INSTRUCTION MANUAL

CT - 90

Portable Frequency Counter

- Portable battery power
- 3 ranges
- Gate indicator
- 9 digit display
- 3 gate times

ramsey electronics inc.

Introduction: The CT-90 is a laboratory quality frequency counter that is capable of use in the lab as well as in the field. Utmost care has been taken in all the design stages to insure that sensitivity and reliabilty were not compromised. The CT-90 has been specifically built for the critical user, as demonstrated by; special timebase options, nine digit display, three gate times, and a count hold feature.

The CT-90 is ideal for portable usage. Leading zero blanking and the micropower oven (optional) allows 2-4 hours of continuous operation using the internal battery supply.

Specifications

Frequency Range:	20hz to 10 mhz (10 mhz range) 100 hz to 60 mhz (60 mhz range) 10 mhz to 600 mhz (600 mhz range)
Sensitivity:	Less than 10 mv to 150 mhz Less than 150 mv to 600 mhz
Resolution:	0.1 hz (10 mhz range) 1.0 hz (60 mhz range) 10.0 hz (600 mhz range)
Input Impedance:	1 meg ohm, 33 pfd (10 and 60 mhz) 50 ohms (600 mhz)
Input Protection:	10 and 60 mhz range; 150 vac to 10 mhz, 50 vac to 60 mhz. 600 mhz range; 5 vac
Time Base:	10.0000 mhz; Standard time base- temperature compensated TCXO- 1.0 ppm 20°-40°C High stability, proportional controlled micro power oven option (OCXO)- 0.1 ppm 20°-30°C
Display:	9 digit, 0.4" height automatic decimal placement
Power:	8-15 v AC/DC at 250 ma max with TCXO, 300 ma max with OCXO, 4 'AA' size nicad batteries
Size, weight:	5" x 5" x 1½", 1 pound with batteries

Operation: Operation of the CT-90 is very simple, simply connect your input signal to the proper input jack (10, 60 mhz or 600 mhz) and select the range and gate time. All switches, except the external time base switch (optional) are mounted on the front panel in easy view of the user. A description of the front panel controls follows.

POWER:
OFF turns the counter off
ON turns the counter on
HOLD stops the clock signals to the counter circuits and holds the count that is displayed.

GATE:
0.1 sec position selects a one tenth second gate period. The gate period is the time interval over which input pulses are counted. The faster gate period allows a faster updated count at the expense of less resolution.
1.0 sec position selects a one second gate period. This position is used when better resolution is required.
10 sec position selects a ten second gate period. This position is used only when extreme accuracy is required and a long term, stable signal is available.

RANGE:
10 mhz position is used when input signals are connected to the 10, 60 mhz input jack. The counter will then count up to 10 mhz with 0.1 hz resolution. (10 sec gate)
60 mhz position is used when the input signals are connected to the 10, 60 mhz input jack. The counter will then count up to 60 mhz with 1.0 hz resolution. (10 sec gate)
600 mhz position is used when the input signals are connected to the 600 mhz input jack. The counter will then count up to 600 mhz with 10 hz resolution. (10 sec gate)

GATE LIGHT:
Indicates when the counter is actually measuring input signals. The gate light gives a visual indication of gate time and counter operation. It is extremely useful when using the longer gate times.

ASSEMBLY DIRECTIONS

Construction Notes:Use a small tipped iron for assembly. A power rating of 30-50 watts is ideal. Do not use a soldering gun! Do not use any sort of additional solder flux, use only a good grade of rosin core solder. Proper soldering techniques are important! Each joint should be shiny and completly surround the lead wire. There should not be just a slight dab of solder barely held on to the lead.

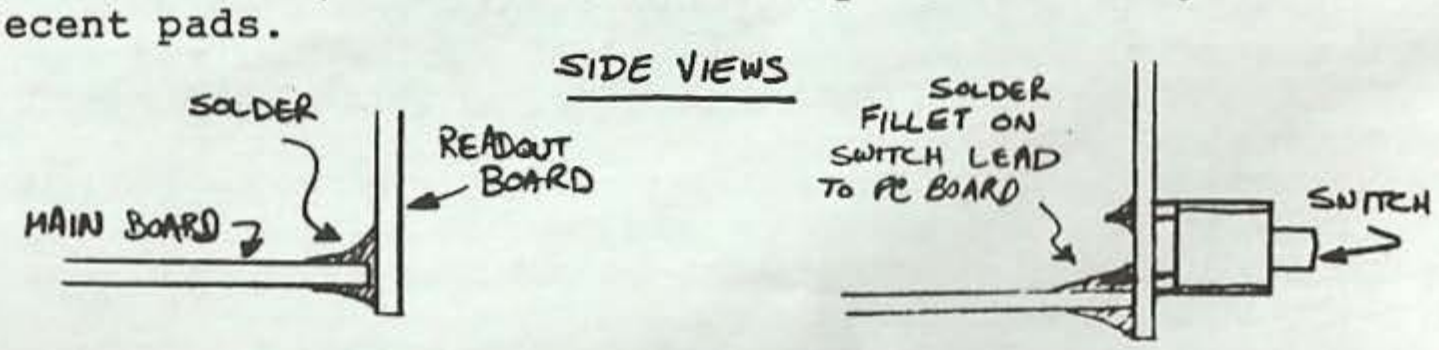
ASSEMBLY DIRECTIONS (continued)

Don't be afraid of damaging a component due to too much heat, modern day semiconductors can withstand more heat than your iron can put out! Use enough heat to form a good solid joint, a quick touch of the iron is usually not enough. The main PC board has plated thru holes, thereby eliminating the need to solder top side of the board. This, however, makes removing a part more difficult, so follow the directions closely. Keep component lead lengths as short as possible. Note that components in the U4,U1 and U2 area must be kept close to the PC board so that the battery holder can be mounted above them. Review all assembly details before beginning construction.

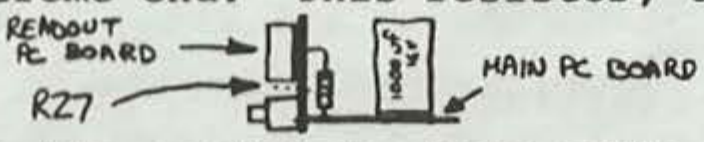
Assembly:

1) Locate the main counter PC board and install the 28 pin socket for U3, the two 16 pin sockets for U1 and U4, and the 14 pin socket for U2.
2) Install C2, C3, C4 and C5; All .01. Do not install C1 at this time.
3) Install C6, 100 pfd and C12, .01.
4) Install C7, C8, C9, C10 and C11; .22 to 10 ufd. Note the polarity on all these capacitors.
5) Install CR1 thru CR6; 1N4148 type small glass signal diodes. Note polarity.
6) Install CR8 thru CR14; 1N4003 type, 1 amp diodes, observe polarity.
7) Install R1, R20, R21, R22, R24, R26, all 10K ohm.
8) Install R2, R10, R12, R13, and R14, R23, all 470 ohm.
9) Install jumper where R3 is located. Use scrap component lead.
10) Install R4; 100 k ohm,and R5; 1 meg ohm.
11) Install R6, R9, R11 and R25; all 1 k ohm.
12) Install R7, R15, R16 and R17; all 270 ohm.
13) Install R8; 150 ohm, Read color coding carefully.
14) Install R18 and R28; both 100 ohms.
15) Install Q1; MRF502, Q2; 2N5484, Q3 and Q4; 2N5771, Q5; 7545 and Q6; 7546. Note the positioning of these transistors before installing. Keep the leads of Q4 and Q1 short so that the total height of each part does not exceed 3/8".
16) Install VR-1; 7805 voltage regulator. Bolt the regulator to PC board before soldering using (1) 4-40 x ¼" screw and nut.
17) Install C15; 1000 ufd and C16; 220 ufd. Be sure both parts are seated against PC board. Note polarity.
18) If you are going to use the standard 1 ppm time base follow steps 19 thru 21. If you are going to use the micro power 0.1 ppm oven proceed directly to step 22. Be sure to read all instructions given with the micro power oven.
19) Install C14 and C17. These part values are matched to the crystal used and may vary. See parts list.
20) Install R19; 22 meg ohms and C13; trimmer capacitor.
21) Install Y1; 10.000 mhz crystal. Note: When using the standard 1.0 ppm crystal time base, diode CR7 is not used. Proceed now to step 24, ignore steps 22and 23.
22) Install the precision oven oscillator module as shown in diagram. Be sure the module is aligned properly and seated firmly against PC board. Note that there are no parts installed or supplied for R19, C13, C14, C17 or Y1.
23) Install CR7 as shown. Note, CR7 is used ONLY with oven option!
24) Install U1; 11C90, U2; 74196, U3; 7216 and U4; 10116 IC's. Be sure that the IC's are installed in the correct sockets and that they are not installed backwards. Are all the IC leads inserted

24) into the socket? It is very easy to have some leads bent under the IC body.
25) Set the main PC board aside and locate the read out board.
26) Carefully examine the readout PC board for any shorts between lands that could have occured in manufacture. The R.E. symbol marks the solder side.
27) Install the nine readouts (DS1 thru 9). Note the position of the ridges on the top of the readouts. Seat all readouts firmly against the PC board. Before soldering be sure they are lined up straight and even. Note that the readout board has many fine PC traces and requires much care in assembly. Inspect each joint after soldering for any possible bridges. It is much easier to find mistakes now, as troubleshooting of solder bridges is quite difficult. Do not rush this portion of assembly!
28) Install CR15; Red LED as shown. Be sure that the long lead is installed in the bottom-most hole.
29) Install the three slide switches as shown in layout. Be sure the switches are seated all the way and that the guide pins are inserted in their holes in the PC board. If the switches are not seated correctly, they will cause assembly problems later. Note that the connections that have to be soldered are very small and close together. Care must be taken not to cause any solder bridges. Do not cut the switch leads after soldering.
30) The readout board mounts at a right angle to the main board with solder pads and switch leads providing both mechanical support and electrical connection between the two boards. The readout board is placed against the main board so that the solder pads on the readout board line up with the solder pads on the main board. Note that there are two sets of pads on the readout board. One set connects to the top of the main board, the other set to the bottom (solder side) of the main board. Solder the bottom row of the readout pads and switch leads flush with main board between the pads on the readout board. Check to be sure the two boards are perpendicular and not tilted, then solder all remaining pads. Use enough solder to provide a good mechanical connection, but don't cause any solder bridges between adjecent pads.

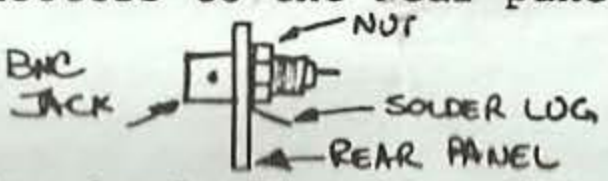


31) Locate R27; 15 ohms. One lead of this resistor mounts on the main board and the other end connects to the read out board at the extreme end. This resistor, therefore stands upright.

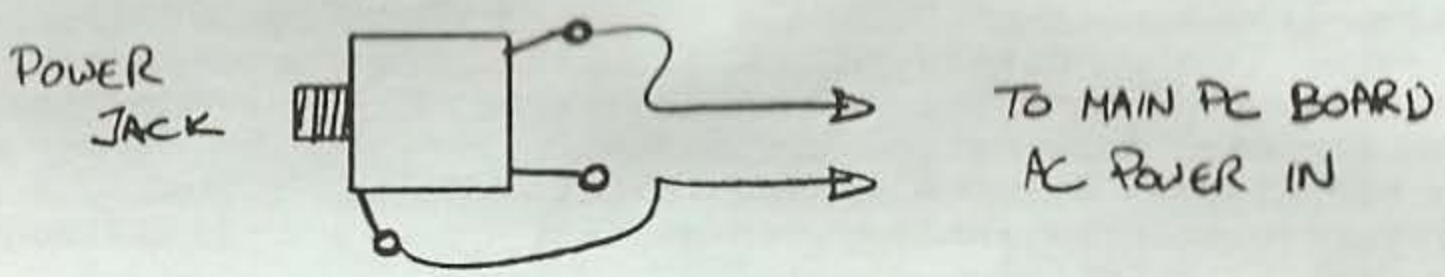


32) Locate the two conductor strip cable and install both leads at one end to the holes marked 'AC'. The other end will be connected later.
33) Locate the battery holder assembly and solder the black and red leads to the holes labeled 'BATT'. (red to plus)

34) Note the location of the battery holder mounting holes and position the battery holder over VR-1 so that the red and black leads face toward the front of the counter (toward readout board). Note which holes in PC board line up with mounting holes in battery holder.
35) Install the two 3/8" standoffs on the componet side of the PC board in the holes that line up with the battery holder. Use two 4-40 x 3/16" screws. Posistion standoffs so they don't short.
36) Mount the battery holder to the top of the standoffs using two 4-40 x 3/16" screws. Be sure not to damage any parts under the battery holder. The two conductor cable from the 'AC' holes should extend out to the rear.
37) Locate the bottom housing. (the half with the two holes)
38) Locate the four rubber feet, peel off the protective paper and mount them in the four corners of the outside bottom cover.
39) Slide the front panel into the groves provided on the bottom housing.
40) Place the main PC board into the bottom housing so that the three slide switches extend thru the switch holes in the front plate.
41) Mount the PC board using the four 4-40 screws. Do not overtighten.
42) Locate the rear panel and mount the miniature phono jack to the center hole.
43) Mount the two BNC connectors to the rear panel. Install a solder lug under each nut.



44) Solder the two remaining leads from the cable connected to the 'AC' holes to the phono jack as shown:



45) Slide the rear panel into the rear slots of the bottom housing.
46) Locate C1; .01, connect one lead to the center of J1 and the other lead to the PC land that connects C2, CR1, and CR2. Keep the leads as short as possible. You may wish to remove the battery holder while doing this.
47) Using a scrap component lead, connect the ground lug of J1 to the ground plane of the PC board. Keep this lead a short as possible.
48) Connect a scrap component lead from the center of J2 to the pad on the main PC board labeled J2. Keep this lead as short as possible.
49) Connect a scrap component lead from the solder lug of J2 to the PC board ground plane. Keep this lead as short as possible.

50) Locate C18; 22 pfd. Connect one lead to the center of J2 and the other lead to the PC board ground plane. Keep leads as short as possible.
51) Locate the red lens and place it between the readouts and the front plate.
52) The unit is now ready for checkout and calibration (note: the precision oven option does not require calibration, it is factory calibrated).
53) If problems occur see the trouble shooting hints and theory of operation. After calibration the top cover can be installed using the two phillips head screws. Do not overtighten. The cover will only mount one way.

Calibration:

1) If nicad batteries are to be used, be sure they are fully charged before attempting to calibrate the counter.
2) Connect a signal of known accuracy to the counter input. A 100 khz calibrator which has just been zero beated to WWV or the CB-1 color burst adaptor works well.
3) Set the gate time to 1.0 seconds and adjust C13 until the display shows the proper frequency.

Theory of Operations:

General: Regardless of the type or complexity of a frequency counter, all instruments measure frequency by counting input pulses with respect to a known frequency or time base. The time base generates a precisely controlled time interval, selectable to be one second or one-tenth of a second. During this period, the counter is enabled and input pulses counted. When the time period is up, the number of pulses counted is then displayed. A long gate period allows more pulses to be counted, and the more pulses counted the better the resolution. The limiting factors governing resolution are the number of digits in the display and the tolerable gate period. Usually 1.0 hz is the best resolution practical for an easy to read updated count. Of course it is not always necessary to read frequency to a hertz or wait for a one second count. By selecting a shorter gate period, you can reduce the display update time and get a faster reading display, but at the expense of poorer resolution.
Detailed Theory: The UHF and VHF inputs have been kept separate to increase the input sensitivity by eliminating switching losses. The UHF signals are feed thru J1, past CR1-CR2 input protection diodes to Q1, the first amplifier/limiter stage. The signal is then sent to U1, divide by ten IC.

The VHF input is much different because it must be of a very high impedance. The signal is feed thru J2, past CR3 and CR4 input protection diodes to the gate of Q2; FET. The combination of the FET and Q3 bootstrap bipolar transistor follower provides the high impedance required. The signal is then sent to the three stage line amp U4. This IC is an ECL device that limits and shapes the signal. Transistor Q4 then converts the ECL level to a TTL level signal that the rest of the counter requires. The input to U2 divider is selected by the range switch.

Its input can come from the UHF section (U4) or the VHF section (Q4). If the 10 mhz mode has been selected U2 is bypassed completely and the signal is sent directly to U3, the counter IC.

The timebase for U3 can be supplied by Y1 and its associated components or by an external timebase. The counter IC will use whichever timebase that has been selected at pin 1. If CR7 is installed, the timebase connected to pin 24 will be used. The counter IC generates all its own housekeeping functions such as multiplex, strobe, gate and reset signals. A logic circuit inside the counter IC senses the scanned readout signals (D0 thru D7) and also the input to pin 14, the gate select input. By comparing these inputs, the counter IC generates the selected gate time. The decimal point is displayed the same way. A logic circuit inside the IC looks at the scanned outputs D0 thru D7 and compares this with the signals selected by S2.

The power supply uses a simple bridge rectifier circuit that will accept an AC or DC input. Regulator VR1 provides a stable 5V power source while R28 and CR12 provide the charging current for the nicads (if used). Capacitors C15 and C16 provided added filtering.

Trouble Shooting Hints: The first step involved in trouble shooting is to carefully examine all your work. Check parts placement against parts list and PC layout. Make sure all diodes, transistors, IC's and capacitors are orientated correctly. Above all, check all solder connections! Examine all PC runs to verify that no solder bridges exist. Carefully check the readout board as it has quite a few close foil runs.

PROBLEM: Entire display does not light;
Check: Power supply voltages, connections to readout board, solder bridges across power switch and correct external supply (if used). Also check the timebase circuit used. If the counter lacks a timebase input the display may blank.

PROBLEM: 5V not present
Check: CR8 thru CR14, VR-1 and battery holder assembly. Check for shorts on the 5V buss. Are any IC's inserted backwards?

PROBLEM: Display lights but shows odd characters
Check: All solder joints on readout board- Look closely for bridges.

PROBLEM: Digit not lit
Check: U3, be sure all pins are seated properly. Check PC traces connecting pins 1 and 6 of readout.

PROBLEM: Segment not lit in all digits
Check: U3, Be sure all pins are seated properly. Check PC traces to readouts for shorts and open connections.

PROBLEM: Only one digit lit.
Check: Timebase circuits, connections to pins 1 and 6 of lit readout. Also look at power supply voltages.

PROBLEM: Display flickering.
Check: Power supply voltages. Note that when unit is used for extended periods from AC adapter, some power is used from batteries (nicads only). A full charge can only be provided when the power switch is in the off position.

PROBLEM: No gate light.
Check: Timebase circuits, Q6 and solder pads at the junction of the readout board and main board. Is the power switch in the hold position?

PROBLEM: No decimal points.
Check: Q5,R27 and S2 connections.

PROBLEM: Only some digits are lit.
Check: Input signal. This unit has leading zero display blanking. The digits before the decimal point will not be turned on until a signal is applied.

HOW TO USE YOUR COUNTER

Using your counter is usually just as easy as connecting the signal to the input jack and counting. However, in some instances, such as noisy signals or low frequencies, care must be taken in applying the signal to the counter. The counter not only has a high input impedance but also high sensitivity. Noise accompanying the desired signal may fall with in the counter's sensitivity and frequency limits, and be counted. This signal plus noise input is amplified and counted within the instrument, and produces a jittery, unstable display. The solution to this problem is to attenuate the signal plus noise to the level where the noise is below the counter threshold. A scope X10 probe is ideal for this purpose, an easily constructed probe of this type is described later on.

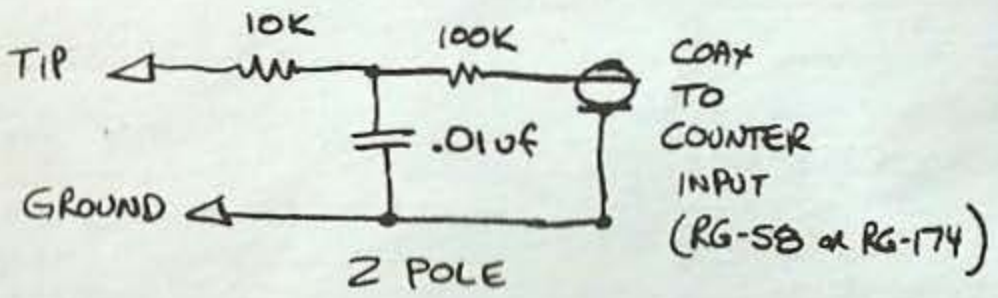
Another problem area is ringing at the counter input. Consider the coax cable from the signal to be measured to the input jack, it's a transmission line, just like your antenna coax on a transmitter. Being so, a standing wave phenomenom can occur if impedances are mismatched. If a signal from a low impedance source is presented to the coax cable, and the cable is connected to the high impedance counter input, the signal will be mismatched. This mismatch will cause the signal to reflect from the input and return, causing again, an unstable display.

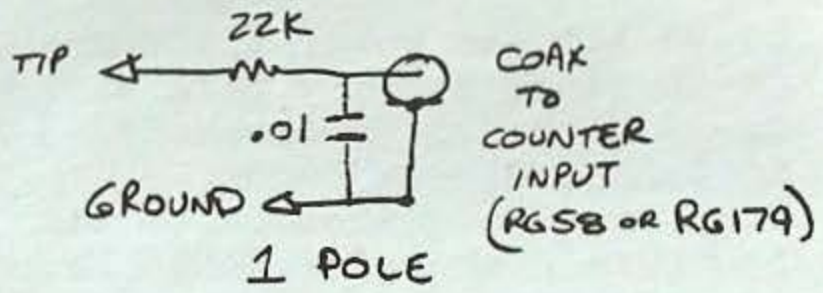
Yet another consideration is that of ground loops. If your counter probe is grounded to the circuit to be measured, and the counter case also grounded (whether physically or induced) a ground current along the cable can exist. This ground current will produce a voltage which, if it is AC, will be counted.

Fortunately, most of these problems are easily solved by thoughtful selection of coupling the input signal. This involves determing just what sort of signal you are attempting to measure.

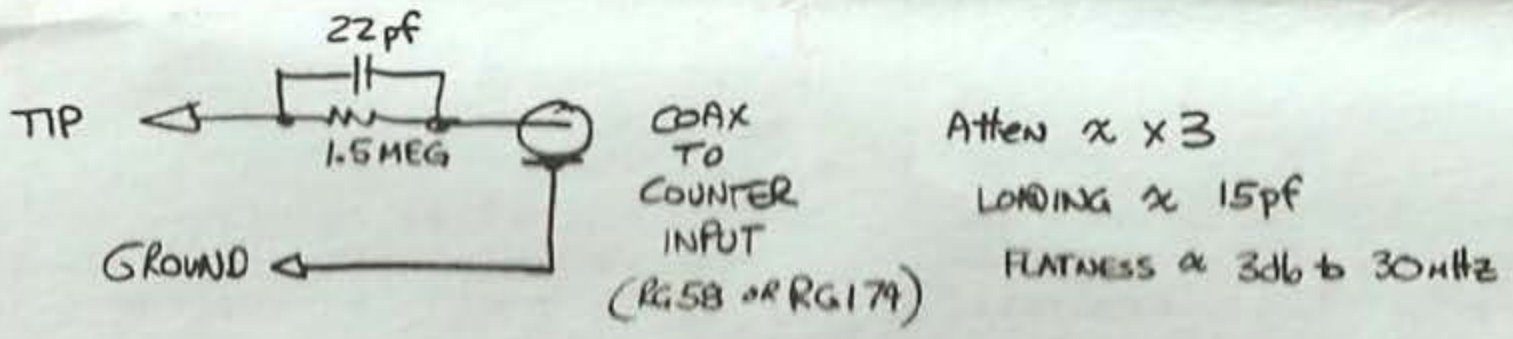
For Low Frequency (less than 20 khz) Measurement: Low frequency measurements are usually upset by excessive noise riding on the input signal, ground loops or ringing. Even though you may feel the signal is very "clean", the counter can count up to VHF and noise or ringing will be counted. The use of a low pass filter will prevent any high frequency noise or ringing to be presented to the counter input. Preventing a ground loop is not quite as easy as using a different probe. Generally, providing a ground path other than the probe's ground will solve the problem. Two simple low pass probes are shown:

LOW PASS PROBES:



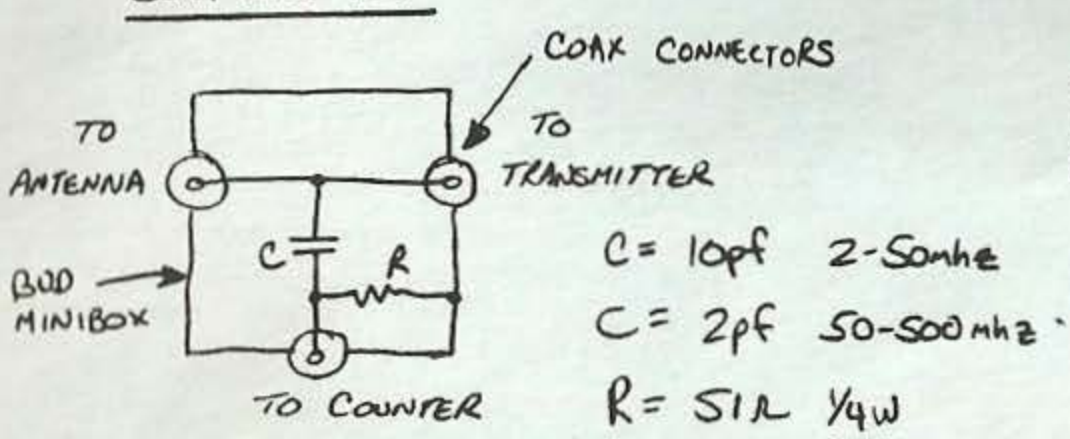


For General Usage (20 khz to 60 mhz) Measurement: The majority of signal measurements are usually within this range. Ringing and noise are the chief culprits in measurement. The only way to counteract these undesirables is to damp the ringing and/ or attenuate the noise (with the signal too, unfortunately). A simple X10 oscilloscope probe works well to attenuate noise as well as providing a less loading probe. If the noise is at a 10 mv level and signal at 1 volt, the X10 probe will reduce the noise to 1 mv and the signal to 100 mv, thus the noise is out of the counter's sensitivity range, while the desired signal isn't. The X10 probe or high impedance probe will also generally damp out ringing. Another benefit of the high impedance probe is that it doesn't load the circuit being measured by the input cable's capacitance. This is especially important when measuring oscillators or amplifiers. A simple high impedance probe is shown below:

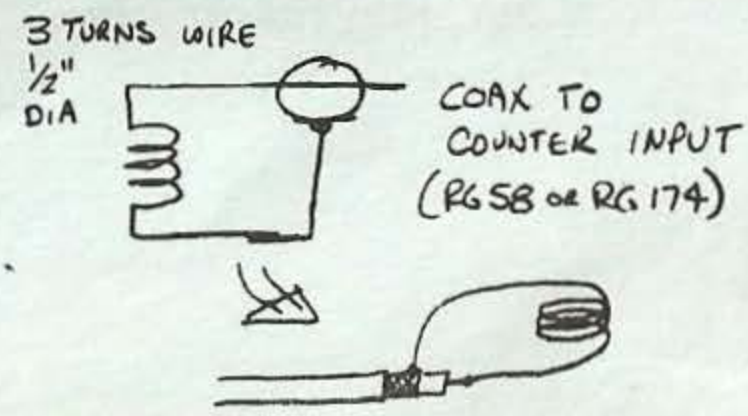


For Direct Transmitter Measurement: Measuring a transmitter requires coupling enough transmitter energy into the counter for a stable count and not so much as to exceed the counter's safe input. Generally, for VHF work, a small 18" whip antenna will pick up a transmitter from 5 to 10 feet away. Direct connection to the transmitter can be made via a coupling box or pick up loop. The pick up loop is simply a few turns of wire wrapped around the transmitter's antenna coax and fed to the counter. The coupling box requires breaking into the transmitter's antenna coax. Schematic is shown below:

COUPLING BOX



SNIFFER LOOP



FREQUENCY COUNTER ACCESSORIES

CT-90 110 vac power adapter
CT-90 Nicad battery pack and adapter
CT-90 External power cable, 8-15 VAC/DC
DC Probe, direct input
High Impedance Probe, low circuit loading
Low pass Probe, for audio measurement
High Pass Probe, reduces low freq pickup
Collapsible whip antenna (20 inches)

CB-1 Color Burst Adapter for calibration, high accuracy, typically .001ppm

PS-2 Audio scaler, multiplies audio signals times 10 or 100, gives 0.1 or 0.01 hz resolution with 1 sec gate — wired kit

OSC-1 Micro power proportional controlled oven--- increases stability to 0.1 ppm, 20-30° C, factory wired and calibrated.

External Timebase input Conversion Kit
Allows connection to external time-base,includes BNC connector, switch, electrical parts needed and new rear panel

WARRANTY

All parts used in the CT-90 counter are warranted to be free from any defects for a period of 90 days. Parts found to be defective within this period will be replaced promptly without charge upon receipt for inspection at the factory After the warranty period has passed, parts may be purchased per the price list. Ramsey Electronics cannot be held responsible for faulty workmanship during assembly or damage/harm caused by construction or installation errors. Units obviously misused or modified are not covered by this warranty.

REPAIR SERVICE

Assembled CT-90 kits may be returned for repair and calibration to factory standards for a fee of $20.00. This fee covers repair, calibration, shipping, insurance, handling and a service report on difficulties found. CT-90 units assembled with paste flux, acid core solder or soldering guns will not be accepted. Ramsey Electronics reserves the right to refuse repair on unreasonably constructed units.

Pack all returns adequately and insure for your own protection.

CT-90 PARTS LIST

DESIGNATOR	DESCRIPTION
C1 thru C5	.01 uf disc
C6	100 pf disc
C7 thru C11	1 to 10 uf
C12	10 uf
C13	4-40 pf (used in std TB)
[illegible], C17	22 pf C14 30 pf disc
C15	1000 uf, 16VDC
C16	100 uf, 16VDC
[illegible] C18	[illegible] 18 pf disc.
CR1 thru CR4,CR6	1N4148type, small signal diode
CR7	1N4148type, (optional Time base)
CR8 thru CR14,CR5	1N4003type,1 amp power diode
CR15	LED, Mini-red
DS1 thru DS9	FND 359,357 Readout
J1, J2	BNC connector
J3	Sub miniature phono jack
Q1	MRF502, NPN transistor,2N5179
Q2	2N5484, FET
Q3, Q4	2N5771, PNP transistor,2N4258
Q5	NPN, 2N3904 type
Q6	PNP, 2N3906 type
R1,R20thru R22 R24, R26	10 k ohms,Brn-Blk-Org
R2,R10,R12, R13, R14,R23	470 ohms, Yel-Vio-Brn
R3	Jumper Wire
R4	100 k ohms, Brn-Blk- Yel
R5	1 Meg ohms, Brn-Blk-Grn
R6, R9, R11, R25	1 K ohms, Brn-Blk-Red
R7, R15, R16, [illegible]	270 ohms, Red-Vio-Brn R17 75 ohm
R8	150 ohms, Brn-Grn-Brn
R18, R28	100 ohms, Brn-Blk-Brn
R19	22 meg ohms, Red-Red-Blue (STD OSC only)
R27	15 ohms, Brn-Grn-Blk
S1, S2, S3	Slide switch, 3 position
U1	11c90, High speed decade prescaler IC,8680
U2	74196, TTL decade counter
U3	7216, MOS, LSI counter
U4	10116, ECL Amplifier
VR-1	7805, voltage regulator, 5V
Y1	10.0000 Mhz crystal

Non- Referenced Items

Socket Set 1-28 pin, 2-16 pin, 1-14 pin
CT-90 PC board
CT-90 Display board
Hook-up wire, 4"- 2 conductor
Phillips head screws, 1", Qty 2
Solder Lug, 3/8" hole size, Qty 2
Rubber feet, strip of four, pressure sensitive
Red lens, 4½" x 3/4"

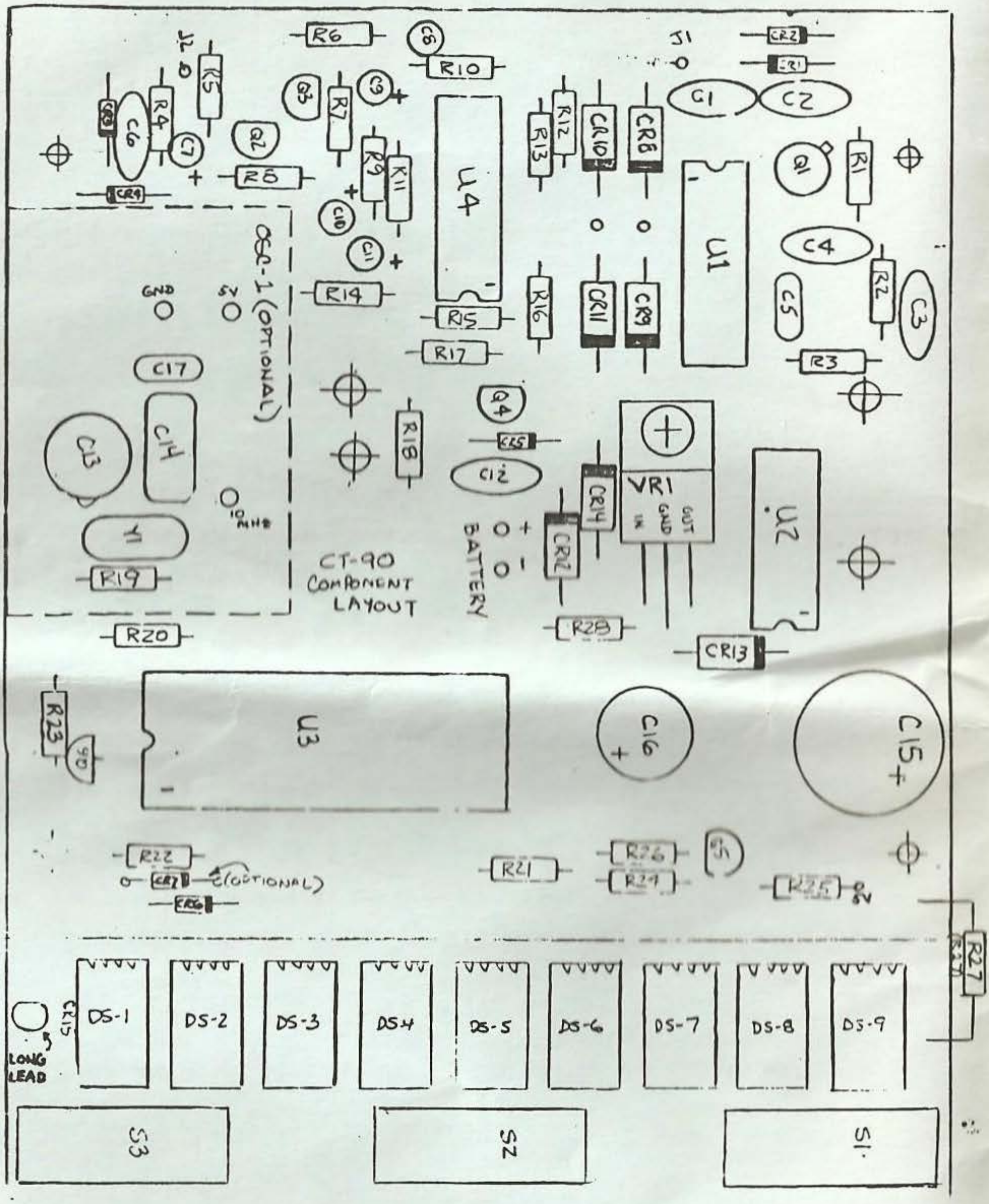
DESIGNATOR	DESCRIPTION

Non-Referenced Items

4-40 x ¼' screws, Qty 5
4-40 x 3/16" screws, Qty 4
4-40 x 3/8" standoff, Qty 4
4-40 Nut, Qty 1
CT-90 Housing, ABS Plastic, top and bottom
CT-90 Front panel, punched, labeled
CT-90 Rear panel, punched
Battery holder, 4-AA cell type

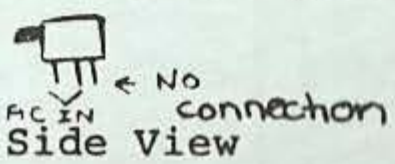
INTERNAL OPTIONS

OSC-1 Micro power, proportional controlled oven
Factory calibrated, 0.1 ppm 20-30°C
External timebase input conversion kit


J1
J2
R6
R10
R5
R14
R17
R16
R18
R20
R23
R22
R21
R26
R24
R25
R27
R19
R28
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
Q1
Q2
Q3
Q4
Q5
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
CR12
CR13
CR14
CR15
U1
U2
U3
U4
VR1
IN
GND
OUT
Y1
10 MHz
GND
5V
8V
BATTERY
OSC-1 (OPTIONAL)
CT-90
COMPONENT
LAYOUT
(OPTIONAL)
DS-1
DS-2
DS-3
DS-4
DS-5
DS-6
DS-7
DS-8
DS-9
LONG
LEAD
S1
S2
S3

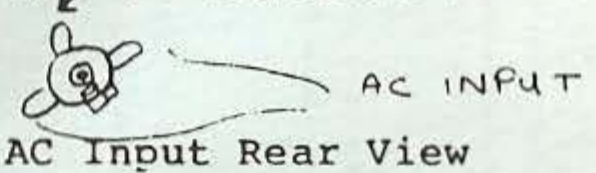
CT-90 REVISIONS

1. Enclosed phono jack may look like:



Side View

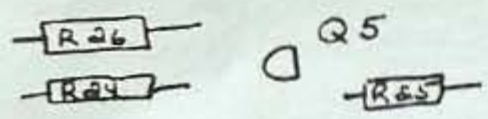
— or —



AC Input Rear View

2. Be sure stand-offs (step 35) do not short 5 volt trace to ground.

3. Q5 is drawn backwards on layout. Should be:



4. R23 is 470 ohms.

5. In step 34, red and black leads may not face forward.

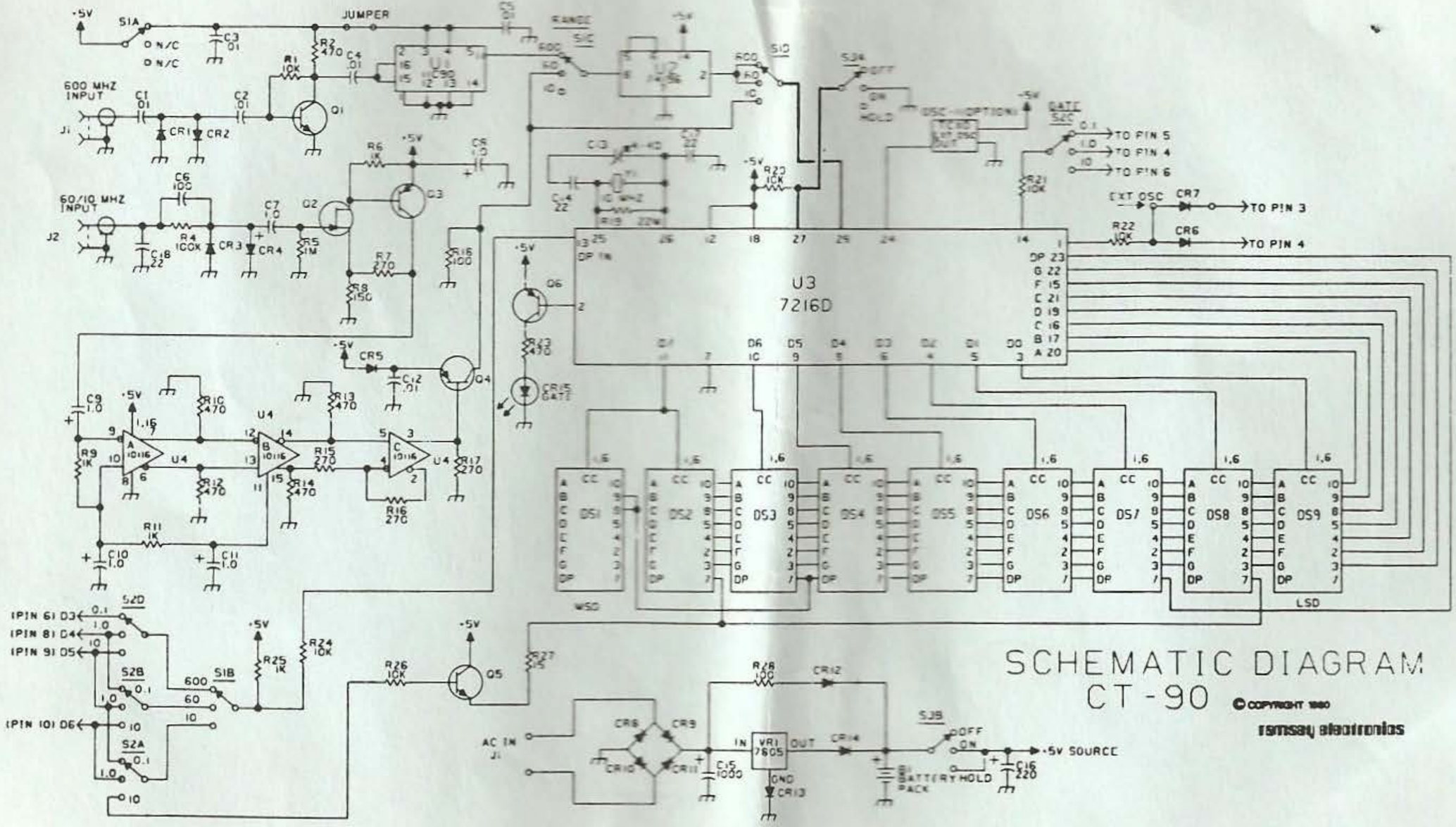
6. C14 is 30 pf.

7. C12 changed from .01 to 10 uf.

8. CR-5 changed from IN914 to IN4003.

9. R17 is 75 ohm

10. SEE ATTACHED SHEET FOR INSTALLATION OF 270 Ω TO SOLDER SIDE OF BOARD.



SCHEMATIC DIAGRAM
CT-90

ramsey electronics