MTS 406.11 Controller +-15 Volt Regulator Test and Modification Procedure

A) Initial Setup

1. Remove external cables from the controller.
2. Attach a dummy load of 150 ohms 1 watt across pins E and B of J229 (servo valve) on the rear panel.
3. Set the "set point" control to 500.
4. Set the "span" control to 000.
5. Place the "limit detect" switch to the "off" position.
6. Place the "feedback select" switch to the "ext" position.
7. Remove the top cover.
8. With the controller switched off, plug the controller into an A.C. power supply set to 130 VAC.

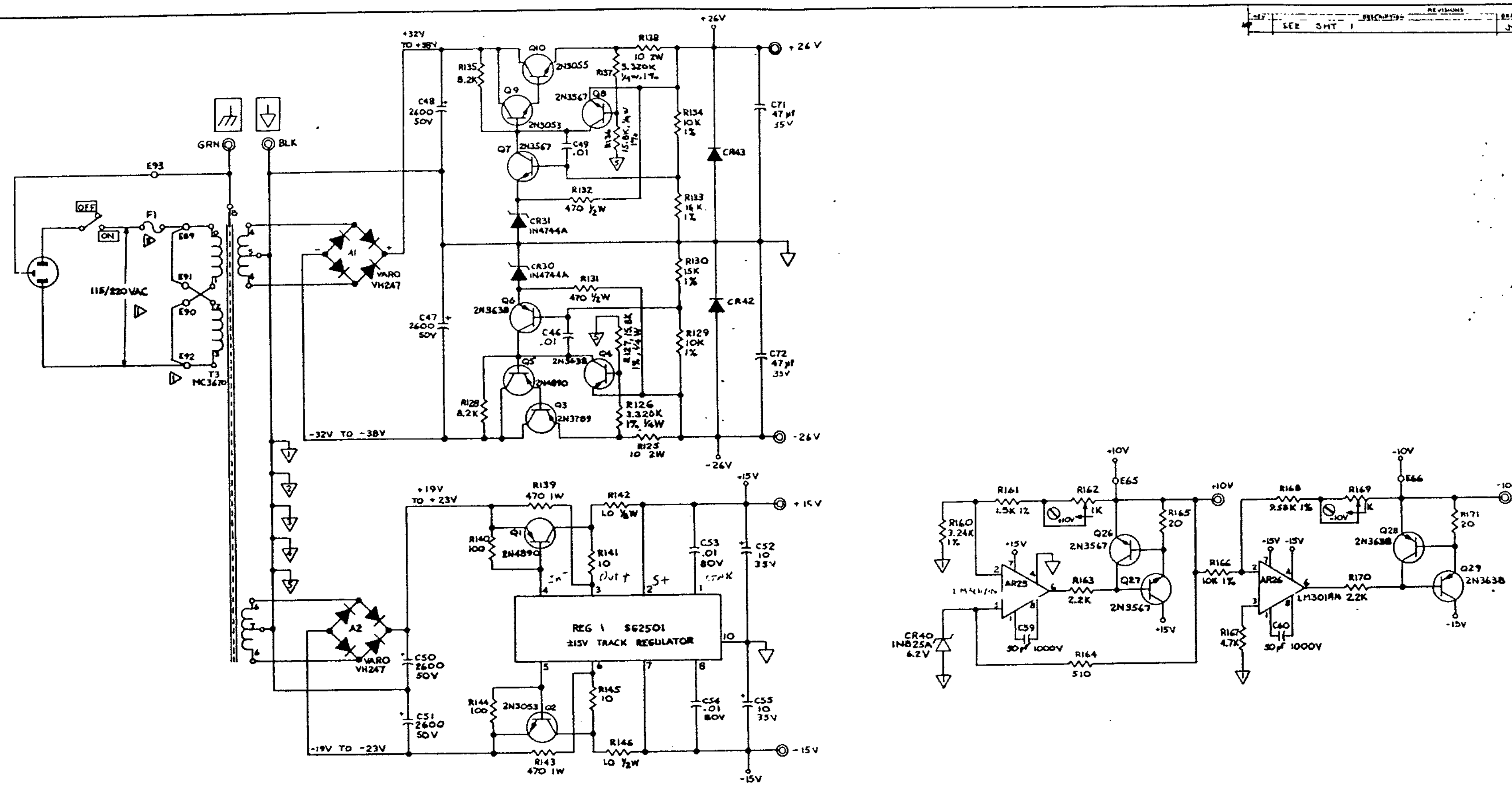
Note: The following instructions for parts B and C concern only the + 15 volt section of the regulator, but they apply equally to the - 15 volt section; the only difference is the test points which will be utilized.

B) 15 Volt Regulator Current Limit Test

1. Place a digital volt meter (DVM) set on the 2 volt scale across the 1 ohm resistor R142 (or R146 for the negative supply). The load current from the regulator passes through the resistor producing a voltage scaled to equal the load current (plus or minus 5%).
2. Place a 2k variable resistor across the +15 volt test point (or the -minus 15 volt test point for the negative supply) and the ground test point with the resistance set to 2k.
3. Apply power to the controller and observe the reading of the DVM.
4. Slowly decrease the value of the 2k variable resistor while observing the DVM. The controller's regulator will shut down when the current limit is reached -- note the DVM reading.
5. Turn off power to the controller.
6. Repeat steps 1 through 5 for the negative supply.
7. If the DVM reading at shutdown did not equal or exceed 275mv then go to part C.
8. Replace the top cover.
9. Place a label on the back panel indicating the current limit was modified or checked and the date.

C) Current Limit Modification

1. Repeat steps 1 and 2 of part B.
2. Place a 100 ohm variable resistor,set to 0 ohms, across R141 (or R145 for the negative supply).
3. Apply power to the controller.
4. Slowly decrease the value of the 2k variable resistor until the DVM reads 275mv.
5. Slowly increase the value of the 100 ohm variable resistor until the regulator shuts down.
6. Turn off power to the controller and remove the 100 ohm variable resistor from the circuit.
7. Measure the value of the 100 ohm variable resistor.
8. Solder a fixed 1/4 watt equivalent resistance of the value measured (or the closest lower value) in parallel with R141 (or R145 for the negative supply).
9. Repeat part B.



3/4 AMP = 115VAC, 1/2 AMP = 220 VAC

FOR 115VAC OPERATION PRIMARIES ARE IN PARALLEL (89-91, 90-92), FOR 220VAC OPERATION PRIMARIES ARE IN SERIES (90-91).

UNLESS OTHERWISE SPECIFIED
ALL DIODES TS-2
RESISTANCE IN OHMS ± 10% 1/4 W
CAPACITANCE IN MFD ± 20%

JMR 8-21-73
RB 9-7-73

CONTROLLER SCHEMATIC
406.11

406.11
D063670-01
SHEET 3 OF 3

SYSTEMS CORPORATION

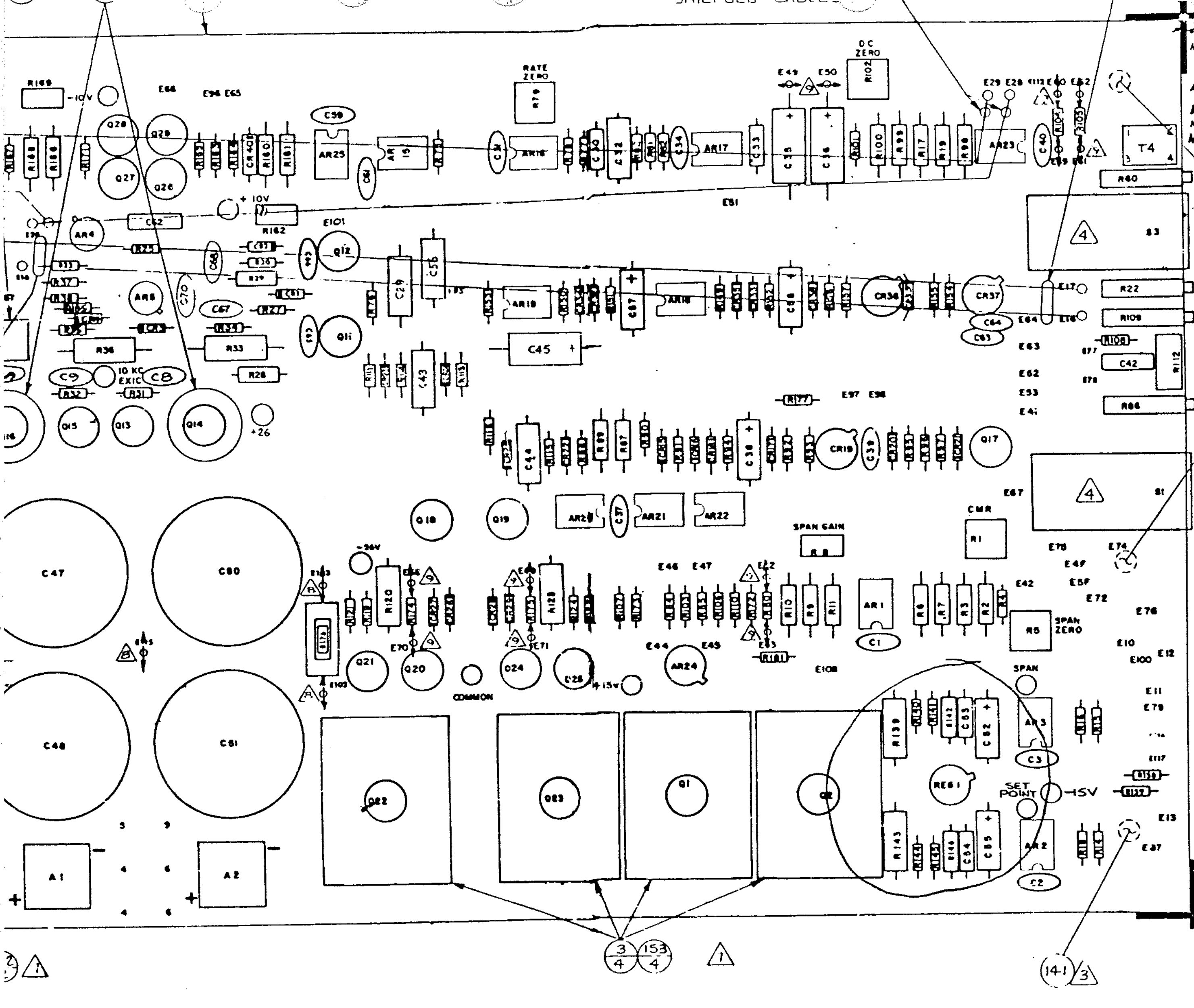
REVISIONS: SEE SHT 1 — JMR — RB — 9-7-73

Rev	Description	By	Appr.
G	REVISED & REDRAWN PER ECO 72-1614	[illegible]	[illegible]
H	REV PER ECO 73-623	SEG	[illegible]
J	DELETE ITEM 21 ECO [illegible]	[illegible]	[illegible]
K	ITEM 77 WAS [illegible]064 PER ECO 7[illegible]	CFC	[illegible]
	DELETE IT. 53 CHA[illegible] R12 PER ECO 73-	RHT.	[illegible]
L	REVISED PER ECO 73-1794	JR	[illegible]
M	REVISED PER ECO 73-2032	WL	[illegible]
N	REVISED PER ECO 74-14	JR	[illegible]
P	ADD C8,9, DELETE C41 ECO 74-663	TS	[illegible]
R	ADD R183, R184 ECO 74-1458	TS	[illegible]
T	ADD NOTES 8,9,10,11 & ITEMS 160,161 ECO 74-1708	TS	SEG
U	CHANGED R126, R127, R136, R137 PER ECO 74-1824	RLL	[illegible]
V	CHANGED ITEM 114 TO .03MF ECO 75-1080	CJM	[illegible]
W	REVISED PER ECO 76-0862	DWH	[illegible]
Y	CHANGE ITEM TO SELECT ECO 76-0998	[illegible]	[illegible]
AA	DELETED CR45-CR47 ECO 77-0400	DWH	[illegible]
AB	ADDED R186, 187 ECO 77-123	CFC	[illegible]
AC	R178 WAS 1.5K - ADDED R181 ECO 77-0487	DWH	[illegible]
AD	ADDED NOTE [illegible] ECO 77-0791	BRN	[illegible]

SHIELDED TWISTED PAIR CABLE

SINGLE CONDUCTOR SHIELDED CABLES

FRONT PANEL



MTS406.11 CONTROLLER CIRCUIT BOARD LAYOUT

COMPONENT TABULATION — TYPE: RESISTORS

ITEM	REF DESIGNATION
162	R137, R126
163	R136, R127
164	R188

COMPONENT TABULATION — TYPE: CAPACITORS

ITEM	REF DESIGNATION	VALUE-µf
21		
36	C38, 57, 56	1
37	C24, 56	.1
38	C33, 53, 54	.01
40	C45	25
42	C32	.022
43	C7, 30	.001
44	C29	.15
45	C35, 36	20
47	C20, 62, 42	1.0
48	C1, 2, 3, 19, 26, 31, 34	50 pf
	37, 40, 59, 60, 61	50 pf
49	C67-70	SELECT
51	C14, 21, 65, 66, 8, 9	22 pf
52	C23	75 pf
53	C71, 72	47
54	C26	220 pf
55	C25	820 pf
56	C27	.0012
57	C4, 5	25
58		
59		
114		
115	C43, 44	.033
129	C52, 55	10
130		
131	C46, 49	.01
157		
157	Q23	2N2102
158	Q22	2N4036

COMPONENT TABULATION — TYPE: SEMICOND & MISC.

ITEM	REF. DESIGNATION
5	AR1, 2, 3, 6, 7, 11, 14, [illegible]
	16, 17, 18, 19, 20, 21, 22, 23, 25, [illegible]
6	REG 1
15	Q10
16	Q3
17	Q1, 5, 12, 16,
18	Q2, 9, 11, 14,
19	Q4, 6, 15, 18, 19, 20,
	28, 29
20	Q7, 8, 13, 17, 24, 26, 2[illegible]
26	CR3, 4, 6, 15-18, [illegible]
	32-35, 38, 39, 41-[illegible]
27	CR7 THRU 14
28	CR30, 31
29	CR40
30	CR19, 36, 37
60	A1, 2
75	AR9, 10, 13
145	CR1, 2, 5
146	AR4, 5, 8, 12
8	T1, T4
9	T2
12	S9
13	S3
14	S1
33	K1
156	Q25

COMPONENT TABULATION — TYPE: RESISTORS

ITEM	REF DESIGNATION	VALUE-Ω
22	R162, 169	1K
23	R8	100K
24	R5, 79, 102	100K
25	R22, 60, 86	10K
31	R3, 61, 62, 63, 64, 87, 89	100K
32	R17, 19, 98, 100, 129, 134, 166	10K

COMPONENT TABULATION — TYPE: RESISTORS

ITEM	REF DESIGNATION	VALUE-Ω
71	R131, 132, 176	470
72	R130, 133	15K
73	R33, 36	100
77	R4, 183, 184, 185	10M
79	R14-16, 37-40, 48, 49, 51,	
	18, 75, 81, 82, 107, 153,	10K

COMPONENT TABULATION — TYPE: RESISTORS

ITEM	REF DESIGNATION	VALUE-Ω
88	R50, 56, 84, 85, 114, 115	27K
89	R52	1M
90	R54, 55	2.1K
91	R71	44.2K
92	R76, R178	470
93	R77, 80, 88, 182	47K

COMPONENT TABULATION — TYPE: RESISTORS

ITEM	REF DESIGNATION	VALUE-Ω
103	R120, 123	10
104	R121, 122, 140, 144	100
	R186, 187	
106	R108, 128, 135	8.2K
108	R164	510
109	R165, 171	20

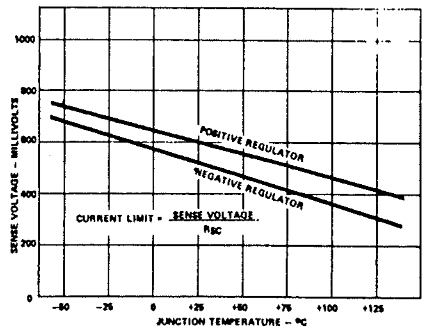
A Description of the MTS 406.11 Controller
+- 15 Volt Regulator

The MTS 406.11 controller utilizes a +- 15 volt regulator to bias most of its circuits and to provide excitation to external transducers. The regulator consists of a SG2501A dual tracking regulator (Reg 1), pass transistors (Q1,Q2), and current sensing resistors. The SG2501A's mode of operation is modified by the pass transistors and current sensing resistors causing unwanted regulator shutdowns when the AC line voltage is high.

In its normal mode of operation, the SG2501A provides +- 15 volt outputs at up to 200 ma with current limiting. An internal reference is used in conjunction with an amplifier to produce -15 volts at the "- sense" pin (refer to the attached diagram). To produce a positive output, the negative output is used as a reference. The positive output at the "+ sense" must equal the magnitude of the - 15 volt output or an error voltage is produced in an internal amplifier to correct the positive output. The current is limited to the outputs when the voltage between the "sense" and "out" pins exceeds a threshold; a resister is used between these pins to sense the current.

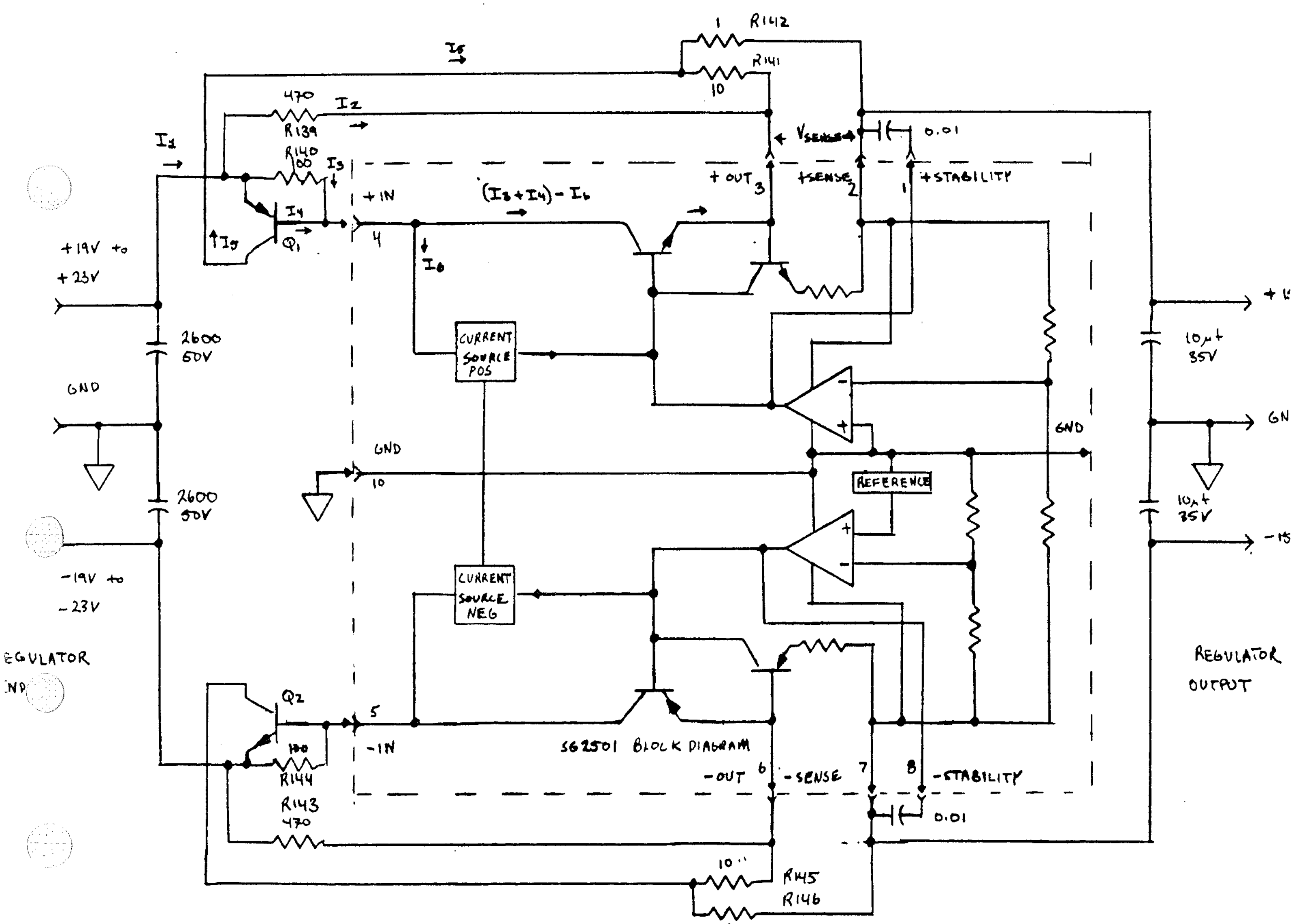
The MTS 406.11 controller modifies the operation of the SG2501A to increase the power capability and to provide foldback current limiting. External pass transistors (Q1,Q2) reduce the current through the regulator by a factor of their current gain. The foldback current limiting functions to require the controller to be powered down once the current limit is exceeded.

A high AC line voltage may cause the regulator to shut down before its specified current limit. This is due to the foldback current limiting circuit which uses unregulated voltage as a reference. To further exacerbate the sensitivity to the high line voltage, the SG2501A's current limit sense voltage decreases in a manner related to an increase in its junction temperature (as shown on the attached graph); the negative regulator is more sensitive in this regard than the positive. Each controller will respond differently to a high AC line voltage due to component tolerances internal and external to the SG2501A.



Current Limiting Characteristics

SG2501A REGULATOR
CURRENT LIMIT SENSE VOLTAGE VS JUNCTION TEMPERATURE



MTS406.11 CONTROLLER
15 VOLT REGULATOR

2/24/84

MAIN LOOP GAIN MODIFICATION FOR THE MTS 406.11 CONTROLLER

MAIN BOARD:

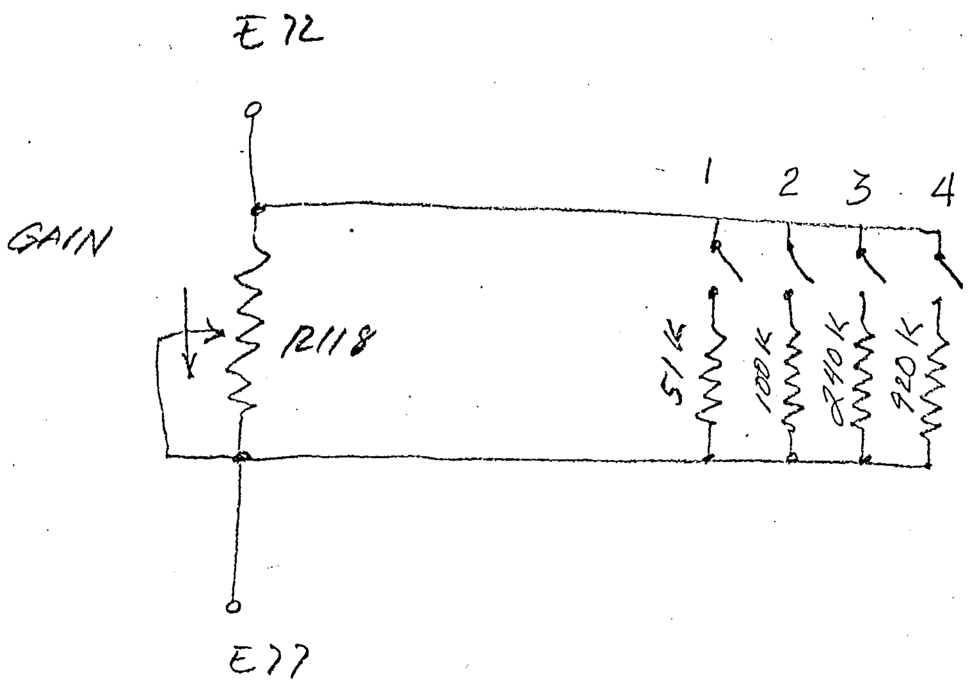
R118 CHANGED TO 1MEG
R104 " " 2.2K
R105 " " 2.2K

DC XDCR BOARD:

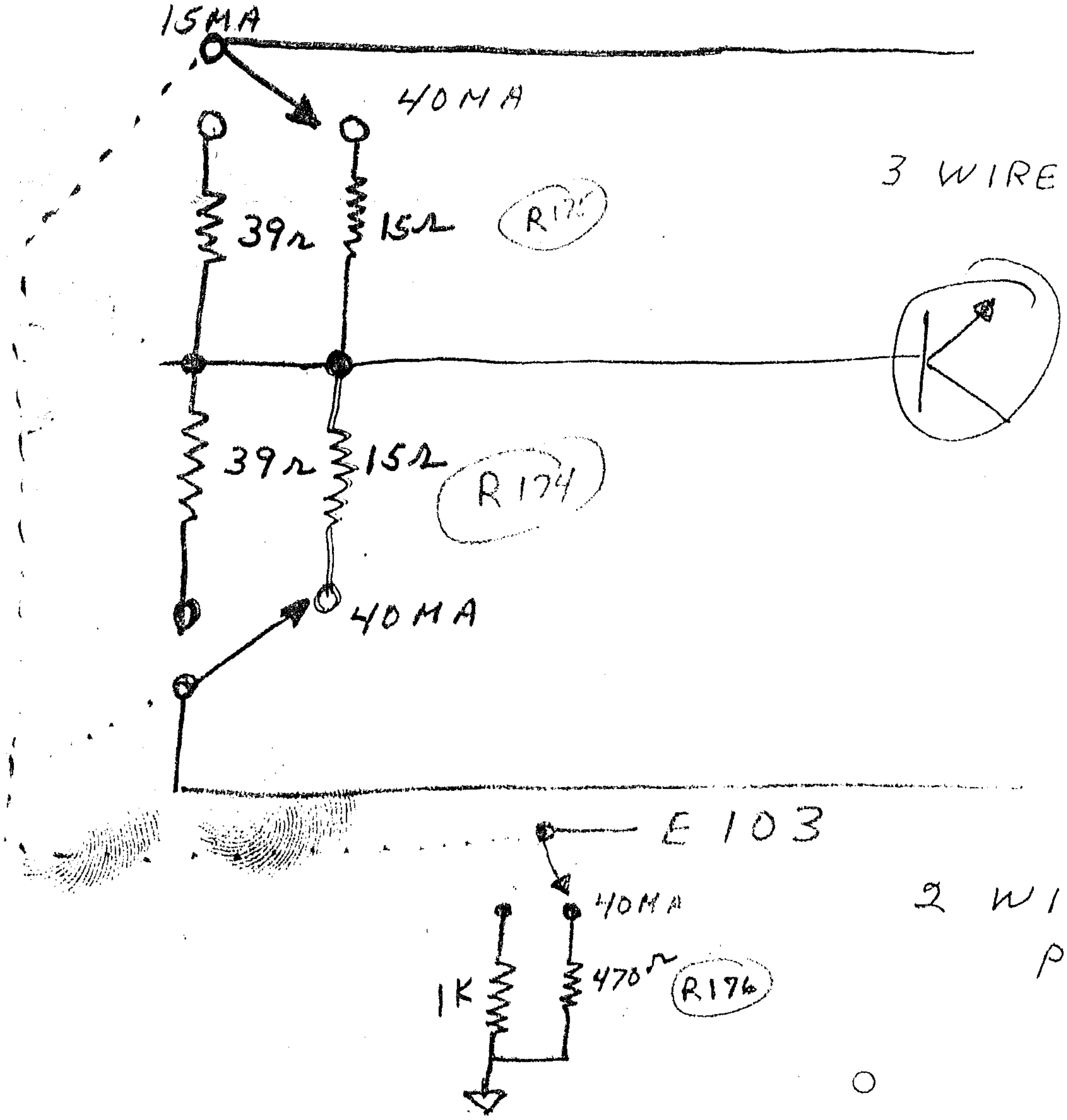
R21 CHANGED TO 2.2K
R22 " " 22K

ADDITIONS:

RESISTORS 51K, 100K, 240K, 920K
1 DIP SWITCH



THE 1 POSITION IS EQUIVALENT TO THE ORIGINAL GAIN RANGE. FOR 2 CLOSED 1,3,4 OPEN THE RANGE IS DOUBLED. ALL OPEN INCREASES THE RANGE 16 TIMES.



3 WIRE BACK PANEL TO P.C. Board

2 WIRE BACK PANEL TO P.C. Board

RESISTOR MOUNTED ON S.W. on REAR PANEL

Parts need. 3 Pole 2 Pos. Wafer Switch
3 Resistor
5 Wire
1 knob per unit.
total 10 unit.

MODEL 406.11 CONTROLLER

MTS®
MTS SYSTEMS CORPORATION
BOX 24012, MINNEAPOLIS, MINNESOTA 55424
TELEPHONE 612-937-4000 TELEX 29-0521 MTSSYSTEMSENPE

0782
111816-07-777

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SECTION I
INTRODUCTION

1.1 FUNCTIONAL DESCRIPTION

The Model 406.11 Controller provides the servo control, transducer conditioning, interlock, and readout functions for one channel of a closed-loop electrohydraulic system. Frequently used controls are located on the controller front panel as shown in figure 1-1. Less frequently used controls are located on an inner panel behind a lift-up door.

Figure 1-1. Model 406.11 Controller

The basic 406.11 Controller consists of the following circuitry:

- ac transducer conditioner
- feedback selector
- servo controller
- limit detector

Figure 1-2 is a block diagram of a typical closed-loop electrohydraulic system containing a basic 406.11 Controller. The internal ac transducer conditioner applies ac excitation to either a resistive or reactive type transducer and amplifies and demodulates the transducer output to ±10 volts full-scale. The transducer conditioner output may be used for readout only or it may also be selected as feedback for the servo controller. The basic 406.11 contains only one transducer conditioner, however an additional optional module may be added to suit a particular system application. If further expansion is necessary, additional modules may be installed in an optional conditioner panel (refer to paragrah 1.2.6).

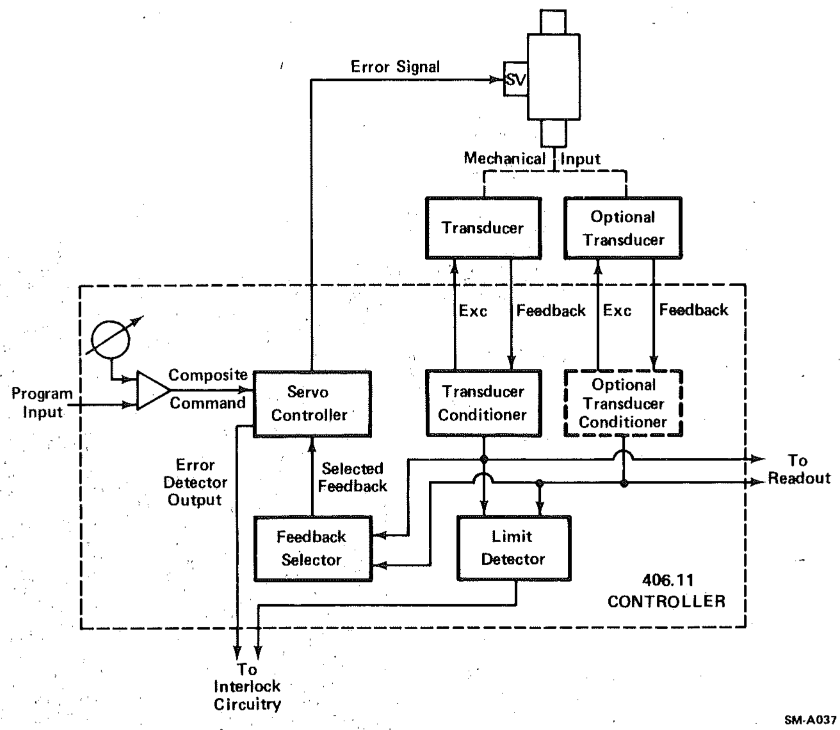

Figure 1-2. Basic 406.11 Block Diagram

When more than one transducer is used in a system configuration, the output of the desired transducer conditioner is routed to the servo controller via the feedback selector. The three position feedback selector switch selects the output of the built-in transducer conditioner, transducer conditioner number two (optional), or an externally located transducer conditioner for feedback. The parameter providing the selected feedback signal is referred to as the controlled variable.

The servo controller compares a composite command signal, which consists of the summation of an external program input signal and parameters established by the front panel SPAN and SET POINT control settings, to the controlled variable feedback signal. The composite command signal represents the desired amount and direction of a physical quantity to be applied by the hydraulic actuator. If composite command and feedback are not equal, an error exists. By comparing these two signals, the servo controller develops an error signal that has a magnitude proportional to the difference between them and a polarity determined by their relative polarities. If composite commmand is more positive or less negative than feedback, a positive error signal results and vice versa.

The error signal is applied to the valve amplifier which develops a valve drive signal to drive the servovalve which in turn controls the hydraulic actuator. The polarity and magnitude of the valve drive signal causes the servovalve to open in the direction and amount required to move the actuator in the direction that reduces the error signal. When the error signal is reduced to zero, the servovalve closes.

The error signal is continuously monitored by an error detector circuit within the servo controller. If the amplitude of the error signal exceeds a preset level, a front panel warning light indicates the condition to the operator. The error detector circuitry may also be used to activate a system interlock circuit in addition to the front panel indicator. The system interlock circuit is typically used to prevent or terminate the application of hydraulic pressure to the servovalve when an abnormal condition is sensed.

The valve amplifier circuitry also includes a dither oscillator which applies a high-frequency signal to the servovalve to help prevent silting and overcome static friction in the servovalve and actuator.

The limit detector circuitry allows the operator to preset upper and lower feedback signal amplitude limits for either of two possible transducer conditioners. A front panel switch determines which transducer conditioner output is being monitored by the limit detector and whether a detected limit will cause system interlock action or simply an indication on the front panel.

1.2 OPTIONS

Several options are available for use with the Model 406.11 Controller. These options include the following:

- Option A - DC Transducer Conditioner Module
- Option B - ΔP Stabilization
- Option C - Reset Integrator/Null Detector
- Option D - Valve Controller Module
- Option E - AC Transducer Conditioner Module
- Option F - Conditioner Panel (for use in expanded system configurations)
- Option G - Limit Detector (for use with option F)
- Option H - Stroke-To-Velocity Converter
- Option J - Dual Accelerometer Conditioner

Options A, D, and E are plug-in modules which insert into the slot on the right-hand side of the 406.11 chassis. When more than one of these options are included in a system configuration, a separate conditioner panel (option F) is required to accomodate the modules.

Options B, C, H, and J are printed circuit cards which plug into the master board within the 406.11 chassis. Option G, when included, is located in the option F panel.

1.2.1 DC TRANSDUCER CONDITIONER MODULE (OPTION A)

The Option A, DC Transducer Conditioner module (XDCR 2 DC), shown in figure 1-3, applies dc excitation (variable from 2 to 22 Vdc) to resistive transducers such as load cells and strain gages, and amplifies the transducer output to ±10 volts full-scale. The transducer output signal is used for readout and may also be selected as the controlled variable for the servo controller.

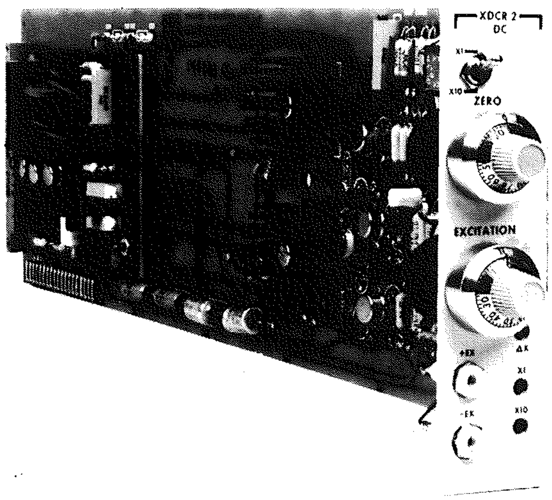

Figure 1-3. DC Transducer Conditioner Module (Option A)

The conditioner provides two operating ranges (X1 and X10) for the associated transducer. In the X10 range, the transducer output signal is amplified so that 10% of the transducers full-scale rating is expanded to represent full-scale in lower force applications. The conditioner also has a zero control to cancel offsets imposed by the weight of grips and other fixtures in the force train.

1.2.2 ΔP STABILIZATION (OPTION B)

ΔP Stabilization is used in conjunction with a resistive-bridge pressure transducer connected across the actuator piston. The ΔP circuitry provides dc excitation for the pressure transducer and amplifies the transducer output signal. The output signal of the pressure transducer represents the analog of the forces being generated by the actuator and is used to stabilize a high-performance control loop when operating in stroke control. Stabilization is accomplished by summing this signal with the dc error signal at the valve amplifier. A single-turn potentiometer, located on the 406.11 front inner-panel, provides amplitude control of the ΔP stabilization signal.

1.2.3 RESET INTEGRATOR/NULL DETECTOR (OPTION C)

Option C contains two separate functional circuits; a reset integrator circuit and a null detector circuit.

The reset integrator circuitry compensates for minor offsets caused by factors such as servovalve unbalance or internal leakage across the actuator piston. This circuitry may be activated automatically (by a programmer dwell signal) or manually by an externally located switching device.

The null detector circuitry is used with programmers that have an interrupt capability (such as MTS digital programmers) to provide program pacing. Program pacing ensures that the program is accurately applied in the minimum practical time. Figure 1-4 illustrates the effect of program pacing. If the program is too fast-paced for the system, feedback will still be moving toward a peak when the program reverses and the peak values will never actually be reached. This is shown in the left-hand example in figure 1-4. To ensure that the program peaks are reached, program pacing automatically holds the program and turns on the reset integrator circuitry if command and feedback are not within a preset percentage of each other (null) at program breakpoints. This is shown in the right-hand example of figure 1-4. The reset integrator speeds up the correction. When command and feedback come within the preset null limit, the hold is automatically removed and the program continues.

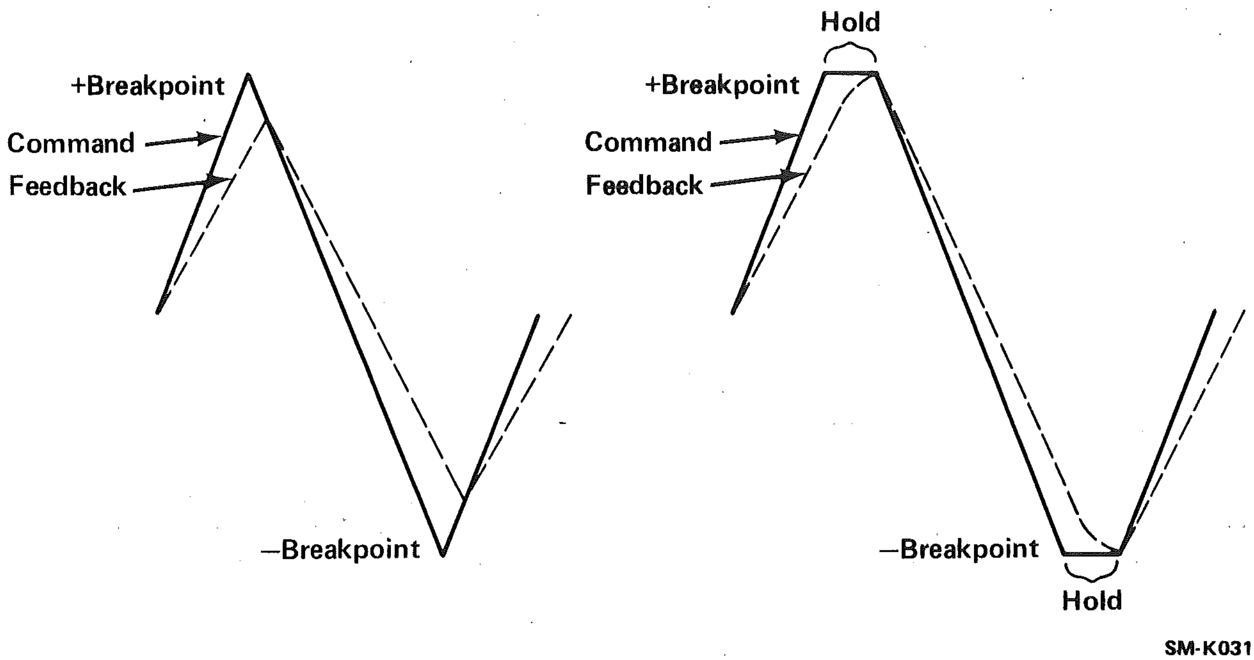

Figure 1-4. Effects of Program Pacing on System Signals

1.2.4 VALVE CONTROLLER MODULE (OPTION D)

The Valve Controller (option D), shown in figure 1-5, contains the necessary circuitry to control the third-stage slave spool position of a three-stage, high-flow, medium-performance servovalve such as the MTS 253 series. The valve controller provides 10 kHz excitation for the third-stage linear variable differential transformer (LVDT) and amplifies and demodulates the output signal of the transducer. The LVDT output signal is compared to the servo controller error signal and any difference is amplified and applied as a command signal to the servovalve first stage to zero the error signal.

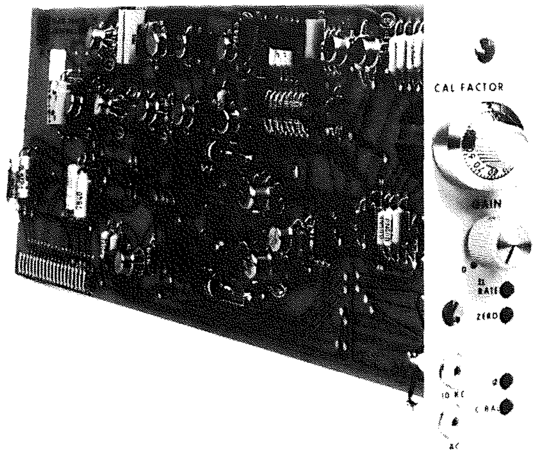

Figure 1-5. Valve Controller Module (Option D)

NOTE

Only one Option D Valve Controller may be used for each 406.11 Controller contained in a system.

1.2.5 AC TRANSDUCER CONDITIONER MODULE (OPTION E)

The option E, AC Transducer Conditioner Module (XDCR 2 AC), shown in figure 1-6, provides ac excitation and transducer output amplification in system configurations requiring more than one ac transducer conditioner. The conditioner output may be used for readout or it may also be selected as the controlled variable for the servo controller.

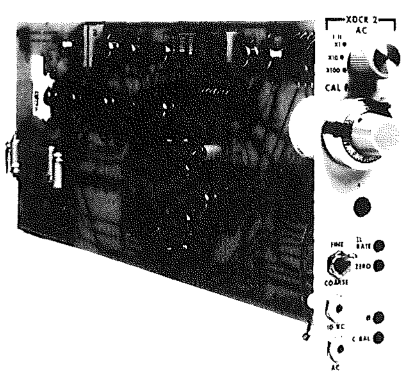

Figure 1-6. AC Transducer Conditioner Module (Option E)

1.2.6 CONDITIONER PANEL (OPTION F)

The Conditioner Panel (option F), shown in figure 1-7, is a separate panel capable of accommodating up to four optional 406.11 modules. Since the basic 406.11 chassis can accommodate only one optional plug-in module, the panel is used in system configurations requiring additional plug-in modules.

Option F contains its own power supply to operate the modules. In addition, it also contains a separate panel meter to monitor the module outputs and may also contain an optional five-input limit detector (option G).

Figure 1-7. Conditioner Panel (Option F) Including Limit Detector (Option G)

1.2.7 LIMIT DETECTOR (OPTION G)

The Limit Detector (option G) may be included in the Conditioner Panel (option F). The option G circuitry operates identically to that of the limit detector in the basic 406.11 chassis. It is used to preset upper and lower feedback signal amplitude limits for any of the five possible transducer conditioners. A selector switch on the front panel selects which transducer conditioner output is being monitored by the limit detector. Another switch selects whether a detected limit will cause system interlock action or simply an indication on the option F front panel. The conditioner panel shown in figure 1-7 includes option G.

1.2.8 STROKE-TO-VELOCITY CONVERTER (OPTION H)

The Stroke-to-Velocity Converter (option H) produces an output signal proportional to the velocity of the actuator stroke. The converter receives the output of the stroke associated transducer conditioner and converts it to a velocity signal typically used for readout purposes only. The converter does not interfere with the normal operation of the transducer conditioner from which it receives its input. Converter input and output are both ±10 volts full-scale. A range switch selects the readout scaling; ±10 volts corresponds to either ±200 volts-per-second (V/S) or ±20 volts-per-second.

1.2.9 DUAL ACCELEROMETER CONDITIONER (OPTION J)

The Dual Accelerometer Conditioner (option J) is used primarily in vibration and shock testing applications to provide excitation current and output signal amplification for up to two piezoelectric accelerometers. The excitation source provides a 3.2 mA constant current excitation to the accelerometers. The amplifier provides adjustable gain for signal amplification over a frequency range of 1 to 2000 Hz.

1.3 SPECIFICATIONS

Table 1-1 lists the specifications for the basic 406.11 Controller. Tables 1-2 through 1-10 list the specifications for the 406.11 options as indicated.

Table 1-1. Basic 406.11 Controller Specifications

POWER SUPPLY	
Operating Current Range,	
±10 volts:	0 to 30 mA (10 mA available for external use)
±15 volts:	0 to 275 mA
±26 volts:	0 to 430 mA

Table 1-1. Basic 406.11 Controller Specifications (Continued)

POWER SUPPLY	
AC Power Requirements:	105 to 125 Vac or 210 to 250 Vac 50/60 Hz
Full-Load Power:	40 W
Ambient Temp Range:	32 to 120°F (0 to 50°C)
Temp Coefficient (±10 volt reference):	±0.005%/°C
Temp Coefficient (±15 volt source):	±0.01%/°C
Temp Coefficient (±26 volt source):	±0.05%/°C
AC TRANSDUCER CONDITIONER	
Excitation Output:	20V p-p (fixed)
Excitation Stability,	
Time:	±0.1%/24 hrs
Temp:	±0.015%/°C
Load:	±0.1% no load to full load
Excitation Frequency:	10 kHz (±2%)
Minimum Excitation Load:	90 Ω
Amplifier Gain:	Variable from X1.1 to X1000
Amplifier Stability:	±0.02%/°C
Amplifier Input Impedance:	100 kΩ minimum
Amplifier Offset Drift,	
Time:	±20μV/8 hrs (referenced to the input)
Temp:	±5μV/°C (referenced to the input)

Table 1-1. Basic 406.11 Controller Specifications (Continued)

AC TRANSDUCER CONDITIONER	
Amplifier Output:	±10V, full-scale
Amplifier Output Impedance:	0.5 Ω maximum at 10 mA
Amplifier Output Linearity:	±0.5%, DC to 100 Hz
Frequency Response:	-3 dB at 2 kHz
SERVO CONTROLLER	
Command Input (from external source):	2 to 25V p-p (preset)
Input Impedance:	100 kΩ
Common Mode Rejection:	60 dB at 60 Hz with 600 Ω source unbalance
Span Control Linearity:	±0.25% maximum
Set Point Linearity:	±0.15% maximum
Set Point Temp Coefficient:	±0.005%/°C
Feedback Input:	±10V, full-scale (from transducer conditioner)
Frequency Response:	-3 dB at 3 kHz
Gain Range:	1 mA/V to 400 mA/V
Zero Drift:	150µV/°C (referenced to the input)
Valve Amplifier:	40 mA or 200 mA
Dither Frequency:	600 to 800 Hz
Dither Amplitude:	0 to 20% of valve amplifier drive current (adjustable)
Error Detector Range:	±1% to 100%
LIMIT DETECTOR	
Input Signal:	0 to ±10V
Input Impedance:	>25 kΩ

Table 1-1. Basic 406.11 Controller Specifications (Continued)

LIMIT DETECTOR	
Frequency Range:	DC to 1 kHz
Detection Accuracy:	±0.5% of range
Detection Linearity:	±0.25%
Detection Repeatability:	0.1% of range
Temp Coefficient:	0.05%/°C
PHYSICAL SPECIFICATIONS	
Height:	5.25 in. (133 mm)
Width:	8.85 in. (225 mm)
Depth:	18.75 in. (476 mm)
Shipping Weight:	12 lbs (5.4 kg).

Table 1-2. DC Transducer Conditioner (Option A) Specifications

Excitation Output Voltage:	2 to 22 Vdc (variable)
Excitation Stability,	
Time:	±0.01%/24 hrs
Temp:	±0.015%/°C
Load:	±0.1%, no load to full load
Minimum Excitation Load:	10 Ω/V (current limited to 100 mA)
Amplifier Gain:	X500 or X5000 (switch selectable)
Amplifier Drift (temp):	±0.02%/°C
Amplifier Input Impedance:	100 kΩ minimum
Amplifier Offset Drift,	
Time:	±1.5μV/8 hrs (referenced to the input)
Temp:	±1.5μV/°C (referenced to the input)
Output Voltage:	±10V, full-scale
Output Impedance:	0.5 Ω maximum at 5 mA
Output Linearity:	±0.1%, DC to 100 Hz
Frequency Response:	-3 dB at 2 kHz (typical)
Common Mode Rejection:	>110 dB, DC to 60 Hz with 350 Ω unbalance >70 dB at 1 kHz with 350 Ω unbalance
Low-Pass Filter Cutoff Frequency:	200 Hz
Amplifier Phase Shift Without Filter:	<10° at 300 Hz
Amplifier Phase Shift With Filter:	11° at 20 Hz

Table 1-3. ΔP Stabilization (Option B) Specifications

Input Impedance:	10 kΩ
Input Offset Drift (temp):	±6 μV/°C
Output Voltage (maximum):	±10V
Output Impedance:	<1 Ω
Output Current (maximum):	15mA at ±10V
Output Noise	<100mV
Amplifier Gain:	approximately 700
Common Mode Rejection:	50dB
Frequency Response:	-3dB at 700 Hz
Excitation Voltage:	-6.2 Vdc

Table 1-4. Reset Integrator/Null Detector (Option C) Specifications

Reset Integrator Input:	±10V (error signal)
Reset Integrator Output:	±10V (to valve driver)
Integrator Time Constant:	100 msec
Null Detector Sensitivity:	0% to 75% of full-scale

Table 1-5. Valve Controller (Option D) Specifications

Power Requirements:	+15 Vdc at 50 mA -15 Vdc at 50 mA +26 Vdc at 70 mA -26 Vdc at 70 mA
AC Excitation Output:	20V p-p (fixed)
Excitation Stability,	
Time:	±0.1%/24 hrs
Temp:	±0.015%/°C
Load:	±0.1% no load to full load
Excitation Frequency:	10 kHz (slaved to 406.11 oscillator)
Minimum Excitation Load:	90 Ω
Phase Shift Range to Demodulator:	1° to 50°
Conditioner Amplifier,	
Gain:	X1.1 to X1000 (variable)
Input Impedance:	100 kΩ (minimum)
Offset Drift:	±20μV/8 hrs (time) ±5μV/°C (temp)
Output:	±10 Vdc, full-scale
Output Linearity:	±0.5% DC to 100 Hz
Output Current:	5 mA maximum
Frequency Response:	-3 dB at 2 kHz (typical) -1 dB at 200 Hz
Gain Range Amplifier Gain:	1 to 100 (variable by resistor change)

Table 1-6. AC Transducer Conditioner (Option E) Specifications

Excitation Output:	20V p-p (fixed)
Excitation Stability,	
Time:	±0.1%/24 hrs
Temp:	±0.015%/°C
Load:	±0.1%, no load to full load
Excitation Frequency:	10 kHz (±2%)
Minimum Excitation Load:	90 Ω
Amplifier Gain:	X1, X10 (switch selectable)
Amplifier Stability:	±0.02%/°C (X1 range)
Amplifier Input Impedance:	100 kΩ minimum
Amplifier Offset Drift,	
Time:	±20μV/8 hrs
Temp:	±5μV/°C
Amplifier Output:	±10V, full-scale
Amplifier Output Impedance:	0.5 Ω maximum at 10 mA
Amplifier Output Linearity:	±0.5%, DC to 100 Hz
Frequency Response:	-3 dB at 2 kHz

Table 1-7. Conditioner Panel (Option F) Specifications

POWER SUPPLY	
Power Requirements:	105 to 125 Vac, or 210 to 230 Vac, 50/60 Hz, 75 W maximum
Ambient Temp Range:	50 to 104°F (10 to 40°C)
Power Supply (±10 Vdc),	
Current:	30 mA (maximum)
Temp Coef:	0.005%/°C
Power Supply (±15 Vdc),	
Current:	500 mA (maximum)
Temp Coef:	0.02%/°C
Power Supply (±26 Vdc),	
Current:	450 mA (maximum)
PHYSICAL SPECIFICATIONS	
Height:	5.25 in. (133 mm)
Width:	8.85 in. (225 mm)
Depth:	18.75 in. (476 mm)
Shipping Weight:	21 lb (9.5 kg)

Table 1-8. Limit Detector (Option G) Specifications

Input Signal:	0 to ±10 V
Input Impedance:	>25 kΩ, DC >10 kΩ, AC
Frequency Range:	DC to 1 kHz
Detection Accuracy:	±0.5% of range
Detection Linearity:	±0.25%
Detection Repeatability:	±0.1%
Temp Coef:	0.05%/°C

Table 1-9. Stroke-To-Velocity Converter (Option H) Specifications

Stroke Input Signal:	±10V, full-scale
Velocity Output Signal:	±10V, full-scale (±200V/s or ±20V/s)
Power Requirements:	+15 Vdc at 80 mA -15 Vdc at 40 mA

Table 1-10. Dual Accelerometer Conditioner (Option J) Specifications

Input (from accelerometer):	0 to ±5V
Output:	±10V
Amplifier Gain:	7.5 to 12.5 (adjustable)
Frequency Response:	-3dB at 30 kHz

SECTION II
OPERATION

2.1 CONTROLS AND INDICATORS

The following paragraphs briefly describe the controls and indicators on the Model 406.11 Controller and the optional 406.11 modules.

2.1.1 BASIC 406.11 CONTROLS AND INDICATORS

Table 2-1 briefly describes the controls and indicators on the basic 406.11 Controller front panel and inner panel as shown in figure 2-1. Refer to the indicated paragraphs for detailed instructions.

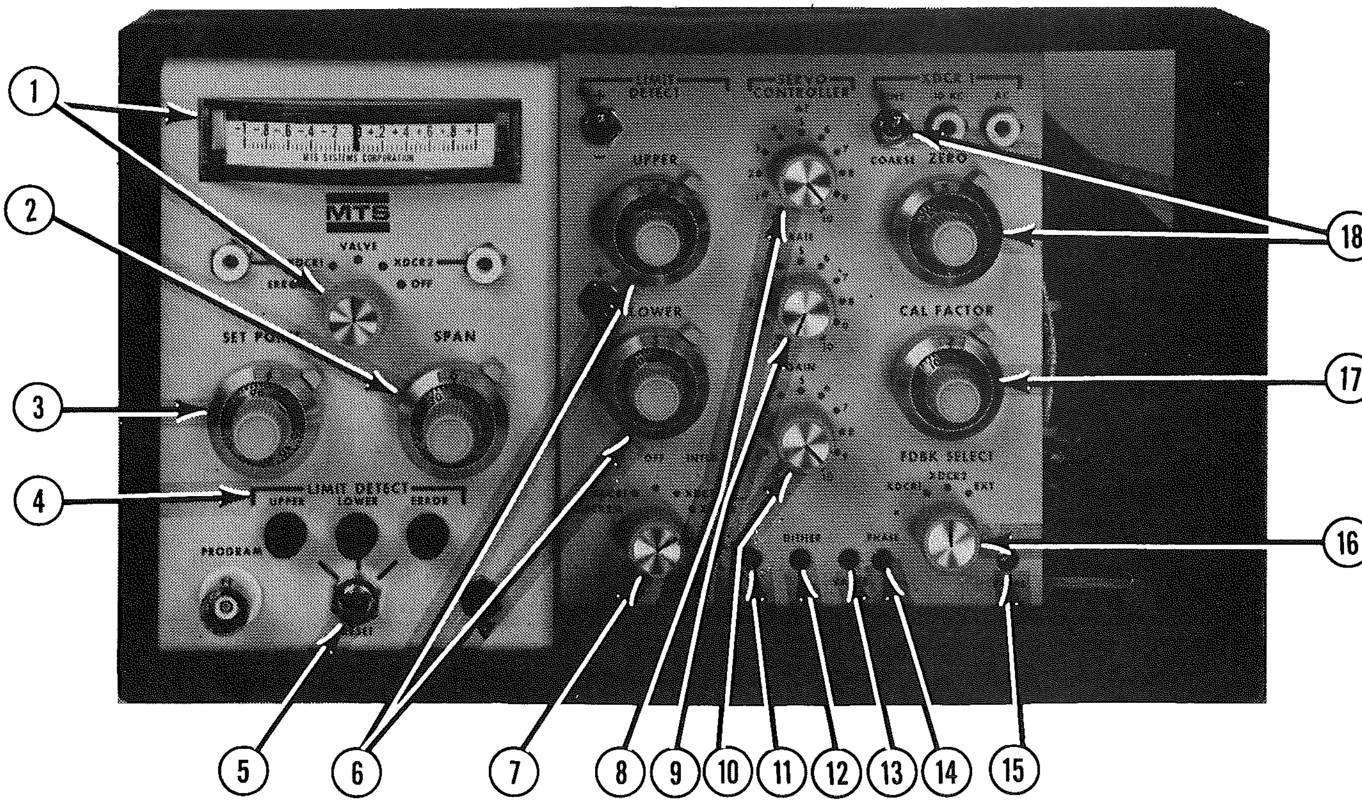

Figure 2-1. Basic 406.11 Controls and Indicators

Table 2-1. Basic 406.11 Controls And Indicators

ITEM	CONTROL/INDICATOR	FUNCTION
1	Panel Meter and Meter Switch	The panel meter and meter switch are used to monitor various signals within the system. By selecting the various switch positions, the operator may monitor the output of transducer conditioner 1 (XDCR 1), an optional transducer conditioner (XDCR 2), the system dc error signal (ERROR), or the servovalve drive signal (VALVE). Test jacks are also provided for XDCR 1 and XDCR 2 outputs. Refer to paragraph 2.2.1 for panel meter operation.
2	SPAN control	The SPAN control is a ten-turn control which is used to precisely attenuate the program input, thus determining the dynamic amplitude of the composite command signal. SPAN settings of 000 to 1000 represent zero to ±100% of the system operating range. Refer to paragraph 2.2.3 to determine the proper SPAN adjustment.
3	SET POINT control	The SET POINT control is a ten-turn control which is adjusted to provide a precise static offset to establish the mean level of the composite command signal. SET POINT scaling is from -100% of the system operating range (control setting 000) through 0% (control setting 500) to +100% (control setting 1000). Refer to paragraph 2.2.4 to determine the proper SET POINT adjustment.
4	LIMIT DETECT indicators	The LIMIT DETECT indicators light to indicate when preset feedback levels have been exceeded. The UPPER or LOWER indicator lights when the selected transducer feedback signal exceeds a positive (least negative) or negative (least positive) limit respectively. These limits are established by the adjustment of the UPPER and LOWER LIMIT DETECT controls (item 6). The ERROR indicator lights when the system dc error signal (the difference between command and feedback) exceeds a level established by the adjustment of the ED potentiometer (item 11).

Table 2-1. Basic 406.11 Controls and Indicators (Continued)

ITEM	CONTROL/INDICATOR	FUNCTION
5	RESET pushbutton	Pressing the RESET pushbutton extinguishes the LIMIT DETECT indicators and resets the interlock circuitry (if active) after the limit detector or error detector circuitry has activated. If the exceeded limit or dc error is still present and it is desired to over-ride the interlock circuitry, the interlock circuitry remains inactive as long as the RESET pushbutton is pressed.
6	UPPER and LOWER LIMIT DETECT controls and +/- toggle switches	Adjusting the UPPER and LOWER LIMIT DETECT controls and the position of the associated +/- toggle switches establishes the transducer output signal level which activates the limit detector circuitry. The ten-turn UPPER control establishes the most positive (least negative) limit. The ten-turn LOWER control establishes the most negative (least positive) limit. Control scaling is from 000 to 1000, representing 0% to 100% of the system operating range. The position of the +/- toggle switch associated with each control determines whether the limit is of positive (+) or negative (-) polarity. Refer to paragraph 2.2.6 to determine the proper adjustment.
7	IND/OFF/INTLK switch	The position of the IND/OFF/INTLK switch determines which transducer output signal is being monitored by the limit detector circuitry and whether an exceeded limit will cause interlock action and indicator illumination or indicator illumination only. Selecting the XDCR 1 or XDCR 2 position under IND provides only indicator illumination; selecting the XDCR 1 or XDCR 2 position under INTLK provides interlock action in addition to indicator illumination. Selecting the OFF position (center) de-activates the limit detector circuitry.
8	ΔP control	The single-turn ΔP control provides amplitude control of the ΔP stabilization signal in 406.11 Controllers containing option B (refer to paragraph 2.2.7 or 2.2.8). The ΔP control is inactive if option B is not included.

Table 2-1. Basic 406.11 Controls and Indicators (Continued)

ITEM	CONTROL/INDICATOR	FUNCTION
9	RATE control	Adjustment of the single-turn RATE control helps prevent oscillations at high GAIN settings (refer to paragraph 2.2.7 or 2.2.8).
10	GAIN control	The single-turn GAIN control adjusts the system's response (speed of correction) to a given dc error signal (refer to paragraph 2.2.7 or 2.2.8).
11	ED potentiometer	Adjusting the 15-turn ED (error detector) potentiometer determines the dc error signal level at which the error detector circuitry activates (refer to paragraph 2.2.5).
12	DITHER potentiometer	Adjustment of the DITHER potentiometer determines the amplitude of the dither signal applied to the servovalve (refer to paragraph 2.2.10).
13	VALVE potentiometer	The VALVE potentiometer is a calibration control adjusted only during servovalve balance calibration (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.
14	PHASE potentiometer	The PHASE potentiometer is a calibration control adjusted during calibration to compensate for phase shifts introduced by the transducer (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.
15	C-BAL potentiometer	The C-BAL potentiometer is a calibration control adjusted to compensate for phase offsets imposed by transducer cable capacitance (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.

Table 2-1. Basic 406.11 Controls and Indicators (Contintued)

ITEM	CONTROL/INDICATOR	FUNCTION
16	FDBK SELECT switch	The position of the FDBK SELECT switch selects a desired transducer conditioner output signal as the feedback signal for the servo controller circuitry. Three positions provide output signal selection of transducer conditioner 1 (XDCR 1), an optional transducer conditioner (XDCR 2), or an externally located transducer conditioner (EXT).
17	CAL FACTOR control	The ten-turn CAL FACTOR control is a calibration control adjusted to calibrate the XDCR1 amplifier to accomodate transducers of various sensitivities, (refer to section III, Service). A CAL FACTOR RANGE switch is located on the controller rear panel. The position of the CAL FACTOR RANGE switch is selected to correspond with the transducer sensitivity rating in mV/V. Ranges include lmV/V to 11mV/V (1-11), 10mV/V to 110 mV/V (10-110), and 100 mV/V to 1100 mV/V (100-1100). Adjustment should be performed by qualified service personnel only.
18	ZERO control and FINE/COARSE toggle switch	Adjustment of the ZERO control introduces a precise electrical offset into the XDCR 1 transducer conditioner output signal to compensate for minor mechanical offsets imposed on the transducer or to shift the zero reference of the transducer. The position of the FINE/COARSE toggle switch determines the adjustment range of the ZERO control. With the switch in the FINE position, the range of the ZERO control is limited to ±10% of the system operating range. With the switch in the COARSE position, the range of the ZERO control is ±100% of the system operating range. Refer to paragraph 2.2.2 for proper ZERO adjustment.

2.1.2 OPTIONAL MODULE CONTROLS AND INDICATORS

Tables 2-2 through 2-5 briefly describe the controls and indicators of the 406.11 options. Refer to the indicated paragraphs for detailed instructions.

Table 2-2 describes the DC Transducer Conditioner (Option A) controls as shown in figure 2-2.

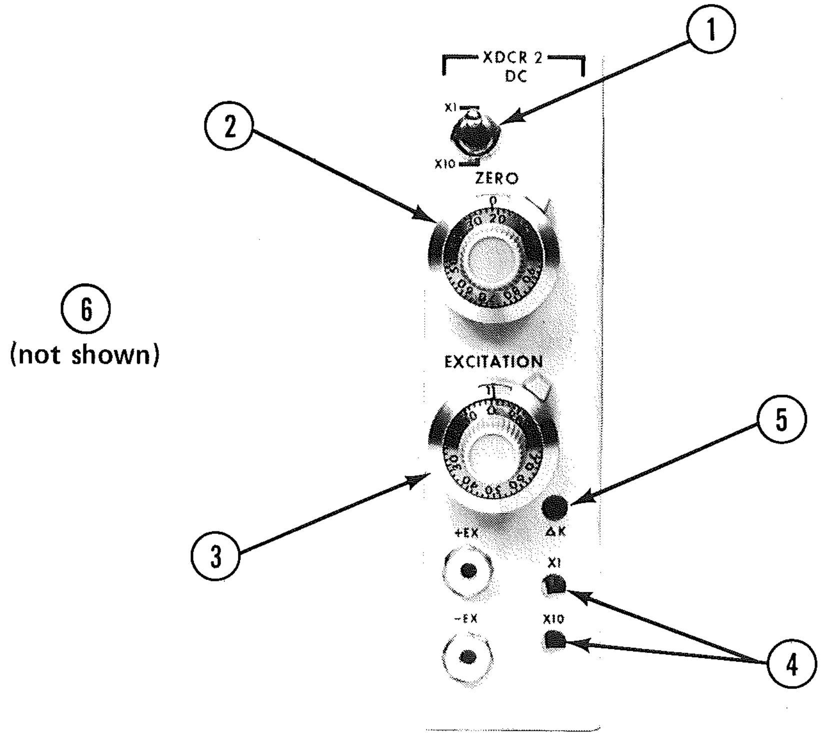

Figure 2-2. DC Transducer Conditioner Module (Option A) Operator Controls

Table 2-2. DC Transducer Conditioner Module (Option A) Operator Controls

ITEM	CONTROL	FUNCTION
1	X1/X10 toggle switch	The position of the X1/X10 toggle switch determines the quantity of the associated transducer signal required to produce a full-scale output signal (±10 volts) from the transducer conditioner. With the switch in the X1 position, a full-scale output from the transducer produces a full-scale output from the conditioner. With the switch in the X10 position 10% of the transducer full-scale output produces a full-scale output from the conditioner.

Table 2-2. DC Transducer Conditioner (Option A) Operator Controls (Continued)

ITEM	CONTROL	FUNCTION
2	ZERO control	Adjusting the ZERO control introduces an electrical offset into the transducer conditioner output to compensate for minor mechanical offsets imposed on the transducer or to shift the zero reference of the transducer (refer to paragraph 2.2.2).
3	EXCITATION control	The EXCITATION control is a calibration control adjusted to calibrate the dc excitation voltage applied to the transducer (refer to section III, Service). Adjustment of this control should be performed by qualified service personnel only.
4	X1 and X10 potentiometers	The X1 and X10 potentiometers are calibration controls adjusted during option A calibration to determine the transducer operating ranges (refer to section III, Service). Adjustment of these potentiometers should be performed by qualified service personnel only.
5	ΔK potentiometer	The ΔK potentiometer is a calibration control adjusted during option A calibration to compensate for the positive/negative calibration curve slope differential of a transducer (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.
6	FILTER IN/OUT switch (not shown)	The position of the FILTER IN/OUT switch determines whether the low-pass filter is in or out of the transducer conditioner amplifier circuit (refer to paragraph 2.2.14).

Table 2-3 describes the Valve Controller (option D) operator controls as shown in figure 2-3.

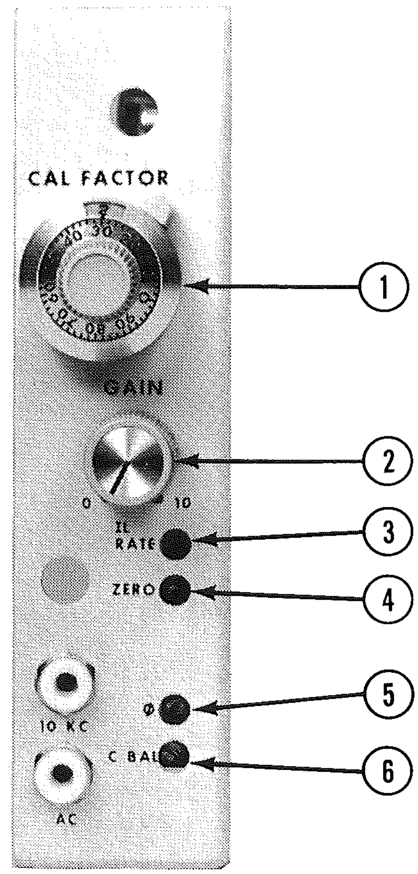

Figure 2-3. Valve Controller Module (Option D) Operator Controls

Table 2-3. Valve Controller Module (Option D) Operator Controls

ITEM	CONTROL	FUNCTION
1	CAL FACTOR control	The ten-turn CAL FACTOR control is a calibration control adjusted during option D calibration to adjust the valve controller amplifier to accomodate servovalve LVDTs of various sensitivities (refer to section III, Service). Adjustment of this control should be performed by qualified service personnel only.
2	GAIN control	The single-turn GAIN control is used to adjust the overall (outer) servo-loop response (speed of correction) for a given dc error signal. The GAIN control works in conjunction with the SERVO CONTROLLER GAIN control on the 406.11 Controller front panel which then becomes the inner loop gain control for 3-stage valve systems (refer to paragraph 2.2.8).
3	IL RATE potentiometer	Adjustment of the IL (inner loop) RATE potentiometer helps stabilize the valve control loop and prevent oscillations at high inner loop gain settings (refer to paragraph 2.2.8). This control works in conjunction with the 406.11 RATE control.
4	ZERO potentiometer	Adjustment of the ZERO potentiometer introduces an electrical offset into the valve controller output to compensate for any unbalance present in the servovalve.
5	Ø potentiometer	The Ø (phase) potentiometer is a calibration control adjusted during servovalve LVDT phase calibration to compensate for any phase shift introduced by the transducer (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.
6	C-BAL potentiometer	The C-BAL potentiometer is a calibration control adjusted to compensate for phase offsets imposed by transducer cable capacitance (refer to section III, Service). Adjustment of this control should be perfomed by qualified service personnel only.

Table 2-4 describes the AC Transducer Conditioner (option E) operator controls as shown in figure 2-4.

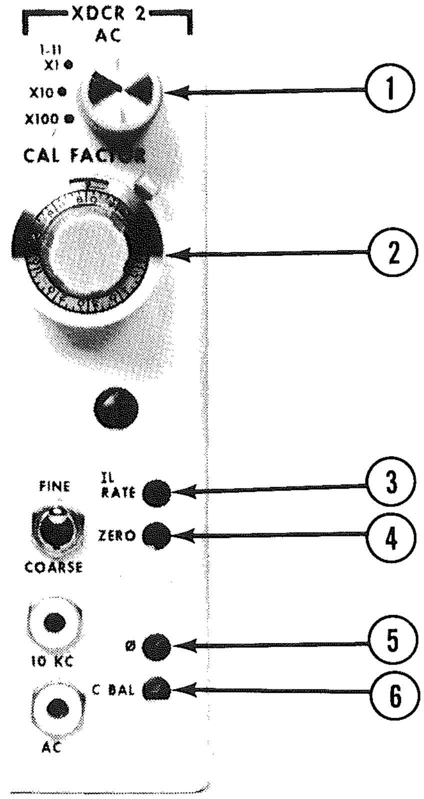

Figure 2-4. AC Transducer Conditioner Module (Option E) Operator Controls

Table 2-4. AC Transducer Conditioner Module (Option E) Operator Controls

ITEM	CONTROL	FUNCTION
1	CAL FACTOR range switch (1-11 X1, X10, X100)	The CAL FACTOR range switch is used in conjunction with the CAL FACTOR control only during option E calibration. The position of the CAL FACTOR range switch is selected to correspond with the transducer sensitivity rating in mV/V. Ranges include 1mV/V to 11mV/V (X1), 10mV/V to 110mV/V (X10), and 100mV/V to 1100mV/V (X100). Refer to section III, Service for the proper calibration procedure. Positioning of this switch should be performed by qualified service personnel only.

Table 2-4. AC Transducer Conditioner Module (Option E) Operator Controls (Continued)

ITEM	CONTROL	FUNCTION
2	CAL FACTOR control	The ten-turn CAL FACTOR control is adjusted only during option E calibration to adjust the conditioner amplifier gain to accomodate transducers of various sensitivity ratings. Scaling of this control depends on the position of the CAL FACTOR range switch (item 1). Refer to section III, Service for the proper calibration procedure. Adjustment should be performed by qualified personnel only.
3	IL RATE potentiometer	The IL RATE potentiometer is not typically used on option E. The potentiometer may be modified for various uses in specific applications.
4	ZERO control and FINE/COARSE toggle switch	Adjustment of the ZERO control introduces an electrical offset into the transducer conditioner output to compensate for minor physical offsets imposed on the transducer or to shift the zero reference of the transducer. The position of the FINE/COARSE toggle switch determines the adjustment range of the ZERO control. With the switch in the FINE position, the range of the ZERO control is limited to ±10% of the system operating range. With the switch in the COARSE position, the range of the ZERO control is ±100% of the system operating range. Refer to paragraph 2.2.2 for proper ZERO adjustment.
5	Ø (phase) potentiometer	The Ø (phase) potentiometer is adjusted only during option E calibration to compensate for phase shifts introduced by the transducer (refer to section III, Service). Adjustment of this potentiometer should be performed by qualified service personnel only.
6	C-BAL potentiometer	The C-BAL potentiometer is adjusted to compensate for phase offsets imposed by transducer cable capacitance (refer to section III, Service). Adjustment of this control should be performed by qualified service personnel only.

Table 2-5 describes the Conditioner Panel (option F) and Limit Detector (option G) controls and indicators as shown in figure 2-5.

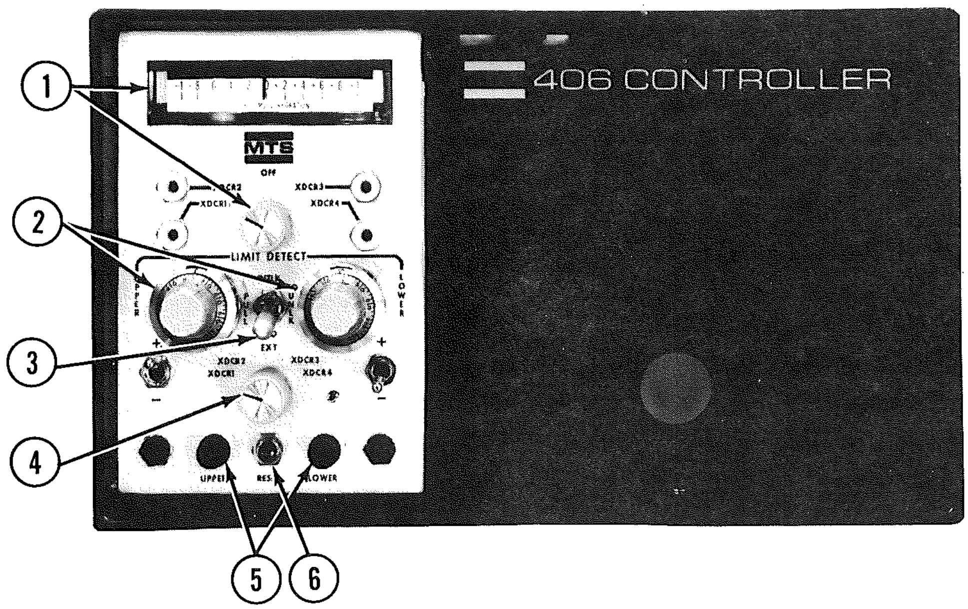

Figure 2-5. Conditioner Panel (Option F) and Limit Detector (Option G) Controls and Indicators

Table 2-5. Conditioner Panel (Option F) and Limit Detector (Option G) Controls and Indicators

ITEM	CONTROL/INDICATOR	FUNCTION
1	Panel Meter and Meter Switch	The panel meter is used to monitor the output signal of one of up to four optional modules installed in the conditioner panel. The meter switch selects the module output signal to be monitored on the panel meter.
2	UPPER and LOWER LIMIT DETECT controls and +/- toggle switches (option G)	The UPPER and LOWER LIMIT DETECT controls are only present on conditioner panels which include the Option G Limit Detector circuitry. Adjusting the UPPER and LOWER controls establishes the transducer output signal levels which activate the limit detector circuitry. The position of the +/-toggle switch adjacent to each control determines whether the limit is of positive (+) or negative (-) polarity (refer to paragraph 2.2.13).

Table 2-5. Conditioner Panel (Options F) and Limit Detector (Option G) Controls and Indicators (Continued)

ITEM	CONTROL/INDICATOR	FUNCTION
3	INTLK/IND toggle switch (option G)	The position of the INTLK/IND toggle switch determines whether the Limit Detector (option G) will cause interlock action and indicator illumination, or only indicator illumination when a limit has been exceeded.
4	LIMIT DETECT selector switch (option G)	The position of the LIMIT DETECT selector switch determines which of the five possible transducer conditioner output signals is being monitored by the Limit Detector (option G) circuitry.
5	UPPER and LOWER indicators (option G)	The UPPER and LOWER indicators illuminate when an upper or lower limit is detected by the Limit Detector (option G) circuitry.
6	RESET pushbutton (option G)	Pressing the RESET pushbutton extinguishes the UPPER or LOWER indicator after a limit has been detected by the Limit Detector (option G) circuitry.

2.2 OPERATING INSTRUCTIONS

The following paragraphs provide information and instructions required for the operation of the 406.11 Controller and its options. Disregard any procedures concerning options not included in the particular system configuration.

2.2.1 USING THE PANEL METER

The panel meter, located on the controller front panel, is used by the operator to monitor various signals while making preliminary adjustments and during the course of system operation. The various signals are selected by the selector switch directly below the meter.

With the selector switch turned to the ERROR position, the dc error signal (the difference between servo controller command and feedback) is indicated on the meter. When the meter is at null (zero), command and feedback are equal. When the needle moves toward the right, feedback is more positive than command; when the needle moves toward the left, feedback is more negative than command. A ± full-scale deflection indicates a ±10Vdc error signal.

The XDCR 1 and XDCR 2 switch positions select the respective transducer conditioner outputs. The XDCR 2 position is used only when an optional module (option A, D, or E) is installed in the controller chassis. When either position is selected, the needle indicates the amplitude and polarity of the selected module output signal (±10V full-scale). For example, if a load signal is selected and the load operating range is ±10,000 pounds, a meter deflection to +.8 typically indicates a tensile load of 80% or 8000 pounds.

The VALVE switch position selects the servovalve drive signal current to be displayed on the meter. This position is primarily used during maintenance procedures.

2.2.2 TRANSDUCER CONDITIONER ZERO ADJUSTMENT

NOTE

> The following procedures apply to all 406.11 transducer conditioners (including options A and E). The procedures do not apply to the Option D Valve Controller.

Zero adjustment of the transducer conditioner(s) is not frequently required. The following are common causes for readjustment:

- o A different tare weight has been introduced by changing fixtures attached to the transducer.
- o A new strain gage has been attached to a specimen and zero conditioner output at zero strain must be established.
- o The starting position of the actuator is to be changed by the ZERO control rather than the SET POINT control to provide zero conditioner output at a reference other than actuator mid-position.

2.2.2.1 Zero Adjustment for Load, Torque, or Strain Transducers

Perform the following procedure for zero adjustment of transducer conditioners associated with load, torque, or strain transducers.

1. Turn off hydraulic pressure. For load or torque cells, remove the specimen (if mounted) but leave the grip or specimen attachment fixture connected to the transducer. Strain transducers must remain attached to the specimen and must be in their intended unstrained condition.

2. If adjusting XDCR 1 or an option E AC Transducer Conditioner (XDCR 2 AC) set the FINE/COARSE toggle switch to the FINE position.

3. Adjust the SET POINT control to 500 and the SPAN control to 000. Lock the controls.

4. Monitor the output of the transducer conditioner on the panel meter and adjust the corresponding transducer conditioner ZERO control to zero the meter.

2.2.2.2 Zero Adjustment for Displacement Transducers

Perform the following procedure for zero adjustment of transducer conditioners associated with displacement transducers. Do not apply hydraulic pressure until instructed to do so.

1. Remove any specimen or fixture that will restrict actuator piston rod movement. The actuator piston rod must be free to move its total displacement without interference.

2. Set the transducer conditioner FINE/COARSE toggle switch to the COARSE position (unless an actuator movement of less than 10% of range is desired).

3. Turn the panel meter selector to the ERROR position.

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

***** WARNING *****

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

5. Apply full hydraulic pressure to the servovalve.

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

7. Adjust the ZERO control on the associated transducer conditioner to move the actuator to the desired reference position.

8. Remove hydraulic pressure from the servovalve.

2.2.3 SPAN ADJUSTMENT

The ten-turn SPAN control is used to precisely attenuate the external program input, thus determining the dynamic amplitude range of the composite command signal. Figure 2-6 shows the direct relationship between SPAN adjustment and dynamic composite command amplitude range for full-scale fluctuating and alternating program input functions.

SPAN control settings of 000 to 1000 represent 0 to +100% or 0 to -100% of the operating range for fluctuating program input functions or +100% to -100% (through 0%) for alternating functions.

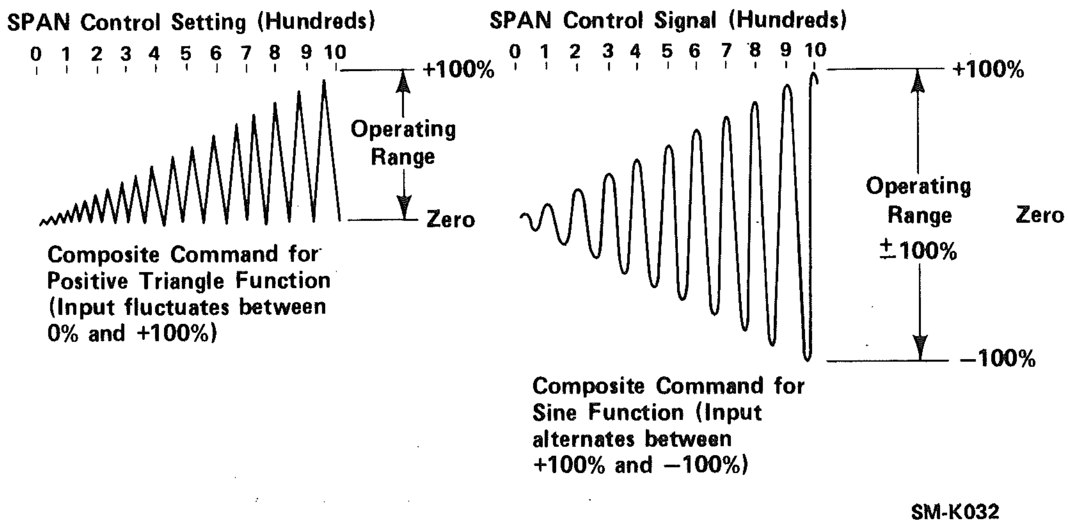

Figure 2-6. Effect of SPAN Adjustment on Composite Command Amplitude Range

The following formula is used to determine the proper SPAN control setting for a specific application:

$$\text{SPAN} = \frac{f(\text{Pmax}-\text{Pmin})}{\text{OR}}$$

Where:

Pmax = the desired maximum value (peak) of the composite command as expressed in positive or negative units of force or displacement (+ pounds, - pounds, + inches, - inches, etc).

Pmin = the desired minimum value (peak) of the composite command as expressed in positive or negative units of force or displacement.

f = the scale factor of the external program input signal.

= 500 for a program input which varies between +100% and -100% (the program input signal crosses 0v in a range of ±10V).

= 1000 for a program input signal which varies either between zero and +100% or zero and -100% (the program input signal does not cross 0v in a range of ±10V).

OR = the operating range as expressed in units of force or displacement.

NOTE

When determining the scale factor (f), do not confuse the external program input with the composite command signal. One signal may cross zero while the other signal may not.

For example, a sinusoidal program input signal which varies between +100% and -100% (crosses zero) is used to apply a force which varies between +9000 pounds (Pmax) and +7500 pounds (Pmin). The system operating range (OR) is ±10,000 pounds. The formula for this example is:

$$\text{SPAN} = \frac{500(9000-7500)}{10,000}$$

$$= \frac{500(1500)}{10,000}$$

$$= 75 \text{ (control setting)}$$

NOTE

SPAN control accuracy is 1% to 2% of full-scale.

2.2.4 SET POINT ADJUSTMENT

The ten-turn SET POINT control provides a precise static offset to establish the mean level of the composite command signal. A given SET POINT setting sets the mean level of the composite command at a percentage of the full-scale operating range in a specific direction from zero. Thus, SET POINT commands may be expressed as positive or negative percentages (+58%, -22.5%, etc) of full-scale operating range. Typically a control setting of 000 = -100%, 500 = 0%, and 1000 = +100%.

Control settings corresponding to percentages of full-scale range (where the percentage and direction from zero for the desired mean level are known) can be determined by the following formulas:

Positive SET POINT = 500 + (% of range x 500)

Negative SET POINT = 500 - (% of range x 500)

For example, the formula to calculate the proper SET POINT setting to produce a SET POINT command of +35% of full-scale is:

$$500 + (0.35 \times 500) = 675 \text{ (control setting)}$$

The following formula may be used to obtain the proper SET POINT control setting when the desired percent of full-scale offset is not known:

$$\text{SET POINT} = 500 + \frac{(250)(\text{Pmax}+\text{Pmin}) - (250)(\text{OR})(\text{SPAN})(\text{UP}+\text{LP})}{\text{OR}}$$

Where:

Pmax = the desired maximum value of the composite command as expressed in positive or negative units of force or displacement (+ pounds, - pounds, + inches, - inches, etc).

Pmin = the desired minimum value of the composite command as expressed in positive or negative units of force or displacement.

OR = the selected operating range as expressed in units of force or displacement.

SPAN = the SPAN control setting (refer to paragraph 2.2.3) in terms of percent. The decimal equivalent must be used in the formula. For example, a control setting of 500 = 50% = 0.50.

UP = the upper peak value of the program signal in terms of percent. A +10V upper peak = +100%, 0V = 0%, -10V = -100%, etc. The decimal equivalents must be used in the formula. For example, a program signal upper peak voltage of 8.5V = 85% = 0.85.

LP = the lower peak value of the program signal in terms of percent. The decimal equivalent must be used in the formula.

For example, a square wave program input which varies between an upper peak (UP) of +100% (+10V) and a lower peak (LP) of 0% (0V) is used to apply a force which varies between +3000 pounds (Pmax) and -2000 pounds (Pmin). The operating range is ±10,000 pounds and the SPAN setting has been determined to be 500 (50% or 0.5). The formula for this example is:

$$\text{SET POINT} = 500 + \frac{(250)(3000\text{-}2000) - (250)(10{,}000)(0.5)(1+0)}{10{,}000}$$

$$= 500 + \frac{-1{,}000{,}000}{10{,}000}$$

$$= 400 \text{ (control setting)}$$

NOTE

SET POINT control accuracy is 1% to 2% of full-scale.

CAUTION

Overprogramming may result in forces up to the full actuator capability. When SET POINT and SPAN settings have been determined, ensure that program peaks do not exceed the rating of any component in the force train.

2.2.5 ERROR DETECTOR ADJUSTMENT

The error detector circuitry is used to monitor the system dc error signal and to activate an indicator and, if desired, the system interlock circuitry when a preset error signal level is exceeded. The following procedures are used to adjust the error detector circuitry to activate at a desired error signal level. Both procedures are performed with hydraulic pressure removed from the servovalve.

2.2.5.1 Error Detector Adjustment for Static or Low-Frequency Applications

Perform the following procedure to adjust the error detector circuitry to activate at a desired error signal level for a static or low-frequency application.

1. With hydraulic pressure off, select ERROR on the panel meter switch.

2. Rotate the SET POINT control to zero the panel meter and record the control setting.

3. If the ERROR indicator is lit, press the RESET pushbutton. The indicator should extinguish.

4. Rotate the SET POINT control five minor dial divisions in either direction for each 2% of allowable error. For example, if the meter zeroed at 500 in step 2, rotating the SET POINT control to 460 or 540 produces an 8% error.

5. If the error detector circuitry did not activate (the ERROR indicator is not lit), turn the ED potentiometer counterclockwise until the ERROR indicator lights. If the error detector activated when adjusting the SET POINT control, turn the ED potentiometer clockwise until the ERROR indicator can be extinguished by pressing the RESET pushbutton. Then, turn the ED potentiometer counterclockwise until the ERROR indicator lights.

6. Return the SET POINT control to the setting recorded in step 2 and press the RESET pushbutton.

2.2.5.2 Error Detector Adjustment for Cyclic Fatigue Tests

The instantaneous percentage of error between command and feedback increases rapidly as the frequency of the program increases. This complicates the matter of determining and adjusting for a minimum dc error level in cyclic fatigue testing applications. Perform the following procedure to adjust the error detector for cyclic fatigue testing applications.

NOTE

The ED potentiometer is a 15-turn potentiometer with no mechanical stop.

1. With hydraulic pressure off, turn the ED potentiometer fully clockwise (15 turns).

2. Apply the desired cyclic command signal to the controller.

3. Turn the ED potentiometer counterclockwise until the ERROR indicator lights.

4. Turn the ED potentiometer 1/4-turn clockwise. This provides a small margin for error, activating the error detector circuitry if the dc error signal level increases.

5. Remove the cyclic command signal and press the RESET pushbutton.

NOTE

Cyclic frequency and the type of interlock provisions used determines whether or not the error detector will prevent damage caused by specimen failure. If the testing application permits, it may be advisable to reduce the frequency just prior to expected specimen failure. In addition, the error detector circuitry is most effective when the system is being operated substantially below its maximum flow capability. If the system is operating at its maximum flow capability, the error detector will most likely be ineffective at detecting failure.

2.2.6 BASIC 406.11 LIMIT DETECTOR ADJUSTMENT

The basic 406.11 limit detector circuitry monitors a selected feedback signal and activates an indicator and, if desired, the system interlock circuit when the signal exceeds preset upper and lower limits. The limits may be preset before starting system operation or, in some cases, immediately after system operation has begun.

The upper and lower quantities of the controlled variable (feedback selected for control) are usually known, therefore these limits can be preset. The upper and lower quantities of the dependent variables are frequently unknown, therefore their limits must be adjusted after system operation has begun.

NOTE

The procedure for adjusting the Limit Detector (option G) differs slightly from the procedure used to adjust the basic 406.11 limit detector (refer to paragraph 2.2.12).

2.2.6.1 Adjusting the Limit Detector Before Starting System Operation

Perform the following procedure to adjust the limit detector before hydraulic pressure is applied to the system.

1. Turn the IND/OFF/INTLK switch to select the transducer conditioner output (XDCR1 or XDCR2) to be monitored by the limit detector. Select the appropriate position under INTLK if system interlock action is desired or select the appropriate position under IND if only an indication is desired.

2. Set the UPPER and LOWER +/- toggle switches to the proper polarities.

If a desired upper or lower feedback signal limit is of positive polarity, set the respective UPPER +/- or LOWER +/- switch to the (+) position. If a desired feedback signal limit is of negative polarity, set the respective UPPER +/- or LOWER +/- switch to the (-) position (refer to figure 2-7). For example, if the desired upper limit is 8000 pounds tension, the UPPER +/- switch should be set to the (+) position (assuming a tensile force causes a positive feedback signal). If the desired lower limit is 6500 pounds compression, the LOWER +/- switch should be set to the (-) position (assuming a compressive force produces a negative feedback signal).

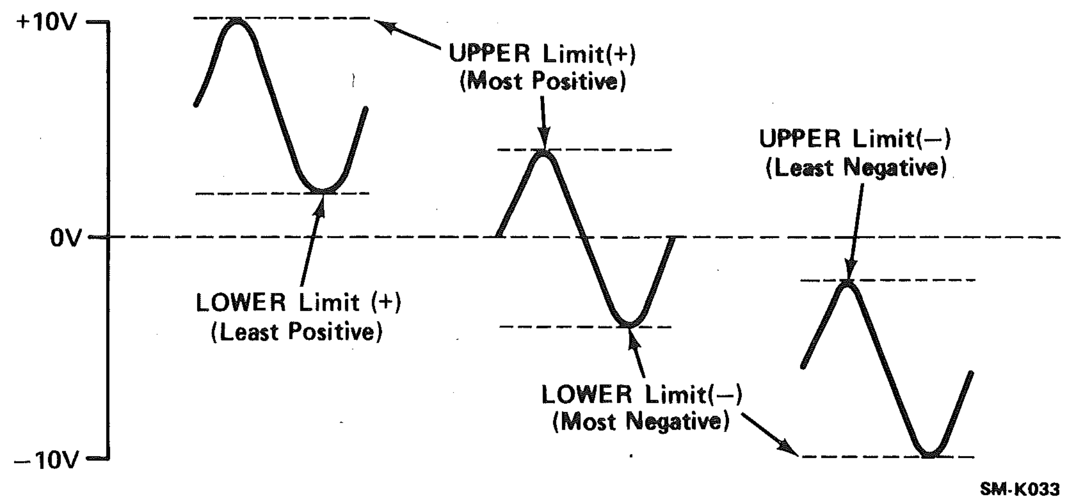

Figure 2-7. Examples of Signal Polarity

3. Adjust the UPPER and LOWER controls to the desired limits.

Control scaling is from 000 to 1000. Each minor dial division represents 0.2% of the operating range. The controls should be adjusted so that a margin of at least 0.5% (2.5 minor dial divisions) exists between each limit detection level and the respective maximum and minimum feedback signal levels likely to be reached.

The upper limit margin is obtained by adding at least 2.5 minor dial divisions to the UPPER control reading when the UPPER +/- toggle switch is in the (+) position and subtracting at least 2.5 minor dial divisions when the switch is in the (-) position. The lower limit margin is obtained by adding at least 2.5 minor dial divisions to the LOWER control reading when the LOWER +/- toggle switch is in the (-) position and subtracting at least 2.5 minor dial divisions when the switch is in the (+) position.

For example, in a given fatigue testing application, load varies between 9000 pounds tension (+) and 2000 pounds tension (+). Operating range is ±10,000 pounds. The UPPER control is set to 905 (90% plus 2.5 minor dial divisions) and the LOWER control is set to 195 (20% minus 2.5 minor dial divisions). 2.5 minor dial divisions are subtracted from the LOWER control setting because the lower limit is of positive polarity (the LOWER +/- toggle switch is in the + position).

2.2.6.2 Adjusting the Limit Detector During System Operation

Peform the following procedure to adjust the limit detector immediately after system operation has begun. Ensure that all elements of the force train (including the specimen) can withstand the applied forces for a short period.

NOTE

Perform step 1 before starting system operation.

1. Before starting system operation:

   A. Set the UPPER +/- toggle switch to the (+) position.

   B. Set the LOWER +/- toggle switch to the (-) position.

   C. Set the UPPER and LOWER controls to 1000 (fully clockwise).

   D. Turn the IND/OFF/INTLK switch to select the desired transducer conditioner output (XDCR 1 or XDCR 2) on the IND side of the switch.

NOTE

Perform the remaining steps of this procedure immediately after system operation has begun.

2. Rotate the UPPER control counterclockwise until the UPPER limit indicator lights. Then, rotate the control clockwise 2.5 minor dial divisions. If the UPPER limit indicator does not light while rotating the control from 1000 to 000, leave the control at 000, place the UPPER +/- toggle switch in the (-) position and rotate the control clockwise until the indicator lights. Then, rotate the control counterclockwise 2.5 minor dial divisions.

NOTE

Rotating the control 2.5 minor dial divisions from the point where the indicator lights establishes a 0.5% margin between the peak quantity of the selected feedback and the limit detection point.

3. Rotate the LOWER control counterclockwise until the LOWER limit indicator lights. Then, rotate the control clockwise 2.5 minor dial divisions. If the LOWER limit indicator does not light while rotating the control from 1000 to 000, leave the control at 000, place the LOWER +/- toggle switch in the (+) position and rotate the control clockwise until the indicator lights. Then, rotate the control counterclockwise 2.5 minor dial divisions.

4. Press the RESET pushbutton to extinguish the UPPER and LOWER limit indicators.

5. If desired, set the IND/OFF/INTLK switch to the appropriate position under INTLK to activate the system interlock circuit when limit detection occurs.

2.2.7 BASIC 406.11 GAIN, RATE, AND STABILITY ADJUSTMENTS (NO OPTION D)

NOTE

The 406.11 rate circuitry may require modification if an ac conditioner is used to control stroke in a system with a natural frequency less than 100 Hz. If this is the case, or if the natural frequency of the system is unknown, perform procedure 2.2.9 before proceeding with either of the following procedures.

Two procedures are provided for basic 406.11 gain, rate, and stability adjustments. The first procedure (2.2.7.1) is used for force or displacment control systems (typically material or structural fatigue testing); the second procedure (2.2.7.2) is used for acceleration control systems (typically vibration testing). No matter what the application, these adjustments are experimental. Initially, the operator should become familiar with the effects of these adjustments while using dummy specimens (do not use a specimen if under stroke control). Once a feeling is developed for proper adjustment, use of the controls under actual operating conditions becomes routine.

Gain, rate, and stability adjustments are made with hydraulic pressure applied to the servovalve, however, do not apply hydraulic pressure until instructed to do so. Additional equipment required for these procedures includes an oscilloscope.

2.2.7.1 Gain, Rate, and Stability Adjustments for Force or Displacement Control

NOTE

The following procedure does not apply to 406.11 Controllers containing an Valve Controller (option D). If the controller contains option D, refer to paragraph 2.2.8.

Performing the following procedure provides gain, rate, and stability settings that are approximately correct for force or displacement control systems. If necessary, the controls may be "trimmed" during actual system operation to further optimize system response.

1. Turn the GAIN, RATE, and ΔP controls to 0 (fully counterclockwise).

***** WARNING *****

Never apply hydraulic pressure without first considering possible actuator movement. Failure to have dc error at zero (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. Apply a low-frequency, low-amplitude square wave program (1 to 2 Hz at 1% to 2% of operating range) to the system.

4. Monitor the feedback signal selected for system control on the oscilloscope. The waveform should appear as in figure 2-8a.

5. Turn the GAIN control clockwise until the waveform starts oscillating as shown in figure 2-8b.

6. Turn the GAIN control counterclockwise until oscillation stops.

7. Turn the RATE control clockwise to reduce waveform overshoot.

8. Sequentially increment the GAIN and RATE controls until an optimum waveform (as shown in figure 2-8c) is achieved.

NOTE

Perform the remaining steps of this procedure only if the 406.11 is equipped with ΔP Stabilization (option B).

9. Turn the GAIN control clockwise until the waveform again starts oscillating.

10. Turn the ΔP control clockwise until waveform oscillation stops.

11. Repeat steps 9 and 10 until an optimum waveform is obtained as shown in figure 2-8c.

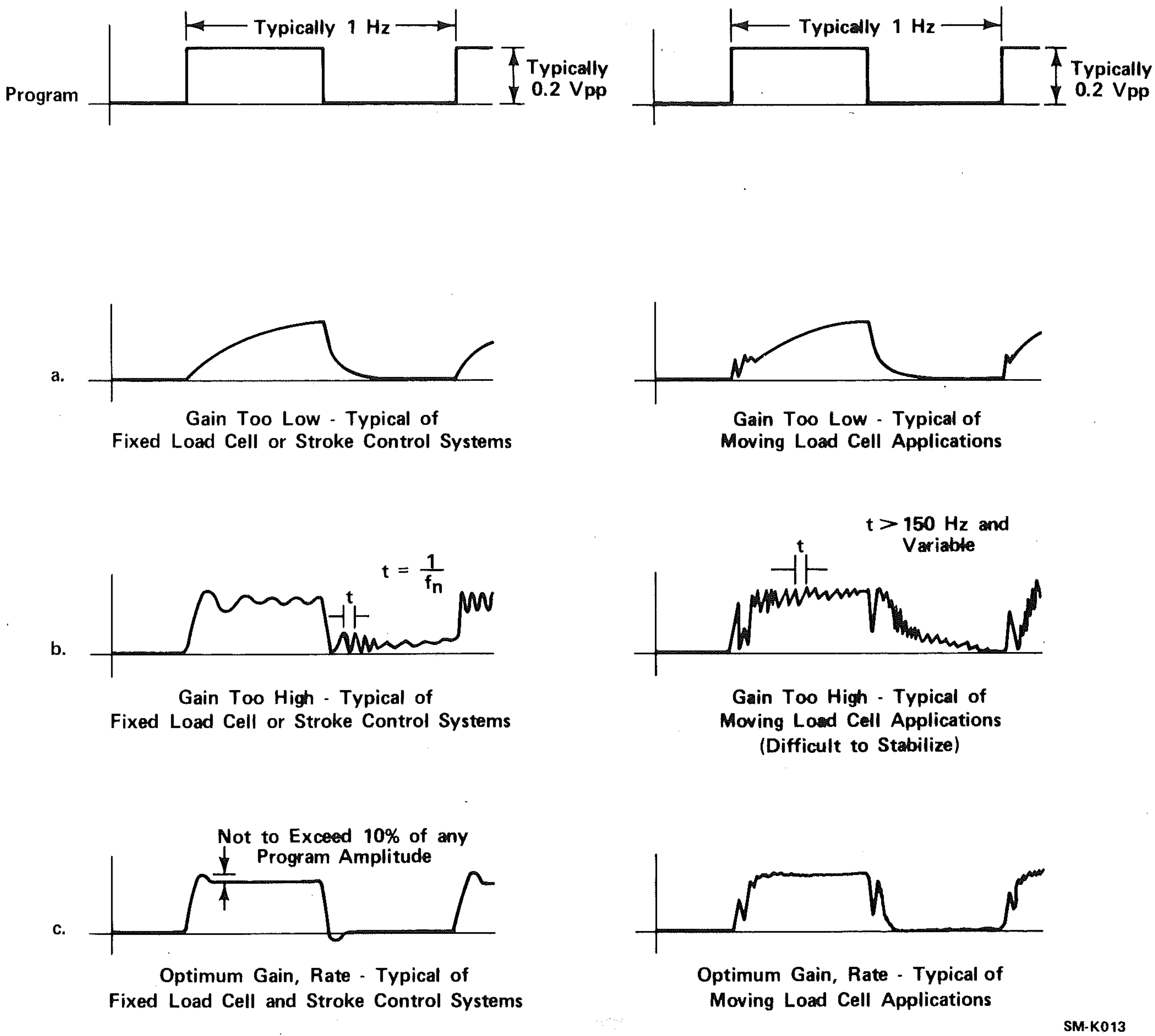

Figure 2-8. Waveform Response to Gain, Rate, and Stability Adjustment

2.2.7.2 Gain, Rate, and Stability Adjustments for Acceleration Control

NOTE

The following procedure does not apply to 406.11 Controllers containing an Valve Controller (option D). If the controller contains option D, refer to paragraph 2.2.8. The controller must, however, contain ΔP Stabilization (option B).

Performing the following procedure provides gain, rate, and stability settings that are approximately correct for acceleration control systems. If necessary, the controls may be "trimmed" during actual system operation to further optimize system response. A dummy specimen of approximately the same mass as the specimen used during actual testing must be mounted.

1. Turn the GAIN and ΔP controls to 3.

2. Turn the RATE control to 0.

3. Select stroke feedback as the controlled variable.

4. Turn the SPAN control to 000.

5. 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 dc error at zero (command = feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

6. Apply full hydraulic pressure to the servovalve.

7. Using the oscilloscope, monitor the output of the accelerometer conditioner to be used for control and apply a low-frequency (1 to 2 Hz), low-amplitude square wave program to the system. The amplitude should be selected so that dc error signal becomes saturated. Acceleration should appear to be approximately one full cycle as shown by call-out A of figure 2-9c.

NOTE

Figure 2-9 shows a typical acceleration waveform with respect to the square wave program. Under optimum conditions a symmetrical sine wave should occur with each edge of the square wave pulse.

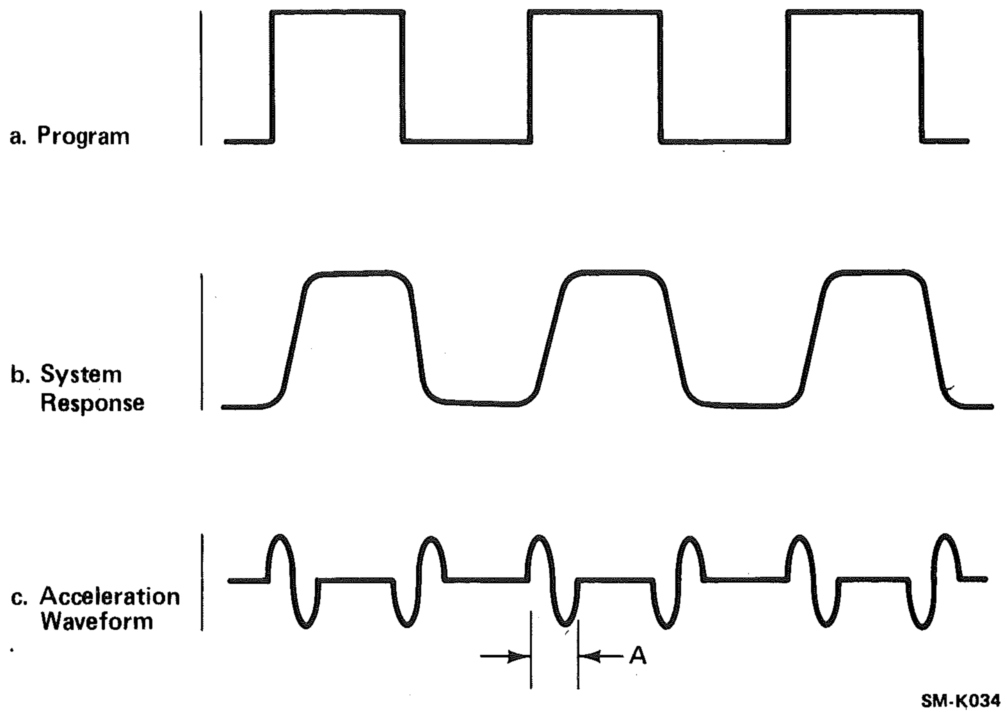

Figure 2-9. Desired Acceleration

8. While monitoring acceleration on the oscilloscope, sequentially adjust the GAIN, RATE, and ΔP controls to achieve the acceleration waveform shown in figure 2-9. Figure 2-10 shows what the acceleration waveform may look like when the controls are misadjusted.

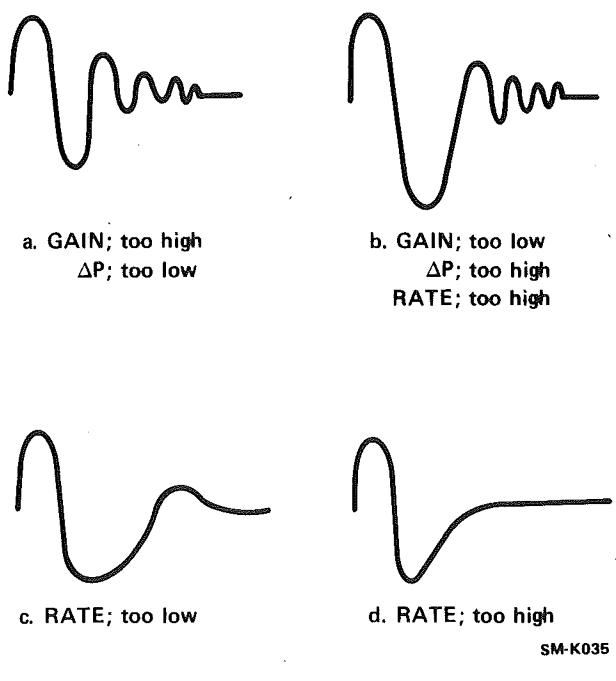

Figure 2-10. Indications of Misadjusted Controls

2.2.8 GAIN, RATE, AND STABILITY ADJUSTMENTS FOR UNITS CONTAINING OPTION D

NOTE

The 406.11 rate circuitry may require modification if an ac conditioner is used to control stroke in a system with a natural frequency less than 100 Hz. If this is the case, or if the natural frequency of the system is unknown, perform procedure 2.2.9 before proceeding with either of the following procedures.

Two procedures are provided for gain, rate, and stability adjustments for 406.11 Controllers which contain an Valve Controller (option D). The first procedure (2.2.8.1) is used for force or displacement control systems (typically material or structural fatigue testing); the second procedure (2.2.8.2) is used for acceleration control systems (typically vibration testing). No matter what the application these adjustments are experimental. Initially the operator should become familiar with the effects of these adjustments while using dummy specimens (do not use a specimen if under stroke control). Once a feeling is developed for proper adjustment, use of the controls under actual operating conditions becomes routine.

When the optional valve controller module (option D) is installed in the 406.11, a second control loop (referred to as the inner loop) is present in the system. The inner loop monitors the position of the servovalve's internal LVDT and sums the LVDT output signal with the dc error signal provided by the primary control loop (outer loop). The following procedures provide gain, rate, and stability adjustments for both control loops. It should be noted that the GAIN control on the 406.11 front panel controls the inner loop gain while the GAIN control on the valve controller module controls the outer loop gain. Adjustment of the outer loop gain has the most noticeable effect on system response.

Gain, rate, and stability adjustments must be made with hydraulic pressure applied to the servovalve. Additional equipment required for these procedures includes an oscilloscope.

2.2.8.1 Gain, Rate, and Stability Adjustments for Force or Displacement Control (Option D)

NOTE

The following procedure applies only to 406.11 Controllers containing an Valve Controller (option D). If option D is not included, refer to paragraph 2.2.7.

Performing the following procedure provides gain, rate, and stability settings that are approximately correct for force or displacement control systems. If necessary, the controls may be "trimmed" during actual system operation to further optimize system response. The inner loop and the outer loop must initially be adjusted individually. Initial adjustment of the inner loop is accomplished by applying full hydraulic pressure to only the servovalve pilot stage and then making the necessary adjustments. If the system configuration does not permit the application of hydraulic pressure to the servovalve pilot stage only, the outer loop feedback signal must be removed before making any inner loop adjustments. If it is necessary to remove the outer loop feedback signal, observe the warning preceding step 4. In either case, do not apply hydraulic pressure until instructed to do so.

NOTE

The following procedure calls for adjustment of controls on both the 406.11 Controller front panel and the Valve Controller (option D) module. Ensure that the proper controls are adjusted as indicated in the procedure.

1. With hydraulic pressure removed from the servovalve, remove any specimen or fixture which may restrict actuator movement. The actuator must be able to move its full displacement without interference.

2. On the 406.11 Controller front panel, turn the SERVO CONTROLLER GAIN, RATE, and ΔP controls to 0 (fully counterclockwise).

3. On the Valve Controller (option D) module, turn the GAIN control and IL RATE potentiometer fully counterclockwise.

***** WARNING *****

If the system configuration does not allow the application of full hydraulic pressure to the servovalve pilot stage only, violent actuator movement to one extreme of its full displacement will occur while performing the next step. Ensure all obstructions are removed from the path of the actuator and keep all personnel away from the immediate area surrounding the actuator to prevent personnel injury and/or equipment damage.

4. If the system configuration permits, apply full hydraulic pressure to the servovalve pilot stage only. If the system configuration does not permit application of hydraulic pressure to the servovalve pilot stage only, first remove the outer loop feedback signal by removing the XDCR 1 cable from cable receptacle J232 on the controller rear panel (or remove the appropriate feedback cable if an external transducer conditioner is being used for feedback). Then, with the outer loop feedback signal removed, apply full hydraulic pressure to the servovalve. The actuator will violently move to one extreme of its full displacement.

5. Adjust the SET POINT control to position the actuator at approximately mid-stroke.

6. Apply a low-frequency, low-amplitude (1 to 2 Hz at approximately 10% of full-scale) square wave program to the system.

7. Connect the oscilloscope between the XDCR 2 jack (valve controller output) and the common (black) jack on the 406.11 front panel. The displayed waveform represents the output of the servovalve's internal LVDT and should appear to be similar to figure 2-11a.

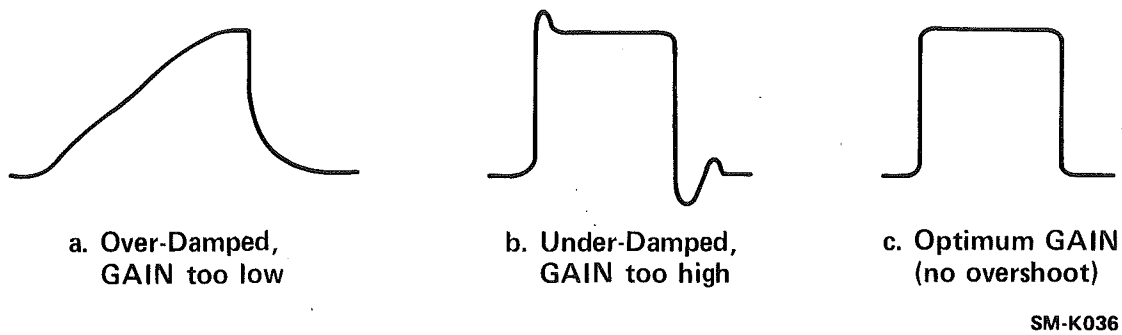

Figure 2-11. Waveform Adjustment

8. On the 406.11 Controller, turn the SERVO CONTROLLER GAIN control clockwise until the waveform starts oscillating as shown in figure 2-11b.

9. Turn the SERVO CONTROLLER GAIN control counterclockwise until waveform oscillation stops.

10. On the Valve Controller (option D) module, turn the IL RATE potentiometer clockwise to reduce waveform overshoot.

11. Sequentially adjust the SERVO CONTROLLER GAIN control on the 406.11 Controller and the IL RATE potentiometer on the valve controller module to achieve optimum gain as shown in figure 2-11c. Check the waveform at different square wave amplitudes to be certain no overshoot occurs at any amplitude. Readjust if necessary.

12. Remove the square wave program and remove hydraulic pressure from the servovalve. Reconnect the outer loop feedback signal cable if it was removed.

13. If a load transducer is being used for feedback, install a dummy specimen. Do not install a dummy specimen if a stroke transducer is being used.

14. Apply full hydraulic pressure to the servovalve and reapply the square wave program.

15. Connect the oscilloscope between the XDCR 1 jack (the outer loop feedback signal) and the common (black) jack on the 406.11 front panel. The displayed waveform represents the output of the feedback transducer and should appear to be similar to figure 2-11a.

16. On the valve controller module, turn the GAIN control clockwise until the waveform starts oscillating as shown in figure 2-11b. Then, turn the GAIN control counterclockwise until waveform oscillation stops.

17. On the 406.11 Controller, turn the RATE control clockwise to reduce waveform overshoot.

18. On the valve controller module, adjust the IL RATE potentiometer to achieve optimum gain as shown in figure 2-11c.

NOTE

Perform the remaining steps of this procedure only if the 406.11 is equipped with Option B, ΔP Stabilization.

19. On the valve controller module, turn the GAIN control clockwise until the waveform starts oscillating.

20. Turn the 406.11 ΔP control clockwise until waveform oscillation stops.

21. Repeat steps 19 and 20 to achieve optimum gain as shown in figure 2-11c.

2.2.8.2 Gain, Rate, and Stability Adjustments For Acceleration Control (Option D)

NOTE

The following procedure applies only to 406.11 Controllers containing an Valve Controller (option D). If option D is not included, refer to paragraph 2.2.7.

Performing the following procedure provides gain, rate, and stability settings that are approximately correct for acceleration control systems. If necessary the controls may be "trimmed" during actual system operation to further optimize system response. Do not apply hydraulic pressure until instructed to do so. A dummy specimen of approximately the same mass as the specimen used during actual testing must be mounted.

NOTE

The following procedure calls for adjustment of controls on both the 406.11 Controller front panel and the Valve Controller (option D) module. Ensure that the proper controls are adjusted as indicated in the procedure.

1. On the 406.11 Controller front panel, turn the SERVO CONTROLLER GAIN control to 3.

2. On the Valve Controller (option D) module, turn the GAIN control to 3.

3. Turn the ΔP control to 3.

4. On the 406.11 Controller, turn the SERVO CONTROLLER RATE control to 0.

5. Select stroke feedback as the controlled variable.

6. Turn the SPAN control to 000.

7. 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 dc error at zero (command = feedback) when hydraulic pressure is applied could result in violent actuator movement causing personal injury.

8. Apply full hydraulic pressure to the servovalve.

9. Apply a low-frequency (1 to 2 Hz), low-amplitude square wave to the system. The amplitude should be selected so that the dc error signal becomes saturated. Acceleration should appear to be approximately one full cycle as shown in call-out A of figure 2-12.

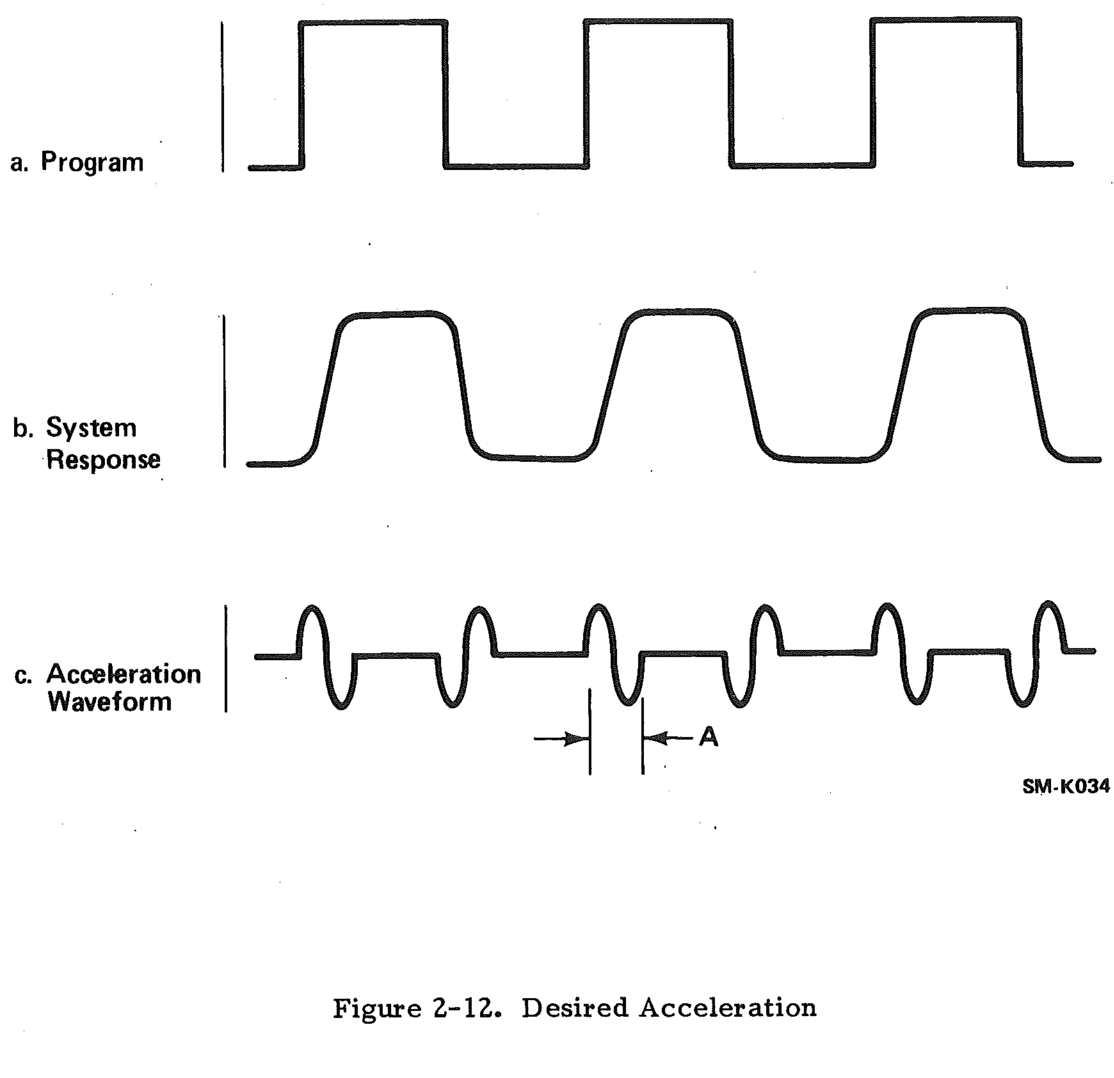

Figure 2-12. Desired Acceleration

10. Using the oscilloscope, monitor the output of the accelerometer conditioner to be used for control. Figure 2-12 shows a typical acceleration waveform with respect to the square wave program. Under optimum conditions a symmetrical sine wave should occur with each edge of the square wave.

11. Sequentially adjust the SERVO CONTROLLER GAIN, RATE, and ΔP controls on the 406.11 Controller front panel, and the GAIN control on the Option D Valve Controller module to achieve an acceleration waveform as shown in figure 2-12. Figure 2-13 shows what the acceleration waveform may look like if these controls are not properly adjusted.

NOTE

The GAIN control on the Valve Controller (option D) module has the most effect on the beginning or end of each step of the square wave. Therefore its effect on the ringing of the waveform is more noticeable.

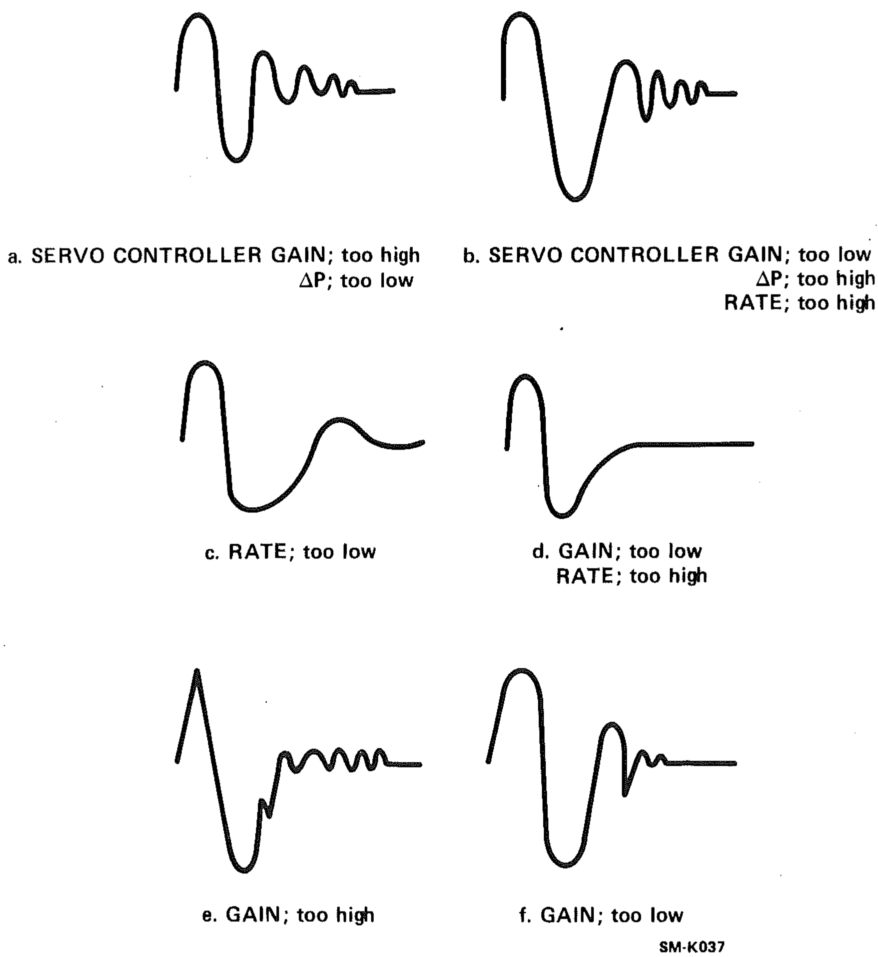

Figure 2-13. Indications and Misadjustment Controls

2.2.9 RATE CIRCUITRY MODIFICATION

The 406.11 rate circuitry may require modification if an ac conditioner is used to control stroke in a system with a natural frequency of less than 100 Hz. Perform the following procedure to determine the natural frequency of the system and, if required, to calculate the values of components which require replacement.

1. Determine the natural frequency of the system by:

   A. Performing the applicable gain, rate, and stability adjustments (2.2.7 or 2.2.8) and observing the frequency (f_n) of the under-damped response signal (gain too high), or by;

   B. Calculating the natural frequency of the system by using one of the following formulas:

   For U.S. Customary units: $f_n \approx \frac{2800A}{\sqrt{WV}}$

   For Metric units: $fn \approx \frac{1172A}{\sqrt{WV}}$

   Where:

   f_n = the natural frequency (in Hz) of a direct coupled mass, plus the mass of the fixtures on the piston, and spring rate of the oil column.

   A = the effective actuator piston area in $in.^2$ (or cm^2).

   W = the mass load in lbs (or kg).

   V = the volume of oil in the actuator in $in.^3$ (or cm^3).

2. If f_n is greater than 100 Hz, skip the remaining steps of this procedure and proceed with the applicable gain, rate, and stability adjustments (paragraph 2.2.7 or 2.2.8). If f_n is substantially less than 100 Hz, use one of the following formulas to calculate an approximate trial value for capacitor C29 on the 406.11 main chassis circuit card.

   For U.S. Customary units: $C29 \approx \frac{XA}{Q}$

   For metric units: $C29 \approx \frac{XA}{4Q}$

Where:

C29 = the value of capacitor C29 in μF.

X = the actuator stroke length in in. (or cm) which provides a ±10 volt feedback signal.

Q = the maximum servovalve flow rate in gpm (or ℓ/min).

A = the effective actuator piston area in in.^{2} (or cm^2).

3. Obtain a 50V capacitor within a suggested tolerance of ±30% of the capacitance value calculated for C29 in step 2.

4. Obtain 50V capacitors within a suggested tolerance of ±30% of the following values for capacitors C30, C33, and C32:

   C30 = 2% of the value selected for C29.

   C33 = 10% of the value selected fo C29.

   C32 = 20% of the value selected for C29.

5. With ac power turned off, replace existing capacitors C29, C30, C33, and C32 with the capacitors obtained in steps 3 and 4. Figure 2-14 shows the location of C29, C30, C33, and C32 on the 406.11 main chassis circuit card.

6. Perform the rate adjustment procedure in paragraph 2.2.7 or 2.2.8. The selected capacitors should allow the rate circuit to generate peak output voltages of approximately ±7 volts. If saturation (over ±10 volts) occurs the value of C29 should be reduced. If the rate signal is insufficient, the value of C29 should be increased.

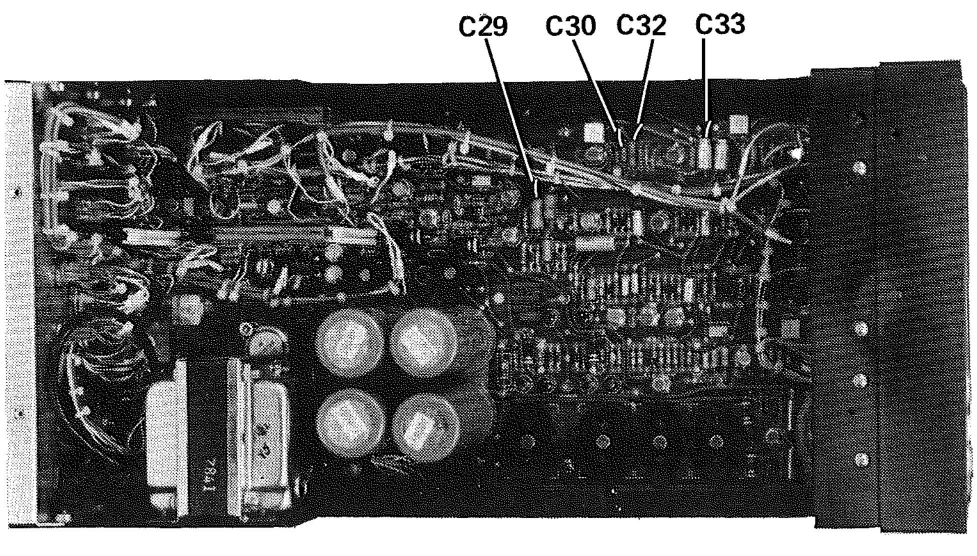

Figure 2-14. Component Locations for Rate Circuitry Modification

2.2.10 DITHER ADJUSTMENT

The DITHER potentiometer is used to control the amplitude of a small electrical signal (dither) which is applied to the servovalve. The purpose of this signal is to prevent silting of the servovalve and to overcome static friction in the servovalve and the hydraulic actuator. Silting and static friction reduce system resolution. A need for dither adjustment becomes apparent when, for example, readout indicates that system response to a slow ramp command is jagged rather than smooth.

Adjust the DITHER potentiometer to a minimum setting consistent with good system resolution. High dither produces an audible whistle at the servovalve. Sufficient dither is usually near the threshold of audibility. It may be an indication of system contamination if an audible dither cannot be obtained.

2.2.11 RESET INTEGRATOR/NULL DETECTOR OPERATION AND ADJUSTMENT (OPTION C)

CAUTION

Transients may be imposed on the specimen if the reset integrator circuit is active while hydraulic pressure is initially being applied to the system. Ensure that the applicable INTEGRATOR, RESET INTEGRATOR, or RESET toggle switch on the programmer or control unit is in the OUT or OFF position before applying hydraulic pressure to the system.

When the 406.11 Controller is equipped with the Reset Integrator/Null Detector (option C) and is used with a Model 436.11 Control Unit, operation is usually automatic. If so, relay contacts within the 436.11 turn the circuitry on and off and no operator involvement is required (refer to the individual 436.11 Control Unit product manual).

Generally, operator action is only required if the system contains an INTEGRATOR, RESET INTEGRATOR, or RESET toggle switch. The switch may either directly turn the circuitry on and off or it may enable a programmer that supplies a dwell signal, such as the Model 410.31 Digital Function Generator, to turn the circuitry on and off automatically.

Refer to the applicable individual product manual for further information.

2.2.11.1 Null Detector Adjustment

The purpose of the following procedure is to establish the percentage of error at which the null detector output switches from the "null" to the "not null" state. The practical range of adjustment is from 0.25% to 2% of the full-scale dc error signal.

Unless otherwise specified, the null detector circuit is factory adjusted to change states at an error signal of 1% of full-scale. This procedure need only be performed if a different percentage is desired. A digital voltmeter (DVM) accurate to 0.03% with 1 mV resolution is required. Refer to figure 2-15 for the location of test points and adjustments. Do not apply hydraulic pressure.

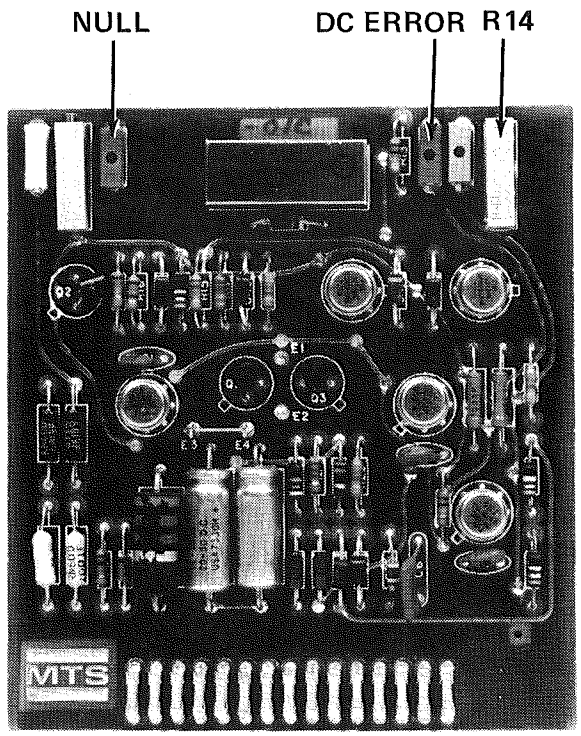

Figure 2-15. Null Detector Test Points and Adjustments

1. With ac power off, remove the controller top cover to gain access to the option C circuit card. Apply ac power to the controller.

2. Connect the DVM between the DC ERROR jack on the option C circuit card and the COMMON jack on the controller main circuit card.

3. Adjust the SET POINT control to 500 and the SPAN control to 000.

4. On a scale where 0.1 Vdc = 1%, adjust the SET POINT control to obtain a reading on the DVM which corresponds to the desired percent of dc error (for example, 0.25% = 0.025 Vdc, 1.75% = 0.175 Vdc, etc). Lock the SET POINT control.

5. Connect the DVM between the NULL jack (TJ3) on the option C circuit card and the common jack on the controller main circuit card. The DVM should read approximately +4.5 Vdc.

6. Adjust the NULL potentiometer (R14) on the option C circuit card to the point where the DVM reading changes from approximately +4.5 Vdc (null) to 0 Vdc (not null).

7. Remove all test leads, turn off ac power and replace the controller top cover.

2.2.12 CONDITIONER PANEL (OPTION F) OPERATION

The Conditioner Panel (option F) is used to accomodate additional transducer conditioner modules (options A and/or E) when required by the system. The Valve Controller (option D) may also be installed in the panel. The conditioner panel is capable of accomodating up to four modules.

The option F panel meter is used to monitor the output signals of the modules installed in the panel. Operation of the panel meter is identical to that of the panel meter on the 406.11 Controller front panel (refer to paragraph 2.2.1). The selector switch located directly below the meter selects the output signal to be monitored on the meter.

NOTE

The selector switch is used for monitoring the selected signal on the panel meter only. It is not a feedback selector for the 406.11 Controller.

2.2.13 LIMIT DETECTOR (OPTION G) ADJUSTMENT

When included in the system configuration, the Limit Detector (option G) is used to set and detect upper and lower feedback limits for modules installed in the Conditioner Panel (option F). The limit detector may be adjusted before starting system operation or, in some cases, immediately after system operation has begun. If the desired upper and lower feedback limits are known, the limit detector may be adjusted before starting system operation. If the feedback limits are not known, and all components of the force train (including the specimen if applicable) can withstand the applied forces for a short time, the limit detector may be adjusted immediately after system operation has begun.

NOTE

If the limit detector is to be adjusted for stroke limits, the starting position of the actuator must be taken into account. If the specimen has been attached with the actuator at other than mid-position, the transducer conditioner output will be a voltage representing that position. This voltage must be taken into account or reduced to zero by the ZERO control on the transducer conditioner.

2.2.13.1 Adjusting the Limit Detector (Option G) Before Starting System Operation

Perform the following procedure to adjust the Limit Detector (option G) before hydraulic pressure is applied to the system.

1. Select the desired transducer conditioner output (XDCR 1, XDCR 2, XDCR 3, or XDCR 4) on the limit detector selector switch (located below the UPPER and LOWER controls).

2. Set the INTLK/IND toggle switch to the desired position.

3. Set the UPPER and LOWER +/- toggle switches to the proper polarities.

   If a desired feedback signal limit is of positive polarity, set the respective UPPER +/-or LOWER +/-toggle switch to the (+) position. If a desired feedback signal limit is of negative polarity, set the respective UPPER +/- or LOWER +/- toggle switch to the (-) position (refer to figure 2-16).

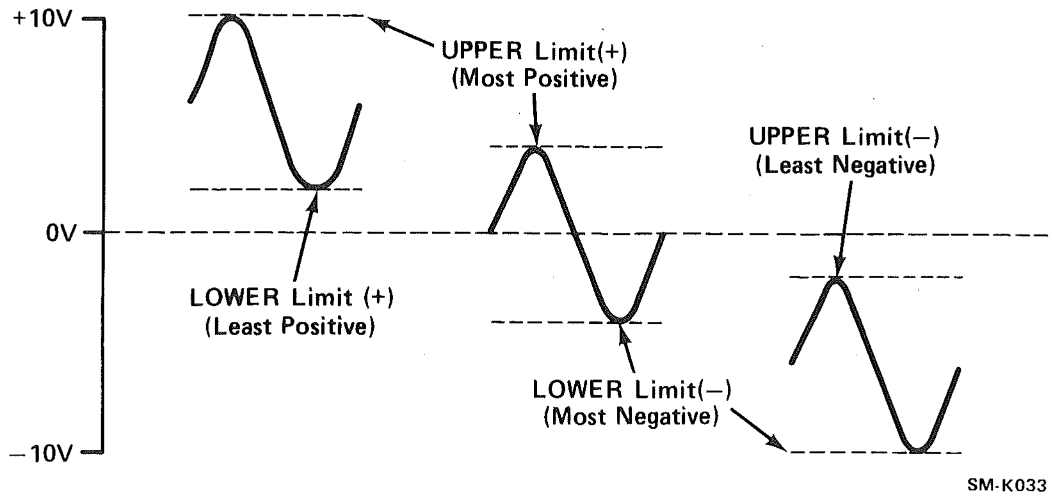

Figure 2-16. Example of Signal Polarity

4. Adjust the UPPER and LOWER controls to the desired limits.

   Control scaling is from 000 to 1000. Each minor dial division represents 0.2% of the operating range. The controls should be adjusted so that a margin of at least 0.5% (2.5 minor dial divisions) exists between each limit detection level and the respective maximum and minimum feedback signal levels likely to be reached. The upper limit margin is obtained by adding at least 2.5 minor dial divisions to the upper dial reading when the UPPER +/- toggle switch is in the (+) position and subtracting at least 2.5 minor dial divisions when the switch is in the (-) position. The lower limit margin is obtained by adding at least 2.5 minor dial divisions to the LOWER dial reading when the LOWER +/- toggle switch is in the (-) position and subtracting at least 2.5 minor dial divisions when the switch is in the (+) position.

   For example, in a given fatigue testing application, load varies between 9000 pounds tension (+) and 2000 pounds tension (+). Operating range is ±10,000 pounds. The UPPER control is set to 905 (90% plus 2.5 minor dial divisions) and the LOWER control is set to 195 (20% minus 2.5 minor dial divisions). 2.5 minor dial divisions are subtracted from the LOWER control setting because the lower limit is of positive polarity (the LOWER +/- toggle switch is in the + position).

2.2.13.2 Adjusting the Limit Detector (Option G) During System Operation

Perform the following procedure to adjust the Limit Detector (option G) immediately after system operation has begun.

NOTE

Perform step 1 before applying hydraulic pressure to the system.

1. Before starting system operation:

   A. Set the UPPER +/- toggle switch to the (+) position.

   B. Set the LOWER +/- toggle switch to the (-) position.

   C. Set the UPPER and LOWER controls to 1000 (fully clockwise).

   D. Select the desired transducer conditioner output (XDCR 1, XDCR 2, XDCR 3, or XDCR 4) on the limit detector selector switch (located below the UPPER and LOWER controls).

   E. Set the INTLK/IND toggle switch to the IND position.

NOTE

Perform the remaining steps of this procedure immediately after system operation has begun.

2. Rotate the UPPER control counterclockwise until the UPPER limit indicator lights. Then, rotate the control clockwise 2.5 minor dial divisions. If the UPPER limit indicator does not light while rotating the control from 1000 to 000, leave the control at 000, place the UPPER +/- toggle switch in the (-) position and rotate the control clockwise until the indicator lights. Then, rotate the control counterclockwise 2.5 minor dial divisions.

NOTE

Rotating the control 2.5 minor dial divisions from the point where the indicator lights establishes a margin between the peak quantity of the selected feedback and the limit detection point.

3. Rotate the LOWER control counterclockwise until the LOWER limit indicator lights. Then, rotate the control clockwise 2.5 minor dial divisions. If the LOWER limit indicator does not light while rotating the control from 1000 to 000, leave the control at 000, place the LOWER +/- toggle switch in the (+) position and rotate the control clockwise until the indicator lights. Then, rotate the control counterclockwise 2.5 minor dial divisions.

4. Press the RESET pushbutton to extinguish the UPPER and LOWER limit indicators.

5. If system interlock action is desired, set the INTLK/IND toggle switch to the INTLK position.

2.2.14 DC CONDITIONER LOW-PASS FILTER (OPTION A)

The dc transducer conditioner (option A) includes a low-pass filter which may be switched in or out of the conditioner amplifier circuit as required. The filter is typically used only in low frequency applications (below 50 Hz) in which problems with excessive noise are encountered. Perform the following procedure to switch the filter in or out of the circuit.

1. Remove hydraulic pressure from the servovalve and turn off ac power to the controller.

2. Remove the controller top cover (if applicable) or otherwise gain access to the interior of the controller chassis.

***** WARNING *****

> If the FILTER IN/OUT switch is set to the IN position during high frequency applications (over 100 Hz), a phase shift will be encountered which may cause the system to become unstable.

3. Place the FILTER IN/OUT switch in the appropriate position (IN or OUT). The switch is located on the low level amplifier circuit card which is plugged into the receptacle toward the rear of the conditioner module (refer to paragraph 2.1.2).

4. Replace the controller top cover.