M306 Servo-Controller

M306 Operations Guide

Revision 5

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TRI-SEN

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Revision History

Rev. 0	October 1996	Initial Issue
Rev. 1	November 1996	Editorial revisions
Rev. 2	January 1997	Error corrections and re-formatting
Rev. 3	January 1998	General revision including technical and editorial changes, and formatting for A4
Rev. 4	June 2001	Updated J6 jumper position tables; pages 21, 26, 37, 45
Rev. 5	November 2008	Made revisions for Tri-Sen acquiring the product; including company name and logo, address, and contact information

Warnings!

READ THIS ENTIRE MANUAL AND ALL RELATED PUBLICATIONS PERTAINING TO THE WORK TO BE PERFORMED BEFORE INSTALLING, OPERATING, OR SERVICING THIS EQUIPMENT.

- **Practice all plant and safety codes and standards. Failure to follow instructions can result in personal injury and/or property damage.**
- To prevent ignition of hazardous atmosphere, do not remove covers of Class I Division I (explosion-proof) units with power applied.
- All servicing should be performed by qualified technicians. Dangerous voltages may be present on the circuit boards.
- Use extreme caution when working around power-input cables. These cables may have potentially lethal voltages on them.
- Be very careful when working on the digital (or discrete) input/output field termination panels. The external devices being controlled can have high, potentially lethal voltages on them. Turn off the power to the external devices before disconnecting or connecting the cable or a wire between the digital (or discrete) input/output field termination panels and the field wiring.
- Replace fuses only with specified parts for continued safe operation.
- Equip the engine, turbine, or other type of prime mover with an overspeed (overtemperature or overpressure, where applicable) shutdown device that operates totally independently of the prime mover control device. This protects against run-away or damage to the engine, turbine, or other prime mover, or personal injury or loss of life, should the mechanical-hydraulic or electronic governor, actuator, fuel control, driving mechanism, linkage, or controlled device fail.
- Make sure the charging device is turned off before disconnecting the battery from the system to prevent damage to a control system that uses an alternator or battery-charging device.
- Prior to energizing the equipment, have qualified personnel verify all wiring and connections against vendor drawings. Incorrect wiring and/or connections can result in equipment damage.
- Contact appropriate manufacturer for instructions on operation of engine, turbine, or driven unit. This manual does not contain this information.

If you have questions or need more information on installing and operating Tri-Sen equipment, contact Tri-Sen.

Disclaimer

Because of the variety of uses for this equipment, the user of and those responsible for applying this equipment must satisfy themselves as to the acceptability of each application and the use of the equipment.

The illustrations in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, Tri-Sen cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

In no event will Tri-Sen be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

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Electrostatic Discharge Awareness

Electrostatic discharge can damage or destroy electronic components, assemblies, or systems.

1. Keep the following materials away from components and work area:
    - Styrofoam® (polystyrene): cups, packing material
    - cellophane: cigarette packages or candy wrappers
    - vinyl: books or folders
    - plastic: cups, bottles, ash trays
2. Avoid synthetic clothing. Instead wear cotton or cotton-blend materials. Keep components away from elastics, clothing, and hair.
3. *Before* handling electronic components, discharge static electricity buildup from your body by using a properly connected wrist strap.
4. *Do not handle components in the field unless properly grounded via wrist strap*. If you are not properly grounded:
    - Do *not* pick up components.
    - Do *not* touch the printed circuit board.
    - Do *not* remove components from the chassis.
5. Transport all static-sensitive components only in static-shielding carriers or packages. Place static awareness labels on all components to prevent removal from static-shielding container during transit.
6. Handle all static-sensitive components at a static-safe work area including floor mat, wrist strap, air ionizer, ground cord, and conductive table mat.
7. *Wear a grounded wrist strap in the field whenever possible*. Where wrist straps are impractical, wear grounded heel straps or special footwear on properly grounded dissipative flooring.
8. Do *not* subject components to sliding movements over any surface at any time.

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Contents

Illustrations

Chapter 1 - Introduction

The *M306* is a general purpose servo-controller, used to implement closed-loop control of hydraulic actuator systems. The *M306* can be configured for a wide range of control applications by placing jumpers in various positions on the circuit board.

About This Manual

As its name implies, this manual is a *guide* to using the M306. In depth user training is available from TriSen.

Since this document is relatively small, an index is not included. Instead, a detailed table of contents is provided. This manual contains the following chapters:

- Chapter 1 - Introduction
  This chapter contains information about this document and related reference documents.
- Chapter 2 -
  This chapter presents an overview of the *M306*, as well as mounting and wiring information, and specifications.
- Chapter 3 -
  This chapter provides function descriptions.
- Chapter 4 -
  This chapter illustrates jumper placements on the *M306* internal circuit board.
- Chapter 5 -
  This chapter describes how to calibrate the *M306* for use as a servo controller if your M306 has a display board.
- Chapter 6 -
  This chapter describes how to calibrate the *M306* for use as a servo controller if your M306 does not have a display board.
- Chapter 7 -
  This chapter presents the calibration of the M306 as a simple current amplifier.
- Appendix A
  This appendix includes instructions for connecting an M306 to a Tricon v9.
- Appendix B
  A comprehensive glossary is provided as the last appendix to this document.

Documentation Conventions

This manual uses the following typographic conventions:

Example	Description
NOTE	Notes contain supplementary information.
CAUTION	This symbol precedes information about potential equipment damage.
WARNING	**This symbol precedes information about potential personnel hazards.**

User Experience Prerequisites

To use the *M306* effectively, users should have some experience with the use of actuator servo systems, and control systems.

Extremely advantageous, though not required, is experience with turbine control systems, and normal operational control procedures within a plant environment.

Reference Documents

- Digital Control System Manual(s); e.g. *Tri-Sen 310SV*, *Tri-Sen TS310*, etc.
- Documentation provided with other components of a system containing an *M306*.

Chapter 2 - Overview, Mounting, Wiring, Specifications

The *M306* is a general purpose servo-controller, used to implement closed-loop control of hydraulic actuator systems. The *M306* can be configured for a wide range of control applications by placing jumpers in various positions on the circuit board.

The unit accepts a 4 to 20 mA or a 0 to 10 VDC command signal input, and an actuator position feedback signal from either an LVDT (linear variable differential transformer) or a 0 to 10 VDC source potentiometer. A jumper is used to select between the LVDT and the potentiometer signal. The *M306 Servo-Controller* outputs a servo-valve current as required to drive the actuator to the position corresponding to the command input signal. Independent proportional/integral/derivative (PID) and dither controls allow for convenient optimization of the system dynamics.

A logic shutdown circuit is also provided on the *M306*. A contact closure at the logic shutdown input forces the servo-valve drive current to zero.

A self-contained digital display continuously indicates the position of the servo-valve to a resolution of 0.1%. A master Operate/Test switch opens the servo loop, allowing the servo-valve to cycle through its entire range during set-up and calibration.

Features

- Digital display, continuously monitoring valve position to a one-part-per-thousand resolution
- Test mode of operation enabling calibration of position transducer and PID loop without the use of additional equipment
- Dither with frequency and amplitude adjustments
- Fully adjustable PID control
  - Proportional (gain) adjustment
  - Integral (reset) rate adjustment
  - Derivative rate adjustment
  - LVDT offset adjustment
- Provision for redundant control
- Optional voltage or current inputs (jumper selectable), fully differential, with *zero* and *balance* adjustment
- Provisions for wiring two *M306*s together to provide high select on two LVDTs with independent position-out indicators
- LVDT modulator/demodulator with 100 mA peak drive current and amplitude adjustment
- LVDT demodulator filter with low noise and short delay time (0.8 ms typical)
- Fully differential external voltage feedback (jumper selectable LVDT or external feedback)
- 4 to 20 mA position output signal
- External logic shutdown
- Bipolar 400 mA current driver with external ± 24 V loop power (jumper programmable ranges)

Mounting

Mounting options for the M306 are as follows:

- DIN rail mount
- Panel mount (on stand-offs)
- In a NEMA 4 enclosure
- In a NEMA 4X enclosure

Wiring

Refer to the figure below for wiring connections to the *M306* terminals.

1. The AC power wiring should be run in a separate conduit from the *M306* DC power and the I/O. All power wiring to and from the *M306* should be in steel conduit and grounded.
2. All LVDT field wiring should be twisted shielded pairs. The shields should be terminated at the *M306* and cut and wrapped at the LVDT end. The twisted pair should be from #18 to #14 AWG full coverage braid or foil with drain wire. The distance from the *M306* to the LVDT can be several hundred feet.
3. The *M306* should be connected to a high quality instrument grade ground with a #14 AWG or larger wire, depending on the distance.

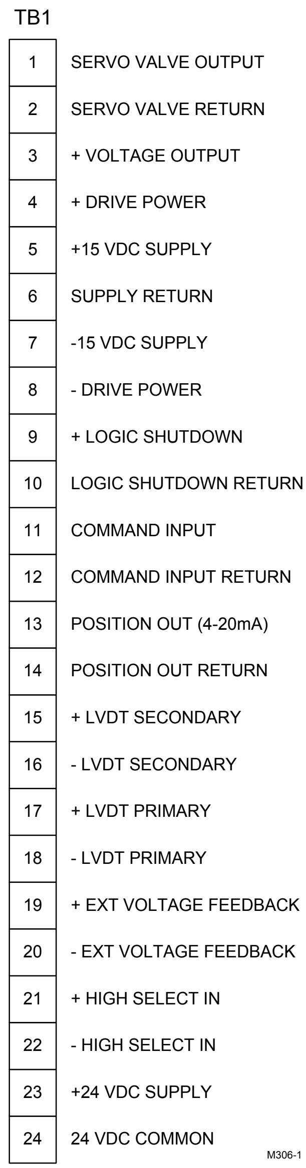


Figure 1. Wiring Connections to the *M306* Terminals

Specifications

Circuit Board

Temperature

Operating Temperature Range:	0° C to 70° C
Storage Temperature Range:	-50° C to 125° C

PID

Proportional (Gain):	0 to 21
Integral (Reset), Time Constant:	Adjustable; 0.12 to 5 seconds, or off
Derivative:	Adjustable; 0 to 1 second

Dither

Frequency:	Adjustable; 0.7 to 36 Hz
Amplitude:	Peak-to-peak adjustable; 0 to 20% of selected full scale servo-valve current

Power

Options:		24 VDC or ±15 VDC
24 VDC	Voltage Range:	22 VDC to 32 VDC
	Isolation:	Up to 500 VDC or 500 VAC peak between 24 V input and circuit common
	Protection Current:	1 amp fuse (typ)
	Protection, Over/Reverse Voltage:	Crowbar , over voltage Shunt diode, reverse voltage
±15 VDC	Voltage Range:	±14 VDC to ±17.5 VDC
	Isolation:	±15 V common is connected to circuit common
	Protection, Over/Reverse Voltage:	Shunt zener diodes between +15 VDC and circuit common, and -15 VDC and circuit common

Drive Power (Optional)

Voltage Range:	±16 VDC to ±28 VDC

NOTE: Power to the servo-valve current amplifier is supplied by either the ±15 V internal bus, or the optional external power supply to the drive power inputs, whichever is greater.

Command Input

Type Input:	4 to 20 mA or 0 to 10 V
Input Impedance, 4 to 20 mA:	249 Ohms
Input Impedance, 0 to 10 V:	3 K Ohms
Span Adjustment Range:	±25% of full scale
Zero Adjustment Range :	±9% of full scale, 4 to 20 mA only

LVDT Input

Type Input:	0 to 8 Vpp maximum (2.83 Vrms), 0 or 180° phase
Input Impedance:	1 M Ohm, typical
Input Voltage Range, Full Scale:	Delta 3.5 Vrms (max) to Delta 0.22 Vrms Maximum input voltage specification is limited to 3.5 volts rms by the range of the input offset control
Input Offset Range:	±1.75 Vrms

External Voltage Feedback Input

Type Input:	Differential
Input Impedance:	50 K Ohm differential, 29 K Ohm common mode
Input Voltage Range, Full Scale:	Delta 1.25 VDC to Delta 24 VDC
Input Voltage Offset Range:	±9.5 Volts
Input Common Mode Range:	±40 Volts

Logic Shutdown Input

Type Input:	600 Ohms to +15 Volts, active low
Input Action:	Reduces servo-valve current out to zero by shorting output of current driver to ground
Impedance to Ground of Servo-Valve Current Out Terminal:	Bipolar configuration - 5 Ohms Positive only configuration - 5 Ohms for negative polarity; open circuit for positive polarity

LVDT Power Output

Output Voltage:	0 to 12.7 Vpp (0 to 4.5 Vrms), adjustable
Output Current:	70 mA rms, maximum
Output Frequency:	2050 Hz, ±10%, fixed

Servo-Valve Current Output

Output Current, Full Scale:	±27 mA to ±400 mA, selectable in approx 32 mA increments
Output Current, Transient:	120% or Full Scale
Output Load With no external drive power (15 V):	100 ohms max for ±100 mA output 20 ohms max for ±400 mA output
With ±24 VDC drive power input:	35 ohms max for ±400 mA output
Position Out:	4 to 20 mA corresponding to 0 to 100% of display indication _______ ? max loop resistance (15 V)
Output Polarity:	Selectable; either bipolar or positive valve current

Display Board

Display

Type:	3½ digit liquid crystal display; continuously indicating position of feedback position transducer
Range:	±125.0% of full scale

Controls

Test/Operate:	Operate - normal operation Test - disables command input signal; enables following three Test Switches and Command Test Control
PID On/Off:	On - enables PID control loop; substitutes test command signal panel control for command signal Off - disables PID control loop leaving null and dither controls active
Full Scale On/Off:	On - injects a test signal that causes servo-valve current out to go to ± maximum output current Off - disables max output test signal
Polarity Select:	Selects polarity of max output test signal
Command Test Control:	Variable 0 to approximately 100% command input test signal

Chapter 3 - Function Descriptions

The *M306* control functions are illustrated in the block diagram on the following page. This block diagram in Figure 2 also shows adjustments (potentiometers), jumpers, and test points contained on the internal printed circuit board (PCB) containing. The adjustment potentiometer designators are specified within their associated functional block. Each individual function block is described in the following paragraphs.

Command Input

The command input circuitry consists of a differential stage which is protected from common mode and differential mode transients. It can accept either a 4-20 mA or a 0-10 VDC signal (TB1-11 and 12). The output signal is adjusted using the *balance* (R206) and *zero* (R207) potentiometers. The voltage at test point TP1 will be 0 VDC to approximately -10 VDC.

High Select Circuit Input

The high-select circuit allows the valve position feedback signal from a second *M306* to be ORed into the error signal so that the highest signal will be used. This is accomplished by the analog OR circuit of U9A. The second *M306* valve position signal input is at TB1-21 (+) and TB1-22 (-).

Position Output

The position output (TB1-13 and 14) provides a 4 to 10 mA signal proportional to the measured valve position. This signal is used to display the measured valve position remotely, and to provide a *feedback* signal for diagnostic comparison of the Command In and the measured valve position.

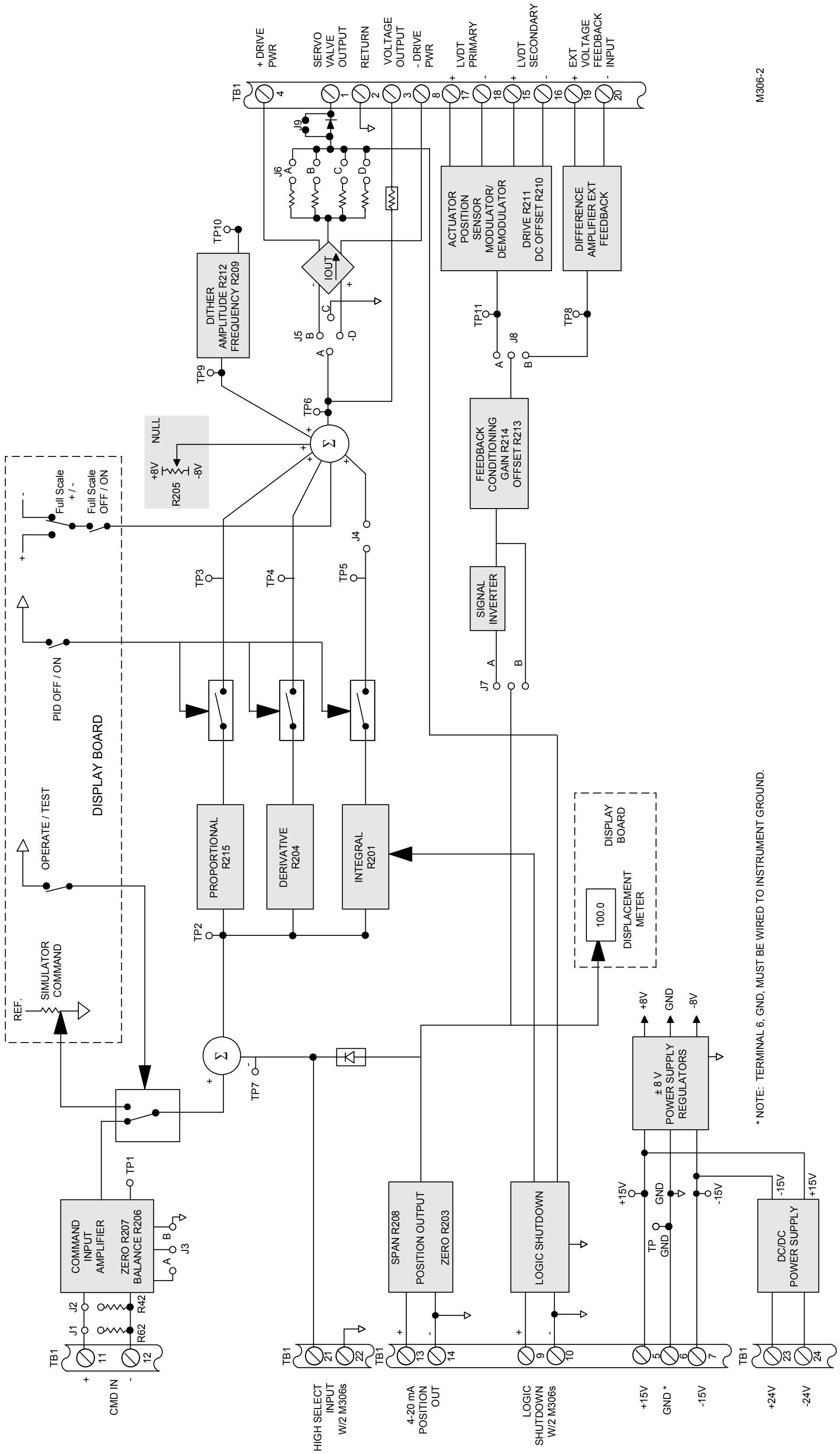


Figure 2. Function Blocks

Logic Shutdown

An external relay contact can be used between screw terminals TB1-9 (+) and TB1-10 (-), as shown in Figure 3, to force the current output to 0 mA.

For redundant operation with two *M306*s, the internal logic shutdown relay for the two M06s must operate complementary to each other; i.e., when one is open, the other is closed. Also, when the system is configured in this manner, both *M306*s must be set up for non-inverted (positive) output current, and jumper J9 (across D9) must be left out (not installed) in both *M306*s.

For redundant operation, position feedback is obtained with ***one*** of the following methods:

1. Two independent LVDTs, one for each *M306*.
2. One LVDT with a relay connected, to switch the LVDT between the two *M306*s.
3. The use of external voltage feedback; in which case the external voltage feedback terminals of the two *M306*s are bused together.

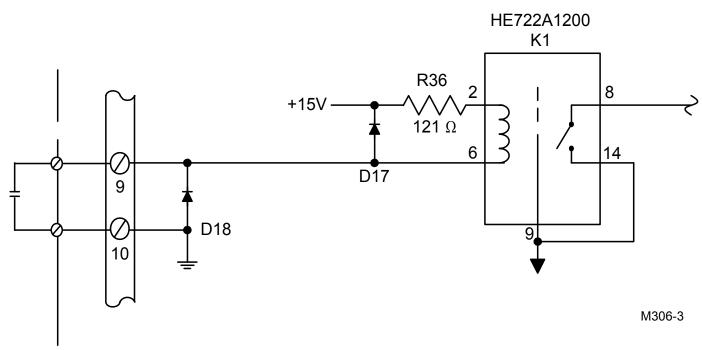


Figure 3. Relay Connections for Logic Shutdown

Power Supply Voltage Regulation

Some of the circuitry on the *M306* board requires power supply voltages which are less than the standard supply voltage. Linear regulators drop the incoming voltage to positive and negative 8 VDC.

DC/DC Power Supply

The DC/DC power supply operates on 22 to 32 VDC. It provides isolated +/- 15 VDC to power the M306.

PID Loop

The PID controls the closed loop dynamics as follows:

Proportional (gain) control produces an output signal which is proportional to the difference, or error, between the command input signal and the valve position feedback signal. Increasing the gain on the *M306*, with potentiometer R215, reduces the system error and increases the system accuracy. Increased system stiffness will be noticed as the gain is increased. However, higher gain will eventually lead to system instability.

$$\text{System Error} = \frac{1}{\text{Proportional} + \text{Integral}}$$

As the error signals sent to the transducer become larger, mechanical inertia causes the system to lag behind the command signal. If the system lag reaches the point that the command and feedback signals are in phase, then oscillation will result and the gain must be reduced. Derivative (R204) can be added to reduce the effect of lag.

Derivative action, adding lead, damping, rate control, or anticipatory control are equivalent terms. When considerable accuracy or stiffness is needed, oscillation may result as described in the previous paragraph. Adding lead compensates for normal system lag and improves stability.

Integral, or reset, action (R201) eliminates system offset so it will eventually force the error to zero. In many instances, a system will have Integration inherent in its operation. If it does, *do not* add Integral.

Feedback Signal Inverter

The feedback inverter circuit inverts the 0 to 10 volt signal to allow use with some LVDTs that do not allow polarity reversing of the secondaries. The normal operation (non-inverting) is with jumper J7 in position B.

Feedback Conditioning

The feedback loop contains a fourth-order low-pass filter. The filter produces very little signal distortion of its own, so only the dynamics of the servo-valve need to be compensated in the PID loop. Adjustments for feedback *gain* (R214) and *offset* (R213) are integrated into the filter.

The *gain* potentiometer and *offset* potentiometer are used to calibrate the servo-valve's maximum closed and maximum open positions to 0.0% and 100.0% respectively as read on the digital displacement meter. This corresponds to nominal 0 and +10 Volts at TP7.

Actuator Position Sensing

On the PCB, the *M306* has an LVDT Modulator/Demodulator chip with a low distortion sine wave oscillator. This circuit has enough drive current (100 mA) to drive most LVDTs, from the modulator. Potentiometer R211 is used to adjust the voltage to the LVDT.

The demodulator part of the chip is essentially a synchronous rectifier which rectifies the amplitude modulated signal from the LVDT. It accomplishes this by alternately switching the signal through inverting and non-inverting equal gain amplifiers. The switching occurs at the *zero* crossings of the drive oscillator.

The *M306* can also accept an external voltage signal from position to voltage transducers. This signal is chosen by moving the jumper on J8 from position A to position B. This input comes through a **differential amplifier** set for a gain of 1/6. Polarity can be reversed by reversing the wiring to terminals 19 and 20.

Null

This adjustment provides a way of matching the servo output to the lapped or null position of the oil relay or servo valve.

Dither

A dither circuit produces a periodic square-wave function. Both the amplitude (R212) and the frequency (R209) of the dither are adjustable. Dither is usually set so that the pilot valve moves, but the ram does not.

Dither can compensate for sticky valves by keeping the valve constantly in motion. Without this motion, material may build up in the valve, eventually causing it to stick.

Dither also compensates for leaky rams or *dead band* in the valve by periodically moving the pilot to permit the porting of hydraulic fluid to the ram.

Although dither may also hide sloppy linkages, it is *not* intended for this purpose. Mechanical problems should be fixed, not compensated.

Servo-Valve Output

The circuitry of the bipolar current output on the *M306* is known as a Howland Current Pump. The polarity of the output is jumper-selectable (J5) and there are 15 different current ranges which are also jumper programmable (J6). The ranges are discussed in the Configuration chapter of this manual. The maximum current range which can be programmed is 400 mA.

If a servo-valve impedance is too high, then the I x R product may be too large for the standard +15 VDC supply. In this case, external supplies up to a maximum of positive and negative 28 VDC may be connected to terminals TB1-4 (+) and TB1-8 (-) with commons connected to TB1-2.

To determine if an external power supply is required for the Drive Power input:

1. Calculate the maximum servo-valve output voltage as follows:
   Voltage = servo-valve current + load resistance
   Where load resistance = servo-valve resistance + line resistance

2. Allow for internal M306 voltage drops as follows:
   Up to 100 mA, 5 V
   250 mA, 6 V
   400 mA, 7 V

3. If the voltage in step 1 above plus the internal voltage drop of step 2 exceed the voltage at TB1-5 or TB1-7, an external Drive Power supply is required.

Example 1:	Maximum current	200 mA
	Servo-valve resistance	30 ohms
	Line resistance	5 ohms

Voltage = 0.200 x (30 + 5) = 7 V

Minimum Supply Voltage = 7 + 6 = 13 V

Since 13 volts is less than TB1-5 and less than TB1-7 (normally 15 V), no additional power supply is required.

Example 2:	Maximum current	100 mA
	Servo-valve resistance	140 ohms
	Line resistance	10 ohms

Voltage = 0.1 x (180 + 20) = 15 V

Minimum Supply Voltage = 15 + 5 = 20 V

In this case, an external power supply of at least 20 V must be connected to the Drive Power Input terminal as follows:

- If the servo-valve output current is primarily *positive*, connect the external supply between TB1-4 and TB1-2.

- If the servo-valve output current is primarily *negative*, connect the external supply between TB1-8 and TB1-2.

See Load Resistance specifications.

Chapter 4 - Jumper Configurations

The *M306* control functions can be custom configured for a particular application using jumpers on the internal circuit board. This chapter provides information on the jumper placements only. The control functions are discussed in Chapter 3, and calibration is discussed in Chapter 5.

Figure 4 shows the locations of the jumpers, as well as potentiometers and test points on the *M306* circuit board. The Glossary contains an illustration of possible *Jumper Positions* discussed in the following paragraphs.

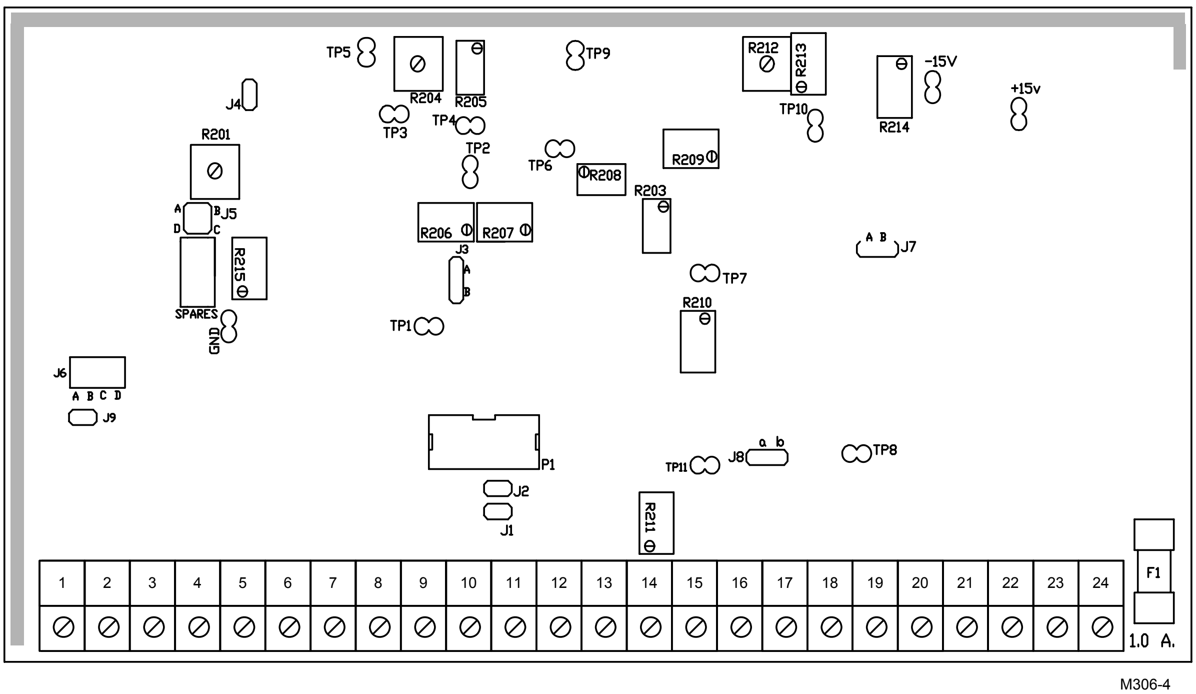


Figure 4. Circuit Board Showing
Adjustment Potentiometers, Test Points, and Jumpers

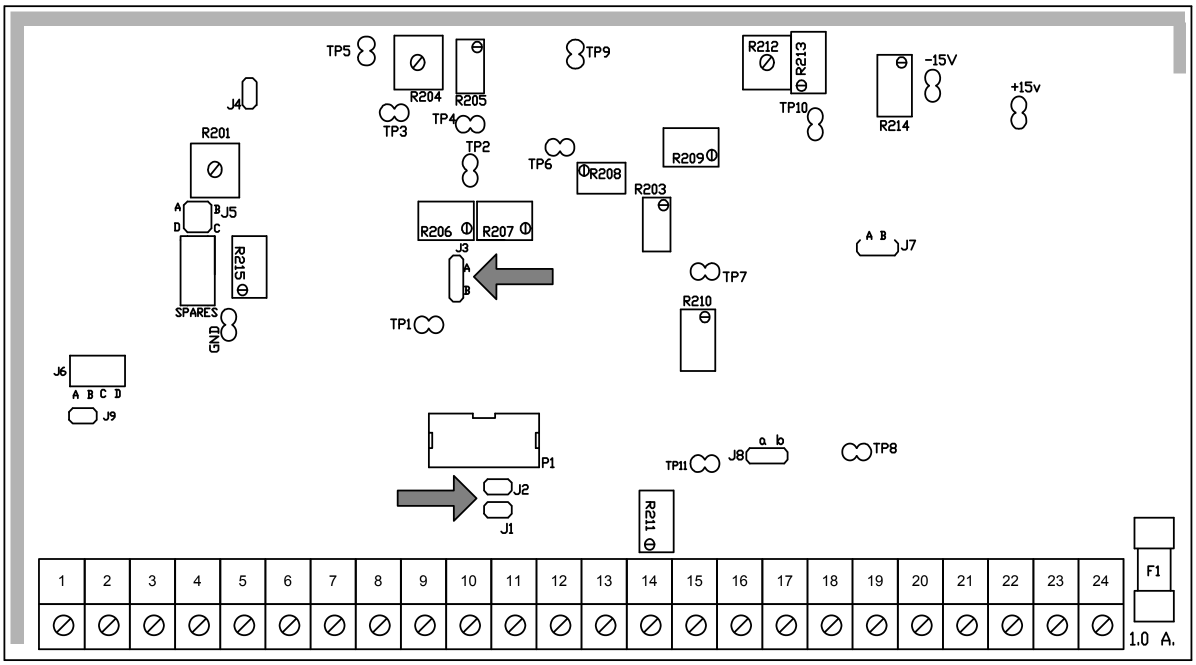
CIRCUIT BOARD COMPONENTS							
Wiring Terminal	**Description**	**Jumper**	**Description**	**Test Point**	**Description**	**Adjust-ment**	**Description**
1.	Servo Valve Outpt	J1	Comnd In 4-20mA	GND	Ground	R201	Integral
2.	Servo Valve Return	J2	Comnd In 0-10Vdc	TP1	Command In		
3.	+ Voltage Output	J3A	Comnd In 4-20mA	TP2	PID	R203	Zero, Position Out
4.	+ Drive Power	J3B	Comnd In 0-10Vdc	TP3	Proportional	R204	Derivative
5.	+15 VDC Supply	J4	Integral Function	TP4	Derivative	R205	Null
6.	Supply Return	J5A-B	Inverted Valve Out	TP5	Integral	R206	Balance, Comnd In
7.	-15 VDC Supply	J5C-D	Inverted Valve Out	TP6	PID Sum	R207	Zero, Command In
8.	- Drive Power	J5A-D	Non-Invrt Vlv Out	TP7	Hi-Select	R208	Span, Position Out
9.	+ Logic Shutdown	J5B-C	Non-Invrt Vlv Out	TP8	Dif Ampl Ext Fdbk	R209	Frequency, Dither
10.	Logic SD Return	J6D	27 mA Output	TP9	Dither Amplitude	R210	DC Offset, LVDT
11.	Command Input	J6C	55 mA Output	TP10	Dither Frequency	R211	Drive, LVDT
12.	Commnd In Return	J6CD	83 mA Output	TP11	Actuator Position	R212	Amplitude, Dither
13.	Positn Out 4-20mA	J6B	110 mA Output		Modulator/Demod	R213	Offset, Feedback
14.	Positn Out Return	J6BD	137 mA Output			R214	Gain, Feedback
15.	+ LVDT Secondary	J6BC	165 mA Output	-15V	Power Supply	R215	Proportional
16.	- LVDT Secondary	J6BCD	193 mA Output	+15V	Power Supply		
17.	+ LVDT Primary	J6A	207 mA Output				
18.	- LVDT Primary	J6AD	234 mA Output				
19.	+ Ext Volt Feedbk	J6AC	262 mA Output				
20.	- Ext Volt Feedbk	J6ACD	290 mA Output				
21.	+ Hi Select In	J6AB	317 mA Output				
22.	- Hi Select In	J6ABD	345 mA Output				
23.	+24 VDC Supply	J6ABC	372 mA Output				
24.	24 VDC Common	J6ABCD	400 mA Output				
		J7A	Inverted Feedback				
		J7B	Non-Inverted Fdbk				
		J8A	LVDT Feedback				
		J8B	Ext Volt Feedback				
		J9	Installed: J6 + & -				
		J9	Removed: J6 + only				
		SPARES	Spare Jumpers				

NOTE: *Values given for jumper J6 are specified maximums with a 20% over-current capability.*

Command Input

The *M306* can be configured for either a 4 to 20 mA current loop input or a 0 to 10 VDC voltage input.

- To select the 4 to 20 mA current input, install jumper J1, and jumper J3 in position A.
- To select the 0 to 10 VDC voltage input, install jumper J2, and jumper J3 in position B.



M306-5

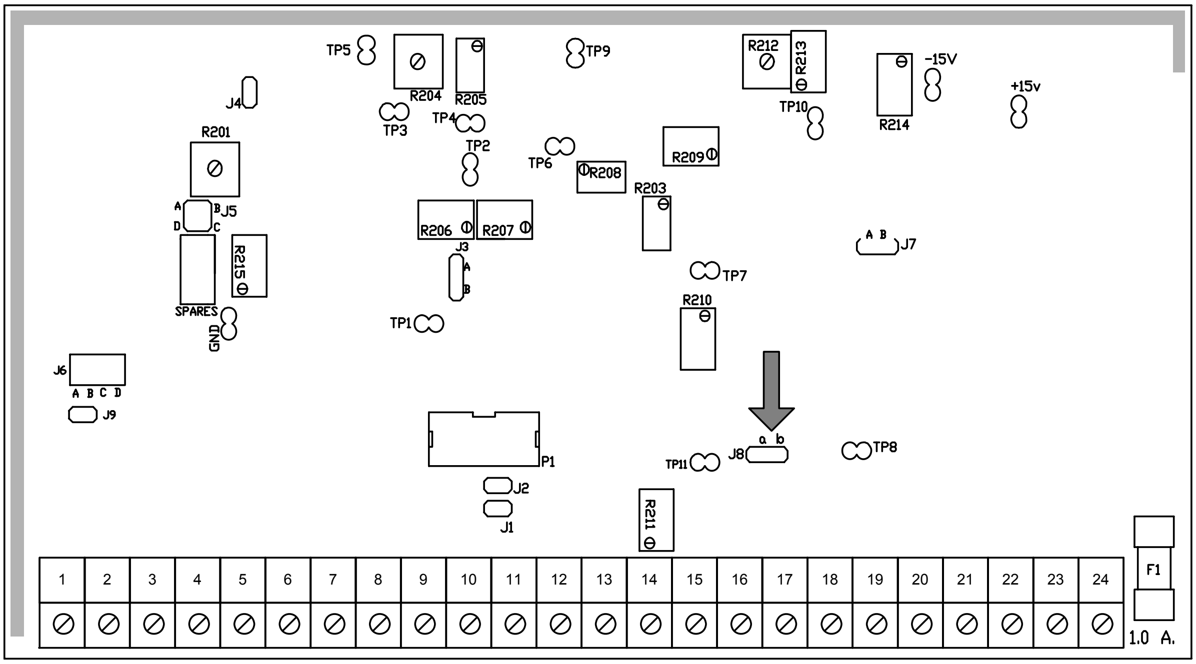
Figure 5. Command Input, J1, J2, J3

***NOTE**:* *This control function is discussed in Chapter 3.*

Actuator Position Sensor Feedback

The *M306* can be configured for either LVDT feedback or external voltage feedback.

- To select the LVDT feedback, install jumper J8 in position A.
- To select the external voltage feedback, install jumper J8 in position B.



M306-6

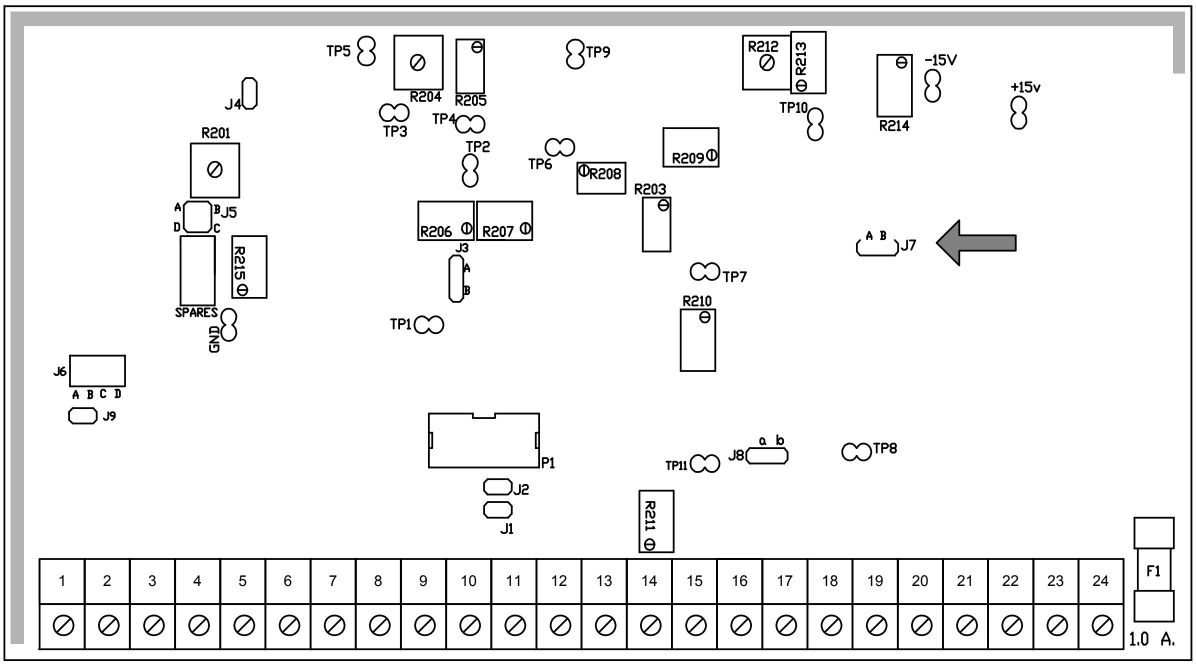
Figure 6. Actuator Position Sense Feedback, J8

NOTE: *This control function is discussed in Chapter 3.*

Position Sensor Feedback Signal Inverter

The *M306* can be configured for either inverted or non-inverted feedback. (The *M306* is normally configured for non-inverted feedback.)

- To select inverted feedback, install jumper J7 in position A.
- To select non-inverted feedback, install jumper J7 in position B.



M306-7

Figure 7. Position Sensor Feedback Signal Inverter, J7

***NOTE**:* *This control function is discussed in Chapter 3.*

Servo-Valve Current Output

Inverted/Non-Inverted

The *M306* can be configured for either inverted or non-inverted output.

- To select inverted output, install jumpers at J5 in positions A-B and C-D.
- To select non-inverted output, install jumpers at J5 in positions A-D and B-C.

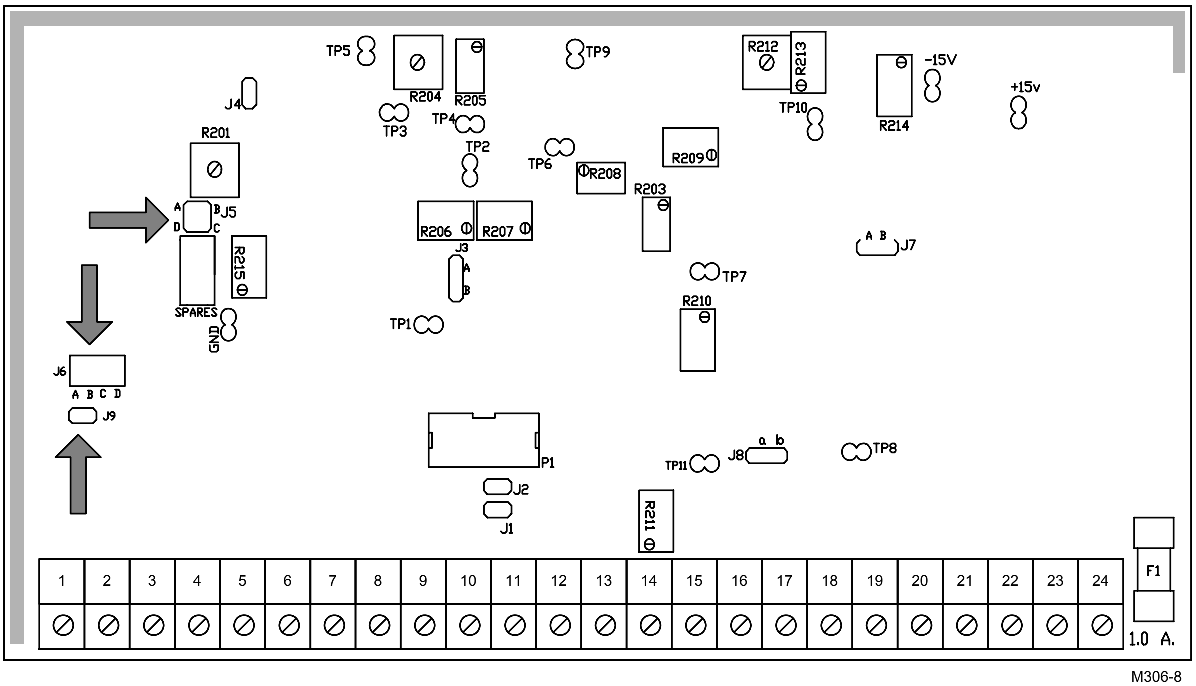


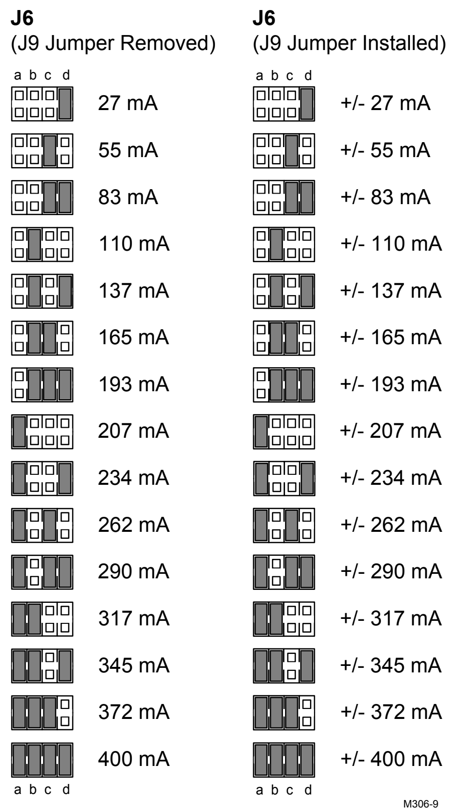
Figure 8. Servo-Valve Current Output Inverted/Non-Inverted, J5

NOTE: *This control function is discussed in Chapter 3.*

Voltage

The *M306* can be configured for many different servo-valve current outputs. The maximum output current can be from 30 mA to 400 mA. This configuration is accomplished with jumper J6 as shown in the figure below. Install jumper J9 to make the current output positive and negative; or remove J9 to make the current output positive only.

NOTE: *Jumper J9 should be removed if the servo-valve is to be driven from more than one* M306*. Jumper J9 should always be installed if the servo actuator is driven from only one* M306*.*



NOTE*: The values given are specified maximums with a 20% over-current capability.*

Figure 9. Servo-Valve Current Output Voltages, J6, J9

NOTE*: This control function is discussed in Chapter 3.*

Integral

The Integral function of the *M306* can enabled or disabled as follows:

- Install jumper J4 to enable the Integral function.
- Remove jumper J4 to disable the Integral function.

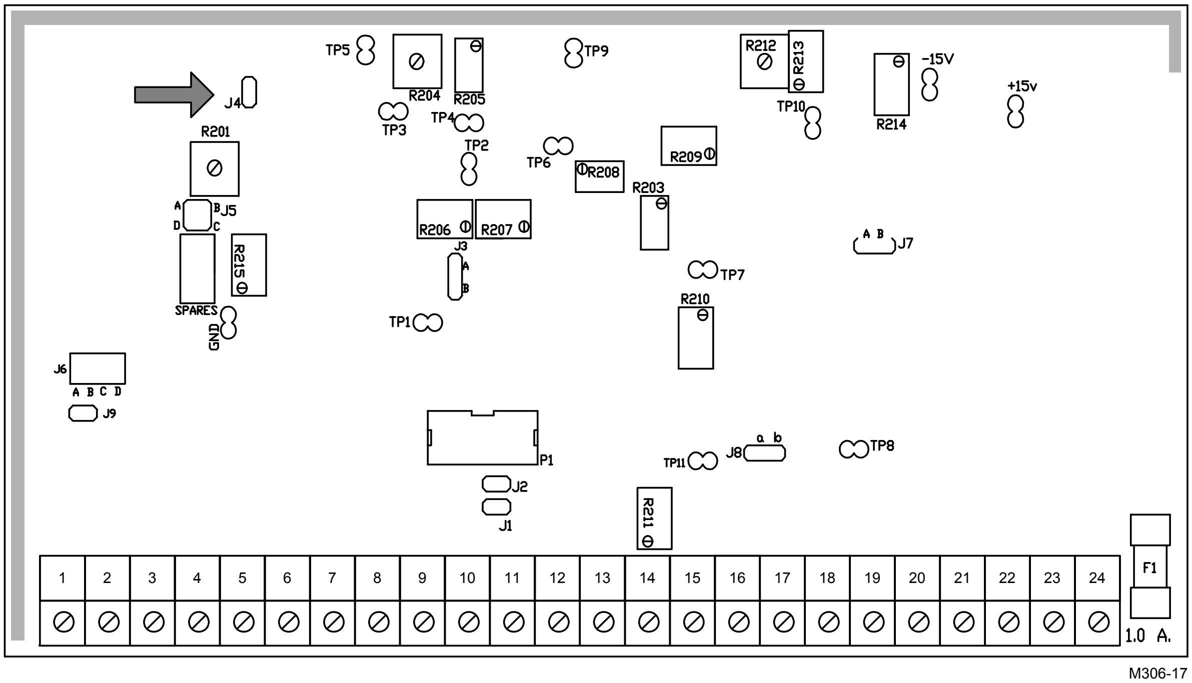


Figure 10. Integral, J4

***NOTE**: This control function is discussed in Chapter 3.*

Chapter 5 - Calibration When M306 is Used as a Servo Controller (*with* Display Board)

A typical application of the *M306* used as a servo-controller is shown in the figure below.

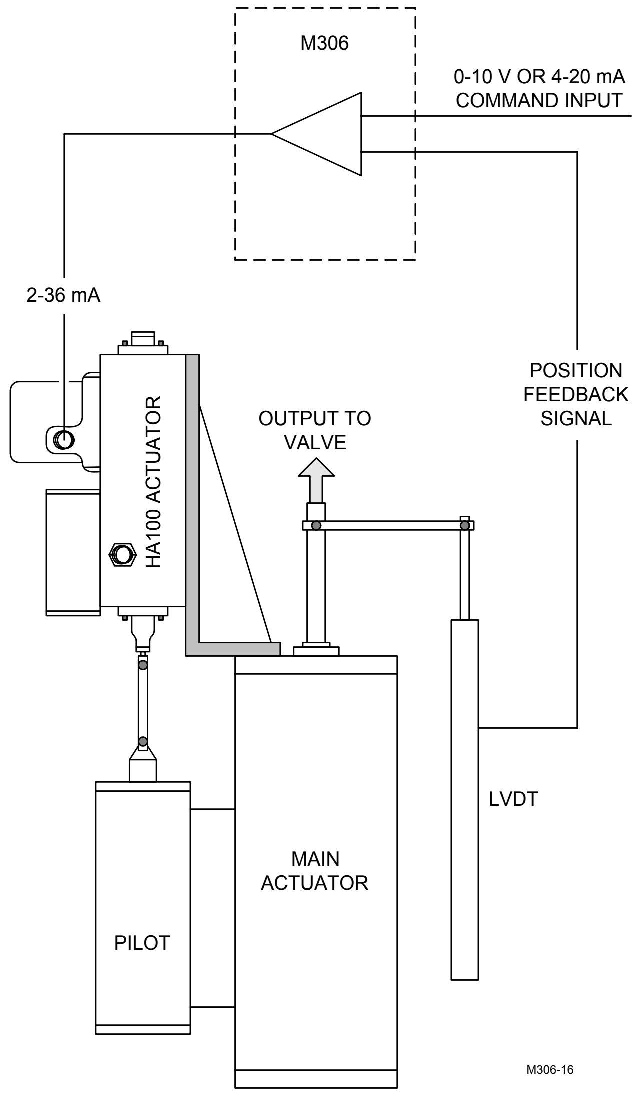


Figure 11. M306 as Servo-Controller, Typical Application

The *M306* is operational with or without a Display Board. If your unit has a Display Board, the following procedures apply.

Before Setting Up the *M306*

WARNING **All personnel must be kept away from all moving parts during calibration.**

1. Prior to *M306* calibration, mechanically adjust the valve and the LVDT (or other position feedback transducer) to insure that the valve will not be over-stroked during calibration adjustments.

   CAUTION Verify that there is oil pressure to the actuator and that it can be stroked safely.

2. If using a high pressure actuator (such as the HA152) with a current source, apply 4 to 6 mA directly to the appropriate pins on the actuator input connector in order to make the actuator stroke fully in one direction. (See actuator documentation.) Observe this action to insure full stroke without over-stroking. Reverse the leads on the pins and observe full stroke in the opposite direction without over-stroking.

3. Determine the specific application of the *M306* servo-controller and verify correct jumper placement on the M306 circuit board in accordance with instructions in Chapter 4 of this manual.

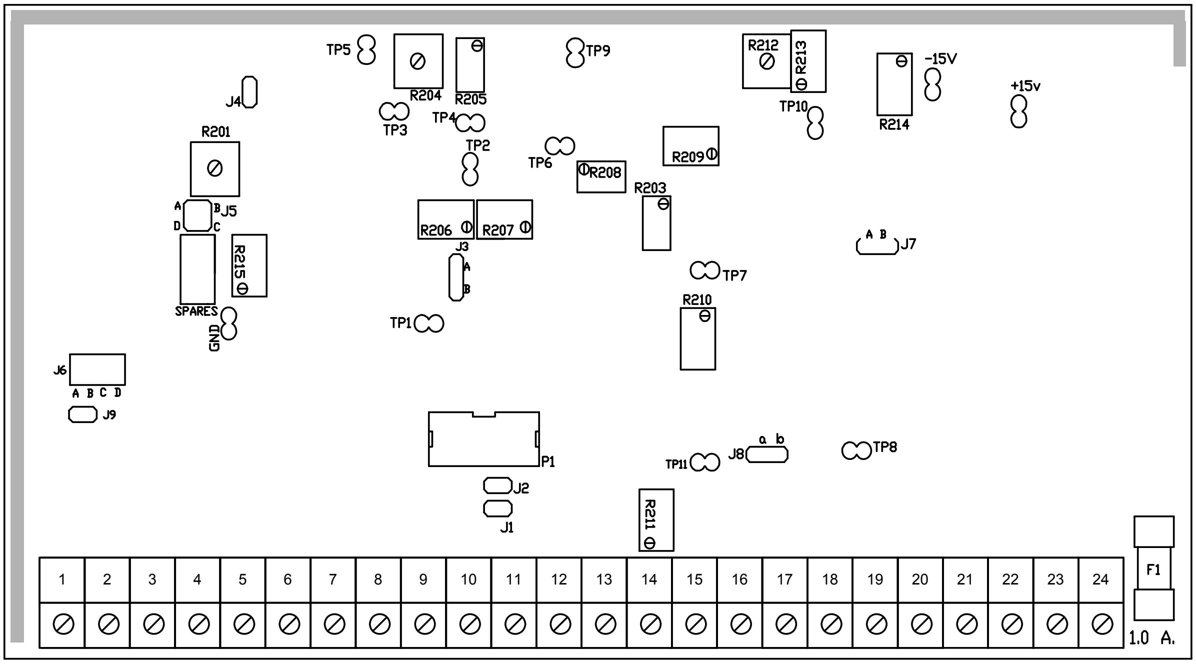
4. Verify accuracy of wiring to the *M306* circuit board, the actuator, and the LVDT (or other position feedback transducer). Refer to the appropriate documentation for the specific components of the servo system.

Initial Set-up of the *M306*

The following procedures provide instructions for setting up the *M306 prior to* calibration.

Circuit Board Initial Set-up

Initial set-up of the *M306* involves removing and installing jumpers, along with various adjustments on the internal circuit board. The Display Board must be removed to gain access to the Circuit Board. The Circuit Board is shown below for reference.



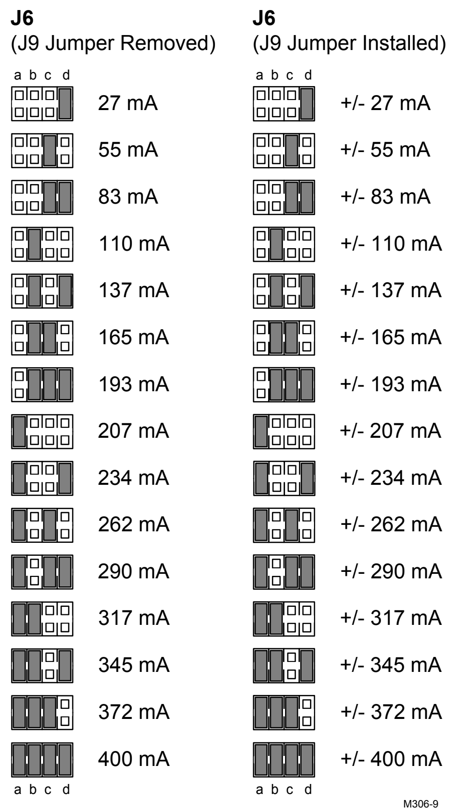
M306-4

Figure 12. M306 Internal Circuit Board

⚠ **CAUTION** Verify that there is no oil pressure to the actuator.

1. Install jumper J6 in the position needed for the maximum required servo-valve output current. The maximum output current can be configured from 30 mA to 400 mA.

NOTE: *Select an output current approximately 1.2 to 2 times the maximum steady state servo-valve current. This increased output current capability will accommodate the higher instantaneous current produced by the derivative component.*



NOTE*: The values given are specified maximums with a 20% over-current capability.*

Figure 13. Servo-Valve Current Output Voltages, J6, J9

2. Install jumper J9.

NOTE: *Jumper J9 must be removed if the servo-valve cannot be subjected to negative current, or if the servo-valve is to be driven from more than one M306. Jumper J9 must be installed if the servo-valve requires positive and negative current for operation.*

3. Remove jumper J4 to temporarily disable the Integral function.
4. Turn the Integral potentiometer (R201) fully counter-clockwise (3/4 turn).
5. Turn the Derivative potentiometer (R204) fully counter-clockwise (3/4 turn).
6. Turn the Dither Amplitude potentiometer (R212) fully counter-clockwise (3/4 turn).
7. Turn the Proportional potentiometer (R215) fully counter-clockwise (20 turns).
8. Remove the wire from terminal TB1-1 (terminals 1 & 2 are the output to the actuator).
9. Apply power to the *M306*.

DC Power Initial Set-up

1. Check the +24 VDC. Voltage between TB1-23 (HOT) and TB1-24 (COMMON) should be between +22 VDC and +32 VDC.

   OR

2. Check the +/- 15 VDC. Terminal TB1-5 is +15 VDC. Terminal TB1-6 is COMMON. Terminal TB1-7 is -15 VDC. Voltage must be between 14.5 VDC and 18.0 VDC.

LVDT Drive Initial Set-up

1. Connect an AC voltmeter to Terminals 17 and 18.
2. Adjust LVDT Drive Voltage potentiometer (R211) for 1.5 VAC (rms); plus or minus 0.3 volts.

Position Sensor Initial Set-up

1. Remove the LVDT secondary wire from TB1-15.
2. Connect an AC voltmeter to terminals 15 and 16.
3. Adjust DC offset, R210, for zero volts.
4. Reconnect the LVDT secondary wire to terminal 15.
5. Connect a current meter in series with the servo-valve current output line (TB1-1). ***Alternatively,*** the servo valve can be disconnected entirely and the current meter connected directly between TB1-1 and TB1-2. This method avoids possible over-current to the servo-valve during the set-up procedure.
   Current measurements are the same, either way.

Display Board Initial Set-up

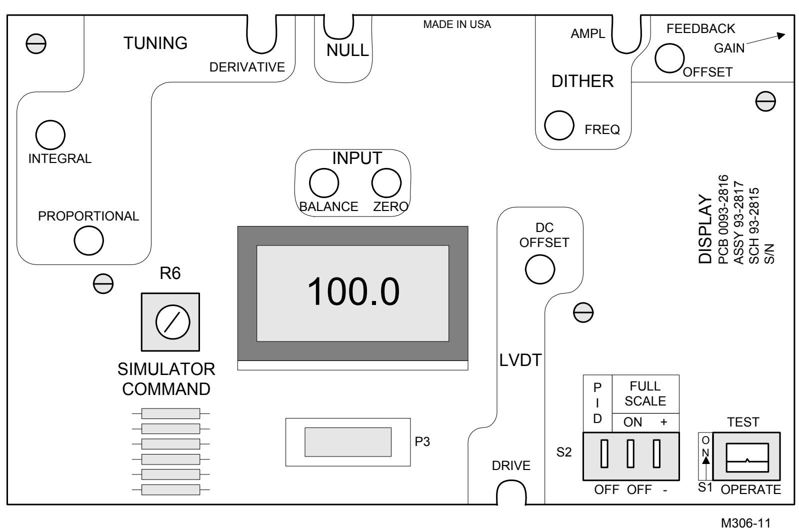


Figure 14. Display Board

On the Display Board (refer to the figure above), do the following:

1. Place the Full Scale switch (S2-C2) to OFF.
2. Place the PID switch (S2-C1) to ON.
3. Place the Full Scale Select switch (S2-C3) to (-).
4. Place the Test/Operate switch (S1) to TEST.

NOTE: *If the driven actuator requires a positive current only, complete steps 5 through 9.*

NOTE: *If the driven actuator requires a current input which goes both negative and positive, complete steps 5A through 9A* ***instead of*** *steps 5 through 9.*

5. Rotate the Simulator Command potentiometer R6 fully counter-clockwise.
6. Adjust the Null potentiometer (R205) for 0.0 mA as indicated on the current meter.
7. Rotate the Simulator Command potentiometer R6 fully clockwise.
8. Increase the Proportional potentiometer (R215) until the desired maximum output current is obtained.
9. Repeat steps 5 through 8 until the desired minimum and maximum output values are correct.

5A. Rotate the Simulator Command potentiometer R6 fully counter-clockwise.

6A. Adjust the Null potentiometer (R205) for approximately one-half (NEGATIVE) of the jumper configured output on the current meter.

7A. Rotate the Simulator Command potentiometer R6 fully clockwise.

8A. Adjust the Proportional potentiometer (R215) for approximately one-half (POSITIVE) of the jumper configured output on the current meter.

9A. Repeat these steps until the PLUS and MINUS values are approximately equal from the full counter-clockwise to the full clockwise adjustments. THEN position the Simulator Command potentiometer R6 at approximately 50% of its range of adjustment and observe that the output as indicated on the current meter is at or near the *zero*-crossing point.

10. Replace the wire on terminal TB1-1 which was removed during initial set-up.

NOTE: *The Simulator Command potentiometer R6 can now be used to vary the output current between minimum and maximum.*

Calibration

Feedback Offset & Gain Calibration

⚠ **CAUTION** Verify that there is oil pressure to the actuator and that it can be stroked safely.

1. Place the Test/Operate switch (S1) to TEST.
2. Place the PID switch (S2-C1) to OFF.
3. Place the Full Scale switch (S2-C2) to OFF.

NOTE: *Verify which of the following two observances is correct for your application before making any adjustments. Also see Figure 13.*

*If J7 is in the **B** position, feedback is NON-INVERTED.*
Offset *potentiometer (R213) is used to set feedback* zero, *and*
gain *potentiometer (R214) is used to set feedback* span.
(i.e., 0% = 00.0 on the display meter and 100% = 100.0 on the display meter.)

*If J7 is in the **A** position, feedback is INVERTED.*
Offset *potentiometer (R213) is used to set feedback* span*, and*
gain *potentiometer (R214) is used to set the feedback* zero.
(When the display board has an input of less than zero, the display board shows a minus sign (-) to the left of the displayed number.)

⚠ **WARNING** **The following steps 5 through 10 will cause the actuator to stroke** FULL SCALE **(to the limits of travel) very quickly.**

4. Place the Full Scale Select switch (S2-C3) to (-).
5. Place the Full Scale switch (S2-C2) to ON. Observe that the actuator travels full stroke as determined by the position of Jumper J7; either
   fully closed for NON-INVERTED output, or fully open for INVERTED output.
6. Adjust the ***Zero*** as follows
   Adjust the *feedback offset* potentiometer (R213) for a display meter reading of 0.0 if the feedback is NON-INVERTED, **OR**
   adjust the *feedback gain* potentiometer (R214) for a display meter reading of 100.0 if the feedback is INVERTED.
7. Change the Full Scale select switch from (-) to (+). Observe that the actuator travels to zero (open for NON-INVERTED output) **OR**
   to full stroke (closed for INVERTED output), depending on the position of jumper (J7).
8. Adjust the ***Span*** as follows:
   Adjust the *feedback gain* potentiometer (R214) for a display meter reading of 100.0 if the feedback is NON-INVERTED, **OR**
   adjust the *feedback offset* potentiometer (R213) for a display meter reading of 0.0 if the feedback is INVERTED. See note.

NOTE: *If the display board indicates a negative value in the previous step, the phase of the position transducer is reversed. Reverse the primary (TB1-17 & TB1-18) or secondary (TB1-15 & TB1-16) wires of the LVDT; or reverse the connections to the external voltage feedback (TB1-19 & TB1-20).*

9. Repeat the *zero* and *span* procedures, steps 5 through 8 above, until the specified readings are obtained without further adjustment.
10. Place the Full Scale test switch to OFF.
11. Adjust the **NULL** potentiometer (R205) for a servo driver output of 50%, or for whatever output is necessary to stop the movement of the main actuator somewhere in mid-range as indicated on the display board.

Servo-Loop (PID) Calibration

Proportional Calibration

1. Place the Full Scale switch (S2-C2) to OFF.
2. Place the PID switch (S2-C1) to ON.
3. Place the Full Scale Select switch (S2-C3) to (-).
4. Place the Test/Operate switch (S1) to TEST.
5. Rotate the proportional potentiometer (R215) several turns clockwise, and test the valve response by changing the Simulator Command potentiometer R6.
6. Place the Simulator Command potentiometer R6 at its mid-position and continue to increase the proportional potentiometer (R215) until the valve begins to oscillate.

NOTE: *It may be necessary to locate an operator at the valve actuator to determine when the valve (or valve actuator servo) begins oscillating or stops oscillating.*

7. Decrease the Proportional potentiometer (R215) (turn counter-clockwise) until the valve stabilizes and oscillations cease.
8. Create an approximate 25% command step change by placing the Simulator Command potentiometer R6 to its 25% position and alternately turning the PID test switch off and on.
9. Adjust the Proportional potentiometer (R215) for the quickest valve response without any oscillations.

NOTE: *The valve can also be exercised by changing the Simulator Command potentiometer R6 with the PID switch ON and the Test/Operate Switch in the TEST position.*

Derivative Calibration

1. Adjust the proportional control as described above.
2. Continue to exercise the valve as described in step 8 above.
3. Gradually increase (turn clockwise) the derivative control.
   The speed of the valve should increase, and the tendency of the valve to oscillate should decrease. The correct amount of derivative is the smallest amount that produces quick valve response with consistent, smooth operation.

NOTE*:* *A small increase or decrease in proportional at this point may bring about further improvement.*

Integral Calibration

When the M306 is used with an actuator system which itself is mechanically integrating, the integral component of the M306 should not be used. (Jumper J4 should not be installed.) An integrating actuator is one whose *rate* of movement (open loop) is proportional to the servo-valve current (as opposed to the *position*, open loop, being proportional to the servo-valve current).

Before adding the integral component to the calibration of the M306, perform the proportional and derivative adjustments as described above. Then, ***for a non-integrating servo actuator system only***, perform the following:

1. Install jumper J4.

   NOTE: *Re-installing jumper J4 puts a small amount of Integral into the output. More integral may be added, if desired, by turning the Integral potentiometer (R201) clockwise.*

   ⚠ **CAUTION** Too much Integral will cause *overshoot* in valve position changes.

2. Adjust input command signal to 4 mA. Insure the display meter reads 0.0
3. Adjust input command signal to 20 mA. Insure the display meter reads 100.0
4. Adjust input command signal to 8 mA. Insure the display meter reads 25.0
5. Adjust input command signal to 12 mA. Insure the display meter reads 50.0
6. Adjust input command signal to 16 mA. Insure the display meter reads 75.0
7. Make 5% to 10% step changes and insure good actuator response with no oscillations. Adjust the proportional potentiometer (R215), as necessary, for any oscillation.

   NOTE*:* *Do not make adjustments larger than one quarter turn.*

8. Place the Test/Operate switch to Operate.

The servo-loop tuning is now complete.

Command In Calibration

Configure the command input for either
4 to 20 mA (J1 installed, J2 removed, J3 in position A), **or**
0 to 10 V (J1 removed, J2 installed, J3 in position B).

***NOTE**: The display board must be removed for access to the jumpers on the circuit board.*

For a **4 to 20 mA command input** configuration:

1. Apply 4 mA to the command input.
2. Adjust the zero potentiometer (R207) for 00.0 as read on the displacement meter.
3. Apply 20 mA to the command input.
4. Adjust the balance potentiometer (R206) for 100.0 as read on the displacement meter.
5. Repeat each adjustment until 00.0 and 100.0 readings are obtained without further adjustment.

For a **0 to 10 V command input** configuration:

1. Apply 10 V to the command input.
2. Adjust the balance potentiometer (R206) for 100.0 as read on the displacement meter.

Position Indication Output Calibration

The position out [TB1-13(+) and TB1-14(-)] is factory calibrated to coincide with 0.0 and 100 or the position displayed: 0.0 = 4.0 mA; 100.0 = 20.0 mA. If a different calibration is required, the *zero* (R203) and *span* (R208) can be used to affect an approximate ±3% change each.

NOTE: *The display board must be removed to gain access to the* zero *and* span *potentiometers.*

LVDT DC Offset Calibration

To calibrate for LVDT DC Offset, disconnect the wire from terminal TB1-15 and adjust the DC Offset potentiometer (R210) until the valve starts to travel in the desired direction.

Dither Calibration

NOTE: *Disconnect any current sources and meters. Reconnect any wires previously removed from the* M306.

NOTE: *Excessive use of dither can accelerate valve wear.*

Dither is used to compensate for hysteresis in the oil relay or servo-valve and to prevent silting. Hysteresis is the characteristic of a valve to have to move significantly before oil begins to flow. Silting is the depositing of small particles from the oil on to the sliding or moving surfaces of the oil relay or servo-valve.

Dither functions by keeping the valve in constant motion thus preventing silting or the build up of particulate mater in the valve. This constant motion also keeps the valve moving back and forth across the lapped position of the valve. This means that as soon as the current signal to the valve changes, the valve will begin to flow oil moving the main actuator for the smallest command change.

A generally satisfactory way to adjust the dither function of the M306 is as follows:

1. Adjust the dither amplitude R212 fully CCW to minimum amplitude.
2. Adjust the dither frequency R209 fully CCW to minimum frequency.
3. Turn the dither amplitude, R212 CW untill the final actuator begins to move slightly.
4. turn the dither frequency, R209 CW until the final actuator just stops moving.

Chapter 6 - Calibration When M306 is Used as a Servo Controller (*without* Display Board)

The *M306* is operational with or without a Display Board. If your unit does not have a Display Board, the following procedures apply.

Before Setting Up the *M306*

WARNING **All personnel must be kept away from all moving parts during calibration.**

1. Prior to *M306* calibration, mechanically adjust the valve and the LVDT (or other position feedback transducer) to insure that the valve will not be over-stroked during calibration adjustments.

   CAUTION Verify that there is oil pressure to the actuator and that it can be stroked safely.

2. If using a high pressure actuator (such as the HA152) with a current source, apply 4 to 6 mA directly to the appropriate pins on the actuator input connector in order to make the actuator stroke fully in one direction. (See actuator documentation.) Observe this action to insure full stroke without over-stroking. Reverse the leads on the pins and observe full stroke in the opposite direction without over-stroking.
3. Determine the specific application of the *M306* servo-controller and verify correct jumper placement on the M306 circuit board in accordance with instructions in Chapter 4 of this manual.
4. Verify accuracy of wiring to the *M306* circuit board, the actuator, and the LVDT (or other position feedback transducer). Refer to the appropriate documentation for the specific components of the servo system.

Initial Set-up of the *M306*

The following procedures provide instructions for setting up the *M306 prior to* calibration.

Circuit Board Initial Set-up

Initial set-up of the *M306* involves removing and installing jumpers, along with various adjustments on the internal circuit board. The Display Board must be removed to gain access to the Circuit Board. The Circuit Board is shown below for reference.

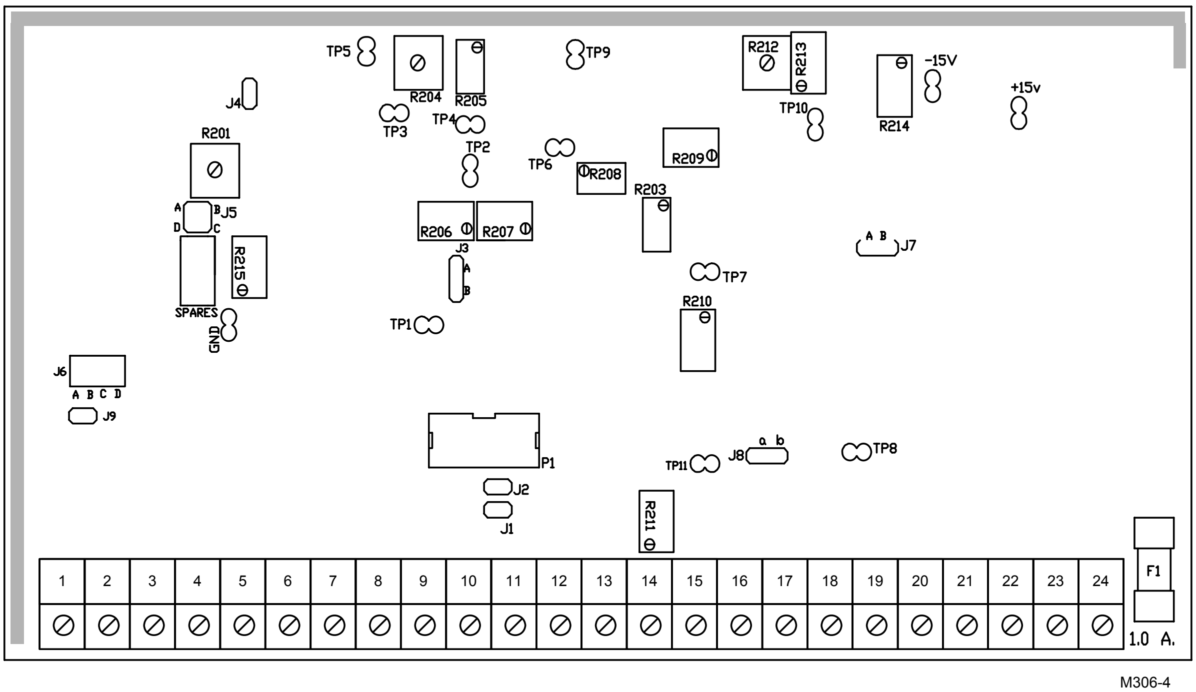


Figure 15. M306 Internal Circuit Board

⚠ **CAUTION** Verify there is no oil pressure to the actuator.

1. Position jumper J6 for the maximum required servo-valve current. The maximum output current can be configured from 30 mA to 400 mA. See figure below.

   NOTE: *Select an output current option of 1.2 to 2 times the maximum steady state servo valve current. This increased output capability will accommodate the higher instantaneous current produced by the derivative component.*

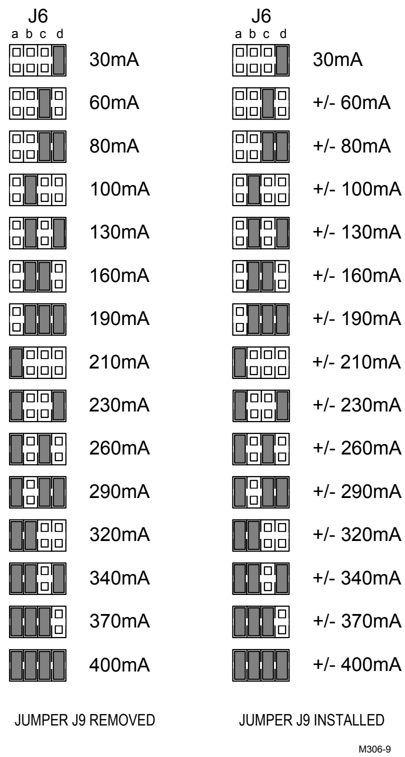


Figure 16. Output Current Jumper Configurations

2. Install jumper J9. This jumper should be removed after calibration if the servo-valve will be driven from more than one *M306*.

NOTE: *Jumper J9 must be removed if the servo-valve cannot be subjected to negative current, or if the servo-valve is to be driven from more than one M306.*
Jumper J9 must be installed if the servo-valve requires positive and negative current for operation.

3. Remove jumper J4 to temporarily disable Integral.
4. Turn the Integral potentiometer (R201) fully counter-clockwise (3/4 turn pot).
5. Turn the Derivative potentiometer (R204) fully counter-clockwise (3/4 turn pot).
6. Turn the Dither potentiometer (R212) fully counter-clockwise (3/4 turn pot).
7. Turn the Proportional potentiometer (R215) fully counter-clockwise (20 turn pot).
8. Turn the Proportional potentiometer (R215) fully counter-clockwise; then turn it clockwise for 5 turns.
9. Remove the wire from terminal TB1-1. (Terminals 1 and 2 are the output to the actuator).

DC Power Initial Set-up

1. Check the +24 VDC. Voltage between TB1-23 (+) and TB1-24 (-) should be between +22 VDC and +32 VDC (power adjustments may need to be made on the power supply).

   OR

2. Check the + / - 15 VDC. Terminal TB1-5 is +15 VDC. Terminal TB1-6 is Common. Terminal TB1-7 is -15 VDC. Voltage must be between 14.5 VDC and 18.0 VDC.

LVDT Drive Initial Set-up

1. Connect an AC voltmeter to terminals 17 and 18. Adjust LVDT Drive Voltage (R211) for 1.5 VAC rms, plus or minus 0.3 volts.
2. Insure your feedback is linear over the entire range. For an LVDT, measure the AC voltage at terminals TB1-15 & TB1-16. For a variable resistor feedback, measure the DC voltage at terminals TB1-19 & TB1-20.

Position Sensor Initial Set-up

1. Remove the LVDT secondary wire from TB1-15.
2. Connect an AC voltmeter to terminals 15 and 16.
3. Adjust DC offset, R210, for zero volts.
4. Reconnect the LVDT secondary wire to terminal 15.
5. Connect a current meter in series with the servo-valve current output line (TB1-1). ***Alternatively,*** the servo valve can be disconnected entirely and the current meter connected directly between TB1-1 and TB1-2. This method avoids possible over-current to the servo-valve during the set-up procedure.
   Current measurements are the same, either way.

Calibration

Feedback Offset & Gain Calibration

⚠ **CAUTION** Verify you have oil pressure to the actuator and that it can be safely stroked.

1. Note the position of jumper J7. It will determine which pots are to be used for the Feedback *zero* and *span* adjustments.

NOTE: *Verify which of the following two observances is correct for your application before making any adjustments. Refer to Figure 16.*

*If J7 is in the **B** position,* feedback is non-inverted.
Offset *potentiometer (R213) is used to set feedback* zero, *and*
gain *potentiometer (R214) is used to set feedback* span.

*If J7 is in the **A** position,* feedback is inverted.
Offset *potentiometer (R213) is used to set feedback* span
gain *potentiometer (R214) is used to set feedback* zero.

2. Remove the servo valve wire from TB1-1.
3. Place a 4-20 mA source negative lead on terminal TB1-2;
   Place the positive lead on the wire that was removed from terminal TB1-1.
4. Set the output of the source at 6 mA. If the valve rack opens, reverse the leads. This will insure positive valve closure.
5. Connect a DC voltmeter to test point GND and test point TP7.
6. Adjust the *zero* pot (R213) if J7 is in the **B** position (or R214 if J7 is in the **A** position) for a reading of 0.0.
7. Reverse the leads. Visually check the valve to insure it is at 100%. Adjust the *span* pot (R214) if J7 is in the **B** position (or R213 if J7 is in the **A** position) for a reading of 10.0 VDC at test point TP7.
8. Repeat the *zero* and *span* procedure above to insure this range is correct.

Input *Zero* Calibration

1. If you choose to drive the *M306* with the controller output signal, leave the wires on terminals TB1-11 and TB1-12 connected. If not, disconnect them and connect a 4-20 mA current source positive lead to terminal TB1-11 and the negative lead to terminal TB1-12.
2. Input 4 mA to the *M306*.
3. Connect the DC voltmeter between test point GND (negative meter lead) and test point TP1 (positive meter lead). Adjust the *zero* potentiometer (R207) for 0.0 VDC.
4. Remove jumper J4.
5. Disconnect the 4-20 mA source leads from TB1-11 and TB1-12. Reconnect the wire which was disconnected from TB1-1 in Initial Set-up, Step 9.
6. Connect the DC meter to test point TP2. The reading should be 0.0 VDC, plus or minus 0.03 VDC. The reading should not be higher than the minimum setting on the *zero* and *span* procedure above.

Null And Balance Calibration

1. Apply 12 mA on terminals TB1-11 & TB1-12.
2. Move the positive meter lead to test point TP2 and adjust the null potentiometer (R205) for a reading of 0.0 VDC.

NOTE: *Verify visually that the valve actuator is physically at the approximate 50% position.*

3. Move the positive meter lead to test point TP7 and adjust the balance potentiometer (R206) for a reading of 5.0 VDC.
4. Repeat the above 2 steps until the voltages are correct.

Servo-Loop (PID) Calibration

Proportional Calibration

NOTE: *If possible, use a fast response meter, or an oscilloscope to more clearly indicate any possible valve oscillation through the feedback measurement. If the reading oscillates, turn the proportional potentiometer (R215) counter-clockwise until any oscillation ceases.*

1. Test the valve response by changing the input command to the *M306* and observing the valve response.
2. Input 12 mA to the *M306* and increase the proportional potentiometer (R215) until the valve begins to oscillate.

NOTE: *It may be necessary to locate an operator at the valve actuator to determine when the valve (or valve actuator servo) begins oscillating or when it stops oscillating.*

3. Decrease the proportional potentiometer (R215) until the valve stabilizes and oscillations cease.

Derivative Calibration

1. Adjust the proportional control as described above.
2. Continue to exercise the valve as described in step 8 above.
3. Gradually increase (turn clockwise) the derivative control.
   The speed of the valve should increase, and the tendency of the valve to oscillate should decrease. The correct amount of derivative is the smallest amount that produces quick valve response with consistent, smooth operation.

NOTE: *A small increase or decrease in proportional at this point may bring about further improvement.*

Integral Calibration

When the M306 is used with an actuator system which itself is mechanically integrating, the integral component of the M306 should not be used. (Jumper J4 should not be installed.) An integrating actuator is one whose *rate* of movement (open loop) is proportional to the servo-valve current (as opposed to the *position*, open loop, being proportional to the servo-valve current).

Before adding the integral component to the calibration of the M306, perform the proportional and derivative adjustments as described above. Then, ***for a non-integrating servo actuator system only***, perform the following:

1. Re-install jumper J4. Jumper J4 is optional. If valve action is satisfactory, leave J4 off. If using a high pressure actuator such as a HA-152, Integral may not be necessary.

   NOTE: *Re-installing jumper J4 puts a small amount of Integral into the output. More Integral may be added, if desired, by turning the Integral potentiometer (R201) clockwise.*

   ⚠ **CAUTION** Too much Integral will cause *overshoot* in valve position changes.

2. Adjust input source on terminals TB1-11 (+) and TB1-12 (-) to 4 mA. Insure that test point TP7 goes to 0.0 VDC, or to the minimum value previously obtained.
3. Adjust input source on terminals TB1-11 (+) and TB1-12 (-) to 20 mA. Insure that test point TP7 goes to 10.0 VDC; plus or minus .09 VDC.
4. Adjust input source on terminals TB1-11 (+) and TB1-12 (-) to 8 mA. Insure that test point TP7 goes to 2.5 VDC.
5. Adjust input source on terminals TB1-11 (+) and TB1-12 (-) to 12 mA. Insure that test point TP7 goes to 5.0 VDC.
6. Adjust input source on terminals TB1-11 (+) and TB1-12 (-) to 16 mA. Insure that test point TP7 goes to 7.5 VDC.
7. Make 5% to 10% step changes and insure good actuator response with no oscillations. Adjust the proportional potentiometer (R215), as necessary, for any oscillation.

   NOTE: *Do not make adjustments larger than one quarter turn.*

8. If the actuator or actuator spool valve (if using a high pressure actuator) oscillate after a step change, reduce the gain (turn R215 counter-clockwise to reduce gain).
9. Insure that the feedback does not have greater than 5% difference from the command signal over the entire range.

Position Output Calibration

The position out [TB1-13(+) and TB1-14(-)] is factory calibrated to coincide with 0.0 and 100 or the position displayed: 0.0 = 4.0 mA; 100.0 = 20.0 mA. If a different calibration is required, the *zero* (R203) and *span* (R208) can be used to affect an approximate ±3% change each.

NOTE: *The display board must be removed to gain access to the* zero *and* span *potentiometers.*

LVDT DC Offset Calibration

1. To calibrate for LVDT DC Offset, disconnect the wire from terminal TB1-15 and adjust the DC Offset potentiometer (R210) until the valve starts to travel in the desired direction.

NOTE: *In Step 1, more turns to R210 will determine the speed at which the actuator moves to the fail-safe position.*

2. Reconnect the wire to terminal TB1-15.

Dither Calibration

NOTE: *Disconnect any current sources and meters. Reconnect any wires previously removed from the* M306.

Dither is used to compensate for hysteresis in the oil relay or servo-valve and to prevent silting. Hysteresis is the characteristic of a valve to have to move significantly before oil begins to flow. Silting is the depositing of small particles from the oil on to the sliding or moving surfaces of the oil relay or servo-valve.

Dither functions by keeping the valve in constant motion thus preventing silting or the build up of particulate mater in the valve. This constant motion also keeps the valve moving back and forth across the lapped position of the valve. This means that as soon as the current signal to the valve changes, the valve will begin to flow oil moving the main actuator for the smallest command change.

A generally satisfactory way to adjust the dither function of the M306 is as follows:

1. Adjust the dither amplitude R212 fully CCW to minimum amplitude.
2. Adjust the dither frequency R209 fully CCW to minimum frequency.
3. Turn the dither amplitude, R212 CW untill the final actuator begins to move slightly.
4. turn the dither frequency, R209 CW until the final actuator just stops moving.

Chapter 7 - Calibration When *M306* is Used as a Current Amplifier

The M306 can be used in a servo system as a simple current amplifier. A possible application is shown in the figure below.

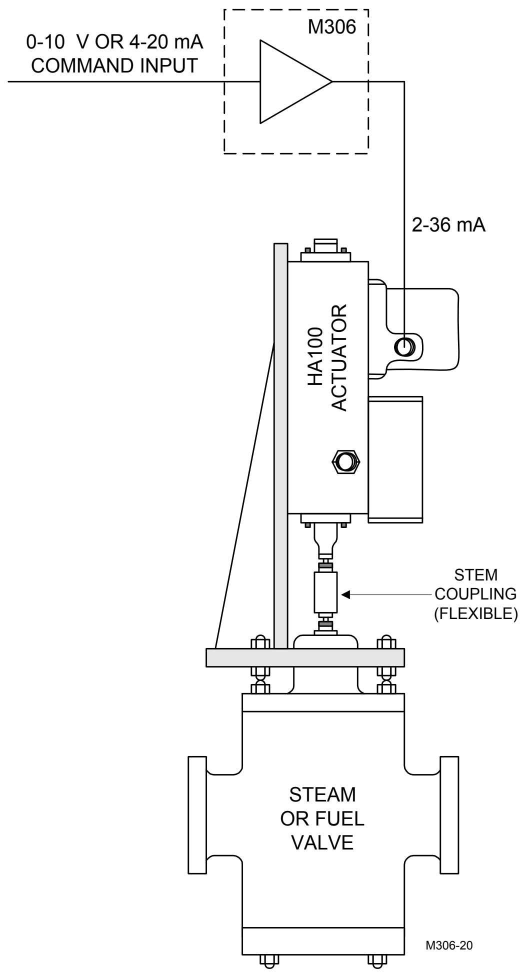


Figure 17. M306 Used as a Current Amplifier

Before Setting Up the *M306*

WARNING **All personnel must be kept away from all moving parts during calibration.**

1. Prior to *M306* calibration, mechanically adjust the valve to insure that it will not be over-stroked during calibration adjustments.

   CAUTION Verify that there is oil pressure to the actuator and that it can be stroked safely.

2. Determine the specific application of the *M306* servo-controller and verify correct jumper placement on the M306 circuit board in accordance with instructions in Chapter 4 of this manual.

Initial Set-up

The following procedures provide instructions for setting up the *M306 prior to* calibration.

Circuit Board Initial Set-up

Initial set-up of the *M306* involves removing and installing jumpers, along with various adjustments on the internal circuit board. The Display Board, if any, must be removed to gain access to the Circuit Board. The Circuit Board is shown below for reference.

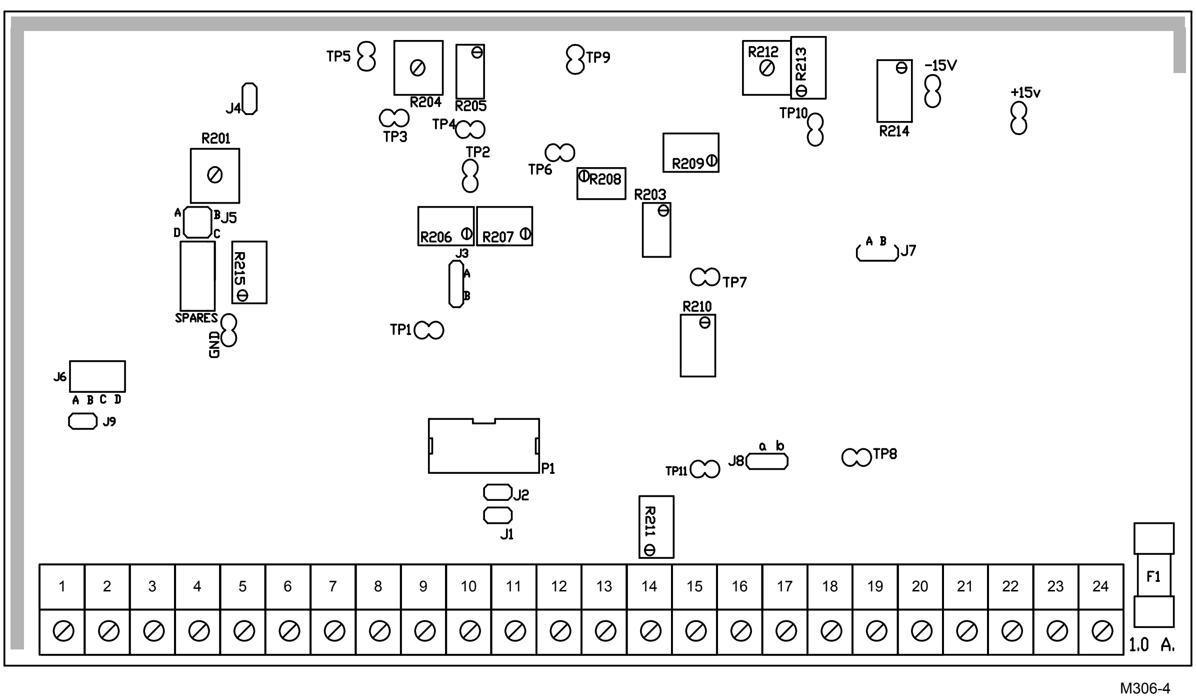


Figure 18. M306 Internal Circuit Board

CAUTION Verify there is no oil pressure to the actuator.

1. Position jumper J6 for the maximum required servo-valve current. The maximum output current can be configured from 30 mA to 400 mA. See figure below.

***NOTE**: Select an output current option of 1.2 to 2 times the maximum steady state servo valve current. This increased output capability will accommodate the higher instantaneous current produced by the derivative component.*

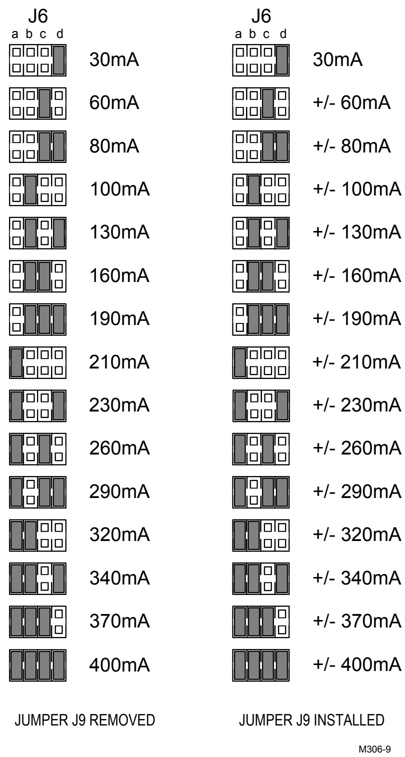


Figure 19. Output Current Jumper Configurations

2. Install jumper J9. This jumper should be removed after calibration if the servo-valve will be driven from more than one *M306*.

***NOTE:** Jumper J9 must be removed if the servo-valve cannot be subjected to negative current, or if the servo-valve is to be driven from more than one M306. Jumper J9 must be installed if the servo-valve requires positive and negative current for operation.*

3. Otherwise ensure that the jumper configuration of the board is correct for your application in accordance with instructions in Chapter 4.

4. Remove jumper J4. Do not reinstall this jumper when the calibration is completed.

5. Ensure that jumper J8 is in the B position.

6. Place a jumper between TB1-19 andTB1-20.

DC Power Initial Setup

1. Check the +24 VDC. Voltage between TB1-23 (HOT) and TB1-24 (COMMON). Voltage should be between +22 VDC and +32 VDC.

   OR

2. Check the +/- 15 VDC. Terminal TB1-5 is +15 VDC. Terminal TB1-6 is COMMON. Terminal TB1-7 is -15 VDC. Voltage must be between 14.5 VDC and 16.0 VDC.

Calibration

1. Adjust the following potentiometers to the full counter-clockwise (left) position:
   - Proportional Gain (R215)
   - Integral (R201)
   - Derivative (R204)
   - Dither Amplitude (R212)
   - Dither Frequency (R209)
2. Reference the GND test point and test point TP7, and adjust the feedback offset potentiometer (R213) for 0.0 VDC at TP7.
3. Place a current meter in series with a load representing the actuator, and TB1-1 and TB1-2.
4. Input the minimum command input to the *M306* at TB1-11 (+) and TB1-12 (-).
5. Adjust the null potentiometer (R205) for the desired minimum current output as indicated on the ammeter.
6. Provide the maximum command input to the *M306*.
7. Adjust the proportional gain potentiometer (R215) for the desired maximum current output as indicated on the ammeter.
8. Repeat steps 4 through 7 until both the minimum and maximum current outputs are at the desired values and will reliably repeat.

Dither Calibration

NOTE: *Disconnect any current sources and meters. Reconnect any wires previously removed from the* M306.

Dither is used to compensate for hysteresis in the oil relay or servo-valve and to prevent silting. Hysteresis is the characteristic of a valve to have to move significantly before oil begins to flow. Silting is the depositing of small particles from the oil on to the sliding or moving surfaces of the oil relay or servo-valve.

Dither functions by keeping the valve in constant motion thus preventing silting or the build up of particulate mater in the valve. This constant motion also keeps the valve moving back and forth across the lapped position of the valve. This means that as soon as the current signal to the valve changes, the valve will begin to flow oil moving the main actuator for the smallest command change.

A generally satisfactory way to adjust the dither function of the M306 is as follows:

1. Adjust the dither amplitude R212 fully CCW to minimum amplitude.
2. Adjust the dither frequency R209 fully CCW to minimum frequency.
3. Turn the dither amplitude, R212 CW untill the final actuator begins to move slightly.
4. turn the dither frequency, R209 CW until the final actuator just stops moving.

Appendix A. Connecting an M306 to a Triconex Tricon v9

When connecting a self-powered device to a Triconex™ Tricon v9 analog input, it is sometimes necessary to add an isolator. An isolator should not be necessary if the external signal is powered with the same power supply as the Tricon v9 analog input, which is generally the case with an M306.

The figure below shows how to connect the position feedback signal from an M306 to a Tricon v9 analog input termination panel. Note that only one wire is connected since there is not a ground terminal on the Tricon v9 termination panel. This is not a problem since both the Tricon v9 and the M306 are referenced to the same ground. Note that since the feedback output is a differential output, a jumper must be attached from its ground to the power supply ground.

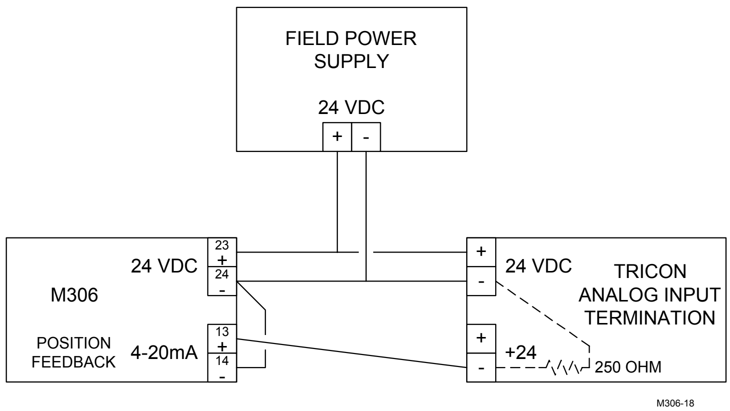


Figure 20. Connecting the Position Feedback Signal from an M306 to a Triconex Tricon v9

The following figure shows how to monitor the current output of an M306 that is used as a servo current amplifier and does not have LVDT feedback. As in the previous example only one wire is used for the analog input since there is not a ground terminal, which is not a problem since both the M306 and the Tricon v9 are referenced to the same ground.

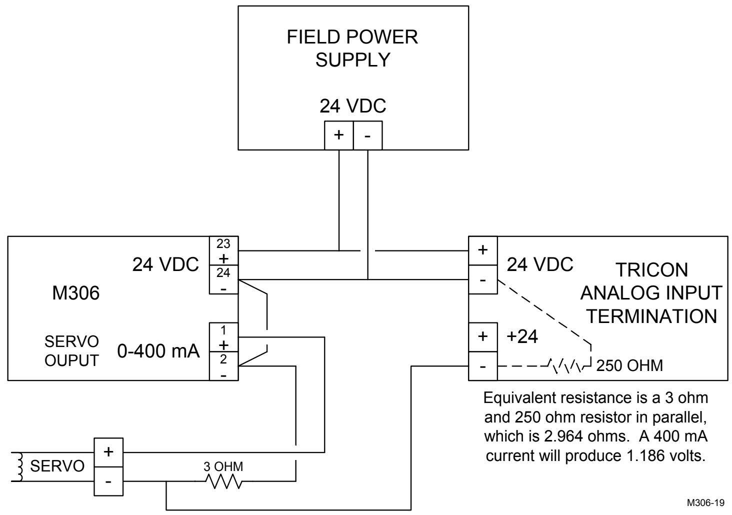
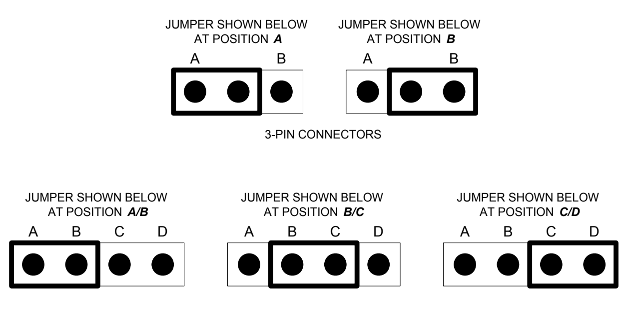


Figure 21. Monitoring Current Output of M306 Servo-Amplifier Without LVDT Feedback

Appendix B. Glossary of Terms & Acronyms

Term/Acronym	*Meaning in the Context of this Manual*
A/D	Analog-to-digital signal conversion.
AC	Alternating current (amps)
AEL	Absolute Excitation Limit
AI Board	Analog Input Board. A class of input/output board which supports analog inputs from transmitters, sensors, or thermocouples.
AO Board	Analog Output Board. A class of input/output board which supports system generated analog outputs for controller setpoints, chart recorders, etc.
Availability	The probability that the control system is operational at some instant of time.
Backplane	A component of the Card Cage that contains card slots, and mounts to the rear of the Card Cage to become the mother board into which all other boards are connected.
Board	An electronic circuit board, also called a card.
Bus	A means for connecting components together so that information can be passed from one to another. In this manual, generally refers to the backplane/ motherboard inside the card cage.
Card	An electronic circuit card, also called a board.
Card Cage	A metal enclosure which houses electronic subassemblies and can be mounted in a standard 19" rack mountable NEMA cabinet.
Chassis	See Card Cage.
CJ	Cold junction; refers to temperature inside cabinet. Each analog input termination panel has a CJ device installed. Also, refers to normal operating parameters entered into a controller configuration.
Configuration	The arrangement of the programmable electronics and the combination of programmable and non-programmable equipment within an installation.
Control System	The system which governs the operation of plant, machinery or other equipment by producing appropriate instructions in response to input signals.
CPU	Central Processing Unit
Cross-talk	Some printed circuit boards have a tendency to talk to each other or to create electronic chatter when placed side-by-side in the Card Cage.
D/A	Digital-to-analog signal conversion.
DC	Direct current (amps)
Debug	The act of locating and correcting faults: 1) one of the normal operations in software development such as editing, compiling, debugging, loading, and verifying; or 2) identification and isolation of a faulty physical component, including its replacement or repair to return the controller to operational status.
Design	That part of a system which actually supports and controls the interaction of the components. The design does not refer to any document, circuit diagram or software flow chart.
DI Board	Digital Input Board. A class of input/output boards which supports up to 48 input circuits from two 24-point optically isolated termination panels.
DIN Rail	Vertical snap-connect mounting rails inside the cabinet which hold system components (except card cage and power supplies).
DMA	Direct Memory Access

Term/Acronym	*Meaning in the Context of this Manual*
DO Board	Digital Output Board. A class of input/output boards which supports up to 48 output circuits from two 24-point optically isolated termination panels.
EU	Engineering units of measure.
Fail-safe	The characteristic of a device or system to always assume a safe, predictable state, even when one or more of its internal elements has failed.
Failure	Occurs when some part of a system resource perceives that a service resource has ceased to deliver the expected services.
Fault	The cause of a failure or error is referred to as a fault. A fault is detected either when a resource failure occurs, or when an error is observed within the resource.
Field	Another name for the rotating generator winding
FIFO	First in, first out data buffer
FSR (Full Scale Range)	Specifies an operating range for input or output signals. For example, if 0-5 V is the "range," then 5 V is the "full scale" range.
Function Module	A set of software data and commands that perform a fundamental control task.
Handshaking	Establishment of communications between components before data are actually transferred.
Hysteresis	A lag of the effect in a body when the force acting on it is changed; especially a lag in the changes of magnetization behind the varying magnetizing force
Hz	Hertz (unit of frequency; cycles per second)
I/O	Input/Output
IC	Integrated Circuit
Interposing Relays	Some of the output devices driven by the control system may have a power consumption higher than that which can be handled by the system's digital output boards. To solve this problem, interposing relays are used. Isolation relays are mounted on DIN rails near the digital output termination panels. The isolation relays have a rating of about 10 amps. Optical relays on the termination panels have a maximum rating of about 3 amps.
Jumper Positions	Jumpers are placed in different positions around pins on circuit boards to accomplish various configurations. The following example illustrates a two-pin jumper on a three-pin connector and a two-pin jumper, at three positions, on a four-pin connector:



LED	Light emitting diode. Usually refers to a display or light on a control panel.
mA	Mili-amps
Magnetic Speed Pickups	Devices mounted on a turbine shaft that convert the rotation of the shaft into voltage pulses. The frequency of the voltage pulses is proportional to revolutions per minute. The control system continuously selects the second highest input of three or more pickups to use as the speed measurement. However, if only two pickups are active, the control system uses the higher of the two.

Term/Acronym	*Meaning in the Context of this Manual*
MAN	Manual control function
MCU	Microcontroller Unit
MLC	Mega-Watt Limit Controller
Modulus 1	Tri-Sen Digital Turbine Control System
MTBF	Mean Time Between Failures. Expected average time between failures of a system, including time taken to repair the system. Usually expressed in hours.
MTTF	Mean Time To Failure. The expected average time to a system failure in a population of identical systems. Usually expressed in hours.
MTTR	Mean Time To Repair. The expected time to repair a failed system or subsystem. Usually expressed in hours.
MW	Mega Watts
NEMA	A rating system pertaining to the ability of a cabinet design to withstand explosion and other hazards, and relating to the use of gaskets, seals, etc.
NVL	Negative Var Limit Controller
Octal Chip	An electronic device used to manage eight data lines.
PAL	Programmable Array Logic
PBA	Printed circuit board assembly.
PCB	Printed circuit board.
PF	Power Factor (negative = leading, positive = lagging)
PID	Proportional, Integral, Derivative (type of controller algorithm)
PIP	Proportional, Integral, Proportional (type of control algorithm)
PLD	Programmable Logic Device
Potentiometer	A knob-type device that can be turned for calibration adjustment.
Program	1) The set of instructions, commands, and/or directions that define output signals in terms of input signals. 2) The act of creating such a set of instructions.
PVL	Positive Var Limit Controller
Rack	See Cabinet.
Ramp	Reference generator. Usually refers to incremental changes in speed, etc.
Rotor	Rotating generator winding
RTD	Resistance Temperature Detector (temperature sensor)
RTL	Rotor Temperature Controller
Rtl	Rotor temperature limit (Deg)
SCR	Silicon Control Rectifier
Setpoint	Desired value to control to
SST	Soft Start/Stop ramp module
Stator	Stationary generator winding
Stl	Stator temperature limit (Deg)
System	Consists of a set of components which interact as a control unit.
TTL Level	Transistor-Transistor Logic.
V/I	A converter which changes a voltage into a current.
Vars	Volt Amps Reactive (unit of reactive power)

Term/Acronym	*Meaning in the Context of this Manual*
V_{CC}	5 V DC, used by all circuit boards in the backplane, and by the digital I/O termination boards.
VHZ	Volts per hertz (flux limit)
Vref	Voltage reference. Calibrated voltage used as a reference.
Zener	A special type of diode which allows current flow in either direction after a specified threshold voltage is applied.