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# Assembly and Maintenance Instructions

## for the MODEL D527-E Servo (KEK Type Servo)



### DESCRIPTION

This servo, one of the smallest linear devices available, is designed specifically for proportional control systems which provide a positive decoder output signal having approximately 1.5 milliseconds neutral timing and one millisecond total control swing. With its high input impedance characteristic, it is also compatible with most standard systems of other manufacture, such as Kraft, PCS, Heathkit, Orbit, Micro, etc.

### SERVO FORMATS

This servo is available as a full kit, as a half-kit and in factory assembled form. All assembly instructions contained herein pertain to the full kit and the builder must perform each step. The half-kit contains assembled and soldered printed circuit boards, so assembly steps 1 through 34 can be omitted. All other information, except assembly steps, is applicable to assembled servos.

### SPECIFICATIONS

Operating Voltage .....	4.8 volts, C.T.
Current Drain (Nominal)	
Idle .....	8 ma. nominal
Run .....	150 ma.
Stall .....	450 ma.
Output Type .....	Dual Linear
Travel .....	5/8-inch
Transit Time (Average) .....	.6 second
Thrust (Nominal) .....	3.5 pounds
Operating Temperature Range .....	0° to +140°F
Dimensions .....	13/16" wide, 1-1/2" hi, 1-15/16" long
Weight (Complete) .....	1.8 ounces

### BASIC THEORY (See Figure 1)

From the decoder a positive pulse of variable width (one to two milliseconds) is fed to the high impedance input of Q1. Its positive square wave output goes to the summing junction and also provides a trigger voltage for the reference generator. This circuit supplies a negative square wave of variable width to the summing junction. Width of the reference generator output pulse is determined and controlled by the setting of the variable feedback potentiometer. The potentiometer arm is mechanically gear driven by

the motor, so as the motor changes servo position it varies the potentiometer setting to change pulse width of the reference generator.

In the summing junction the incoming positive pulse width is compared with the reference generator negative pulse width. If the two pulse widths are different, an error voltage will be present at the summing junction, causing the servo motor to turn. Polarity of the error voltage depends upon which of the two pulses is wider, and also determines direction of motor travel. As the motor turns it varies the feedback pot setting until the reference generator pulse width agrees with that of the incoming pulse. When this occurs the error voltage at the summing junction "nulls" and the servo stops at this position.

From the transmitter a frame of information is transmitted approximately every 14 milliseconds. This means that only once each 14 ms is a pulse sent to the servo for comparison. In order to smooth out servo action and provide continuous drive voltage to the motor during the "off" periods, pulse stretcher amplifiers are used. These activate the following driver stages which control the related output transistors to drive the servo motor in a given direction.

### CIRCUIT OPERATION (See Figure 2)

The positive signal from the decoder is fed to the base of servo input transistor Q1, which is connected as an emitter follower to provide a high impedance input circuit. Extremely light loading is placed on the decoder output circuits. The positive square wave output from Q1 goes to R4 in the summing junction for use as a comparison pulse, and, through C1, the leading edge provides a trigger pulse for reference generator IC-1.

Integrated circuit IC-1 functions as a reference generator. Transistor "W" of IC-1 is employed to trigger the "one-shot" multivibrator consisting of sections "X" and "Z". Transistor "Y" is not used.

In a steady state condition, transistors "W" and "X" in IC-1 are normally OFF, and "Z" is biased to be normally ON. The positive signal pulse from Q1 turns transistor "W" ON momentarily, driving the collector of "X" negative. When this occurs, timing capacitor C2 charges through diode CR1. The charge voltage in C2 holds "Z" in cutoff state until the

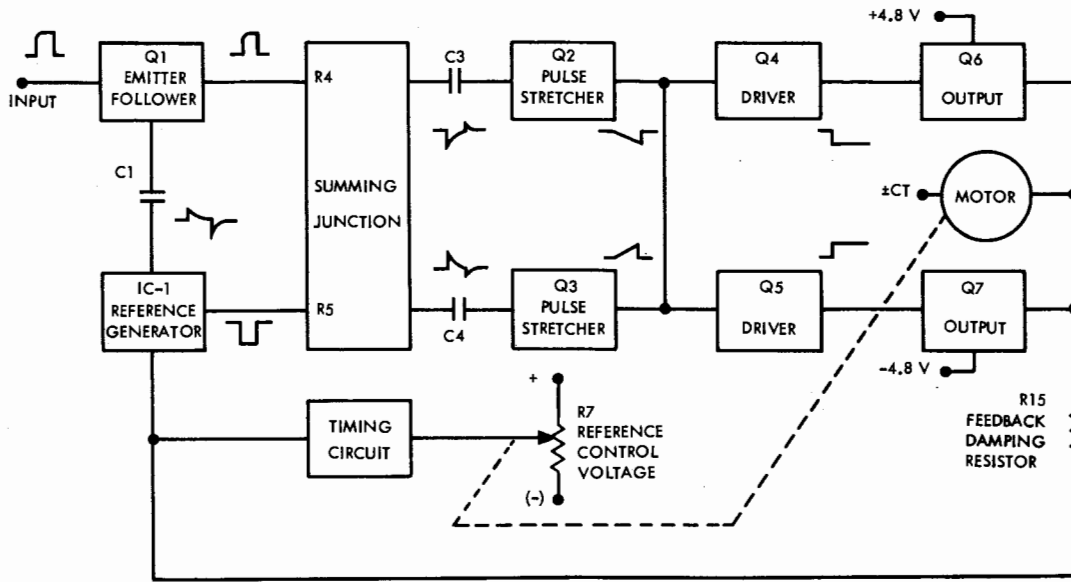


Figure 1. Block Diagram

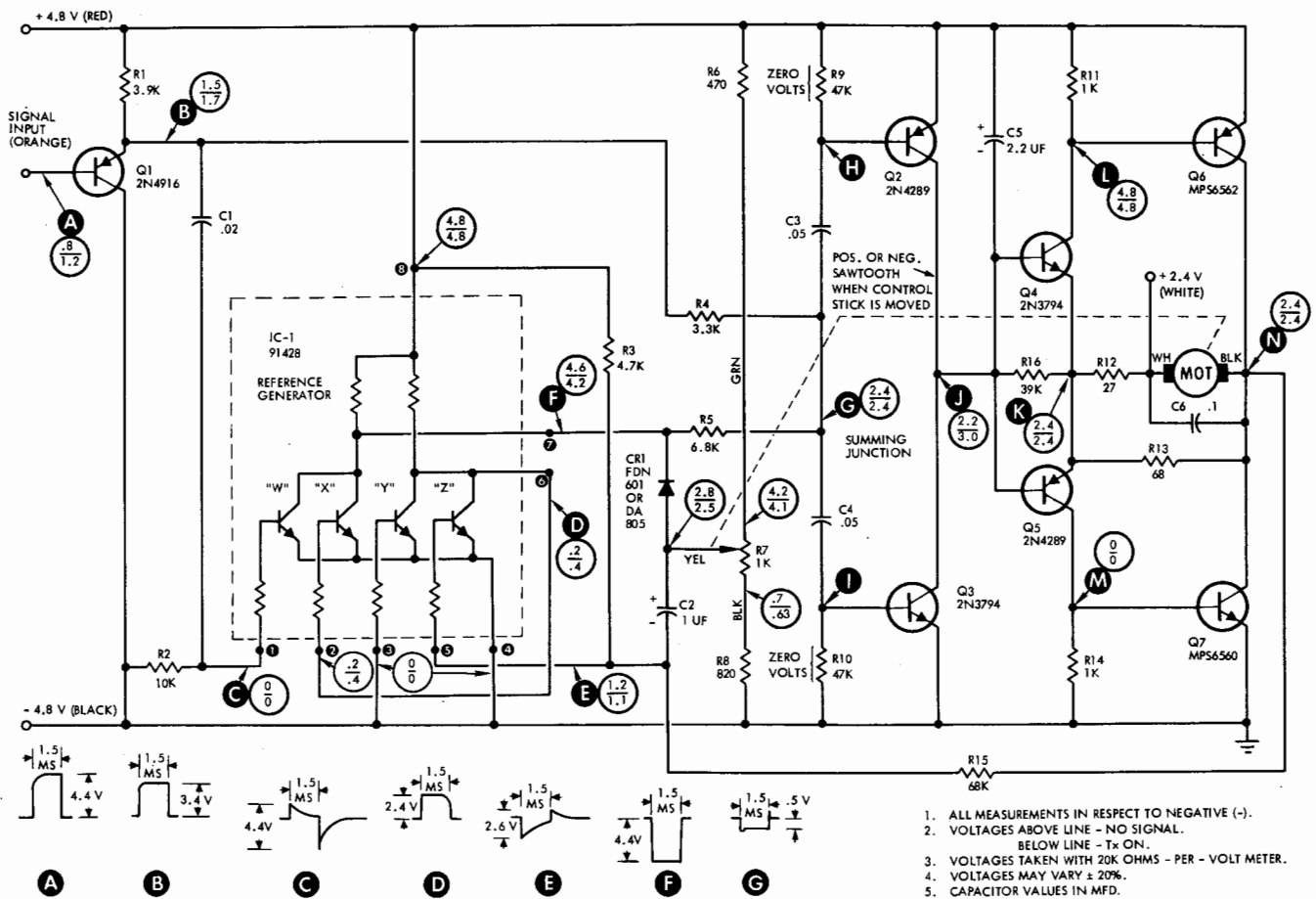


Figure 2. Schematic Diagram

charge bleeds off through timing resistor R3. "X" is held ON as long as "Z" is OFF.

The initial charge present on C2, and consequently the resulting pulse length, is dependent upon the setting of feedback potentiometer R7. Once the charge on C2 has reduced sufficiently, transistor "Z" returns to its steady state ON condition, biasing "X" OFF. The resulting output from pin 7 of IC-1 is a negative square wave, the leading edge of which coincides with that of the servo input signal and whose pulse duration is determined by the setting of the feedback pot.

Since the negative pulse from IC-1 is also fed to the summing junction through R5, the resultant error voltage pulses may be positive, zero or negative, depending on the time coincidence of the positive and negative pulses. If the positive pulse from Q1 is of longer duration than the one-shot output, the voltage at the summing junction will appear positive for a period of time equal to the difference of duration of the two pulses. Should the one-shot output be of longer duration, the summing voltage will be negative. Equal pulse lengths will provide a zero error voltage.

Let us assume a condition where the incoming command pulse is longer than the reference generator pulse. A positive differential will appear at the summing junction and be coupled through C3 and C4 to the bases of complementary transistors Q2 and Q3 respectively. This positive signal will tend to hold Q2 in an OFF condition, but will forward-bias Q3 so that Q5 and Q7 are turned ON. Junction (N) of the motor will go negative with respect to the +2.4 volt center tap connected to the opposite side of the motor. The motor will turn, changing servo position and mechanically varying the position of the feedback pot wiper to lengthen the pulse from the reference generator. When the generator pulse width equals that of the input signal, the summing error voltage will become zero, Q3, Q5 and Q7 will return to normal OFF condition, and the motor will stop. The servo will remain in this position until a new command in the form of a changed input signal is received.

Because of the very short duration of the differential command pulses, a pulse stretching circuit is required to provide smooth voltage flow to the motor. Capacitor C5 charges through Q3 when Q3 is activated by the positive pulse. Discharge of C5 takes place through the base-emitter junction of Q5 to provide a sufficiently long time constant to hold Q5 ON until the next pulse arrives at the base of Q3.

Reverse operation of the servo is obtained when a negative pulse is present at the summing junction. Transistors Q2, Q4 and Q6 are energized, causing application of opposite polarity voltage to the motor for opposite rotation. The reference generator pulse is shortened until a correct width match is obtained.

Feedback resistor R15 provides negative damping required to provide correct centering without over-

shoot. Increasing its value will effectively increase centering resolution and also overshoot.

Resistors R6 and R8 are selected to provide approximately 90 degrees of servo travel (without using trim controls). Increasing R6 and R8 to 680 ohms will increase servo travel to approximately 110 degrees. Smaller values will reduce servo travel.

Resistor R16 clamps transistors Q4 and Q5 to prevent undesired response to transient noise pulses. Capacitor C6 provides motor noise filtering.

#### KIT PARTS LIST

QTY	ITEM	PRICE (ea)
1	P.C. board	\$ 2.00
1	.02 UF disc capacitor	.20
2	.05 UF disc capacitor	.30
1	.1 UF disc capacitor	.30
1	1 UF tantalum capacitor	.75
1	2.2 UF tantalum capacitor	.75
1 ea	1/4 watt resistors, values 27, 68, 470, 820, 3.3K, 3.9K, 4.7K, 6.8K, 10K, 39K, 68K ohms $\pm 10\%$	.15
2 ea	1/4 watt resistors, values 1K and 47K ohms $\pm 10\%$	.15
1	FDN601 (or DA805) silicon diode	.50
1	91428 integrated circuit	1.50
2	2N3794 transistor (yellow dot)	1.00
2	2N4289 transistor (blue dot)	1.25
1	2N4916 transistor	1.00
1	MPS6560 transistor	1.25
1	MPS6562 transistor	1.25
1	24" solder, .031 diameter	.10 ft
1	P.C. board assembly, with all parts assembled and soldered in place	\$ 21.00

This P.C. assembly is supplied in Half-Kits in place of above separate components

Following parts are supplied in both Kits and Half-Kits.

QTY	ITEM	PRICE (ea)
1 ea	No. 26, 19 strand insulated wire in following lengths and colors: 2" yellow, 2" green, 10" orange, 10" red, 12" white, 14" black	.05 ft
1	4-pin male plug (Brunner type)	.75
	OR	
1	4-pin Multicon plug and cable assembly (for Super-Flite only) (replaces orange, red, white, black wires and plug listed above)	1.75
1	3/32" x 3" shrink tubing	.50 ft
1	Cannon adhesive label	.20
1	Assembly and Maintenance Instructions for KEK Servo	.50

1 set Servo mechanics, unassembled, with 2.4V motor (includes the following parts) \$ 12.00

CIRCUIT BOARD ASSEMBLY

PREPARATION FOR ASSEMBLY

PART NO.	QTY	ITEM	PRICE (ea)
S-041	1	No. 3 Gear	\$ .60
S-043	2	Rack Gear	.60
S-046	1	Shaft (Long)	.25
S-047	1	Shaft (Short)	.25
S-048	1	Case Top	1.00
S-050	1	Case Bottom	1.50
S-051	1	Rack Deck	.60
S-053	1	Feedback Potentiometer (1K)	1.25
S-060	2	No. 1 & No. 2 gear	.60
S-081	1	Motor (2.4 VDC)	6.50
S-082	1	Case Middle Section (includes wiper and No. 4 gear)	2.50
P-009	2	No. 2 x 3/16" sheet metal screw	.05
P-010	2	No. 2-56 x 3/16" flat head machine screw	.05
P-021	4	Rubber Grommets	.05
P-022	2	No. 2-56 x 3/16" machine screw	.05

- Read these instructions and the General Assembly Instructions over thoroughly before starting servo assembly.
- Check kit parts against the parts list.
- Choose a smooth, clean work area so parts are not easily lost.
- The following tools are required:
  - Needle nose pliers, 4" long.
  - Diagonal cutters, 4" long, flush-cutting type preferred.
  - Wire strippers for no. 26 wire.
  - Soldering iron, 30 to 47-1/2 watts.
  - Pencil tip for soldering iron.
  - Damp cellulose sponge for cleaning soldering iron.
  - Rosin core solder, 60-40 type, .031" diameter (supplied with kit).
  - Small metal screwdriver, 1/8" blade.
  - Small Phillips head screwdriver.
  - Fine-tooth metal file, 8" long.
  - Small, stiff bristle brush.
  - Lacquer thinner.
  - Silicone rubber compound (RTV).

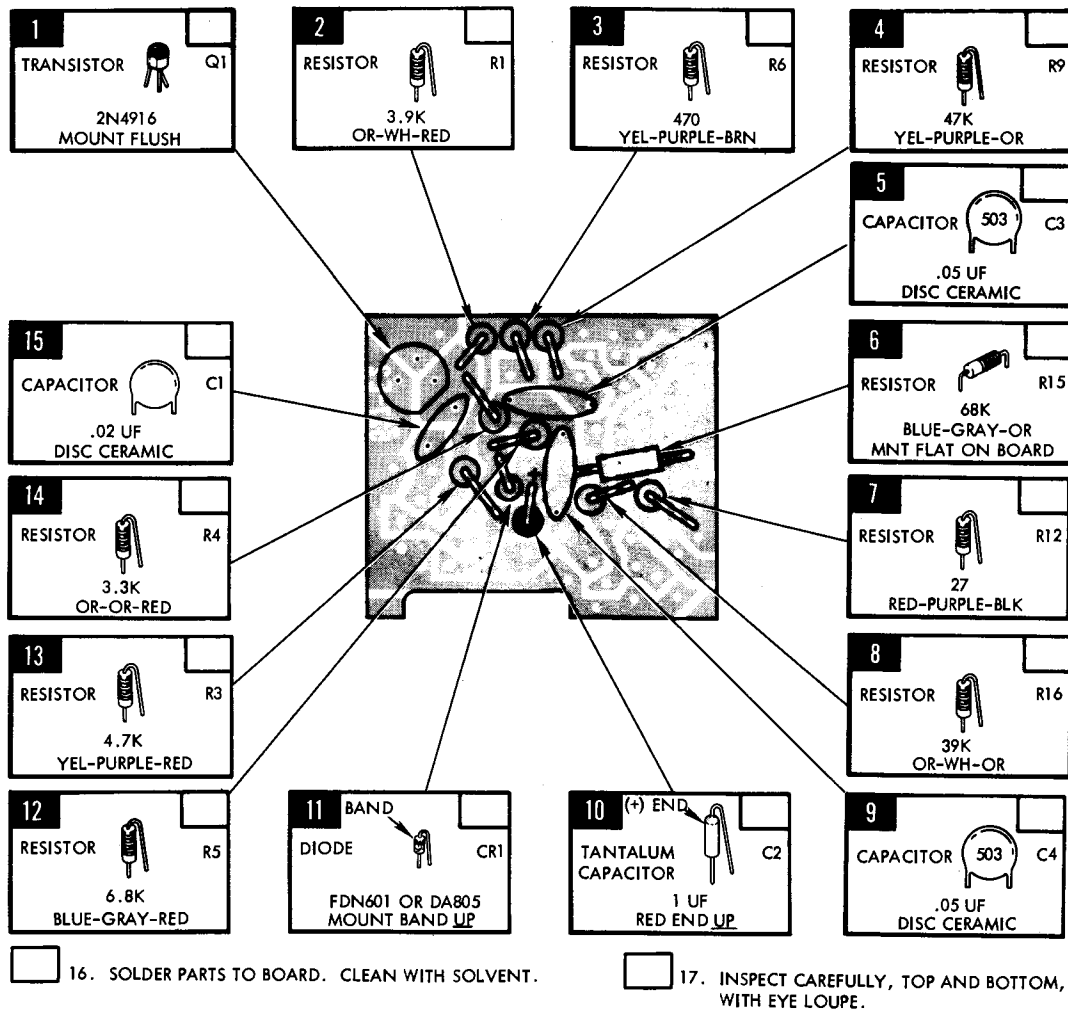


Figure 3. Assembly of P.C. Board (Sheet 1 of 2)

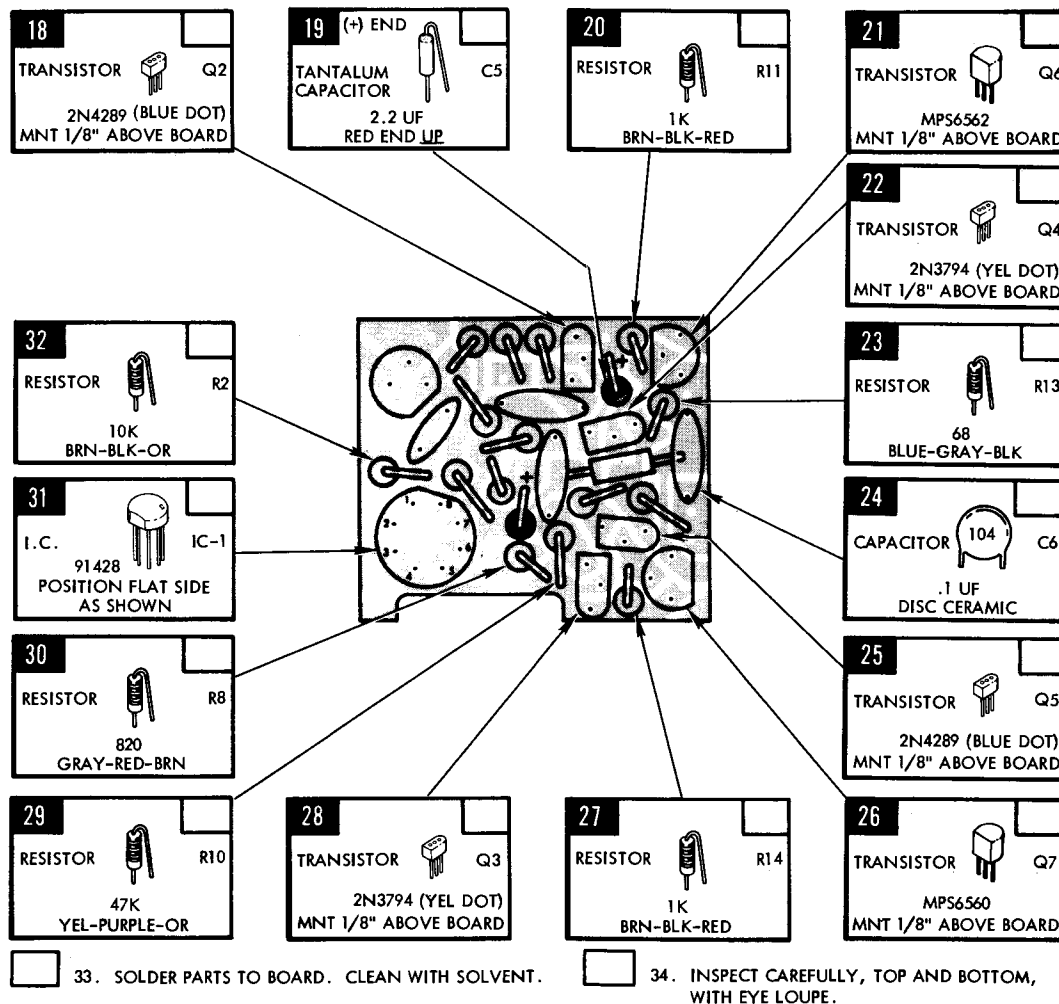


Figure 4. Assembly of P.C. Board (Sheet 2 of 2)

- 14. X-acto knife.
- 15. Eye loupe.
- 16. Servo centering tool. (Grind end of long shaft of a 3/32" allen wrench to a 1/16" square cross-section).
- e. Check that outer trim edges of P.C. board are flush with outer edges of copper lands. If necessary, dress edges slightly with a file.
- f. When soldering P.C. board, use as little solder as possible to reduce bulk on back side of board.
- g. Use caution in handling subminiature 2N3794 and 2N4289 transistors. Their construction is delicate, and placing undue stress on the wire legs by spreading too far may fracture them internally.

**BOARD ASSEMBLY**

a. Position printed circuit board, metal side down, so that hole arrangement corresponds with layout in figure 3. Proceed with steps 1 through 17, then repeat process with steps 18 through 34, figure 4. Omit steps 1 through 34 on Half-Kits.

**DETAIL ASSEMBLY**

35. Cut following lengths of #26 wire. Keep in separate groups for later use.

**Group "A" - Board-to-pot wiring**

1	yellow wire	1-1/2" lg
1	green wire	1-1/2" lg
1	black wire	1-5/8" lg

**Group "B" - Board-to-motor wiring**

1	black wire	1-5/8" lg
1	white wire	2" lg

**Group "C" - Servo cable wires**

1	red wire	10" lg
1	white wire	10" lg
1	black wire	10" lg
1	orange wire	10" lg

**NOTE**

Super-Flite servo kits contain a preassembled cable instead of the Group "C" wires.

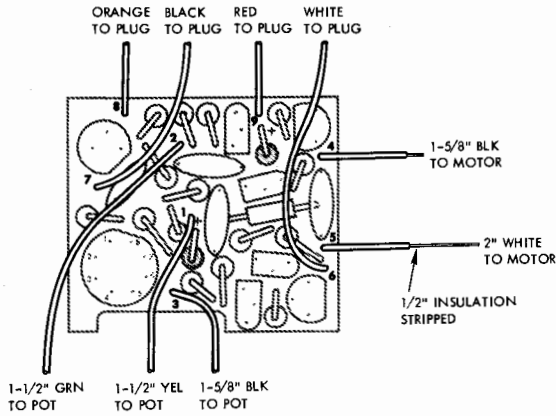


Figure 5. Servo Board Wire Connections

- 36. Using wire strippers, remove 1/8" insulation from both ends of each wire above, except remove 1/2" insulation from end of 1-5/8" black wire in Group "B".
- 37. Twist strands of exposed wire ends tightly, then tin both ends of all wires cut. Use as little solder as possible to avoid solder lumps on wires.
- 38. Insert yellow wire from Group "A" through hole No. 1 in board, and solder in place. (See figure 5.)
- 39. Install and solder green and black wires from Group "B" into holes 2 and 3 respectively in board.
- 40. Twist the three pot wires from holes 1, 2 and 3 together and position them so they lie towards the bottom side of the board closest to the feedback pot.
- 41. Connect black wire from Group "B" to hole 4 in board.
- 42. Solder white wire from Group "B" to hole 5 on board.

- 43. Clip soldered wires where they protrude through back side of board.
- 44. Clamp servo cable male plug in a small vise so that plug pins are held in the vise and plastic body sits flush on top of vise. Solder connections should be up.
- 45. Insert .301" solder into cavity of pin "A" of plug (see figure 6). Apply tip of soldering iron to upper side of pin until solder melts and fills cavity. No overflow, please.
- 46. Insert end of 10" orange wire into molten solder in cavity, then remove iron and allow to cool. Check that wire is securely soldered to pin. Caution: Do not overheat pin or plastic on plug may melt and pin may come out of seat.
- 47. Repeat above procedure and solder 10" black, white and red wires into pins "B", "C" and "D" of plug.
- 48. Slide a section of 3/32" x 1/2" shrink tubing over each of the orange, black, white and red wires until tubing covers plug pin fully. Apply heat and shrink the tubing tightly around wires and pins.
- 49. Hold plug in left hand and twist all four wires together until cable is smoothly formed.
- 50. Slide 3/32" x 1/4" shrink tubing over wire ends. Position close to plug as shown in figure 6. Apply heat to shrink in place.

NOTE

For Super-Flite servo, cable is preassembled, so steps 44 through 50 are not necessary. See figure 7 for cabling arrangement.

- 51. Slide a piece of 3/32" x 1/4" shrink tubing over wire ends. Position 6-5/8" from plug as shown. Shrink into place. Note - On Super-Flite cable, position tubing 8-1/4" from plug.
- 52. Untwist ends of wires beyond shrink tubing. Cut each wire to length shown (figures 6 and 7). Strip 1/8" from end of each wire, and tin the ends.

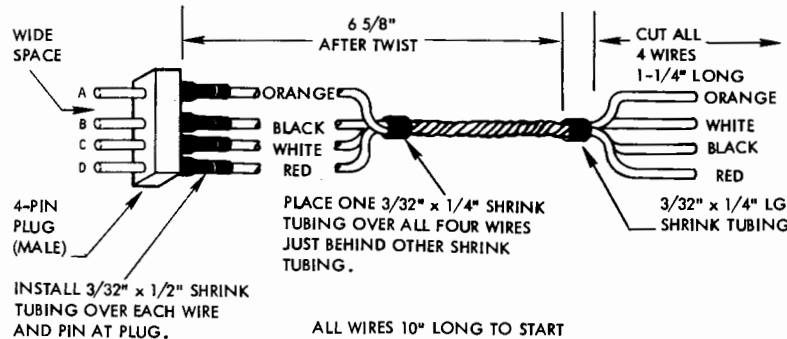


Figure 6. Standard Servo Cable Assembly

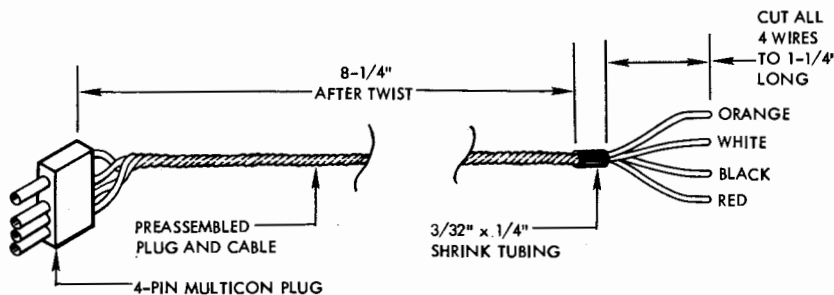


Figure 7. Super-Flite Servo Cable Assembly

- 53. Slide cable end through hole in case bottom until about 4" of wire extends from inside of case. (See figure 8.)
- 54. Insert white wire from cable through hole no. 6 in top of P.C. board (figure 5). Solder in place. Clip off excess wire.
- 55. Likewise, connect the black, orange and red cable wires to holes 7, 8 and 9 respectively in the board.
- 56. Use lacquer thinner and a stiff bristle brush to remove solder flux from back side of P.C. board.
- 57. Using an eye loupe, carefully inspect board, top and bottom. Check for shorted leads, parts touching each other, shorted lands, solder across lands, correct wire placement, etc. Sometimes solder shorts are hard to find. Compare back side of board with land diagram, figure 9. Remove all defects found. Put board assembly aside until later.

#### ASSEMBLY OF SERVO MECHANICS

Refer to figure 8 for identification of servo components and placement of parts. Assemble servo as follows:

- 58. Before assembly, inspect all servo parts carefully. Check plastic parts, especially gears, for defects or pieces of "flash". Remove foreign particles with a sharp X-acto knife.
- 59. Install 3/4" long Scotch tape on opposite sides of motor as shown. Note position of tape relative to motor ground lug.
- 60. Slide motor into mounting tabs on case center section until fully seated. Position ground lug at end of servo.
- 61. Press both long and short metal shafts into bosses in top side of center section.
- 62. Slide No. 1 gear over long shaft and No. 2 gear over short shaft. Check for proper gear mesh between all gears.
- 63. Install both rack gears through slots and into slide channels in case top. Install rack deck, positioned as shown.
- 64. Slide rack gears in opposite directions until both gears are seated against opposite stops. Insert No. 3 gear through large hole in rack deck to mesh with both rack gears. Check smoothness of gear operation and movement of racks to extremes in both directions.
- 65. Turn No. 4 gear by hand to position pot wiper as shown in figure 8.
- 66. Move rack gears to center position. While holding wiper and rack gears in place, carefully slide case top assembly down over case center section until gears mesh and top seats fully against center section. It may be necessary to rock the rack gears back and forth slightly to obtain correct gear alignment.
- 67. Move servo racks carefully in opposite directions to determine that gears are correctly meshed and racks move smoothly back and forth without requiring excessive applied force. Caution: If racks are hard to move, do not force; recheck gear mesh.
- 68. Recheck that pot wiper position is correct when rack gears are centered.

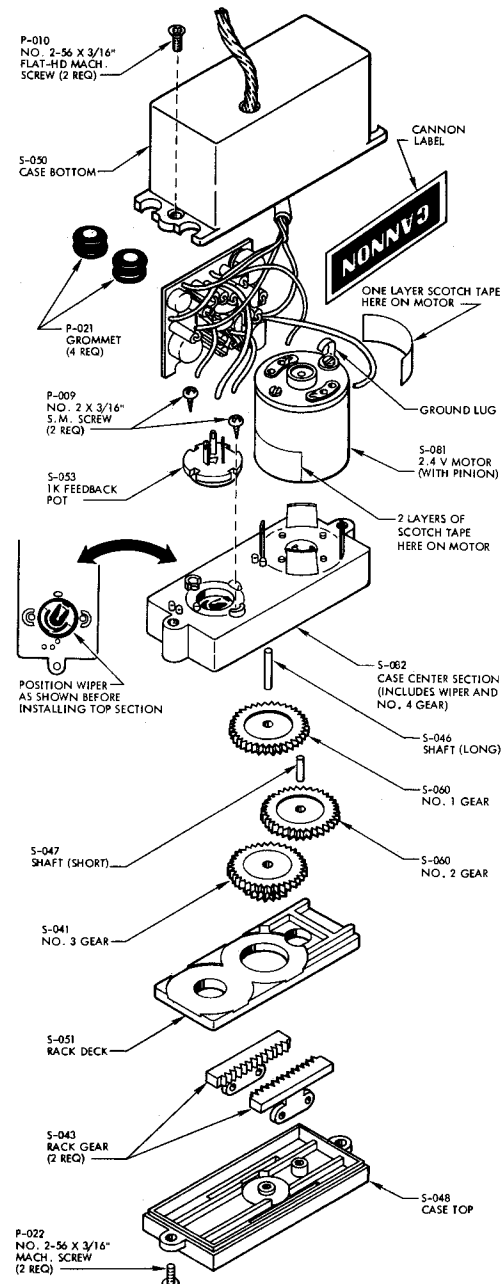


Figure 8. Exploded View of Servo

- 69. Once gear operation is satisfactory, attach top with two no. 2-56 x 3/16" machine screws.
- 70. Check that pot wiper contacts have sufficient tension to insure proper contact with feedback pot element.
- 71. Install feedback pot over pot wiper; note keyway mating with large slot in pot. Attach with two no. 2 x 3/16" sheet metal screws. Do not over-tighten, or pot element may break.
- 72. Bend tabs down on feedback pot as shown in figure 10.
- 73. Use an X-acto knife to scrape top surface of each of the three brass feedback pot tabs.
- 74. Apply heat and a small spot of solder to both connections on top of motor. Do not put solder on ground lug.

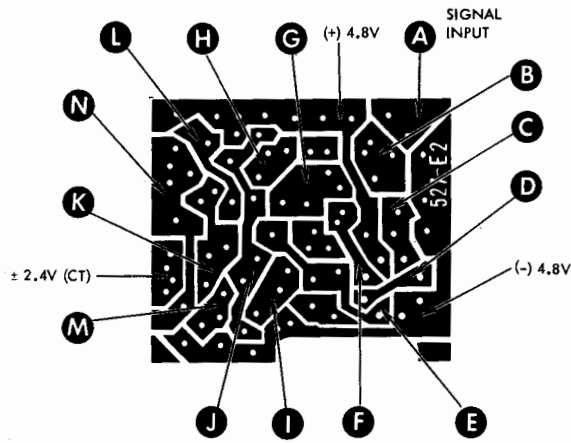


Figure 9. Test Point Locations

- 75. Position white motor wire so bare lead runs across right terminal and across to ground lug (figure 10). Solder wire to terminal. Fold ground lug over bare lead and solder.
- 76. Solder black wire from board to red insulator terminal on motor.
- 77. Solder the yellow, black and green wires from board to proper tabs on feedback pot.
- 78. Seat P.C. board between mounting tabs on bottom of case center section. Dress motor and pot wires neatly away from board.
- 79. Inspect board and wiring once more before test.

TEST AND ADJUSTMENT

- 80. Plug servo into desired channel in receiver plug. Leave transmitter OFF and turn receiver battery ON. Servo may jump momentarily, but should not run to an extreme position. If so, refer to Troubleshooting section, and repair servo.
- 81. Place transmitter controls in neutral, then turn transmitter ON. Servo should move to an approximate neutral position, then stop. Operate control stick and see if servo responds in both directions.
- 82. Center servo output arms by inserting the 1/16" square centering tool into square hole in top of

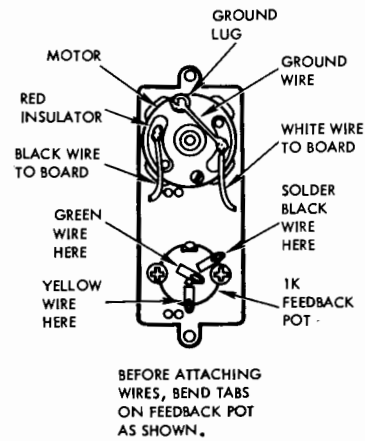


Figure 10. Feedback Pot and Motor Wire Connections

- servo until tool bottoms. Rotate tool with a quick, slight twist until arms come to neutral position.
- 83. Operate servo several times. Servo action should be snappy, with positive return to exact neutral each time. If action is not correct, refer to instructions on Feedback Adjustment.

FINAL ASSEMBLY

- 84. Apply silicone rubber compound to ends of all wires where they solder to boards and motor.
- 85. Make sure board is installed in mounting tabs, and wires are properly dressed.
- 86. Carefully slide cover down cable until it is positioned directly over motor and board. Align internal slot in case bottom with outer edge of P.C. board, then slide case bottom down until it seats against servo center section.
- 87. Attach bottom with two no. 2-56 x 3/16" flat head machine screws.
- 88. Install Cannon adhesive label on side of case bottom so that cover can still be removed without damage to label. Use razor blade to separate label from backing.
- 89. Add end mounting grommets to servo. Install servo in airframe, and it is ready for use. A servo tray is recommended for installation.



## MAINTENANCE AND ADJUSTMENT

### GENERAL MAINTENANCE

- a. If servo gear lubrication is required, use fine powdered graphite or "Dry Lube". Never use grease or liquid lubricant of any type on servo.
- b. Should servo motor be removed from servo, do not attempt to reinstall it with gears in place or gear teeth will be nicked. Disassemble servo, take out gears, slide motor fully into position, then replace gears.
- c. Periodically clean pins on servo plug and matching receiver plug. Use end of an X-acto blade to bend pins of Brunner-type female plug together to restore friction fit.
- d. Disassemble feedback pot every 6 months or so, and clean wiper arms and pot element with an electronic lubricant and cleaning agent. Adjust tension on wipers.
- e. Always remove and check servo gears after a crash or extremely hard landing. Replace those with nicks, burrs and bent or broken teeth.

### FEEDBACK POT WIPER ADJUSTMENT

- a. When servo feedback pot is cleaned or trouble is suspected in the pot, take out the two screws and lift out pot element.
- b. Using an electronic cleaning fluid and tissue, wipe away loose residue on contacts and pot element.
- c. With a small screwdriver, reach into pot cavity and spring the three contacts upward very slightly to insure good wiper contact. Reinstall pot element and recenter servo.

### REVERSING SERVO DIRECTION

- a. To reverse operating direction of servo, interchange positions of black and white motor wires, and reverse positions of black and green wires to feedback pot. Do not change position of yellow wire to feedback pot. It is not necessary to change positions of ground wire when reversing motor wires. Re-centering of servo will be required.

### CHANGING SERVO TRAVEL

- a. Servos are designed to provide nominal 5/8-inch total travel with trim controls.
- b. To decrease total travel, reduce values of resistors R6 and R8 until desired travel is obtained.
- c. Increase values of R6 and R8 to increase travel.

### FEEDBACK ADJUSTMENT

- a. Servo centering accuracy and "overshoot" action are controlled by negative feedback resistor R15.
- b. If servo does not return to exact center each time, negative feedback is excessive. Increase R15 to the next standard value to tighten centering accuracy.
- c. Insufficient feedback (R15 too large) will make a servo "jumpy" and overshoot will be noticeable at extreme and when servo returns to neutral. Reduce value of R15 until servo centers properly without excessive "bounce-back". A small degree of overshoot is desirable to insure centering accuracy.

## TROUBLESHOOTING AND REPAIR

### GENERAL

Following are a number of tips and techniques describing methods of locating circuit faults, isolating troubles, basic repair procedures, etc. A troubleshooting chart is included as an aid in isolating and locating a defect.

### SECTIONAL ANALYSIS

- a. For service, consider your servo as being electronically in three separate sections: Plug, cabling and individual wires; a front end consisting of the input circuit, reference generator and timing circuits; and a rear end consisting of the six transistors and associated circuitry which drive the motor. This includes everything from the summing junction (point © on schematic) through the motor.
- b. The front section further subdivides into the input transistor stage, the reference generator, and the timing circuit.

- c. Basically the rear end can be further considered in two parts: Transistors Q2, Q4, Q6 plus related parts which drive the motor in one direction; transistors Q3, Q5, Q7 and parts to drive the motor in the opposite direction.

d. In case of servo trouble, your first job is to isolate the problem to one of the major areas listed above, then localize the fault to a specific component.

- e. Before any troubleshooting is attempted, inspect entire servo very carefully to make sure all components and wires are correctly installed.

### INITIAL CHECK-OUT

- a. Plug servo into receiver. With transmitter OFF, servo should not move appreciably. If servo runs solidly to one extreme position, a defect exists in the rear end. This is usually caused by a solder short, an incorrect part installation, or a shorted transistor.
- b. If rear end appears O.K., turn transmitter ON. Servo should move to a specific point, then stop. If

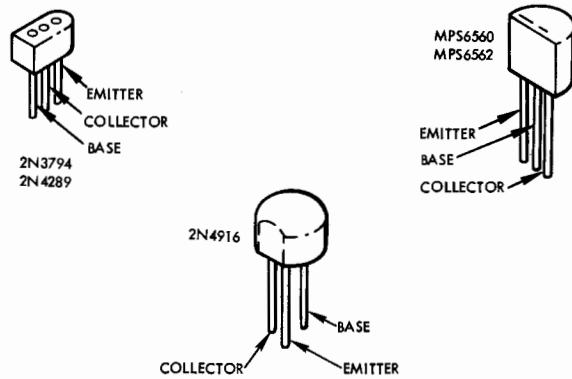


Figure 11. Transistor Identification

front end is O.K., servo should follow stick movement, and all that is required is to center servo and check operation. Front end may be inoperative if servo is dead, runs constantly in one direction or runs to an extreme.

c. If above check-out steps produce no results, refer to procedures under "Dead Servo" or "Defective Front End", as applicable.

#### DEAD SERVO

a. Use a voltmeter to check for correct voltages on back side of servo boards. See figure 9 for voltage test points.

b. If voltages are incorrect, inspect all wires for proper hook-up. Check continuity of all related wires from plug pins to the circuit boards. Voltage reversals may indicate wire reversals.

c. After voltages check O.K., check waveforms at test points (A) and (B) (figures 2 and 9).

d. If decoder output is normal without servo plugged in, but no signal appears at (A) with servo energized, trouble is either in the orange signal wire connections, or the servo input circuit has a short. Check for solder shorts on back of board. If none, replace Q1.

e. If signal is at (A) but not at (B), transistor Q1 is open or this circuit output has a solder short.

f. Check waveform at (C). If servo is correctly centered and front end is operating, (C) should show alternate plus and minus signals as transmitter stick is moved from one extreme to the other. If so, front end is operating; refer to section entitled "Defective Rear End". If waveform at summing junction is incorrect, refer to "Defective Front End".

#### DEFECTIVE FRONT END.

a. Check input circuit as outlined in steps c, d and e of last paragraph.

b. If (C) shows a narrow pulse which varies with control movement, servo may be completely out of center. Change centering and see if waveforms become normal. If not, wrong value capacitor may have been installed in place of C2 to upset system timing.

c. If (C) waveform is similar to (B), reference generator circuit is inoperative. Check feedback pot wipers for contact. Check back of board for solder shorts. Observe waveforms at (C), (D), (E) and (F). Replace IC-1 if these are not correct.

#### DEFECTIVE REAR END

a. Use a 470 ohm resistor to short from emitter to collector of output transistor Q6. If power is applied to servo (transmitter OFF), motor should run in one direction. Note direction of rotation. This verifies motor operation. Otherwise, recheck for correct voltage and/or replace motor.

b. Connect 470 ohm resistor from base to collector of Q6. Again, motor should run in same direction as before. If not, replace Q6.

c. Check motor run (same direction) by using 470 ohm resistor from base to collector of Q4. Replace Q4 if motor action is incorrect.

d. Repeat with 470 ohm resistor across base-collector junction of Q2. Replace Q2 if inoperative.

e. Repeat steps a through d above on transistors Q7, Q5 and Q3. Test results and corrections are the same except that motor should run in opposite direction. These five steps will locate an open or burned out transistor, evidenced primarily by an inclination of the servos to run in one direction only (Tx ON) and not returning to neutral (assuming correct front end operation).

f. With transmitter OFF, if motor persists in running in one direction, a short exists in the three-transistor circuit which controls motor rotation in that direction. With an eye loupe, check for possible solder bridges between lands or traces of copper on board.

g. Check voltages across resistors R9 and R10. If voltage is not zero, the related capacitor (C3 or C4) is shorted, or the related transistor is shorted.

h. Use an ohmmeter and voltmeter to check resistances and voltages across the emitter, base, and collector junctions of the three transistors. Compare resistances with those of the complementary transistors on the opposite side to determine the shorted part. Replace as necessary.

i. If servo hums or chatters constantly, check C5 for open circuit.

#### CIRCUIT BOARD REPAIR

a. After bent over and soldered in place, parts are difficult to remove without damage to circuit board lands.

b. When a part must be removed, if possible use a solder "sucker" to remove excess solder from joint. Otherwise, heat the joint until solder melts, then "flip" the board to throw solder off.

c. Using diagonal cutters, clip off part leads below board. With application of a small amount of heat, parts should be easily taken out. We recommend use of small size surgical clamps to assist in removing parts.

d. Open holes with soldering iron or small drill (no. 60) before installing new parts.

## TROUBLESHOOTING CHART

TROUBLE	POSSIBLE CAUSE	REMEDY
Servo dead	Solder short on board	Inspect, remove short
	Q1 defective	Replace Q1
	Poor plug contact	Clean, adjust plugs
	Motor defective	Replace motor
	Q6, Q7 burned out	Replace
	White lead from battery open	Check and repair
Servo runs to extreme (Tx OFF)	Solder short in servo rear end	Inspect, remove short
	Q2 through Q7 shorted	Locate and replace bad transistor
	C3 or C4 shorted	Check and replace
	Broken red or black battery wire	Check, repair wire
	Incorrect part installation	Check all parts for value and placement
Servo O.K. with Tx OFF, but runs to extreme with Tx ON	Feedback pot wiper not making contact	Tighten wiper arms
	Incorrect part installation	Check all parts for correctness
	C1 open	Replace C1
	C2 wrong value	Check, replace
	Reference generator not working	Check for shorts. Check components. Replace IC-1.
	Solder short in rear end	Remove short
Servo follows control stick in one direction but will not return	One transistor (Q2 through Q7) defective	Perform in-circuit test. Replace as necessary.
	C3 or C4 open	Check, replace
	Solder short in rear end	Remove short
Servo works, speed and power below normal	Weak battery	Charge or replace battery
	Damaged output transistors	Replace transistors
	Weak motor	Replace motor
	Bind in servo mechanics	Disassemble servo. Check gear teeth. Check for binds in all drive components.
Servo jumpy. Operation erratic.	Loose pot wiper	Adjust wiper arms
	Loose solder joint	Resolder
	Plug contacts loose	Tighten female plug contacts
	C5 defective	Replace

### MECHANICAL REPAIR

a. Servo mechanical parts requiring repair or replacement will become obvious on close inspection. Replacement is recommended where there is any question of serviceability.

b. Clicking noises in servos are usually caused by defective gear teeth. Small burrs can be removed with a sharp X-acto knife. Gears with chipped or broken teeth should be replaced.

### ORDERING INFORMATION

On all servo parts orders under \$10.00, include .50 for cost of shipping and handling. Minimum order \$1.00 (+.50). No C.O.D.'s.

### REPAIR SERVICE

In event of trouble send unit direct to the factory, NOT to the dealer. Repairs are not priced for dealer discounts. Equipment will be serviced and returned within a few days. Be sure and include detailed information on the problem. After repair is completed, you will be notified regarding cost and shipping.

KITS ARE WARRANTED ONLY FOR COMPLETENESS OF PARTS. NO PARTS EXCHANGE WILL BE MADE AFTER THE PART HAS BEEN INSTALLED OR SOLDERED ON.

Litho in U.S.A.

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