

**EET Senior Design Project**

IMS Dynamic Display

Submitted to

Professor Robert Weissbach, PhD  
Professor William Lin, PhD  
Electrical Engineering Technology Program  
Engineering & Technology Department

by

John Tyler Boggess  
Michael Lee Elkins

Apr. 29, 2019

Authors:

Approval By:

Submission Date:

Version:

## IMS Dynamic Display

### Abstract

The Indianapolis Motor Speedway Museum has a display transmission that is still actively used in IndyCar today. The museum wants to incorporate this transmission into an interactive display, so guests of all ages can see internal gears spin as well as see the transmission shift between its gears. This project includes mechanical and electrical engineering technology students working together to mount wire motors and sensors. The transmission will have a user-friendly interface allowing the guests to change gears and to turn the transmission on and off. The transmission will be driven by a 24V DC motor and uses a 24V DC linear actuator to rotate a barrel cam to change the position of the forks, allowing the gears to get shifted up and down. A metal enclosure houses the electrical components that provide power and control to the system. The outcome of this project is a failsafe and robust system that will operate within the IMS Museum while being continually updated.

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**Revision History**

<b>Version</b>	<b>Date</b>	<b>Contributors</b>	<b>Description</b>
1.0	23, Oct. 2018	John Boggess Michael Elkins	Initial Version
2.0	25, Oct. 2018	Michael Elkins	Student Peer Review changes added
3.0	27, Nov. 2018	Michael Elkins	Reformatted to match recommended style
4.0	13, Dec. 2018	John Boggess Michael Elkins	Final Version – Senior Design Phase I
5.0	04, Mar. 2019	Michael Elkins John Boggess	Polished Draft – Senior Design Phase II
6.0	04, Apr. 2019	Michael Elkins John Boggess	Final Draft – Senior Design Phase II
7.0	30, Apr. 2019	John Boggess Michael Elkins	Final Paper Submitted to University Library

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## IMS Dynamic Display

### Introduction

Xtrac, Inc., has supplied a cutaway gearbox to the Indianapolis Motor Speedway (IMS) Museum. The IMS wants to make the gearbox display interactive by having the gears shift up and down at the press of a button. [We will create a](#) panel to allow users to approach the gearbox display, turn the transmission mechanism, and shift gears. The mechanical and electronic components that operate the gearbox will be enclosed as much as possible to create an appealing museum display.

A transmission is an essential part to a complete vehicle, but how well can people comprehend how a transmission works if they don't see it in working condition? A transmission allows a vehicle to shift with gears as a motor spins faster or slower. Using an engine and transmission in a race setting requires higher torque to maintain higher speeds. A transmission by itself requires some form of electrically powered input to operate independently from a racing engine. The IMS has an IndyCar transmission that has been donated by a company named Xtrac, Inc. The IMS has contacted the engineering department at IUPUI to get students to make their transmission interactive.

The IMS wants an interactive display that shows how the transmission turns and shifts through the gears and allows people of all ages to learn. The project covers 2 semesters because the Electrical Engineering Technology (EET) curriculum has the design process in the fall semester and implementation in the spring semester. Since a transmission has mostly a mechanical aspect, a team of Mechanical Engineering Technology (MET) students are paired with a team of EET students. Any mounting and specification requirements are a part of the MET students' project requirements. Details regarding electrical power, circuit design, and electromechanical integration will be generated by the EET students.

### Problem Statement

The IMS Dynamic Display will have a user-friendly interface allowing students, mentors, [lecturers](#), and guests to control all actions of the transmission. The interior gears of the transmission are going to be rotated with a 24V DC permanent magnet motor. A 24V DC linear actuator will be used to rotate a barrel cam that shifts forks back and forth to shift throughout the gears. The user interface (UI) will be robust allowing [for a](#) large amount of wear and tear to [the](#) electrical buttons as well as [the](#) mechanical parts.

### System Overview

Having a display transmission is useful but is not [at](#) its full potential because no gears are turning around, and nothing can be viewed in a [real-time](#) setting. Having a transmission that will turn the interior gears and shift through the positions will be educational and useful for audiences of all ages. Allowing the audience to see the difference between first neutral and 6<sup>th</sup> gear can be mesmerizing at a young age.

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**Referenced Documents**

**Table 1: Referenced Documents**

<b>Title</b>	<b>Document Reference Number</b>	<b>Comment</b>
Project Proposal and Specifications	PPS001 rev. 1	Submitted 10/05/18
User Interface Design	UID001 rev. 1	Submitted 12/05/18
Control Box Schematic	CBS001 rev. 2	Submitted 03/28/18
Final Project Proposal	FPP001 rev. 1	Submitted 01/31/19
CCW PLC Code	Ladder Logic	Phase I Complete

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## IMS Dynamic Display

### Project Design Decisions

The purpose of this project is getting the transmission gears to move and to increment and decrement by electronic control. A 24V DC motor will be mounted to the input shaft of the transmission that allows the inner gears to spin. A 24V DC linear actuator will increment or decrement the gear position from neutral through 6<sup>th</sup> gear and back down again. The permanent magnet DC motor in the actuator will be controlled using PLC ladder logic to allow the cylinder to extend/retract from a specific point. A Selector Switch provides power, Start and Stop pushbuttons control the gear motor, and 2 yellow pushbuttons control shifting.

#### Inputs/Outputs

The primary means of control for this project will be PLC ladder logic. Our design includes 5 inputs in its current state. The user will have access to 4 of these inputs: Start, Stop, Shift Up, and Shift Down (Figure. 2). The other input will be an analog signal that will communicate automatically to the PLC to determine actuator position. A Selector Switch will be placed between the incoming AC voltage and the control box components (Figure. 2). Five outputs are currently in the design (Figure. 3). The gear motor is connected via a relay to the PLC, the linear actuator is connected through 4 relays to the PLC (Figure. 4), and 2 lights are connected to indicate system status (On/Off).

#### Behavior

The Selector Switch will provide power to the control box. The Start pushbutton will turn the gear motor, while the Stop pushbutton will be used to halt any movement on the display (Figure 5 – Rung 1). Shift Up and Shift Down both communicate through the PLC to the linear actuator to turn the permanent magnet DC motor clockwise (CW) or counterclockwise (CCW) (Figure 8 – Rungs 23-24). Two yellow pushbuttons will contain the shifting inputs. The analog signal from a potentiometer will provide positional feedback of the linear actuator's shaft to the PLC. The internal ladder logic will move the actuator automatically based on the shaft position (Figure 6 – Rungs 9, 13; Figure 7 – Rung 19). The ladder logic will also prevent actuator movement based on the gear position of the transmission. The system will not be able to attempt shifting beyond 6<sup>th</sup> gear or below neutral gear (Figure 6 – Rung 10). The gear change operation requires 2 different outputs to control, so the ladder logic will include latched bits and timers to prevent a short.

#### User Interface (UI)

The UI for this display will be a neatly laid out panel. The Start, Stop, and shifting pushbuttons will be placed close together, since they will be used most often. Indicator lights will be placed at the bottom of the UI to indicate the gear motor's state (On/Off). A proposed labeling for the UI can be seen in Figure 9.

#### Safety

Safety features will be included into the programming, such as: if the motor is turned on and left alone, a timer will end and automatically shut down the gear motor (Figure 5 – Rung 1). Another issue that could occur is motor(s) stalling during operation. This stalling could burn up either motor if not addressed. Our ladder logic includes latches and timers to avoid shorts and prevent an operation that could cause burn up (Figure. 6 – Rung 13; Figure. 7 – Rungs 14, 19-

**Commented [PK1]:** I won't mark this going forward. Basically, the capitalization is inconsistent. Two paragraphs above, they are "start," "stop," etc. Either is fine, but be consistent in how you capitalize...and be consistent Selector Switch, Stop, Start....selector switch, stop, start.... Also, buttons or pushbuttons?

**Commented [PK2]:** A couple of things.... Inconsistency in the use of two, five, 2, 5, etc. However, when starting a sentence with a number, always spell it out (or adjust the sentence so that it doesn't start with the number). You can be inconsistent in this case (Two outputs are fine for 5 seconds....)

**Commented [PK3]:** Where are the references to Figure 1-4?

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20) A major safety feature in the system will be the placement of the control box, which will be underneath the display and out of reach to users. Fuses are in place throughout the control box circuitry to account for excessive current. Special time-delay fuses will be used on the gear motor to account for inrush current at startup (Figure 4).

#### Construction

The control box will be an 18" x 18" x 6" metal enclosure. Two DIN rails will hold all mounted components placed within the control box enclosure. Wireway will be used to conceal internal wiring (Figure. 1).

### Hardware

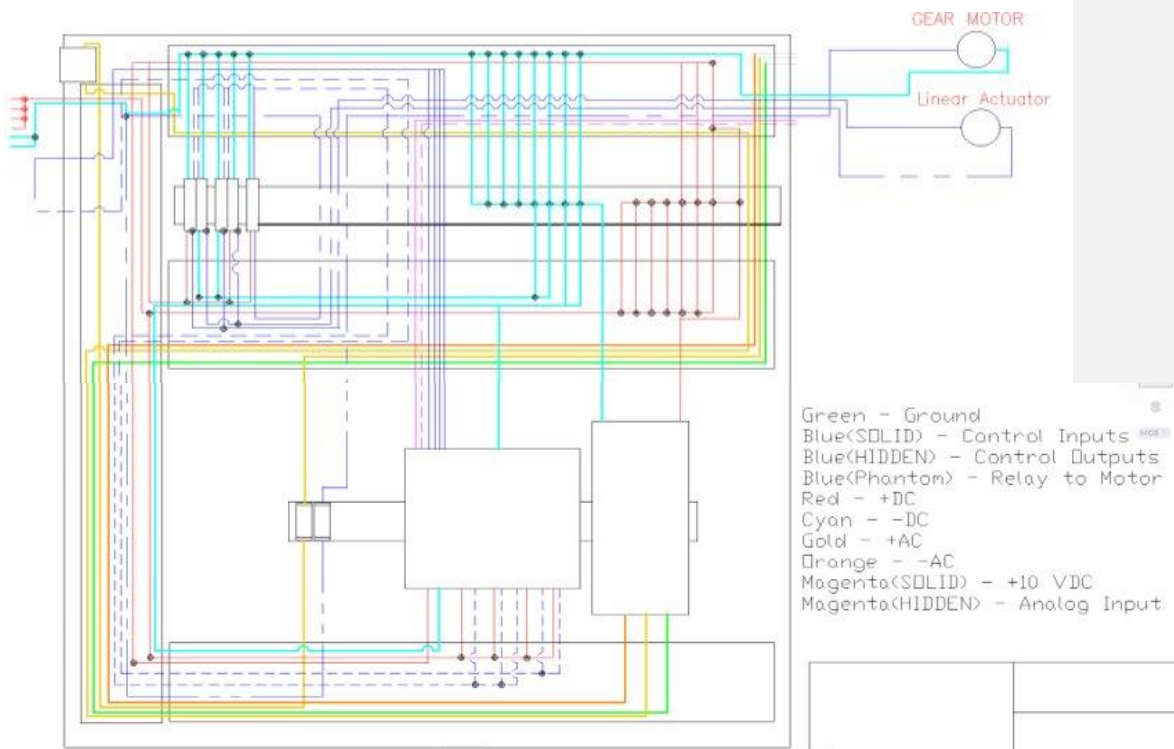
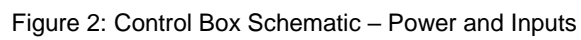


Figure 1: Control Box Wiring Layout



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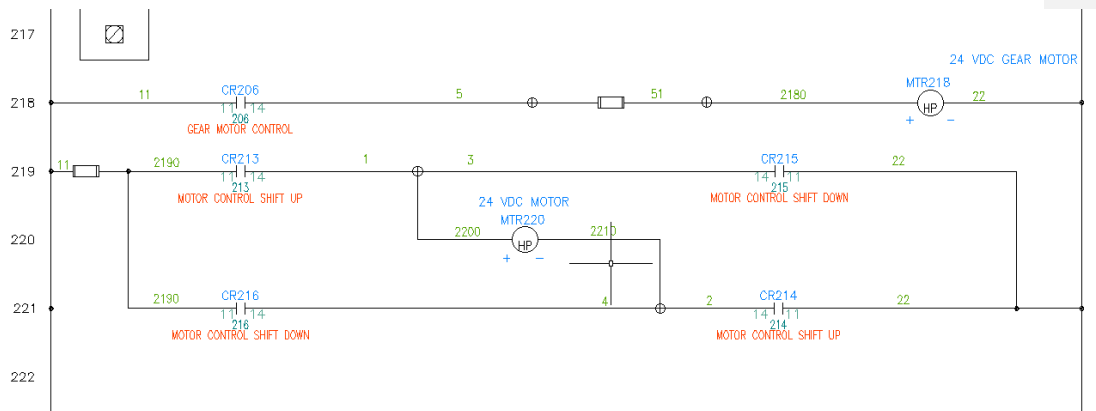


Figure 4: Control Box Schematic – Relay to Motor Connections

Authors:

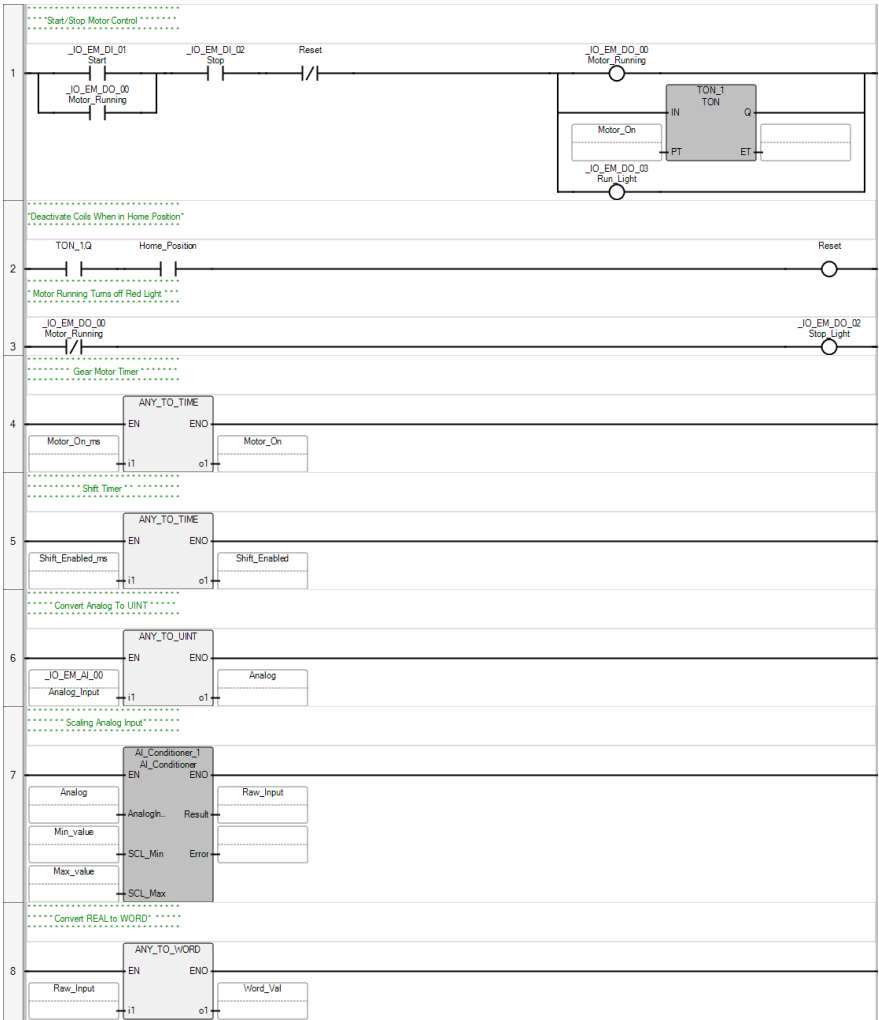
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Software - Connected Components Workbench Software (CCW)



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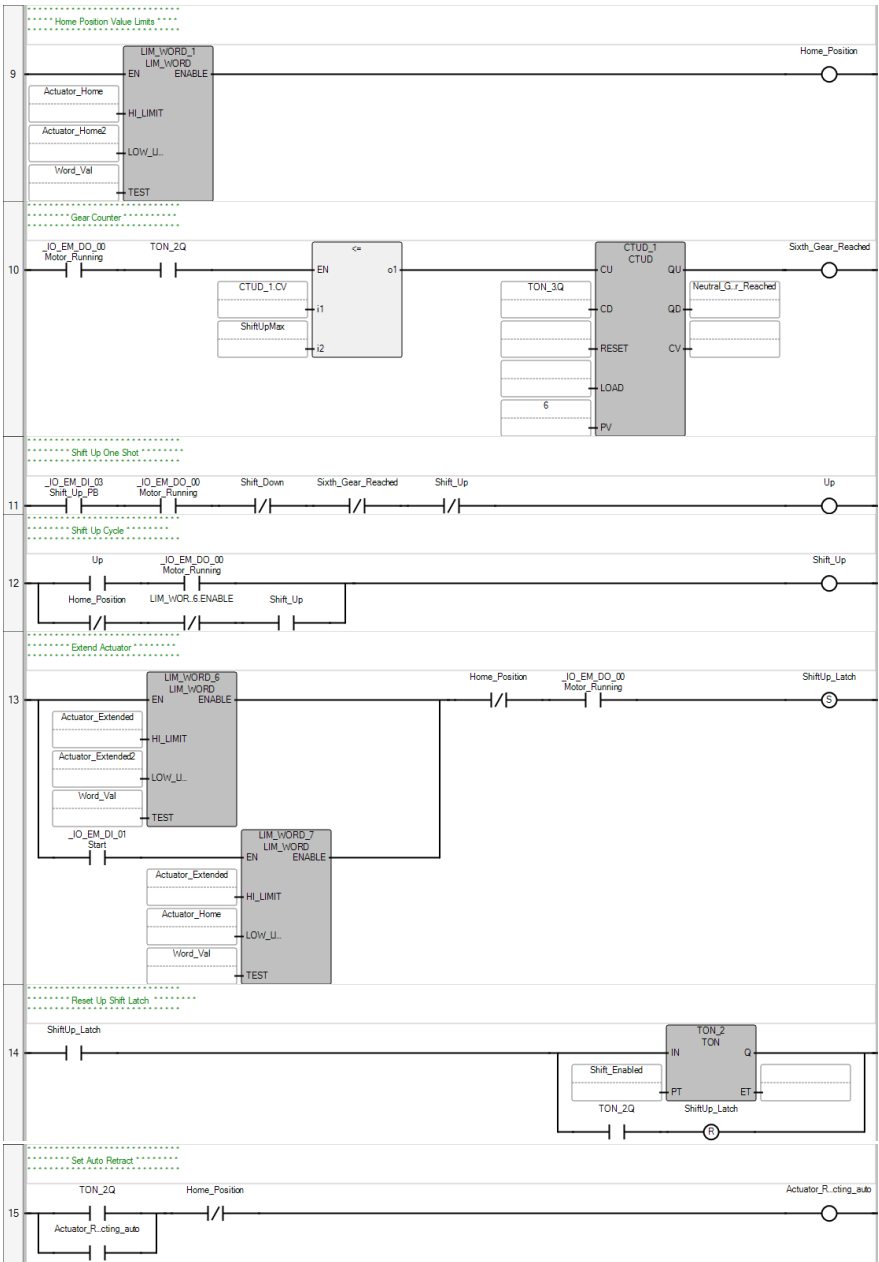


Figure 6: Rungs 9 - 15

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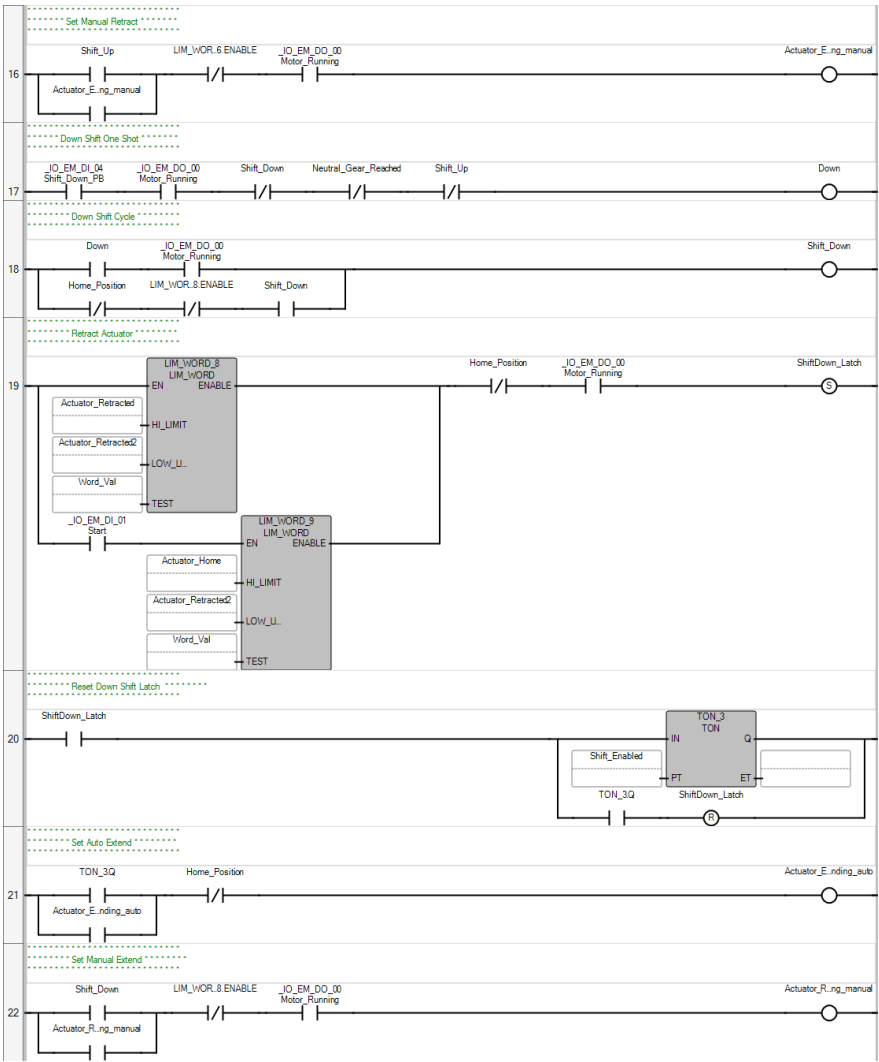


Figure 7: Rungs 16 - 22

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Figure 8: Rungs 23 - 24

Interface

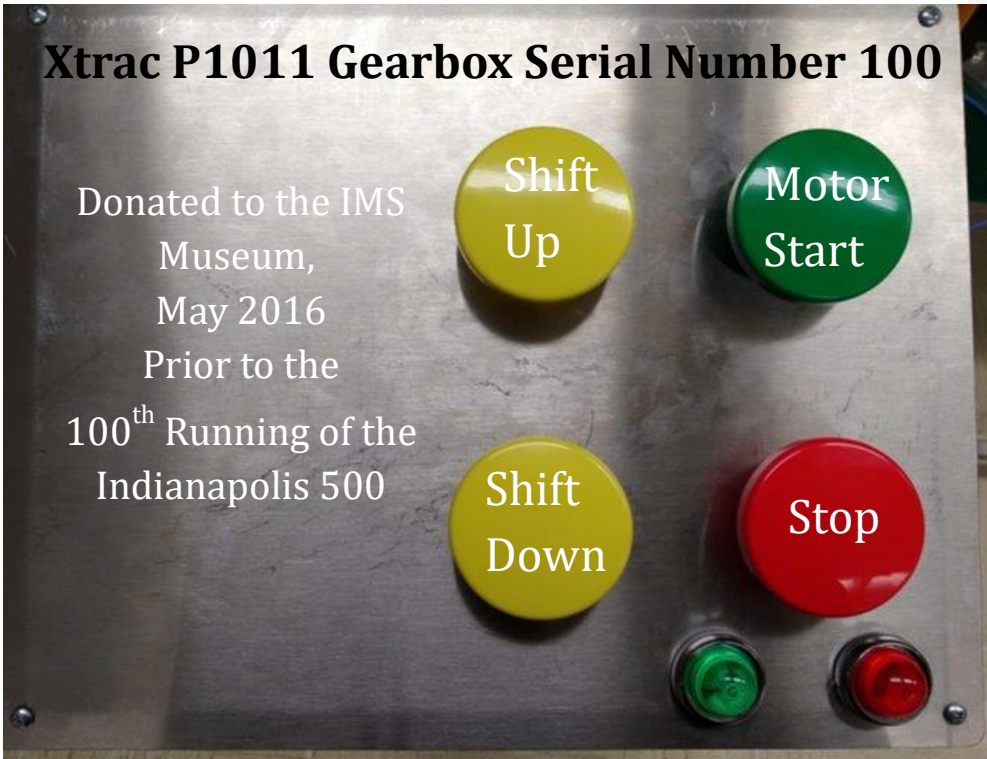


Figure 9: User Interface

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### Setup and Operation

The power cord will be plugged into the wall. The Selector Switch will be turned [CW](#) to provide power to the 24V DC power supply in the control box. After a few seconds, all systems should have power and be ready to be operated. The Start pushbutton should be pressed first, which will turn the gear motor. While the internal mechanism of the transmission is turning, the yellow pushbuttons can be pressed to shift up or down. The engaged gears will be seen through the display case, and the system should respond accurately based on the current gear position. After a set run time, the gear motor will turn off. The Stop pushbutton can be pressed at any time to halt the gear motor and reset the system timer. The display will be powered down by turning the Selector Switch [CCW](#) while the transmission's internal mechanism is stationary.

### Testing

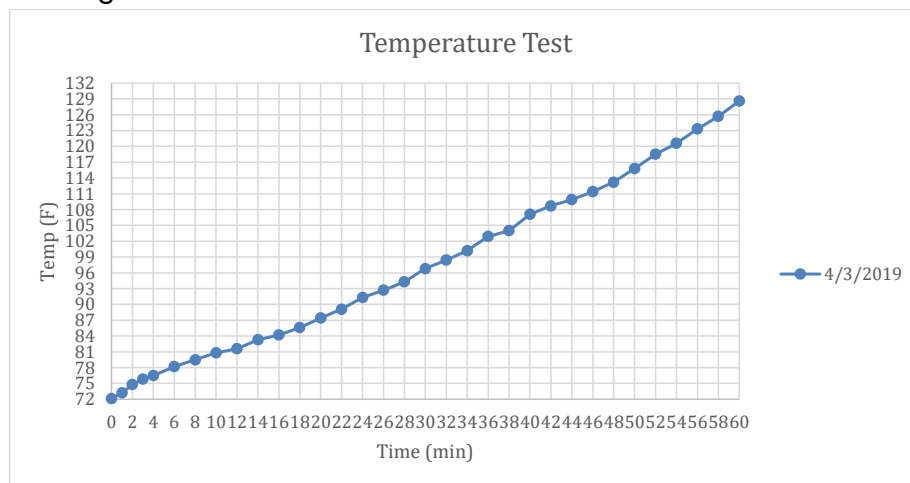


Figure 10: Gear Motor Surface Temperature

Current from Power Supply (A)			
	Shift Down	Home	Shift Up
	2.22	2.60	3.12
	2.23	2.74	3.03
	2.25	2.71	3.12
avg	2.23	2.68	3.09

Figure 11: System Current Test



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Gear	Motor RPM	Gear RPM	Gear Motor Current (A)		avg
neutral	140	0	1.20	1.30	1.25
1st	130	11	1.62	1.60	1.61
2nd	126	15	1.91	1.90	1.91
3rd	122	19	2.17	2.20	2.19
4th	115	24	2.65	2.60	2.63
5th	115	24	2.67	2.70	2.69
6th	115	24	2.72	2.80	2.76

Figure 12: Gear Ratio/Gear Motor Current Test

### Analog signal

Min Output Range	Max Output Range	Analog Input Value	Scaled Output Value
0	1000	3031	740
0	1000	3049	744
0	1000	3032	741
0	1000	3031	740
0	1000	2993	731
0	1000	3036	742
0	1000	3218	786
0	1000	3220	787
0	1000	3213	785
0	1000	3210	784
0	1000	3233	788
0	1000	3540	864
0	1000	3549	867
0	1000	3533	863
0	1000	3538	864
0	1000	3546	866

Figure 13: Analog Scaling Test

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### Conclusion

The IMS is involving the Engineering Technology Department at IUPUI in designing and implementing an interactive display for their transmission. The result should include a working transmission that shifts through all the gears using a lifelike racing simulated steering wheel. The transmission will be in a Lexan box with many safety features. The IMS is allowing us students the opportunity to get involved with the racing community as well as have a high-profile project to add to a resume. Allowing a neat but robust interface that will be used by guests is necessary so that electrical and mechanical parts do not fail inside a museum setting.

### Recommendations

This project will require further work in coming semesters to bring it to its best possible conclusion. The design of the control box is such that modifications and improvements can be made very quickly. The UI and motor will need to be updated to better fulfill requirements given by Xtrac, Inc., and the IMS Museum. Below is a more detailed list of aspects of the project that:

- Will be changed by future project owners
  - Should be updated based on tests and observations
  - Can be modified if future project owners deem it useful and/or necessary
- a) Necessary Updates
    - a. The UI (Figure. 9) will be replaced by a Cosworth Steering Wheel and Paddle Shifters. An existing mounting system designed by a MET team will hold the steering wheel.
    - b. Concurrent with the UI is the communication to the Micro 820 Controller. All UI controls will have to be transferred to the steering wheel and must be able to directly communicate with the current program downloaded to the controller.
  - b) Physical Updates
    - a. Currently, the wiring throughout the project does not perfectly match with NEMA standards. As the project continues, wires internal and external to the control box should be swapped with the correct wire colors based on the type of connection (AC, DC, Ground, with load, etc.).
    - b. The current 24V DC gear motor can turn the gearbox's internal mechanisms, but it does heat up steadily over time. When 4<sup>th</sup> gear is reached, current and rpm level out. The greatest concern is that the motor is not strong enough to compensate for the higher torque in 4<sup>th</sup> - 6<sup>th</sup> gear. An incident occurred while the transmission was resting in 5<sup>th</sup> gear which caused the motor to break. This issue has been partially resolved, but a larger motor would be necessary to ensure no breakage in the future.
    - c. The current setup of the electromechanical relays connected to the linear actuator is enough for the project to run, but there is a possible concern that a short could occur. Software changes have been made to deal with the issue, but a physical interlock between the sets of relays would further prevent the chance of a short.
  - c) Optional Updates
    - a. The CCW program for this project does not contain any subroutines. If desired, some of the functions of the program could be consolidated into subroutines to simplify the main program. This type of change would require knowledge of the main program structure and functions.
    - b. There is a need for increased fault protection in the software. Some possible solutions can be seen in Appendix B.

**Commented [PK4]:** This just sort of appears.... Need transition to this.

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### **IMS Dynamic Display**

## Appendices

### Appendix A: Datasheets/Product Documentation

[https://literature.rockwellautomation.com/idc/groups/literature/documents/um/2080-um005\\_-en-e.pdf](https://literature.rockwellautomation.com/idc/groups/literature/documents/um/2080-um005_-en-e.pdf)

<http://www.xtrac.com/sectors/motorsport/single-seater/product/77>

[https://literature.rockwellautomation.com/idc/groups/literature/documents/pp/700-pp020\\_-en-p.pdf](https://literature.rockwellautomation.com/idc/groups/literature/documents/pp/700-pp020_-en-p.pdf)

### Features

- Self locking Acme screw
- Internal, non-adjustable limit switches
- IP66 Sealing
- 25% allowable duty cycle
- 25° to 65°C (-13° to 150°F) operating temperature



### Specifications

Model #	DC Voltage	Rated Load		Speed at Rated Load		Speed at No Load		Full Load Amps
		Newtons	lbs.	mm/sec	in/sec	mm/sec	in/sec	
AL1000	12V	1000	225	100	4.0	150	6.0	1.5
AL1500	12V	1500	335	150	6.0	200	8.0	2.0
AL2000	12V	2000	450	200	8.0	250	10.0	2.5
AL2500	12V	2500	560	250	10.0	300	12.0	3.0
AL3000	12V	3000	670	300	12.0	350	14.0	3.5
AL3500	12V	3500	780	350	14.0	400	16.0	4.0
AL4000	12V	4000	890	400	16.0	450	18.0	4.5
AL4500	12V	4500	1000	450	18.0	500	20.0	5.0
AL5000	12V	5000	1120	500	20.0	550	22.0	5.5
AL6000	12V	6000	1350	600	24.0	650	26.0	6.5
AL7000	12V	7000	1570	700	28.0	750	30.0	7.5
AL8000	12V	8000	1790	800	32.0	850	34.0	8.5
AL9000	12V	9000	2010	900	36.0	950	38.0	9.5
AL10000	12V	10000	2250	1000	40.0	1050	42.0	10.5

\* = Stroke in millimeters

### Installation & Operating Instructions

#### 1. Application

The LT series actuators are intended for industrial use only and should not be used to lift, support, or otherwise transport people or loads over people. The actuator is designed for lifting or pushing loads no more than its load rating, on an intermittent basis, not for applications requiring continuous operation. The actuator is designed for clevis mounting and cannot support side loading of the tubes. The actuator is not suitable for use in areas containing explosive dust, vapors, or gases.

The actuator translating tube is keyed to prevent rotation; however, external torques should not be applied to the actuator, as this could result in un-screwing of the tube from the actuator.

#### 2. Installation

The actuator should be connected with a 1/4 inch (6.35 mm) steel clevis pin at each end. If using a threaded fastener, be sure that the screw has an unthreaded shank long enough to extend through the actuator clevis.

#### 3. Wiring

All electrical connections are made to the pigtail cable. Refer to the diagrams following for standard models, with and without potentiometer. End of travel limit switches are internally connected and non-adjustable. Motor reversal requires use of a DPDT -center-off switch.

The optional 10K ohm potentiometer may be excited with up to 24 vdc to provide a proportional feedback voltage for various electronic position indicators or controls.

When supplied with optional suffi x "C" plug, LT series actuators may be plugged directly into Duff-Norton LC series controllers, eliminating the need for additional power supplies or switches. See the LC controller catalog for applications.

For non-stock options, including Third Limit Switch, Signal-sending Limit Switch, and Hall Effect Pulse Generator, contact Duff-Norton for appropriate wiring diagram.

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**DUFF-NORTON ELECTROMECHANICAL ACTUATOR  
LIMITATION OF WARRANTIES, REMEDIES AND DAMAGES**

The warranty stated below is given in place of all other warranties, express or implied, of merchantability, fitness for a particular purpose or otherwise. No promise or affirmation of fact made by any agent or representative of seller shall constitute a warranty by seller or give rise to any liability or obligation.

Seller warrants that on the date of its delivery to carrier the goods are free from defects in workmanship and materials.

Seller's sole obligation in the event of breach of warranty or contract or for negligence or otherwise with respect to goods sold shall be exclusively limited to repair or replacement, f.o.b. seller's point of shipment, of any parts which seller determines to have been defective or if seller determines that such repair or replacement is not feasible, to a refund of the purchase price upon return of the goods to seller.

**⚠ WARNING ⚠**

The equipment shown in this catalog is intended for industrial use only and should not be used to lift, support, or otherwise transport people unless you have a written statement from Duff-Norton, which authorizes the specific actuator used in your applications as suitable for moving people.

**NOTE**

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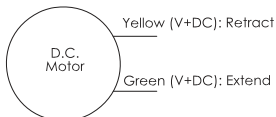
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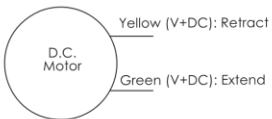
## IMS Dynamic Display

Duff-Norton has made every effort to ensure that the information contained in this publication is accurate and reliable. Determining the suitability of our products for specific applications is the user's responsibility.

### Standard Model



### Potentiometer Model



Potentiometer Stroke mm[in.]	50 [1.97]	100 [3.94]	150 [5.91]	200 [7.87]	250 [9.84]	300 [11.81]
POT Travel (% of 10K)	47%	94%	71%	94%	39%	47%

RETRACT      EXTEND

0 K      10 K

BLK      RED      WHT

Any action against seller for breach of warranty, negligence or otherwise must be commenced within one year after such cause of action accrues.

No claim against seller for any defect in the goods shall be valid or enforceable unless buyer's written notice thereof is received by seller within one year from the date of shipment.

Seller shall not be liable for any damage, injury or loss arising out of the use of the goods if, prior to such damage, injury or loss, such goods are (1) damaged or misused following seller's delivery to carrier; (2) not maintained, inspected, or used in compliance with applicable law and seller's written instructions and recommendations; or (3) installed, repaired, altered or modified without compliance with such law, instructions or recommendations.

Under no circumstances shall seller be liable for incidental or consequential damages as those terms are defined in section 2-715 of the uniform commercial code.



PO Box 7010 • Charlotte, NC 28241-  
Phone (800) 477-5002 • (704) 588-4870 • (704) 588-  
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## IMS Dynamic Display

### Appendix B: CCW Documentation

#### Project Controller

This is the body section for a project. This section should contain general information about the project and its properties.

#### Configuration Micro820

The detailed description of the configuration goes here

#### Resource Micro820

(\* \*)

Status: Readable, Modifiable, Deletable

The resource defines 50 variable(s).

#### Variable \_IO\_EM\_DO\_00

(\* \*)

Direction: VarDirectlyRepresented

Alias: Motor\_Running

Data type: BOOL

Attribute: Read/Write

Direct variable (Channel): %QX0.0.0

#### Variable \_IO\_EM\_DO\_01

(\* \*)

Direction: VarDirectlyRepresented

Data type: BOOL

Attribute: Read/Write

Direct variable (Channel): %QX0.0.1

#### Variable \_IO\_EM\_DO\_02

(\* \*)

Direction: VarDirectlyRepresented

Alias: Stop\_Light

Data type: BOOL

Attribute: Read/Write

Direct variable (Channel): %QX0.0.2

#### Variable \_IO\_EM\_DO\_03

(\* \*)

Direction: VarDirectlyRepresented

Alias: Run\_Light

Data type: BOOL

Attribute: Read/Write

Direct variable (Channel): %QX0.0.3

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#### Variable \_IO\_EM\_DO\_04

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Rotate\_CW  
Data type: BOOL  
Attribute: Read/Write  
Direct variable (Channel): %QX0.0.4

#### Variable \_IO\_EM\_DO\_05

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read/Write  
Direct variable (Channel): %QX0.0.5

#### Variable \_IO\_EM\_DO\_06

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Rotate\_CCW  
Data type: BOOL  
Attribute: Read/Write  
Direct variable (Channel): %QX0.0.6

#### Variable \_IO\_EM\_DI\_00

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.0

#### Variable \_IO\_EM\_DI\_01

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Start  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.1

#### Variable \_IO\_EM\_DI\_02

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Stop  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.2



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#### Variable \_IO\_EM\_DI\_03

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Shift\_Up\_PB  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.3

#### Variable \_IO\_EM\_DI\_04

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Shift\_Down\_PB  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.4

#### Variable \_IO\_EM\_DI\_05

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Actuator\_Home\_LS  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.5

#### Variable \_IO\_EM\_DI\_06

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Actuator\_Extended\_LS  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.6

#### Variable \_IO\_EM\_DI\_07

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Actuator\_Retracted\_LS  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.7

#### Variable \_IO\_EM\_DI\_08

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.8

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### IMS Dynamic Display

#### Variable \_IO\_EM\_DI\_09

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.9

#### Variable \_IO\_EM\_DI\_10

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.10

#### Variable \_IO\_EM\_DI\_11

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: BOOL  
Attribute: Read  
Direct variable (Channel): %IX0.1.11

#### Variable \_IO\_EM\_AI\_00

(\* \*)  
Direction: VarDirectlyRepresented  
Alias: Analog\_Input  
Data type: WORD  
Attribute: Read  
Direct variable (Channel): %IW0.2.0

#### Variable \_IO\_EM\_AI\_01

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: WORD  
Attribute: Read  
Direct variable (Channel): %IW0.2.1

#### Variable \_IO\_EM\_AI\_02

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: WORD  
Attribute: Read  
Direct variable (Channel): %IW0.2.2

#### Variable \_IO\_EM\_AI\_03

(\* \*)  
Direction: VarDirectlyRepresented

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**IMS Dynamic Display**

Data type: WORD  
Attribute: Read  
Direct variable (Channel): %IW0.2.3

**Variable \_IO\_EM\_AO\_00**

(\* \*)  
Direction: VarDirectlyRepresented  
Data type: WORD  
Attribute: Read/Write  
Direct variable (Channel): %QW0.3.0

**Variable Motor\_On**

(\* \*)  
Direction: Var  
Data type: TIME  
Attribute: Read/Write

**Variable Analog**

(\* \*)  
Direction: Var  
Data type: UINT  
Attribute: Read/Write

**Variable ShiftDown\_Latch**

(\* Hold timer while shifting down \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable ShiftUpMax**

(\* \*)  
Direction: Var  
Data type: DINT  
Attribute: Read/Write

**Variable ShiftUp\_Latch**

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable \_\_SYSVA\_CYCLECNT**

(\* Cycle counter \*)  
Direction: VarGlobal  
Data type: DINT

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**IMS Dynamic Display**

Attribute: Read

**Variable \_\_SYSVA\_CYCLEDATE**

(\* Timestamp of the beginning of the cycle in milliseconds \*)

Direction: VarGlobal

Data type: TIME

Attribute: Read

**Variable \_\_SYSVA\_KVPERR**

(\* Kernel variable binding producing error (production error) \*)

Direction: VarGlobal

Data type: BOOL

Attribute: Read

**Variable \_\_SYSVA\_KVBCERR**

(\* Kernel variable binding consuming error (consumption error) \*)

Direction: VarGlobal

Data type: BOOL

Attribute: Read/Write

**Variable \_\_SYSVA\_RESNAME**

(\* Resource name (max length=255) \*)

Direction: VarGlobal

Data type: STRING

Attribute: Read

**Variable \_\_SYSVA\_SCANCNT**

(\* Input scan counter \*)

Direction: VarGlobal

Data type: DINT

Attribute: Read

**Variable \_\_SYSVA\_TCYCYCTIME**

(\* Programmed cycle time \*)

Direction: VarGlobal

Data type: TIME

Attribute: Read/Write

**Variable \_\_SYSVA\_TCYCURRENT**

(\* Current cycle time \*)

Direction: VarGlobal

Data type: TIME

Attribute: Read

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### IMS Dynamic Display

#### Variable \_\_SYSVA\_TCYMAXIMUM

(\* Maximum cycle time since last start \*)

Direction: VarGlobal  
Data type: TIME  
Attribute: Read

#### Variable \_\_SYSVA\_TCYOVERFLOW

(\* Number of cycle overflows \*)

Direction: VarGlobal  
Data type: DINT  
Attribute: Read

#### Variable \_\_SYSVA\_RESMODE

(\* Resource execution mode \*)

Direction: VarGlobal  
Data type: SINT  
Attribute: Read

#### Variable \_\_SYSVA\_CCEXEC

(\* Execute one cycle when application is in cycle to cycle mode \*)

Direction: VarGlobal  
Data type: BOOL  
Attribute: Read/Write

#### Variable \_\_SYSVA\_REMOTE

(\* Remote status \*)

Direction: VarGlobal  
Data type: BOOL  
Attribute: Read

#### Variable \_\_SYSVA\_SUSPEND\_ID

(\* Last Suspend ID \*)

Direction: VarGlobal  
Data type: UINT  
Attribute: Read

#### Variable \_\_SYSVA\_TCYWDG

(\* Software Watchdog \*)

Direction: VarGlobal  
Data type: UDINT  
Attribute: Read/Write

#### Variable \_\_SYSVA\_MAJ\_ERR\_HALT

(\* Major Error Halted status \*)

Direction: VarGlobal

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Data type:        BOOL  
Attribute:        Read

Variable \_\_SYSVA\_ABORT\_CYCLE

(\* Aborting Cycle \*)  
Direction:        VarGlobal  
Data type:        BOOL  
Attribute:        Read

Variable \_\_SYSVA\_FIRST\_SCAN

(\* First scan bit \*)  
Direction:        VarGlobal  
Data type:        BOOL  
Attribute:        Read

Variable \_\_SYSVA\_USER\_DATA\_LOST

(\* User data lost \*)  
Direction:        VarGlobal  
Data type:        BOOL  
Attribute:        Read/Write

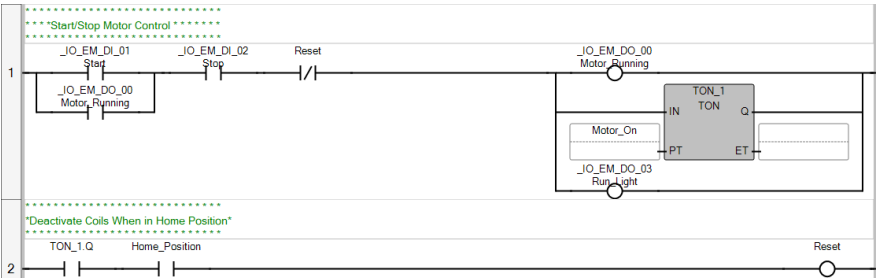
Variable \_\_SYSVA\_POWERUP\_BIT

(\* Power-up bit \*)  
Direction:        VarGlobal  
Data type:        BOOL  
Attribute:        Read

Variable \_\_SYSVA\_PROJ\_INCOMPLETE

(\* Project Incomplete \*)  
Direction:        VarGlobal  
Data type:        UDINT  
Attribute:        Read

Controller.Micro820.Micro820.Prog1



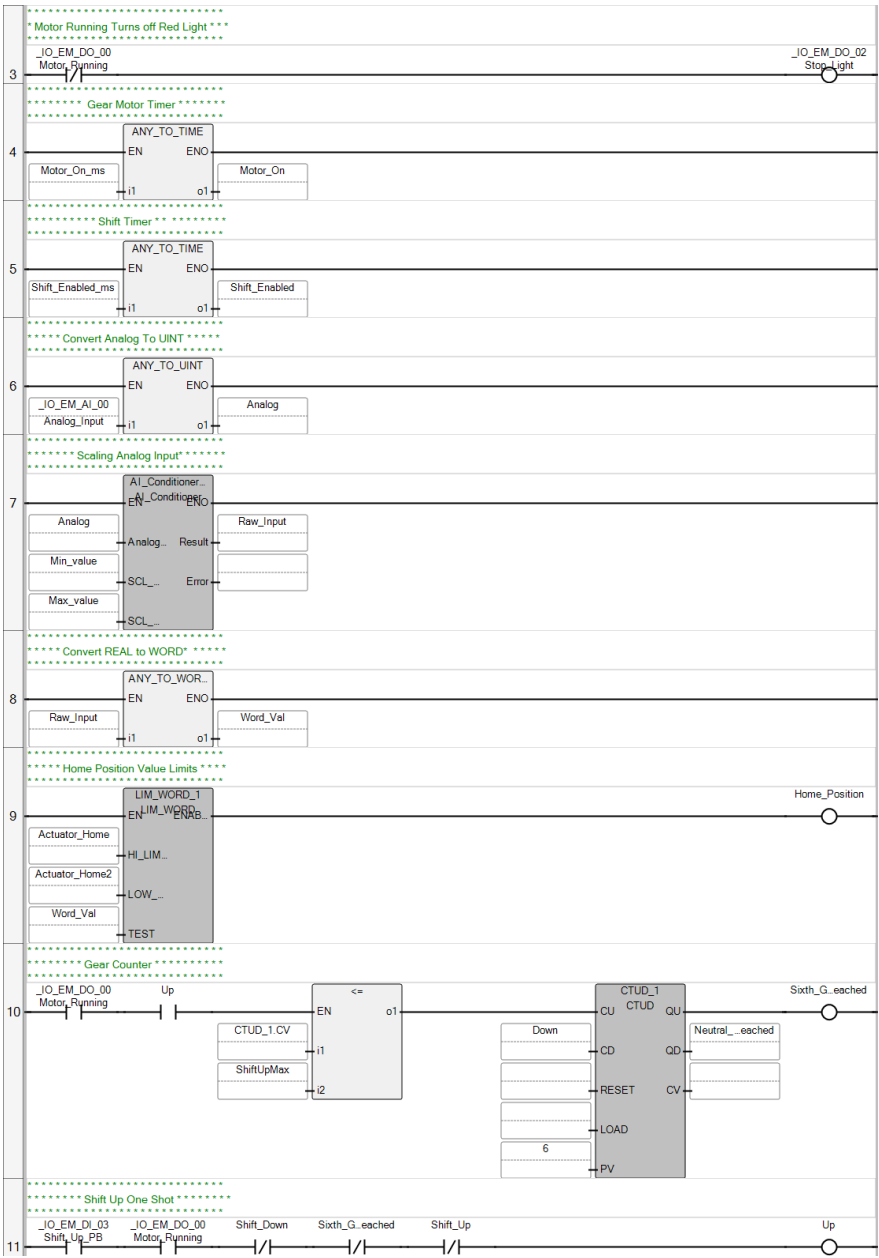
Authors:

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Submission Date:

Version:

IMS Dynamic Display



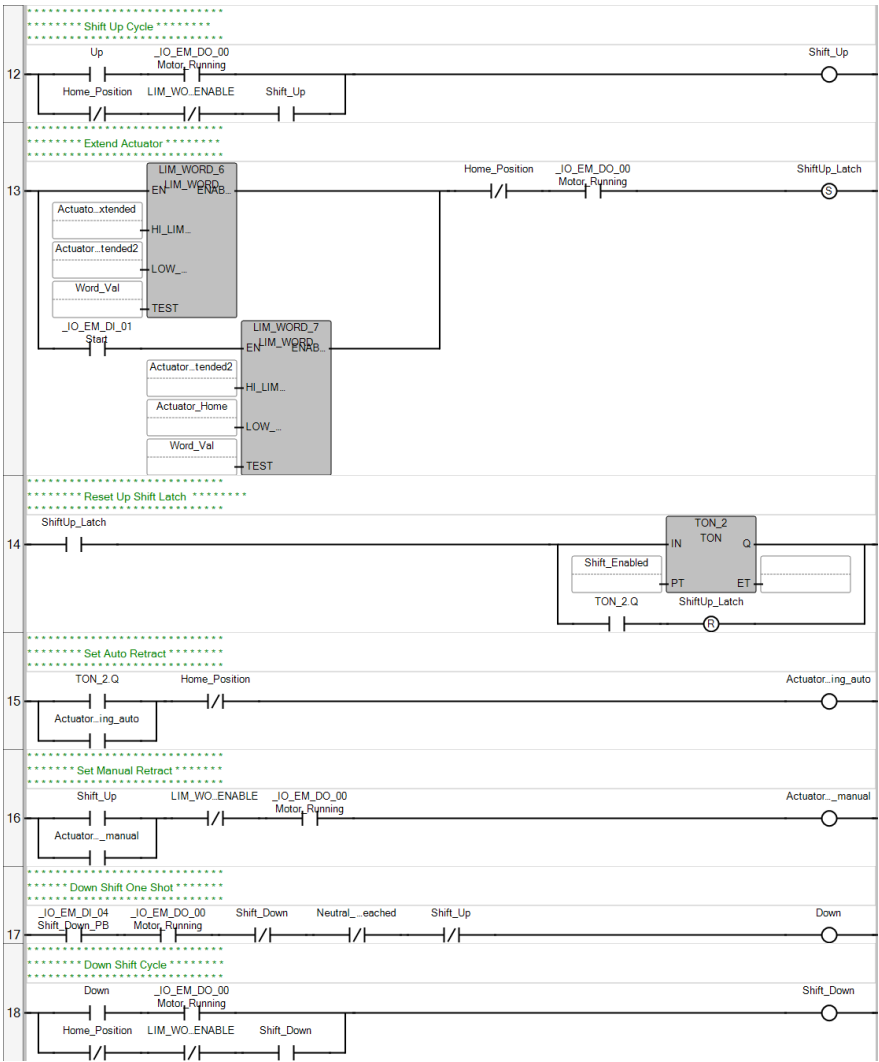
Authors:

Approval By:

Submission Date:

Version:

IMS Dynamic Display





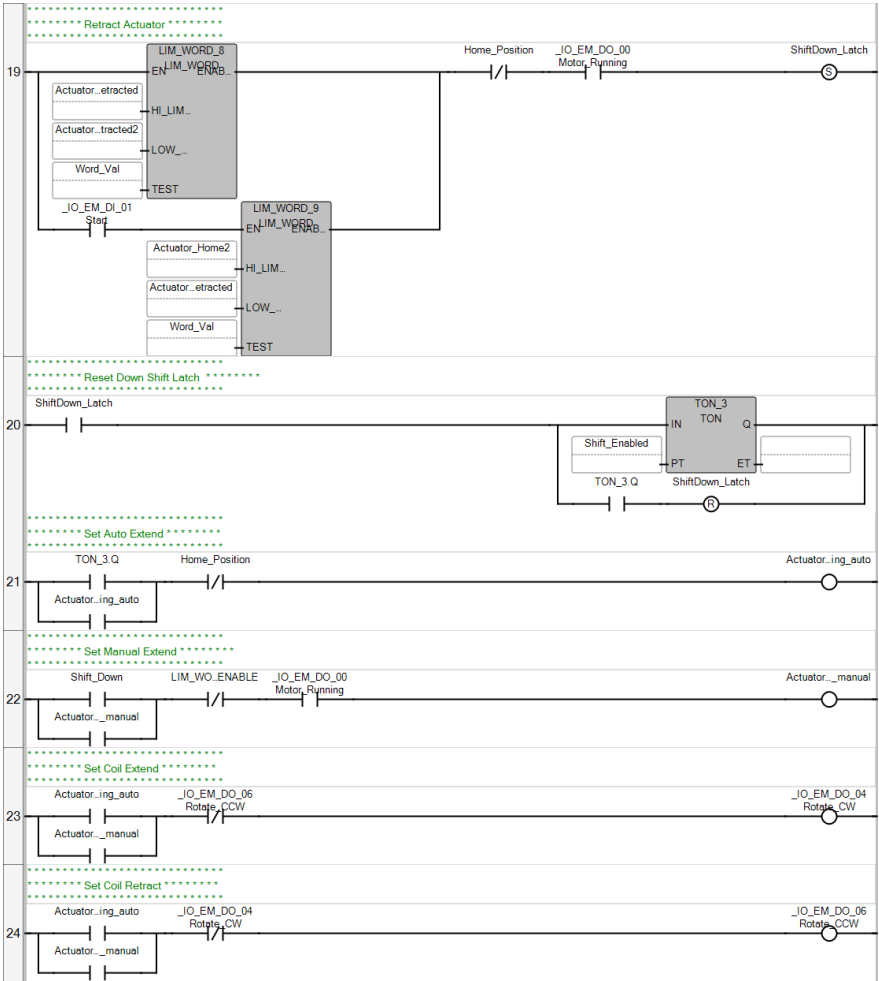
Authors:

Approval By:

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POU Prog1

The POU defines 45 variable(s).

Variable Start

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

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**IMS Dynamic Display**

**Variable Motor\_On**

(\* \*)  
Direction: Var  
Data type: TIME  
Attribute: Read/Write

**Variable CTUD\_1**

(\* \*)  
Direction: Var  
Data type: CTUD  
Attribute: Read/Write

**Variable Motor\_On\_ms**

(\* \*)  
Direction: Var  
Data type: DINT  
Attribute: Read/Write

**Variable Sixth\_Gear\_Reached**

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable Neutral\_Gear\_Reached**

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable Shift\_Up**

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable Shift\_Down**

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

**Variable Up**

(\* \*)  
Direction: Var

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Data type:            BOOL  
Attribute:            Read/Write

**Variable Down**

(\* \*)  
Direction:            Var  
Data type:            BOOL  
Attribute:            Read/Write

**Variable Actuator\_Extending\_auto**

(\* \*)  
Direction:            Var  
Data type:            BOOL  
Attribute:            Read/Write

**Variable Actuator\_Extending\_manual**

(\* \*)  
Direction:            Var  
Data type:            BOOL  
Attribute:            Read/Write

**Variable Actuator\_Retracting\_auto**

(\* \*)  
Direction:            Var  
Data type:            BOOL  
Attribute:            Read/Write

**Variable Actuator\_Retracting\_manual**

(\* \*)  
Direction:            Var  
Data type:            BOOL  
Attribute:            Read/Write

**Variable Raw\_Input**

(\* \*)  
Direction:            Var  
Data type:            REAL  
Attribute:            Read/Write

**Variable Actuator\_Extended**

(\* \*)  
Direction:            Var  
Data type:            WORD  
Attribute:            Read/Write

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IMS Dynamic Display

Variable Actuator\_Retracted

(\* \*)  
Direction: Var  
Data type: WORD  
Attribute: Read/Write

Variable Actuator\_Home

(\* \*)  
Direction: Var  
Data type: WORD  
Attribute: Read/Write

Variable Home\_Position

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

Variable Shift\_Enabled\_ms

(\* \*)  
Direction: Var  
Data type: INT  
Attribute: Read/Write

Variable Shift\_Enabled

(\* \*)  
Direction: Var  
Data type: TIME  
Attribute: Read/Write

Variable Max\_value

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

Variable Min\_value

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

Variable Actuator\_Home2

(\* \*)  
Direction: Var

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**IMS Dynamic Display**

Data type: WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_1**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable Word\_Val**

(\* \*)  
Direction: Var  
Data type: WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_2**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable Actuator\_Extended2**

(\* \*)  
Direction: Var  
Data type: WORD  
Attribute: Read/Write

**Variable Actuator\_Retracted2**

(\* \*)  
Direction: Var  
Data type: WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_3**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable AI\_Conditioner\_1**

(\* \*)  
Direction: Var  
Data type: AI\_Conditioner  
Attribute: Read/Write

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**IMS Dynamic Display**

**Variable LIM\_WORD\_4**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_5**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable TON\_1**

(\* \*)  
Direction: Var  
Data type: TON  
Attribute: Read/Write

**Variable TON\_2**

(\* \*)  
Direction: Var  
Data type: TON  
Attribute: Read/Write

**Variable TON\_3**

(\* \*)  
Direction: Var  
Data type: TON  
Attribute: Read/Write

**Variable LIM\_WORD\_7**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_8**

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

**Variable LIM\_WORD\_9**

(\* \*)  
Direction: Var

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### IMS Dynamic Display

Data type: LIM\_WORD  
Attribute: Read/Write

#### Variable Reset

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write

#### Variable Input\_Min\_value

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

#### Variable Input\_Max\_value

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

#### Variable Output\_Min

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

#### Variable Output\_Max

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

#### Variable LIM\_WORD\_6

(\* \*)  
Direction: Var  
Data type: LIM\_WORD  
Attribute: Read/Write

#### Controller.Micro820.Micro820.AI\_Conditioner

Value\_4mA := 0.0;  
Value\_20mA := 4095.0;  
AnalogInput\_Real := Any\_To\_Real(AnalogInput);

IF AnalogInput\_Real > Value\_4mA AND AnalogInput\_Real < Value\_20mA THEN

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**IMS Dynamic Display**

```
Error := FALSE;
ELSE
    Error := TRUE;
END_IF;
SCALE_AI(AnalogInput_Real,Value_4mA, Value_20mA, SCL_Min, SCL_Max);
Result := Scale_AI.Output;
```

**POU AI\_Conditioner**

The POU defines 9 variable(s).

**Variable AnalogInput**

(\* \*)  
Direction: VarInput  
Data type: UINT  
Attribute: Read

**Variable SCL\_Min**

(\* \*)  
Direction: VarInput  
Data type: REAL  
Attribute: Read

**Variable SCL\_Max**

(\* \*)  
Direction: VarInput  
Data type: REAL  
Attribute: Read

**Variable Result**

(\* \*)  
Direction: VarOutput  
Data type: REAL  
Attribute: Write

**Variable Error**

(\* \*)  
Direction: VarOutput  
Data type: BOOL  
Attribute: Write

**Variable Value\_4mA**

(\* \*)  
Direction: Var



Authors:

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IMS Dynamic Display

Data type: REAL  
Attribute: Read/Write

Variable Value\_20mA

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

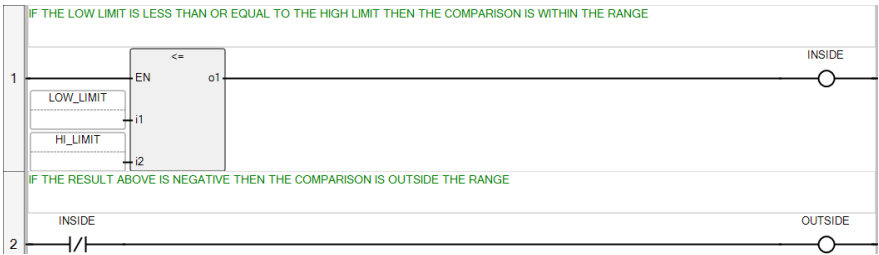
Variable SCALE\_AI

(\* \*)  
Direction: Var  
Data type: SCALER  
Attribute: Read/Write

Variable AnalogInput\_Real

(\* \*)  
Direction: Var  
Data type: REAL  
Attribute: Read/Write

Controller.Micro820.Micro820.LIM\_WORD



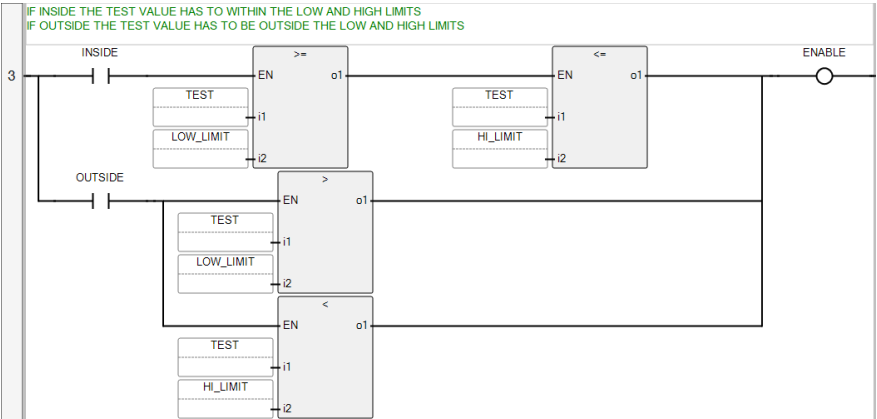
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Version:

IMS Dynamic Display



POU LIM\_WORD

The POU defines 6 variable(s).

Variable HI\_LIMIT

(\* \*)  
Direction: VarInput  
Data type: WORD  
Attribute: Read

Variable LOW\_LIMIT

(\* \*)  
Direction: VarInput  
Data type: WORD  
Attribute: Read

Variable TEST

(\* \*)  
Direction: VarInput  
Data type: WORD  
Attribute: Read

Variable ENABLE

(\* \*)  
Direction: VarOutput  
Data type: BOOL  
Attribute: Write

Variable INSIDE

(\* \*)

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Approval By:

Submission Date:

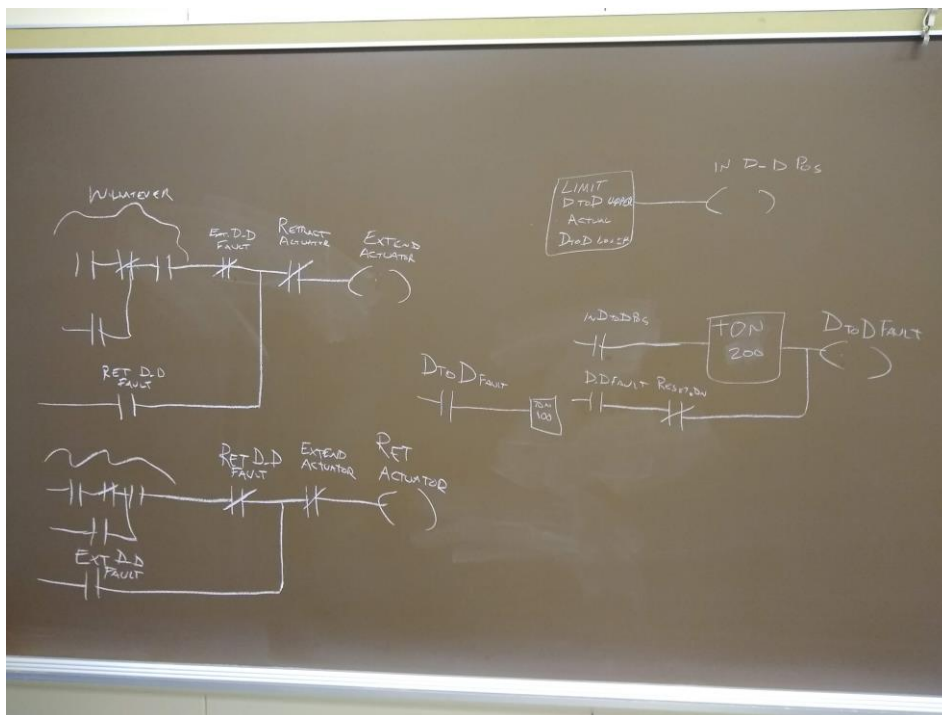
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### IMS Dynamic Display

Direction: Var  
Data type: BOOL  
Attribute: Read/Write

#### Variable OUTSIDE

(\* \*)  
Direction: Var  
Data type: BOOL  
Attribute: Read/Write



#### Appendix C: Resources

[http://www.xtrac.com/the\\_company.php](http://www.xtrac.com/the_company.php)