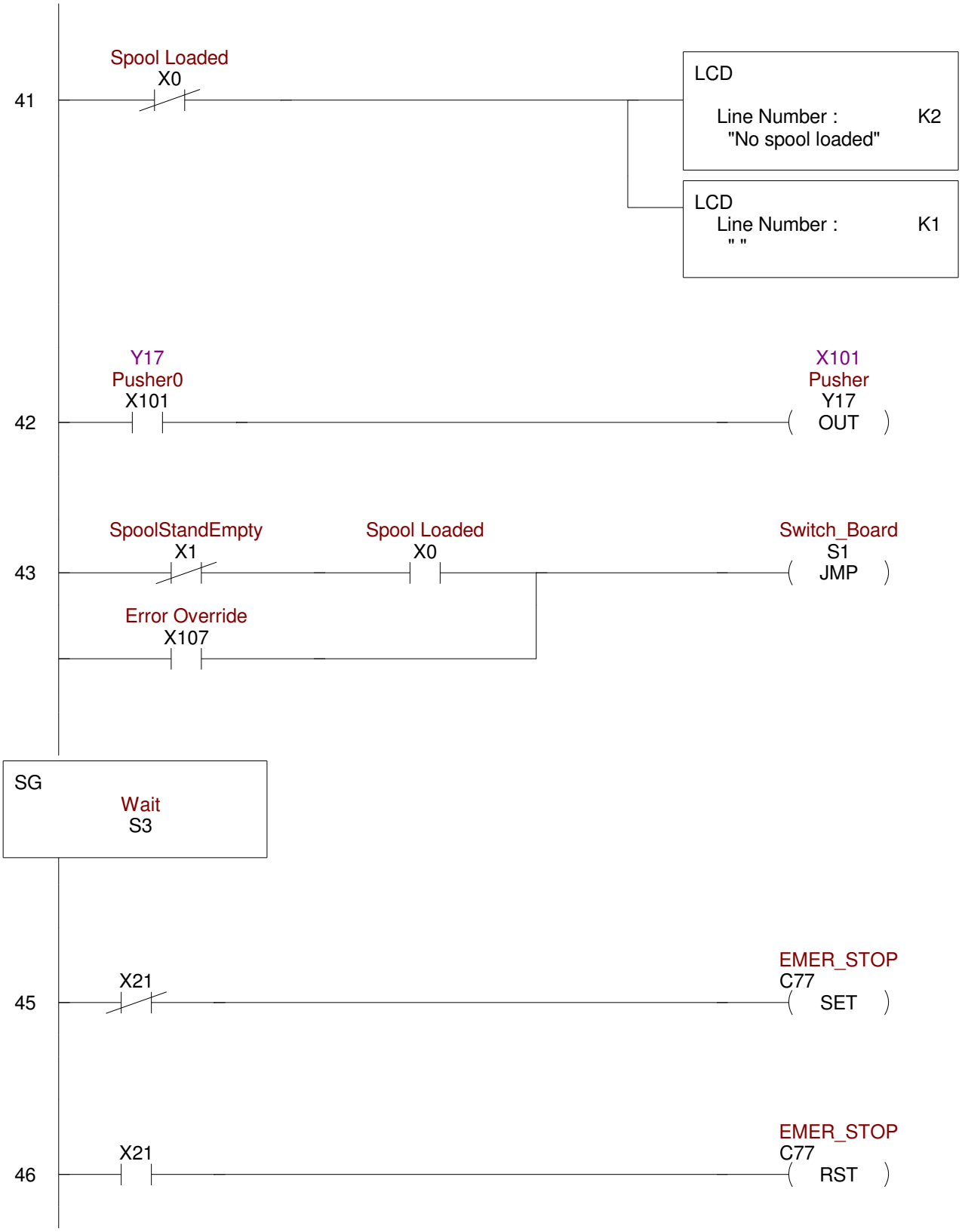

14
X22
C1000
Sub1
S5
JMP
15
X21
EMER_STOP
C77
SET
16
X21
EMER_STOP
C77
RST
17
_On
SP1
LCD
Line Number :
"Auto"
K1
SG
Switch_Board
S1
_On
SP1
E/R
TMR
TSwithces
T1
K3
20
TSwithces
T1
Switches
X23
Ready
S0
JMP

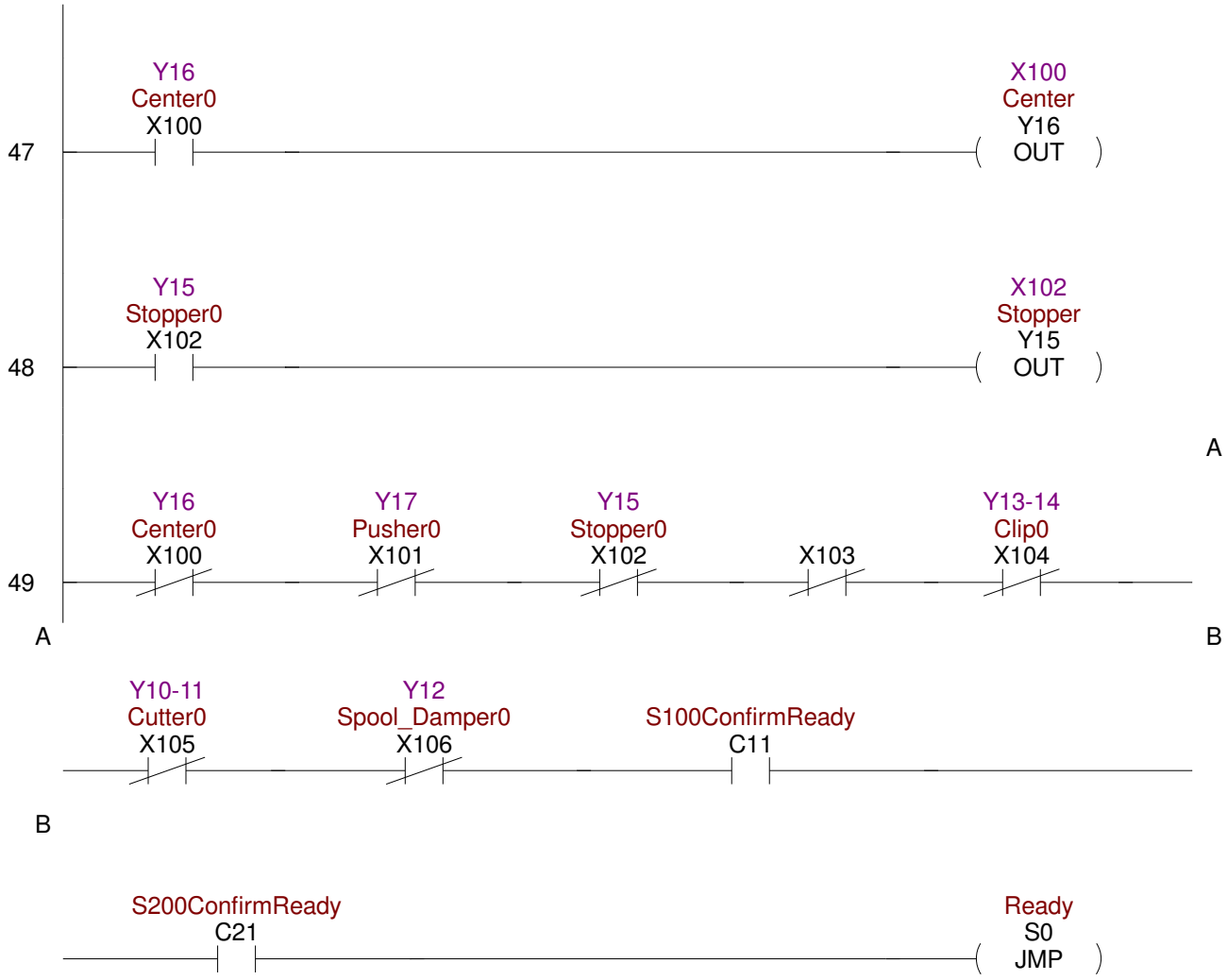

21
Y13-14
Clip0
X104
X104
Clip_Pneum
Y14
OUT
TMR
E/R
TClip
T2
K5
22
TClip
T2
X104
Clip_Jaws
Y13
OUT
23
Y16
Center0
X100
X100
Center
Y16
OUT
24
Y17
Pusher0
X101
Y15
Stopper0
X102
Y16
Center0
X100
X101
Pusher
Y17
OUT
25
Y17
Pusher0
X101
Y15
Stopper0
X102
Gate_Error
S4
JMP
Y17
Pusher0
X101
Y16
Center0
X100

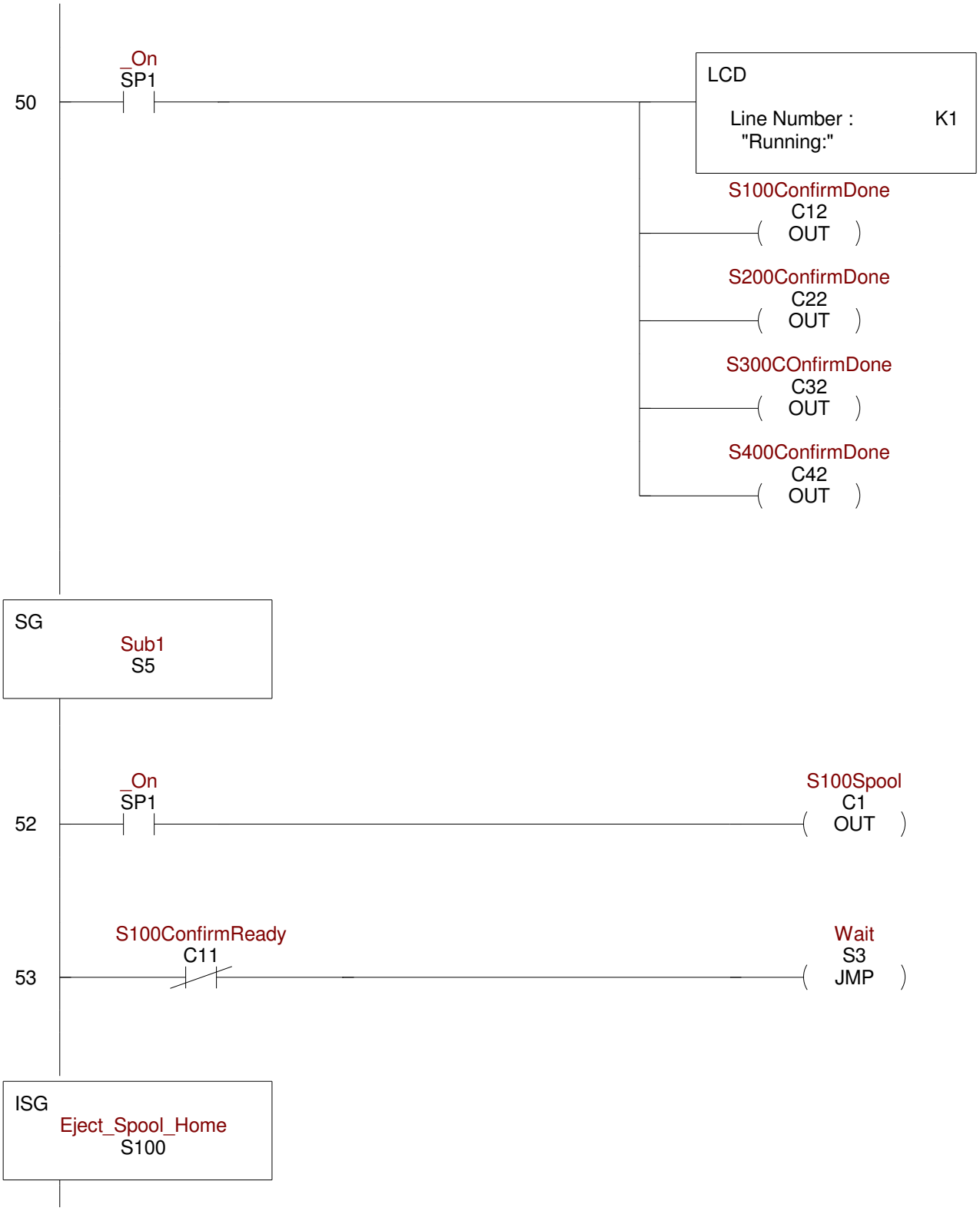

A
SpoolStandEmpty
X1
Error Override
X107
26
Y16
Center0
X100
Spool Loaded
X0
A
Sensor Error
S2
JMP
_On
SP1
27
LCD
Line Number :
K1
"Switches"
Y15
Stopper0
X102
X102
Stopper
Y15
28
OUT
Y10-11
Cutter0
X105
TMR
TCutter
T3
29
E/R
K3
X105
Cutter_Pneum
Y10
OUT
TCutter
T3
X105
Cutter_Jaws
Y11
30
OUT

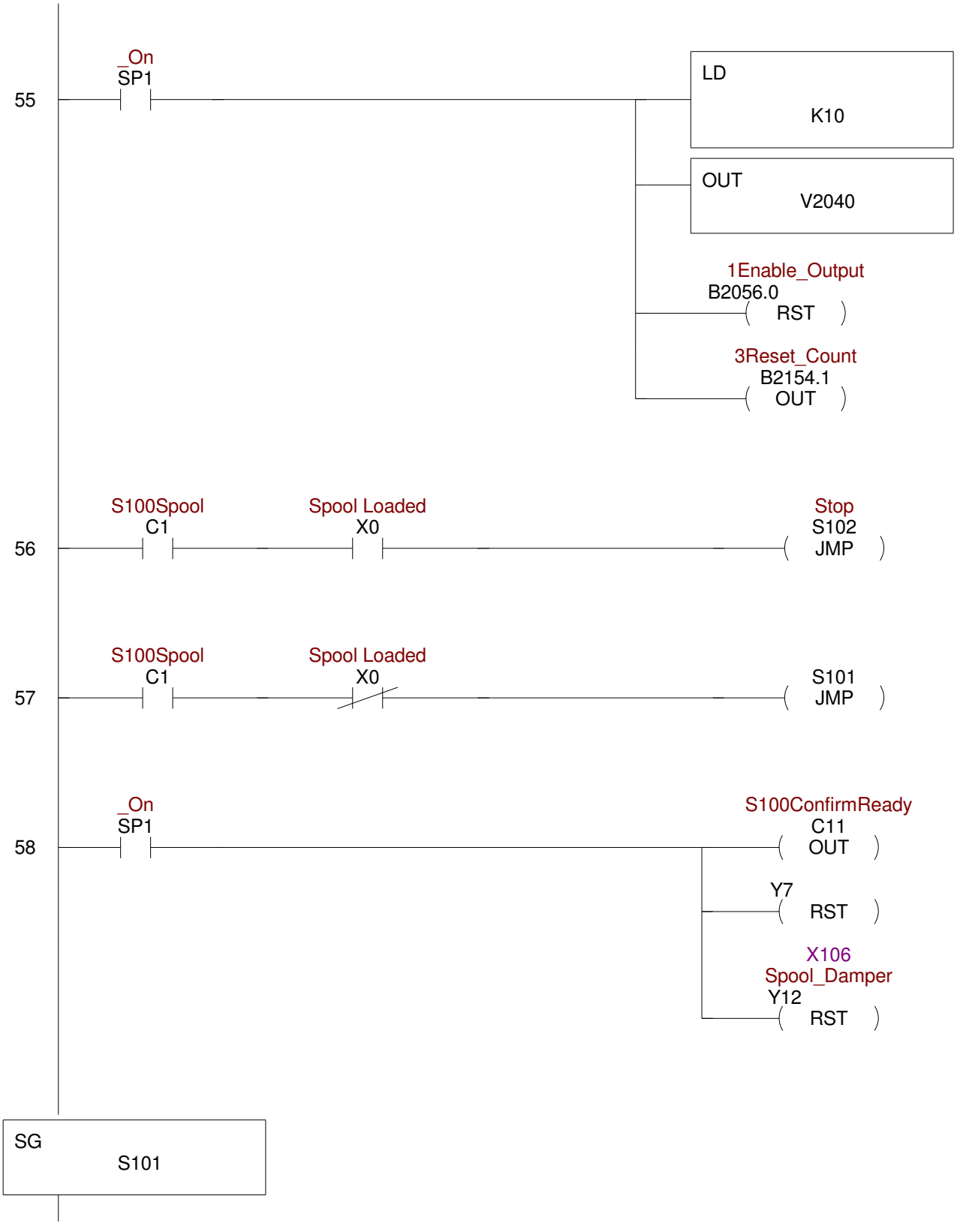

31
Y12
Spool_Damper0
X106
X106
Spool_Damper
Y12
OUT
SG
Gate_Error
S4
33
Y15
Stopper0
X102
LCD
Line Number : K1
"Error: Flip X102"
X102
Stopper
Y15
OUT
34
Y15
Stopper0
X102
LCD
Line Number : K1
" "
Y16
Center0
X100
LCD
Line Number : K2
"Error: Flip X100"
X100
Center
Y16
OUT

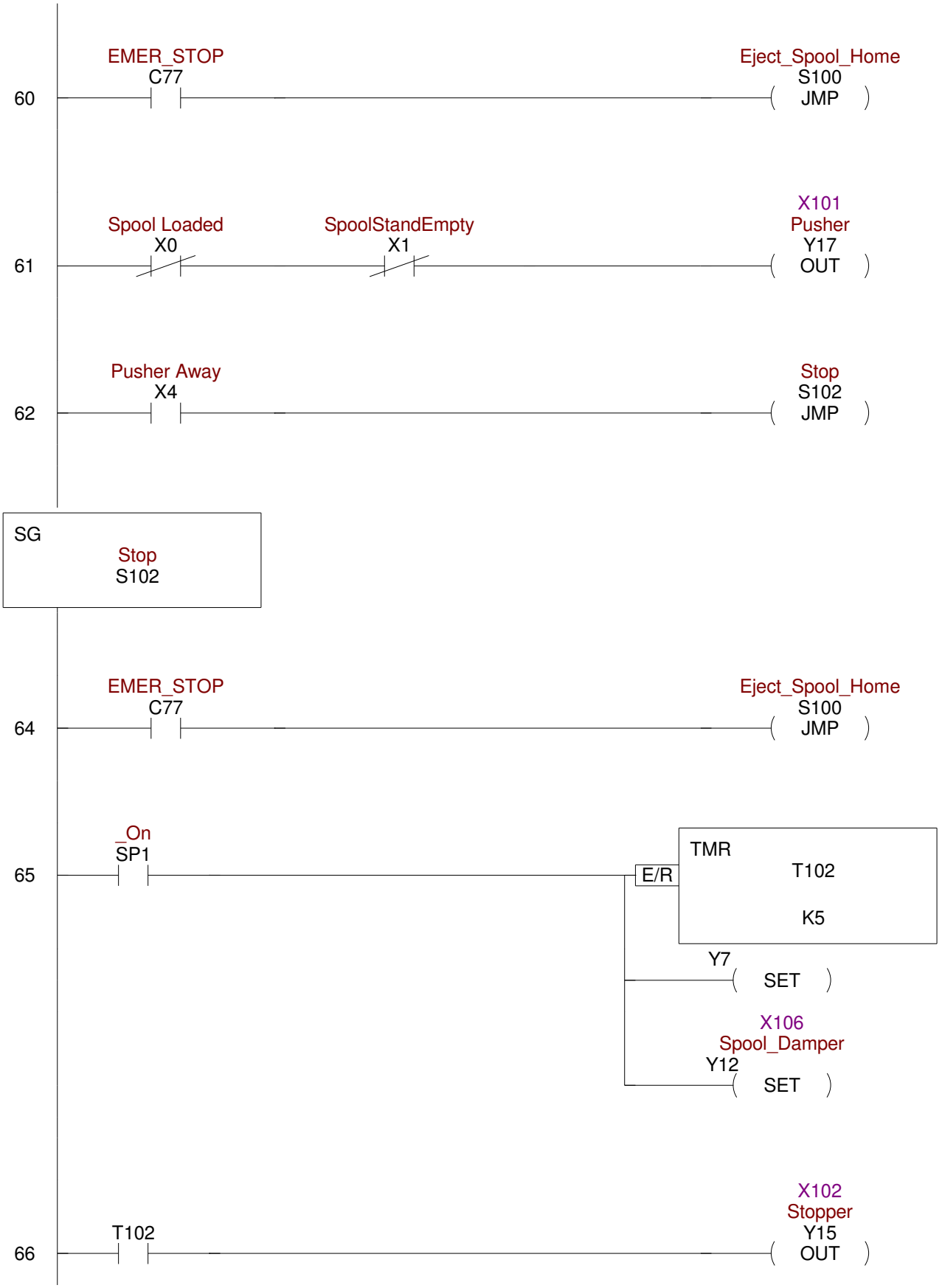

36
Y16
Center0
X100
LCD
Line Number :
" "
K2
37
Y16
Center0
X100
Y15
Stopper0
X102
Y17
Pusher0
X101
LCD
Line Number :
"Error: Flip X101"
K1
A
38
Y16
Center0
X100
Y17
Pusher0
X101
Y15
Stopper0
X102
Pusher Home
X3
A
Switch_Board
S1
JMP
SG
Sensor Error
S2
40
SpoolStandEmpty
X1
LCD
Line Number :
"No spools"
K1
LCD
Line Number :
" "
K2

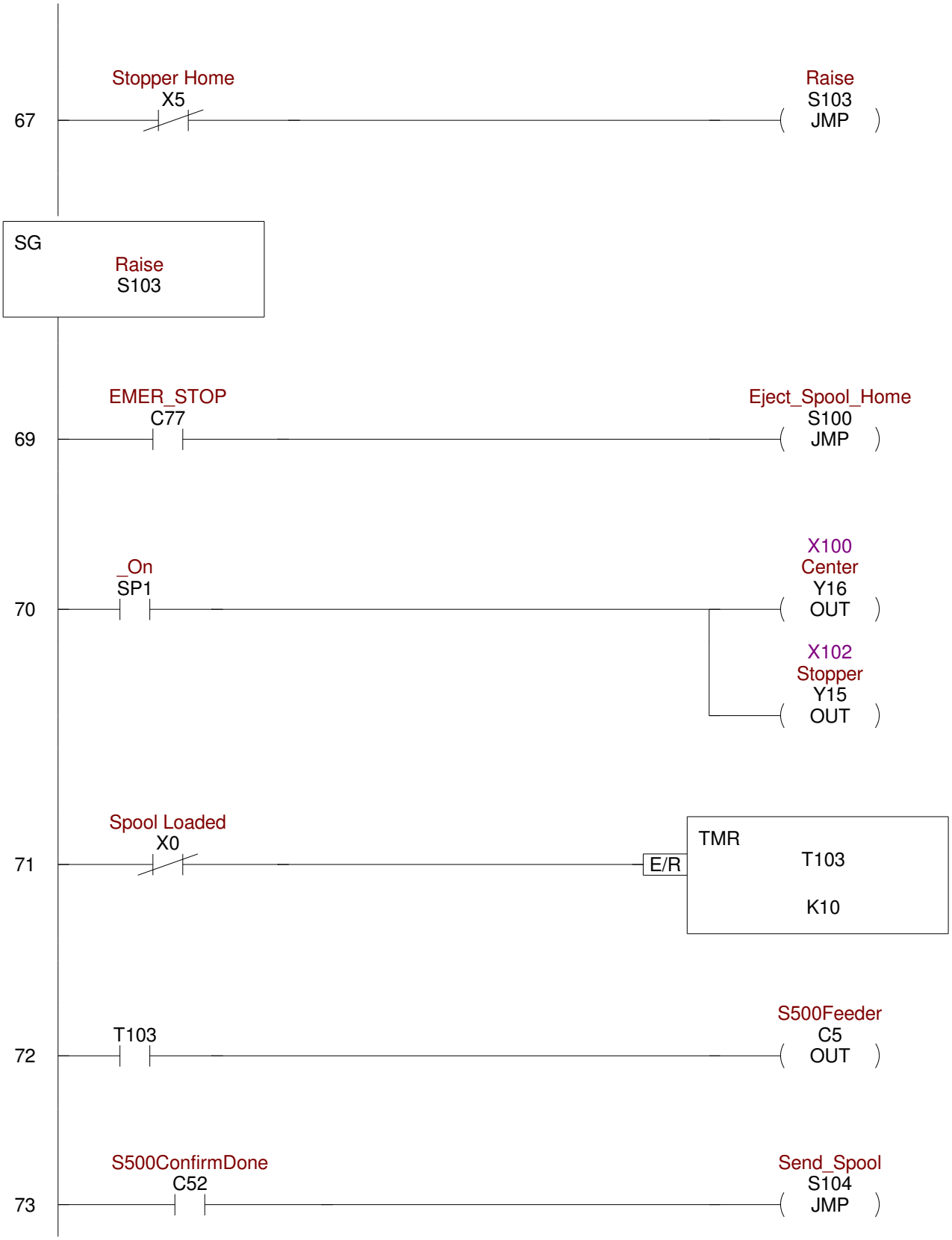

41
Spool Loaded
X0
LCD
Line Number : K2
"No spool loaded"
LCD
Line Number : K1
" "
42
Y17
Pusher0
X101
X101
Pusher
Y17
OUT
43
SpoolStandEmpty
X1
Spool Loaded
X0
Switch_Board
S1
JMP
Error Override
X107
SG
Wait
S3
45
X21
EMER_STOP
C77
SET
46
X21
EMER_STOP
C77
RST

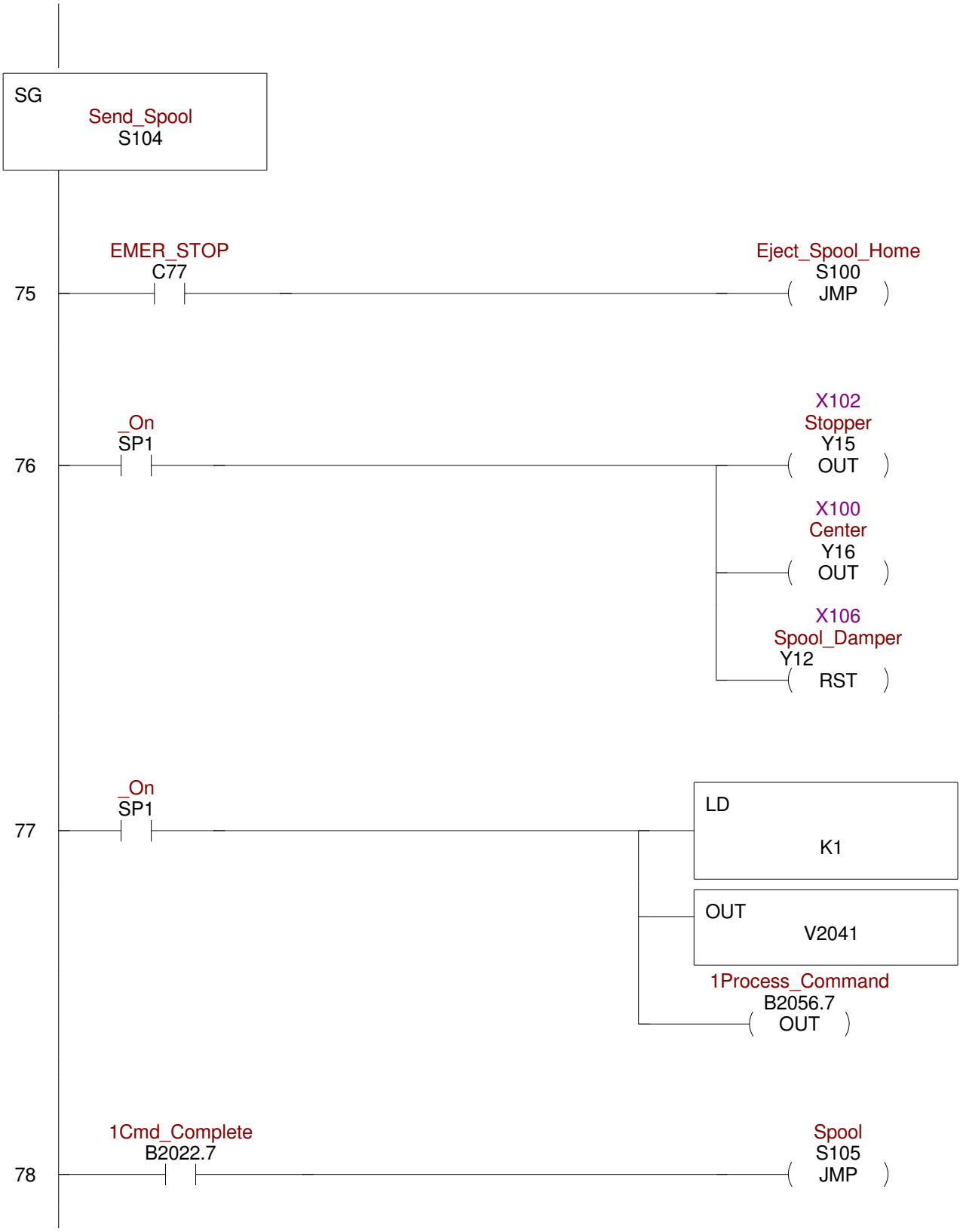

47
Y16
Center0
X100
X100
Center
Y16
OUT
48
Y15
Stopper0
X102
X102
Stopper
Y15
OUT
A
49
Y16
Center0
X100
Y17
Pusher0
X101
Y15
Stopper0
X102
X103
Y13-14
Clip0
X104
A
B
Y10-11
Cutter0
X105
Y12
Spool_Damper0
X106
S100ConfirmReady
C11
B
S200ConfirmReady
C21
Ready
S0
JMP

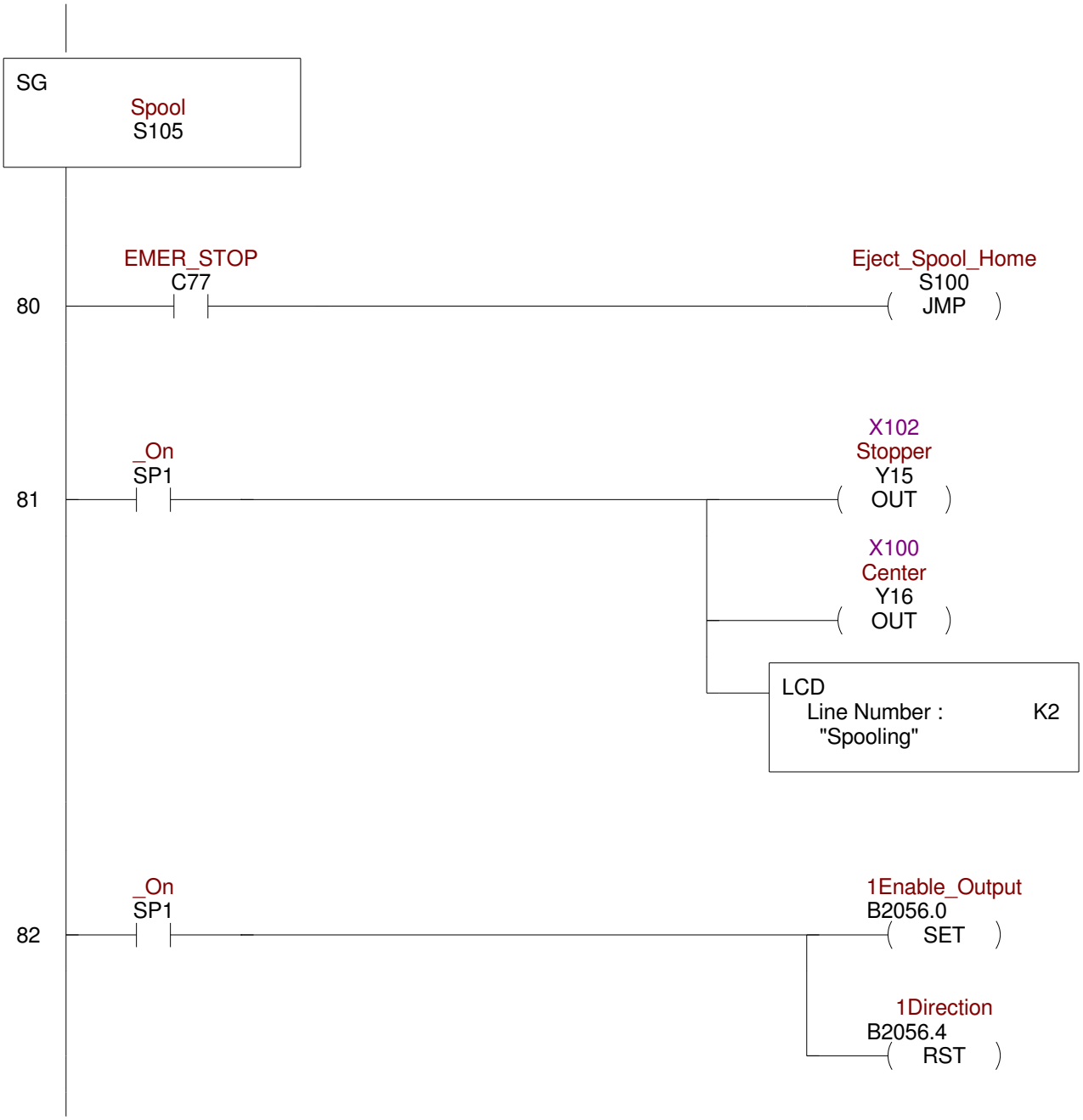

50
_On
SP1
LCD
Line Number : K1
"Running:"
S100ConfirmDone
C12
OUT
S200ConfirmDone
C22
OUT
S300COnfirmDone
C32
OUT
S400ConfirmDone
C42
OUT
SG
Sub1
S5
52
_On
SP1
S100Spool
C1
OUT
53
S100ConfirmReady
C11
Wait
S3
JMP
ISG
Eject_Spool_Home
S100

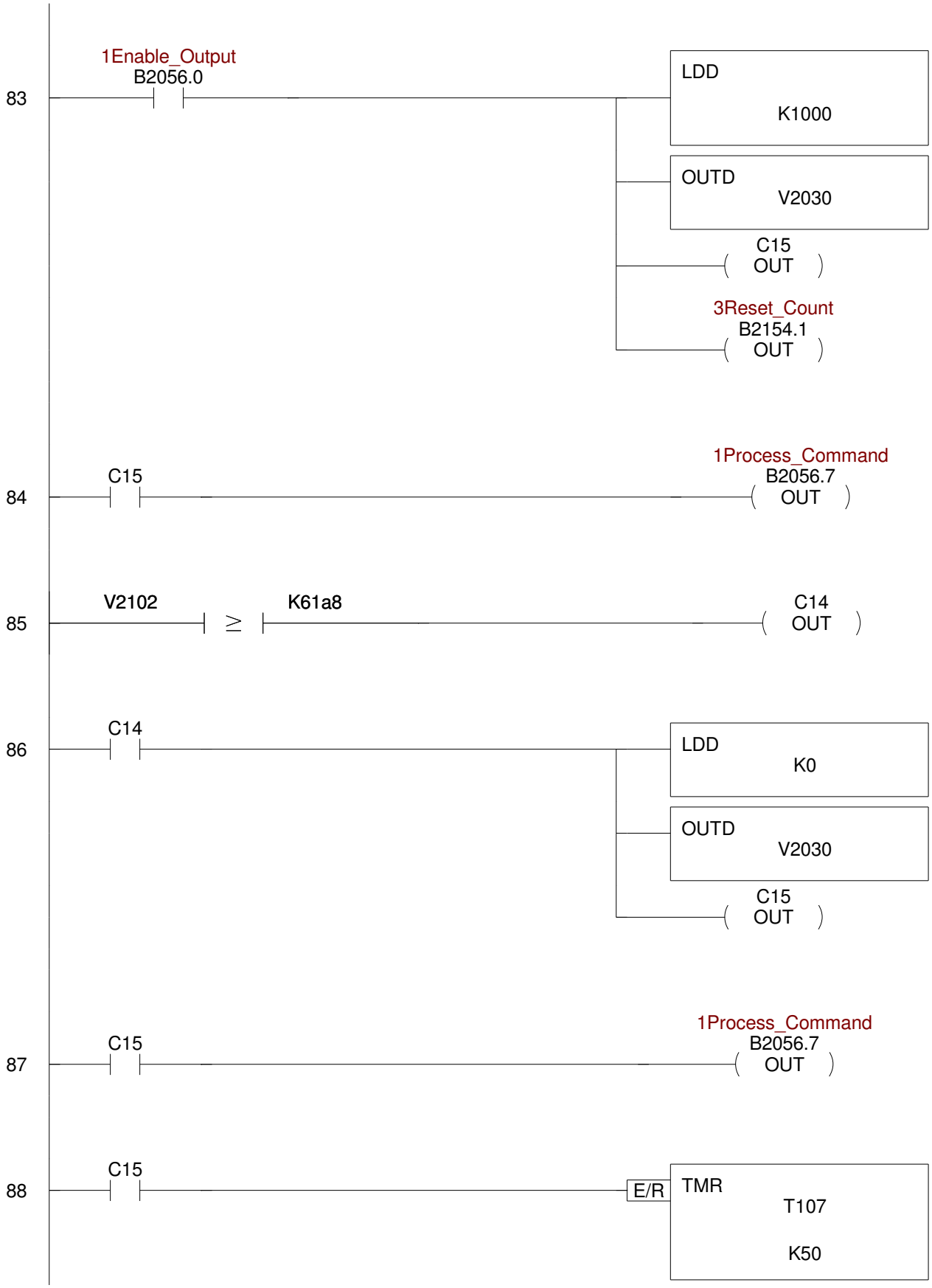

55
_On
SP1
LD
K10
OUT
V2040
1Enable_Output
B2056.0
RST
3Reset_Count
B2154.1
OUT
56
S100Spool
C1
Spool Loaded
X0
Stop
S102
JMP
57
S100Spool
C1
Spool Loaded
X0
S101
JMP
58
_On
SP1
S100ConfirmReady
C11
OUT
Y7
RST
X106
Spool_Damper
Y12
RST
SG
S101

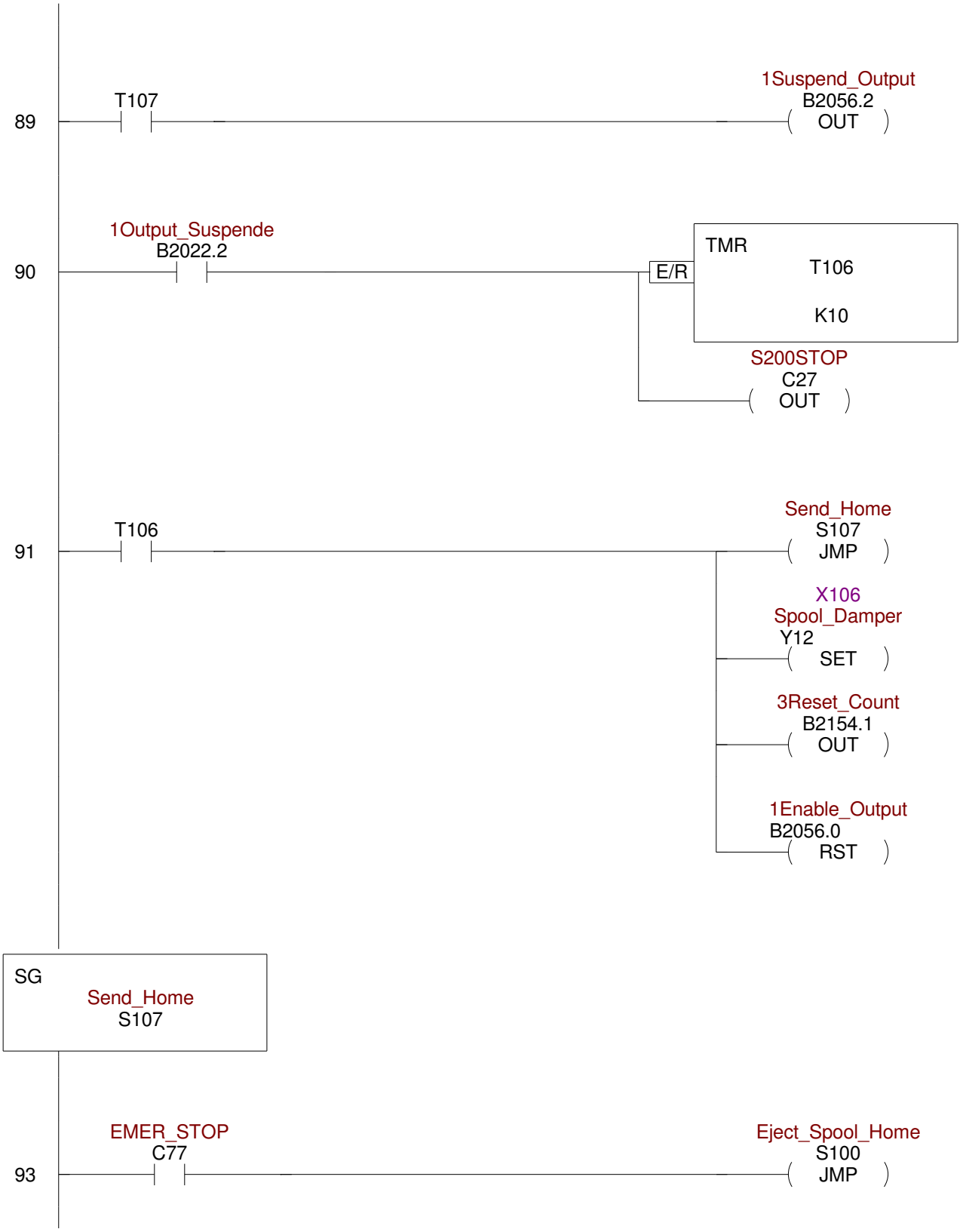

60
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
61
Spool Loaded
X0
SpoolStandEmpty
X1
X101
Pusher
Y17
OUT
62
Pusher Away
X4
Stop
S102
JMP
SG
Stop
S102
64
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
65
_On
SP1
E/R
TMR
T102
K5
Y7
SET
X106
Spool_Damper
Y12
SET
66
T102
X102
Stopper
Y15
OUT

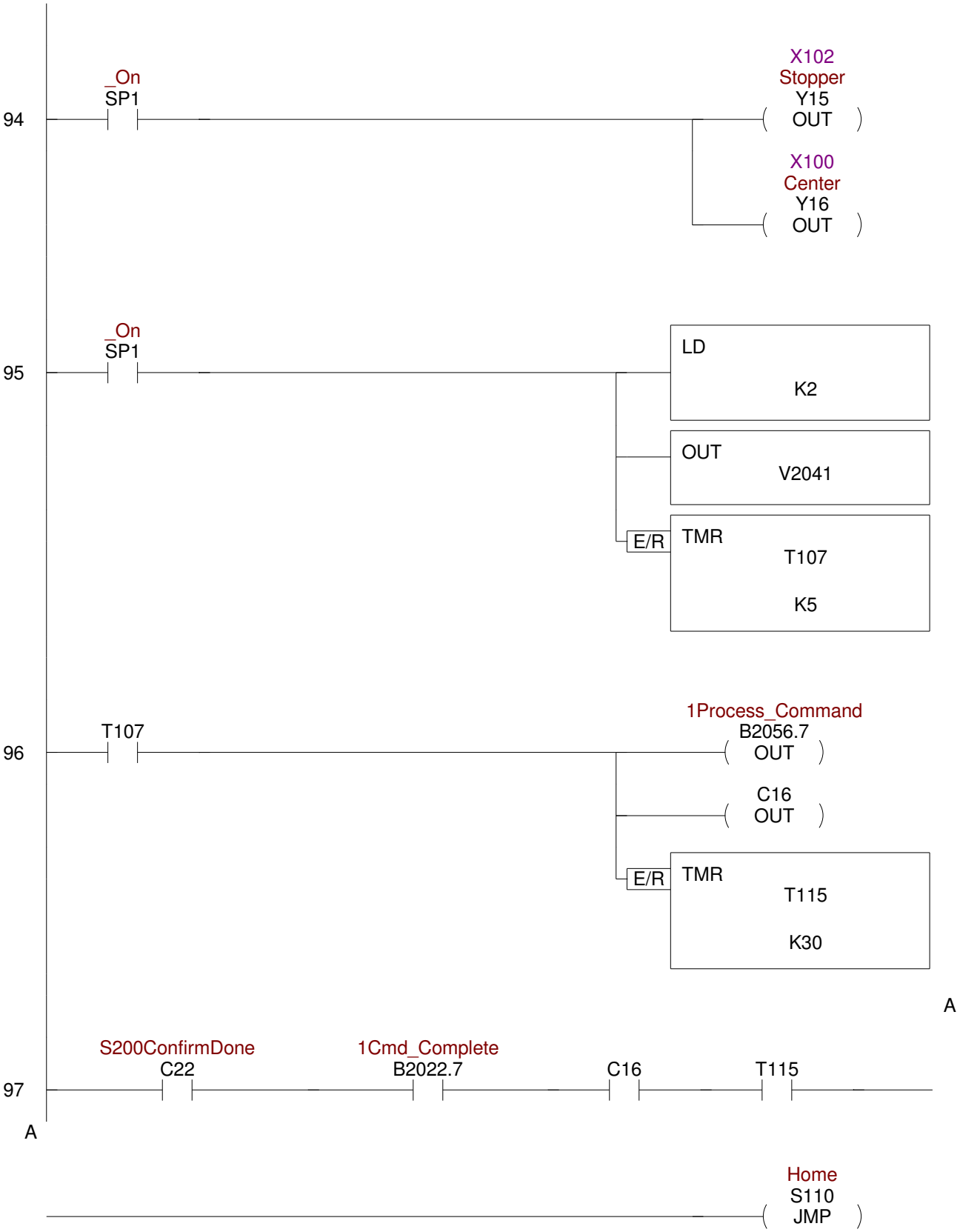

Stopper Home
X5
67
Raise
S103
JMP
SG
Raise
S103
EMER_STOP
C77
69
Eject_Spool_Home
S100
JMP
_On
SP1
70
X100
Center
Y16
OUT
X102
Stopper
Y15
OUT
Spool Loaded
X0
71
E/R
TMR
T103
K10
T103
72
S500Feeder
C5
OUT
S500ConfirmDone
C52
73
Send_Spool
S104
JMP

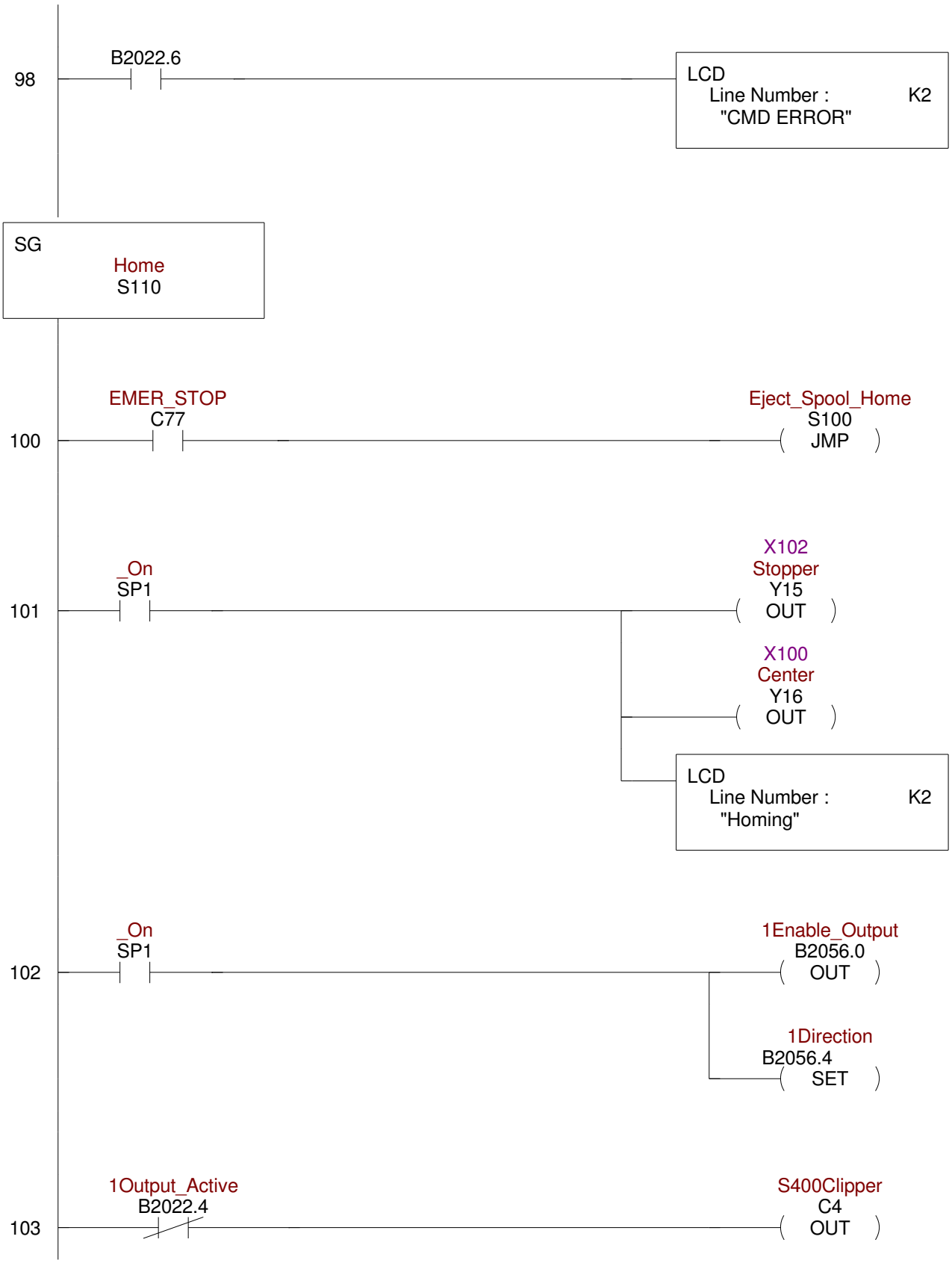

SG
Send_Spool
S104
EMER_STOP
C77
75
Eject_Spool_Home
S100
JMP
_On
SP1
76
X102
Stopper
Y15
OUT
X100
Center
Y16
OUT
X106
Spool_Damper
Y12
RST
_On
SP1
77
LD
K1
OUT
V2041
1Process_Command
B2056.7
OUT
1Cmd_Complete
B2022.7
78
Spool
S105
JMP

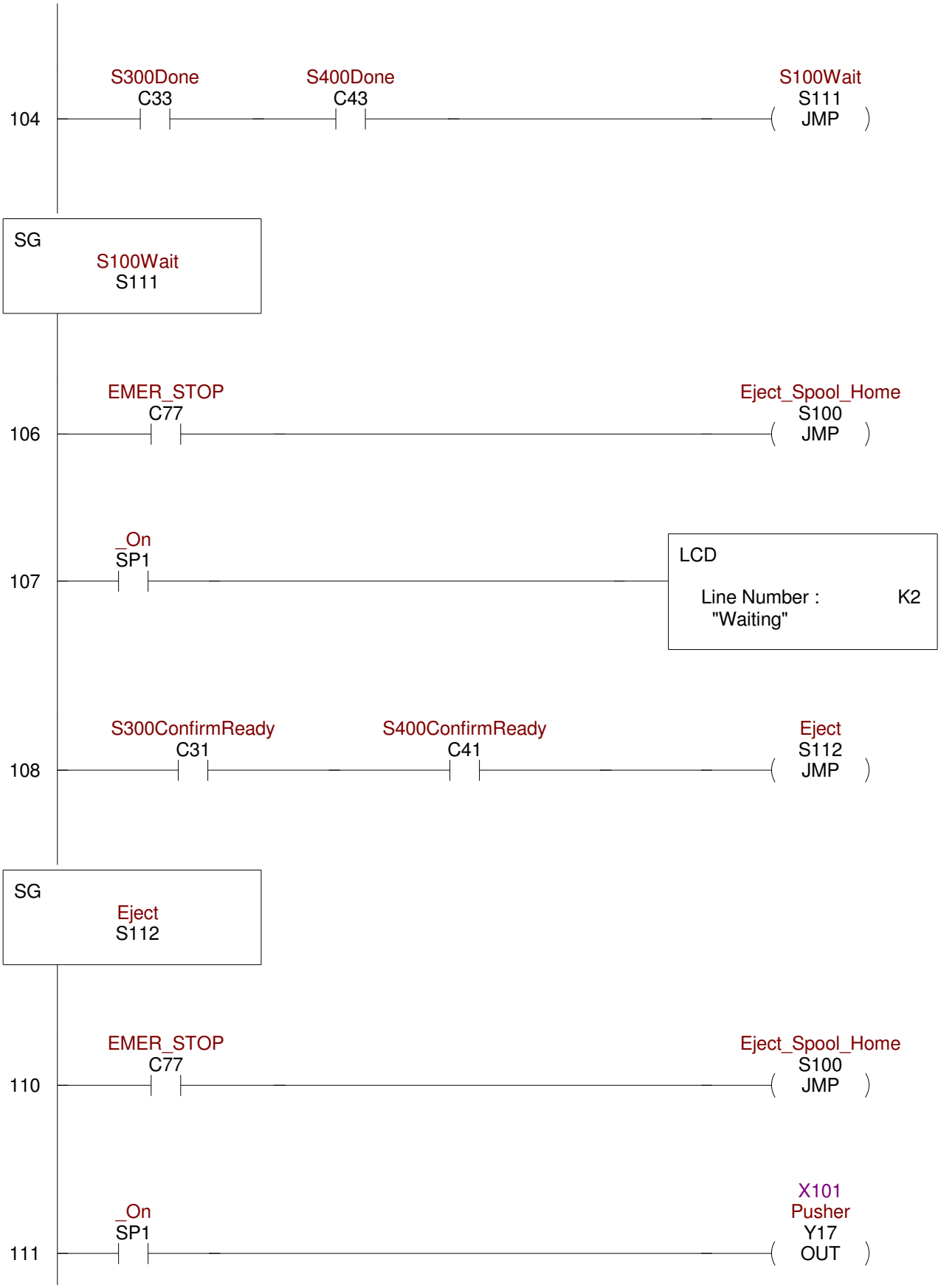

SG
Spool
S105
80
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
81
_On
SP1
X102
Stopper
Y15
OUT
X100
Center
Y16
OUT
LCD
Line Number : K2
"Spooling"
82
_On
SP1
1Enable_Output
B2056.0
SET
1Direction
B2056.4
RST

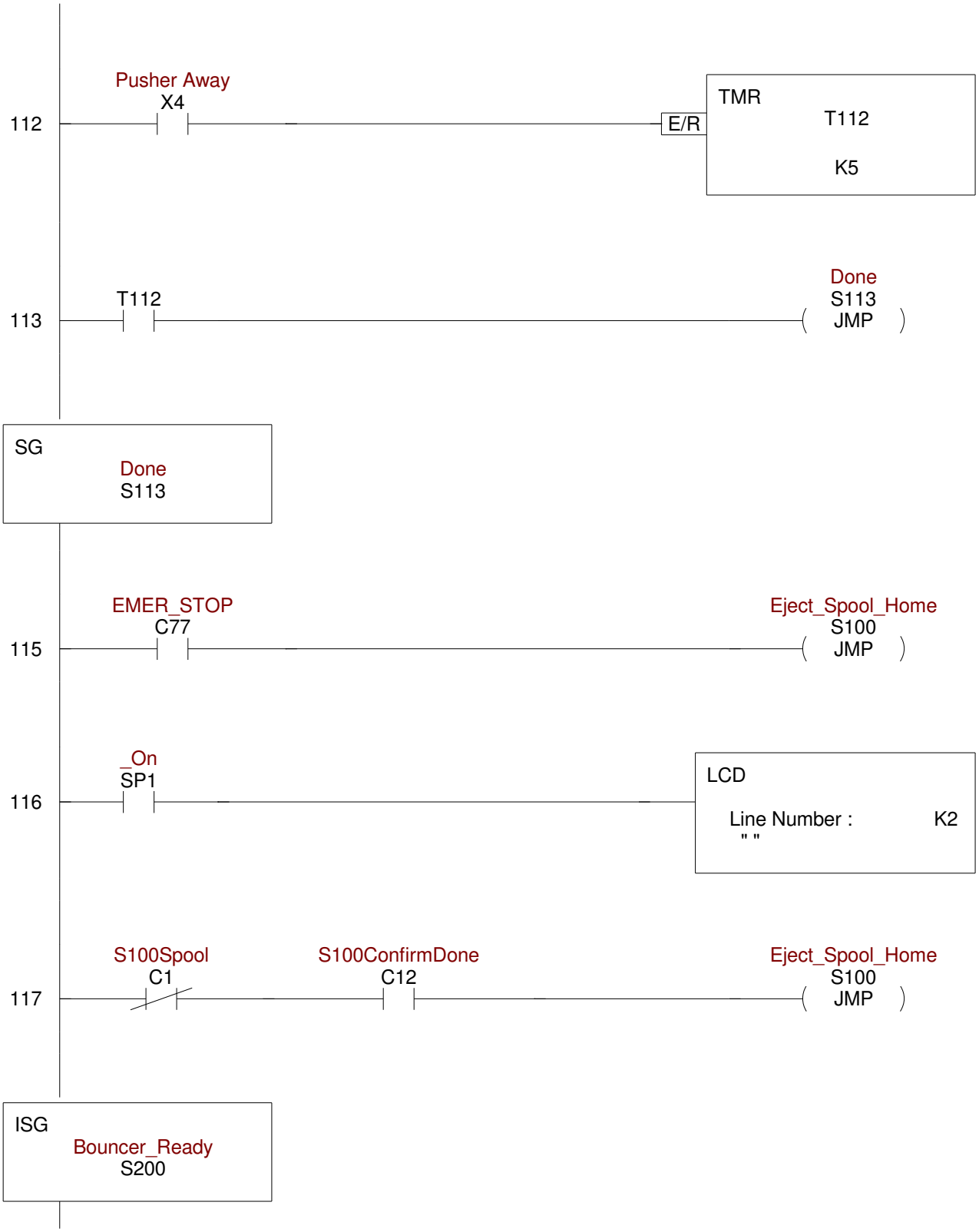

83
1Enable_Output
B2056.0
LDD
K1000
OUTD
V2030
C15
OUT
3Reset_Count
B2154.1
OUT
84
C15
1Process_Command
B2056.7
OUT
85
V2102
≥
K61a8
C14
OUT
86
C14
LDD
K0
OUTD
V2030
C15
OUT
87
C15
1Process_Command
B2056.7
OUT
88
C15
E/R
TMR
T107
K50

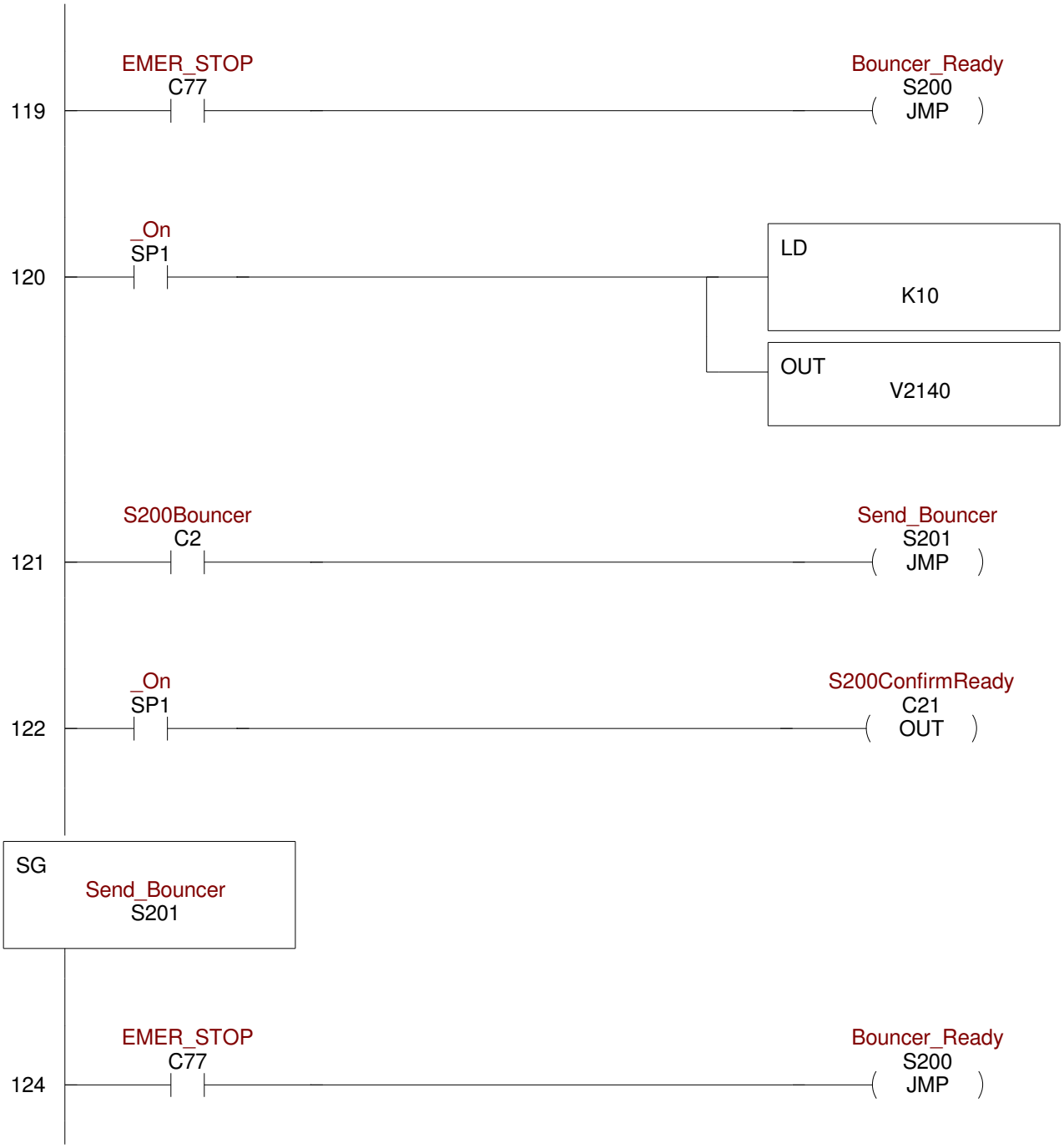

89
T107
1Suspend_Output
B2056.2
OUT
90
1Output_Suspende
B2022.2
E/R
TMR
T106
K10
S200STOP
C27
OUT
91
T106
Send_Home
S107
JMP
X106
Spool_Damper
Y12
SET
3Reset_Count
B2154.1
OUT
1Enable_Output
B2056.0
RST
SG
Send_Home
S107
93
EMER_STOP
C77
Eject_Spool_Home
S100
JMP

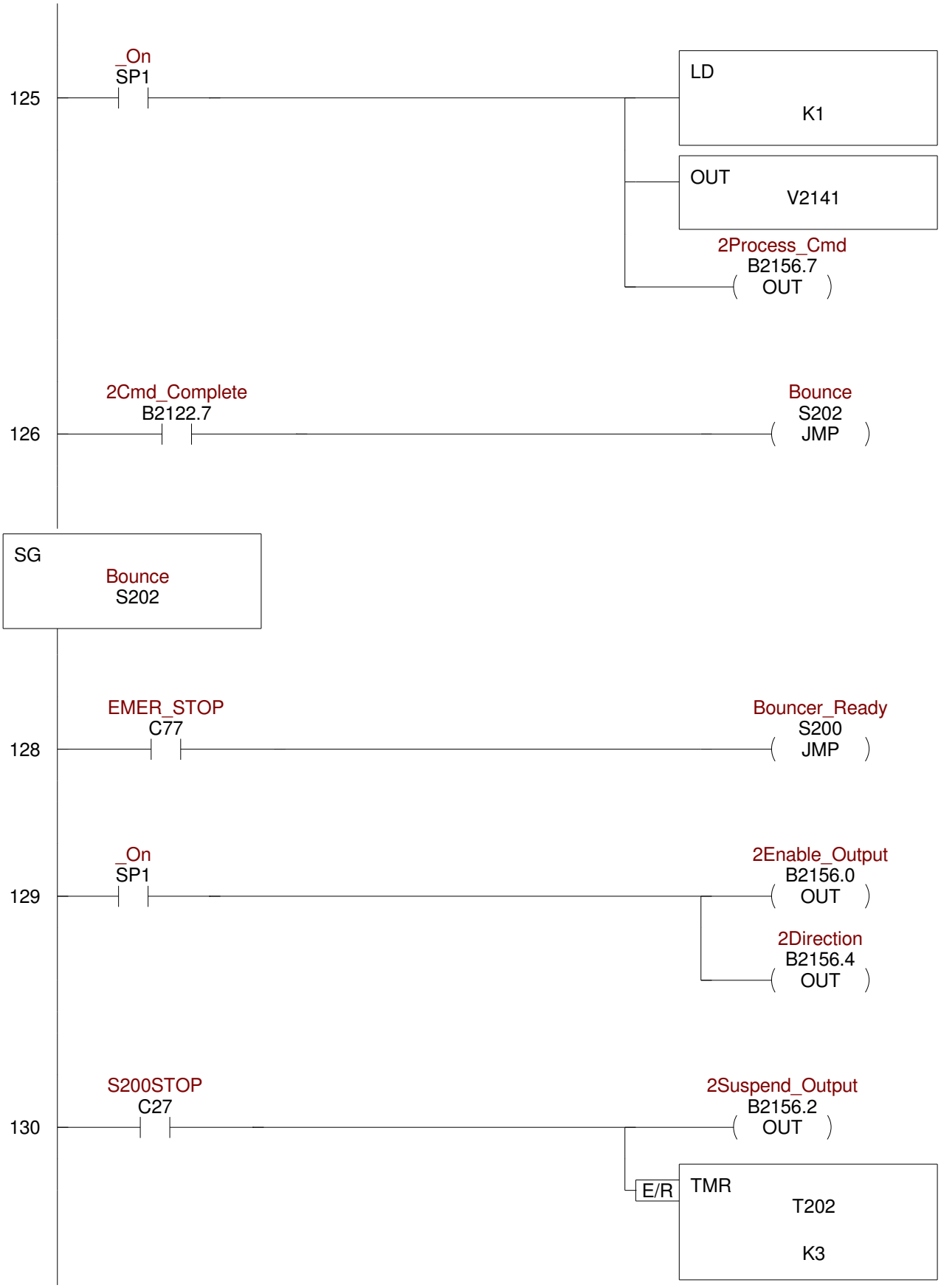

94
_On
SP1
X102
Stopper
Y15
OUT
X100
Center
Y16
OUT
95
_On
SP1
LD
K2
OUT
V2041
E/R
TMR
T107
K5
96
T107
1Process_Command
B2056.7
OUT
C16
OUT
E/R
TMR
T115
K30
A
97
S200ConfirmDone
C22
1Cmd_Complete
B2022.7
C16
T115
A
Home
S110
JMP

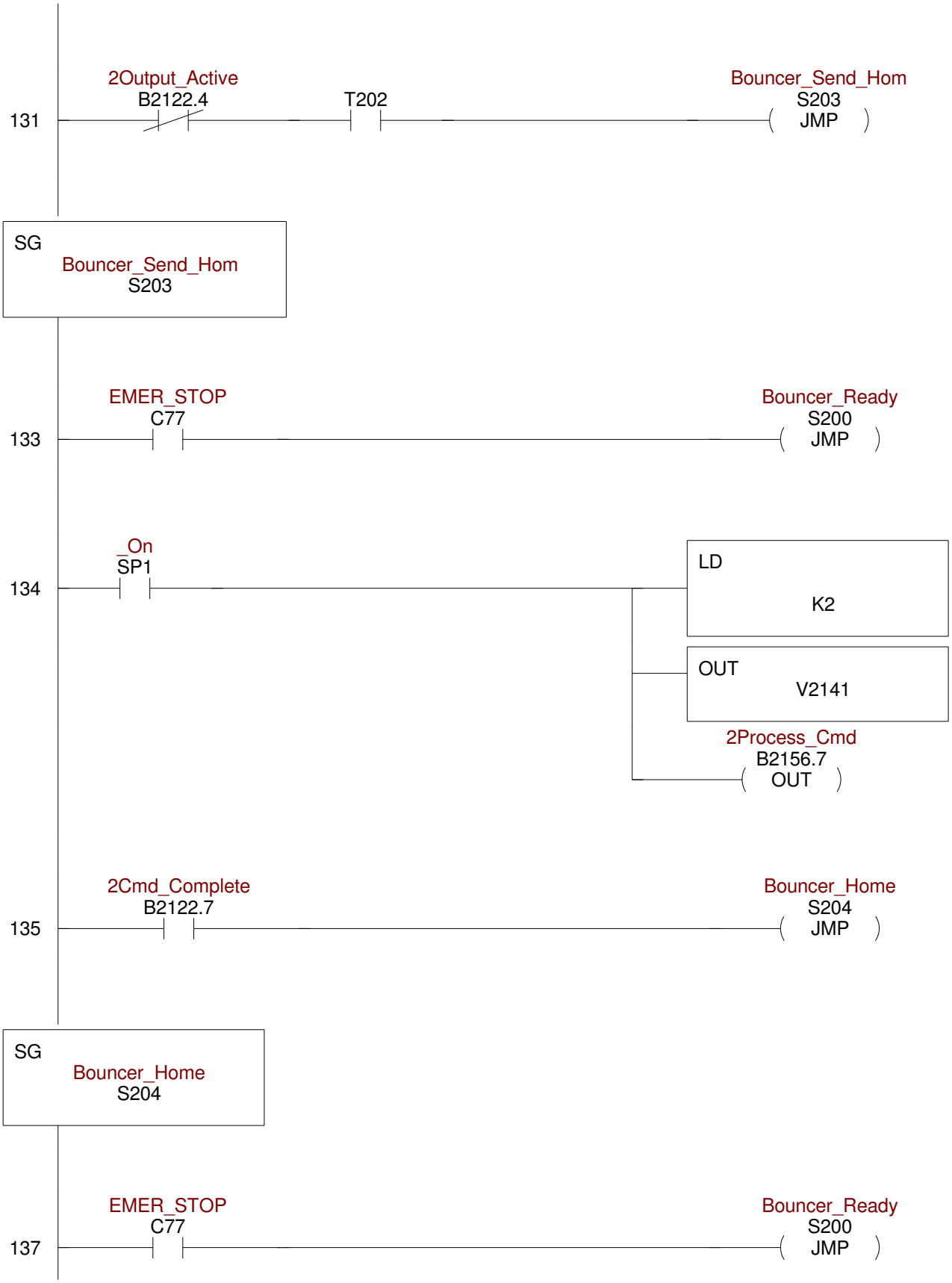

98
B2022.6
LCD
Line Number : K2
"CMD ERROR"
SG
Home
S110
100
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
101
_On
SP1
X102
Stopper
Y15
OUT
X100
Center
Y16
OUT
LCD
Line Number : K2
"Homing"
102
_On
SP1
1Enable_Output
B2056.0
OUT
1Direction
B2056.4
SET
103
1Output_Active
B2022.4
S400Clipper
C4
OUT

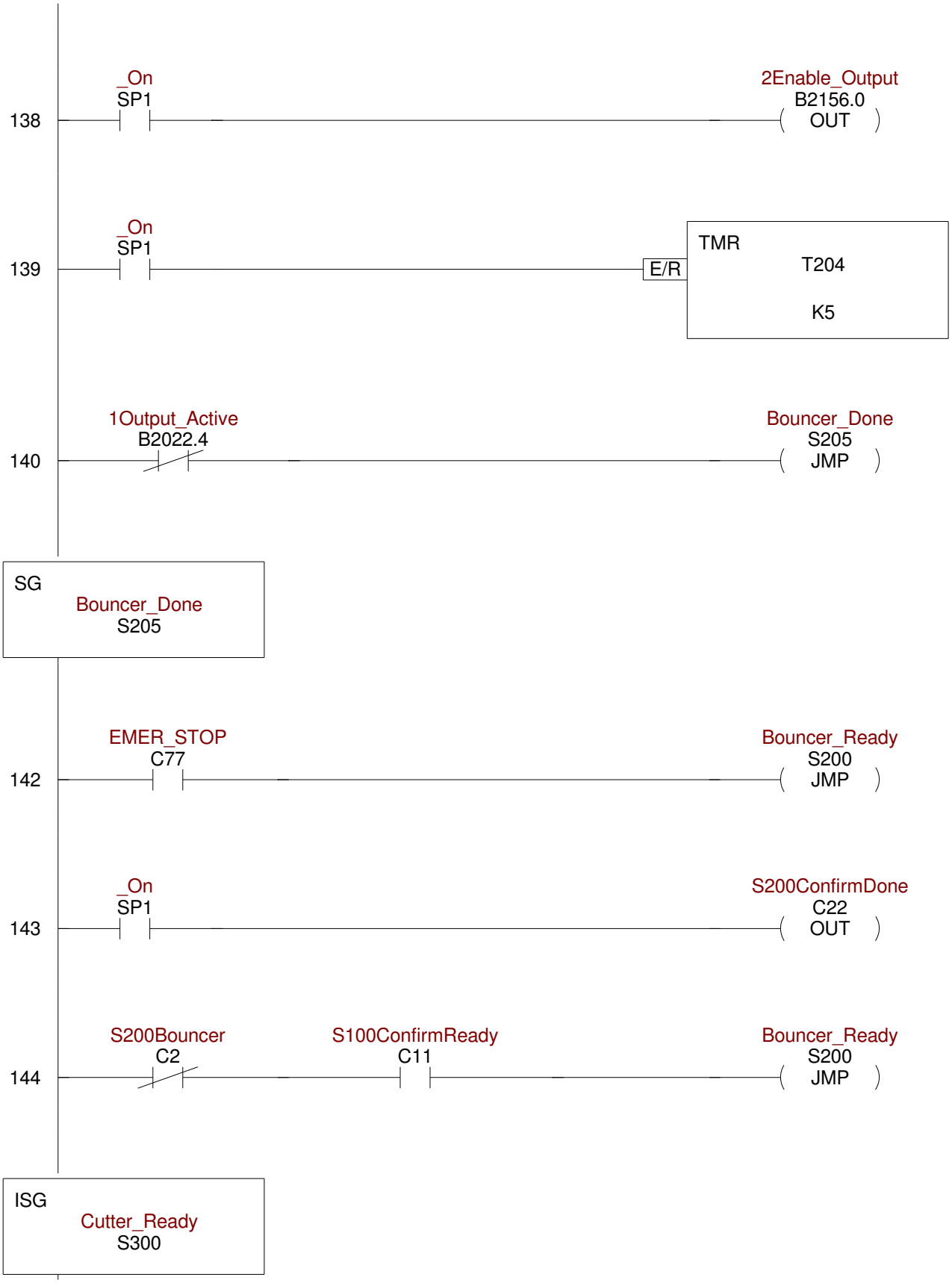

104
S300Done
C33
S400Done
C43
S100Wait
S111
JMP
SG
S100Wait
S111
106
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
107
_On
SP1
LCD
Line Number :
K2
"Waiting"
108
S300ConfirmReady
C31
S400ConfirmReady
C41
Eject
S112
JMP
SG
Eject
S112
110
EMER_STOP
C77
Eject_Spool_Home
S100
JMP
111
_On
SP1
X101
Pusher
Y17
OUT

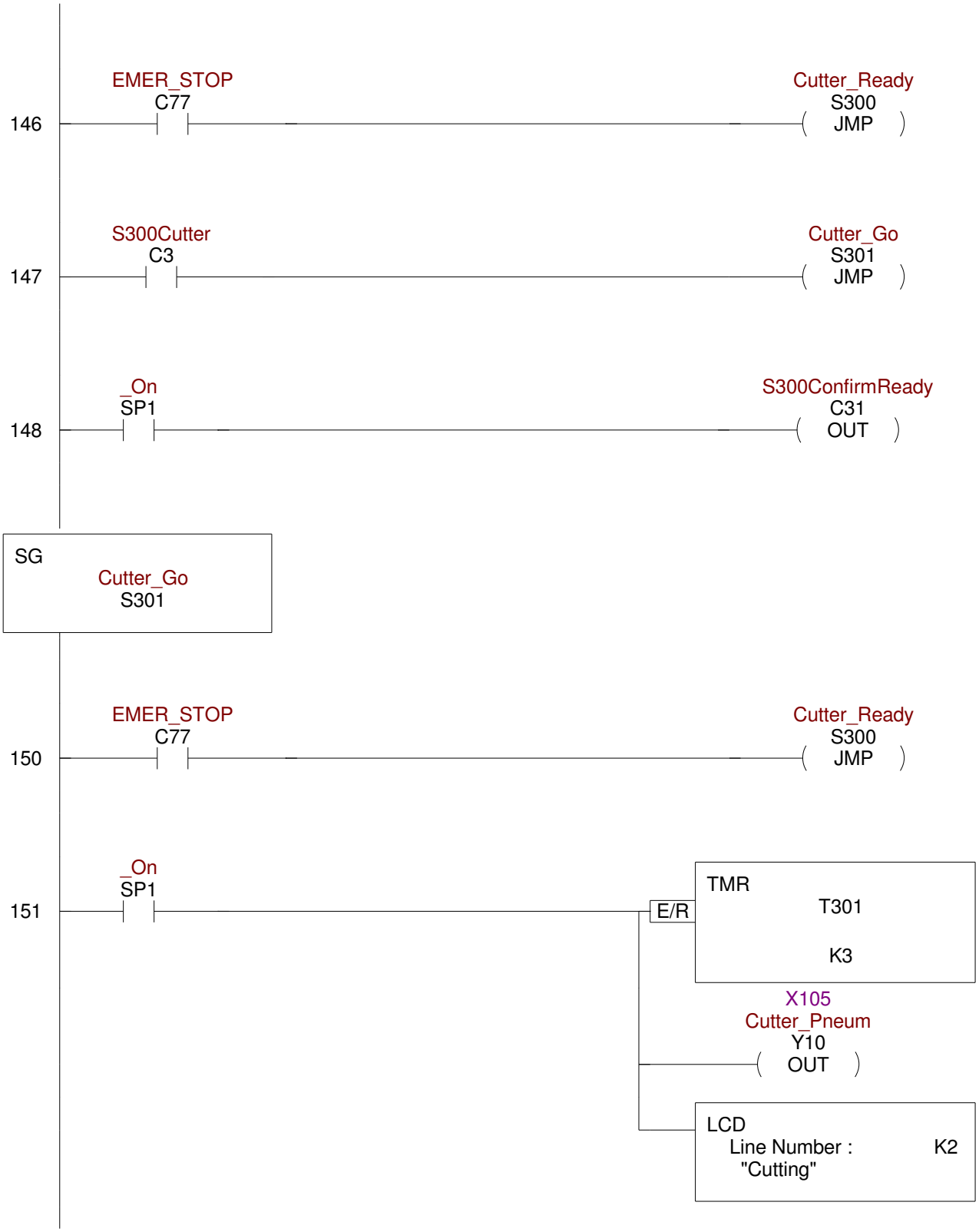

Pusher Away
X4
112
E/R
TMR
T112
K5
T112
113
Done
S113
JMP
SG
Done
S113
EMER_STOP
C77
115
Eject_Spool_Home
S100
JMP
_On
SP1
116
LCD
Line Number :
K2
" "
S100Spool
C1
S100ConfirmDone
C12
117
Eject_Spool_Home
S100
JMP
ISG
Bouncer_Ready
S200

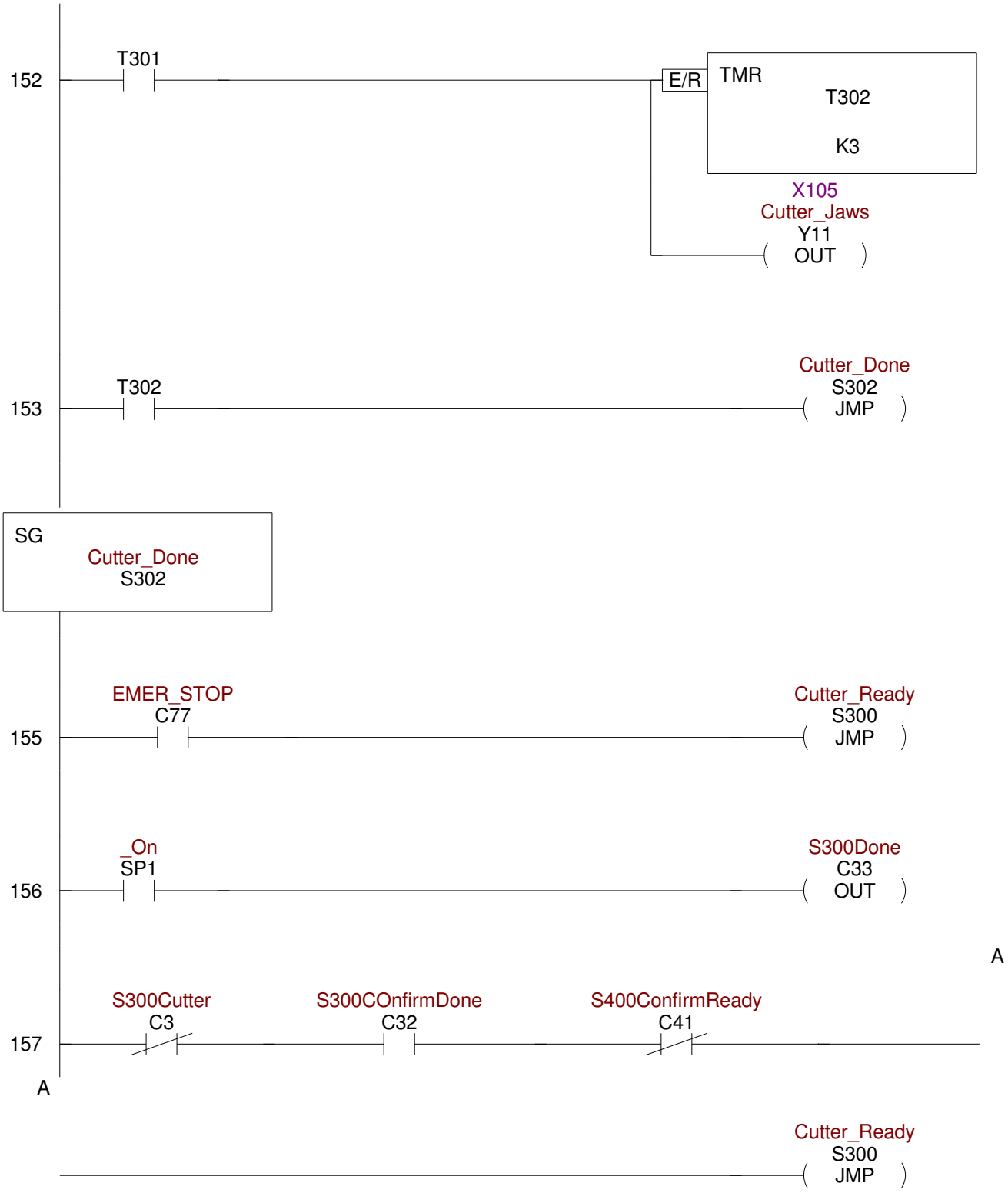

EMER_STOP
C77
Bouncer_Ready
S200
JMP
119
_On
SP1
120
LD
K10
OUT
V2140
S200Bouncer
C2
Send_Bouncer
S201
JMP
121
_On
SP1
S200ConfirmReady
C21
OUT
122
SG
Send_Bouncer
S201
EMER_STOP
C77
Bouncer_Ready
S200
JMP
124

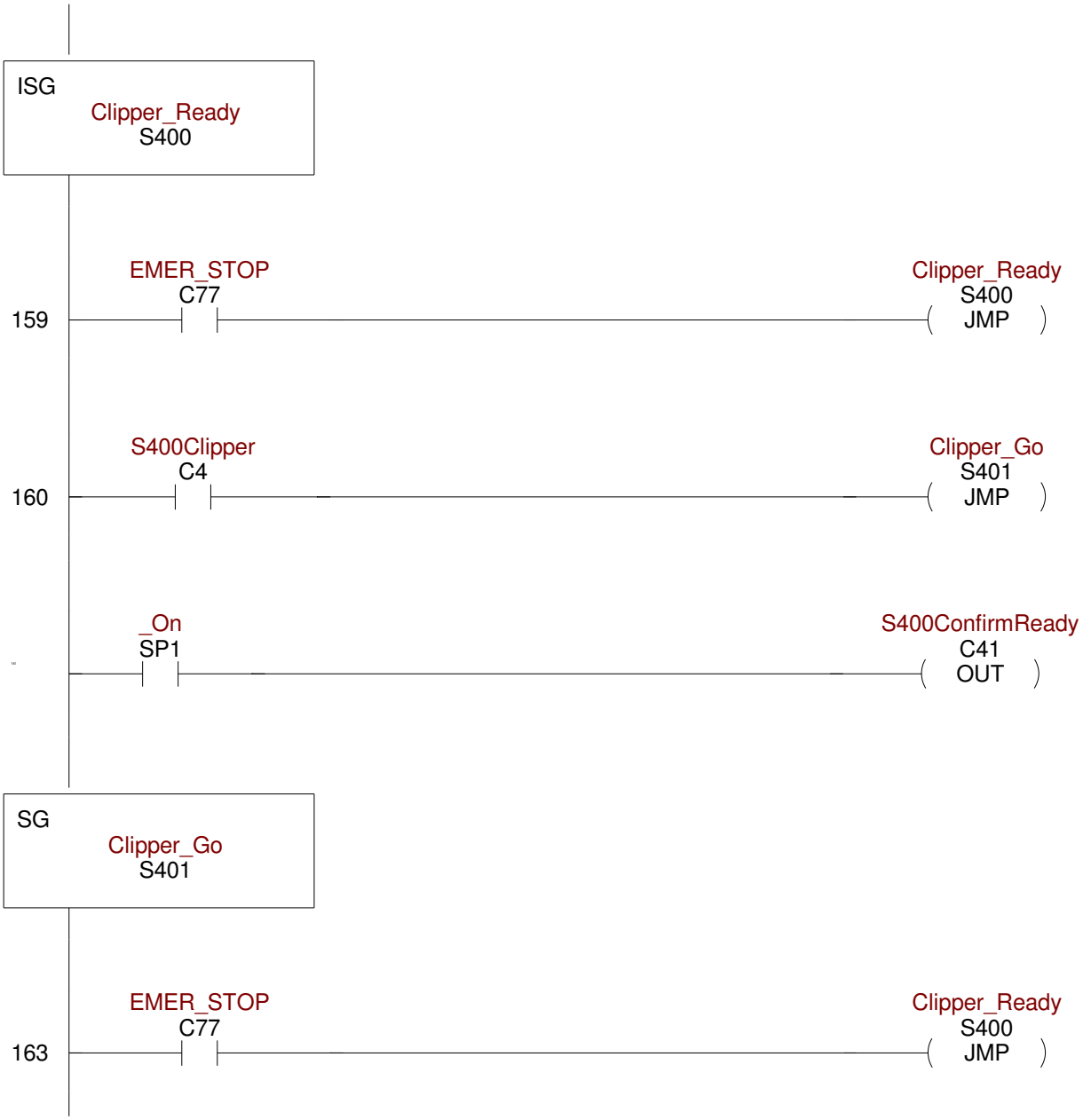

125
_On
SP1
LD
K1
OUT
V2141
2Process_Cmd
B2156.7
OUT
126
2Cmd_Complete
B2122.7
Bounce
S202
JMP
SG
Bounce
S202
128
EMER_STOP
C77
Bouncer_Ready
S200
JMP
129
_On
SP1
2Enable_Output
B2156.0
OUT
2Direction
B2156.4
OUT
130
S200STOP
C27
2Suspend_Output
B2156.2
OUT
E/R
TMR
T202
K3

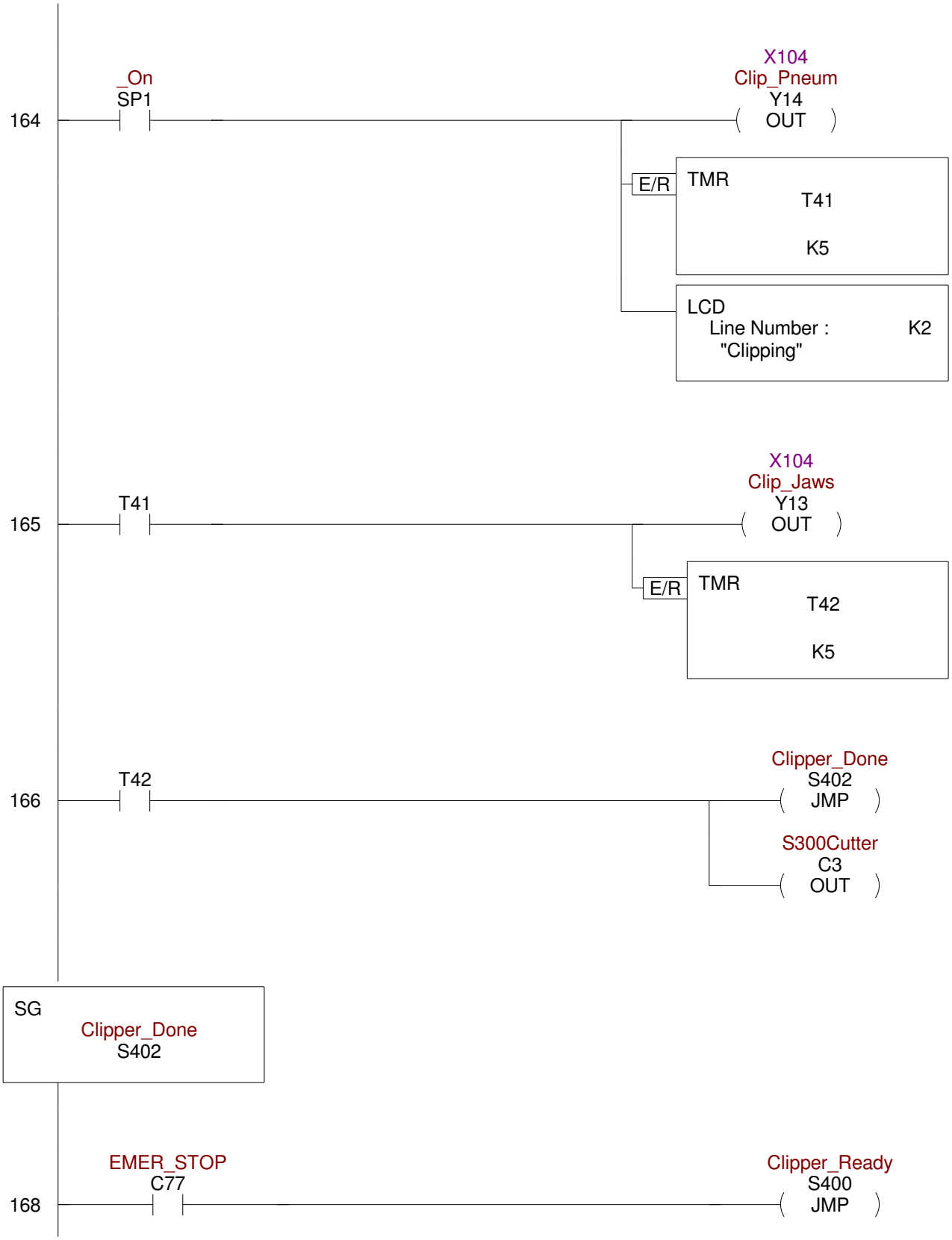

131
2Output_Active
B2122.4
T202
Bouncer_Send_Hom
S203
JMP
SG
Bouncer_Send_Hom
S203
133
EMER_STOP
C77
Bouncer_Ready
S200
JMP
134
_On
SP1
LD
K2
OUT
V2141
2Process_Cmd
B2156.7
OUT
135
2Cmd_Complete
B2122.7
Bouncer_Home
S204
JMP
SG
Bouncer_Home
S204
137
EMER_STOP
C77
Bouncer_Ready
S200
JMP

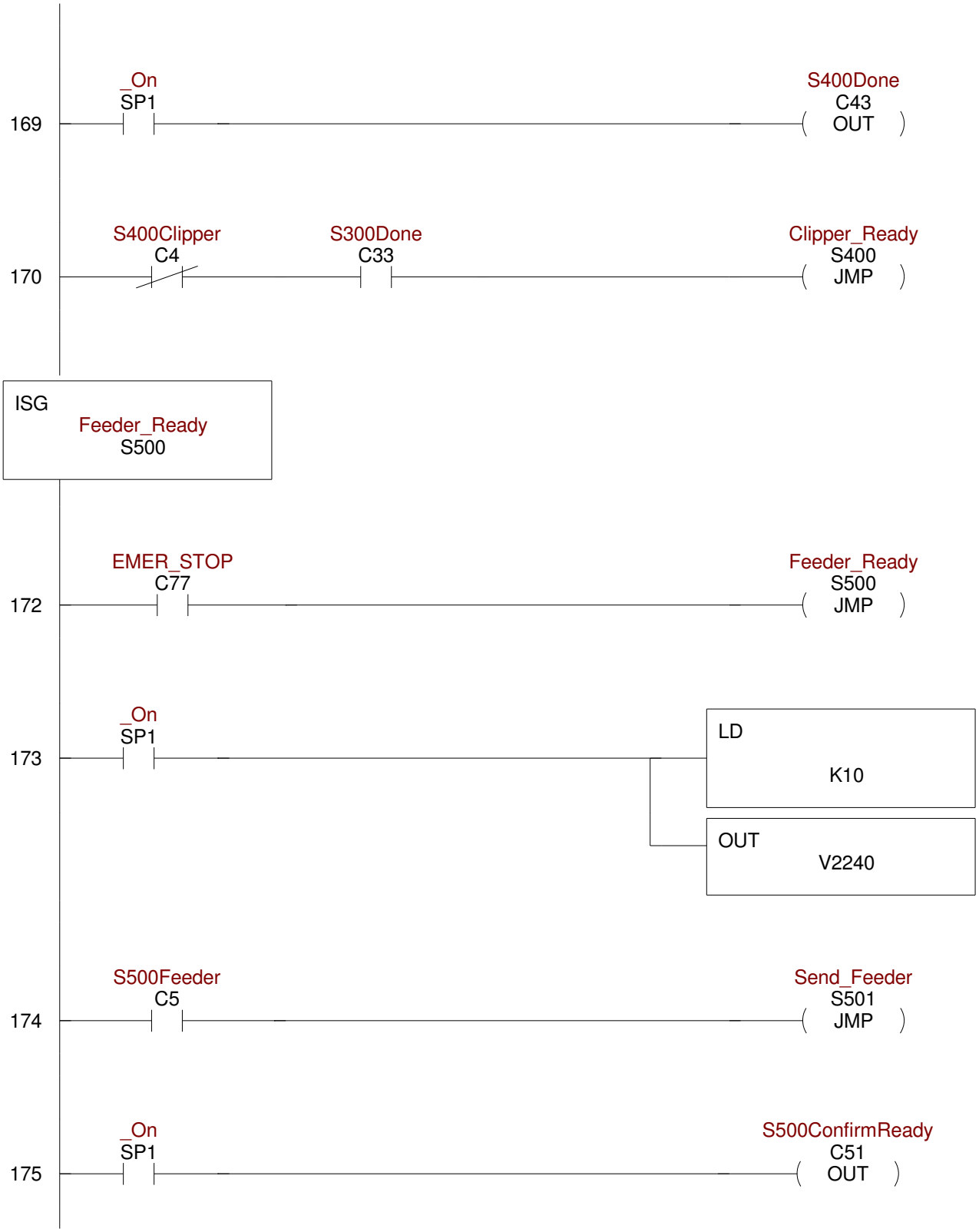

138
_On
SP1
2Enable_Output
B2156.0
OUT
139
_On
SP1
E/R
TMR
T204
K5
140
1Output_Active
B2022.4
Bouncer_Done
S205
JMP
SG
Bouncer_Done
S205
142
EMER_STOP
C77
Bouncer_Ready
S200
JMP
143
_On
SP1
S200ConfirmDone
C22
OUT
144
S200Bouncer
C2
S100ConfirmReady
C11
Bouncer_Ready
S200
JMP
ISG
Cutter_Ready
S300

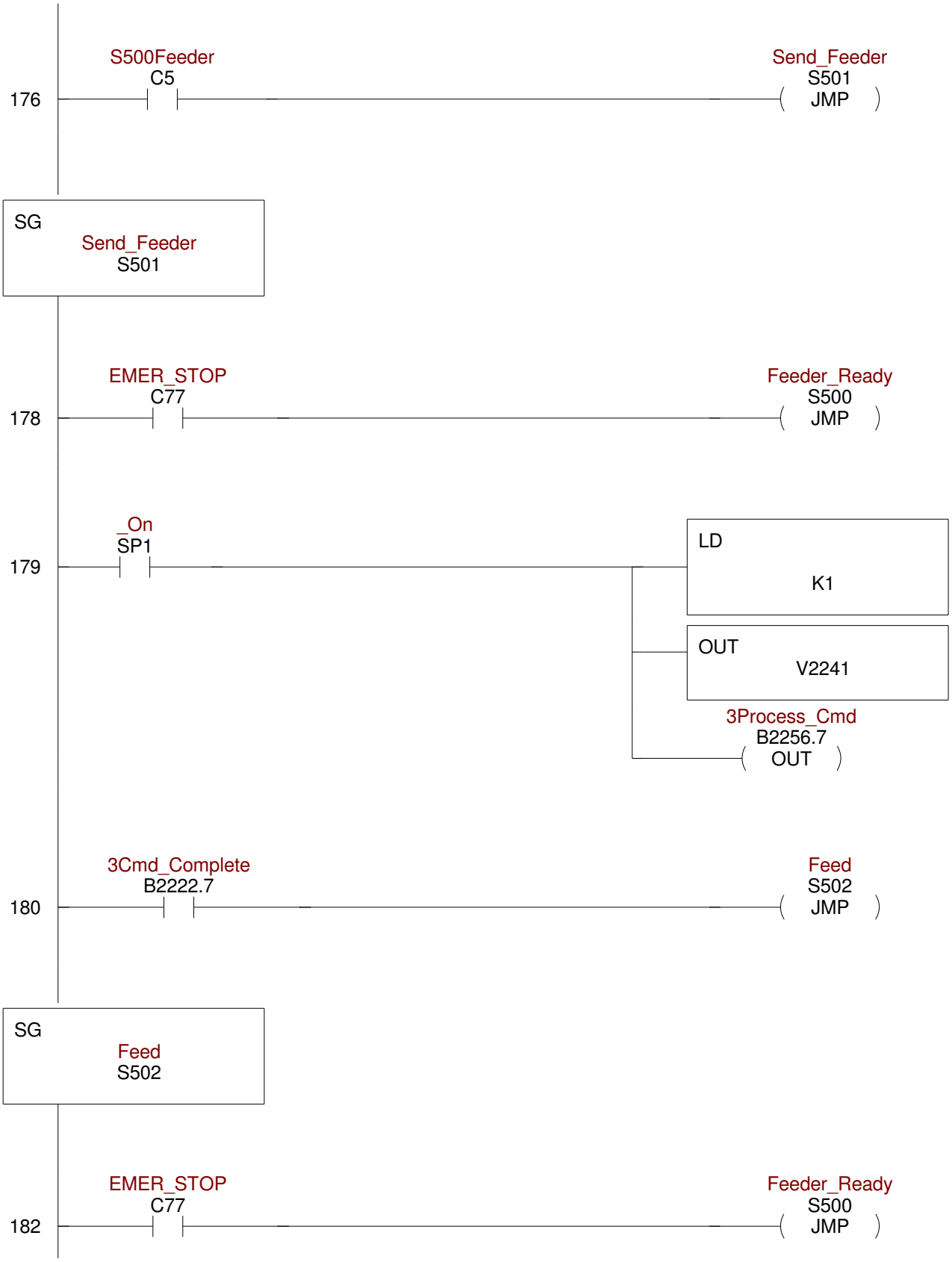

146
EMER_STOP
C77
Cutter_Ready
S300
JMP
147
S300Cutter
C3
Cutter_Go
S301
JMP
148
_On
SP1
S300ConfirmReady
C31
OUT
SG
Cutter_Go
S301
150
EMER_STOP
C77
Cutter_Ready
S300
JMP
151
_On
SP1
E/R
TMR
T301
K3
X105
Cutter_Pneum
Y10
OUT
LCD
Line Number :
K2
"Cutting"

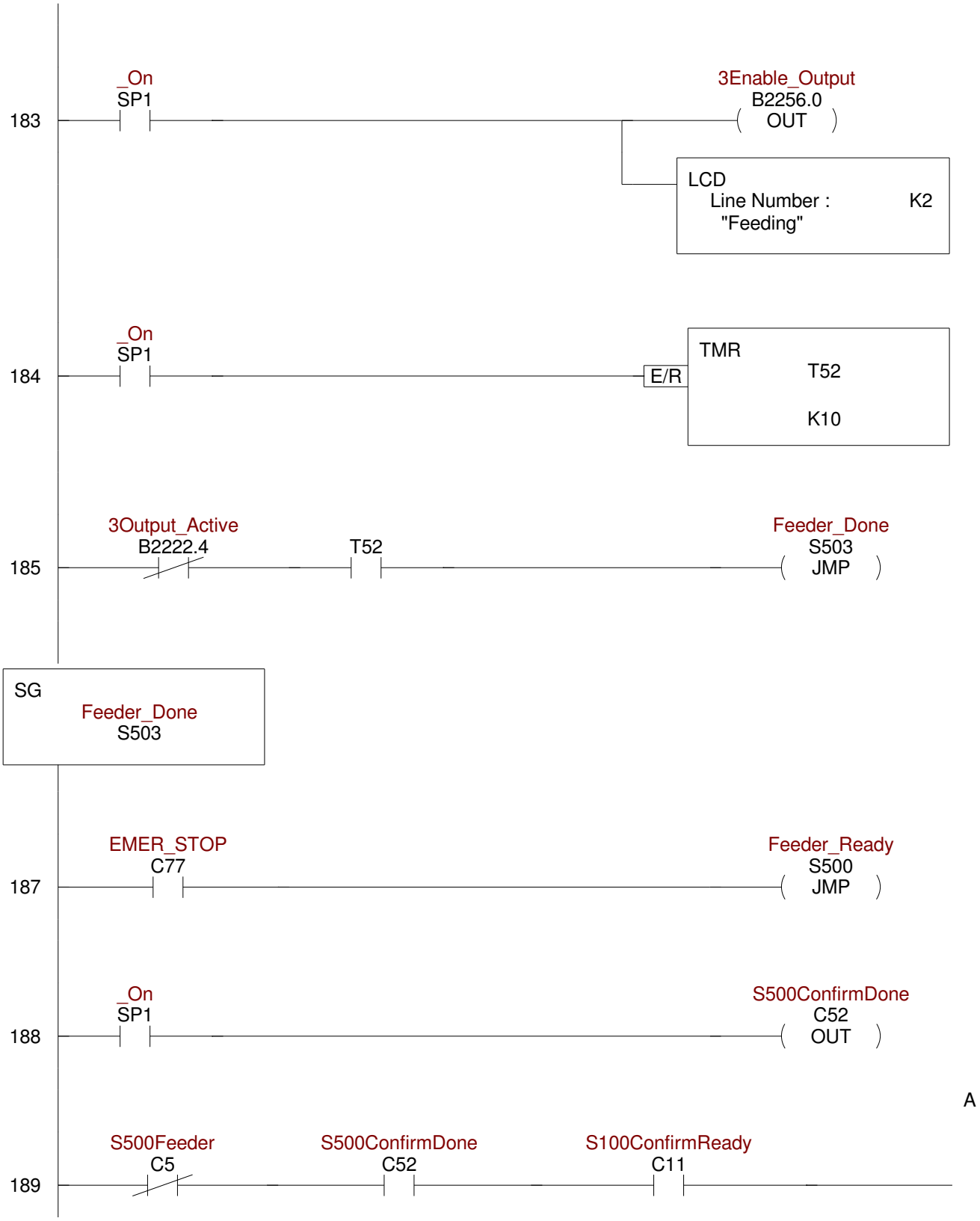

152
T301
E/R
TMR
T302
K3
X105
Cutter_Jaws
Y11
OUT
153
T302
Cutter_Done
S302
JMP
SG
Cutter_Done
S302
155
EMER_STOP
C77
Cutter_Ready
S300
JMP
156
_On
SP1
S300Done
C33
OUT
A
157
S300Cutter
C3
S300COnfirmDone
C32
S400ConfirmReady
C41
A
Cutter_Ready
S300
JMP


ISG
Clipper_Ready
S400
EMER_STOP
C77
Clipper_Ready
S400
JMP
159
S400Clipper
C4
Clipper_Go
S401
JMP
160
_On
SP1
S400ConfirmReady
C41
OUT
SG
Clipper_Go
S401
EMER_STOP
C77
Clipper_Ready
S400
JMP
163

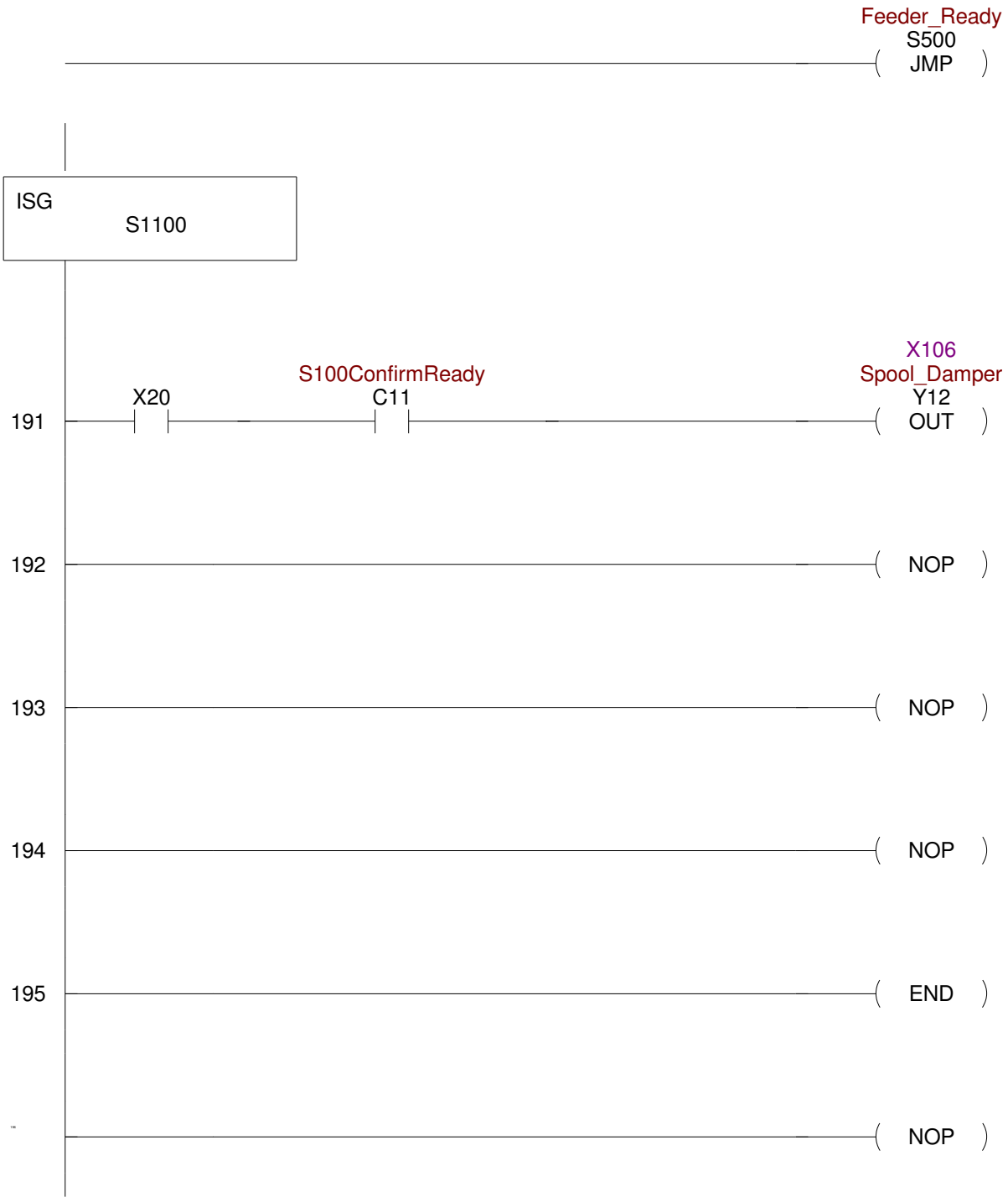

164
_On
SP1
X104
Clip_Pneum
Y14
OUT
E/R
TMR
T41
K5
LCD
Line Number :
K2
"Clipping"
165
T41
X104
Clip_Jaws
Y13
OUT
E/R
TMR
T42
K5
166
T42
Clipper_Done
S402
JMP
S300Cutter
C3
OUT
SG
Clipper_Done
S402
168
EMER_STOP
C77
Clipper_Ready
S400
JMP


169
_On
SP1
S400Done
C43
OUT
170
S400Clipper
C4
S300Done
C33
Clipper_Ready
S400
JMP
ISG
Feeder_Ready
S500
172
EMER_STOP
C77
Feeder_Ready
S500
JMP
173
_On
SP1
LD
K10
OUT
V2240
174
S500Feeder
C5
Send_Feeder
S501
JMP
175
_On
SP1
S500ConfirmReady
C51
OUT


176
S500Feeder
C5
Send_Feeder
S501
JMP
SG
Send_Feeder
S501
178
EMER_STOP
C77
Feeder_Ready
S500
JMP
179
_On
SP1
LD
K1
OUT
V2241
3Process_Cmd
B2256.7
OUT
180
3Cmd_Complete
B2222.7
Feed
S502
JMP
SG
Feed
S502
182
EMER_STOP
C77
Feeder_Ready
S500
JMP


183
_On
SP1
3Enable_Output
B2256.0
OUT
LCD
Line Number :
K2
"Feeding"
184
_On
SP1
E/R
TMR
T52
K10
185
3Output_Active
B2222.4
T52
Feeder_Done
S503
JMP
SG
Feeder_Done
S503
187
EMER_STOP
C77
Feeder_Ready
S500
JMP
188
_On
SP1
S500ConfirmDone
C52
OUT
A
189
S500Feeder
C5
S500ConfirmDone
C52
S100ConfirmReady
C11

A


Feeder_Ready
S500
JMP
ISG
S1100
X106
Spool_Damper
S100ConfirmReady
X20
C11
Y12
191
OUT
192
NOP
193
NOP
194
NOP
195
END
NOP