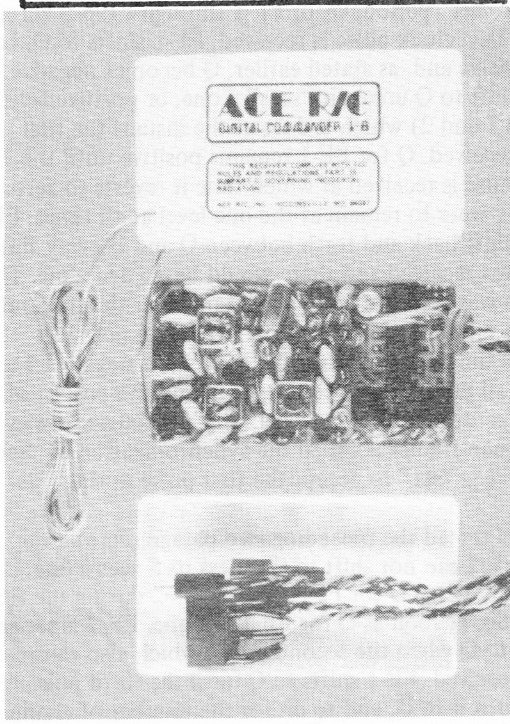
ACE R/C INC.

DIGITAL COMMANDER

BY FRED M. MARKS

1-8 RECEIVER



I. RECEIVER SECTION DESIGN

The receiver section is superheterodyne, utilizing a double tuned front end. The use of an IC to perform squaring and pulse stretching in the decoder section permits the receiver to be simplified and the space used to provide good stability. The receiver is quite stable and tuning is easy and solid.

Refer to the block diagram, Figure 1, and schematic, Figure 2, for the discussion to follow. The RF tuning, i.e., front end, uses two parallel pass filters (L2, C5) and (L3, C7) which are coupled by C6. This double tuned circuit provides the proper front end selectivity even when an adjacent channel transmitter is close by. The front end components are C5, 6, & 7, L2, 3, & 4.

The output from the secondary winding L4 of L3/L4 is fed directly to the base of the mixer, Q2, which is biased to a given d.c. level via R6. The output from the local oscillator is injected at the emitter of Q2.

The local oscillator usually operates at a frequency 455 KHz below the transmitted frequency. The local oscillator (LO) used is simply a crystal controlled oscillator feeding a tapped inductor. The shorter winding above the tap forms a secondary as well as part of the total inductor. The output of the LO is coupled via C4 to Q2.

Two frequencies appear at the input to Q2; the transmitted frequency and a frequency separated 455 KHz from the transmitted frequency. For example, assume a transmitted frequency of 26.995 MHz. The LO operates at 26.995 MHz minus 0.455 MHz or 26.540 MHz. The function of Q2 is to "mix" these frequencies to produce a 455 KHz intermediate frequency (IF). When two separate frequencies are mixed or "heterodyned", they produce the following frequencies, for our example:

† The sum of the two frequencies or 53.535 MHz,
† The difference between the two frequencies or 455KHz, and
† The two original frequencies.

In order to provide the desired selectivity, we wish to work only with the 455 KHz IF frequency. This is the function of the IF strip to be described a little later. The local oscillator is formed of R1, R3, R4, C3, L1, C1, C2, Q1, and the crystal. C4 is the coupling interface with the mixer formed of C8, L4, Q2, R6, and R7.

The IF strip operates on the 455 KHz signal out of Q2 and excludes all other frequencies. By so doing, it increases the selectivity of the receiver to 5 KHz as desired. The output from T3 is rectified by D1 and the output from Q5 appears as the rectified 455 KHz envelope. This means that the base of Q5 sees only the positive going portion of the IF envelope which occurs when a pulse is received in the RF envelope. Q5 amplifies the pulses to an amplitude which is dependent on the signal input to the receiver; i.e., amplitude increases as signal strength increases. One can visualize that the output amplitude of Q5 would fluctuate continually as range and aspect to the transmitter changes. This is highly undesirable and it results in glitching and/or swamping of the receiver.

The above is prevented by coupling back the detected D C signal out of Q5 to the preceding IF stages to reduce their gain as signal input is increased. Ideally, then, the output from Q5 remains constant from zero range to the maximum anticipated operating range. Within the limits of simple circuitry this is the case. This function is called automatic gain control (AGC). The AGC circuit is formed by C20, C21, R14, R18, and R19. All the remaining circuitry between the output of Q2 and the output of T3 constitutes the IF circuitry (commonly called the IF strip).

The output from Q5 is coupled to a limiter stage consisting of D2, R21, and R22. The function of the limiter is twofold: it tends to limit the amplitude of the detected signal when the transmitter is close to the receiver and thus helps prevent overloading. More importantly, it "clips" noise spikes which could occur under low signal conditions resulting in servo jitter. The net result is that the receiver output remains "clear" to maximum range, then cuts off sharply. This also is important in the rejection of strong adjacent channel signals. The output from the limiter stage is then fed to the decoder board.

For the 1-8 receiver, we feel that the added complexity of a voltage regulator/active filter for the receiver is justified. Actually, no more components are required; but one active component (the transistor) is added. The filter/regulator functions as follows. The transistor (Q6) is forward biased to a specific level via R25 in the static condition. Under these static conditions (which actually occur only when the receiver is on without any incoming signal), capacitor C-24 charges to supply level. However, in the presence of a fluctuating supply voltage (which is almost all the time), the capacitor tends to charge and discharge through the transistor to maintain equilibrium voltage. In so doing, the transistor adds gain such that the apparent value of the capacitor is many times the actual value. The performance observed under test is that the regulator maintains receiver voltage within 10-15 millivolts of the desired level with pulsed fluctuations of up to 150 millivolts in the supply line.

A "keep alive" (R26) maintains operation at low signal levels.

II. DECODER SECTION DESIGN

The decoder section is functional one thru eight channels, and is based on the use of CMOS (Complementary Metal Oxide-Silicon) integrated circuits offering the utmost in stability, noise rejection, and low current drain.

The decoder is also designed to perform the squaring and pulse stretching functions needed to provide clock and synchronization pulses via an IC thus relieving the receiver of this function and, in turn, permitting the receiver to be as simple as practical with a very low parts count but excellent selectivity and sensitivity.

The decoder is shown functionally in the block diagram, Figure 1 and in the schematic, Figure 2. The description which follows is keyed to these two figures. The hexagon inverter 74C04 consists of six transistors contained in the chip. Digital information operates between two levels; i.e., it is binary. These voltage levels are usually slightly above zero volts and slightly below 4.8 volts for the decoder. An inverter will show the opposite output from the input.

Let us examine the function of inverter No. 1 in the diagrams, as an example. The receiver output is a train of from two (for one channel) to nine (for eight channels) pulses per frame with an upper level of near 4.8V. Each pulse drops to near zero volts. The inverters in the 74C04 will switch at these levels, thus the first stage shown inverts and slightly amplifies the pulse train.

The pulse train now proceeds to two separate stages; the one at the top (Inverters 4 and 5) of both the block diagram and schematic generate the "set" pulse and the lower one (Inverters 2 and 3) simply shapes and squares the pulse train to form clock or "shift" pulses.

The shift pulse shaper accepts the pulse train, squares, and stretches it slightly by feeding back via C27.

The output from Inverter No. 2 is negative but is reinverted by No. 6 to remain positive at the output. The shaped clock pulses then are passed to the eight bit shift register, the 74C164.

Upon receipt of the first, or "synchronization" pulse, the diode D3 and C26 act as a "sample and hold" or pulse stretcher. C26 discharges through Inverter No. 4 and places it in an inverted, positive-going state. At this point, the pulse is stretched across the entire pulse train. The output from Inverter No. 4 is still slightly rounded and is of the wrong level, i.e., positive going for "set" so further stretching is provided by C28. The output from Inverter No. 5 is quite square and is negative-going during the period when the pulse train is present. The shift register is "set" by having the output of Inverter No. 5 be one at the instant the first clock pulse is received. The "set" is immediately driven to ground at the first clock pulse and remains so until after the last pulse is received. In doing so, the first stage of the register, which is a flip-flop, is inhibited from shifting back to Q until the next frame of information is received.

The eight bit shift register consists of eight R-S (as opposed to J-K) flip-flops. Requirements for the decoding function are as follows:

a) No flip flop will respond to a clock pulse, i.e., Q becomes a one (positive) unless S is a one at the time the clock pulse is received (CP).

b) If the "clear" line is a zero (negative), none of the registers will shift and any that is a one will be "cleared", i.e., becomes zero.

c) Making SA or SB a one (positive) permits the first flip flop to clock (i.e., Q1 becomes a one) upon receipt of the first clock pulse.

The simplest flip-flop works as follows: It shifts its binary one (high voltage out) back and forth between Q and $\overline{Q}$ each time a clock pulse is received. Whenever Q is positive (one), $\overline{Q}$ is negative (zero) and vice versa. By adding a bit more sophistication, additional control may be added to inhibit the shift or to arbitrarily "clear" the flip-flop by setting it on $\overline{Q}$. The two functions we use for control are entered at the "set" input of FF-1 (the S input) and at the clock inputs.

When there is no information present, during the synchronization pause or "set" period, Q for FF-1 through FF-8 is zero. As soon as the first clock pulse is received, FF-1 shifts to Q, i.e., Q becomes positive and, as stated earlier, $\overline{Q}$ becomes negative. FF-1 can not shift to Q unless it "sees" a one, or positive level, at SA/SB (pins 1 and 2) which it does at the instant the first clock pulse is received. Q for FF-1 remains positive until the second clock pulse is received at which time it reverts to zero.

If S for FF-1 were to remain at the one level at all times, FF-1 would simply shift back and forth between Q and $\overline{Q}$ every time a clock pulse was received and there would be no decoding. Thus, the "set" pulse was driven to zero an instant after the first pulse was received as mentioned earlier. Now, FF-1 can not shift again as long as the output from Inverter No. 5 is negative, i.e., not until after all pulses have been received and the output of Inverter No. 5 returns to the one level. This, of course, is why the pause between frames is called the synchronization or "set" pause since FF-1 is "set" to accept the first pulse during this pause.

Go back and reread the preceding two paragraphs and remember that FF-2 can not shift to Q unless its S sees a one. It sees a one only when Q for FF-1 is a one, i.e., during the first control pulse. So, as soon as Q for FF-1 is a one, FF-2 is set and is free to shift to Q when the second pulse, which also returns FF-1 to $\overline{Q}$, is received. FF-1 shifts to Q until the third pulse is received to return it to $\overline{Q}$, and so on for the number of channels chosen up to eight. As soon as C26 and C28 have discharged after the last pulse, the output of Inverter No. 5 returns to a one and FF-1 is reset to be ready for the next frame.

The lengths of the control pulses are determined by the length of time (1.5 milliseconds $\pm$ 0.5 milliseconds for control motion) between the clock pulses. The synchronization pause is nominally 4 milliseconds, thus the entire frame is 4 plus 1.5 ms per channel. This makes the frame rate about 65 per second for an eight channel set.

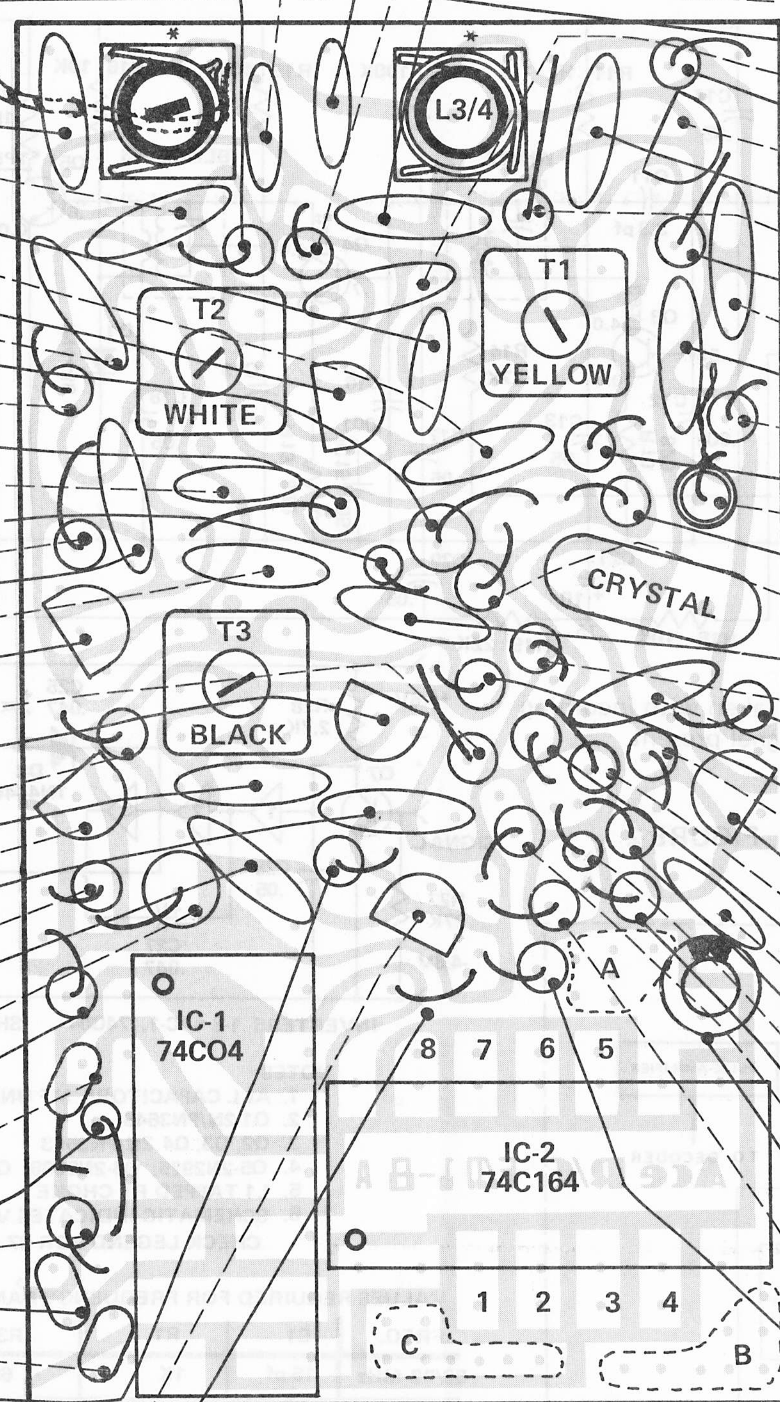
The decoder has been tested with just about every servo available that requires a positive control pulse, and has been found compatible with all of them. Negative going servos operating from $\overline{Q}$ such as the Controlaire S-4a and S4d and the EK MM3 can be used by making the modification indicated to access $\overline{Q}$. Reread the text on the decoding function of the dual R-S flip-flop and it will be noted that, once FF-2 has completed its cycle with the receipt of pulses two and three, neither flip-flop can be shifted again until a synchronization pause. This has the beauty that the decoder can be used with any transmitter whether it is one channel or eight. The decoder simply decodes the first functions from one or eight that arrive. It is held off for extraneous pulses. In general, then, the decoder could be used for any glider, car, boat, or plane as a second multi channel system operating from an existing transmitter.

The Digital Commander system will not work with Bonner Digimite, Jerobee, or Kraft KP2B (early two channel). Digital Commander servos will not work with Hobby Lobby 5 (amps are in decoder). A pulse inverter is available for using the Digital Commander servos with negative pulse systems.

1. ( ) C6 1.5 pf disc
2. ( ) R11 1K **(BrBkRd)**
3. *( ) ANTENNA 36 in. (a)*
4. ( ) C5 15 pf disc
5. ( ) C13 .05 mf disc
6. ( ) C12 .001 mf disc
7. ( ) C10 .05 mf disc
8. *( ) Q3 2N/PN3563 (e)*
9. ( ) C14 .05 mf disc
10. *( ) C21 10 mf; + UP (b)*
11. ( ) R12 100K **(BrBkYe)**
12. ( ) R14 4.7K **(YeViRd)**
13. ( ) C16 .001 mf disc
14. *( ) D1 1N4446; BAND DOWN (C)*
15. ( ) R13 820 ohm **(GyRdBr)**
16. ( ) C15 .05 mf disc

16A. ( ) C17 .05 mf disc

17. *( ) Q4 2N/PN3563 (e)*
18. ( ) R17 1K **(BrBkRd)**
19. *( ) Q5 2N2925 (e)*
20. ( ) R15 100 ohm **(BrBkBr)**
21. ( ) C19 .05 mf disc
22. *( ) Q6 2N5088 (e)*
23. ( ) C20 .05 mf disc
24. ( ) R25 10K **(BrBkOr)**
25. ( ) C25 .05 mf disc
26. *( ) C24 10 mf; + UP (b)*
27. ( ) R24 100 ohm **(BrBkBr)**
28. ( ) C27 .047 mf (473) Bluecap
29. *( ) D3 1N4446; BAND DOWN (c)*
30. ( ) R29 100K **(BrBkYe)**
31. ( ) C26 .047 mf (473) Bluecap
32. ( ) C28 .047 mf (473) Bluecap
33. ( ) R27 27K **(RdViOr)**
34. *( ) Q7 2N4124 or 2N4400 (e)*
35. *( ) RESISTOR LEAD JUMPER*



DO NOT INSTALL IC'S UNTIL INSTRUCTED TO DO SO

36. ( ) C7 22 pf
37. ( ) R10 820 ohm **(GyRdBr)**
38. ( ) C9 .05 mf disc
39. ( ) C11 3.1 or 3.3 pf disc
40. ( ) R6 330K **(OrOrYe)**
41. *( ) Q2 2N/PN3563 (e)*
42. ( ) C8 .05 mf disc
43. ( ) R8 1K **(BrBkRd)**
44. ( ) R7 1K **(BrBkRd)**
45. ( ) C4 .05 mf disc
46. ( ) C3 .05 mf disc
47. ( ) R4 1K **(BrBkRd)**
48. ( ) R9 15K **(BrGrOr)**
49. *( ) L1; TAP END UP (g)*
50. ( ) R18 10K **(BrBkOr)**
51. ( ) R19 22K **(RdRdOr)**
52. ( ) C18 .05 mf disc
53. ( ) R20 1K **(BrBkRd)**
54. *( ) R3 68K * (d)* **(BlGyOr)**
55. *( ) C1 15 pf disc * (d)*
56. *( ) R16 10K* **(BrBkOr)**
57. *( ) R1 1K * (d)* **(BrBkRd)**
58. *( ) Q1 2N/PN3646 (e)*
59. ( ) R26 330K **(OrOrYe)**
60. *( ) C22 1 mf; + DOWN (b)*
61. ( ) C2 .001 mf disc
62. ( ) R21 33K **(OrOrOr)**
63. *( ) D2 1N4446; BAND DOWN (c)*
64. ( ) R22 33K **(OrOrOr)**
65. ( ) R23 270K **(RdViYe)**
66. *( ) C29 47 mf;* **Dark Band (–) Toward Top**
67. *( ) C23 1 mf; + UP (b)*
68. ( ) R28 2.7K **(RdViRd)**

The steps in italics have special instructions.

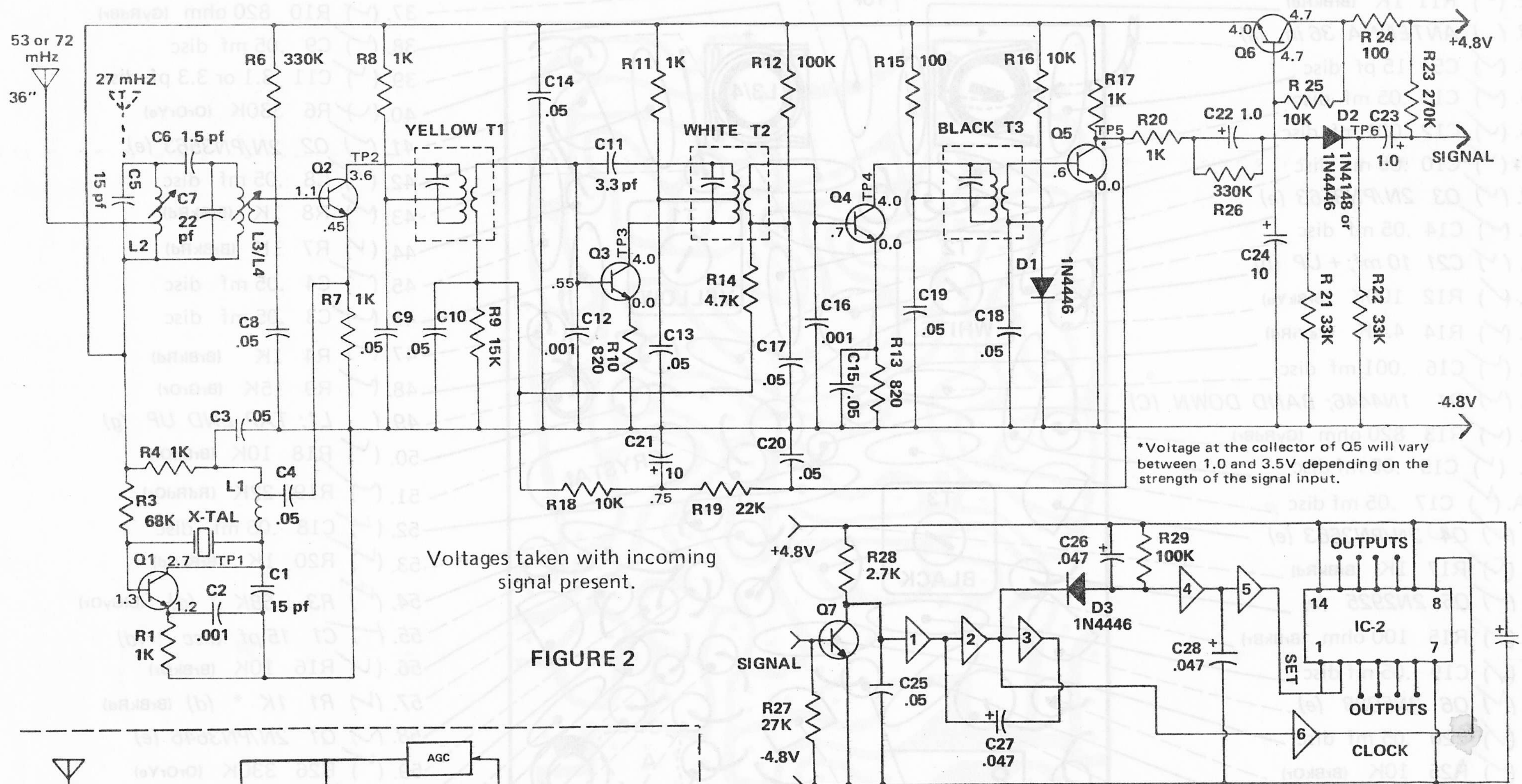


FIGURE 2

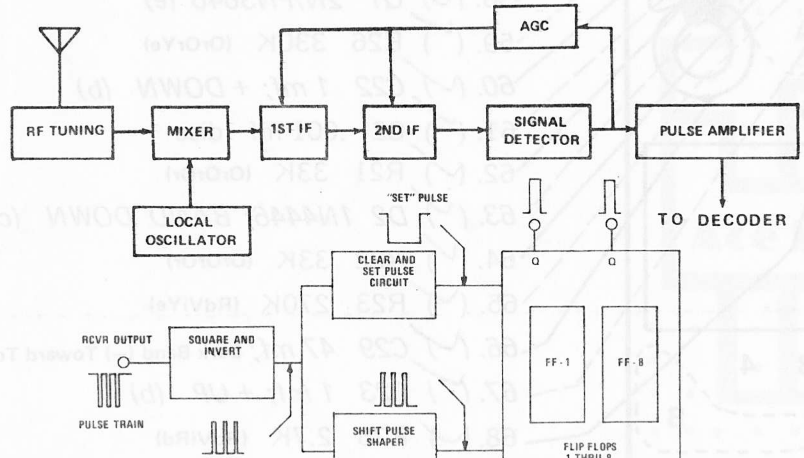


FIGURE 1

NOTES:
1. ALL CAPACITORS MF UNLESS OTHERWISE NOTED
2. Q1 2N/PN3646
3. Q2, Q3, Q4 2N/PN3563
4. Q5-2N2925; Q6-2N5088; Q7-2N4124 or 2N4400
5. L1 TAPPED RF CHOKE
6. SCHEMATIC INDICATES VALUES FOR 72 MHZ. CHECK LEGEND FOR 27 AND 53 MHZ CHANGES.

VALUES REQUIRED FOR FREQUENCY BANDS:

FREQ.	C1	R1	R3
53/72 MHz	15 pf	1K	68K
27 MHz	47 pf	470 OHM	47K

Coils L2 and L3/4 are wound differently for each frequency band. These coils, plus the crystal, plus the components indicated to the left must be changed if the frequency band is changed.

1-8 RECEIVER PARTS LIST

( ) 1 Printed Circuit Board
( ) 1 Receiver Crystal
( ) 1 L2 Tuning Coil
( ) 1 L3/L4 Tuning Coil
( ) 1 L1 Tapped RF Choke
( ) 2 10 uhy Chokes

( ) 1 Yellow IF Transformer
( ) 1 White IF Transformer
( ) 1 Black IF Transformer

SEMICONDUCTORS

( ) 3 1N4148 or 1N4446 Diodes
( ) 3 2N/PN3563
( ) 1 2N/PN3646
( ) 1 2N2925 or 2N2926 Green
( ) 1 2N4124 or 2N4400
( ) 1 2N5088
( ) 1 74C04 IC
( ) 1 74C164 IC

RESISTORS

ALL RESISTORS ARE 1/4W, 10%
( ) 2 100 ohm (brown, black, brown)
( ) 1 470 ohm (yellow, violet, brown)
( ) 2 820 ohm (grey, red, brown)
( ) 7 1K (brown, black, red)
( ) 1 2.7K (red, violet, red)
( ) 1 4.7K (yellow, violet, red)
( ) 3 10K (brown, black, orange)
( ) 1 15K (brown, green, orange)
( ) 1 22K (red, red, orange)
( ) 1 27K (red, violet, orange)
( ) 2 33K (orange, orange, orange)
( ) 1 47K (yellow, violet, orange)
( ) 1 68K (blue, grey, orange)
( ) 2 100K (brown, black, yellow)
( ) 1 270K (red, violet, yellow)
( ) 2 330K (orange, orange, yellow)

CAPACITORS

( ) 1 1.5 pf disc
( ) 1 3.1 or 3.3 pf disc
( ) 2 15 pf disc
( ) 1 22 pf disc
( ) 1 47 pf disc
( ) 3 .001 mf disc
( ) 13 .05 mf disc
( ) 3 .047 mf Bluecap (473)
( ) 2 1 mf Tantalum
( ) 2 10 mf Tantalum
( ) 1 47 mf Electrolytic

( ) Wire: 36" antenna wire
30" red
30" black
6" blue
6" orange
6" yellow
6" green
( ) 48" Micro Solder
( ) 1 Receiver Case
( ) 1 No. 1 Grommet
( ) 1 FCC Sticker
( ) 1 Switch and plug pkg. (Flite paks and systems only)

III. RECEIVER ASSEMBLY

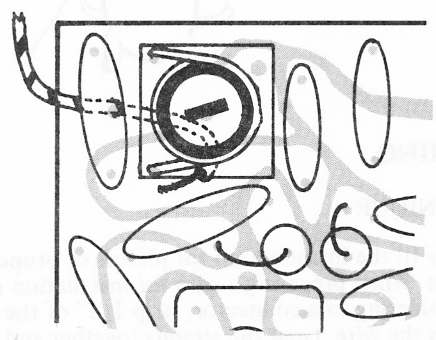
A. PC BOARD CONSTRUCTION

( ) Re-read the introduction concerning general info and soldering techniques.
( ) Using fine steel wool, clean the foil side of the board until it is shiny.
( ) If tuning slugs are present in the two tuning coils (L2 and L3/4), remove them with a small screwdriver and set them in a safe place until later. Note that L2 has a single coil of wire and may or may not have a tap exiting out a third hole in the coil form, depending on the frequency band. L3/4 has two overlapping coils.
( ) Using an Exacto knife, scrape the ends of the wire for L2 and L3/4 that will protrude through the PC board absolutely free of enamel.
( ) Install L2 and L3/4 in the locations indicated on the parts overlay page with the red dot on the coil form toward the top of the board, indicated by asterisks (*). Glue the coil forms to the board by sparingly using 5 Minute Epoxy or "Hot Stuff". Solder to the PC board making sure of a good joint.
( ) Solder in the IF cans next, following the color code (yellow, white, and black). Make sure the leads and lugs line up with the holes before inserting, and that the IF can is flat on the board when soldering. DO NOT install the crystal or IC's yet.
( ) Install the remainder of the components (except crystal and IC's) in the order indicated by the parts overlay. Keep all components except transistors flat on the board and mount the components away from the edge of the board as far as possible to assure case clearance upon completion.

For the steps in italics, refer to the following special instructions. The letter in parenthesis indicates which instruction to refer to.

a. The antenna is soldered to the land indicated and then threaded through the hole in the PC board for strain relief. The solder connection as indicated on the parts overlay page is for the 53 and 72 MHz version only. If you're building a 27 MHz receiver, solder the antenna as indicated in Figure 3.

If you think the antenna will get in your way as you proceed with construction, you may want to leave it off until the rest of the parts are installed.



WIRE ANTENNA AS SHOWN FOR 27 MHZ.

FIGURE 3

b. The tantalum capacitors must be installed with the proper polarity. The plus end is either colored red or "shouldered". The proper position of the plus ends is identified as "up" or "down".
c. The banded end on the diodes identifies the cathode. Be sure to install them as indicated.
d. If you are building a receiver on 27 MHz, the values of the components indicated by an asterisk (*) are different than shown. See the legend on the schematic page to obtain the proper value. Since you have been supplied the values for all frequency bands there will be a few parts left over.
e. Make sure the transistors are installed with the flat part as shown on the overlay.
f. Use a scrap resistor lead for a jumper in step 35.
g. Notice that the tap coming off of the tapped choke is nearer to one end. Install this end up. Thread the tap over to the hole indicated and solder.

( ) Install the crystal where indicated. It must match the frequency of the transmitter you're going to use. It may have the transmitted frequency (e.g. 26.995) and/or the actual crystal frequency which is 455 KHz above or below the transmitted frequency (e.g. 26.540 or 27.450). Check Figure 4 for the 72 MHz doubler crystal designation.

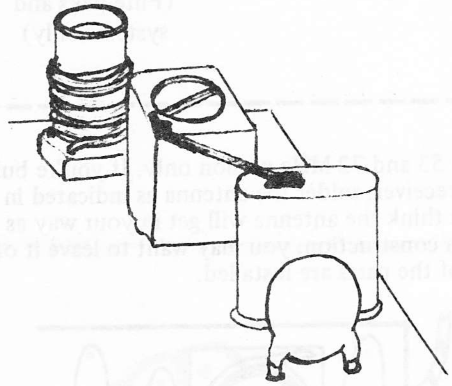
72 MHZ DOUBLER CRYSTAL DESIGNATIONS

72.08	(brown/white)	– .455	=	71.625/2	=	35.8125
72.16	(light blue/white)	– .455	=	71.705/2	=	35.8525
72.24	(red/white)	– .455	=	71.785/2	=	35.8925
72.32	(violet/white)	– .455	=	71.865/2	=	35.9325
72.40	(orange/white)	– .455	=	71.945/2	=	35.9725
72.96	(yellow/white)	– .455	=	72.505/2	=	36.2525
75.64	(green/white)	– .455	=	75.185/2	=	37.5925

FIGURE 4

( ) Ground the crystal case by soldering a scrap resistor lead between the middle of the top of the crystal case to the top of the yellow IF can. Make sure you don't solder to the corner of the crystal case that already has solder on it; if you do so, you may unsolder the internal connection.

DO NOT install the IC's yet.



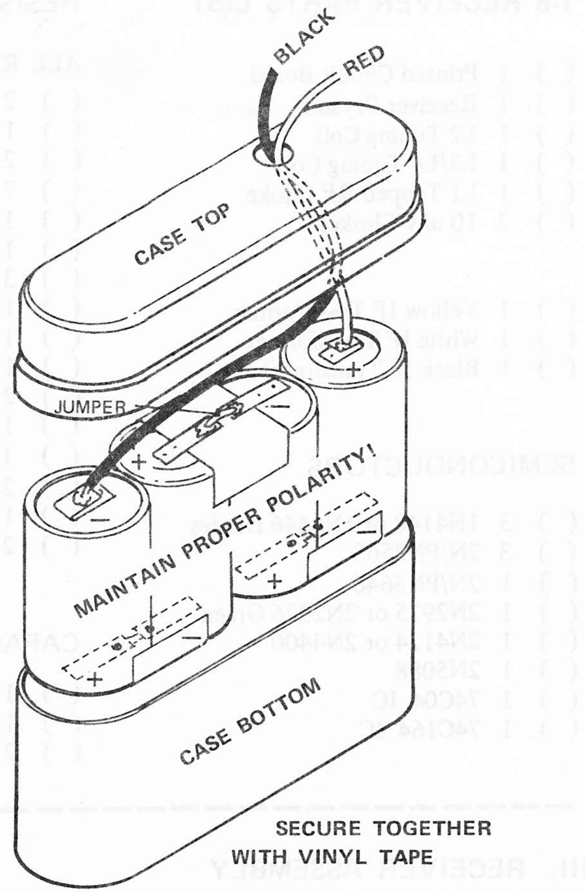
IV. WIRING

A. TECHNIQUE

Refer to the introduction for photos of proper wire preparation. When preparing a wire for installation in a PC board or soldering to a connector, strip 1/8" of the insulation from the wire, twist the strands together and apply a small amount of solder to the wire. This is called "tinning". Be sure not to cut any of the wires when you strip off the insulation.

The introduction shows an illustration on proper hook-up to Deans connectors. Before soldering up to the connector always slip the wire through the appropriate sleeving, heat shrink, and grommet to avoid unsoldering later. Don't use too much heat or you'll melt the plastic. It's a good idea to mate the plugs together when soldering; this will help dissipate heat, make sure you're soldering to the correct end of the pins, and help prevent wiring errors. If both the wire and connector pin are "tinned" before soldering, the joint forms quickly and little heat is needed. A clothespin is a handy holding fixture for the connectors.

NOTE: When twisting the wires together, make them so they exit out the end of the receiver board (see introductory photo). Leave some slack in the red wires that go to land "A" and if applicable, the wires going to holes 5, 6, 7, and 8 so that IC-2 can slip under the wires when it is installed. Another option is to not twist the wires into cables until after the IC's are installed.



AIRBORNE BATTERY PACK WIRING

FIGURE 5

B. FLITE PACK BATTERIES (Complete Systems Only--not supplied in flite pak or receiver only kits).

( ) Following the illustration, wire the batteries together using scrap resistor leads as jumper wires--be sure to maintain proper polarity. The shouldered end of the cell is positive and the flat end is negative.

Use a piece of tape between the solder lugs and the cells when soldering together. This helps hold the cells together and helps insulate. Don't apply too much heat so you keep from melting through the tape and plastic insulator.

( ) For strain relief, tie a knot in the red/black leads before they exit the hole in the case top; or put a gob of silastic or epoxy on the leads where they exit thru the hole; or tape the leads down to the case after assembly.

( ) Secure the case together using vinyl tape and twist the leads together.

IMPORTANT: Give the Battery Pack a 24 hr. Charge Before Using

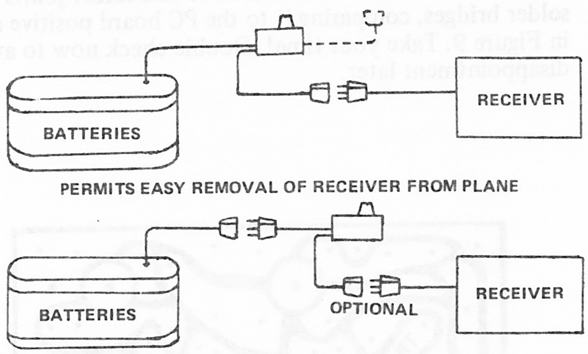
C. SWITCH HARNESS (Complete Systems and Flite Paks Only).

Lead length and plug placement is left up to the builder's discretion, depending on your application and personal preference. Refer to the illustration and determine how you want to wire in your switch.

Don't have the leads too long between the batteries and the receiver or you'll have a mess of extra wire when you install the equipment but don't make the leads so short that there is strain on the connections upon installation. Generally, 6" between the battery and the switch/connector and 6" between the receiver and the switch/connector is adequate.

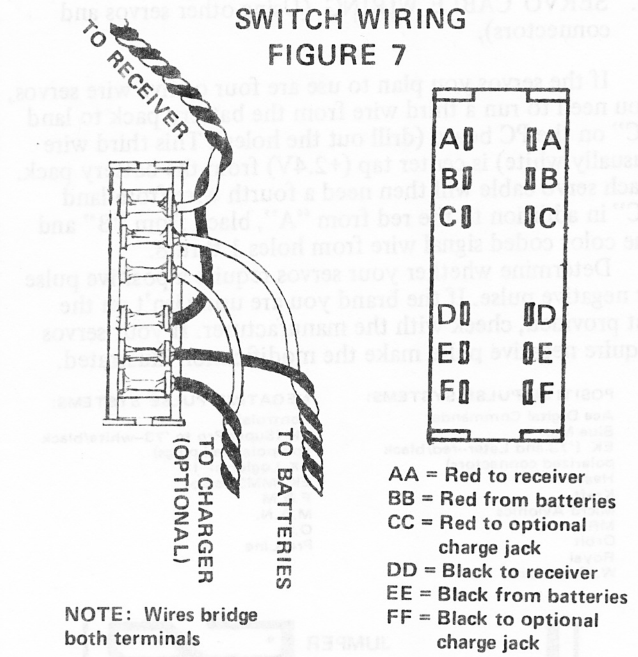
( ) Wire the switch as illustrated--make sure all joints are secure and there is no strain on the connections. Insure that positive from the battery is making connection with positive to the receiver and the same for negative.

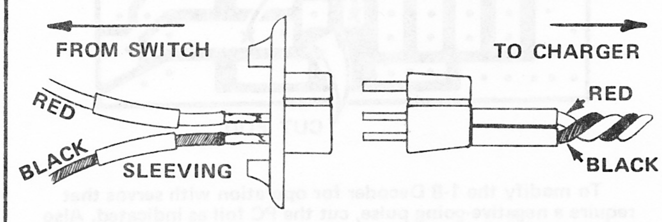
( ) An optional charging plug may be installed on the unused end of the DPDT switch or the batteries may be charged thru the existing connector. Note that in the first plug location option, if you charge thru the existing connector, the switch must be on for the batteries to receive a charge. Maintain proper polarity when hooking the charger up.



PLUG LOCATION OPTIONS
FIGURE 6

SWITCH WIRING
FIGURE 7





OPTIONAL CHARGE CONNECTOR WIRING
(Ace Cat No. 19K55)

D. RECEIVER POWER WIRING

( ) Install a 6" long red wire into any hole in land "A". Put a 6" black wire in any hole in land "B". Twist them together so they exit out the end of the PC board--leave some slack in the red so it can go over IC-2.

( ) Slip the No. 1 grommet over the pair of wires and solder them to either the switch or connector, depending on the switch harness configuration you are using. Make sure that the red wire hooks up to +4.8V and the black wire hooks up to OV (ground) of the battery pack.

E. SERVO CABLE WIRING (Systems and Flite Paks using Ace servos and Deans connectors).

( ) Begin with the aileron servo cable. Prepare 6" of red, black, and orange; solder the red into a hole in land "A", black in a hole in "B", and the orange into the hole marked "2" (the signal output for the second channel.) Twist these three wires together and thread them thru the No. 2 grommet with the power cable. Trim the end of the cable even and solder to a 3 pin female Deans plug as illustrated.

( ) The block connector is next. Prepare a cable with 6" of red from land "A", 6" of black from land "B", 6" of blue from hole "1", 6" of yellow from hole "3", and 6" of green from hole "4". Twist these together, run them thru the grommet, and solder to the block connector as shown.

( ) If additional functions are desired (5th, 6th, 7th, and 8th channels), wire them as the aileron servo cable with the signal wires in hole 5, 6, 7, and 8 using additional 3 pin female Deans connectors (not furnished.)

Any or all of the outputs can be used. An unoccupied output won't hurt a thing.

PLUG WIRING

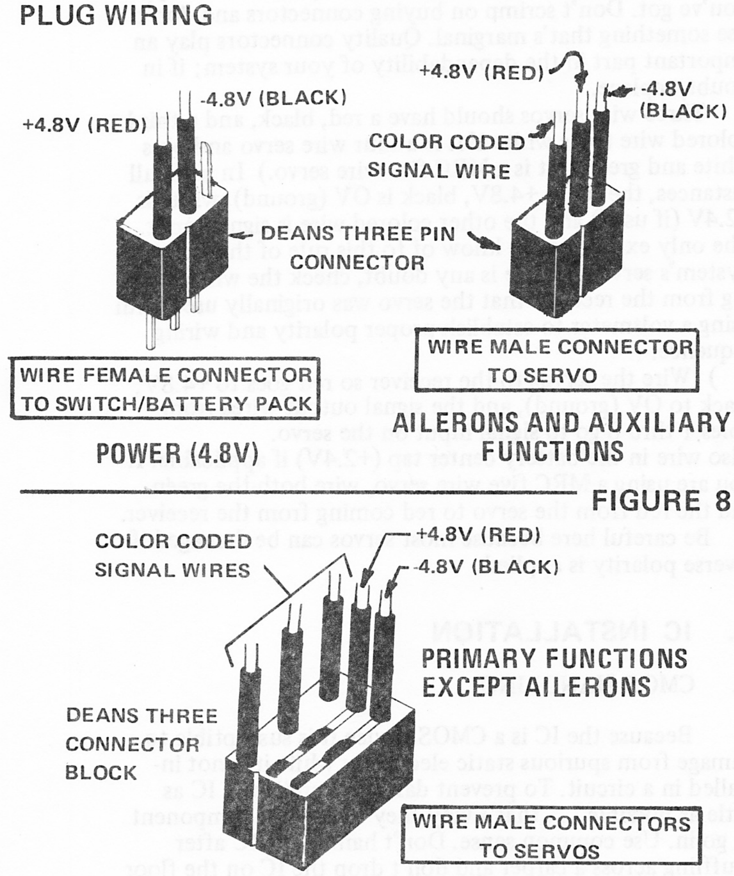


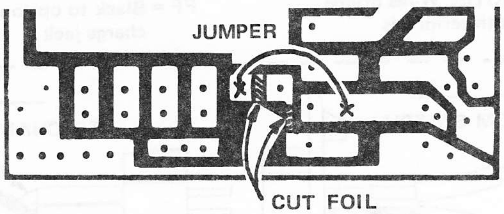
FIGURE 8

F. SERVO CABLE WIRING (Using other servos and connectors).

If the servos you plan to use are four or five wire servos, you need to run a third wire from the battery pack to land "C" on the PC board (drill out the holes). This third wire (usually white) is center tap (+2.4V) from the battery pack. Each servo cable will then need a fourth wire from land "C" in addition to the red from "A", black from "B" and the color coded signal wire from holes 1 thru 8.

Determine whether your servos require a positive pulse or negative pulse. If the brand you are using isn't on the list provided, check with the manufacturer. If your servos require negative pulse make the modification illustrated.

POSITIVE PULSE SYSTEMS:	NEGATIVE PULSE SYSTEMS:
Ace Digital Commander	Controlaire
Blue Max	EK (Super Pro to '73--white/black non-polarized plugs)
EK ('73 and Later--red/black polarized connectors)	EK Logictrol II
Heath	EK MM3 servos
Kraft	F & M
Micro Avionics	M.A.N.
MRC	O.S.
Orbit	Pro-Line
Royal	
W. E. Midget	



To modify the 1-8 Decoder for operation with servos that require a negative-going pulse, cut the PC foil as indicated. Also install a jumper wire between the two lands as shown. The decoder will now emit a negative pulse to all channels.

Wiring to the connectors you use depends on the type you've got. Don't scrimp on buying connectors and don't use something that's marginal. Quality connectors play an important part in the dependability of your system; if in doubt, replace.

Three wire servos should have a red, black, and a third colored wire (plus white if it is a four wire servo and plus white and green if it is a MRC five wire servo.) In most all instances, the red is +4.8V, black is OV (ground), white is +2.4V (if used) and the other colored wire is signal input. The only exception we know of to this rule of thumb is RS System's servo. If there is any doubt, check the wires coming from the receiver that the servo was originally used with using a voltmeter to establish proper polarity and wiring sequence.

( ) Wire the servos to the receiver so red goes to +4.8V, black to OV (ground), and the signal output wires from holes 1 thru 8 go to signal input on the servo.
Also wire in the battery center tap (+2.4V) if applicable. If you are using a MRC five wire servo, wire both the green and the red from the servo to red coming from the receiver.

Be careful here because most servos can be damaged if reverse polarity is applied.

V. IC INSTALLATION

A. CMOS HANDLING

Because the IC is a CMOS device it is susceptible to damage from spurious static electricity while it is not installed in a circuit. To prevent damage, handle the IC as little as possible .... that's why they're the last component to go in. Use common sense. Don't handle the IC after shuffling across a carpet and don't drop the IC on the floor or on your lap. Just keep it on the workbench and leave it in the foil package until ready.

( ) Take IC-1, 74C04 out of the foil. The leads of the IC are spread somewhat. Press the entire row on one side against a flat surface to bend them in simultaneously. Install and solder in the PC board with the dot indicating pin 1 in the location indicated in the overlay. Repeat for IC-2, 74C164 making sure the dot is where indicated. Let the red wires go over the top of IC-2.

B. INSPECTION

( ) Double check the overlay for proper parts placement. Make sure all leads are clipped short. Scrub the bottom of the board with alcohol or dope thinner and an old toothbrush to remove the solder rosin. Use a magnifying glass to inspect the bottom of the board for bad solder joints and solder bridges, comparing it to the PC board positive shown in Figure 9. Take your time! Double check now to avoid disappointment later.

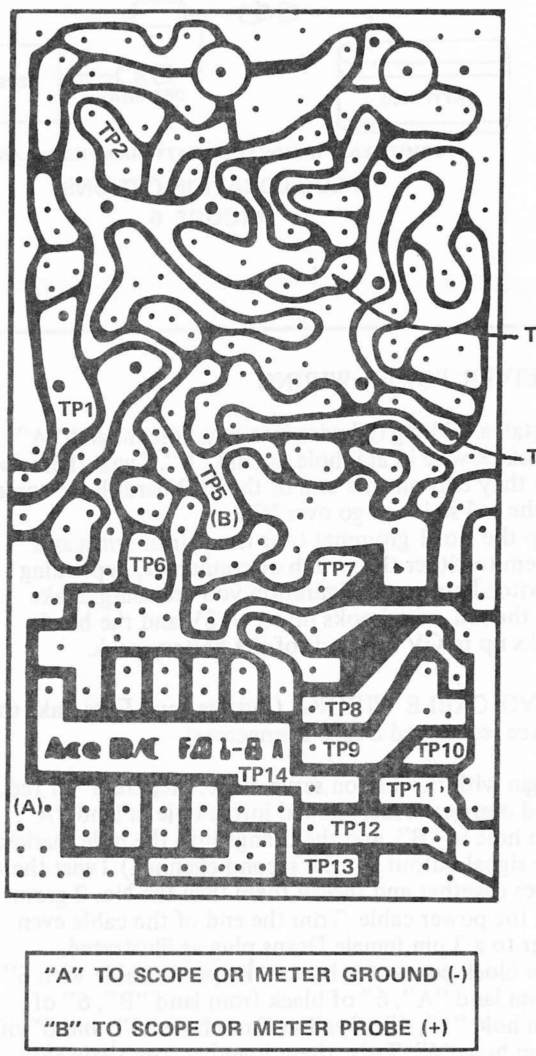


FIGURE 9

VI. TUNING

( ) The Digital Commander receiver is very easy to tune and all that is required is either an oscilloscope or a voltmeter. If you have both, they can both be hooked up at the same time to insure exact tuning.

( ) Start by installing the two RF chokes as shown in Fig. 10. Connect the ground lead of your meter and/or scope to the choke going to the receiver ground and the positive lead of your meter and/or scope to the choke connected to the collector of Q5 (test point 5).

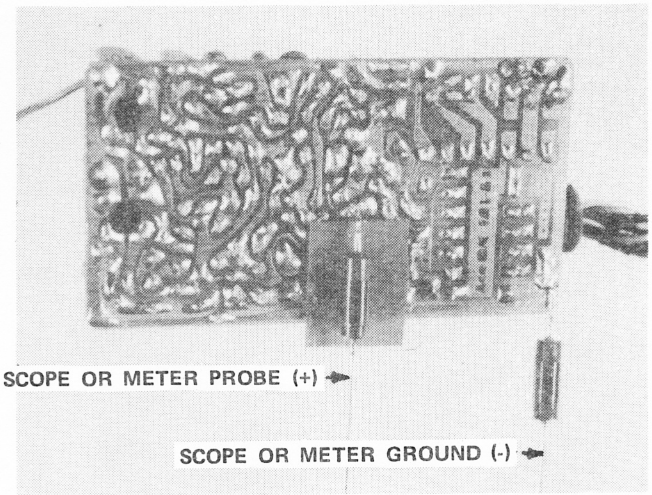


FIGURE 10

( ) Set your voltmeter on the 0-5 volt DC range or a range similar. Set the scope on 0.5V/div. vertical and 1 ms/div. horizontal or a range similar.

( ) The receiver should be positioned on a wooden bench or table and the test leads should not be laying over the receiver. Do not place receiver on a metal bench or on a work bench with a lot of electrical wiring which could act as an antenna.

( ) The two front end coil slugs fit very snug and to avoid breaking the slugs, drip a drop of molten candle wax on the inside of each coil form for lubrication; this will allow the slug to screw up and down easily.

If one of the slugs should break, it must be replaced with a replacement slug from Ace only. The white color coded slugs are for the 72-75 MHz receivers and the plain slugs are for the 27 MHz and 53 MHz receivers.

( ) Let the receiver antenna wire dangle over the work bench edge. Keep your body away from the receiver antenna while tuning. The tuning should be done using a non-metallic tuning wand. Use a small piece of wood to hold the receiver while tuning; don't hold on to it with your hand.

( ) With the transmitter sitting next to the receiver and the antenna extended about 12", turn on the transmitter and receiver. Note, the waveform should be like No. 5 in the troubleshooting section; this is the waveform we will be working with.

( ) Run the coil slugs in coils L2 and L3/4 to the top of the form, adjust the yellow IF T1 for maximum amplitude on the scope and/or minimum voltage on the meter. (NOTE: THROUGHOUT THE TUNING PROCEDURE WE ARE TRYING TO ACHIEVE MAXIMUM AMPLITUDE ON THE SCOPE AND/OR MINIMUM VOLTAGE ON THE VOLTMETER.) Adjust T2 (White IF) and T3 (Black IF) for maximum amplitude and minimum voltage.

( ) If possible, remove the transmitter antenna, (only operate the transmitter for a minimum amount of time with the antenna removed) and adjust all three IF cans (white, black, and yellow) for maximum amplitude and/or minimum voltage. Adjust the antenna coil L2 for maximum amplitude/minimum voltage.

( ) Take the transmitter back about 10-15 ft. and adjust the IF cans for maximum amplitude/minimum voltage. Then rotate the slug in L2 counterclockwise until it is halfway between the top of the coil form and where you started. Then adjust L3/4 for maximum amplitude and/or minimum voltage. The tuning is close, now.

( ) Move the transmitter back until you are at near maximum range but still have good operation. Adjust the three IF cans and two antenna coils for maximum amplitude and/or minimum voltage.

( ) Install the transmitter antenna and extend it. Place the transmitter antenna next to the receiver antenna, the waveform or meter should remain solid.

( ) Turn the transmitter off and observe the scope and/or the meter. The scope should have a base line with just a few small noise spikes and the meter should rise to approximately 5 volts and be fairly stable.

( ) If there is excessive noise in the receiver (large spikes in the baseline or a jumpy meter), detune the yellow IF can (T1) up to 1/4 turn counterclockwise until the noise is reduced. Move the transmitter out to maximum range and repeat the white and black IF cans and both antenna coils.

( ) Remove the probes and chokes. To prevent detuning from vibration, drip some candle wax into the IF cans and tuning coils.

SERVO INTEGRATION

( ) Plug the servos in and check operation with the transmitter. If you wish to change the sequence of the servos, it's easiest to change them around at the PC board. Example; if you get elevator function on the aileron servo cable, unsolder and switch the blue and orange wires going to holes "1" and "2" on the PC board rather than change the cabling.

VII. INSTALLATION IN THE CASE

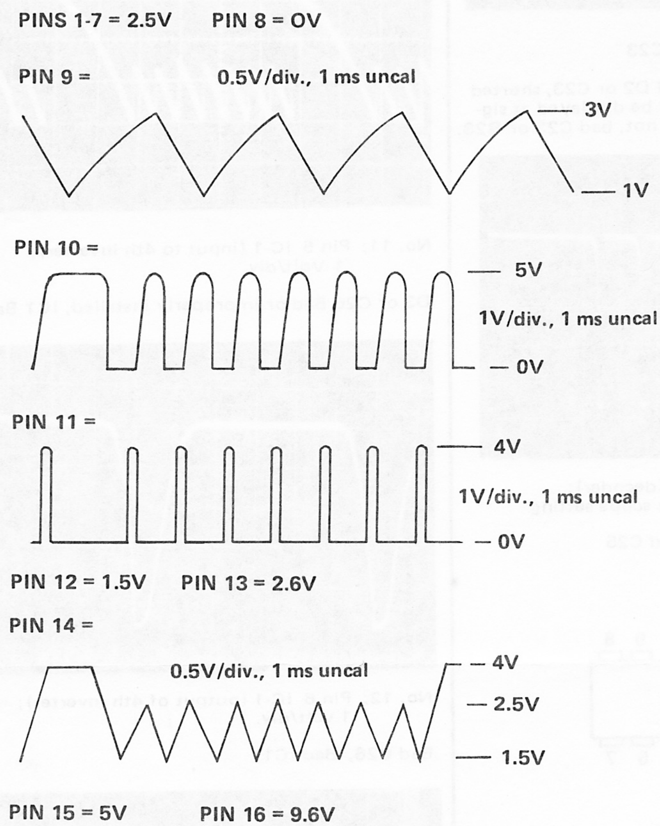
( ) Check the fit of the PC board in the bottom of the case. It may be necessary to file the corners of the board off slightly for good fit.

( ) Thread the antenna thru the small hole in the case top and slip the component side of the receiver into the top . . . it's a tight fit and some juggling around will probably be necessary for fit. Particularly C3 and C4, C13 and C14, plus Q1 might have to be slanted inward. Be careful not to break any of the components; melt the solder and reposition the components if necessary.

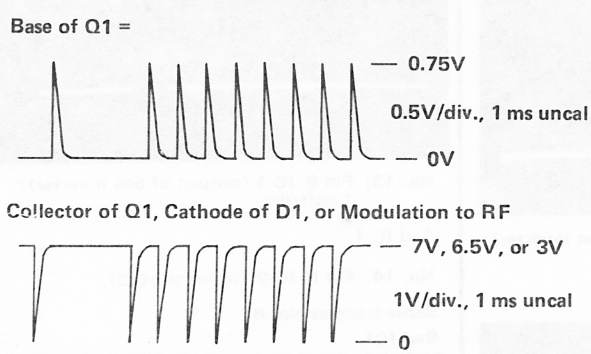
( ) Slip the grommet into the U shaped hole while sliding the top on. Secure the bottom on using vinyl or Scotch tape. Remove the backing and stick the label FCC compliance sticker on the top of the case.

This completes your Digital Commander 1-8 Receiver.

Signetics NE5044
ENCODER IC WAVEFORMS



MODULATOR WAVEFORMS



V. 1-8 RECEIVER/DECODER TROUBLESHOOTING

Recheck battery condition, component placement, component leads touching one another, solder joints and bridges, broken or misplaced wiring.

There are several common physical problems that should be checked out before you proceed. R19 can short to the crystal case which is ground. R8 can short to L4 and kill the signal. Caps C6 and C13 can short if not installed properly. C18 can short to black IF (Double Deck). It is easy to transpose R14 (4.7K-Yel, Vi, Red) and R23 (270K-Red, Vi, Yel). In the Single Deck version, C27 can short to D3 and R29/C26/C28 can short together.

Do all troubleshooting on a wooden work surface with no extraneous tools close by. For isolation, hook the scope leads through the 10 uhy chokes by temporarily soldering them to the appropriate lands. Scope ground goes to 0V. Scope test points for the receiver are indicated on the receiver schematic and on the PC board illustration (Figure 9). Voltage readings are also supplied on the schematic. They should be taken with a VOM or VTVM with at least 10,000 ohms/volt input impedance.

The voltage readings and waveforms given are typical and will vary with battery condition and tolerances in the circuit and test equipment. Voltages should be considered relative and may vary as much as 20% before being suspected. The number of pulses displayed will depend on the number of channels transmitted.

Proceed through the scope traces and voltage checks in the order presented. At any point there is a significant deviation. refer to the probable solutions offered.

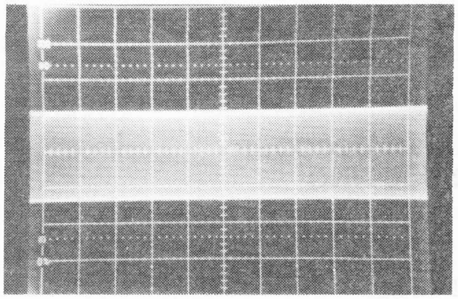
When you have found the problem area, resistance readings can be taken while the parts are in the board to check for an open IF can, open resistor, shorted components, etc. The resistances won't be exactly the actual value of a given part since it is in the circuit, but they will be close.

If the scope traces look good but range is poor, go through the tuning procedure again. Make sure the transmitter output is OK. Double check all batteries under load. You may have to improve sensitivity by increasing the value of R9 from 15K to 18K. One can go to a 22K if needed but make sure the receiver doesn't swamp at close range.

If range is good but in flight the receiver is "glitchy" it is probably caused by a defective mixer transistor, Q2.

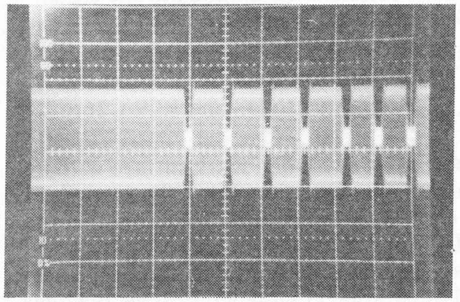
Vibration problems can come from several sources. Check the battery pack/switch harness for poor switch contact, bad wire or joint in the battery pack, intermittent cell in pack (tap each cell individually to detect it). Poor wiper contact in a servo can cause problems--clean and lube pot and raise the wiper contacts. In the receiver, the crystal or an IF can can be susceptible to vibration; wiring can have a poor joint; a cold solder joint can exist, causing an intermittent; a component can be physically broken; insulation on a resistor body can be chipped off and intermittently short the resistor out to an adjacent part.

All scope traces taken with a Techtronics 453A; voltages with a RCA Master Volt Ohmist; 72 mHz receiver; power source-nicads @ 5V; signal ON; transmitter antenna off. Scope is set at .5V/ division vertical and 1 ms horizontal unless specified.



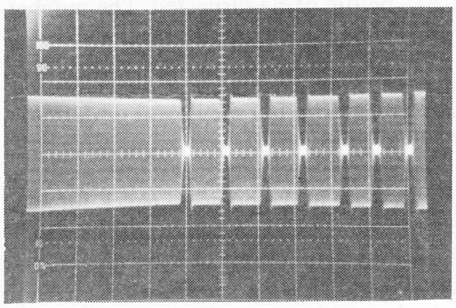
No. 1; TP1; Collector Q1

Bad crystal, bad or improperly installed Q1, open L1, C3 shorted, R1, R3, or R4 open.



No. 2; TP2; Collector Q2

Amplitude will vary depending on the output of the transmitter and its distance from the receiver. Bad or improperly installed Q2, L1 installed incorrectly with tap end down, open primary in T1, open C4, antenna wire soldered to the wrong land, open, improperly orientated, or poorly soldered L2 or L3/4, open R6, R7.

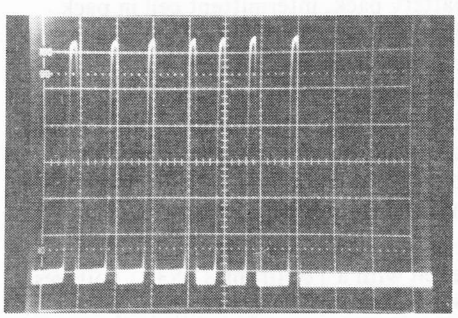


No. 3; TP3; Collector Q3

Q3, Q4 bad, open secondary in T1, open primary T2, R9, 10, 11 open. Can also be upset by shorts in AGC line: R18, 19, C20, 21, D1. AGC operation can be checked by observing voltage at positive side of C21--it should be .75V with signal present, 1.5V with no signal.

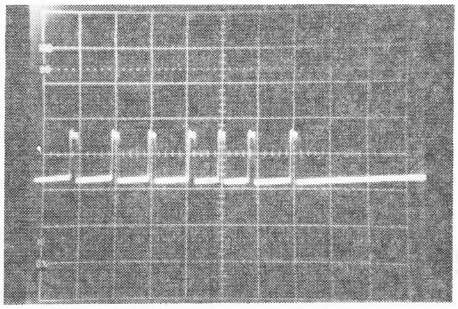
No. 4; TP4; Collector Q4

Same trace as No. 3 with greater amplitude. Q4 bad, open secondary in T2, primary in T3, R12, 13, 14, 15 open.



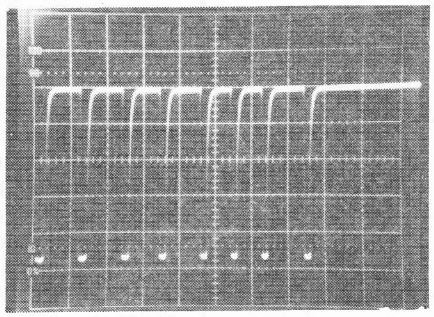
No. 5; TP5; Collector Q5 (Tuning test point)

Bad Q5, D1 bad, T3 secondary open, AGC components bad, R16, 17 bad. Same should be displayed at junction R20-C22; if not R20 is open. Same should also be displayed at junction R22--anode D2; if not, bad or improperly installed C22 or D2.



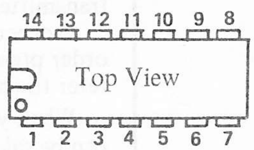
No. 6; TP6; Junction D2-C23

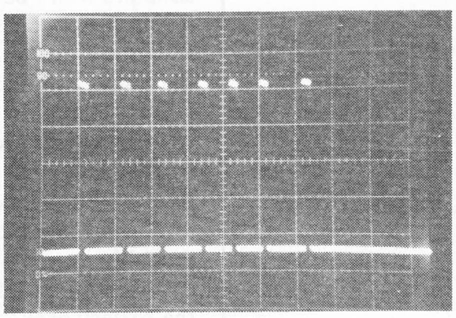
Bad or improperly installed D2 or C23, shorted Q7 (decoder). Same should be displayed at signal output (white wire); if not, bad C23 or R23.



No. 7; Collector Q7 (decoder);
1 volt/division scope setting

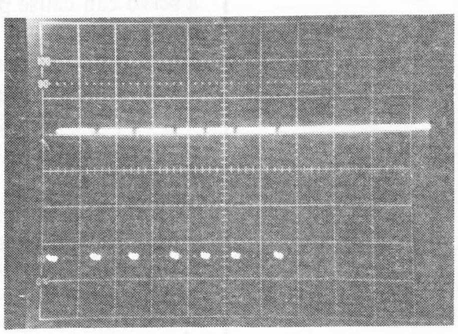
Bad Q7, Bad R28, Bad C25





No. 8; Pin 12, IC-1 (output from 1st inverter);
1 volt/div.

Bad IC1

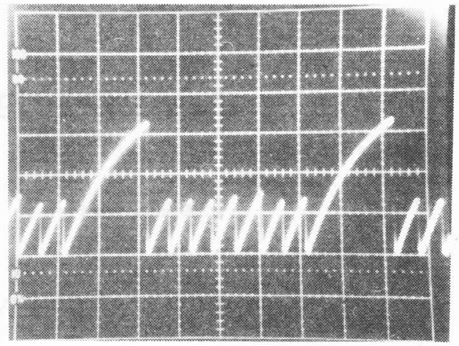


No. 9; Pins 2 and 3, IC-1 (output from 2nd inverter); 1 volt/dvi.

Bad IC1, C27 Shorted

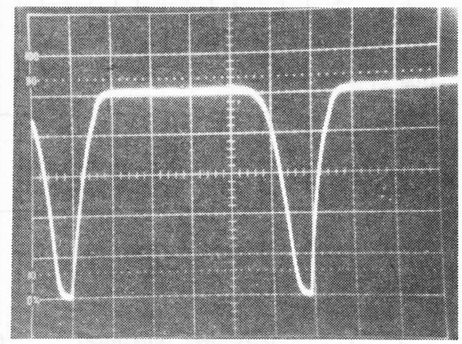
No. 10; Pin 4 IC-1 (output from 3rd inverter);
1 volt/div.

Same trace as No. 8
IC-1 bad



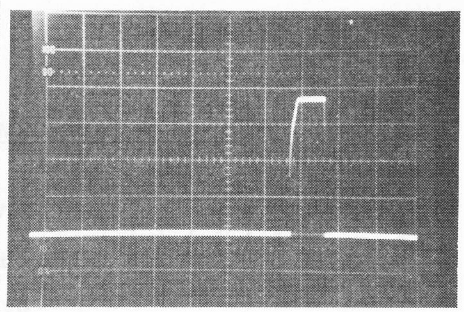
No. 11; Pin 5 IC-1 (input to 4th inverter);
1 Volt/div.

D3 or C26 Bad or improperly installed, IC1 Bad



No. 12; Pin 6 IC-1 (output of 4th inverter);
1 volt/div.

Bad C26, Bad IC1

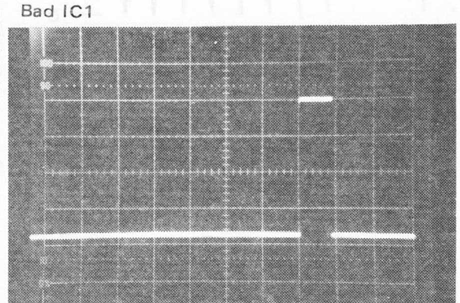


No. 13; Pin 8 IC-1 (output of 5th inverter);
1 volt/div.

Bad IC-1.

No. 14; Pin 8 IC-2 (input to IC-2).

Same trace as No. 8.
Bad IC1



No. 15; Pins 3, 4, 5, 6, 10, 11, 12, 13 IC-2
(outputs to servo)

Bad IC-2, may also be degraded by a bad servo.