Allen-Bradley

Using the 1756-M02AE with the TR Encoder
(Cat. No. 1756-2.9)

Application Note

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Contrologix Servo Module – TR Encoder

Contrologix Servo Module – TR Encoder

Using the 1756-M02AE servo module with the TR encoder to for absolute feedback.

Purpose

The following note shows how to wire, configure, and program the 1756-M02AE servo module, a Contrologix system, along with the TR Absolute Encoder to attain absolute position information.

Hardware Equipment Used

1756-M02AE	Contrologix Servo Module
1394-SJT05-A	1394 System Module 5 Kw
1394-AM03	2 Kw Axis Module
1326AB-B410G-21	1326 Servo Motor
1326-CCU-005	Feedback/Commutation Cable
1326-CPB1-005	Power Cable
CE-65-M ISI	TR Multi Turn Absolute Incremental Encoder
	TR Encoder Cable
1756-OB16I/A	24 V DC Output Module
1756-IB16D	24 V DC Input Module

TR Description

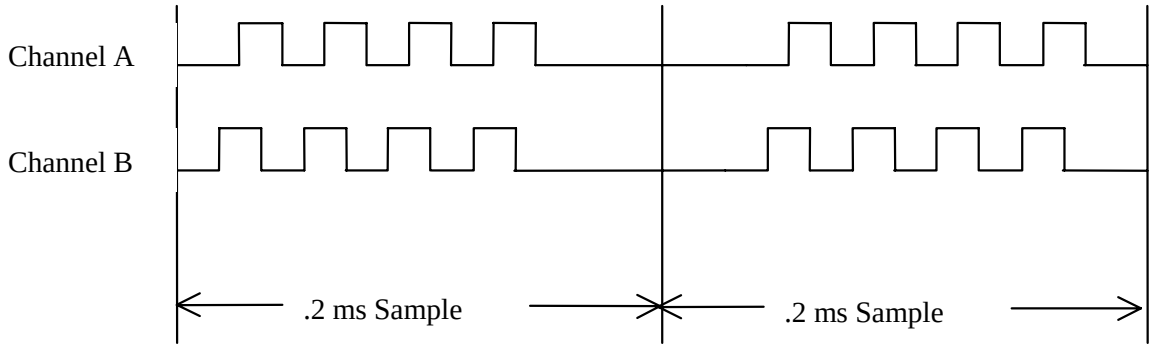
The TR encoder used in this Application Note is model CE-65. TR has developed an incremental A Quad B interface which is integrated into their absolute encoders. The transmission of the absolute position is accomplished via a quadrature signal. Upon strobing the encoder a pulse train is sent to the controller which represents the absolute position of the device, after which the encoder operates as an incremental device.

The multiturn encoder takes the rotation of the shaft and using a coded disk divides the rotation into a maximum of 8192 revolutions. The position data consists of the angular position and the number of revolutions. This is then processed and transmitted as an incremental signal by activating the “load input”. The number of incremental pulses is then sent proportional to the absolute position of the encoder. This “load” frequency is programmable up to 125 kHz.

The encoder can be programmed using TR’s configuration software called EPROG. This ability to program this device lets you custom configure the encoder for your particular application. The device has a number of programmable features such as a Signal bit for over-speed. There are four limit switch outputs that act as cam switches. These switches can also be programmed.

This is a sampled system. The onboard electronics takes a sample of the encoder position every 200 µSec. It then calculates the change in position since the last sample and outputs a *burst* of pulses that represents this distance.

The following drawing shows what the output looks like on a scope – it is a pulse stream followed by a dead space.



Encoder Configuration

The TR is a programmable encoder. The device comes pre-configured and may not require any further programming. However, if your application requires changes to the programmable settings, see the *TR Encoder – EPROG Software Guide* section in this *Application Note* for information on changing the programmable settings.

TR Encoder - EPROG Software Guide

This guide provides the programmer with information to setup or program their application. If there are any questions, TR product support can be reached at 519-452-1999.

Options

The selections are extended and standard, use **standard**.

Axis Name

Enter a name that is appropriate for the axis.

STROKE

To use the Preset inputs, this field must be **enabled**. If you do not plan to use presets, set the field to **disabled**.

The STROKE field is discussed in greater detail below. Please refer to that text for programming information.

Signal Bits

This section can be disregarded.

ISI

This field should be set to **YES**.

Loading Edge refers to whether the encoder starts sending its position when pin 7 goes falling (high to low transition) or rising (low to high transition).

Response Time can be set from 0 to 255 msec. This is used to debounce a possible noisy Load Input (pin 7) signal. The Response Time field determines how long the signal must stay in the first state before it recognizes the second state.

Max. frequency should always be set to 124,756 to enable the highest resolutions. Most devices accept 1 MHz or greater. Also see the ISI section below.

Position Field

This is a read/write field. While the software is communicating to the encoder, the field displays the correct number of counts. This field can be changed to any value and then you program the encoder to reset the present position to that value.

Stroke

This is the area that describes and determines the range that the encoder measures without repeating a value. It is a general field that encompasses the number of steps per revolution, number of revolutions and the origin or starting point of the range. The device has a predetermined *Stroke*. There are a few options with this field and this is directly related to the number of revolutions.

Power of 2: The number of revolutions must be a power of two (i.e. 1, 2, 4, 8, 16, 32, 64, etc.). Any other values are not accepted.

Integer: The number of revolutions can be any whole number.

Note: If power is off and the shaft is rotated more than 1600 revolutions, the absolute value may not be correct.

Fraction: The number of revolutions is entered as a frictional value. This enables the user to have a decimal value for the number of revolutions (i.e. 25/3 = 8.3333 revolutions).

1 Revol: The number of revolutions is forced to 1. This renders the encoder to be a single turn encoder.

If you have a linear axis, the Power of 2 mode works for most cases. Make sure that you stay within the selected range type.

If you have a rotary axis, you must select the proper mode based on the machine mechanics. Lets assume that the encoder is on the motor. If your motor turns 1, 2, 4, 8, 16, 32, 64, etc (Power of 2) times to one rotary cycle of your program, then use Power of 2. However, if your motor turns 18 times (possibly a gearbox) for a 360 degree index, then you use the Integer mode. If the motor turns 25 times for 3 cycles of the axis, you must use the Fraction mode. See example below for more information.

Revol. per stroke

This field determines how many revolutions there are in the "stroke" or range. The permissible values are directly related to the setting of the "**Stroke"** field.

Steps per rev.

This is the field where you set the number of steps per revolution. The number of steps per revolution is directly related to but not equal to the number of incremental pulses per revolution. To generate one full cycle of an incremental pulse, four steps are required. This is necessary so that the A and B signals can be 90× phase shifted. Therefore if you require 1000 pulses per revolution (lines), you would need to program the encoder for 4000 steps per revolution.

The total number of steps per stroke is 16,777,216. The device comes pre-configured for 8192 steps per revolution. If we divide the total number of steps by the steps per revolution, we have a total range of 2048 revolutions. The Max output frequency is in Hertz. The unit is preset for 124,756 Hz. If we have 8192 steps per revolution, we have a speed limitation on our motor of 3654 RPM. If you re-program the encoder for 4096 counts / rev and 4096 turns, it allows a maximum motor speed of 7308 RPM. This covers the entire speed range of all A-B motors.

Note: If the "Stroke" field has been set to Fraction, then the fields "Revol. per stroke" and "Steps per rev." change.

R.p.s.denominator: This field is added below the **"Revol. per stroke"** and is the denominator of the fraction which determines the total number of revolutions.

Steps per stroke: This field is now the total number of steps in the range of travel. This value is determined by multiplying the number of steps per revolution by the total number of revolutions. There is no longer a field to enter the number of steps per revolution. The user must multiply by hand the steps per revolution by the revolutions and enter that total value in this field.

Count direction

The count direction simply determines whether the counts increase or decrease if the shaft is rotating in the clockwise direction. Changing this field has the same effect as physically switching the A and B channels in the panel. In some encoders there is a special input called **Fwd/Rev** which changes the direction of count as well. There are four options with this field.

0V= Increase cw. The counts increase while the shaft is rotating in a clockwise direction if the Fwd/Rev input is low. Applying 24 volts DC to the Fwd/Rev input changes the direction of counting.

0V= Decrease cw. The counts decrease while the shaft is rotating in a clockwise direction if the Fwd/Rev input is low. Applying 24 DC Volts to the Fwd/Rev input changes the direction of counting. The counts increase while the shaft is rotating in a clockwise direction. The Fwd/Rev input is disabled and has no effect on the direction of count.

Increase cw. The counts increase while the shaft is rotating in a clockwise direction. The Fwd/Rev input is disabled and has no effect on the direction of count.

Decrease cw: The counts decrease while the shaft is rotating in a clockwise direction. The Fwd/Rev input is disabled and has no effect on the direction of count.

Origin type:

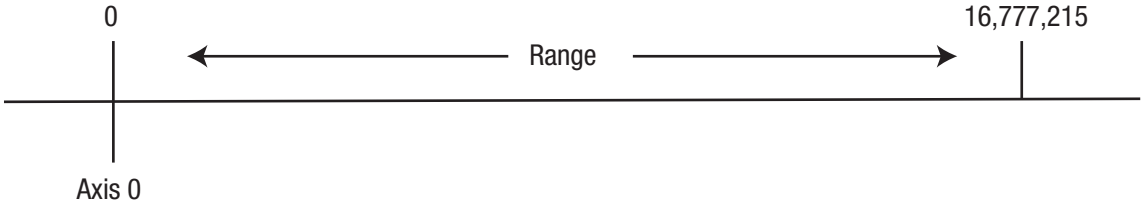
To understand the origin type it is important to know the range limits. The maximum value of the range is determined by multiplying the Steps / Rev by the Revolutions. If you use the following values:

Steps / Rev = 8192
Revolutions = 2048

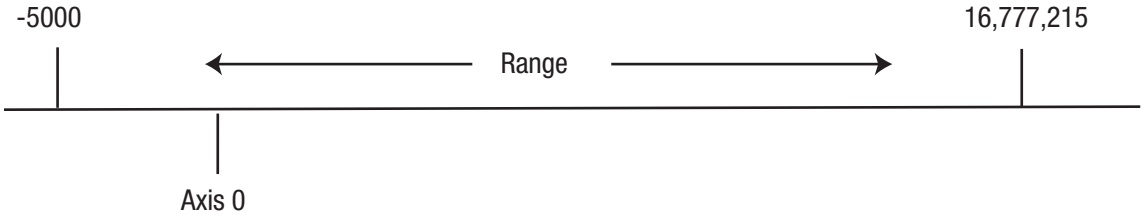
The total range becomes 0 to 16,777,215 steps (8192 x 2048).

There are three different origin types: Zero, Asymmetrical, and Symmetrical

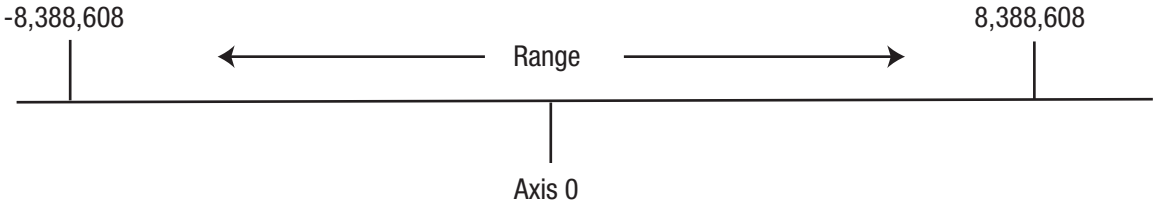
Zero: The origin is at zero and continues until the maximum positional value of 16,777,215 is reached. After this point the value wraps around to zero again.



Asymmetrical: The origin is some negative value (determined by the user).



Symmetrical: The origin is negative one half of the total range. The zero point is in the middle of the range.



Note: In some cases the Symmetrical mode is not available and the field defaults to Asymmetrical. The Asymmetrical mode can be used to mimic the Symmetrical mode by simply entering a negative value that is half of the total range.

The need to change the origin arose after various application problems were solved. The problem occurred when the origin was set to zero, the axis moved to home and the encoder preset zero. In this instance if the axis moved past zero just one step, then the absolute value would be a very large number. If the encoder was asked to send out Its position at this point, the value to send was very large. The controller interpreted this as the axis having moved out of operating limits and faulted out.

To solve this problem, set the encoder to asymmetrical and enter a value of -8,388,608 into the origin. This gives the encoder a symmetrical offset. Now the axis can be moved to its home position and the encoder set to zero. If the axis drifts past zero just one step and the position is requested, a value of -1 is sent back from the encoder. This is the proper value and the controller knows the axis position.

ISI

This area is used to setup and optimize the ISI interface of the encoder. There are two options: Yes & No.

Yes – ISI output is enabled.
No – ISI interface is disabled.

Max.frequency/Hz

This is the most important field in this section. The output frequency of the encoder is programmable from 2 kHz to 125 kHz. This lets you match the maximum output frequency of the encoder to the maximum input frequency of the connected counter module. Once the maximum input frequency of the controller has been found, enter the value into this field. The value that you enter may change slightly since the microprocessor must find a value that it can generate from it's internal clock. The maximum value accepted is 124,756 Hz. Any value entered that is greater than this causes an error message and resets the frequency to this maximum value. TR Electronics sets all encoders to the maximum value of 125 kHz.

Example:

A setup using the following values provides 20,480 counts per 2.5 revs. This application would require a 2.5 motor (and encoder) revs per axis cycle.Using rotary user units of degrees, the 1394 K constant is 56.888888889 and the unwind is 20,480. This lets the encoder and the 1394 to roll over at the same increments, thus giving us continuous rotary motion with absolute positioning.

Encoder Values

Stroke	Fraction
Revol. per stroke	25
R.p.s. denominator	10
Steps per stroke	20,480
Count direction	Increase clockwise
Origin Type	Zero

The maximum motor (encoder) velocity is 3654 rpm.

20,480 / (25 / 10) = 8192 (2048 lines at 4X)
8192 / 4 = 2048, 124,756 Hz / 2048 = 60.916 revs / sec.,
60.916 * 60 sec/min = 3654.96 revs/min.

Therefore, you must consider your resolution setting based on the speed of your motor and application.

Servo Module Configuration

You may configure the servo module as follows:

General:	
Type:	- Position Only or Servo
Positioning Mode:	- Linear or Rotary
Feedback:	- Counts / Unwind must be an integer
Homing:	- Can't use Passive Homing
	- Active Homing –'Immediate' or 'Switch only' any configuration except using a 'marker' type configuration is acceptable
Servo:	- 'Velocity' or "Torque'
	- 'Drive Fault Input' should be used and set to 'Normally Closed' this is what we use to tie into the e-stop string

Note: You can also use the 'Drive OK' contacts wired in series with the 'Drive Fault' input as shown in the interconnect diagram

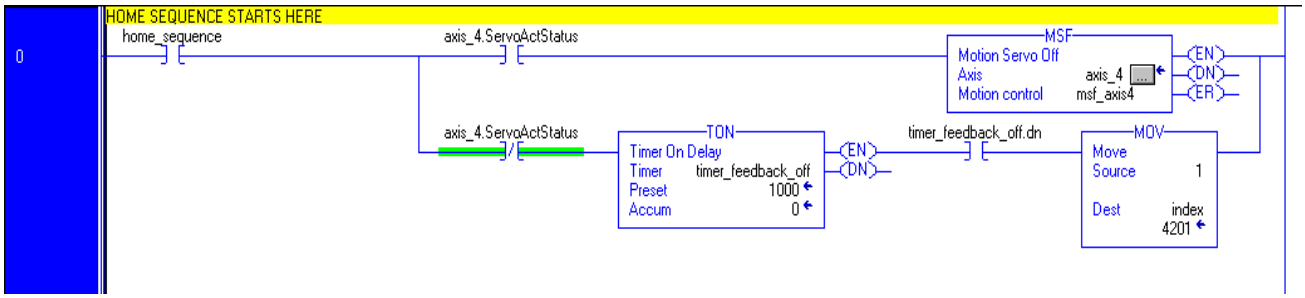
Homing The Axis

The transmission of the absolute position is accomplished via a quadrature signal. Upon strobing the encoder one pulse train is sent to the controller which represents the absolute position of the device. Then the encoder operates as an incremental device.

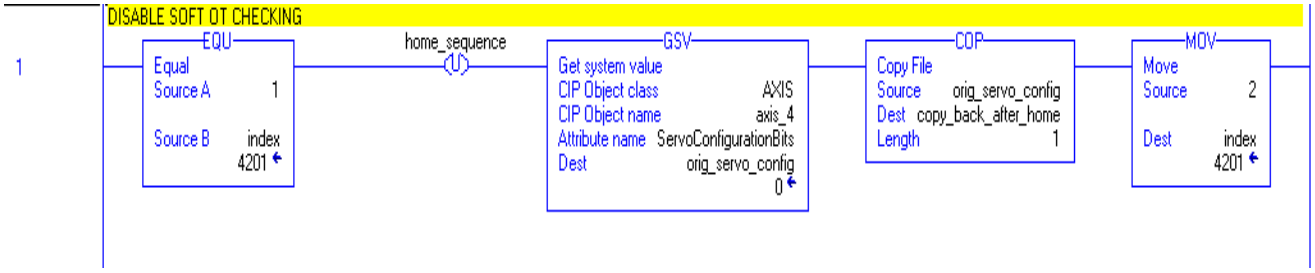
When you request an absolute home for the axis, a handshake between the controller and the encoder occurs. You can use a 24V output card to send the 'load output' or 'strobe' to the encoder to receive back position. One 'strobe' obtains all the position data (you don't need to issue multiple strobes). Once the encoder receives the 'strobe' output, it sets a 24V input high, and when the 'strobe' output goes low, the position is sent to the controller as a stream of pulses. When the position is complete, the input also goes low.

Homing Routine

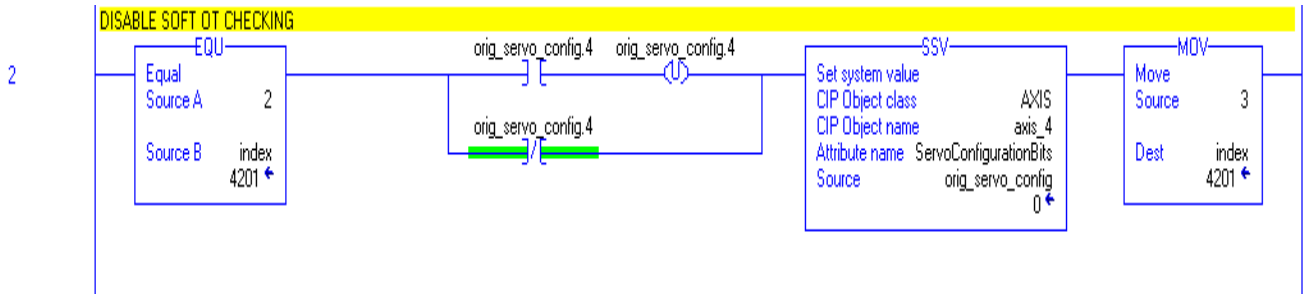
The following ladder program contains the homing routine for the TR to 1756-MO2AE.



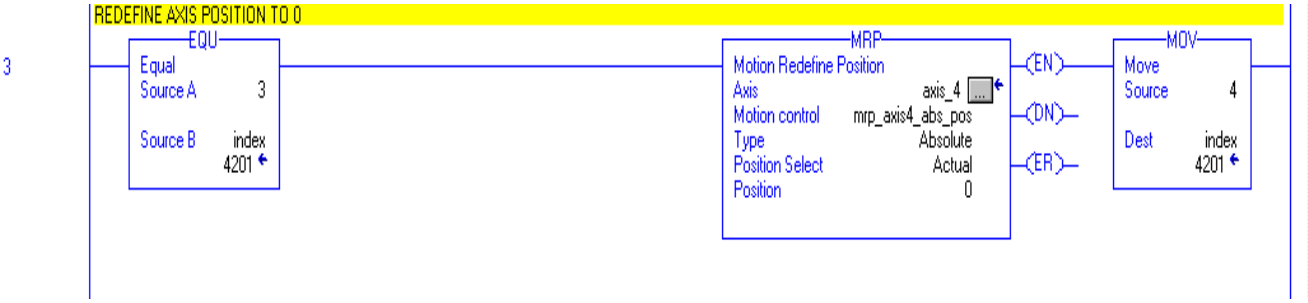
Rung 0: When home_sequence is set, check to see if the feedback is on. If it is, turn it off and wait for the axis to come to a stop.



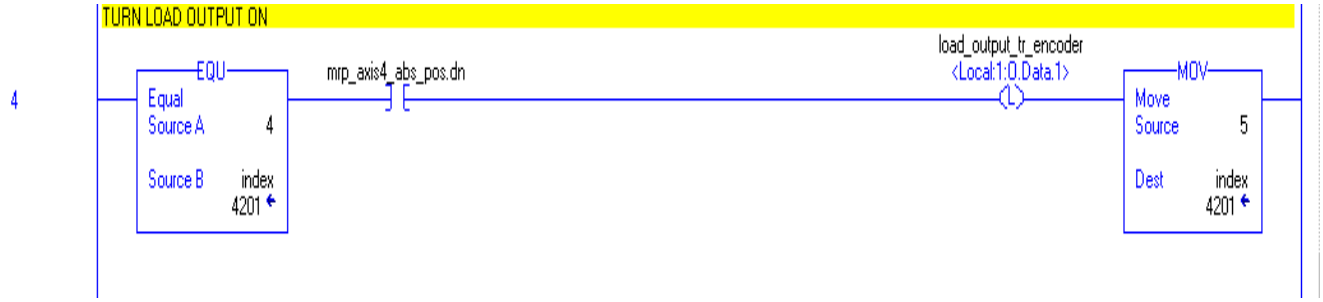
Rung 1: Clear the home_sequence bit and get the servo configuration. This is later used to determine if the axis has software overtravel enabled or not. When you get this value, copy it to another tag so that it can be replaced at the end of the checking procedure.



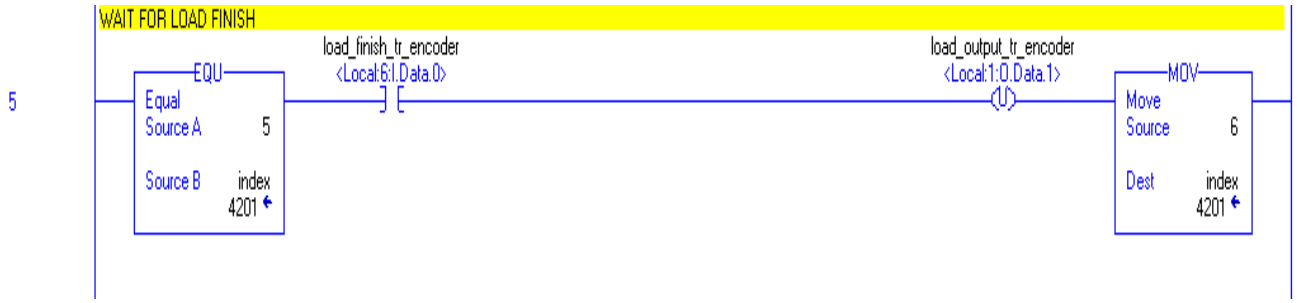
Rung 2: Check to see if the 'Soft Over Travel Checking' is enabled. If it is, turn it off and save the value to the servo module.



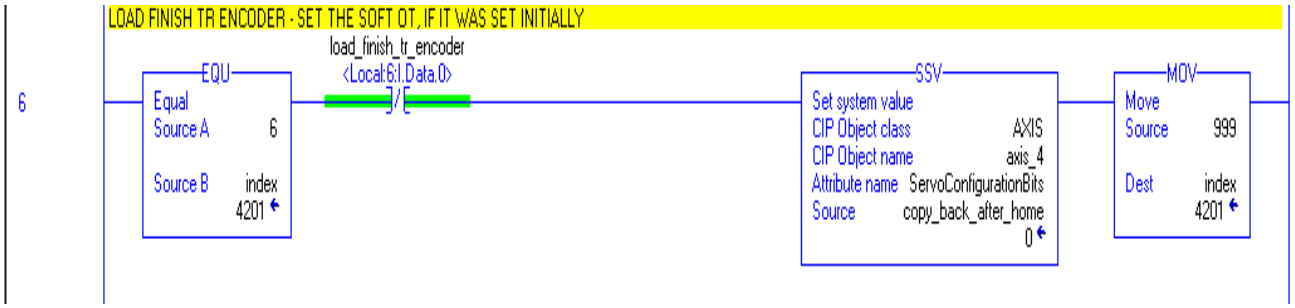
Rung 3: Clear the Actual_Position Accumulator so the value from the encoder can be stored in it.



Rung 4: When the redefine is completed, set the strobe output (or load output) to the encoder.

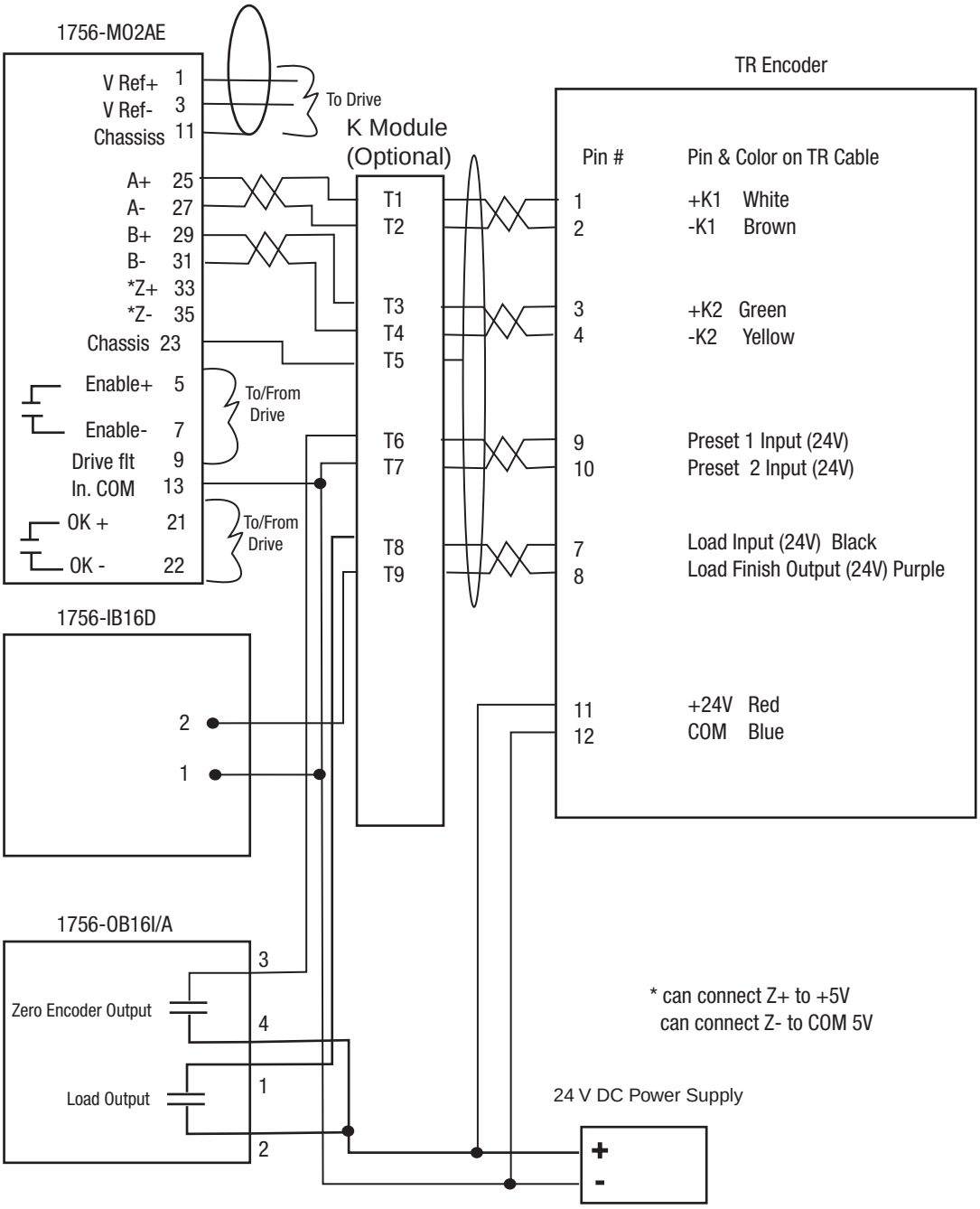


Rung 5: When the handshake input from the encoder (load finish) is set, clear the strobe output.



Rung 6: When the handshake input gets cleared from the encoder, the position data is sent to the controller, and the actual_position is received from the encoder. The Software Over Travel checking can be restored, if it was enabled by saving the original value to the Servo Module.

The following wiring diagram shows how to connect the TR Encoder to the 1756-MO2AE.



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