SECTION III
SERVICE

This section provides adjustment and calibration procedures to ensure that optimum performance is obtained from the Model 406.11 Controller. Perform the individual procedures in the order in which they are given. Some procedures may assume that a previous procedure has been performed. Skip procedures which do not apply to the specific system configuration.

All procedures assume that the appropriate connections (as described in section IV, Installation) have been made to the controller. All applicable procedures must be performed on each 406.11 Controller in a multi-channel system. All service procedures should be performed by qualified service personnel only.

NOTE

Procedures 3.1 and 3.2 are performed at the factory and need not be performed unless deemed necessary.

3.1 REFERENCE VOLTAGE ADJUSTMENT

The following procedure is used to adjust the controller power supply to provide the proper reference voltages required for accurate operation. Additional equipment required for this procedure includes a digital voltmeter (DVM) accurate to 0.03% with 1mV resolution. Perform this procedure with hydraulic pressure off. Refer to figure 3-1 for the location of test points and adjustments.

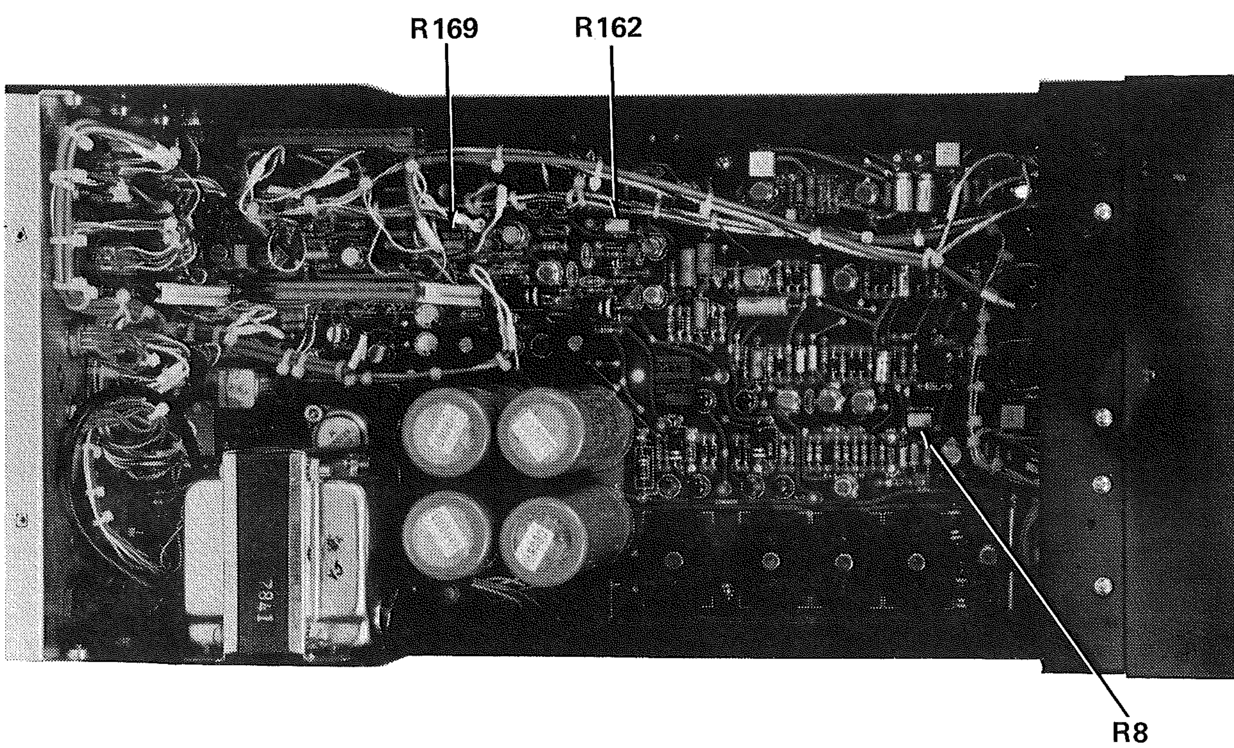

Figure 3-1. Model 406.11 Controller (Top View)

1. Turn off electrical power to the controller. If rack mounted, remove all cables and remove the controller from the rack (refer to section IV, paragraph 4.2). Remove the controller top cover to gain access to the controller main circuit card.

2. Connect the DVM between the +10V test jack and common.

***** WARNING *****

A potential shock hazard exists whenever making adjustments inside any electrical device. Use caution when approaching these areas.

3. Apply electrical power to the controller and adjust variable resistor R162 to obtain a reading of +10.00, ±0.01 Vdc on the DVM.

4. Connect the DVM between the -10V test jack and common.

5. Adjust variable resistor R169 to obtain a reading of -10.00, ±0.01 Vdc on the DVM.

3.2 SPAN AMPLIFIER GAIN ADJUSTMENT

NOTE

Unless otherwise specified, the span amplifier gain has been factory-adjusted for use with a programmer which provides a zero referenced 20 volt peak-to-peak (±10V) full-scale output. It is not necessary to perform the following procedure unless the controller is to be used with a programmer which provides a different full-scale output. The controller may be adjusted for use with any programmer which provides a full-scale output within a range of 2 to 25 volts peak-to-peak (±1V to ±12.5V).

The following procedure adjusts the amplitude of a full-scale program input signal to a level corresponding to the designed controller full-scale input level. Perform this procedure with hydraulic pressure off. Refer to figure 3-1 for the location of test points and adjustments.

1. With electrical power applied to the controller, adjust the SET POINT control to 500 and the SPAN control to 000.

2. Turn the FDBK SELECT switch to XDCR 1.

3. Turn the panel meter selector switch to ERROR.

4. If the XDCR 1 ZERO control has been adjusted for a specific transducer, record the XDCR 1 ZERO control setting. Adjust the XDCR 1 ZERO control to zero the panel meter.

5. Adjust the programmer to provide a negative full-scale output. The signal may be a negative cyclic waveform at a frequency of approximately 0.1 Hz or a ramp signal held at the negative full-scale level.

6. Adjust both the SET POINT and the SPAN controls to 1000.

7. Adjust variable resistor R8 (SPAN GAIN) to obtain a precise zero reading on the panel meter. For cyclic signals, adjust R8 so that the panel meter zeros on the negative peaks.

8. Return the XDCR 1 ZERO control to the position recorded in step 4.

3.3 VALVE CONTROLLER (OPTION D) CALIBRATION

NOTE

The following procedures apply only to 406.11 Controllers containing a Valve Controller (option D).

The Valve Controller (option D) must be calibrated for use with the particular servovalve used in the system configuration. Valve controller calibration includes the following procedures:

- Servovalve LVDT phase adjustment
- Servovalve LVDT null adjustment
- Servovalve LVDT dc zero adjustment
- Servovalve LVDT position adjustment

Additional equipment required for calibration includes an oscilloscope and a digital voltmeter (DVM) accurate to 0.03% with lmV resolution. When performing the following procedures, do not apply hydraulic pressure until instructed to do so.

3.3.1 SERVOVALVE LVDT PHASE ADJUSTMENT

1. Connect the oscilloscope vertical input to the AC jack on the valve controller module.

2. Connect the oscilloscope horizontal input to the 10 KC jack on the valve controller module.

3. Adjust the oscilloscope to obtain a lissajous pattern similar to that shown in figure 3-2.

4. Adjust the Ø (phase) adjustment on the valve controller module to minimize dimension "A" of the lissajous pattern.

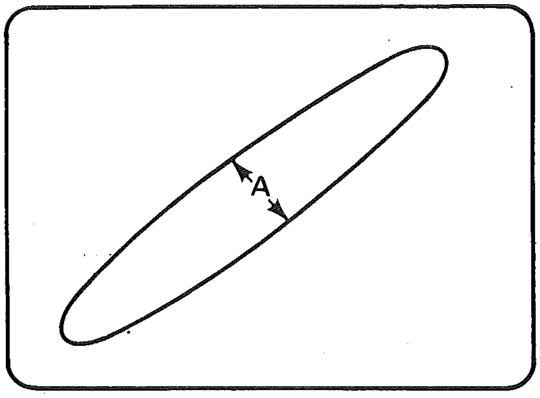

Figure 3-2. Lissajous Pattern for Phase Adjustment

3.3.2 SERVOVALVE LVDT NULL ADJUSTMENT

1. Turn the panel meter switch to the ERROR position. Adjust the SET POINT control to zero the panel meter.

*** WARNING ***

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command = feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

2. Apply full hydraulic pressure to the servovalve.

3. Connect the oscilloscope vertical input to the AC jack on the valve controller module. Connect the horizontal input to the controller common (black) jack. Adjust the oscilloscope for a horizontal sweep.

4. Loosen the locknut on the servovalve LVDT. Figure 3-3 shows the location of the locknut on a typical servovalve.

5. Rotate the LVDT body to obtain a minimum signal amplitude on the oscilloscope.

6. Tighten the locknut. Ensure that the signal amplitude remains at minimum while tightening.

7. Adjust the C-BAL adjustment on the valve controller to obtain a minimum signal amplitude on the oscilloscope.

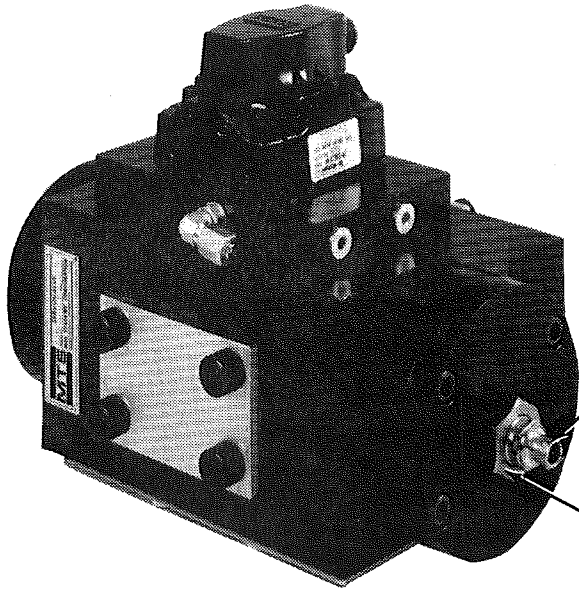

Figure 3-3. Typical Servovalve

3.3.3 SERVOVALVE LVDT ZERO ADJUSTMENT

1. With hydraulic pressure applied, connect the DVM between the XDCR 2 test jack (assuming the valve controller module is installed in the XDCR 2 slot) and the common (black) test jack on the controller front panel.

2. Adjust the ZERO potentiometer on the valve controller to obtain a reading of 0.00, ±0.01 Vdc on the DVM.

3.3.4 SERVOVALVE LVDT POSITION ADJUSTMENT

CAUTION

Ensure any fixture which may restrict actuator movement is removed from the actuator. The actuator will stroke to one extreme during the following procedure.

1. With hydraulic pressure applied, disconnect the servovalve cable from connector J229 on the controller rear panel. The actuator will stroke to one extreme.

2. Connect the oscilloscope vertical input to the AC jack on the valve controller. Connect the horizontal input to the 10 KC jack. Adjust the oscilloscope for a lissajous pattern and ensure that the phase adjustment made in procedure 3.3.1 has not changed. If the phase adjustment has changed, repeat procedure 3.3.1.

3. Connect the DVM between the XDCR 2 (valve controller output) and common (black) jacks on the controller front panel.

4. Adjust the CAL FACTOR control on the valve controller to obtain a reading of +10.00, ±0.01 Vdc on the DVM.

5. Reconnect the servovalve cable to connector J229 on the controller rear panel and remove hydraulic pressure.

3.4 SERVOVALVE BALANCE

The following procedure is an adjustment for proper servovalve balance. Proper servovalve balance ensures that hydraulic null (zero flow) corresponds with electrical null (zero dc error signal) when the servovalve is at its normal operating temperature.

Perform the following procedure to obtain proper servovalve balance. Additional equipment required for this procedure includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution.

NOTE

If the controller contains a Valve Controller (option D), ensure that the procedures contained in paragraphs 3.3.1 through 3.3.4 have been performed before proceeding with the following steps. If the controller contains a Reset Integrator/Null Detector (option C), the integrator circuit must be turned off during the procedure.

Do not apply hydraulic pressure until instructed to do so.

1. Select stroke feedback as the controlled variable if available. If load or strain feedback must be used, install a dummy specimen for mechanical input to the transducer.

2. Turn the SPAN control to 000.

3. Turn the panel meter selector to the ERROR position and adjust the SET POINT control to zero the meter (as near to zero as possible).

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command = feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

4. Apply full hydraulic pressure to the servovalve.

5. Adjust the programmer and the SPAN control to apply a low-amplitude, low-frequency sine wave program (1% to 2% of operating range at 1Hz to 2 Hz). Run the program for approximately 30 minutes before proceeding with step 6.

NOTE

Due to temperature sensitivity of the servovalve, it is important that the servovalve and the hydraulic fluid be at normal operating temperature before proceeding with this procedure.

6. Connect the DVM between the XDCR 1 or XDCR 2 jack (depending on which transducer feedback has been selected as the controlled variable) and the common (black) jack on the controller front panel.

7. Remove the sine wave program. Do not remove hydraulic pressure.

NOTE

If the controller contains a Valve Controller (option D), adjust the GAIN control on the valve controller module whenever the GAIN control is referred to in the remaining steps of this procedure.

8. Rotate the GAIN control back and forth between zero (fully counterclockwise) and the highest stable setting. Note the change in voltage readings on the DVM.

9. Adjust the VALVE potentiometer to minimize the change in the DVM voltage readings while rotating the GAIN control as described in step 8. The ideal VALVE setting results in the same voltage reading at the minimum GAIN setting as at the maximum stable GAIN setting.

10. Leave the GAIN control at the highest stable setting and remove hydraulic pressure.

3.5 AC TRANSDUCER CONDITIONER CALIBRATION (XDCR 1 AND OPTION E)

Transducer conditioner 1 (XDCR 1) and the option E AC Transducer Conditioner (XDCR 2 AC) are identical universal carrier type transducer conditioners which may be calibrated for use with either a resistive or reactive type transducer. Transducer sensitivity must be within a range of 1mV/V to 1100mV/V. The following paragraphs contain calibration procedures which apply to both transducer conditioners. Do not apply hydraulic pressure unless instructed to do so.

3.5.1 PRELIMINARY CAL FACTOR ADJUSTMENT

The following procedure adjusts the ac conditioner CAL FACTOR to an approximate level suitable for the specific transducer application.

1. Determine the sensitivity of the transducer in millivolts output per volt of excitation (mV/V). Transducer sensitivity is typically provided with the transducer.

NOTE

The XDCR 1 CAL FACTOR RANGE switch is located on the controller rear panel. Switch positions 1-11, 10-110, and 100-1100 correspond to transducer sensitivity ranges of 1 to 11 mV/V, 10 to 110 mV/V, and 100 to 1100 mV/V respectively. The Option E CAL FACTOR range switch is located on the option E module front panel. Switch positions 1 - 11 X1, X10, and X100 correspond to transducer sensitivity ranges of 1 to 11mV/V, 10 to 110 mV/V, and 100 to 1100mV/V respectively.

2. Set the applicable CAL FACTOR RANGE switch to the proper transducer sensitivity range. For example, for a transducer sensitivity of 2 mV/V, set the switch to the 1-11 or X1 position.

3. Set the CAL FACTOR control to correspond to transducer sensitivity. For example, for a transducer sensitivity of 2 mV/V, set the CAL FACTOR control to 200.

4. Set the FINE/COARSE toggle switch to the FINE position.

3.5.2 C-BAL ADJUSTMENT

Adjusting the C-BAL potentiometer compensates for phase offsets caused by transducer cable capacitance. To adjust C-BAL, the transducer must be in a zero output condition. An oscilloscope is required for this procedure.

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

1. If the transducer is a stroke transducer, turn the SET POINT control to 500 (zero command) and apply hydraulic pressure to the servovalve. If the transducer is not a stroke transducer, do not apply hydraulic pressure at this time.

2. Connect the oscilloscope vertical input to the transducer conditioner AC test jack. Connect the oscilloscope horizontal input to the common (black) jack.

3. Switch the oscilloscope to a horizontal time base and adjust the C-BAL potentiometer for minimum signal amplitude on the oscilloscope.

4. Remove hydraulic pressure if applied.

3.5.3 PHASE ADJUSTMENT

Performing the following procedure compensates for slight phase shifts that may occur in some transducers. A dummy specimen must be installed if a load, torque or strain transducer is being used. Do not install a dummy specimen if a stroke transducer is being used. An oscilloscope is required for this procedure.

1. Turn the FDBK SELECT switch to select the transducer conditioner being calibrated.

2. Turn the panel meter switch to the ERROR position and adjust the SET POINT control to zero the meter (as close to zero as possible).

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

3. Apply hydraulic pressure to the servovalve.

4. Adjust the SET POINT control to a setting either above 750 or below 250.

5. Connect the oscilloscope vertical input to the transducer conditioner AC jack and the oscilloscope horizontal input to the 10 KC jack.

6. Adjust the oscilloscope for a lissajous pattern similar to that shown in figure 3-4.

7. Adjust the transducer conditioner PHASE (XDCR 1) or Ø (XDCR 2 AC) potentiometer to minimize dimension "A" of the lissajous pattern.

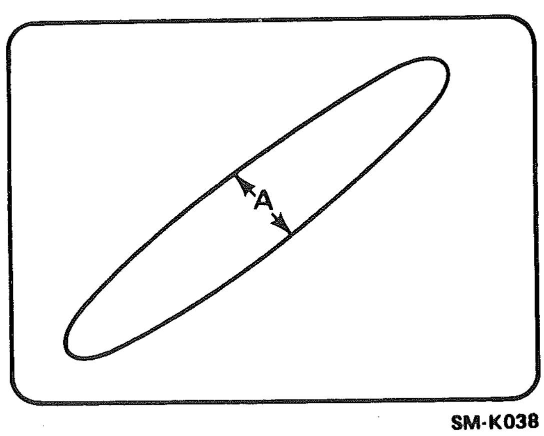

Figure 3-4. Lissajous Pattern for Phase Adjustment

3.5.4 AC CONDITIONER CALIBRATION FOR A SPECIFIC TRANSDUCER APPLICATION

The following procedures are used to calibrate the ac transducer conditioner for specific transducer applications. Perform only the applicable procedure.

3.5.4.1 AC Conditioner Calibration for Load or Torque Transducers

NOTE

Procedures 3.5.1, 3.5.2, and 3.5.3 must be performed before proceeding with the following procedure.

The following procedure ensures that the desired load or torque is actually applied by the actuator. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and a load or torque standard with a readout indicator. Do not apply hydraulic pressure until instructed to do so.

1. Mount the calibration standard in the force train as shown in figure 3-5.

NOTE

All elements in the force train must be capable of withstanding the full-scale force capability of the system.

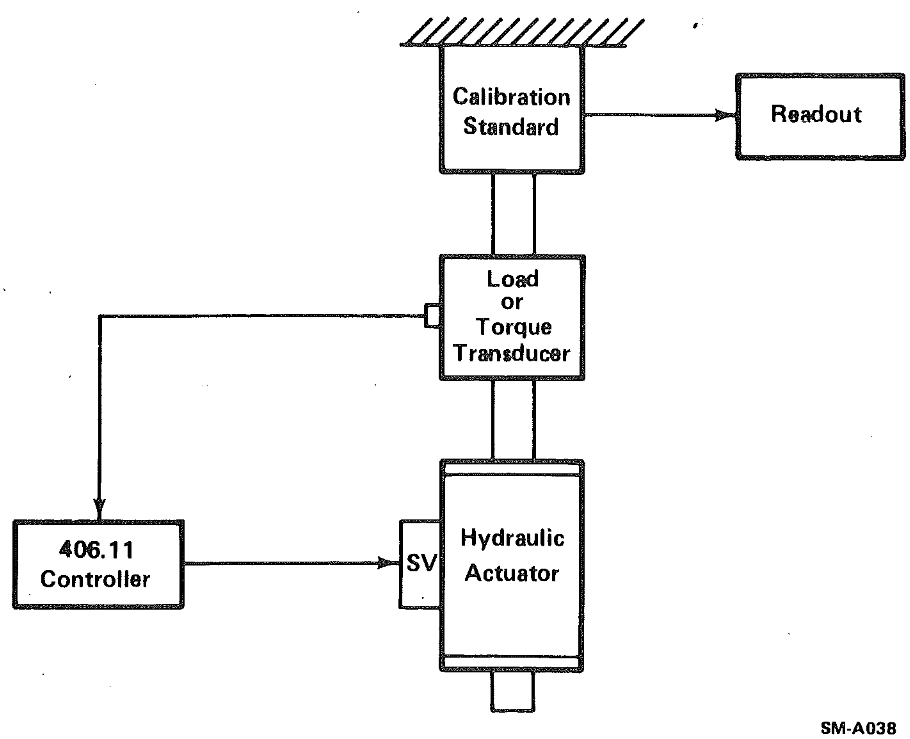

Figure 3-5. Typical Load or Torque Calibration Setup

2. Turn the FDBK SELECT switch to select the ac transducer conditioner being calibrated.

3. Connect the DVM between the applicable XDCR 1 or XDCR 2 test jack and the common (black) jack.

4. Turn the SPAN control to 000. Turn the SET POINT control to 500.

5. Turn the panel meter switch to ERROR.

6. Set the conditioner FINE/COARSE toggle switch to the FINE position and adjust the conditioner ZERO control to zero the meter.

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

7. Apply full hydraulic pressure to the servovalve.

8. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

9. Adjust the conditioner ZERO control for a zero indication on the load or torque standard readout.

10. Adjust the SET POINT control for a 100% command (000 or 1000) in the direction most commonly used during system operation. This results in a +10.00 or -10.00 Vdc reading on the DVM.

11. Adjust the conditioner CAL FACTOR control to obtain a reading of precisely 100% of the transducer rating (or a percentage of the transducer rating which is defined as full-scale) on the calibration standard readout. For example, if a load cell rated at 5000 pounds is being used, the CAL FACTOR control should be adjusted until the load standard readout indicates precisely 5000 pounds. Or, if a load cell rated at 5000 pounds is being used but designated full-scale is only 4000 pounds, the CAL FACTOR control should be adjusted until the load standard readout indicates precisely 4000 pounds.

12. Repeat steps 8 through 11 to ensure accurate calibration.

3.5.4.2 AC Conditioner Calibration for Stroke or Angular Displacement Transducers

NOTE

Procedures 3.5.1, 3.5.2, and 3.5.3 must be performed before proceeding with the following procedure.

Performing the following procedure ensures that the intended stroke or angular displacement is actually applied by the hydraulic actuator. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and an instrument to measure full-scale stroke (such as a dial indicator or vernier height gage) or angular displacement (such as a protractor). The actuator must be free to move full-scale without interference.

1. Turn the FDBK SELECT switch to select the ac transducer conditioner being calibrated.

2. Connect the DVM between the applicable XDCR 1 or XDCR 2 test jack and the common (black) test jack.

3. Turn the panel meter selector to ERROR and adjust the SET POINT control to zero the meter (as close to zero as possible).

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

4. Apply full hydraulic pressure to the servovalve.

5. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

NOTE

Perform step 6A for transducer conditioners used with stroke transducers; perform step 6B for transducer conditioners used with angular displacement transducers.

6. Attach the measuring instrument to read in the direction most commonly used during system operation.

   A. For stroke transducers, attach the dial indicator or vernier height gage between the actuator piston rod and a stationary point such as the actuator end cap.

   B. For angular displacement transducers, attach the protractor to the end of the actuator shaft and establish a reference position.

7. Record the reading of the measuring instrument.

8. Adjust the SET POINT control to obtain a reading of +10.00 Vdc or -10.00 Vdc (depending on the actuator direction most commonly used) on the DVM.

9. Record the reading of measuring instrument.

10. Calculate the difference between the readings recorded in steps 7 and 9. The result should be precisely 100% of the transducer range in one direction from zero (or the percentage of the transducer range in one direction from zero defined as full-scale). If the calculated difference is not precisely 100% of full-scale, adjust the conditioner CAL FACTOR control so that the difference equals full-scale.

    For example, if a stroke transducer with a full scale range of ±5 inches (10 inches total displacement) is being used, the CAL FACTOR control should be adjusted until the deflection of the measuring instrument is precisely 5 inches. Or, if a stroke transducer with a full-scale range of ±5 inches is being used but full-scale range is defined as ±4 inches (8 inches total displacement), the CAL FACTOR control should be adjusted until the deflection of the measuring instrument is precisely 4 inches.

11. Turn off hydraulic pressure.

3.5.4.3 AC Conditioner Calibration for Resistive Strain Gages

NOTE

Procedures 3.5.1, 3.5.2, and 3.5.3 must be performed before proceeding with the following procedure.

Resistive strain gages are typically bonded directly to a specimen to measure its deformation under stress. The gages are usually connected in a four-arm Wheatstone bridge configuration such as that shown in figure 3-6. For axial strain measurements, two of the bridge arms are usually active and the other two arms are connected transversely or bonded to a dummy specimen. For torsional strain measurements, either two or all four bridge arms may be active.

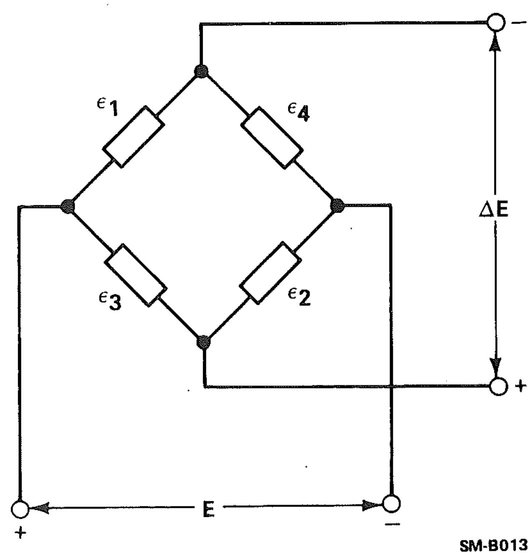

Figure 3-6. Strain Gage Bridge Configuration

Since these applications are typically continued to specimen failure, it is impractical to attempt to calibrate the conditioner under actual operating conditions. The following procedure simulates strain by unbalancing the bridge configuration with a shunt resistor. The strain gages must be in a static condition. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution. Do not apply hydraulic pressure for this procedure.

The following terms are used in the calculations made in the procedure:

K = the gage factor of the strain gages

K_b = the bridge sensitivity of the strain gage configuration in volts/volt

ε_s = the desired simulated full-scale microstrain in microinches/inch

ε_n = the desired full-scale microstrain on strain gage n (+ = tension; - = compression)

E = the bridge excitation in volts

N = the number of active gages in the strain gage configuration

R_s = the required shunt resistance in ohms

R_g = the strain gage resistance in ohms

1. Determine the CAL FACTOR range appropriate for the intended stress by first calculating the bridge sensitivity using the following formula:

$$K_b = \frac{K(\varepsilon_1 + \varepsilon_2 - \varepsilon_3 - \varepsilon_4)}{4 \times 10^6}$$

For example, determine the bridge sensitivity for the bending beam strain measurement shown in figure 3-7 given K=2.06 and the desired full-scale strain is ±1500 microstrain (ε_1 = +1500, ε_2 = 0, ε_3 = -1500, ε_4 = 0). Figure 3-7 also shows the configuration schematically.

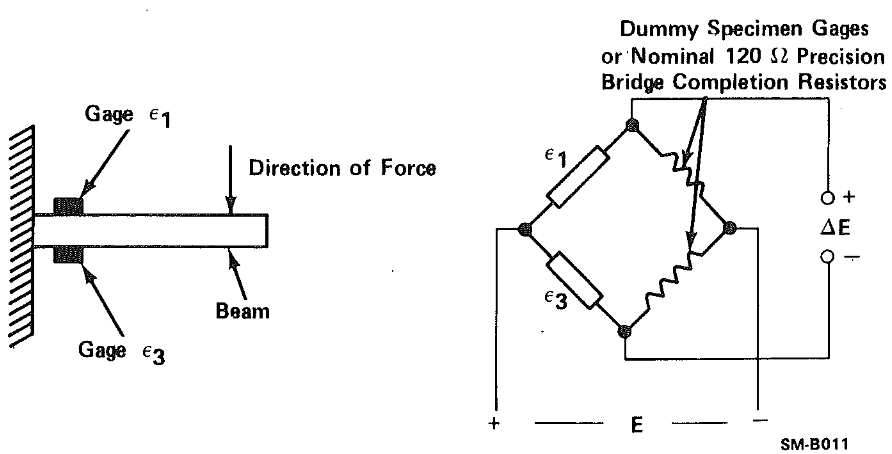

Figure 3-7. Typical Strain Gage Configuration

$$K_b = \frac{2.06(1500 + 0 - (-1500) - 0)}{4x10^6}$$

$$= \frac{2.06(3000)}{4x10^6}$$

$$= 0.001545 \text{ volts/volt (at 1500 microstrain)}$$

NOTE

The XDCR 1 CAL FACTOR RANGE switch is located on the controller rear panel. Switch positions 1-11, 10-110, and 100-1100 correspond to sensitivity ranges of 1 to 11 mV/V, 10 to 110 mV/V, and 100 to 1100 mV/V respectively. The XDCR 2 AC CAL FACTOR range switch is located on the XDCR 2 AC front panel. Switch positions 1-11 X1, X10, and X100 correspond to sensitivity ranges of 1 to 11mV/V, 10 to 110 mV/V, and 100 to 1100 mV/V respectively.

2. Set the appropriate CAL FACTOR RANGE switch to the position corresponding to the calculated sensitivity. The proper CAL FACTOR RANGE switch position for the example in step 1 (1.545 mV/V) is 1-11 (XDCR 1) or X1 (XDCR 2 AC).

3. Connect the DVM between the applicable XDCR 1 or XDCR 2 test jack and the common (black) test jack.

4. Set the conditioner FINE/COARSE switch to the FINE position.

5. Adjust the conditioner ZERO control to obtain a reading of 0.00 Vdc on the DVM.

6. An MTS Shunt Calibrator may be provided for strain gage calibration. If a shunt calibrator is not available, calculate the required value of shunt resistance by using the following formula:

$$R_s = \frac{R_g \times 10^6}{N \varepsilon_s K} - R_g$$

For example, determine the shunt resistance required to simulate full-scale microstrain given the following values:

$R_g = 121.2\,\Omega$

$N = 2$

$\varepsilon_s = 1500$

$K = 2.06$

For this example, the formula is:

$$R_s = \frac{121.2 \times 10^6}{(2)(1500)(2.06)} - 121.2$$

$$= 19{,}490\ \Omega$$

7. If available, insert the shunt calibrator into the proper R/CAL jacks on the controller rear panel. If a shunt calibrator is not available, obtain a 1% precision resistor of the value calculated in step 6 or, if necessary, of a value slightly greater than that calculated in step 6. Connect the resistor to the proper R/CAL jacks.

   The offset imposed by the shunt resistor is either positive or negative, depending on which bridge arm is shunted. If the shunt resistor is precisely the calculated value, the offset is 100%, simulating full-scale microstrain. If the shunt resistor is of a slightly greater value, the offset is proportionally decreased. For example:

   R_s for 100% µstrain = 19,490 Ω

   Available precision resistor = 19,600 Ω

   $$\text{Offset} = \frac{19490}{19600} = 99.4\%$$

8. Adjust the conditioner CAL FACTOR control to obtain a voltage reading on the DVM which corresponds to the percent of offset produced by the shunt calibrator or shunt resistor. For a 100% offset, adjust the control for a DVM reading of 10.00 Vdc. For the example in step 7 (99.4% offset), the control is adjusted for a DVM reading of 9.94 Vdc. Lock the CAL FACTOR control when it is properly adjusted.

3.5.4.4 AC Conditioner Calibration for Resistive Extensometers

NOTE

Procedures 3.5.1, 3.5.2, and 3.5.3 must be performed before proceeding with the following procedure.

Performing the following procedure ensures that the intended strain is actually applied to the specimen. MTS Systems Corporation manufactures resistive bridge type extensometers that can be readily attached to materials test specimens to measure their deformation under stress. Since such tests are usually continued to specimen failure, it is impractical to attempt to calibrate the conditioner under actual testing conditions. The following procedure simulates full-scale strain mechanically.

Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and an MTS Model 650.03 Extensometer Calibrator or equivalent. Do not apply hydraulic pressure.

1. Connect the DVM between the appropriate XDCR 1 or XDCR 2 test jack and the common (black) test jack.

2. Attach the extensometer gage arms to suitable points on the fixed and moveable rods of the calibrator. It may be necessary to attach adaptors to the rods to provide a solid mechanical connection.

3. Adjust the calibrator to obtain the precise gage length.

4. Adjust the conditioner ZERO control to obtain a reading of 0.00 Vdc on the DVM.

5. Adjust the calibrator for a displacement of the extensometer arms equal to precisely +100% or -100% of the intended full-scale displacement.

6. Adjust the conditioner CAL FACTOR control to obtain a reading of 10.00 Vdc on the DVM (the polarity depends on the direction of displacement).

7. Repeat steps 3 through 6 to ensure accurate calibration.

3.5.4.5 AC Conditioner Calibration for Pressure Transducers

NOTE

Procedures 3.5.1, 3.5.2, and 3.5.3 must be performed before proceeding with the following procedure.

The following procedure applies to pressurization control systems. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and a pressure standard such as a dead-weight standard, a 0.1% accuracy pressure gage, or a pressure transducer with readout capable of measuring full-scale pressure. In some cases, a gage is supplied as part of the system. In other cases, a gage can usually be attached to the system at the specimen attachment port. No specimen need be attached prior to calibration, however, the attachment port must be dead-ended to prevent leakage of the pressurizing medium.

Do not apply hydraulic pressure until instructed to do so.

1. Attach the pressure standard to the system at the specimen attachment port. Ensure all connections can withstand full-scale system pressure without leakage.

2. With hydraulic pressure off, turn the FDBK SELECT switch to select the ac transducer conditioner being calibrated.

3. Turn the panel meter selector to ERROR and adjust the conditioner ZERO control to zero the meter.

4. Connect the DVM between the appropriate XDCR 1 or XDCR 2 test jack and the common (black) test jack.

5. Apply full hydraulic pressure to the servovalve.

6. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

7. Adjust the conditioner ZERO control to obtain a zero indication on the pressure standard.

8. Adjust the SET POINT control to obtain a reading of +10.00 Vdc on the DVM.

9. Adjust the conditioner CAL FACTOR control to obtain a reading of 100% of the full-scale system pressure on the pressure standard.

10. Repeat steps 6 through 9 to ensure accurate calibration.

11. Adjust the SET POINT control to 500.

12. Turn off hydraulic pressure.

3.6 DC TRANSDUCER CONDITIONER CALIBRATION (OPTION A)

The dc transducer conditioner (option A) can be calibrated for use with any dc resistive transducer having a sensitivity within a range of 1mV/V through 10mV/V. The conditioner is typically calibrated for two operating ranges; X1 and X10. The X10 range is simply an amplification of the transducer signal by a factor of 10. In the X10 range, 10% of the transducer rating is expanded to represent full-scale conditioner output (±10V). This provides a high level transducer conditioner output signal for a relatively small transducer output.

NOTE

The internal gain of the dc conditioner may be altered to accommodate transducers with a sensitivity not within the specified sensitivity range (refer to paragraph 3.6.3).

The following paragraphs provide procedures for adjusting excitation and calibrating the conditioner for use with specific transducer types. Do not apply hydraulic pressure unless instructed to do so.

3.6.1 EXCITATION ADJUSTMENT (OPTION A)

NOTE

The following procedure is also included as part of the Transducer 2 Phasing instructions (section IV, paragraph 4.10.4). If previously performed for the specific transducer for which the conditioner is being calibrated, this procedure need not be repeated.

Perform the following procedure to adjust the excitation voltage for a specific transducer application. Proper excitation adjustment is required for all option A calibration procedures that follow. Do not apply hydraulic pressure at this time.

1. Determine the sensitivity of the transducer in millivolts output per volt of excitation (mV/V). This information is typically provided with the transducer.

NOTE

If the dc transducer conditioner is being used with a resistive strain gage configuration, the sensitivity of the configuration must be determined by calculation. Therefore, skip the remaining steps of this procedure and perform Calibration for Resistive Strain Gages (paragraph 3.6.2.2).

2. Determine the correct excitation voltage using the following formula:

$$E = \frac{0.02}{k_b}$$

Where:

E = the transducer excitation in volts

K_b = the transducer sensitivity in volts/volt

For example, the correct excitation voltage for a transducer with a sensitivity of 2 mV/V is:

$$\frac{0.02}{0.002} = 10 \text{ Vdc}$$

NOTE

Do not adjust excitation to a voltage above that recommended by the transducer manufacturer. If the voltage calculated in step 2 is above the recommended voltage, the internal gain of the dc conditioner must be changed to accommodate the transducer (refer to paragraph 3.6.3).

3. Connect the DVM between the +EX and -EX jacks on the XDCR 2 DC front panel.

4. Adjust the XDCR 2 DC EXCITATION control to obtain a reading on the DVM which corresponds to the voltage calculated in step 2. Record the setting of the EXCITATION control for future reference.

3.6.2 CALIBRATION FOR SPECIFIC TRANSDUCER APPLICATIONS (OPTION A)

The following procedures are used to calibrate the dc transducer conditioner (option A) for specific transducer applications. Perform only the applicable procedure. All procedures assume that the conditioner is installed in the XDCR 2 slot of the 406.11 chassis.

3.6.2.1 Calibration for Load or Torque Transducers (Option A)

NOTE

Perform procedure 3.6.1 before performing the following procedure.

The following procedure applies to load or torque control systems. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and a load or torque standard with a readout indicator. Do not apply hydraulic pressure until instructed to do so.

Figure 3-8 shows a typical load control calibration setup. The setup principles are the same for torque cells, differential pressure cells, etc.

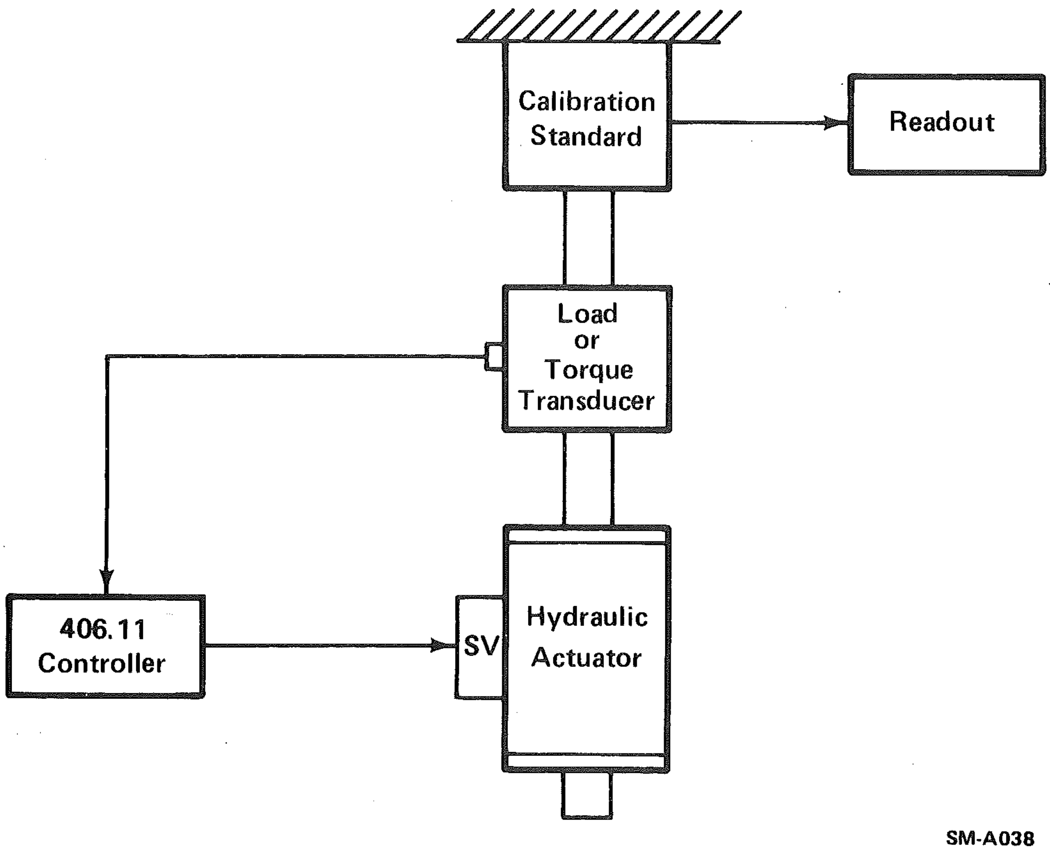

Figure 3-8. Typical Load Control Calibration Setup

1. Mount the calibration standard directly in the force train as shown in figure 3-8. All elements in the force train must be capable of withstanding the full force to be applied by the actuator in either direction.

2. With hydraulic pressure off, set the XDCR 2 DC X1/X10 toggle switch to X1.

3. Turn the FDBK SELECT switch to XDCR 2.

4. Connect the DVM between the XDCR 2 test jack and the common (black) test jack.

5. Turn the SPAN control to 000 and the SET POINT control to 500.

6. Turn the panel meter selector to ERROR and adjust the XDCR 2 DC ZERO control to zero the panel meter.

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command = feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

7. Apply full hydraulic pressure to the servovalve.

8. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

9. Adjust the XDCR 2 DC ZERO control to obtain a zero indication on the calibration standard readout.

10. Adjust the SET POINT control toward 000 to obtain a reading of -10.00 Vdc on the DVM (-100% of range).

11. Adjust the XDCR 2 DC X1 potentiometer to obtain an indication of precisely -100% of system full-scale range (or the percentage of the transducer's range defined as full-scale) on the calibration standard readout. For example, if a load cell rated at 5000 pounds is being used, the X1 potentiometer should be adjusted until the load standard readout indicates precisely 5000 pounds. Or, if a load cell rated for 5000 pounds is used but the defined full-scale range is only 4000 pounds, the X1 potentiometer should be adjusted until the load standard readout indicates precisely 4000 pounds.

12. Adjust the SET POINT control toward 1000 to obtain a reading of +10.00 volts on the DVM (+100% of full-scale).

NOTE

If 100% of system full-scale can not be obtained during ΔK adjustment (step 13), diode CR3 must be reversed on the dc conditioner circuit card and steps 5 through 13 must be repeated. Figure 3-9 shows the location of CR3 on the circuit card.

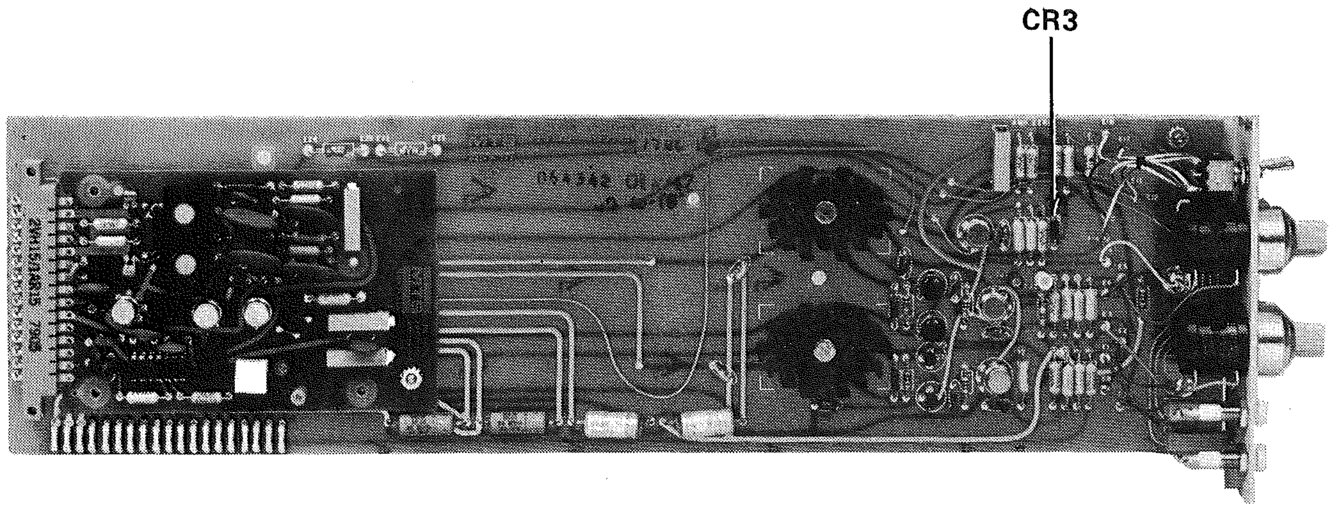

Figure 3-9. DC Conditioner Circuit Card

13. Adjust the XDCR 2 DC ΔK potentiometer to obtain an indication of precisely +100% of system full-scale on the calibration standard readout.

14. Remove hydraulic pressure from the servovalve.

15. Set the XDCR 2 DC X1/X10 toggle switch to X10.

16. Adjust the SET POINT control to zero the panel meter.

17. Apply full hydraulic pressure to the servovalve.

18. Adjust the SET POINT control toward 000 to obtain a reading of -10.00 Vdc on the DVM.

19. Adjust the XDCR 2 DC X10 potentiometer to obtain an indication of precisely -10% of system full-scale range (or -10% of the percentage of range defined as full-scale) on the calibration standard readout.

20. Turn off hydraulic pressure.

3.6.2.2 Calibration for Resistive Strain Gages (Option A)

NOTE

Perform procedure 3.6.1 before performing the following procedure.

Resistive strain gages are typically bonded directly to a specimen to measure its deformation under stress. The gages are usually connected in a four-arm Wheatstone bridge configuration such as that shown in figure 3-10. For axial strain measurements, two of the bridge arms are usually active and the other two arms are connected transversely or bonded to a dummy specimen. For torsional strain measurements, either two or all four bridge arms may be active.

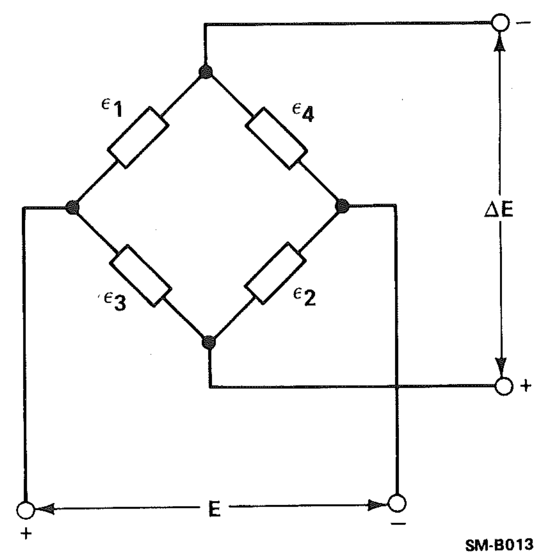

Figure 3-10. Strain Gage Bridge Configuration

Since these applications are typically continued to specimen failure, it is impractical to attempt to calibrate the dc conditioner under actual operating conditions. The following procedure simulates strain by unbalancing the bridge configuration with a shunt resistor. The strain gages must be in a static condition. A digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution is required for this procedure. Do not apply hydraulic pressure.

The following terms are used in the caluclations made in the procedure:

K = the gage factor of the strain gages

K_b = the bridge sensitivity of the strain gage configuration in volts/volt

ε_s = the desired simulated full-scale microstrain in microinches/inch

ε_n = the desired full-scale microstrain on strain gage n (+ = tension; - = compression)

E = the bridge excitation in volts

N = the number of active gages in the strain gage bridge configuration

R_s = the required shunt resistance in ohms

R_g = the strain gage resistance in ohms

1. Calculate the sensitivity of the strain gage configuration by using the following formula:

$$K_b = \frac{K(\varepsilon_1 + \varepsilon_2 - \varepsilon_3 - \varepsilon_4)}{4x10^6}$$

For example, determine the bridge sensitivity for the bending beam strain measurement shown in figure 3-11 given K = 2.06 and a desired full-scale strain of ±1500 microstrain (ε_1 = +1500, ε_2 = 0, ε_3 = -1500, ε_4 = 0). Figure 3-11 also shows the bridge configuration schematically.

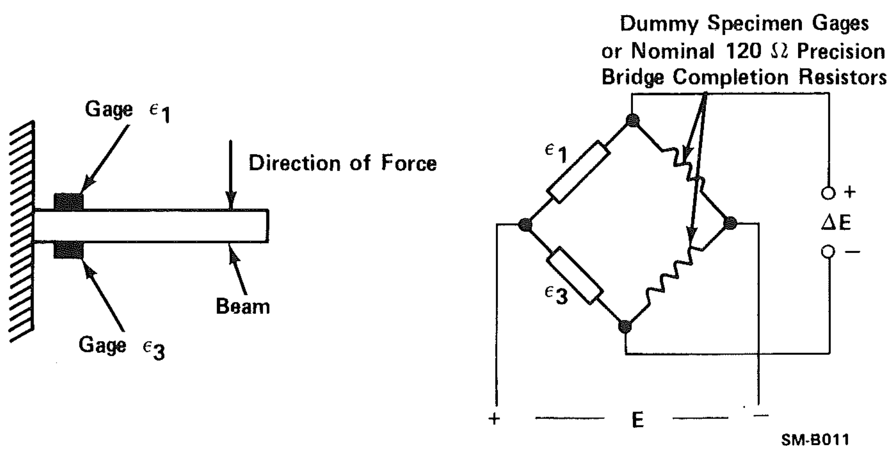

Figure 3-11. Typical Strain Gage Configuration

$$K_b = \frac{2.06(1500+0-(-1500)-0)}{4x10^6}$$

$$= \frac{2.06(3000)}{4x10^6}$$

$$= 0.001545 \text{ volts/volt at 1500 microstrain}$$

2. Calculate the correct bridge excitation voltage using the following formula:

$$E = \frac{0.02}{K_b}$$

The correct bridge excitation voltage for the example given in step 1 is:

$$E = \frac{0.02}{0.001545}$$

$$= 12.9 \text{ volts}$$

NOTE

Do not adjust excitation to a voltage above that recommended by the strain gage manufacturer. If the voltage calculated in step 2 is above the recommended voltage, the internal gain of the dc transducer conditioner must be changed to accommodate the strain gage configuration (refer to paragraph 3.6.3).

3. Connect the DVM between the +EX and -EX jacks on the XDCR 2 DC front panel.

4. Adjust the XDCR 2 DC EXCITATION control to obtain a reading on the DVM which corresponds to the voltage calculated in step 2. Note the setting of the EXCITATION control for future reference.

5. Connect the DVM between the XDCR 2 test jack and the common (black) test jack.

6. Adjust the XDCR 2 DC ZERO control to obtain a reading of 0.00 Vdc on the DVM. Lock the control.

7. Set the XDCR 2 DC X1/X10 toggle switch to X1.

8. An MTS Shunt Calibrator may be provided for strain gage calibration. If a shunt calibrator is not available, calculate the required value of shunt resistance by using the following formula:

$$R_s = \frac{R_g \times 10^6}{N\epsilon_s K} - R_g$$

For example, determine the shunt resistance required to simulate full-scale microstrain given the following values:

$R_g = 121.2\,\Omega$

$N = 2.0$

$\varepsilon_s = 1500$

$K = 2.06$

For this example, the formula is:

$$R_s = \frac{121.2 \times 10^6}{(2)\,(1500)\,(2.06)} - 121.2 = 19{,}490\,\Omega$$

*** WARNING ***

Do not insert a shunt calibrator or connect a resistor between the R/CAL jacks when hydraulic pressure is applied to the servovalve. Sudden actuator movement will result.

9. If available, insert the shunt calibrator into the XDCR 2 R/CAL jacks on the controller rear panel. If a shunt calibrator is not available, obtain a 1% precision resistor of the value calculated in step 8 or, if necessary, of a value slightly greater than that calculated in step 8. Connect the resistor to the XDCR 2 R/CAL jacks.

   The offset imposed by the shunt resistor is either positive or negative, depending on which bridge arm is shunted. If the shunt resistor is precisely the calculated value, the offset is 100%, simulating full-scale microstrain. If the shunt resistor is of slightly greater value than the calculated value, the offset is proportionally decreased. For example:

   R_s for 100% μstrain = 19,490 Ω

   Available precision resistor = 19,600 Ω

   $$\text{Offset} = \frac{19490}{19600} = 99.4\%$$

10. Adjust the XDCR 2 DC X1 potentiometer to obtain a voltage reading on the DVM which corresponds to the percent of offset produced by the shunt calibrator or shunt resistor. For a 100% offset, adjust for a DVM reading of 10.00 Vdc. For the example in step 9 (99.4% offset), the proper adjustment is 9.94 Vdc.

3.6.2.3 Calibration for Resistive Extensometers (Option A)

NOTE

Perform procedure 3.6.1 before proceeding with the following procedure.

Resistive extensometers are typically attached to materials test specimens to measure specimen deformation under stress. Since such tests are usually continued to specimen failure, it is impractical to attempt to calibrate the dc conditioner under actual operating conditions. The following procedure mechanically simulates full-scale strain to calibrate the dc conditioner. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and an MTS Model 650.03 Extensometer Calibrator or equivalent. Do not apply hydraulic pressure at this time.

1. Set the XDCR 2 DC X1/X10 toggle switch to X1.

2. Connect the DVM between the XDCR 2 test jack and the common (black) test jack.

3. Attach the extensometer gage arms to the fixed and movable rods of the calibrator. It may be necessary to attach adaptors to the rods to provide a solid mechanical connection.

4. Adjust the calibrator to obtain the precise extensometer gage length.

5. Adjust the XDCR 2 DC ZERO control to obtain a reading of 0.00 Vdc on the DVM. Lock the control.

6. Adjust the calibrator for a compressive extensometer gage arm displacement of precisely 100% of system full-scale (typically the maximum rating of the extensometer).

7. Adjust the XDCR 2 DC X1 potentiometer to obtain a reading of -10.00 Vdc on the DVM.

8. Adjust the calibrator for a tensile extensometer gage arm displacement of precisely 100% of system full-scale.

NOTE

If +10 Vdc cannot be obtained during ΔK adjustment (step 9), diode CR3 must be reversed on the dc conditioner circuit card and steps 4 through 9 must be repeated. Figure 3-9 shows the location of CR3 on the circuit card.

9. Adjust the XDCR 2 DC ΔK potentiometer to obtain a reading of +10.00 Vdc on the DVM.

10. Set the XDCR 2 DC X1/X10 toggle switch to X10.

11. Adjust the calibrator for a compressive extensometer gage arm displacement of precisely 10% of system full-scale.

12. Adjust the XDCR 2 DC X10 potentiometer to obtain a reading of -10.00 Vdc on the DVM.

NOTE

The ΔK adjustment made in step 9 provides tensile calibration in the X10 range as well as the X1 range.

3.6.2.4 Calibration for Pressure Transducers (Option A)

NOTE

Procedure 3.6.1 must be performed before proceeding with the following procedure.

The following procedure applies to pressurization control systems. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and a pressure standard such as a dead-weight standard, a 0.1% accuracy pressure gage, or a pressure transducer with readout capable of measuring system full-scale pressure. In some cases, a gage is supplied as part of the system. If not, a gage can usually be attached to the system at the specimen attachment port. No specimen need be attached prior to calibration, however, the attachment port must be dead-ended to prevent leakage of the pressurizing medium.

Do not apply hydraulic pressure until instructed to do so.

1. Ensure that the specimen attachment port is dead-ended and that the pressure standard is installed to read output pressure. Ensure that all connections can withstand full-scale system pressure without leakage.

2. Set the XDCR 2 DC X1/X10 toggle switch to X1.

3. Turn the FDBK SELECT switch to XDCR 2.

4. Connect the DVM between the XDCR 2 test jack and the common (black) test jack.

5. Turn the panel meter selector to ERROR.

6. Adjust the XDCR 2 DC ZERO control to zero the panel meter.

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

7. Apply full hydraulic pressure to the servovalve.

8. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

9. Adjust the XDCR 2 DC ZERO control to obtain a zero indication on the pressure standard. Lock the control.

10. Adjust the SET POINT control to obtain a reading of +10.00 Vdc (+100% of range) on the DVM.

11. Adjust the XDCR 2 DC X1 potentiometer to obtain a reading of precisely 100% of system full-scale (typically the maximum transducer rating) on the pressure standard.

12. Remove hydraulic pressure from the servovalve.

CAUTION

Do not change the position of X1/X10 toggle switch while hydraulic pressure is applied to the servovalve. Violent actuator movement may occur resulting in personal injury and/or equipment damage.

13. Set the XDCR 2 DC X1/X10 toggle switch to X10.

14. Adjust the SET POINT control to zero the panel meter.

15. Apply full hydraulic pressure to the servovalve.

16. Adjust the SET POINT control to obtain a reading of +10.00 Vdc on the DVM.

17. Adjust the XDCR 2 DC X10 potentiometer to obtain a reading of precisely 10% of system full-scale on the pressure standard.

18. Remove hydraulic pressure from the servovalve.

3.6.2.5 Calibration for DC Stroke or Angular Displacement Transducers (Option A)

NOTE

Procedure 3.6.1 must be performed before proceeding with the following procedure.

The following procedure applies only to dc stroke or angular displacement transducers. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution and an instrument to measure full-scale stroke or angular displacement.

The actuator rod or shaft must be free to move to full-scale in either direction without interference. Do not apply hydraulic pressure until instructed to do so.

1. Set the XDCR 2 DC X1/X10 toggle switch to X1.

2. Turn the FDBK SELECT switch to XDCR 2.

3. Connect the DVM between the XDCR 2 test jack and the common (black) test jack.

4. Turn the XDCR 2 DC ZERO control to 500.

5. Turn the panel meter selector switch to ERROR.

6. Adjust the SET POINT control to zero the panel meter.

*** WARNING ***

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command=feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

7. Apply full hydraulic pressure to the servovalve.

8. Adjust the SET POINT control to obtain a reading of 0.00 Vdc on the DVM.

9. Attach the measuring instrument so that it can read system full-scale displacement in either direction.

10. Record the reading of the measuring instrument. This is the actuator mid-position reading.

11. Adjust the SET POINT control toward 000 to obtain a reading of -10.00 Vdc (-100% of range) on the DVM.

12. Record the reading of the measuring instrument.

13. Calculate the difference of the readings recorded in steps 10 and 12. The calculated difference should be precisely 100% of system full-scale in one direction from mid-position. If not, adjust the XDCR 2 DC X1 potentiometer to obtain the proper displacement. For example, if a stroke transducer with a full-scale range of ±5 inches is being used, adjust the X1 potentiometer until the deflection of the measuring instrument indicates precisely 5 inches. Or, if a stroke transducer with a full-scale range of ±5 inches is being used but system full-scale is defined as ±4 inches, adjust the X1 potentiometer until the deflection of the measuring instrument indicates precisely 4 inches.

14. Adjust the SET POINT control toward 1000 to obtain a reading of +10.00 Vdc on the DVM.

NOTE

If 100% of system full-scale cannot be obtained during ΔK adjustment (step 15), diode CR3 must be reversed on the dc conditioner circuit card and steps 4 through 15 must be repeated. Figure 3-9 shows the location of CR3 on the circuit card.

15. Adjust the ΔK adjustment to obtain actuator movement of precisely 100% of system full-scale in the opposite direction from the mid-position that was adjusted for in step 13.

16. Remove hydraulic pressure from the servovalve..

CAUTION

> Do not change the position of the X1/X10 toggle switch with hydraulic pressure applied to the servovalve. Sudden actuator movement may result.

17. Set the XDCR 2 DC X1/X10 toggle switch to X10.

18. Adjust the SET POINT control to zero the panel meter.

19. Apply full hydraulic pressure to the servovalve.

20. Adjust the SET POINT control toward 000 to obtain a reading of -10.00 Vdc on the DVM.

21. Adjust the XDCR 2 DC X10 potentiometer to position the actuator at precisely 10% of system full-scale displacement in one direction from mid-position.

NOTE

> The ΔK adjustment made in step 15 adjusts the X10 range as well as the X1 range.

22. Remove hydraulic pressure from the servovalve.

3.6.3 CHANGING THE INTERNAL GAIN OF THE DC CONDITIONER

If a 20mV full-scale output cannot be obtained from a specific transducer without exceeding the maximum recommended excitation voltage, the internal gain of the dc conditioner (option A) must be changed. If necessary, perform the following procedure to change the internal gain of the conditioner to suit a particular transducer application.

The following terms are used in the calculations made in the procedure:

ΔE = the transducer full-scale output in volts

E = the transducer excitation in volts

K_b = the transducer sensitivity in volts/volt

A_v = the amplifier gain

R2 = the gain resister value in ohms

1. Turn off ac power to the controller and remove the dc conditioner module from the controller chassis.

2. Remove the low-level amplifier circuit card from the dc conditioner module. The circuit card is mounted in a circuit card connector at the rear of the module main circuit card (refer to figure 3-1).

3. Using the following formula, calculate the full-scale output voltage of the transducer at the maximum recommended excitation voltage.

$$\Delta E = EK_b$$

For example, calculate the transducer full-scale output given E = 10 Vdc and K_b = 2 mV:

$$\Delta E = (10)(0.002) = 0.02 \text{ volts}$$

4. Using the following formula, calculate the gain required to produce an amplifier output of 10V when the calculated full-scale transducer output (step 3) is applied.

$$A_v = \frac{10}{\Delta E}$$

5. Using the following formula, calculate the gain resistor value (in ohms) required to produce the gain calculated in step 4.

$$R2 = \frac{99{,}800}{A_v - 1}$$

6. Remove resistor R2 on the low-level amplifier circuit card. R2 is mounted on resistor mounting posts next to the AC CMR potentiometer on the circuit card.

7. Obtain a 1% precision resistor of the value calculated in step 5 (or of slightly greater resistance) and solder it to the R2 mounting posts.

8. Re-install the low-level amplifier circuit card.

9. Re-install the dc conditioner module into the controller chassis.

3.7 OPTION F CONDITIONER PANEL CALIBRATION

Calibration of the Option F Conditioner Panel includes adjustment of the power supply. The adjusted voltage serves as a reference for the limit detector circuitry (option G) and optional modules installed in the panel.

Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution. Refer to figure 3-12 for the location of test points and adjustments. Do not apply hydraulic pressure.

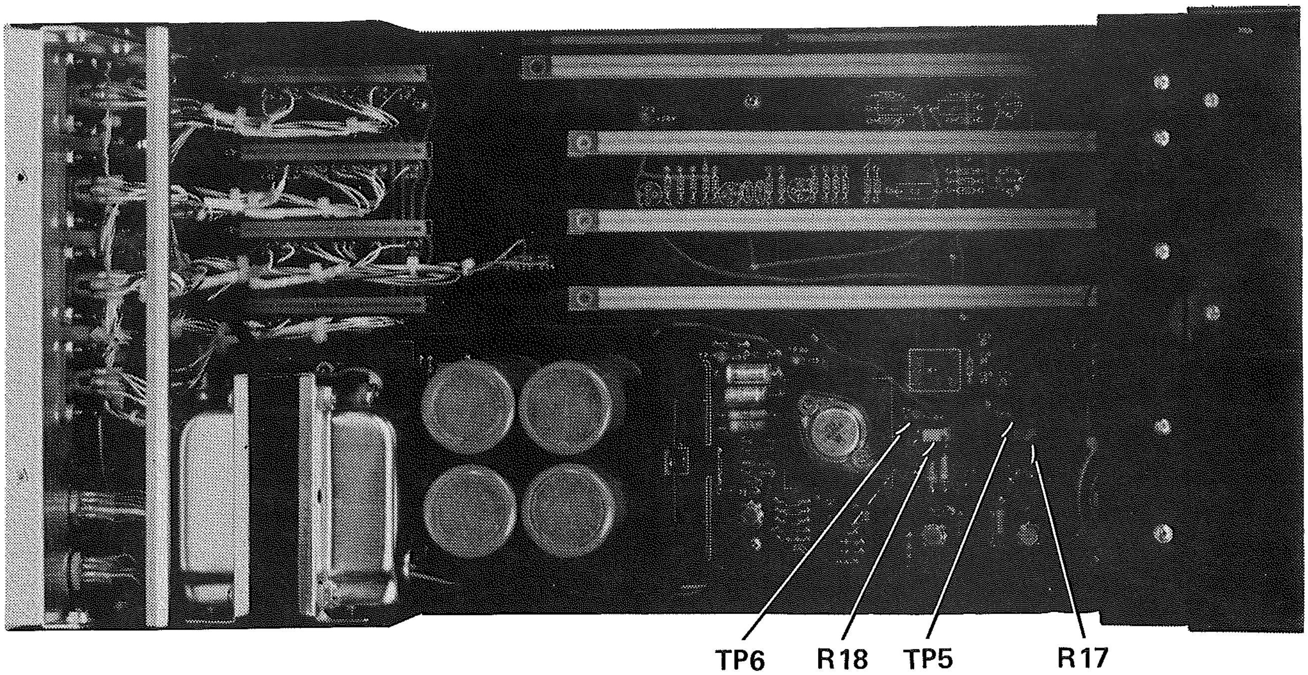

Figure 3-12. Option F Conditioner Panel (Top View)

1. Turn off ac power to the conditioner panel, remove the conditioner panel from the equipment rack (if rack mounted) and remove the top cover.

2. Connect the DVM between test point 5 and the common test jack.

***** WARNING *****

A potential shock hazard exists whenever making adjustments inside any electrical device. Use extreme caution when approaching these areas.

3. Apply ac power to the conditioner panel.

4. Adjust variable resistor R17 to obtain a reading of +10.000, ±0.002 Vdc on the DVM.

5. Connect the DVM between test point 6 and the common test jack.

6. Adjust variable resistor R18 to obtain a reading of -10.000, ±0.002 Vdc on the DVM.

7. Turn off ac power, replace the top cover, and replace the panel in the rack.

3.8 STROKE-TO-VELOCITY CONVERTER CALIBRATION (OPTION H)

Calibration of the stroke-to-velocity converter (option H) is generally performed as part of periodic calibration of the entire system. Refer to the system Calibration Checklist located in the Service section of the System Reference Manual for the proper calibration sequence. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution, an oscilloscope, and a function generator.

Refer to figure 3-13 for the location of test points and adjustments on the option H circuit card. Do not apply hydraulic pressure for this procedure.

1. Turn off ac power to the controller and remove the controller from the equipment rack (if rack mounted) and remove the top cover if not already removed. Locate the stroke-to-velocity converter circuit card (circuit card assembly 082235-01).

***** WARNING *****

A potential shock hazard exists whenever making adjustments inside any electrical device. Use extreme caution when approaching these areas.

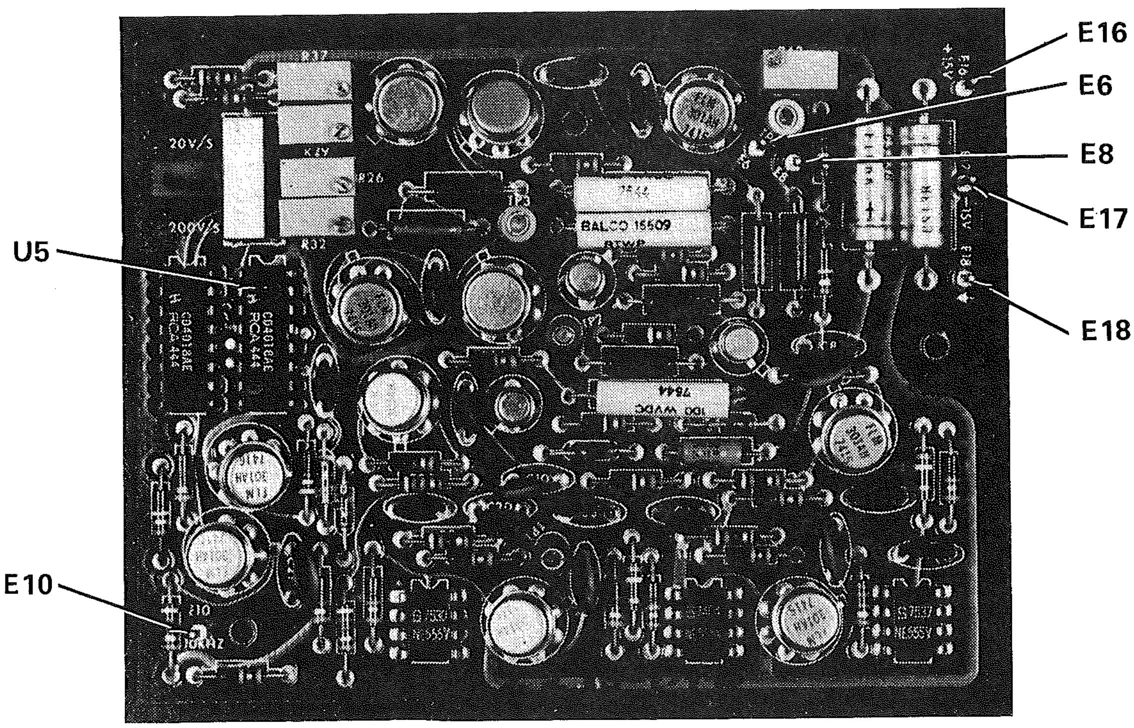

Figure 3-13. Stroke-To-Velocity Circuit Card (Option H)

2. Apply ac power to the controller.

3. Connect the DVM between the appropriate XDCR 1 or XDCR 2 test jack and common (black) test jack on the controller front panel.

4. Adjust the appropriate XDCR 1 or XDCR 2 ZERO control to obtain a reading of 0.000, ±0.002 Vdc on the DVM.

5. Connect the DVM between test point 2 (red) on the option H circuit card and the common test jack.

6. Adjust variable resistor R26 to obtain a reading of 0.000, ±0.002 Vdc on the DVM.

7. Connect the DVM to the output of integrated circuit AR6 (junction of pin 6 of AR6 and resistor R30).

8. Adjust variable resistor R29 to obtain a reading of 0.000, ±0.002 Vdc on the DVM.

9. Connect the oscilloscope between test point 3 (orange) and common. Connect the DVM between the appropriate XDCR 1 or XDCR 2 test jack and common on the controller front panel.

10. Adjust the appropriate XDCR 1 or XDCR 2 ZERO control to obtain a reading of +5.00 Vdc on the DVM.

11. Adjust variable resistor R32 to bring the base line of the waveform on the oscilloscope to near zero.

12. Adjust the appropriate XDCR 1 or XDCR 2 ZERO control to obtain -5.00 Vdc on the DVM.

13. Adjust variable resistor R32 to bring the base line of the waveform to near zero.

14. Repeat steps 10 through 13 until minimum base line shift is observed on the oscilloscope.

15. Connect the DVM between test point 3 (orange) and common.

16. Adjust variable resistor R29 to obtain a reading of 0.00, ±0.01 Vdc.

17. Connect the DVM between test point 4 (yellow) and common.

18. Adjust variable resistor R37 to obtain a reading of 0.000, ±0.005 Vdc on the DVM.

NOTE

The function generator will now be used to calibrate the output amplifier for full-scale velocity amplitude. For this purpose, it is necessary to calculate the freqency which will produce full-scale output (±10 Vdc) in the selected velocity range. Velocity range is determined by the position of a slide switch on the stroke-to-velocity circuit card, typically shown in volts per second (V/S).

19. Select a triangle waveform on the function generator (peak output must be 10V).

20. Compute the required frequency setting using the following formula:

$$\text{Frequency} = \frac{1}{4(\text{Ramp Time Base})}$$

Where:

$$\text{Ramp Time Base} = \frac{10}{\text{range in V/S}}$$

For example, in the 200 V/S range;

$$\text{Ramp Time Base} = \frac{10}{200} = 0.05 \text{ sec}$$

$$\text{Frequency} = \frac{1}{4(0.05)} = 5 \text{ Hz}$$

21. Set the function generator for the calculated frequency.

22. Connect the function generator output between point E8 and common.

23. Connect the oscilloscope between test point 4 (yellow) and common.

24. A square wave should be observed on the oscilloscope. Adjust variable resistor R42 for square wave peaks of ±10V.

25. Turn off ac power to the controller, remove all test leads, replace the controller top cover, and replace the controller in the equipment rack (if applicable).

3.9 DUAL ACCELEROMETER CONDITIONER CALIBRATION (OPTION J)

The Dual Accelerometer Conditioner (option J) may be calibrated for use with one or two piezoelectric accelerometers. Whenever possible, the amplifier should be calibrated with the accelerometer(s) operating at a known acceleration level.

Calibration must be performed under actual operating conditions, however, do not set the accelerometer(s) in motion until instructed to do so. Additional equipment required for calibration includes a digital voltmeter (DVM) accurate to 0.03% with 1mV resolution and an oscilloscope. Refer to figure 3-14 for the location of test points and adjustments.

NOTE

The top cover of the 406.11 Controller must be removed to gain access to the option J circuit card. The option J circuit card is mounted in the XDCR 2 connector slot.

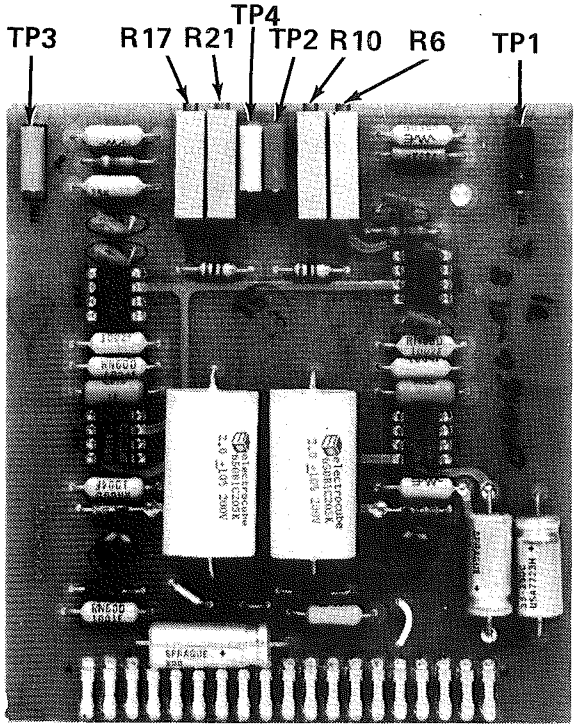

Figure 3-14. Dual Accelerometer Circuit Card

Perform the following procedure to calibrate the acceleration conditioner. Do not apply hydraulic pressure until instructed to do so.

***** WARNING *****

An electrical shock hazard exists whenever making adjustments within any electrical device. Use extreme caution when approaching these areas.

1. Connect the DVM between test point 2 and common.

2. Adjust variable resistor R6 to obtain a reading of 0.00 Vdc on the DVM.

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have zero dc error (command = feedback) when hydraulic pressure is applied will result in violent actuator movement which may cause personal injury.

3. Apply full hydraulic pressure to the servovalve.

4. Set accelerometer 1 in motion.

5. Connect the oscilloscope between the appropriate XDCR 1 or XDCR 2 jack (whichever is the stroke transducer) and the common jack on the controller front panel.

6. Monitor the oscilloscope and determine the frequency and peak-to-peak amplitude of the stroke feedback signal.

7. Calculate acceleration using formula A for U.S. customary units or formula B for metric units.

   A. acceleration = (0.0511)(frequency ^{2})(displacement in inches)

   B. acceleration = (2.013)(frequency ^{2})(displacement in metres)

   For example, with 0.05 inches displacement and a frequency of 19.78 Hz:

   $$\text{acceleration} = (0.0511)(19.78^2)(0.05)$$

   $$= (0.0511)(391.248)(0.05)$$

   $$= 1\text{ g}$$

8. Disconnect the DVM and connect the oscilloscope between test point 2 and common.

9. While monitoring the acceleration waveform (test point 2) on the oscilloscope, adjust variable resistor R10 to set the peak-to-peak amplitude of the waveform to the voltage desired to represent the acceleration calculated in step 7. For example, if the acceleration calculated in step 7 is 1g, and for readout or control purposes it is desired that 1 volt represent 1g, adjust R10 until the peak-to-peak amplitude of the waveform on the oscilloscope is 1 volt.

NOTE

Perform steps 10 through 15 only if a second accelerometer is present in the system.

10. Connect the DVM between test point 4 and common.

11. Adjust variable resistor R17 to obtain a reading of 0.00 Vdc on the DVM.

12. Set accelerometer 2 in motion.

13. Calculate acceleration (refer to step 7).

14. Disconnect the DVM and connect the oscilloscope between test point 4 and common.

15. Adjust variable resistor R21 to obtain an output signal corresponding to the voltage desired to represent the acceleration calculated in step 13.

16. Remove hydraulic pressure from the servovalve, turn off ac power to the controller, remove all test leads, replace the controller cover and (if applicable) replace the controller in the equipment rack.

SECTION IV
INSTALLATION

This section provides instructions for making appropriate power, ground, and system connections to the Model 406.11 Controller; mounting the controller(s) in a rack if desired; and checking controller operation once all connections have been made. All connections are made to the cable connectors on the controller rear panel (refer to figure 4-1). For a complete system installation, it is necessary to refer to the instructions provided for the other system components.

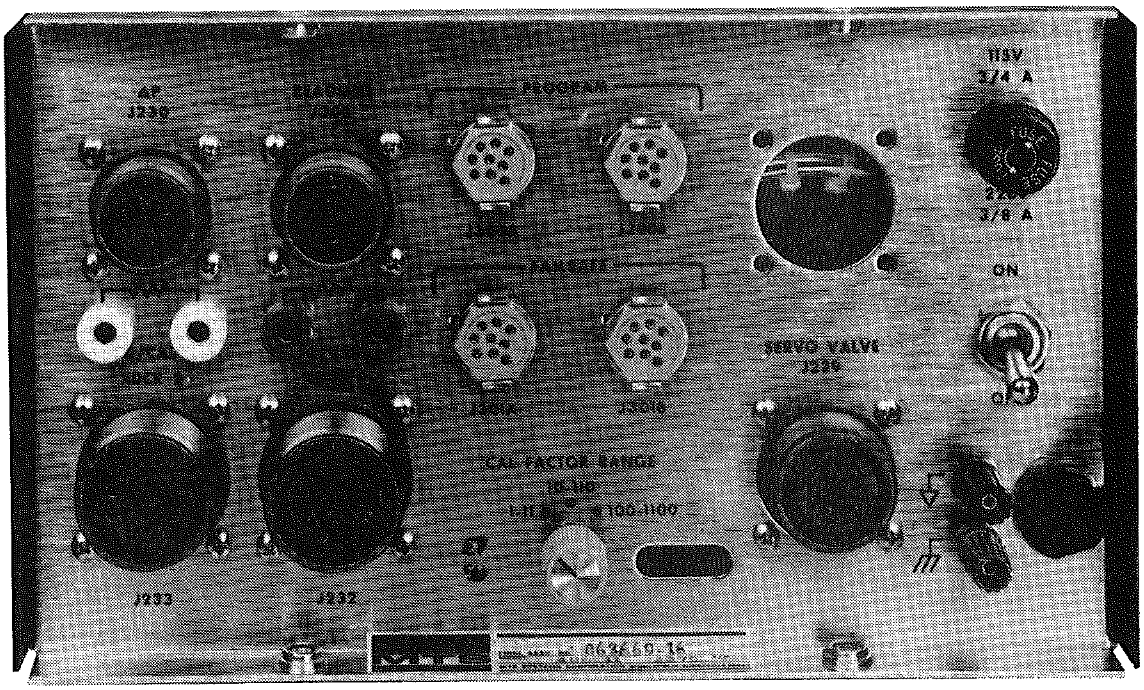

Figure 4-1. 406.11 Controller Rear Panel

4.1 ELECTRICAL POWER CONNECTIONS

The 406.11 Controller receives ac power from the permanent 3-wire power cord. The power ground wire of the cord is connected to the controller chassis and to the green terminal on the controller rear panel.

The two primary windings of the controller power transformer are connected in parallel for 105 to 125 Vac operation or in series for 210 to 250 Vac operation. Transformer wiring is accomplished by the connection of jumper wires between points on the controller main circuit card. Unless otherwise specified, the controller is factory wired for 105 to 125 Vac operation.

4.1.1 TRANSFORMER JUMPER WIRE CONNECTIONS

The transformer jumper wire solder terminals (labeled E89, E90, E91, and E92) are located just below the power transformer inside the controller chassis. It may be necessary to remove the transformer to gain access to the terminals. To remove the transformer turn off ac power, remove the four screws holding the transformer to the side of the chassis, and set the transformer aside. Do not disconnect the transformer.

To connect the transformer for 105-125 Vac operation:

1. Remove any existing jumper wires.
2. Solder a jumper wire from terminal E89 to E90.
3. Solder a jumper wire from terminal E91 to E92.
4. Install a 115 V, 3/4 A fuse in the fuseholder on the controller rear panel.

To connect the transformer for 210-250 Vac operation:

1. Remove any existing jumper wires.
2. Solder a jumper wire from terminal E90 to E91.
3. Install a 220 V, 3/8 A fuse in the fuseholder on the controller rear panel.
4. Install a Hubbell 5666 or equivalent power plug.

4.1.2 SYSTEM COMMON AND GROUND CONNECTIONS

The signal common terminal (black) and the electrical power ground terminal (green) are located on the controller rear panel. Proper grounding of signal common is important for minimum signal noise.

For a system containing only one 406.11 Controller, simply connect a jumper wire from the signal common terminal to the electrical power ground terminal. For a system containing more than one controller, it is recommended that all electrical power ground terminals be connected together with an 8 or 10 AWG wire, and then connected to a single power ground point.

4.2 RACK MOUNTING

Model 406.11 Controllers may be mounted singly or side-by-side in any 19-1/16 inch RETMA-type rack with standard EIA hole spacing. Mounting kits for single or double controller installations are available from MTS Systems Corporation. The kits contain a support shelf and all necessary hardware for front and rear support. In addition, the kit contains a blank panel to fill the space to the side of a singly installed controller.

Figure 4-2 shows a single controller installed in a typical rack.

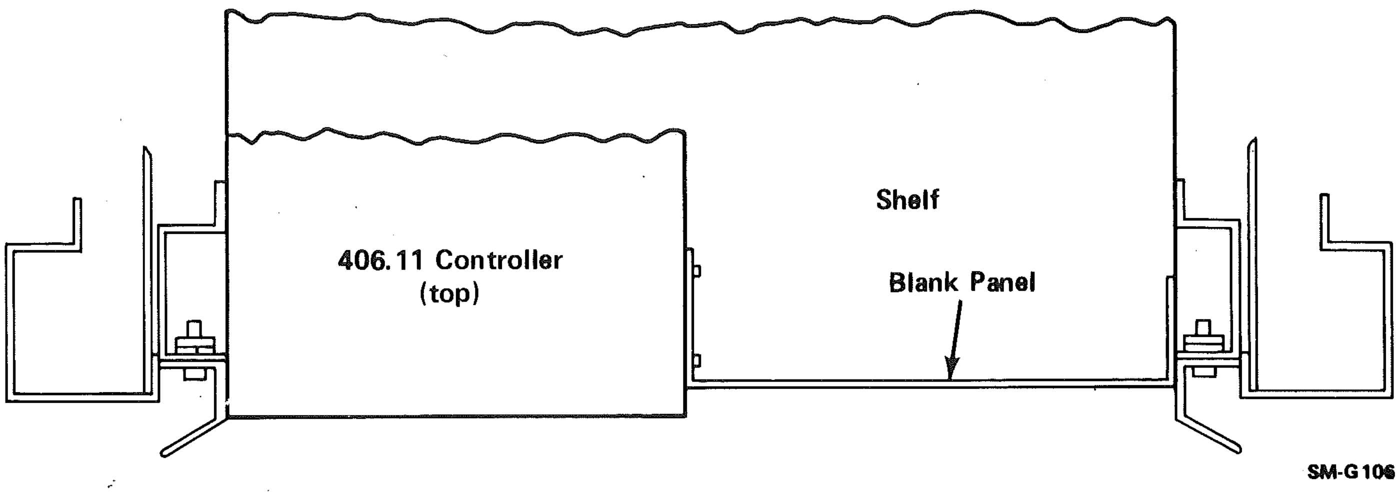

Figure 4-2. Single Controller Mounting (Top View)

Figure 4-3 shows two controllers mounted side-by-side. In either case, ensure that support is provided for the rear of the shelf as well as the front.

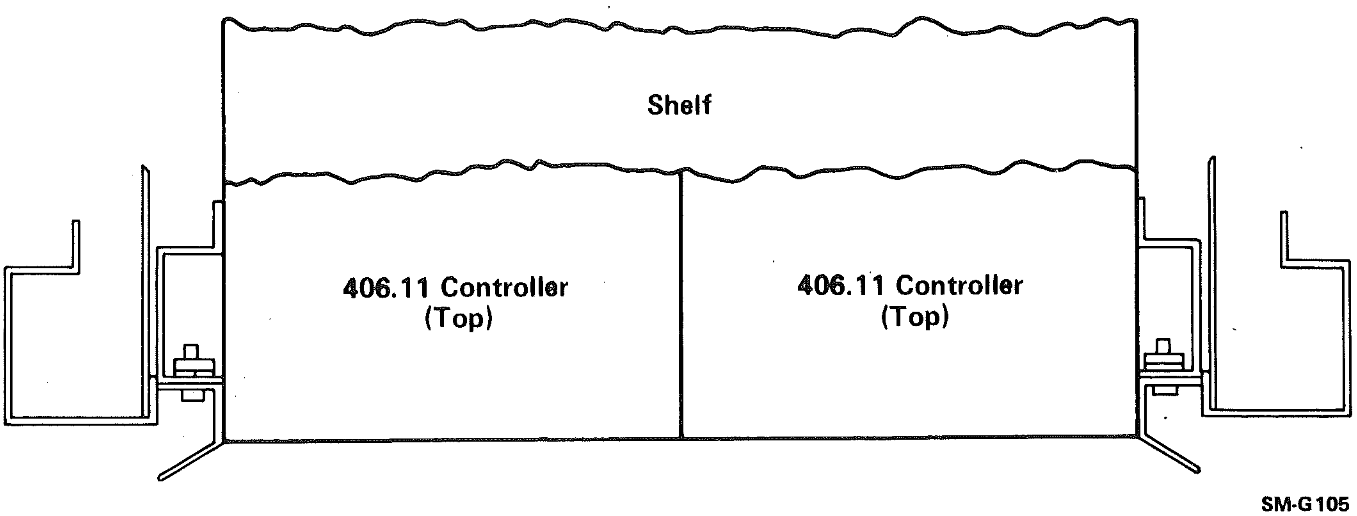

Figure 4-3. Double Controller Mounting (Top View)

NOTE

Consult MTS Systems Corporation if it is desired to mount the controller in a rack without EIA spaced holes.

4.3 SERVOVALVE CONNECTIONS

Servovalve connections are made to cable receptacle J229 on the controller rear panel. Figure 4-4 shows the recommended servovalve cable. As shown in figure 4-4, the controller drives the two servovalve coils in series. The jumper wire between pins B and C on the servovalve plug completes the series connection.

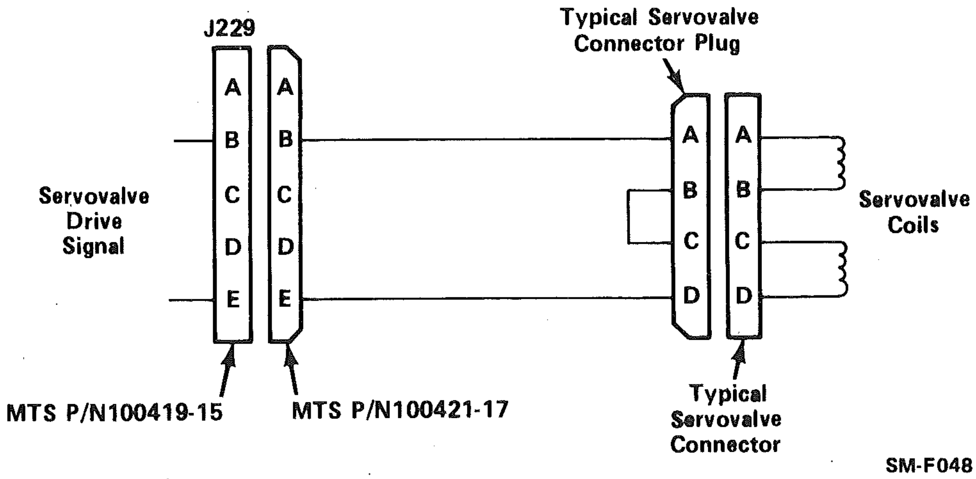

Figure 4-4. Recommended Servovalve Cable

If an MTS servovalve cable is not supplied, construct the cable using 18 AWG conductors with a 600 volt type SO neoprene jacket. It is not necessary to consider servovalve phasing when constructing the cable. A valve phase switch is provided on the controller rear panel to reverse the valve drive signal polarity if necessary. Use of the switch is explained in paragraph 4.10.1. It is necessary, however, to observe consistent polarity of the individual coils of series connected multiple coil servovalves.

***** WARNING *****

Ensure that the servovalve cable is well constructed and protected from damage after installation. If an open or short circuit occurs while hydraulic pressure is applied, loss of closed-loop control will result causing sudden and violent actuator movement.

4.3.1 DUAL SERVOVALVE CONNECTIONS

The controller is capable of simultaneously driving two servovalves for high frequency applications. Dual servovalves must be driven in parallel. The parallel connections may be made by either installing a second servovalve connector receptacle on the controller rear panel or by constructing a dual-plug cable to drive both servovalves from cable receptacle J229.

If it is necessary to drive dual servovalves and provisions for doing so have not been provided, perform one of the following procedures.

4.3.1.1 Connecting Dual Servovalves Using an Additional Cable Receptacle

Perform the following procedure to connect dual servovalves by installing an additional servovalve cable receptacle on the controller rear panel.

1. With ac power off, install a second cable receptacle (MTS P/N 100419-15) in the hole provided directly above cable receptacle J229 on the controller rear panel.

2. Using 18 AWG conductors, connect J229 pins B and E respectively to pins B and E of the second cable receptacle.

3. Obtain or construct a second servovalve cable (refer to figure 4-4) to connect the second servovalve to the controller.

4. Modify the controller for dual servovalve current requirements (refer to paragraph 4.3.2).

4.3.1.2 Connecting Dual Servovalves Using a Dual-Plug Cable

Perform the following procedure to construct a dual-plug cable to connect dual servovalves to the controller.

1. Obtain or construct a servovalve cable as shown in figure 4-4.

2. Obtain a second servovalve connector plug.

3. Using 18 AWG conductors with a 600 volt type S0 neoprene jacket, connect pin A of one plug to pin A of the other plug.

4. Connect pin D of one plug to pin D of the other plug.

5. Connect a jumper wire (18 AWG) between pins B and C of each plug but do not interconnect the two plugs at pins B and C.

6. With ac power off, connect the cable assembly between the controller and the two servovalves.

7. Modify the controller for dual servovalve current requirements (refer to paragraph 4.3.2).

4.3.2 CONTROLLER MODIFICATION FOR PROPER SERVOVALVE CURRENT

Unless otherwise specified, the controller is wired and adjusted for a single servovalve having a full-scale coil current rating of 40 mA. For servovalves with full-scale current ratings other than 40 mA, or for the operation of dual servovalves, resistors R174, R175, and R176 on the controller main circuit card must be replaced. Figure 4-5 shows the location of these resistors.

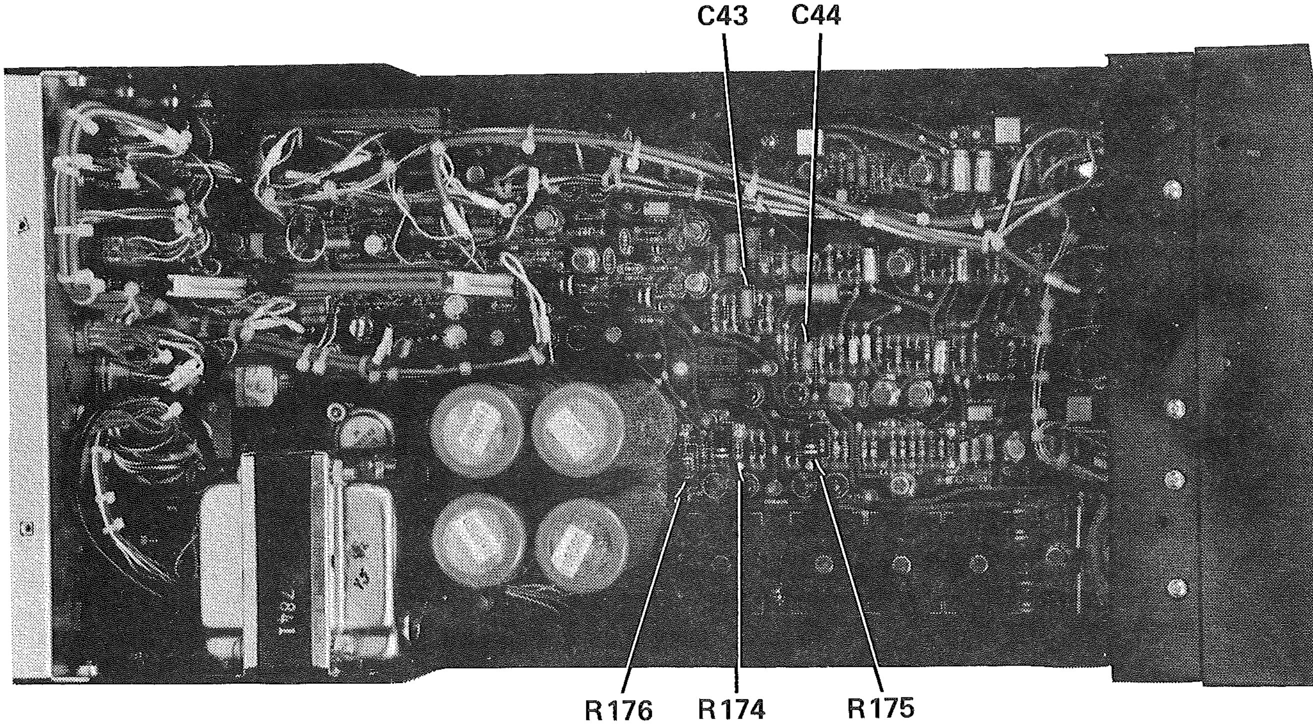

Figure 4-5. Internal (Top) View of 406.11 Controller

Table 4-1 shows the values of R174, R175, and R176 for common servovalve current ratings in single servovalve configurations.

Table 4-1. Resistor Values for Common Servovalve Current Ratings

Servovalve Current Ratings	Resistor Value (Ohms)	
	R174, R175	R176
15 mA	39 Ω 1/4 W	1K Ω 1/4 W
40 mA	15 Ω 1/4 W	470 Ω 1/2 W
200 mA	5.6 Ω 1/4 W	100 Ω 2 W

If a servovalve with a current rating other than those listed in table 4-1 must be used, use the following formulas to calculate approximate values for R174, R175, and R176:

$$R174 = R175 = \frac{0.77}{\text{valve current rating}}$$

$$R176 = \frac{10}{\left(\frac{\text{valve current rating}}{2}\right)}$$

For the operation of dual servovalves, the values of R174, R175, and R176 must be divided by two. Use only 1% precision resistors for all applications.

4.3.3 DITHER FREQUENCY RANGE MODIFICATION

Unless otherwise specified, the servo controller dither frequency is set up for a range of approximately 600 to 800 Hz. This is the frequency range suitable for the commonly used MTS Series 252.2X servovalves. The frequency range is determined by the value of capacitors C43 and C44 (normally 0.033 μF) on the controller main circuit card. Figure 4-5 shows the location of C43 and C44.

To change to a frequency range of 400 to 600 Hz (the suitable range for an MTS Series 252.3X servovalve) replace capacitors C43 and C44 with 0.047 μF capacitors. To change to another frequency range, an approximate calculation may be made by using the following formula:

$$C43 = C44 = \frac{1}{(47{,}000)(\text{lowest frequency of range})}$$

4.4 TRANSDUCER CONNECTIONS

The recommended cables for all transducers are constructed from a 4-conductor cable consisting of two individually twisted pairs having separate isolated shields as shown in figure 4-6. If unavailable, the use of dual twisted shielded cable may be satisfactory. It is not necessary to consider transducer phasing when constructing the cables. Phasing is described in paragraphs 4.10.3 through 4.10.5.

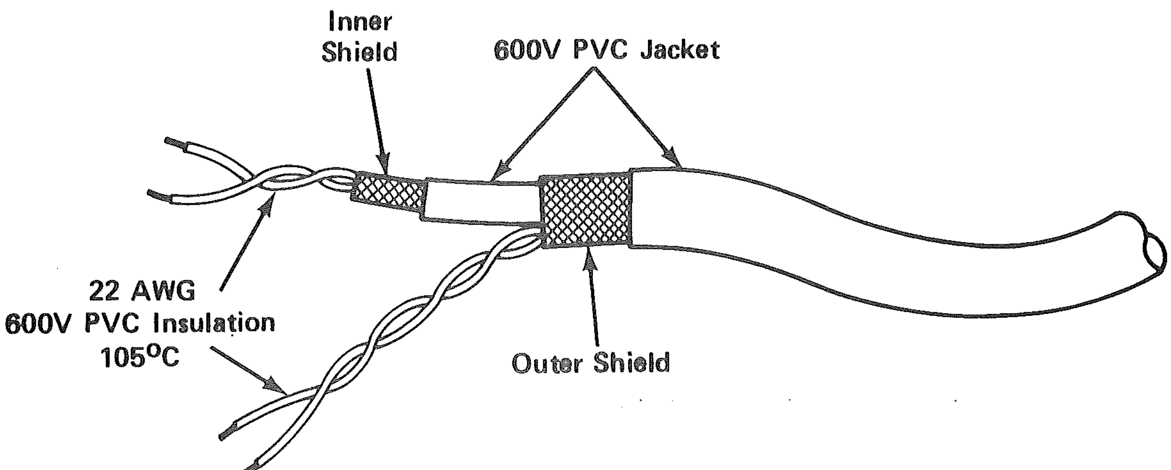

Figure 4-6. Recommended Transducer Cable Type

If the controller is provided as part of a system configuration and cables have been supplied, refer to the Console Drawing located in the Service section of the System Reference Manual for proper receptacle/transducer connections and cable part numbers.

***** WARNING *****

Ensure all transducer cables are well constructed and protected from damage after installation. If an open or short circuit should occur with hydraulic pressure applied, loss of closed-loop control may result causing sudden and violent actuator movement.

4.4.1 XDCR 1 CONNECTIONS

Cable receptacle J232 (XDCR 1) on the controller rear panel (refer to figure 4-1) is used to complete connections between the built-in transducer conditioner (XDCR 1) and either a resistive or reactive type transducer. Figure 4-7 shows the recommended cable construction for a typical resistive bridge transducer.

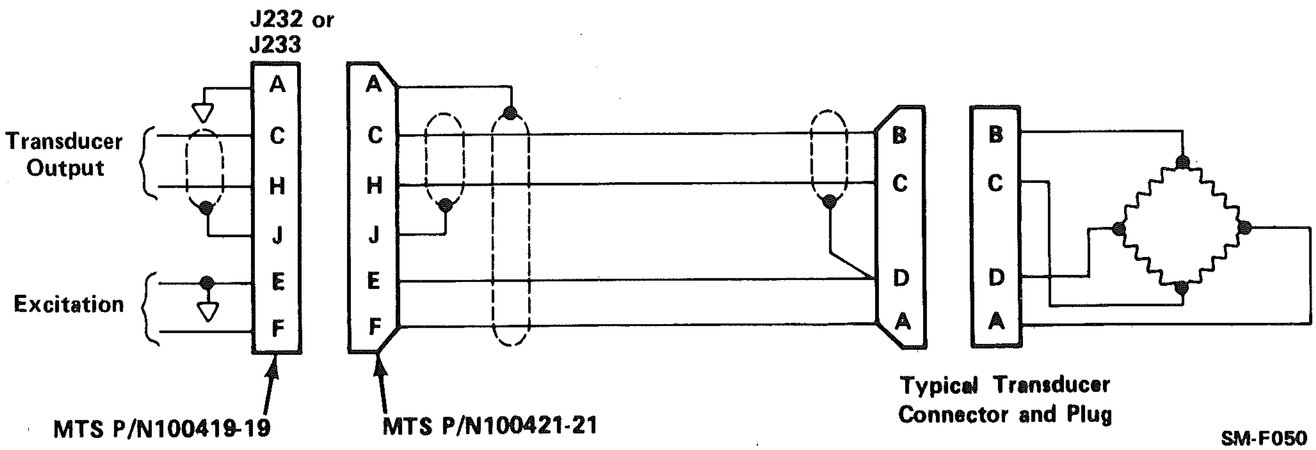

Figure 4-7. Recommended Cable for Resistive Transducers

Figure 4-8 shows the recommended cable construction for a typical reactive type transducer.

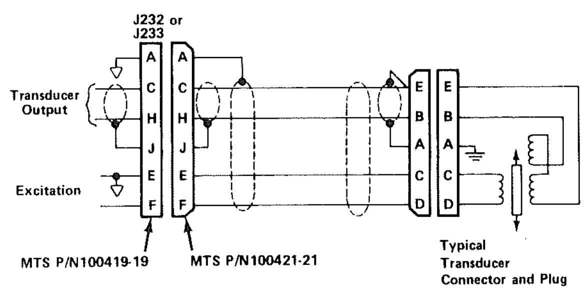

Figure 4-8. Recommended Cable for Reactive Transducers

4.4.2 XDCR 2 CONNECTIONS (OPTION A, D, E, OR J)

Cable receptacle J233 (XDCR 2) on the controller rear panel (refer to figure 4-1) is used to complete connections between option A, D, E, or J (installed in the XDCR 2 slot) and the transducer designated as transducer 2.

When the DC Transducer Conditioner (option A) is installed, a resistive transducer cable such as that shown in figure 4-7 is used to connect the module to a resistive transducer via receptacle J233.

When the Valve Controller (option D) is installed, a reactive transducer cable such as that shown in figure 4-8 is used to connect the module to the internal LVDT of the servovalve via J233.

When the AC Transducer Conditioner (option E) is installed, either a resistive transducer cable such as that shown in figure 4-7, or a reactive transducer cable such as that shown in figure 4-8 (depending on transducer type) is used to connect the module to the transducer via receptacle J233.

When the Dual Accelerometer Conditioner (option J) is installed, a transducer cable such as that shown in figure 4-9 is used to connect the circuit card to the accelerometer(s) via receptacle J233.

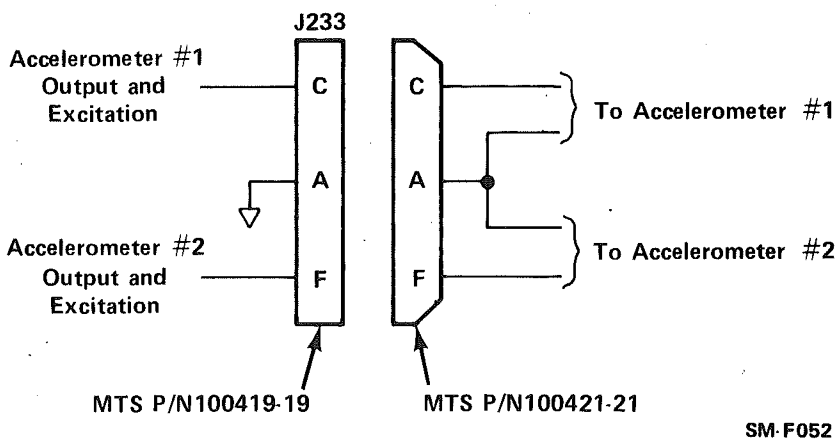

Figure 4-9. Recommended Dual Accelerometer Transducer Cable

4.4.3 ΔP TRANSDUCER CONNECTIONS (OPTION B)

Cable receptacle J230 (ΔP) on the controller rear panel is used to complete connections between the ΔP Stabilization (option B) circuit card and a resistive-bridge pressure transducer connected across the actuator piston. Figure 4-10 shows the recommended cable construction.

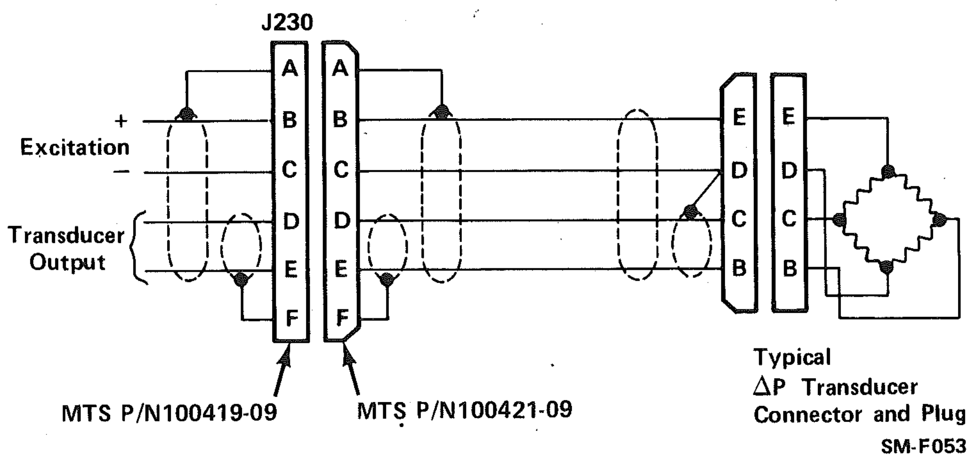

Figure 4-10. Recommended ΔP Transducer Cable

4.5 READOUT AND EXTERNAL FEEDBACK CONNECTIONS

Cable receptacle J302 (READOUT) on the controller rear panel may be simultaneously used for two separate functions:

- o To provide readout connections between the transducer conditioner output(s) and a readout device, and;
- o To provide connections for a third, external feedback input from a remote transducer conditioner.

Figure 4-11 shows the recommended cable construction. The cable may be constructed to accommodate either one or both functions. Cable shielding is not typically required, although it may be used if desired. The outputs for readout are designed for high-impedance readout instruments that require no more than 5 mA drive current.

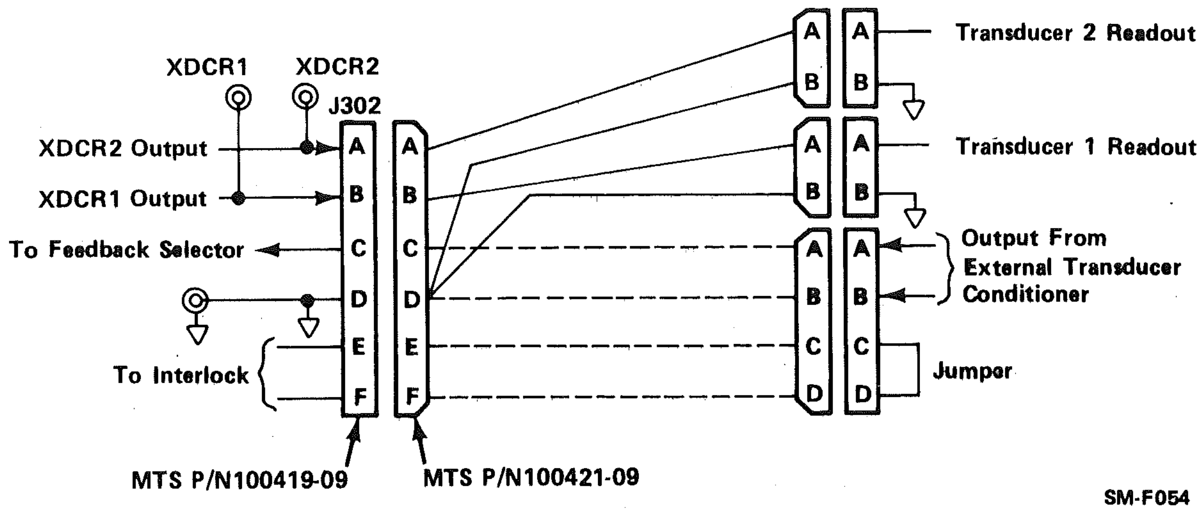

Figure 4-11. Recommended Readout and External Feedback Cable

Readout devices may also be connected to the XDCR 1 and, if applicable, XDCR 2 test jacks on the controller front panel.

***** WARNING *****

Use extreme care when connecting any device to the front panel XDCR 1 and XDCR 2 test jacks. Accidental grounding of the feedback signal during system operation will result in unexpected, rapid actuator reactions causing injury to personnel and/or equipment damage.

4.6 PROGRAM CONNECTIONS

Cable receptacle J300A (PROGRAM) on the controller rear panel (refer to figure 4-1) accepts the program signal from an external programmer such as a function generator, magnetic tape reproducer, etc. Cable receptacle J300B is connected in parallel with J300A to enable convenient connection of the program signal to the next channel of a multi-channel system. J300B is not intended to be used as an additional program input. A cable from J300B may be connected to J300A of a controller of an additional channel. The PROGRAM cable receptacle on the controller front panel is also connected in parallel with J300A and J300B.

The output signal of any programmer connected to J300A must have a full-scale zero referenced amplitude between 2 V p-p (±1V) and 25 V p-p (±12.5V). Typical MTS programmers provide full-scale output signals of 20 V p-p (±10V).

Figure 4-12 shows the recommended construction of a programmer cable containing all possible connections. The dotted lines indicate wires which are not required for basic operation. A simple function generator requires only a two-wire twisted pair cable. The cable should be constructed to provide only the connections required by the system.

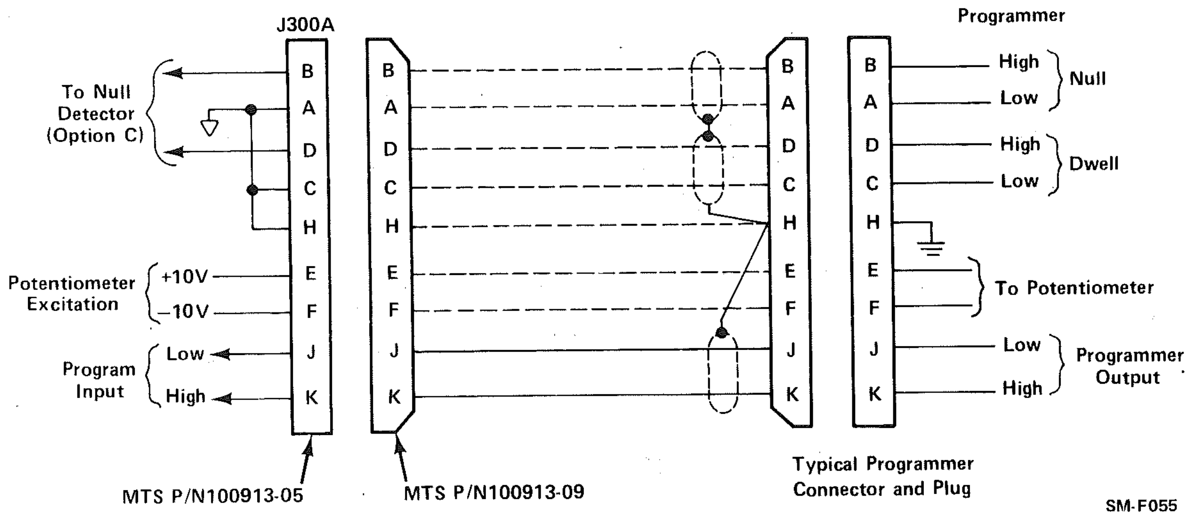

Figure 4-12. Recommended Programmer Cable

A potentiometric programmer requires an additional shielded twisted pair for the ±10 Vdc potentiometer excitation. The potentiometer must have a resistance of 2000 ohms or greater since the maximum permissible current load is 10 mA.

If the controller is equipped with the Reset Integrator/Null Detector (option C), and the programmer is equipped for null pacing, two additional twisted pairs with individual shields (or a common shield) are required for the null and dwell signals.

4.7 INTERLOCK, INTEGRATOR, AND 10 KHZ SYNCRONIZATION CONNECTIONS

Cable receptacle J301A (INTERLOCK) on the controller rear panel (refer to figure 4-1) is used for three separate functions which must be completed before the controller is placed into operation:

- Interlock connections
- Integrator connections (units containing option C only)
- 10 kHz synchronization connections (multi-channel systems)

Interlock connections enable an external interlock control circuit to automatically shut down the system in the event of an abnormal condition. In multi-channel systems, the channel that has sensed an abnormal condition automatically locks out the interlock function of all other channels to enable the operator to tell in which channel the malfunction occurred.

Integrator connections provide a means of ensuring that the integrator circuitry (option C) is off until full hydraulic pressure is applied to the system.

*** WARNING ***

A step input and undesired actuator movement may result if the integrator circuit is on while hydraulic pressure is initially being applied.

Connection of one channels 10 kHz oscillator in a multi-channel system eliminates "beating" between separate oscillators. One oscillator may be used to excite transducer power drivers in up to 75 separate channels.

Figure 4-13 shows the recommended cable construction required to complete all three connections. Cable shielding is not required.

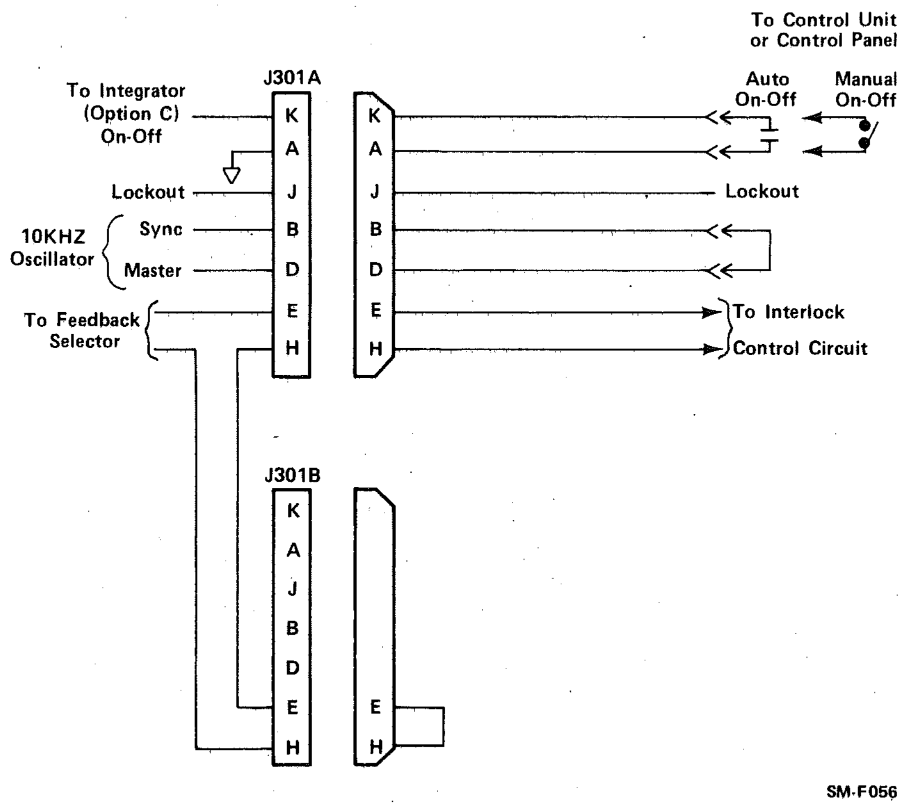

Figure 4-13. Recommended Interlock Cable

Cable receptacle J301B is used to make the required connections to additional channels in a multi-channel system. In a single-channel system, a jumper must be installed in J301B (pins E and H), as shown in figure 4-13, to complete the interlock connections. All other respective connector pins are connected in parallel.

Figure 4-14 shows typical cabling between controllers in a multi-channel system. A jumper wire is required on J301B (pins H and E) of the final controller to complete the interlock connections.

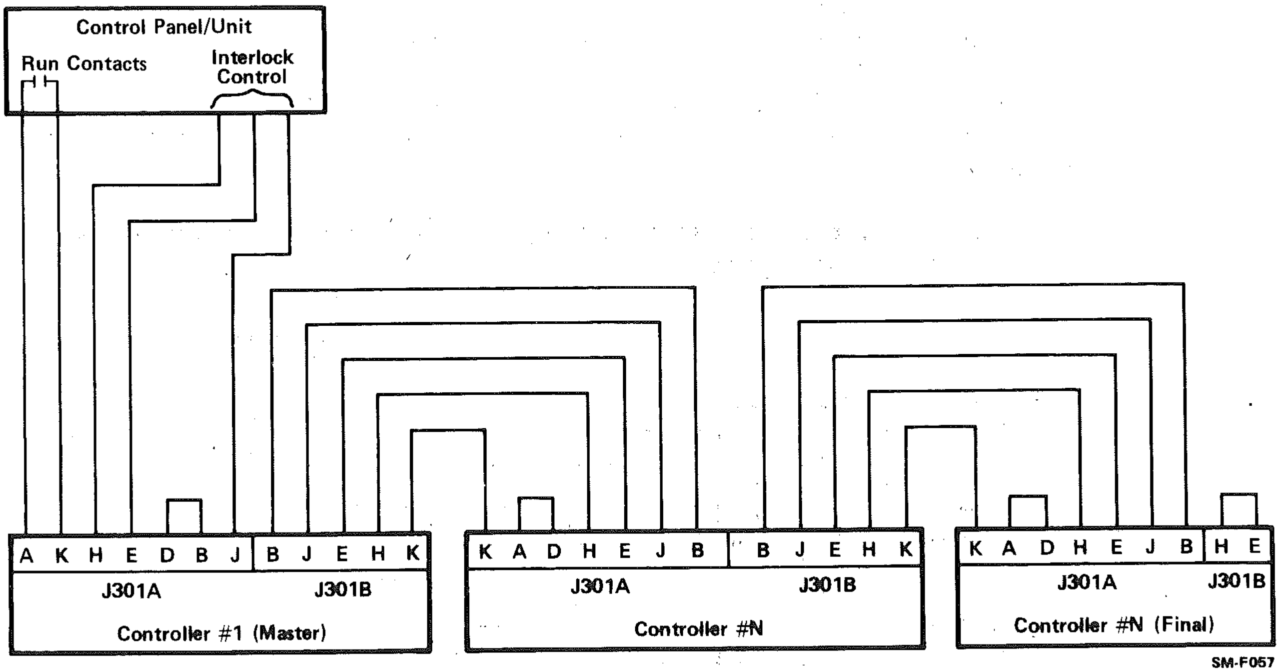

Figure 4-14. Recommended Multi-Channel Interlock Cables

Any controller in a multi-channel system may be used as the master for the 10 kHz excitation signal by jumpering pins B and D of J301A together. All other controllers must have their 10 kHz signals shorted by jumpering pins A and D together and all pin B signals connected together as shown in figure 4-14.

For cabling to the control unit or control panel, a two-wire twisted pair may be used. Shielding is not required. For connections between controllers, an untwisted multi-conductor cable without shielding may be used.

4.8 INSTALLATION OF OPTIONS IN THE CONTROLLER CHASSIS

Options A, B, C, D, E, H, and J are designed to be installed inside the controller chassis. Only one option A, D, E, or J module may be installed in the controller chassis. Only one option B, C, or H circuit card may be installed in the controller chassis.

Removal of the controller top cover is required for installation of the fore-mentioned options. Removal of the front panel plexiglass door and the blank filler panel (if equipped) is required for the installation of option A, D, or E. Certain options require modification to the controller.

*** WARNING ***

An electrical shock hazard exists whenever working inside any electrical device. Remove electrical power before installing or removing modules or circuit cards in the controller.

Refer to figure 4-15 for the location of circuit card receptacles and modification points.

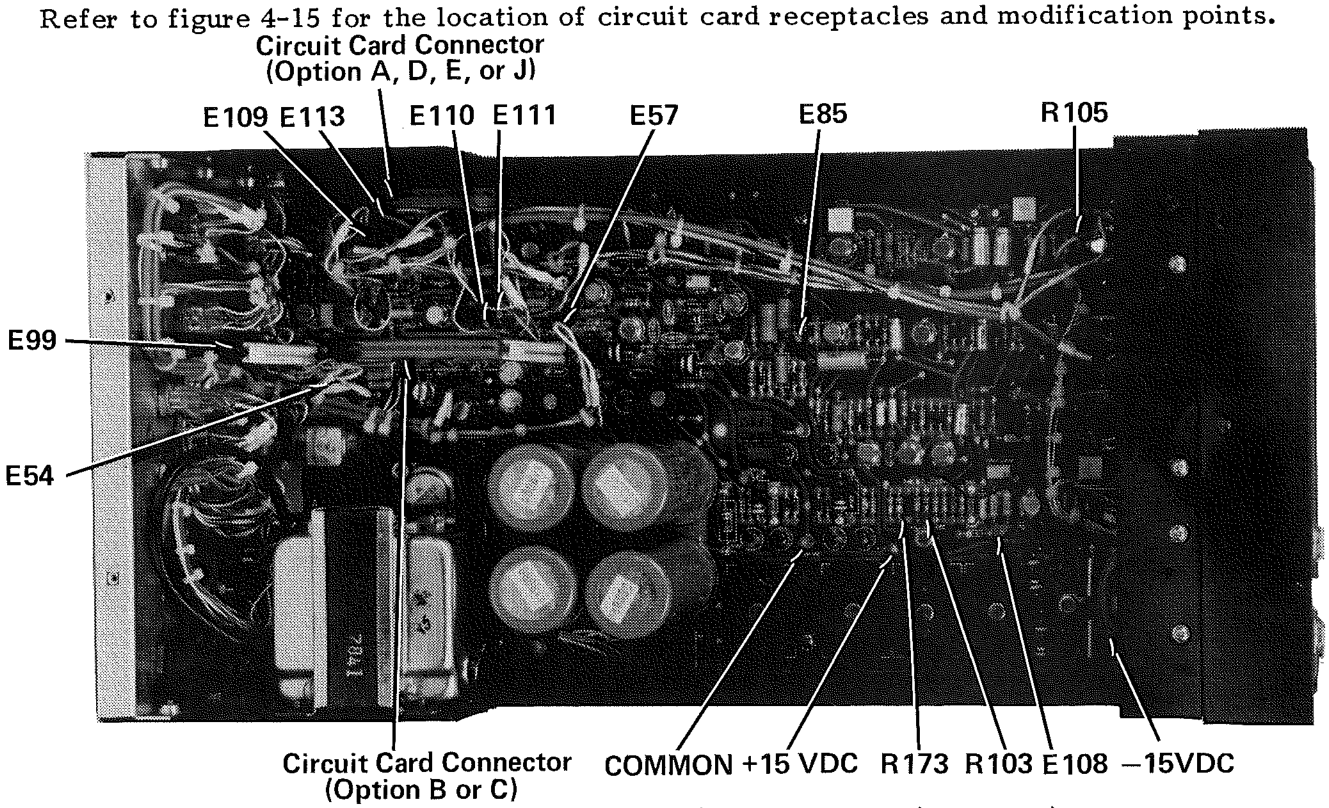

Figure 4-15. Internal 406.11 Controller (Top View)

4.8.1 DC TRANSDUCER CONDITIONER INSTALLATION (OPTION A)

Perform the following steps to install the dc transducer conditioner (option A) in the controller chassis:

1. With ac power removed, insert the module through the front panel opening, keeping the rear of the module slightly raised to prevent bending of the connector pins.

2. Insert the module circuit card into the circuit card receptacle at the rear of the controller chassis (refer to figure 4-15). Ensure the circuit card is firmly inserted in the receptacle.

3. Fasten the module to the controller chassis with the two screws and spacers provided. No additional wiring is required.

4.8.2 ΔP STABILIZATION (OPTION B) OR RESET INTEGRATOR/NULL DETECTOR (OPTION C) INSTALLATION

The ΔP stabilization (option B) or the reset integrator/null detector (option C) circuit card is installed by inserting it into the circuit card receptacle in the center rear portion of the chassis (refer to figure 4-15) with the component side facing toward the right hand side of the controller when viewed from the front. No additional wiring is required.

4.8.3 VALVE CONTROLLER INSTALLATION (OPTION D)

Perform the following steps to install the valve controller (option D) module in the controller chassis:

1. With ac power removed, insert the module through the front panel opening, keeping the rear of the module slightly raised to prevent bending of the connector pins.

2. Insert the module circuit card into the circuit card receptacle at the rear of the chassis (refer to figure 4-15). Ensure the circuit card is firmly inserted.

3. Fasten the module to the chassis with the two screws and spacers provided.

4. Remove resistors R103 and R105 from the controller main circuit card.

5. Connect jumper wires from point E57 to E109, from point E99 to E113, and from point E108 to the "A" end (toward E46) of resistor R173 on the controller main circuit card.

4.8.4 AC TRANSDUCER CONDITIONER INSTALLATION (OPTION E)

Perform the following steps to install the ac transducer conditioner (option E) module in the controller chassis:

1. With ac power removed, insert the module through the front panel opening, keeping the rear of the module slightly raised to prevent bending of the connector pins.

2. Insert the module circuit card into the circuit card receptacle at the rear of the chassis (refer to figure 4-15). Ensure the circuit card is firmly inserted.

3. Fasten the module to the chassis with the two screws and spacers provided.

4. Connect a jumper wire from point E57 to E109 on the controller main circuit card.

4.8.5 STROKE-TO-VELOCITY CONVERTER INSTALLATION (OPTION H)

The stroke-to-velocity converter (option H) is provided with a mounting bracket which fastens to the controller main circuit card. With ac power off, install the circuit card and mounting bracket in the two holes in the center of the controller main circuit card. Table 4-2 lists connections which must be made between the option H circuit card and the controller. Make connections using 20 AWG sleeved wire.

Table 4-2. Stroke-to-Velocity Converter to Controller Connections

Option H		Controller
E8	to	E110 or E111
E6	to	J301A, pin C
E10	to	E54
E16	to	+15Vdc supply
E17	to	-15Vdc supply
E18	to	common

4.8.6 DUAL ACCELEROMETER CONDITIONER INSTALLATION (OPTION J)

Perform the following steps to install the dual accelerometer conditioner (option J) circuit card:

1. Remove ac power and insert the option J circuit card into the XDCR 2 circuit card receptacle on the controller main circuit card. The option J circuit card does not extend through the front panel, therefore, it is not necessary to remove the blank filler panel (if equipped).

2. Secure the circuit card to the controller chassis with the provided screw and spacer.

3. Using 20 AWG sleeved wire, connect a jumper wire from point E85 to E109 on the controller main circuit card.

4.9 OPTION F CONDITIONER PANEL INSTALLATION

The Option F Conditioner Panel is installed similar to the 406.11 Controller. To mount the conditioner panel in a rack, refer to paragraph 4.2, Rack Mounting.

4.9.1 TRANSFORMER JUMPER WIRE CONNECTIONS FOR OPTION F

The two primary windings of the conditioner panel power transformer are connected in parallel for 105 to 125 Vac operation or in series for 210 to 250 Vac operation. Transformer wiring is accomplished by the connection of jumper wires between terminals on the conditioner panel main circuit card. Unless otherwise specified, the transformer is factory-wired for 105 to 125 Vac operation.

The transformer jumper wire solder terminals (labeled E1, E2, E3, and E4) are located just below the power transformer inside the chassis. It may be necessary to remove the transformer to gain access to the terminals. To remove the transformer, turn off ac power, remove the four screws holding the transformer to the chassis and set the transformer aside. Do not disconnect the transformer.

To connect the transformer for 105 - 125 Vac operation:

1. Remove any existing jumper wires.
2. Solder a jumper wire from terminal E1 to E3.
3. Solder a jumper wire from terminal E2 to E4.
4. Install a 115 V, 1 A slow-blow fuse in the fuse holder on the rear panel.

To connect the transformer for 210 - 250 Vac operation:

1. Remove any existing jumper wires.
2. Solder a jumper wire from terminal E2 to E3.
3. Install a 220 V, 1/2 A slow-blow fuse in the fuse holder on the rear panel.
4. Install a Hubbell 5666 or equivalent power plug.

4.9.2 OPTION F CABLE CONNECTIONS

Cable receptacles J301, J302, J303, and J304 complete connections between the modules installed in the conditioner panel and their respective transducers. The cables used are identical to those used for the 406.11 Controller (refer to paragraph 4.4, Transducer Connections).

Cable receptacles J201, J202, J203, and J204 are used for the module outputs, interlock connections, and servo controller gain for each of the four possible modules. Figure 4-16 shows the J201 through J204 pin assignment.

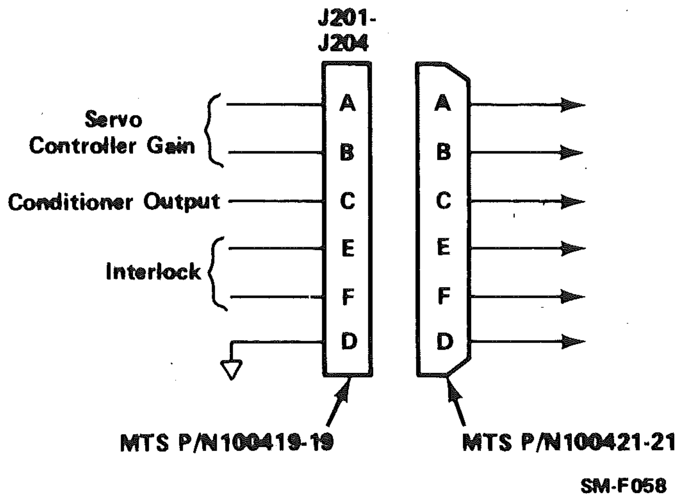

Figure 4-16. J201 Through J204 Pin Assignment

Limit detector (option G) interlock detection, 10 kHz synchronization, and interlock lock-out may be controlled through cable receptacles J101 and J102. The master 10 kHz oscillator output from the controller must be connected to pin B of J101 or J102 when one or more ac conditioners are installed in the conditioner panel. Cabling of the interlock detection and lock-out is identical to that of the 406.11 Controller (refer to paragraph 4.7).

4.9.3 INSTALLATION OF MODULES IN THE CONDITIONER PANEL

Up to four option A, D, and E modules may be installed in the conditioner panel. Perform the following steps to install a module in the panel.

1. Turn off ac power and remove the conditioner panel top cover.

2. Remove the blank panel (if equipped) from the desired front panel opening.

3. Insert the module through the desired front panel opening, keeping the rear of the module slightly raised to prevent bending of the connector pins.

4. Insert the module into the circuit card receptacle at the rear of the unit. Ensure that the module is positioned in the respective module guide. No additional connections (except cable connections) are required.

4.10 CHECKING CONTROLLER OPERATION

Perform the following procedures to ensure correct controller operation and servovalve/transducer phasing. For multi-channel systems, repeat each procedure for each 406.11 Controller in the system. All procedures assume that all system cables are in place and that the system is ready for operation. All controls and indicators are located on the controller front panel unless otherwise indicated. Do not apply hydraulic pressure until instructed to do so.

Perform the following steps before proceeding with any checkout procedures:

1. Apply ac power to the controller.

2. Turn the ED potentiometer fully clockwise to disable the error detector.

3. Turn the LIMIT DETECT IND/OFF/INTLK selector to OFF.

4. Set the panel meter selector to ERROR.

5. Press the LIMIT DETECT RESET pushbutton.

6. Turn the SERVO CONTROLLER ΔP and RATE controls to 0.

7. Turn the SERVO CONTROLLER GAIN control to 3.

8. Turn the FDBK SELECT switch to XDCR 1 or XDCR 2 (whichever is the displacement transducer).

9. Remove <u>all</u> obstructions from the actuator piston rod so that it is free to move its total displacement without interference. Do not install any specimen, grips, or fixtures which may be damaged by actuator movement.

***** WARNING *****

Unexpected actuator movement is likely during the following procedures. Keep all personnel away from the actuator(s) when hydraulic pressure is applied to the servovalve(s).

4.10.1 SERVOVALVE PHASING

Perform the following procedure to ensure proper servovalve phasing.

1. Disconnect the cable from receptacle J232 on the controller rear panel. If option D is included in the controller chassis also remove the cable from receptacle J233.

2. Apply ac power to the controller.

3. Adjust the SET POINT control to 500.

4. Apply low hydraulic pressure to the servovalve. The actuator may move rapidly to one end of its travel.

5. Turn the SET POINT control toward 1000 (postive command). The actuator should move in the direction desired for a positive command. If the actuator moves in the opposite direction than that desired, turn the SET POINT control to 500 and move the SERVOVALVE PHASE switch on the controller rear panel to the opposite position. Then, turn the SET POINT control toward 1000 and verify proper actuator movement for a positive command.

6. Turn the SET POINT control toward 000. The actuator should move in the direction desired for a negative command.

7. Remove hydraulic pressure from the servovalve.

8. Reconnect the respective cables to receptacle J232 and, if applicable, to J233.

4.10.2 SERVOVALVE LVDT PHASING (OPTION D ONLY)

Perform the following procedure to ensure proper phasing of the internal servovalve LVDT. This procedure applies only to controllers containing an Option D Valve Controller.

1. With hydraulic pressure off, turn the SERVO CONTROLLER GAIN control fully counterclockwise.

2. Turn the GAIN control on the Option D Valve Controller module fully counterclockwise.

3. Disconnect the cable from receptacle J232 on the controller rear panel.

4. Set the panel meter selector to XDCR 2 (valve controller output).

5. Apply low hydraulic pressure to the servovalve.

6. Rotate the SET POINT control through its entire range (000 - 1000). The panel meter should follow the SET POINT control rotation. If servovalve LVDT phasing is incorrect, the panel meter will indicate one extreme and will not respond to the SET POINT control.

7. If servovalve phasing is incorrect:

   A. Remove hydraulic pressure from the servovalve and remove ac power to the controller.

   B. Remove the cable from receptacle J233 on the controller rear panel.

   C. Interchange the wires connected to pins C and H of the cable plug.

   D. Reconnect the cable to J233, apply ac power, and apply low hydraulic pressure to the servovalve.

   E. Repeat step 6 to verify servovalve LVDT phasing.

8. Reconnect the cable to J232.

9. Remove hydraulic pressure from the servovalve.

4.10.3 XDCR 1 PHASING

Perform the following applicable procedure to ensure proper phasing of the transducer designated as transducer 1. Separate procedures are provided for resistive and reactive type transducers.

4.10.3.1 XDCR 1 Phasing for Resistive Transducers

Additional equipment required for the following procedure includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution. Perform the entire procedure with hydraulic pressure off and ac power applied to the controller.

1. Turn the FDBK SELECT switch to XDCR 1.

2. Set the CAL FACTOR RANGE switch on the controller rear panel and the CAL FACTOR control for the sensitivity of the transducer (transducer sensitivity in mV/V is typically provided with the transducer). For example, for a transducer sensitivity of 2 mV/V, set the CAL FACTOR RANGE switch to 1-11 and the CAL FACTOR control to 200.

3. Turn the XDCR 1 ZERO control to 500.

4. Connect the DVM between the XDCR 1 and common test jacks.

5. With hydraulic pressure off, manually apply a force to the transducer in the direction that should produce a negative output from the transducer. If a negative voltage is indicated on the DVM as the force is being applied, transducer phasing is correct. If a negative voltage is not indicated, proceed with step 6.

6. If transducer phasing is incorrect, remove ac power and remove the cable connected to receptacle J232 on the controller rear panel. Interchange the wires connected to pins C and H of the cable plug. Reconnect the cable, apply ac power and repeat step 5 to verify correct phasing.

4.10.3.2 XDCR 1 Phasing for Reactive Transducers

1. Apply ac power to the controller and turn the FDBK SELECT switch to XDCR 1.

2. Set the CAL FACTOR RANGE switch on the controller rear panel and the CAL FACTOR control for the sensitivity of the transducer. For example, for a transducer sensitivity of 2 mV/V, set the CAL FACTOR RANGE switch to 1-11 and the CAL FACTOR control to 200.

NOTE

If the sensitivity of an LVDT is not known, set the CAL FACTOR RANGE switch to 100-1100. The sensitivity of most LVDT's is within this range. The CAL FACTOR control setting is not critical at this time.

3. Turn the XDCR 1 ZERO control to 500.

4. Turn the panel meter selector to XDCR 1 and adjust the SET POINT control to zero the panel meter.

5. Apply low hydraulic pressure to the servovalve.

6. Adjust the SET POINT control toward 1000 (positive command). The actuator rod should move in the direction desired for a positive command.

7. If transducer phasing is incorrect, the actuator will be out of control. If this is the case;

   A. Remove hydraulic pressure from the servovalve and remove ac power from the controller.

   B. Remove the cable from receptacle J232 on the controller rear panel.

   C. Interchange the wires connected to pins C and H on the cable plug.

   D. Reconnect the cable to J232, then apply ac power.

8. Repeat steps 4 through 6 to verify proper phasing.

4.10.4 XDCR 2 PHASING (OPTION A OR E)

The following procedures apply only to controllers containing a DC Transducer Conditioner (option A) or an AC Transducer Conditioner (option E). Separate procedures are provided for resistive and reactive type transducers. Perform the applicable procedure.

4.10.4.1 XDCR 2 Phasing for Resistive Transducers (Option A or E)

Additional equipment required for the following procedure includes a digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution. Perform the entire procedure with hydraulic pressure off.

1. Apply ac power to the controller and turn the FDBK SELECT switch to XDCR 2.

NOTE

> Perform step 2A if option A is installed in the controller; perform step 2B if option E is installed in the controller.

2. Determine the transducer sensitivity in mV/V (transducer sensitivity is typically provided with the transducer) and;

   A. Perform Option A Excitation Adjustment (refer to section III, paragraph 3.6.1).

B. Set the CAL FACTOR range selector and CAL FACTOR control on the option E front panel for the transducer sensitivity. For example, for a transducer sensitivity of 700 mV/V, set the CAL FACTOR range switch to X100 and the CAL FACTOR control to 700.

3. Turn the XDCR 2 ZERO control to 500 (option A) or approximately mid-position (option E).

4. Connect the DVM between the XDCR 2 and common (black) test jacks.

5. With hydraulic pressure off, manually apply a force to the transducer in the direction that should produce a negative output from the transducer. If a negative voltage is indicated on the DVM, transducer phasing is correct. If a negative voltage is not indicated, proceed with step 6.

6. If transducer phasing is incorrect;

   A. Remove ac power to the controller.

   B. Remove the cable connected to receptacle J233 on the controller rear panel.

   C. Interchange the wires connected to pins C and H of the cable plug.

   D. Reconnect the cables apply ac power to the controller and repeat step 5 to verify proper phasing.

4.10.4.2 XDCR 2 Phasing for Reactive Transducers (Option E Only)

The following procedure applies only to controllers containing an AC Transducer Conditioner (option E).

1. Apply ac power to the controller and turn the FDBK SELECT switch to XDCR 2.

2. Set the CAL FACTOR range switch and the CAL FACTOR control on the XDCR 2 AC front panel for the transducer sensitivity. For example, for a transducer sensitivity of 700 mV/V, set the CAL FACTOR range switch to X100 and the CAL FACTOR control to 700. Most LVDTs will use the X100 range; control setting is not critical at this time.

3. Turn the XDCR 2 ZERO potentiometer to approximately mid-position.

4. Turn the panel meter selector to XDCR 2 and adjust the SET POINT control to zero the meter.

5. Apply low hydraulic pressure to the servovalve.

6. Adjust the SET POINT control toward 1000 (positive command). The actuator rod should move in the direction desired for a positive command.

7. If transducer phasing is incorrect, the actuator will be out of control. If this is the case;

A. Remove hydraulic pressure from the servovalve and remove ac power to the controller.

B. Remove the cable from receptacle J233 on the controller rear panel.

C. Interchange the wires connected to pins C and H on the cable plug.

D. Reconnect the cable, apply ac power to the controller and repeat steps 5 and 6 to verify proper phasing.

4.10.5 ΔP TRANSDUCER PHASING (OPTION B)

Proper ΔP transducer phasing can best be determined experimentally during system operation. The following steps may be used as a general guide.

1. Apply ac power to the controller.

2. Apply full hydraulic pressure to the servovalve.

3. Operate the system in stroke control with a low-frequency square wave program (1 to 2 Hz).

4. Turn the SERVO CONTROLLER GAIN and ΔP controls to approximately 2. Turn the RATE control to 0.

5. Monitor the stroke signal with an oscilloscope and advance the GAIN control until ringing appears in the waveform.

6. Advance the ΔP control and note if ringing decreases.

7. Experiment with the GAIN and ΔP controls until it is apparent whether increasing ΔP causes an improvement or deterioration of system stability. If advancing the ΔP control appears to reduce stability;

   A. Remove hydraulic pressure from the servovalve and remove ac power to the controller.

   B. Remove the cable from receptacle J230 on the controller rear panel.

   C. Interchange the wires connected to pins D and E of the cable plug.

   D. Reconnect the cable to receptacle J230.

   E. Apply ac power to the controller and apply full hydraulic pressure to the servovalve.

8. Repeat steps 1 through 7 to ensure that stability is improved.

SECTION V
THEORY OF OPERATION

This section describes the operation and circuitry of the Model 406.11 Controller and the 406.11 options. Refer to the indicated schematic diagrams for the following discussions. Components are referred to by the letter and number designators assigned to them on the diagrams. All referenced schematic diagrams are included in section VI of this manual.

5.1 406.11 CONTROLLER CHASSIS POWER SUPPLIES

Refer to schematic diagram D063670-01 (sheet 3) for the following paragraphs.

5.1.1 ±26 VDC POWER SUPPLY

The ±26 Vdc power supply is a series type regulator. Power is derived from full-wave bridge rectifier A1. Input filtering is provided by capacitors C47 and C48. The operation of the +26 Vdc section of the power supply and the -26 Vdc section of the power supply is identical, therefore only the +26 Vdc section is discussed.

The +26 Vdc series regulator is comprised of a detector reference, a feedback control amplifier, a series control element, and a short circuit foldback circuit. The detector reference is provided by zener diode CR31 which receives its zener current from the regulated output through resistor R132. Transistor Q7 (the feedback control amplifier) compares a feedback voltage to the reference voltage (+15 Vdc) provided by CR31. The feedback voltage is produced by the divider circuit comprised of resistors R133 and R134. Based on the feedback voltage and the reference voltage, Q7 controls the series control element which consists of transistors Q9 and Q10 (Darlington pair). Capacitor C49 provides regenerative feedback to Q7, stabilizing operation.

Transistor Q8 and resistors R136, R137, and R138 make up the short circuit foldback current circuit. Q8 is reverse-biased when the supply is delivering maximum output current (430 mA) to the load. When the supply is over loaded, Q8 is turned on, thus removing the base drive of Q9 and limiting the output current. Once the current is limited, any further attempt to increase the load current will decrease the output voltage. The foldback current circuit limits the output current to approximately 1/4 of the maximum output current under a short circuit condition.

5.1.2 ±15 VDC POWER SUPPLY

The main component of the ±15 Vdc power supply is an integrated circuit dual tracking regulator (REG 1) internally set for ±15 Vdc outputs. Series pass transistors Q1 and Q2 limit the output current to 100 mA. Short circuit foldback current is provided by resistors R139, R141, and R142 for the +15 Vdc supply and resistors R143, R145, and R146 for the -15 Vdc supply. These resitors form a divider circuit around the series pass transistors for foldback limiting. Power is derived from full-wave bridge rectifier A2 and filtered by capacitors C50 and C51.

5.1.3 ±10 VDC POWER SUPPLY

The ±10 Vdc power supply derives its power from the ±15 Vdc power supply. Operation of the +10 Vdc section and -10 Vdc section is identical, therefore only the +10 Vdc section is discussed.

A 6.2 zener diode (CR40) provides a stable reference to amplifier AR25-3. Resistors R160, R161, and R162 (variable) determine the amplifier gain. R162 is a 15-turn potentiometer which precisely adjusts the power supply output. The output of AR25 drives series control transistor Q27. Transistor Q26 limits the output current by reducing the base drive of Q27 when the current through resistor R165 becomes excessive (approximately 30 mA).

5.2 AC TRANSDUCER CONDITIONER

Figure 5-1 is a block diagram of the ac transducer conditioner circuitry. Refer to this figure and schematic diagram D063670-01 (sheet 2) for the following discussion.

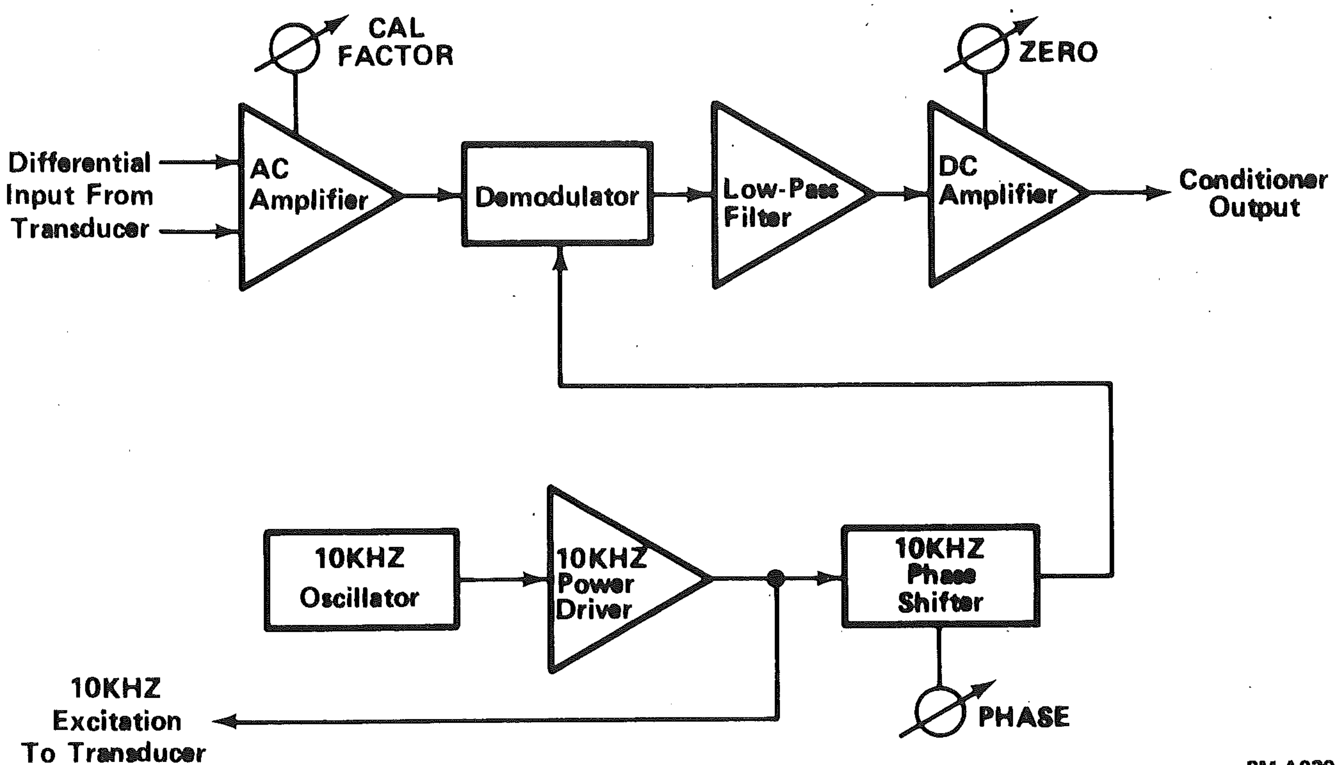

Figure 5-1. AC Transducer Conditioner Block Diagram

5.2.1 10 KHZ OSCILLATOR

The 10 kHz oscillator is an amplitude controlled, twin-tee sine wave oscillator consisting of amplifiers AR6, AR7, and AR8. The twin-tee configuration consists of capacitors C16, C17, and C18 and resistors R53, R54, and R55. The basis for oscillation is that the twin-tee feedback loop around AR8 is exactly 180°. Total phase shift, including amplifier inversion, is 360°. The frequency of oscillation is calculated by the following formula:

$$\text{frequency} = \frac{1}{(2\pi)(R54)(C16)}$$

The output voltage of integrating amplifier AR7-6 controls the peak-to-peak amplitude of the oscillator. The input to AR7-2 is a series of pulses from comparator AR6-6. At power-up, resistor R52 forces the output of AR7-6 to integrate in a positive direction, causing an increase in the oscillator amplitude until AR6-6 starts producing positive pulses. The positive output pulse of AR6-6, combined with the negative bias of resistor R52, holds the output of AR7-6 at a constant voltage (approximately +5 Vdc).

5.2.2 10 KHZ POWER DRIVER AND PHASE SHIFTER

The 10 kHz power driver circuit is a class B push-pull unity gain amplifier consisting of amplifier AR5 and output transistors Q14 and Q16. The input to the power driver circuit is provided by the internal 10 kHz oscillator (paragraph 5.2.1) or, in a multi-channel system, from an external master 406.11 10 kHz oscillator through connector J301A (E57). Transistors Q13 and Q15 provide short circuit current limiting at approximately 110 mA.

The 10 kHz power driver output provides 20 volt peak-to-peak (±10V) excitation to the transducer through pin F of connector J232 (E16) and is also applied to phase shifter amplifier AR4. AR4 and transistors Q11 and Q12 provide an adjustable phase shift (0° to 60°) to the demodulator reference to compensate for any phase shift associated with the transducer. Variable resistor R22 (the PHASE control on the controller front panel) controls the degree of the phase shift introduced. Turning R22 fully counterclockwise introduces a 60° phase shift; turning R22 fully clockwise introduces only a 1° phase shift. Output transistors Q11 and Q12 provide a push-pull drive signal sufficient to drive the demodulator transformer (T2).

5.2.3 AC AMPLIFIER

The differential output of the transducer is applied to the ac transducer conditioner at connector receptacle J232, pins C and H. High impedance voltage followers AR9 and AR10 provide high common mode rejection (CMR) for differential amplifier AR11. High CMR is required due to any impedance changes which may occur in the transducer. AR11 is a unity gain amplifier. Because the phase shift circuitry (paragraph 5.2.2) provides only a phase lag to the demodulator, select capacitors C12 and C13 may be installed to provide a phase lead to compensate for a transducer with a phase lead. C12 and C13 are not typically installed since the majority of transducers introduce a phase lag.

The output of AR11-6 provides the input for CAL FACTOR amplifier AR12-2. Variable resistor R46 and switch S7 provide gain adjustment of AR12 from 0.2 to 222. Variable resistor R60 (C BAL) is adjusted to compensate for any phase offsets imposed by transducer cable capacitance. The amplified signal provided by AR12-6 drives demodulator input transformer T1.

5.2.4 DEMODULATOR

The ac transducer conditioner demodulator is a dual-ring, phase sensitive diode demodulator circuit consisting of diodes CR7 through CR14. The demodulator input is provided by transformer T1, a 5:1 step-up transformer. Transformer T2, a 10:1 step-up transformer, provides the 10 kHz demodulator reference signal from the 10 kHz phase shifter circuitry (paragraph 5.2.2). The demodulator output is a full-wave rectified signal of either positive or negative polarity. Signal polarity is determined by the phase relationship between the demodulator input signal and the demodulator reference signal.

5.2.5 LOW PASS FILTER AND DC OUTPUT AMPLIFIER

The low pass filter consists of amplifier AR13, capacitors C25, C26, and C27, and resistors R65, R66, and R67 in a Bessel filter configuration. The filter receives the rectified signal from the demodulator circuitry and provides an analog output representing the physical input to the transducer. The filter network is the primary limiting factor for the frequency response of the transducer conditioner.

Final amplification of the signal is provided by amplifier AR14. The gain of AR14 is set at 2.5. Variable resistor R73 (ZERO) introduces an adjustable offset of either ±10 Vdc or ±1 Vdc depending on the position of switch S6 (FINE/COARSE). The offset voltage is summed with the amplifier input to adjust the zero reference of the transducer conditioner.

5.3 SERVO CONTROL

Refer to schematic diagram D063670-01 (sheet 1) for the following paragraphs.

5.3.1 PROGRAM CONDITIONING AND COMPOSITE COMMAND

External program input signals are applied via cable receptacle J300A (pins J and K) to span isolation amplifier AR1. Adjustment of variable resistor R1 provides optimum common mode rejection. Variable resistor R8 provides AR1 gain adjustment from 0.8 to 10, allowing the controller to accept program input signals within a full-scale range of 2 to 25 volts peak-to-peak. Variable resistor R4 provides an offset voltage to establish the zero reference for AR1.

The output of AR1-6 is applied to span amplifier AR3-3 via variable resistor R12 (SPAN). Adjustment of R12 attenuates the program signal to a level directly proportional to the program input. Attenuation is necessary to set the dynamic signal level within the determined limits of the system operating range. The attenuated output of AR3-6 is applied to summing amplifier AR23-2. In addition to the output of AR3-6, voltage follower AR2 applies a static voltage to AR23-2. The static voltage is determined by the adjustment of variable resistor R13 (SET POINT) and establishes the mean level of the command signal. The resultant sum of the signal applied by AR3-6 and the static voltage applied by AR2-6 represents the composite command signal.

Summing amplifier AR23 compares the composite command signal applied to its inverting input (pin 2) to the feedback signal from the transducer conditioner (pin 3). The transducer conditioner feedback signal is applied to AR23-3 via FDBK SELECT switch S3A (refer to paragraph 5.3.3, Feedback Selection). The resultant output of AR23-6 is the dc error signal representing the difference between composite command and feedback.

5.3.2 VALVE AMPLIFIER

Valve amplifier AR24 receives the dc error signal from summing amplifier AR23-6 on its inverting input (pin 2). AR24 amplifies the signal and applies it to the power driver circuit comprised of transistors Q21, Q22, Q23, and Q25 in a push-pull configuration. The gain of AR24 is controlled by switch S3B (refer to paragraph 5.3.3, Feedback Selection) and variable resistor R118 (GAIN). The power driver applies the signal to the servovalve via switch S9 (VALVE PHASE) and connector receptacle J229, pins B and E. Switch S9 is a valve phase switch which may be used to reverse the current drive to the servovalve. Current limiting is provided by transistor Q20 and Q24.

5.3.3 FEEDBACK SELECTION

Switch S3 (FDBK SELECT) is a three-position, three-pole switch used to select the feedback signal for closed-loop servo control. Switch section S3A selects one of three possible signals for feedback to the summing amplifier (AR23). Position 1 selects the output of the built-in ac transducer conditioner (XDCR 1) for feedback; position 2 selects the output of an optional module (option A, D, or E) installed in the XDCR 2 slot; position 3 selects an external transducer conditioner output received at connector receptacle J302 (pin C).

Switch section S3B is used to change the servo controller gain to compensate for a gain change between transducer conditioners by switching in different resistance values for each conditioner. For example, if the ac transducer conditioner gain is 50 and switch S3 is switched to a dc transducer conditioner with a gain of 500, the servo controller gain has to be increased by a factor of 10 to maintain an overall constant-loop gain for optimum stability.

Switch section S3C is used for the system interlock circuitry. For example, if switch S3 was turned to position 2 (XDCR 2) and a module was not installed in the XDCR 2 slot, the interlock circuit would open to prevent or terminate the application of hydraulic pressure.

5.3.4 RATE STABILIZATION

Rate stabilization is a differentiator circuit (responds only to voltage changes) which, through the use of the feedback signal, creates a feed-forward compensation to improve the dynamic stability of the valve amplifier. Amplifier AR15 is used as a voltage follower for isolation between switch S3A and the remainder of the rate stabilization circuitry. The actual differentiator circuit is comprised of amplifier AR16, input capacitor C29, and feedback resistor R182. Resistor R76 is connected in series with C29 to reduce noise and prevent instability. Capacitor C30 is connected in parallel with R182 to provide high frequency rolloff for filtering high frequency noise. Amplifier AR17, capacitors C32 and C33, and resistors R81 and R82 form a low-pass active filter to further minimize undesired signals.

The adjustment of variable resistor R83 (RATE) determines the amount of compensation applied to valve amplifier AR24. A jumper wire is connected between the wiper arm of R83 and point E46 or E47 as required for proper rate stabilization phase.

5.3.5 DITHER

The dither circuitry applies a small signal to the valve amplifier (AR24) to prevent servovalve silting and to overcome static friction in the servovalve and actuator. The circuitry consists of a bistable multivibrator comprised of transistors Q18, Q19, and the associated circuitry. The circuit changes from one state to another at intervals determined by the time constants of resistor R114 and capacitor C43, and resistor R115 and capacitor C44. The adjustment of variable resistor R112 (DITHER) determines the amplitude of the dither signal applied to valve amplifier AR24-2.

5.4 LIMIT DETECTION

The controller limit detection circuitry consists of an error detector circuit which activates when a preset dc error level is exceeded and an upper and lower limit detector circuit which activates when preset upper and lower feedback signal levels are exceeded. The circuitry also contains a lock-out feature which disables the limit detection circuitry of other controllers in multi-channel systems. This enables the operator to determine in which channel an exceeded level occurred. Refer to schematic diagram D063670-01 (sheet 1) during the following discussion.

5.4.1 ERROR DETECTION

The primary components of the error detection circuitry are comparators AR21 and AR22. Comparator AR21 is used to detect a positive dc error limit while comparator AR22 is used to detect a negative dc error limit. The dc error signal output of summing amplifier AR23-6 is applied to one input of each comparator. Adjustment of variable resistor R86 (ED) provides the reference voltage for the other input of each comparator. The reference voltage for comparator AR22 however, is inverted by inverter AR20 to provide the correct reference voltage polarity.

If the dc error signal does not exceed the reference voltage established by R86, the outputs of both comparators are negative and SCR CR19 remains in an off condition. With CR19 off, transistor Q17 is turned on, causing relay K1 to be energized. This closes the normally open contacts in the interlock path, thus satisfying the interlock conditions required for normal operation.

If the dc error signal exceeds the reference voltage in either a positive or negative direction, the respective comparator switches from negative saturation to positive saturation, turning on CR19. With CR19 turned on, Q17 is turned off, de-energizing K1. De-energizing K1 opens the interlock circuit and the desired interlock action takes place. In addition to turning off Q17, turning on CR19 illuminates indicator DS3 (ERROR). The interlock circuit remains open and DS3 remains illuminated even if the dc error signal decreases below the reference voltage. Pressing pushbutton switch S8 (RESET) resets the error detector circuitry. Capacitor C38 prevents comparator output transients of less than 2 msec duration from turning on CR19.

5.4.2 UPPER AND LOWER LIMIT DETECTION

The limit detection circuitry is capable of detecting preset upper (most positive or least negative) and lower (most negative or least positive) feedback signal limits through the use of comparators AR18 and AR19. Comparator AR18 is used to detect the upper limit while AR19 detects the lower limit. The output signal of either XDCR 1 or XDCR 2 is applied to one input of each comparator. Selection of the desired transducer conditioner output is provided by switch S1A. The reference voltages applied to the other comparator inputs are determined by the adjustment of variable resistors R147 (UPPER) and R148 (LOWER) for AR18 and AR19 respectively. The reference voltage polarities are determined by the position of toggle switches S4 and S5.

If the selected transducer conditioner output does not exceed either of the preset reference voltages, operation continues as normal. If the selected output exceeds either of the preset reference voltages, the respective comparator switches from negative saturation to positive saturation and turns on either SCR CR36 (upper limit) or CR37 (lower limit). This in turn illuminates indicator DS1 (UPPER) or DS2 (LOWER) and, if desired, turns off transistor Q17 and opens the interlock circuit by de-energizing relay K1. The position of switch S1C determines if an exceeded limit will cause an indication and interlock action or only an indication.

5.4.3 LOCK-OUT

In multi-channel systems containing two or more 406.11 Controllers, the lock-out circuit enables the operator to determine in which channel an exceeded level has occurred by disabling the error detector and upper/lower limit detector circuits of the other channels. An exceeded error level always activates the lock-out circuit while an exceeded upper or lower feedback signal level only activates the lock-out circuit when the upper and lower limit detectors are used to initiate system interlock action (switch S1 is turned to position 4 or 5).

When transistor Q17 is turned off by an exceeded dc error level or upper/lower feedback signal level (refer to paragraphs 5.4.1 and 5.4.2), relay K1 is de-energized and the normally closed K1 contacts in the lock-out path are closed. This provides a path to common via cable receptacles J301A and J301B (pin J), thus preventing the limit detector and error detector comparator outputs (AR18, AR19, AR21, and AR22) of the other controllers from turning on their respective SCRs (CR36, CR37, and CR19). Switch S1B must be in position 4 or 5 for the upper/lower limit detectors to be included in the lock-out function.

5.5 DC TRANSDUCER CONDITIONER (OPTION A)

The dc transducer conditioner (option A) performs two primary functions; dc transducer excitation and transducer output signal amplification. Refer to schematic diagrams C064340-01 (dc conditioner main circuit card) and C081557-01 (low-level amplifier circuit card) during the following discussion.

5.5.1 DC TRANSDUCER EXCITATION

The dc transducer conditioner provides a positive and a negative excitation voltage to the transducer. The positive excitation voltage is dervied from the +10 Vdc reference voltage obtained from the controller power supply via circuit card connector pin W. Adjustment of variable resistor R36 (EXCITATION) applies a reference voltage to amplifier AR1-3 which drives transistors Q1 and Q2 to produce the desired positive excitation voltage at circuit card connector pin S (+EX). Transistor Q3 functions to limit current to approximately 120 mA by reducing the forward bias of Q1 when excessive current is being drawn.

The positive excitation voltage is also applied to AR2-2. AR2 inverts the voltage and drives transistors Q4 and Q5 to produce the negative excitation voltage at circuit card connector pin R (-EX). Transistor Q6 functions to limit current in the same manner as Q3.

5.5.2 TRANSDUCER OUTPUT SIGNAL AMPLIFICATION

The transducer output signal is preamplified by the low-level amplifier circuit (C081557-01) before being applied to the dc conditioner. The low-level amplifier receives the transducer output signal, which represents any unbalancing of the transducer bridge circuit, at inputs VIN+ (pin P) and VIN- (pin N). RF noise is filtered by the RLC network comprised of components L1, R1, R3, C18, C19, and C20. AR1 and AR2 are ultra-low-drift preamplifiers and are coupled to amplifiers AR3 and AR4 respectively to provide a differential input/differential output, composite amplifier with a gain of 500. Variable resistor R10 (ZERO) provides an amplifier offset adjustment for minimum temperature drift. Adjustment of variable resistor R19 (AC CMR) balances any phase lag which may be present.

The differential output of the composite amplifier (AR1 through AR4) is applied to amplifier AR5. Adjustment of variable resistor R11 (DC CMR) balances the inputs to AR5 for maximum common mode rejection. AR5 is used as a buffer/inverter to apply the preamplified transducer signal to the dc conditioner main circuit card (C064340-01). Depending on the position of switch SW-1, the output of AR5 is either applied directly to the main circuit card or it is applied via the low-pass filter circuitry of AR6.

The preamplified signal is applied via circuit card receptacle J1 (pin H) to amplifier AR3-2 (on the main circuit card) where the signal is again amplified and inverted. Adjustment of variable resistor R18 (AMP ZERO) establishes the zero reference for AR3. Adjustment of variable resistor R35 (ZERO) sums an offset voltage with the preamplified transducer signal to counteract physical offsets which may be imposed on the transducer.

The gain of AR3 is determined by the resistance values switched into the amplifier feedback path by switch S1B. Variable resistors R27 (X1) and R28 (X10) provide adjustment of the resistance values.

The ΔK circuitry, comprised of components CR3, R26, R29, and R33, compensates for non-linear negative to positive transducer output signals. The circuit reduces the feedback resistance for positive output voltages, thus reducing the amplifier gain. For transducers with opposite characteristics, the orientation of diode CR3 may be reversed. Variable resistor R26 (ΔK) provides adjustment of the amount of ΔK compensation.

Switch S1A selects the gain resistor (R21 or R22) which is switched into the main controller valve amplifier feedback circuit to maintain the relationship between the valve amplifier and the dc conditioner amplifier when the X1/X10 range switch position is changed.

5.6 ΔP STABILIZATION (OPTION B)

Refer to schematic diagram C064136-01 during the following discussion.

The ΔP stabilization circuit (option B) is used in conjunction with a resistive-bridge pressure transducer connected across the hydraulic actuator piston. The ΔP circuit provides dc excitation to the transducer and amplifies the transducer output signal.

Zener diode CR3 provides a -6.2 Vdc excitation voltage to the transducer via circuit card connector pins M (-EXC) and R (+EXC). The transducer output signal, representing the analog of the applied forces, is applied to amplifier AR3 via circuit card connector pins N and P. The gain of AR3 is approximately 680. Variable resistor R7 (ZERO) provides adjustment of the zero reference for AR3.

The output of AR3-6 is typically capacitively coupled to the controller main circuit card by capacitors C2 and C3. If it is desired to directly couple the signal to the main circuit card, a jumper wire is connected between points E3 and E4. Direct coupling of the signal is frequently required on systems with a low natural frequency (less than 10 Hz).

On the controller main circuit card (schematic D063670-01, sheet 1), variable resistor R74 provides adjustment of the ΔP signal amplitude. The ΔP signal is then summed into the inverting input (pin 2) of the valve amplifier (AR24).

5.7 RESET INTEGRATOR/NULL DETECTOR (OPTION C)

Refer to schematic diagram C064136-01 during the following discussion.

The null detector circuit is used with programmers that have an interrupt capability to provide program pacing. The programmer periodically applies a "dwell" signal to the null detector circuit. If the difference between command and feedback (dc error) is within the limits defined as a "null" condition, the null detector outputs a null signal to inform the programmer to continue the program. If dc error is not within the defined limits, the null signal is not output by the null detector and the programmer holds the present program level until dc error is within the defined limits.

Comparators AR1 and AR2 compare the dc error signal to an adjustable reference voltage to determine if a "null" or "not null" condition exists. The reference voltage represents the maximum dc error level which is still considered a "null" condition.

The dc error signal is applied to comparators AR1-3 and AR2-2 via circuit card connector pin A. Adjustment of variable resistor R14 (NULL) applies the desired reference voltage to the comparators. The reference voltage is applied directly to AR1-2 to establish the maximum allowable positive dc error level. The reference voltage applied to AR2-3 is first inverted by inverter AR4 to establish the maximum allowable negative dc error level. The output of the comparators depends on whether the dc error level exceeds the reference voltage in either a positive or negative direction. If dc error does not exceed the reference voltage, the outputs of both comparators are negative. If dc error exceeds the reference voltage in a positive direction, the output of AR1 goes positive. If dc error exceeds the reference voltage in a negative direction, the output of AR2 goes positive.

The programmer dwell signal is applied to the circuit card via circuit card connector pin J. When a dwell signal is not applied by the programmer, transistor Q1 is turned off. The voltage at the collector of Q1 under this condition is approximately +15 Vdc, causing transistor Q2 to be turned on, maintaining zero output (0.0 to 0.6 Vdc) at the NULL output (connector pin S). When the programmer dwell signal (+2.6 to 4.5 Vdc) is applied to connector pin J, Q1 is turned on, removing the forward bias of Q2. The conductive state of Q2 is now dependent on the output of comparators AR1 and AR2. If dc error does not exceed the reference voltage established by the adjustment of R14, the comparator outputs remain negative and transistor Q2 is not turned on. This applies approximately +15 Vdc to connector pin S, informing the programmer that a "null" condition exists and to proceed with the program.

If dc error exceeds the reference voltage in either a positive or negative direction, one of the comparator outputs (depending on dc error polarity) goes positive. The positive comparator output then turns on Q2 and the null signal is not applied to the programmer. Under this "not null" condition, the programmer holds its present output until dc error is reduced to a level below the reference voltage. The comparator output then returns to its negative state, Q2 is turned off, and the programmer resumes normal operation.

In addition to interrogating the null detector circuitry, the dwell signal activates the reset integrator circuit. When a dwell signal is applied, transistor Q3 is turned on, energizing relay K1. This closes the K1 contacts and completes the feedback circuit for amplifier AR5. The dc error signal is applied to AR5-2 which inverts and amplifies the signal and applies it to the valve amplifier on the 406.11 main chassis, speeding up system correction. When the dwell signal is removed, Q3 turns off, and opens the relay contacts. If the programmer does not have program pacing capabilities, a switching device may be installed between points E1 and E2 to turn the integrator on and off.

5.8 VALVE CONTROLLER (OPTION D) AND AC TRANSDUCER CONDITIONER (OPTION E)

The circuitry of the Valve Controller (option D) and the AC Transducer Condtioner (option E) is identical except for a small number of variations. The operation of both options is discussed in the following paragraphs. Refer to schematic diagram D067281-01 during the following discussion.

5.8.1 10 KHZ POWER DRIVER AND PHASE SHIFTER

The 10 kHz power driver is a class B push-pull unity gain amplifier consisting of amplifier AR8 and output transistors Q3 and Q5. Transistors Q4 and Q6 provide short circuit current limiting at approximately 110 mA. The 10 kHz input to the power driver circuit is provided by the master controller 10 kHz oscillator via circuit card connector pin L. The excitation output (20 volts peak-to-peak) provided by transistors Q3 and Q5 is applied to the transducer via circuit card connector pin S and also to the 10 kHz phase shifter circuitry.

The phase shifter circuitry, amplifier AR5 and transistors Q1 and Q2, provides a variable phase shift (1° to 60°) to the demodulator reference to compensate for any phase shift which may be introduced by the transducer. Variable resistor R18 (Ø) controls the amount of the phase shift introduced. Rotating R18 fully clockwise introduces a 60° phase shift while rotating it fully counterclockwise introduces a 1° phase shift. Output transistors Q1 and Q2 provide a push-pull drive signal to demodulator transformer T2.

5.8.2 AC AMPLIFIER

The differential output of the transducer being used with option E, or the servovalve LVDT being used with option D, is applied to the circuit card via circuit card connector pins E (-) and F (+). High impedance voltage followers AR1 and AR2 provide high common mode rejection for differential amplifier AR3. Because the phase shifter circuitry provides only a phase lag to the demodulator, capacitors C1 and C2 may be used to provide a phase lead to compensate for transducers which introduce a phase lead. Since the majority of transducers introduce a phase lag, capacitors C1 and C2 are not typically used.

The output of AR3-6 is applied to the inverting input of amplifier AR4-2. Variable resistor R8 (CAL FACTOR) and switch S1 (option E only) provide gain adjustment for AR4. For a full-scale output voltage (10 Vdc) the voltage present at TP2 (AC) is 5.0 volts peak-to-peak. The output of AR4-6 is capacitively coupled to demodulator transformer T1 by capacitor C6.

5.8.3 DEMODULATOR

The demodulator consists of a dual-ring, phase sensitive diode demodulator consisting of diodes CR3 through CR10. The demodulator input is provided by transformer T1, a 5:1 step-up transformer. For a full-scale output signal (10 Vdc), the input to the demodulator is a 25 volt peak-to-peak 10 kHz signal. Transformer T2, a 10:1 step-up transformer, provides the 10 kHz demodulator reference signal from the phase shift circuitry (paragraph 5.8.1). The output of the demodulator circuitry (present at TP4) is a full-wave rectified signal of either positive or negative polarity. Polarity of the signal is dependent on the phase relationship between the input and the reference signals.

5.8.4 LOW PASS FILTER AND DC OUTPUT AMPLIFIER

The low pass filter consists of amplifier AR6, capacitors C9, C10, and C11, and resistors R23, R24, and R25 in a Bessel filter configuration. The filter receives the rectified signal from the demodulator circuitry and provides an analog output (AR6-6) representing the physical input to the transducer. The filter network is the primary limiting factor for the frequency response of the entire circuit.

Final amplification of the signal is provided by amplifier AR7-2. Variable resistor R31 (ZERO) and switch S2 (FINE/COARSE switch on option E only) introduces an adjustable offset voltage which is summed with the input at AR7-2 to establish the zero reference of the circuit. The output of AR7-6 is applied to the controller main circuit card via circuit card connector pin P.

5.8.5 INNER LOOP/OUTER LOOP SUMMING (OPTION D ONLY)

Summing amplifier AR13 is used to sum the slave spool position signal (output of AR7-6), an inner loop rate signal (differentiated slave spool position signal), and the dc error signal to create a feedforward compensation to the controller main valve amplifier. The provided compensation improves the dynamic stability of the system.

The inner loop rate circuitry, comprised of amplifiers AR9, AR10, and AR11, differentiates the slave spool position signal. AR9 serves as a voltage follower to isolate the output of AR7-6 from the differentiator circuit. Amplifier AR10, with input capacitor C15 and feedback resistor R48, comprise the differentiator circuit. Since the differentiator has very high gain at high frequencies, the circuit may be susceptible to random noise. Resistor R47 is connected in series with C15 to reduce noise and prevent instability. Capacitor C16 is connected in parallel with R48 to provide high frequency rolloff and filter high frequency noise. AR11 serves as a low-pass filter to provide further high frequency attenuation. Adjustment of variable resistor R54 (IL RATE) determines the amplitude of the inner loop rate signal applied to the summing amplifier (AR13-3).

The dc error signal is applied to amplifier AR14-2 via circuit card connector pin N. The output of AR14-6 is applied to amplifier AR12-2 via variable resistor R56 (GAIN). Adjustment of R56 determines the gain of AR12 and thus the amplitude of the dc error signal applied to summing amplifier AR13-2. The slave spool position signal (output of AR7-6) is also applied to AR13-2. The three signals are then summed by AR13 and output to the valve amplifier via circuit card connector pin M.

5.9 CONDITIONER PANEL (OPTION F) POWER SUPPLY

Refer to schematic diagram D071980-01 (sheet 1) during the following discussion.

The option F ±10 Vdc and ±26 Vdc power supplies are similar to the 406.11 Controller main chassis power supplies. Refer to paragraphs 5.1.1 and 5.1.3 for a detailed explanation.

Integrated circuit regulator U regulates the +15 Vdc power supply output. The integrated circuit includes its own pre-adjusted reference and complete overload protection. Diodes CR16 and CR20 provide reverse bias protection for the regulator. Capacitor C18 serves to improve the regulator's load transient response.

The -15 Vdc supply utilizes the reference provided by regulator U. Amplifier AR5 drives transistors Q14 and Q15 such that the voltage at the junction of resistors R54 and R55 is zero. In this condition, the magnitude of the -15 Vdc output (TP20) is equal (within 1%) to the magnitude of the +15 Vdc output (TP19). Foldback current limiting is provided by transistor Q16. When the output current attempts to exceed the current limit value, Q16 turns on and applies current to AR5-8, clamping the output (AR5-6) to Q14 and Q15. Zener diodes CR14 and CR15 pre-regulate the supply for AR5. Diodes CR17 and CR21 provide reverse bias protection.

5.10 LIMIT DETECTOR (OPTION G)

Refer to schematic diagram D071980-01 (sheet 2) for the following paragraphs.

The limit detector circuit (option G) monitors a selected transducer signal and detects when that signal has exceeded a preset upper or lower limit by the use of comparators AR3 and AR4. The signal is selected by the position of switch S5 and applied to comparator inputs AR3-3 and AR4-2. Reference voltages are applied to AR3-2 and AR4-3. The reference voltage amplitudes are determined by the adjustment of variable resistors R27 (UPPER) and R28 (LOWER). The reference voltage polarities are determined by the position of switches S2 (UPPER +/-) and S3 (LOWER +/-).

If the selected signal does not exceed either of the preset reference voltages, operation continues as normal. If the selected signal exceeds either of the preset reference voltages, the respective comparator switches from negative saturation to positive saturation and turns on either SCR CR8 (upper limit) or CR9 (lower limit). This in turn illuminates indicator DS1 (UPPER) or DS2 (LOWER) and, if desired, turns off transistor Q13 and opens the interlock circuit by de-energizing relay K1. The position of switch S6 determines if an exceeded limit will cause an indication and interlock action or only an indication.

5.11 STROKE-TO-VELOCITY CONVERTER (OPTION H)

Figure 5-2 is a functional block diagram of the stroke-to-velocity converter (option H). Refer to this figure and schematic diagram D082233-01 during the following discussion.

The 10 kHz excitation voltage from the controller main chassis is applied to amplifier AR11, producing a square wave output. The clamping circuit, comprised of components R45, C22, and CR4, clamps the negative-going alternation at approximately -0.6 V. The square wave is then applied to counters U4 and U5 to produce pulses which are applied to amplifier AR10 at a rate determined by the counter output used and the position of switch S1A. Refer to chart A on the schematic diagram for the jumper connections for the available stroke rates. AR10 applies timing pulses to the clock circuitry which produces three sequenced clock pulses to clock the sample and hold circuitry. U1 is triggered by the output of AR10, while each successive clock (U2 and U3) is triggered by the negative-going edge of the preceding clocks output. Figure 5-3 illustrates the timing relationship of the clock outputs.

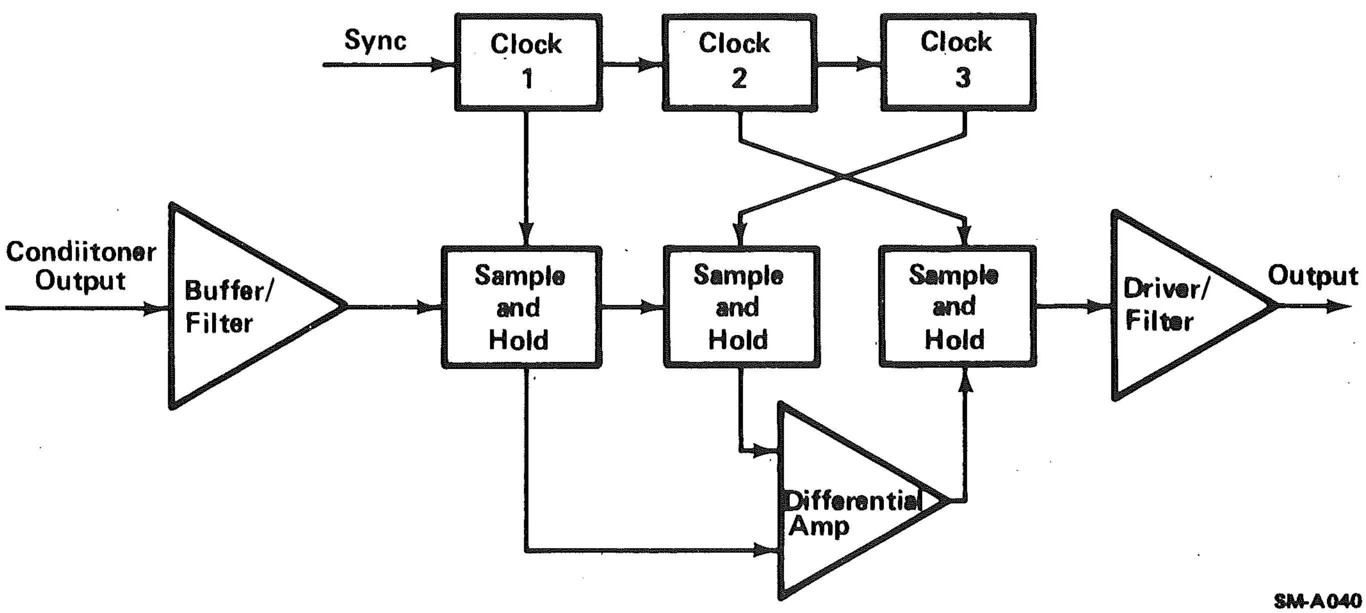

Figure 5-2. Stroke-To-Velocity Converter Block Diagram

The high level feedback from the ac transducer conditioner output is applied to AR4, which serves as an input buffer and filter. At time T1, Q1 is pulsed and a sample of the input voltage at that instant is clocked into the sample and hold circuitry of AR5. This sample is compared by differential amplifier AR7 to the previous sample now in the sample and hold circuitry of AR6. At time T2, Q3 is pulsed and the output of AR7 (the difference between the two samples) is clocked into the sample and hold circuitry of AR8 which applies the voltage to output driver/filter AR9. At time T3, Q2 is pulsed and the voltage in the first sample and hold circuit (AR5) is clocked into the second sample and hold circuit (AR6) to be compared to the next sample voltage when the cycle starts again at T1.

Converter calibration is provided by variable resistors R26, R29, R32, and R37. R42 provides gain adjustment for output driver AR9. Switch S1B selects the appropriate output range to correspond with the volts-per-second (V/S) rate selected by S1A.

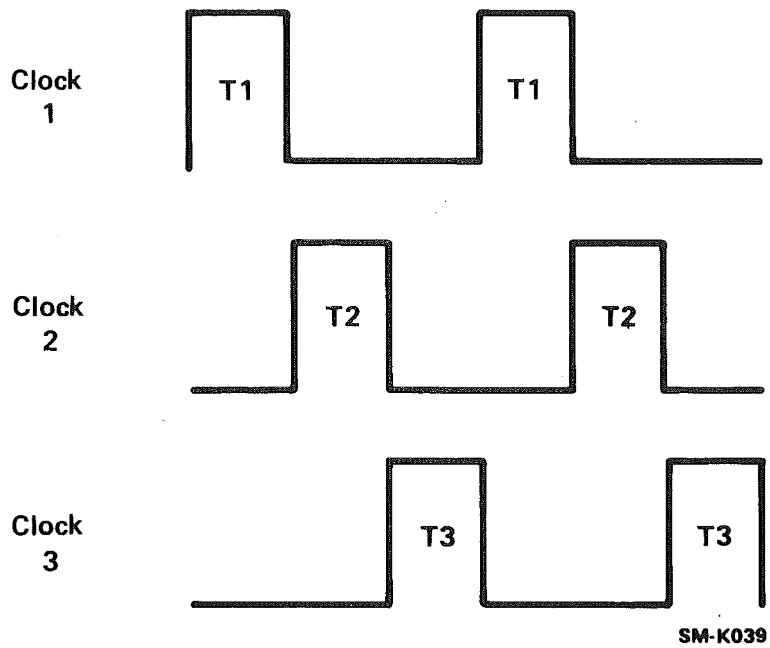

Figure 5-3. Clock Timing Diagram

5.12 DUAL ACCELEROMETER CONDITIONER (OPTION J)

The dual accelerometer conditioner (option J) provides excitation current and output signal amplification for two piezoelectric accelerometers. The circuitry of both channels of the amplifier are identical, therefore only channel 1 is discussed. Refer to schematic diagram C096187-01 during the following discussion.

Transistor Q1 and diodes CR1 and CR3 provide a constant 3.2 mA excitation current to the channel 1 accelerometer. The acclerometer output signal is capacitively coupled to amplifier AR1-3 by capacitor C1. The output of AR1-6 is then applied to amplifier AR2-2. Variable resistor R10 (GAIN) provides gain adjustment of AR2. Variable resistor R6 (ZERO) provides the zero reference for the accelerometer. The maximum output of AR2-6 is ±10 Vdc at 4 mA.