Subject: Technical Note	Product: NS300/NS500	Doc#: EM.MCD.05.106
Title: NS300/500 Master Ladder Example		

Technical Note

NS300/500 Master Ladder Example

NS300 and NS500 Application Modules

Summary

This document describes the example ladder program for implementing control of the NS300 and NS500 application modules in a master PLC. This example code demonstrates how to control motion and how to use the set/read commands. Example ladder files are available in .pdf and .mal formats as a guide for implementing the code into any type of ladder language. Please see document eng.MCD.05.105 for the example ladder files.

Demonstrated Features

Motion commands: Feed Command, Step Command, Point Table Command, Station Command, Zero Point Return, Simple Positioning, External Positioning, Notch Output Positioning, Multi-Speed Positioning

Set/Read commands: Read Parameter, Write Parameter, Set Current Position, Set Zero Point, Read Alarm, Reset Module

Development Setup

The setup used to write and test the example ladder is shown below. An MP940D was used as the DeviceNet master, and NS300 demo was used as the test unit. Note that operation is identical on the NS500, except that the PROFIBUS protocol is used instead of DeviceNet. Ladder code was written in the MPE720 MotionWorks software environment, and local I/O of the MP940 was used to simulate PLC signals.

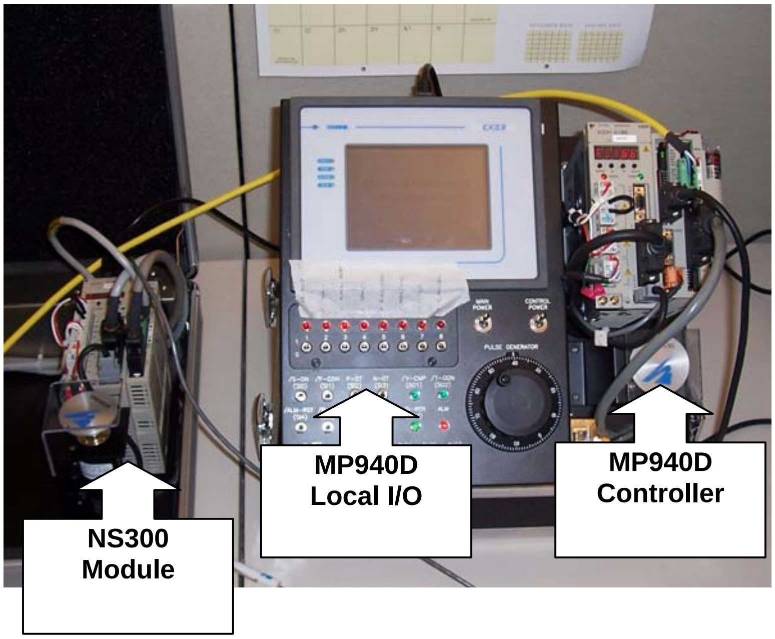


Fig 1. Setup for Writing Example Master Ladder

Before Programming

Before beginning programming for the NS300/500 master ladder, be sure to do the following:

- **Configure communications in the PLC**. Follow the setup procedure provided with the PLC for adding a device to the scan list of the selected network. The NS300/500 requires 8 bytes in/out. It is recommended to configure the second four bytes as data type long (or double-word) for convenience. If using a PLC that requires a setup file, the DeviceNet and PROFIBUS files can be found as shown below:

Table 1. Network Configuration Files

Category	NS300	NS500
Setup File	NS300(rotary).eds NS300(linear).eds	NS500.gsd
Location	www.yaskawa.com - search FAQ	www.yaskawa.com - search FAQ

- **Configure communications in the NS300/500**. This entails setting the DIP switches properly for communications baud rate and network address. See the NS300/500 manual for proper settings.

- **Verify the functionality of E-stop, POT, and NOT on CN4 of the NS300/500**. If using the hardware E-stop, monitor the status of this bit using the NSxxx software to ensure that it is working as intended. Disable this input if not being used by setting Pn81B, bit 0 = 0. Verify POT and NOT are connected properly to the SGDH by monitoring these with the NSxxx software. If not using either of these signals, they can be masked off by setting Pn50A.3 = 8, and Pn50B.0 = 8.

- **Test communications between the PLC and NS300/500**. Make sure the two devices are communicating by opening a watch window in the PLC software. Test the E-stop bit from the PLC (be sure the E-stop bit at CN4 of the NS300/500 is set) and verify that a response is being received from the NS300/500 as the bit is toggled. Spin the motor by hand and monitor motor position by observing bytes 4 thru 7 of the response message.

Register Summary

The chart below shows the assignment of the global and I/O registers used in the example program. Local registers are used throughout the program, but are not listed in this chart. This chart contains the registers accessed directly by the user.

Table 2. Example Master Ladder Register Addressing

MP940D Local I/O Inputs
User inputs to simulate PLC signals

Input	Function	Input Bit
Input 0	/E-Stop	IB00000
Input 1	Servo On	IB00001
Input 2	Alarm Reset	IB00002
Input 3	Start	IB00003
Input 4	Direction	IB00004
Input 5	Inc/Abs	IB00005
Input 6	Hold	IB00006
Input 7	Cancel	IB00007

PLC Command Bits
Bits to be controlled by PLC program

Bit	Symbol	Functionality
MB00000	PLC_ESTP	N.C. E-stop
MB00001	PLC_SVON	Enables Servo
MB00002	PLC_ALARM_RESET	Clears NSxxx Alarm
MB00003	PLC_COMMAND_START	Starts motion command
MB00004	PLC_DIR	Selects forward/reverse
MB00005	PLC_ABS_INC	Incremental or absolute
MB00006	PLC_HOLD	Pauses motion command
MB00007	PLC_CANCEL	Cancels motion command

PLC Command Registers
Command data loaded into these registers

Symbol	Register
PLC_COMMAND_SELECT	MW00002
PLC_RESPONSE_CODE	MW00003
PLC_FEED_SPEED	ML00004
PLC_STEP_NUMBER	ML00006
PLC_STATION_NUMBER	ML00008
PLC_POINT_TABLE_ROW	ML00010
PLC_TARGET_POSITION	ML00012
PLC_PARAMETER_NUMBER	MW00014
PLC_PARAMETER_DATA	ML00016
PLC_CURRENT_POSITION_SET	ML00018

PLC_RESPONSE_CODE Settings
Determines meaning of response message

Follow response code settings as listed in user's manual.

PLC_COMMAND_SELECT Settings
Value to be loaded for type of motion command

Setting	Description
0	No operation
1	Feed
2	Step
3	Station
4	Point Table
5	Zero Point Return
6	Positioning
7	External Positioning
8	Notch Output Positioning
9	Multi-Speed Positioning
10	Read Parameter
11	Write Parameter
12	Set Current Position
13	Set Zero Point
14	Read Alarm
15	Reset Module

Programming the NS300/500 Master Ladder

Properly programming the network master controller of the NS300/500 is essential for success when implementing one of these application modules. Most application issues identified in the field are the result of an application program that does not adhere to the NS300/500 timing diagrams. This technical note is intended to explain how the example master ladder program operates, and how it effectively eliminates common programming mistakes. Following the principles described in this tech note will greatly reduce troubleshooting by eliminating the majority of application issues. Three main issues are addressed; general program flow, best practices programming, and proper command bit sequencing and interlocking. After addressing these issues, specific highlights of the program are also discussed.

Program Flow

The first topic is general program flow. This program has been arranged so that it mimics the structure of the command message. Three distinct sections of the program have been identified in the table below:

Table 3. Program Sections

Command Message	Description	Program Lines
Bytes 0-1	General Commands	Lines 0-31
Bytes 2-3	Motion Command Bits/ Set/Read Parameter No.	Lines 32-48
Bytes 4-7	Command Data	Lines 49-57

Organizing the program in this manner makes the ladder easy to navigate and easy to identify what is being accomplished at any given line. In addition, an easy to navigate program makes troubleshooting at later dates much easier. The table below identifies the main tasks to be completed in each section of the program.

Table 4. Program Section Tasks

Program Section	Tasks
Lines 00-31 *Bytes 0-1*	▪ General interlocking – emergency stop, alarm reset, servo enable ▪ Command identification – set/read (MOD) ▪ Determining and loading the command and response codes
Lines 32-48 *Bytes 2-3*	*These two bytes are formatted differently for a motion command versus a set/read command.* ▪ Motion command bit sequencing ▪ Setting the proper motion command bit (FEED, HOME, etc.) ▪ Loading parameter number data for set/read commands requiring parameter information
Lines 49-57 *Bytes 4-7*	▪ Load the command data properly for the selected command (motion or set/read)

Incorporating Best Practices

The second main topic is incorporating best practices programming into the ladder code. It is strongly recommended to follow best practice programming recommendations, as these have been developed through a wealth of application experience. Three main best practices are recommended for this program:

1. **Write to each register/bit only one time in the program**. Writing to registers in multiple locations is highly discouraged. Use the waterfall technique to load registers with the proper values.

2. **Avoid using set/reset coils**. Set and reset coils can be hard to identify what has caused the current state of the bit, making diagnosis very difficult. Instead, use latching circuits to latch and unlatch bits.

3. **Force non-utilized command bits off**. By forcing command bits that are not being used off, interference between commands cannot occur. With proper interlocking, no two commands will be set together.

Each of these practices have been demonstrated in the example program. The first best practice is writing to a register or bit only once. Errors can occur when registers are accessed multiple times, as improper data can accidentally be loaded. When using the waterfall technique, data is loaded into the accumulator, the accumulator is manipulated based upon logic conditions and required math operations, and then moved to the selected register at the end of the section once all operations have been performed.

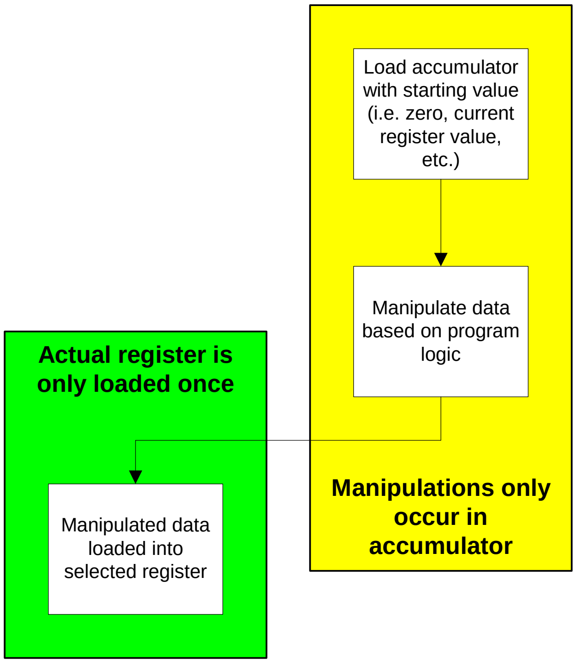
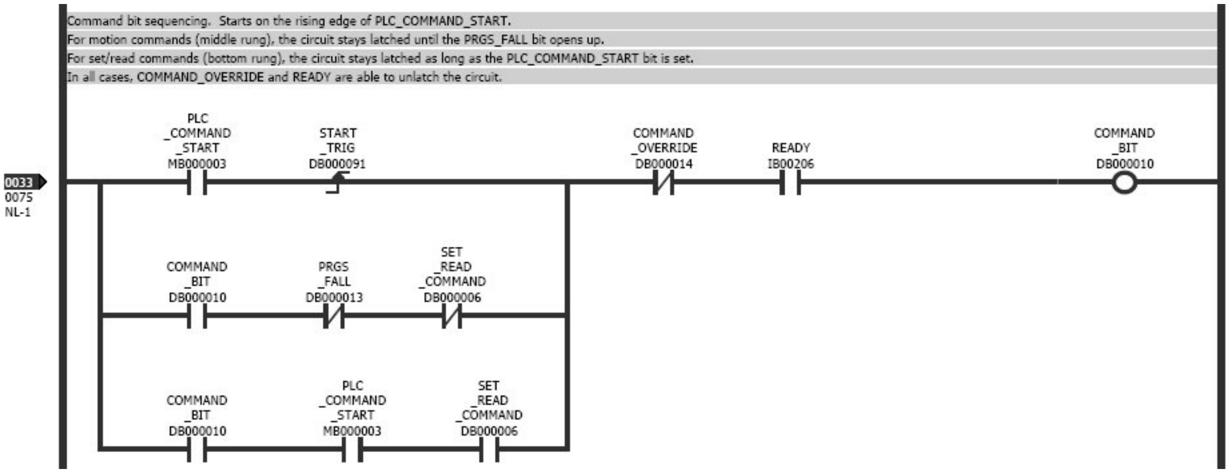

Load accumulator with starting value (i.e. zero, current register value, etc.)
Manipulate data based on program logic
Manipulations only occur in accumulator
Actual register is only loaded once
Manipulated data loaded into selected register

Fig 2. Waterfall Technique

This technique is easily visible in the last section of code. Starting in line 49, the long accumulator is loaded with zero. The starting value of the accumulator is recommended to either be the current value of the selected register (load the accumulator with the register value), or the desired register value if no data manipulation occurs. Lines 50 thru 56 perform the manipulation by loading the accumulator based on the selected command, as well as range check and limit functions for certain command types. Lastly, the actual output register to the NS300/500 is then loaded in line 51.

Another added feature of using the waterfall technique is that important registers are updated each scan. In this example, the output register is loaded with zero on the first scan after the user sets the command to no operation. This is very useful as it eliminates any residual data that may otherwise cause command errors if the residual data is out-of-range or improperly formatted for the ensuing command.

The second recommended best practice is to avoid using set/reset coils. Set/reset coils are never recommended; these coils are extremely difficult to troubleshoot since identifying the condition that caused a set or reset may not be visible. For this reason, latch circuits are always recommended. Latch circuits are recommended as they can be used to easily identify the cause of the current state of the coil. An example of a latch circuit is the command bit circuit shown on line 33 of the example master ladder.



Command bit sequencing. Starts on the rising edge of PLC_COMMAND_START.
For motion commands (middle rung), the circuit stays latched until the PRGS_FALL bit opens up.
For set/read commands (bottom rung), the circuit stays latched as long as the PLC_COMMAND_START bit is set.
In all cases, COMMAND_OVERRIDE and READY are able to unlatch the circuit.

0033
0075
NL-1
PLC _COMMAND _START MB000003
START _TRIG DB000091
COMMAND _OVERRIDE DB000014
READY IB00206
COMMAND _BIT DB000010
COMMAND _BIT DB000010
PRGS _FALL DB000013
SET _READ _COMMAND DB000006
COMMAND _BIT DB000010
PLC _COMMAND _START MB000003
SET _READ _COMMAND DB000006

Fig 3. Command Bit Sequencing Circuit

The coil is set on the rising edge of the PLC_COMMAND_START bit as long as the COMMAND_OVERRIDE and READY contacts are satisfied. COMMAND_BIT latches itself in the middle and last rungs. In the middle rung, the circuit will stay latched until the PRGS_FALL or SET_READ_COMMAND contacts open. In the last rung, the circuit will stay latched as long as the PLC_COMMAND_START and SET_READ_COMMAND contacts remain closed. If the command bit is set unexpectedly, monitoring this circuit will indicate exactly what is causing the coil to remain on as the coil status is updated every scan.

The last recommended programming practice is to force off any non-utilized command bits. Two bits are provided in order to modify the motion command by indicating a direction, using the DIR bit, or indicating that the move should be absolute or incremental, using the INC bit. These bits are only valid for selected commands, and otherwise have no significance. When a command is selected that renders these specific bits inactive, they should be set off. This is shown below in line 41, which controls the DIR bit.

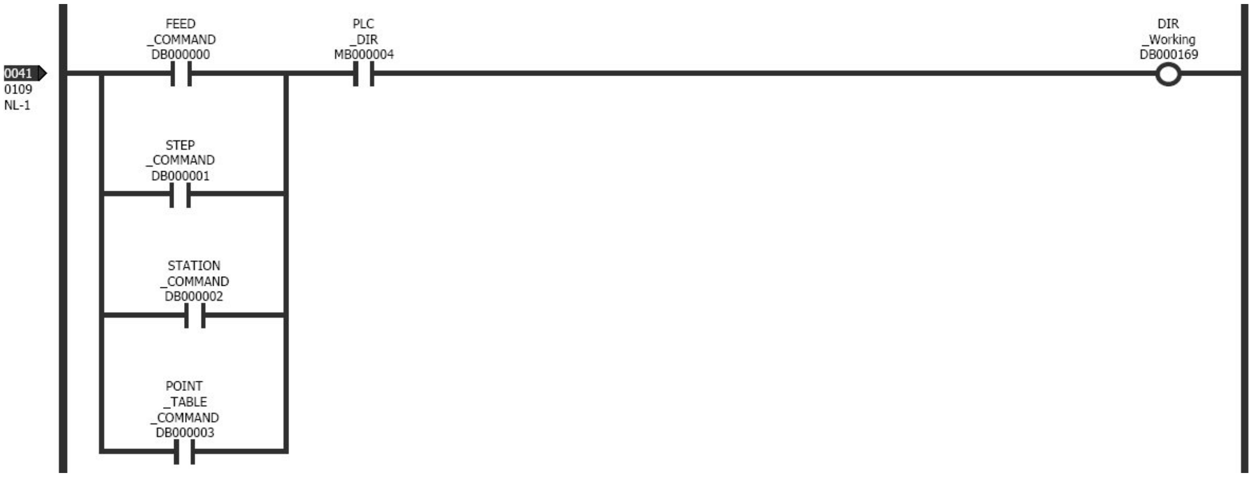


Fig 4. DIR Bit Circuit

The PLC_DIR bit commands the DIR coil. However, the DIR coil is only valid during feed, step, station, or point table commands. If the PLC_DIR is set, but the current command is not of the commands that can utilize the DIR command, then this bit is left off and properly follows the recommended practice.

Command Bit Sequencing

The last main topic is proper command bit sequencing and interlocking. One command bit circuit is used in this program for all commands. The coil of the command bit circuit is then interlocked with the selected command to set the appropriate command bit of the output message. The command bit circuit is shown below.

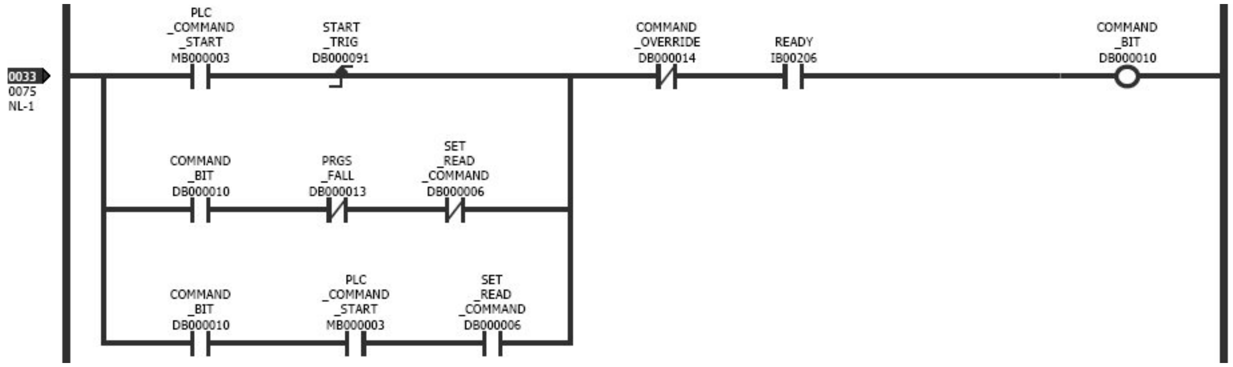

0033
0075
NL-1
PLC _COMMAND _START MB000003
START _TRIG DB000091
COMMAND _OVERRIDE DB000014
READY IB00206
COMMAND _BIT DB000010
COMMAND _BIT DB000010
PRGS _FALL DB000013
SET _READ _COMMAND DB000006
COMMAND _BIT DB000010
PLC _COMMAND _START MB000003
SET _READ _COMMAND DB000006

Fig 5. Command Bit Sequencing Circuit

As previously described, the COMMAND_BIT coil is set on the rising edge of the PLC_COMMAND_START bit as long as the COMMAND_OVERRIDE bit remains low and the READY bit remains high. READY is an input from the NS300/500 indicating that a command can be executed, and COMMAND_OVERRIDE is a coil in the program that is used to lockout any commands from being executed under certain conditions. The COMMAND_OVERRIDE circuit in line 32 is shown below.

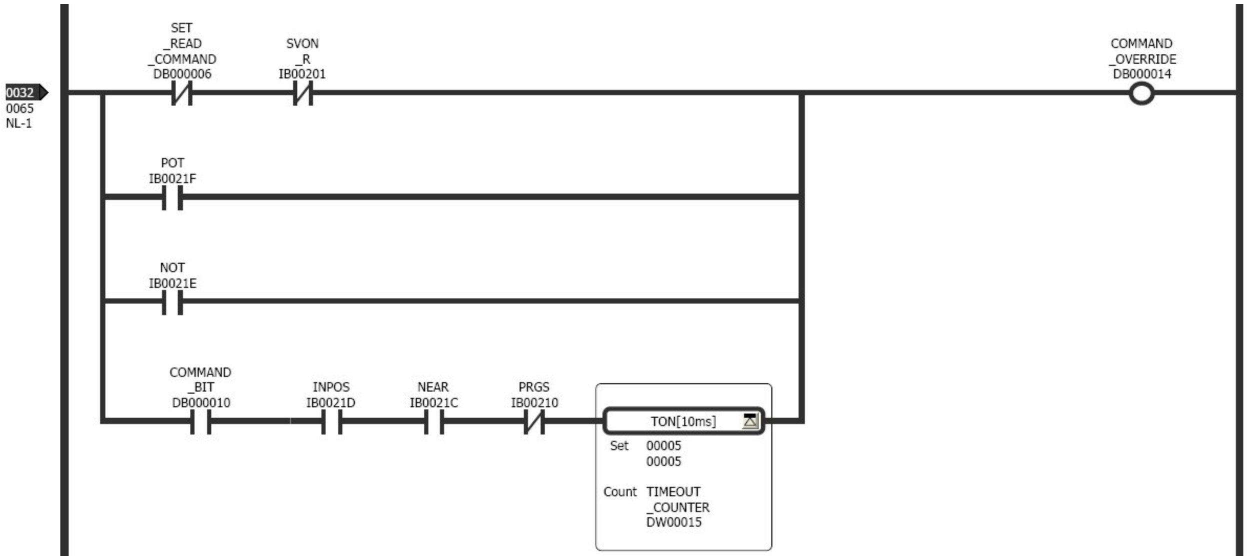


Fig 6. Command Override Circuit

The COMMAND_OVERRIDE coil is set in any one of four conditions. The first occurs if the servo is disabled as reported by the SVON_R response bit from the NS300/500. A normally closed contact of SET_READ_COMMAND is also included in this first rung. During set/read commands, the NS300/500 allows the servo to be disabled. The second and third conditions for setting the command override occur in an over-travel condition. It may be beneficial to the user to add an additional interlock to this circuit in order to jog back across the over-travel sensor.

The last condition occurs after the command has actually been activated. Completed motion commands are identified on the falling edge of the PRGS bit. Some conditions occur in which the PRGS bit never cycles, eliminating a falling edge of the PRGS bit from occurring. This last rung of logic is used to clear the command bit in cases where the PRGS bit never cycles. If the NS300/500 reports that the motor is in position (INPOS and NEAR), and the PRGS bit is low (meaning a falling edge cannot occur), then the motor is in position. If this occurs while COMMAND_BIT is still high, a timer checks for 50ms and then sets COMMAND_OVERRIDE in order to clear the latched COMMAND_BIT. This can occur in the following two conditions:

1. Commanding the servo to move to its current position. PRGS bit never goes high because the servo is already in position and no move is required.
2. The move distance is short, so the timing of the PRGS bit is less than one transmission cycle.

Once COMMAND_BIT is set, the coil must be latched in order for the coil to remain active. The bottom two rungs of the COMMAND_BIT circuit are shown above (also from line 33). The middle rung is selected as the latch circuit for motion commands (non set/read) and the bottom rung is selected as the latch circuit for set/read commands.

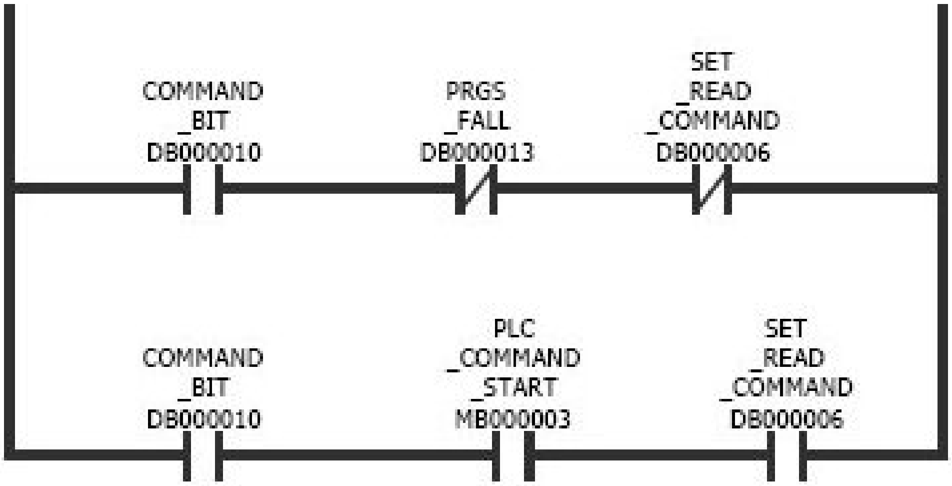


Fig 7. Command Bit Latch Circuits

When a set/read command is active (bottom rung), the coil will remain latched as long the PLC_COMMAND_START bit is held on. When a motion command is active (middle rung), the circuit will remain latched until the PRGS_FALL bit is set, opening up the normally closed contact. The PRGS_FALL bit is the one-shot falling edge of the PRGS response bit, shown in line 34 below. The falling edge of the PRGS bit indicates the NS300/500 has completed the motion profile, and COMMAND_BIT can be removed.

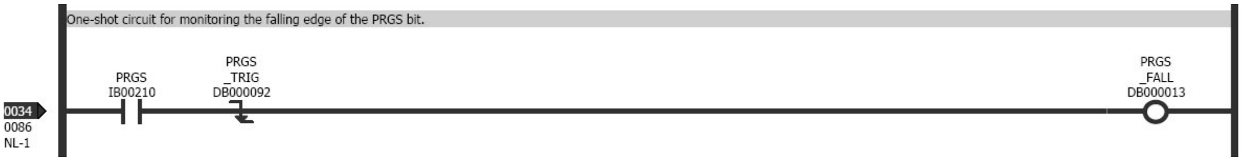

One-shot circuit for monitoring the falling edge of the PRGS bit.

Fig 8. PRGS Falling Edge Circuit

Once COMMAND_BIT is set, ANDing COMMAND_BIT with the selected command sets the specific command bit. An example of this is shown below. Command bits for feed, step, and station are shown in lines 35 thru 37 (this operation occurs on lines 35 thru 40). When the selected command and COMMAND_BIT are both active, the coil will be set. This allows one command bit circuit to control all of the commands as well as preventing multiple commands from being active together. Note that for feed, PLC_COMMAND_START must be active to set the output. This has been added to provide jog functionality by stopping motion whenever the command is removed.

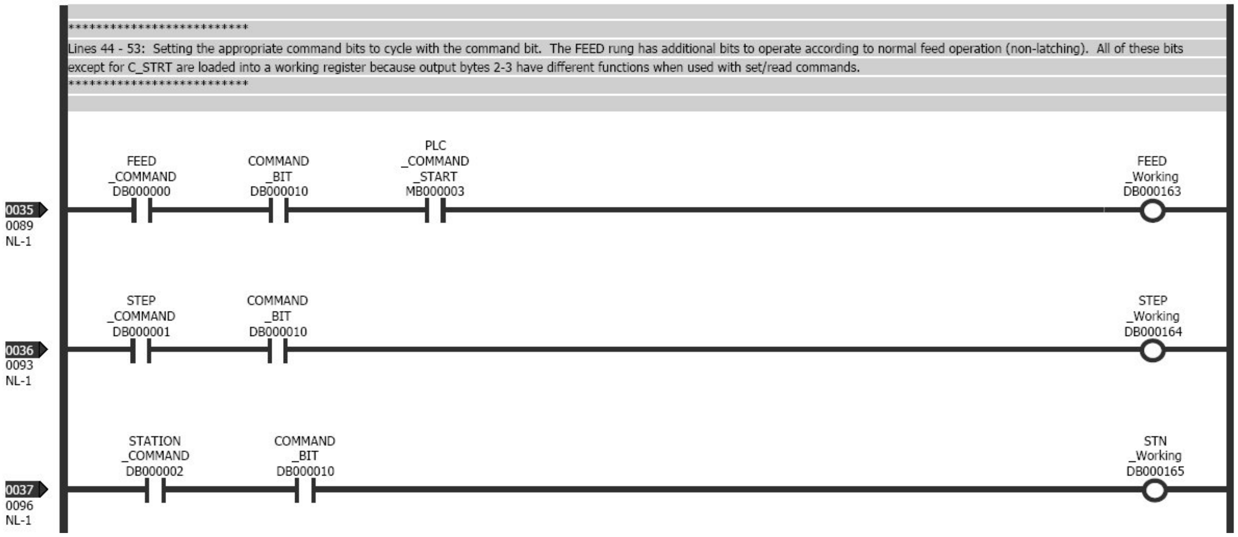

****
Lines 44 - 53: Setting the appropriate command bits to cycle with the command bit. The FEED rung has additional bits to operate according to normal feed operation (non-latching). All of these bits except for C_STRT are loaded into a working register because output bytes 2-3 have different functions when used with set/read commands.
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Fig 9. Setting Individual Command Bits

Additional Topics

In addition to the three main topics described above, a handful of specifics in the program are worth noting. Here is a list of these items:

- Servo-on latch circuit
- Bit/byte manipulation for response/command codes in output bytes 0-1
- Working registers and selecting the proper data to place in output bytes 2-3
- Using MOD_R to load data with set/read commands

Servo on latch circuit

The servo on latch circuit is shown below. SVON can be enabled when the NS300/500 is not indicating an emergency stop, the PLC_ESTP bit is set, and main power is applied to the servo amplifier. The coil is set on the rising edge of the PLC_SVON bit. Note that the READY bit response from the NS300/500 must be active on the rising edge of the PLC_SVON bit. The READY bit is only included in setting the coil, but does not participate in latching the SVON coil. This setup is required as the READY bit changes state during the execution of the SVON command. Once the coil is set, it is unlatched either by clearing the PLC_SVON command, by an emergency stop occurring in either the PLC or the NS300/500, or if main power is removed from the servo.

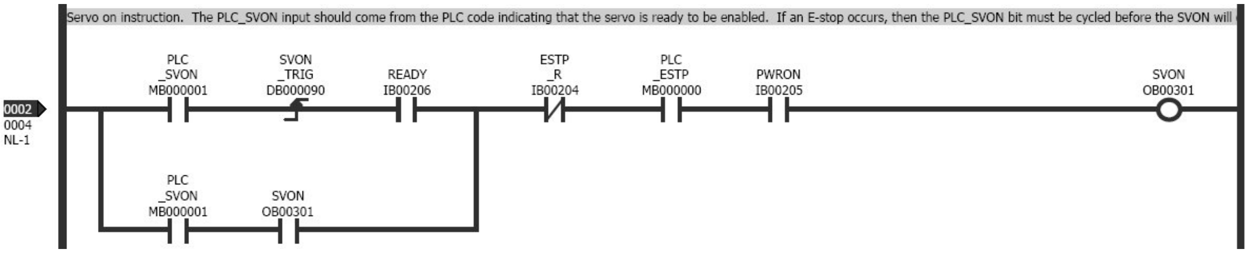

Servo on instruction. The PLC_SVON input should come from the PLC code indicating that the servo is ready to be enabled. If an E-stop occurs, then the PLC_SVON bit must be cycled before the SVON will

Fig 10. Servo On Latch Circuit

Bit/byte manipulation for response/command codes in output bytes 0-1

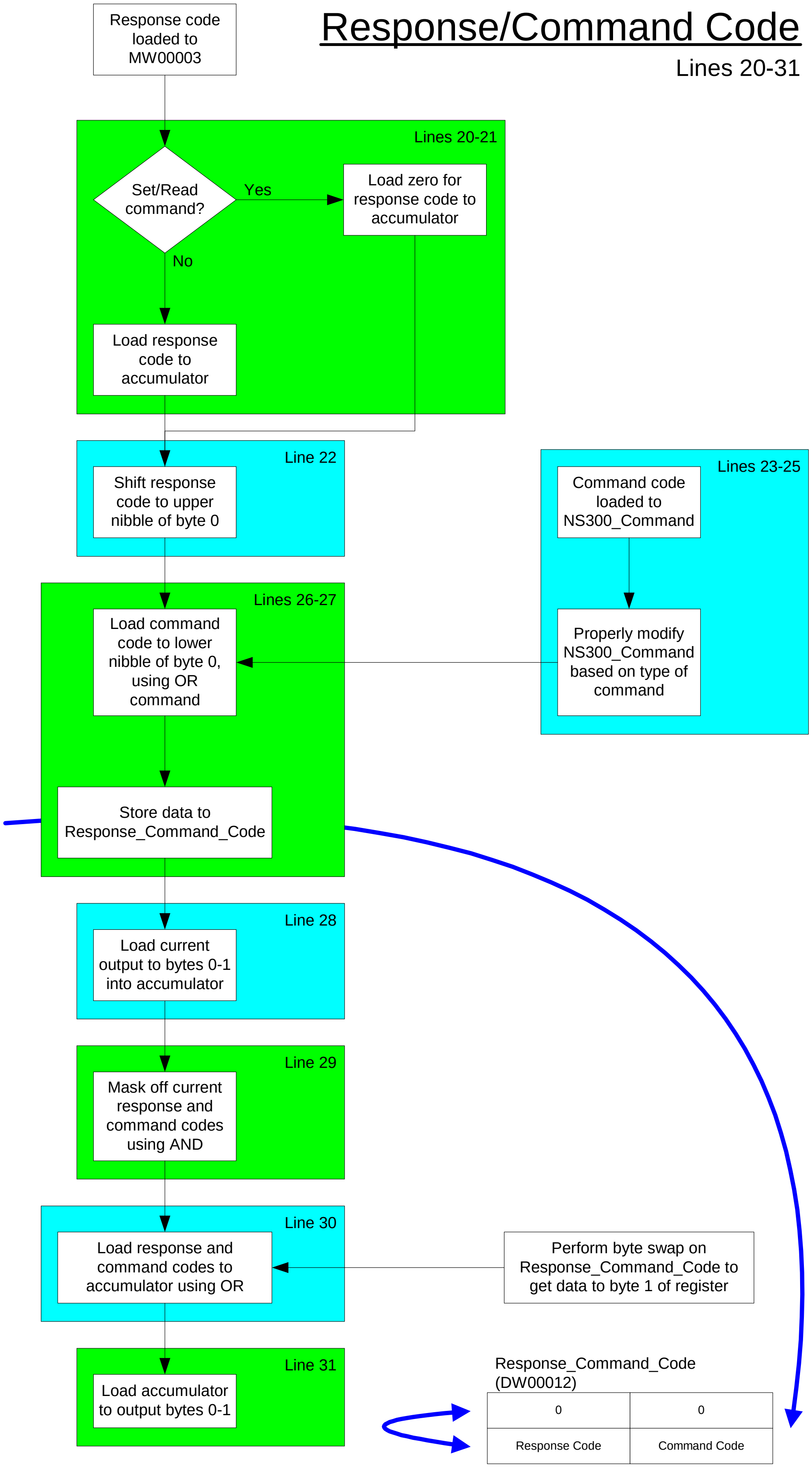
Bit and byte manipulation is required when loading the response and command codes into output bytes 0-1. This is necessary as the controller used in the example works in bit or word data types, and output bytes 0-1 use bit and nibble data types for the associated commands. The flowchart on the following page describes this process. Included with the flowchart are contents of the registers as the code is executed. Note: the first step of the flowchart, loading the response code to MW00003, is completed by the user in other portions of the PLC code.

Response/Command Code

Lines 20-31

Register Legend

Byte 0, Upper Nibble	Byte 0, Lower Nibble
Byte 1, Upper Nibble	Byte 1, Lower Nibble


Response code loaded to MW00003
Lines 20-21
Set/Read command?
Yes
Load zero for response code to accumulator
No
Load response code to accumulator
Line 22
Shift response code to upper nibble of byte 0
Lines 23-25
Command code loaded to NS300_Command
Properly modify NS300_Command based on type of command
Lines 26-27
Load command code to lower nibble of byte 0, using OR command
Store data to Response_Command_Code
Line 28
Load current output to bytes 0-1 into accumulator
Line 29
Mask off current response and command codes using AND
Line 30
Load response and command codes to accumulator using OR
Perform byte swap on Response_Command_Code to get data to byte 1 of register
Line 31
Load accumulator to output bytes 0-1

Accumulator_W (DW00026)

0	Response Code
0	0

Accumulator_W (DW00026)

Response Code	0
0	0

Accumulator_W (DW00026)

Response Code	Command Code
0	0

Response_Command_Code (DW00012)

Response Code	Command Code
0	0

Accumulator_W (DW00026)

MOD, ALRST, ESTP	SVON, C_STRT
Current Response Code	Current Command Code

Accumulator_W (DW00026)

MOD, ALRST, ESTP	SVON, C_STRT
0	0

Accumulator_W (DW00026)

MOD, ALRST, ESTP	SVON, C_STRT
Response Code	Command Code

NS300_BytesOut_0_1 (OW00030)

MOD, ALRST, ESTP	SVON, C_STRT
Response Code	Command Code

Response_Command_Code (DW00012)

0	0
Response Code	Command Code

Fig 11. Process for Loading Response and Command Codes

Working registers and selecting the proper data to place in output bytes 2-3

Loading the proper data into output bytes 2-3 requires the use of an accumulator. For motion commands, output bytes 2-3 are bit settings, but for set/read commands, output bytes 2-3 combine to become a word type register.

If the command is a set/read command and, more specifically, a parameter read or parameter write command, the parameter value from MW00014 is loaded to the accumulator once the MOD_R response bit from the NS300/500 is acknowledged. If the command is any other set/read command, the accumulator is loaded with zero. Motion command bits are set in a working register, DW00016, and then loaded to the accumulator for motion commands.

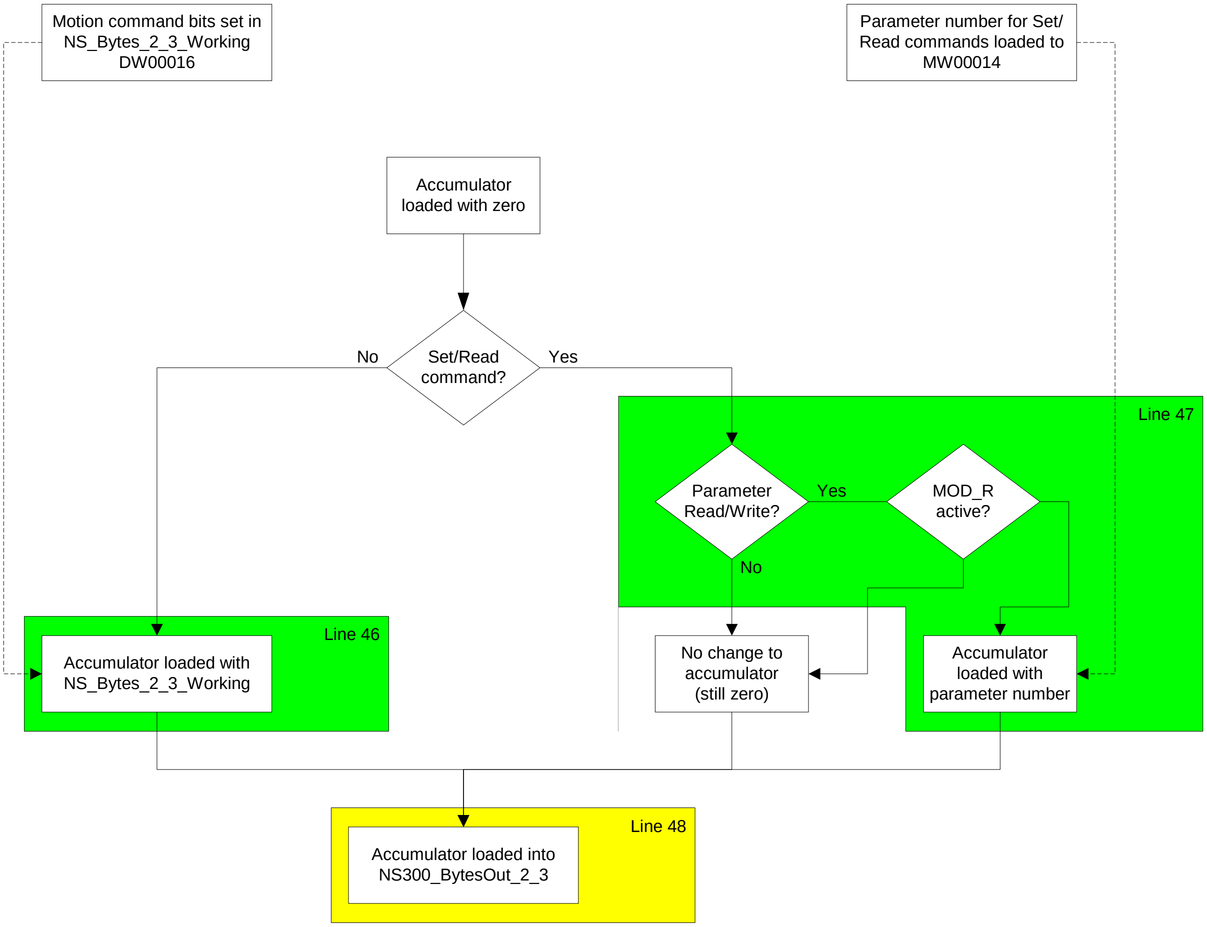
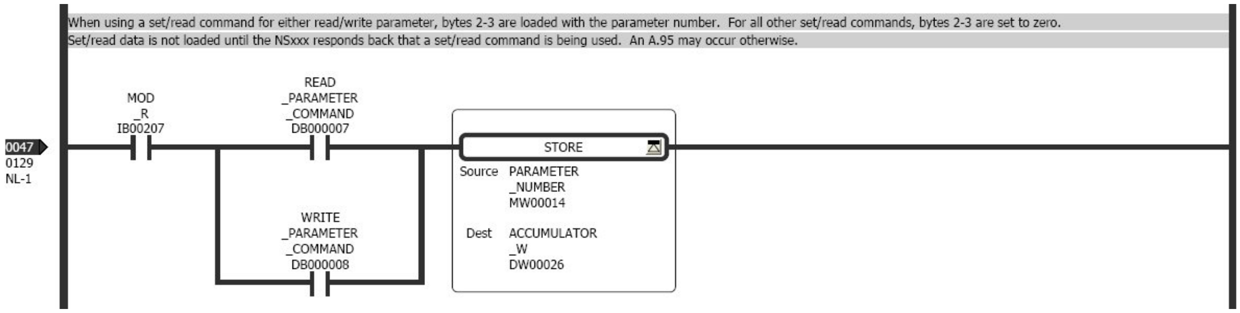

Motion command bits set in NS_Bytes_2_3_Working DW00016
Parameter number for Set/ Read commands loaded to MW00014
Accumulator loaded with zero
No
Set/Read command?
Yes
Line 47
Parameter Read/Write?
Yes
MOD_R active?
No
Line 46
Accumulator loaded with NS_Bytes_2_3_Working
No change to accumulator (still zero)
Accumulator loaded with parameter number
Line 48
Accumulator loaded into NS300_BytesOut_2_3

Fig 12. Output Bytes 2-3 Data Selection Process

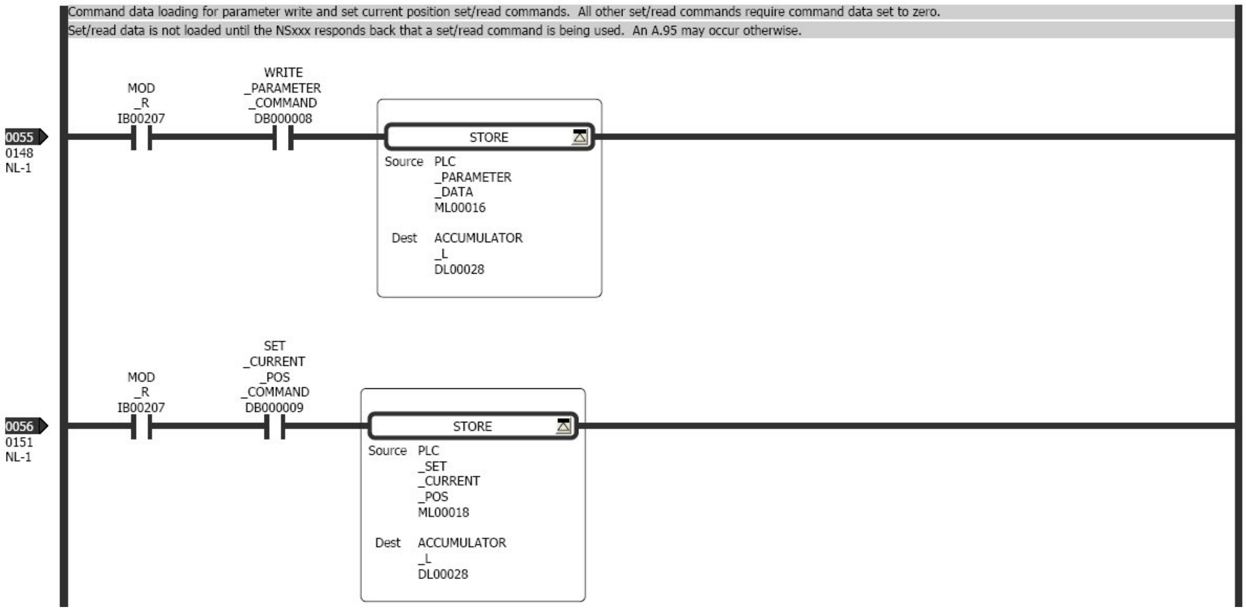
Using MOD_R to load data with set/read commands

When using either the parameter read or parameter write set/read commands, output bytes 2-3 should not be loaded with parameter data until the NS300/500 has acknowledged a set/read command is to be performed via the MOD_R response bit. The MOD bit of the command message indicates a set/read command, and the response is sent by the NS300/500 through MOD_R. This interlocking is shown for both output bytes 2-3 as well as output bytes 4-7. Line 47 demonstrates this interlock for output bytes 2-3, and lines 55 and 56 show this for parameter read/write commands, in addition to the set current position command.



When using a set/read command for either read/write parameter, bytes 2-3 are loaded with the parameter number. For all other set/read commands, bytes 2-3 are set to zero.
Set/read data is not loaded until the NSxxx responds back that a set/read command is being used. An A.95 may occur otherwise.

Fig 13. MOD_R Interlocking for Output Bytes 2-3



Command data loading for parameter write and set current position set/read commands. All other set/read commands require command data set to zero.
Set/read data is not loaded until the NSxxx responds back that a set/read command is being used. An A.95 may occur otherwise.

Fig 14. MOD_R Interlocking for Output Bytes 4-7