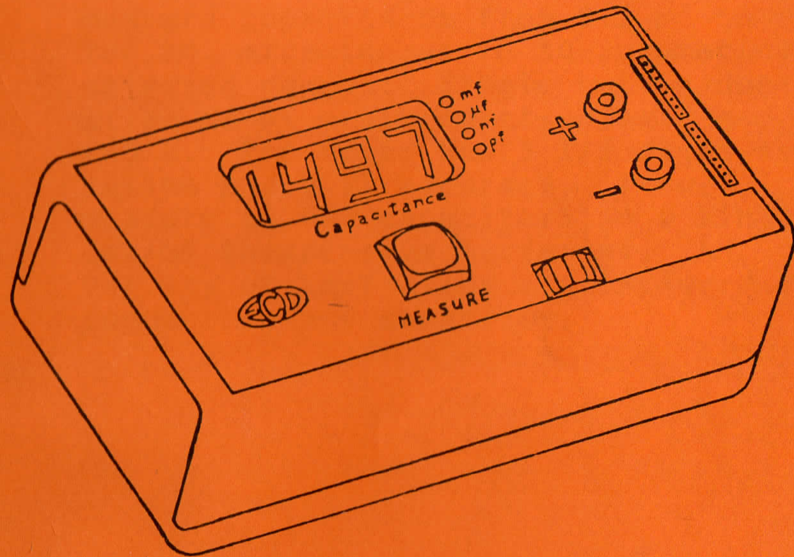
ECD
MODEL 100



digital autoranging capacitance meter

ECD MODEL 100 DIGITAL CAPACITANCE METER

The ECD Model 100 will automatically measure capacitance from 0.1 pf to 200,000 microfarads in 10 automatically selected ranges. Single button operation makes measurements simple and rapid. The meter has 3 1/2 digit resolution and 0.1% accuracy. It will measure 20,000 capacitors on a single set of inexpensive batteries. A variety of test clips are included to connect to any capacitor.

Table of Contents

ECD MODEL 100

SPECIFICATIONS

Range
10 ranges with full scale values from 199.9 picofarads to 199,900 microfarads, automatically selected to give maximum resolution.

Accuracy
0.1% ±1 count to 200 ufd; 1% from 200 ufd to 200,000 ufd. Accuracy on all ranges is maintained over the temperature range of 59 to 95 degrees F. (15 to 35 degrees C.)

Controls
Measure: meter performs measuring cycles while depressed. Cap. Offset: front panel offset adjustment allows for cancelling up to 15 pf. stray capacitance.

Test Characteristics
Measurements are made by determining the time constant of the unknown capacitor and a standard resistor. Maximum potential applied is less than 4.0 volts DC. Maximum current is less than 20 milliamps.

Display
3 1/2 digits, 0.6 inch high liquid crystal display. 4 LED's indicate the units.

Reading Rate
First reading available in 1/2 second for capacitors up to 200 microfarads. Subsequent readings every 600 milliseconds. Reading rate decreases to one every 5 seconds at 199,900 microfarads.

Operating Temperature Range
40 to 160 degrees F. (5 to 50 degrees Centigrade)

Power
4 standard 'AA' cells. Battery life - sufficient to measure at least 20,000 capacitors (except for high value caps). Low battery voltage signified by a flashing display.

Mechanical
Height: 2.25 in. (57,2 mm) Width: 3.15 in. (80,0 mm) Length: 5.90 in. (150,0 mm) Weight: 15 oz. (425 gm.)

OPERATING INSTRUCTIONS

The ECD Model 100 is extremely easy to operate. Simply connect a capacitor to the meter terminals (observing polarity on polarized devices) and press the 'measure' button. The capacitance value will appear on the liquid crystal display, with the proper units indicated by a LED.

Care should be taken to assure capacitors to be measured are initially discharged. Although the input circuit to the Model 100 is protected, large electrolytics or high voltage capacitors could damage the meter if they contained sufficient energy prior to measurement.

The front panel 'capacitance offset' control allows the stray capacitance of the various test clips to be cancelled. With no capacitor connected, rotate the adjustment until the display reads all 0's. If adjusted too far, the leftmost decimal point will turn on, indicating a negative value.

It is recommended that the operator read the pamphlet 'The Secret Life of Capacitors'* before making precision measurements. This pamphlet explains why values of lossy capacitors will be different when measured by different techniques, and describes how dielectric absorbtion causes the apparent value of large electrolytics to

*Extra copies available from ECD.

decrease during measurement.

A variety of methods are provided for connecting capacitors to the meter. The integral clips, to the right of the bananna jacks, accept wire leads up to #20. These clips will even accept components removed from printed circuit boards with leads as short as 0.1 inch. The external component clip allows measuring axial lead capacitors, seperately or on bulk taped rolls. The alligator clips make it easy to connect screw lug electrolytics to the Model 100.

When measuring physically large capacitors of small value it is necessary to minimize 60 Hz. pickup from the air. This is done by connecting the '-' terminal of the meter to the capacitor electrode with the most shielding value, such as the frame of an air variable capacitor or the shield of coax.

Four standard 'AA' batteries power the Model 100. They have sufficient life to measure at least 20,000 capacitors, which should last a year or more in normal laboratory use. Low battery condition is indicated by flashing of the liquid crystal display. The meter remains accurate throughout battery life. The batteries can be changed by removing the four corner screws on the bottom of the meter, and gently pulling the two halves of the box apart.

If a test jig is to be used with the Model 100 which has more than 15 pf, such that the offset control cannot zero the meter, a couple of things can be done. Trimmer capacitor C26, which can be adjusted through the hole in the outer board, can remove at least 20 pf from the reading. Another 27 pf can be deleted by cutting the wire loop in front of trimpot R1. In this way, a jig capacitance of up to at least 62 pf can be offset.

PRINCIPLES OF OPERATION

Overview

The Model 100 measures capacitance by determining the RC time constant of the unknown capacitor and a standard resistor. The meter steps through its 10 ranges, from the 200 millifarad range down. When it arrives at a value which will display between 200 and 1999, independent of decimal point, cycling stops. At this point, or on the lowest range, the value, decimal point, and units are latched and displayed. A new measurement sequence then starts.

Range changing is accomplished by switching between one of 3 standard charging resistors; by selecting the frequency to be counted to measure the RC time constant; and by reducing the charging threshold to 0.1 time constant on the highest range. The capacitance offset adjustment is implemented by variably reducing the time measured by the counting circuits.

The meter is powered by 4 to 6 volts, as provided by 4 'AA' batteries. This is regulated internally to produce +4v, and inverted and regulated to produce +14 volts to run the logic (CMOS) and liquid crystal display. A shutdown circuit causes the display to flash if the battery voltage falls below 4 v.

In the following discussion, the

notation x/y means "the circuit in ICx with output at ICx pin y."

Power Supplies

The digital circuitry in the Model 100 operates from the +14 v. The bulk of the analog section runs off of regulated +4. The +14 is generated by the inverter Q10 and Q11. This is a self-oscillating, self-starting flyback type inverter, which runs around 150 khz. The output is feed-back regulated to 14 v. by zener D4.

The +4 volts is regulated by the 723, IC 26. If the battery voltage drops below 4 v, then excessive cur-rent is drawn through R 28 into the V+ terminal of the 723. The voltage drop across R 28 triggers monostable Q8 and Q9, which temporarily removes the +14. This causes the display to blank.

Analog Front End

The unknown capacitor is placed across C 26 and C 35. Diodes D1 and D2, and fuse F1 protect the input circuitry should the capacitor have been charged. Transistor Q1 discharges the test capa-citor between measurement trials. During each trial Q1 is turned off, whereby the capacitor charges through R4, R5, or R6; depending on the range being tried. The capacitor voltage is compared to a reference voltage via follower Q7 A&B and the 311, IC27. The reference voltage is determined by R13, R14, R15, & R16, and the states of Q5 and Q6. For all but the highest range, Q6 is off. The R13 & R15 voltage divider sets a first threshold, around 0.71 v. The test capacitor charges through this point, whereby Q5 turns on. The capacitor continues to charge until it reaches the 2nd threshold, determined by R13 parallel R14; and R15. This voltage is approximately 2.77 v. This voltage ratio causes the interval between thresholds to be about .988 RC. On the highest range Q6 is on, making the two thresholds be approximately .044 and .417 v., and the time be .0988 RC.

Counting And Display

The timebase used to measure the RC time constant consists of the 5.0 mhz crystal oscillator X1 and 11/11. This 5 mhz is gated and then divided down in decade steps by IC's 16 and 17. Transmission gates IC 14 and IC 15 act as a multiplexer to select the proper time base decade for the particular measurement range being tried. Counters IC 22 and IC 20 count the selected clock to arrive at the measured value. The value present at the end of a particular trial is latched if the control logic determines that it will give the best possible resolution. Display oscillator IC 18 produces a square wave drive which is fed to the latch/LCD drivers (IC's 19, 23, 24, 25) to

energize the display. The appropriate set of units and decimal point are determined from the state of IC 13. The units are latched in IC 24 which drives the appropriate LED.

Control Logic

The ten capacitance ranges are labeled 'A'→'J'; 'A' being 200 millifarads full scale. The range being tested is determined by which output of IC 13 is asserted.

A measurement cycle begins with a trial measurement on range 'A'. If an adequately large count is not obtained, additional trials are performed in rapid succession on progressively lower ranges. When a count in excess of 200 is achieved, or when range 'J' has been reached and tried, the negative pulse from 12/10 is allowed through 12/11 from which it initiates: (1) strobing of count, decimal point, and units to the visible display; (2) reset of IC 13 to range state 'A'; and (3) discharge of C22 to a potential near 0 v.

The combination of C22, R50, and IC1 controls the overall timing of the measurement cycle. The voltage on C22 is detected by IC1, which is wired as a schmidt trigger with both thresholds slightly above the regulated +4 v potential.

Between the successive trials of a single measurement cycle, C22 is discharged to the lower threshold of IC1 by Q12. When R50 brings C22 back up to the upper threshold of IC1, it is T1 (see below) of the next trial. The charging process between the two thresholds takes only a few milliseconds, so successive trials are performed rapidly. The final trail in each cycle, however, is followed by complete discharge of C22. As it takes about 1/2 second to charge back up, ample time is provided for the operator to read the value strobed into the display.

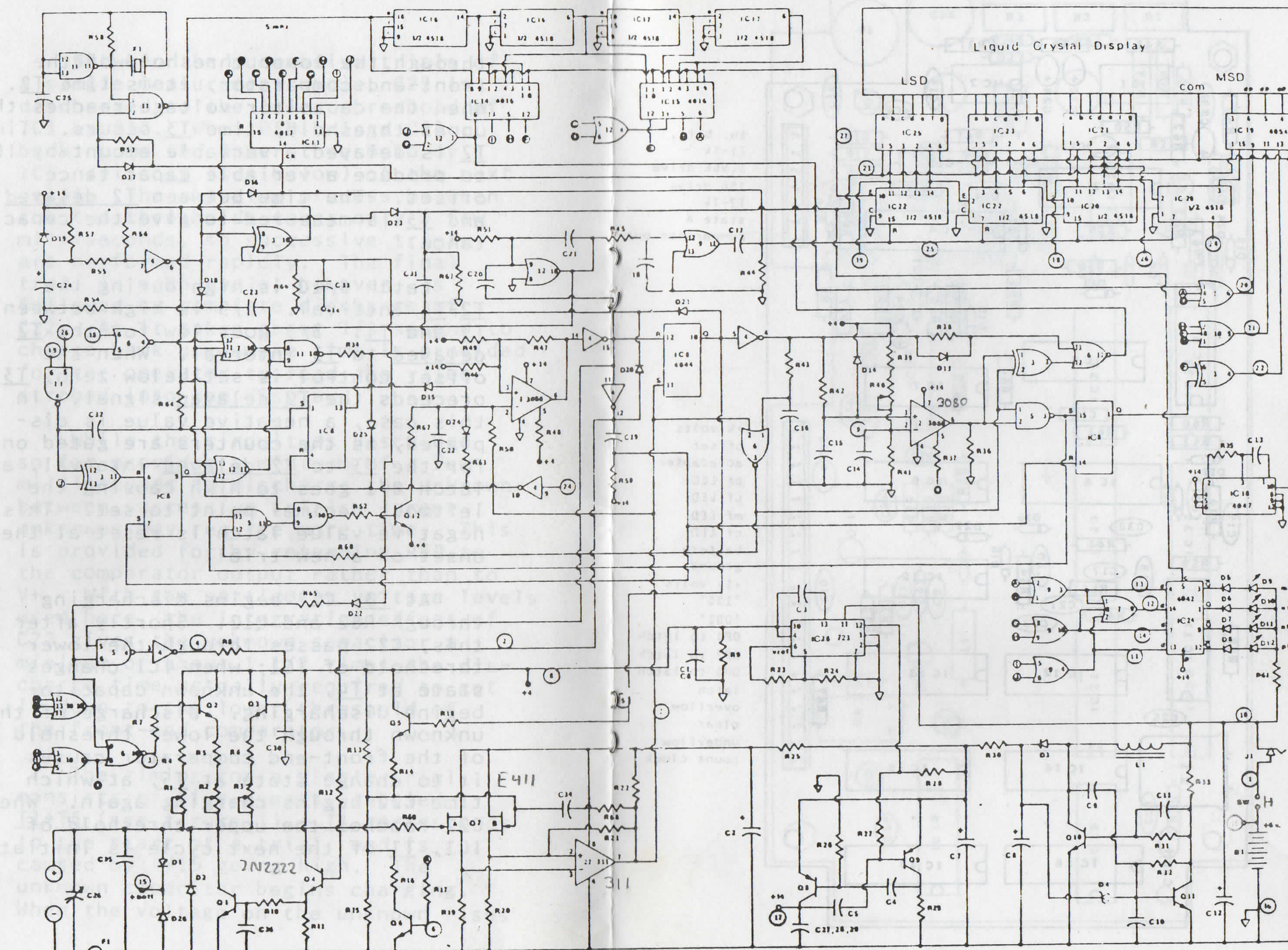
While the circuit as described so far provides a minimum of a few milliseconds to discharge the unknown between successive trials, larger unknowns may require more time. This is provided for by returning R50 to the comparator output rather than to V+. With the particular voltage levels used here, the integrating effect of C22 gives the unknown capacitor a minimum of about 1 1/2 times the discharge time actually required to get it down to the lower threshold of the front-end comparator.

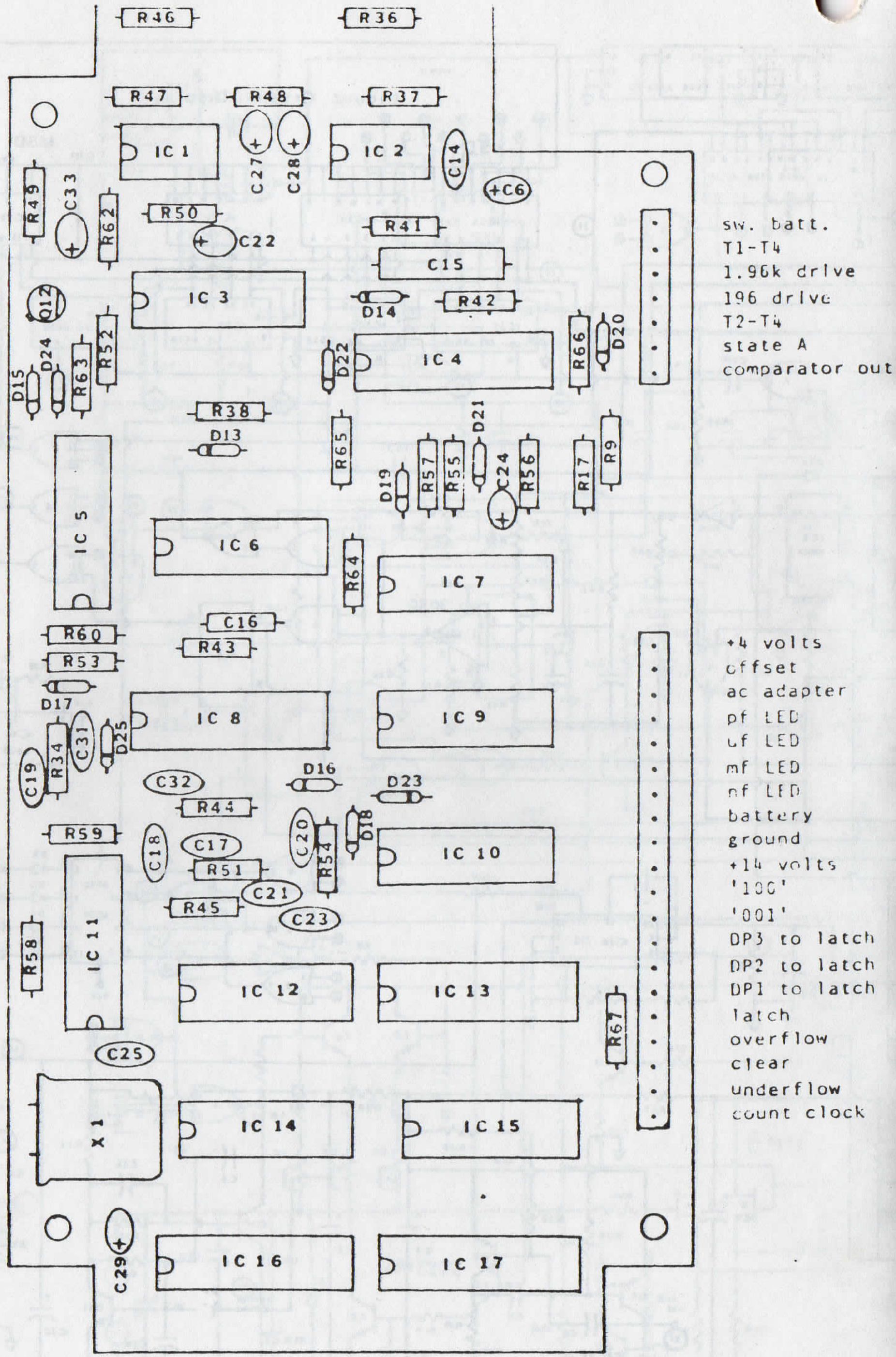
The timing for a single trial consists of five events, labeled T1→T5 (see figure 1). T1 corresponds to the start of a trial, and is caused by 4/15 going high. The unknown capacitor begins charging. When the voltage on the unknown rises

through the lower threshold of the front-end comparator, it is time T2. When the capacitor voltage reaches the upper threshold, time T3 occurs. Time T2 is delayed a variable amount by IC2 to produce a variable capacitance offset. The time between T2 delayed and T3 is measured to give the capacitance.

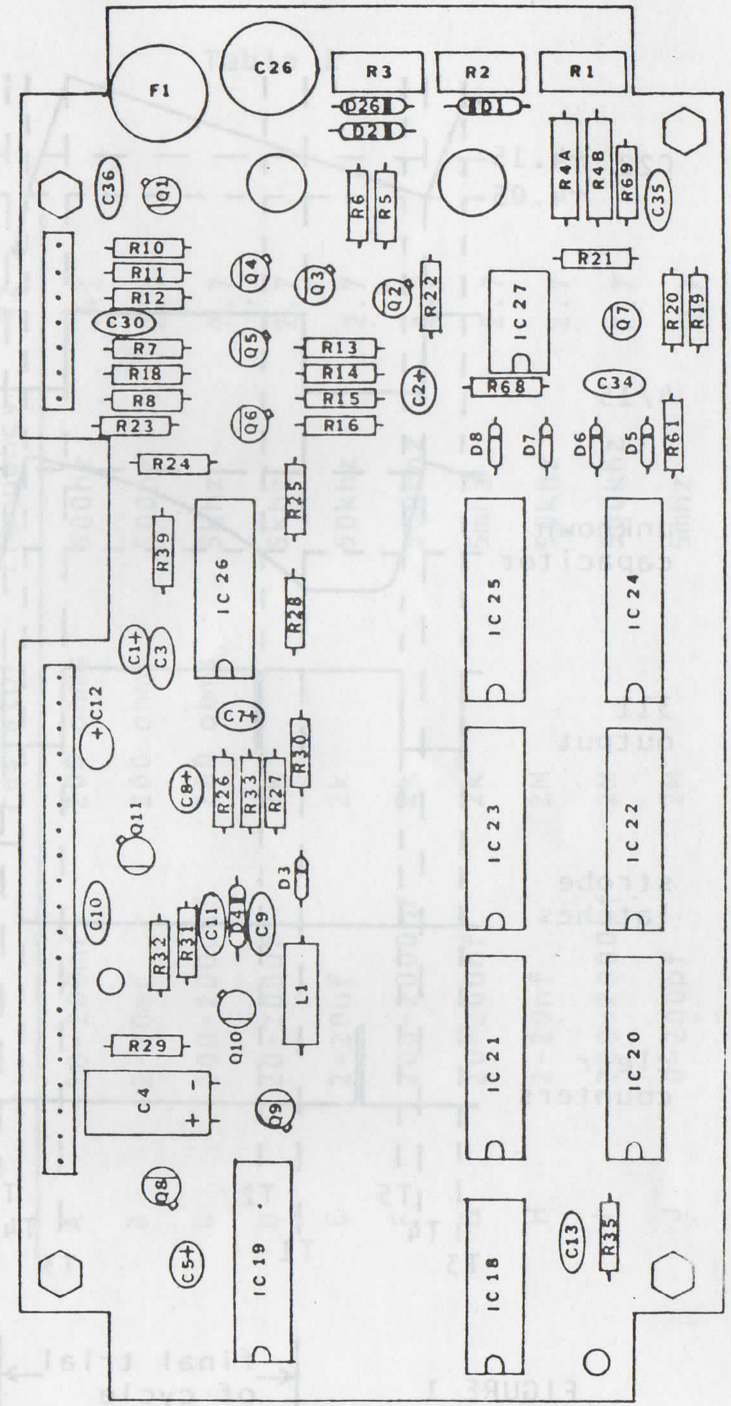
Latch 8/10 is high during the T2→T4 interval. 6/3 is high between T3 and T4. 3/3 goes low for the T2 delayed to T3 interval. When the offset control is set below zero, T3 preceeds the T2 delayed signal. In this case, a negative value is displayed, as the counters are gated on for the T3 to T2 delayed interval, and latch 8/1 goes to high causing the leftmost decimal point to set. This negative value latch is reset at the onset of a new trial.

At T3, C22 begins discharging through R62 and Q12. Shortly after this, C22 passes through the lower threshold of IC1; when IC1 changes state at T4, the unknown capacitor begins discharging. Discharge of the unknown through the lower threshold of the front-end comparator causes it to change state at T5, at which time C22 begins charging again. When C22 reaches the upper threshold of IC1, T1 of the next cycle is initiated.


Liquid Crystal Display
LSD
MSD
com
IC 25
IC 23
IC 21
IC 19
IC 22
IC 20
IC 16
IC 17
IC 14
IC 15
IC 11
IC 8
IC 24
IC 26
IC 18
3080
311
E 411
2N2222



Board I



Board II

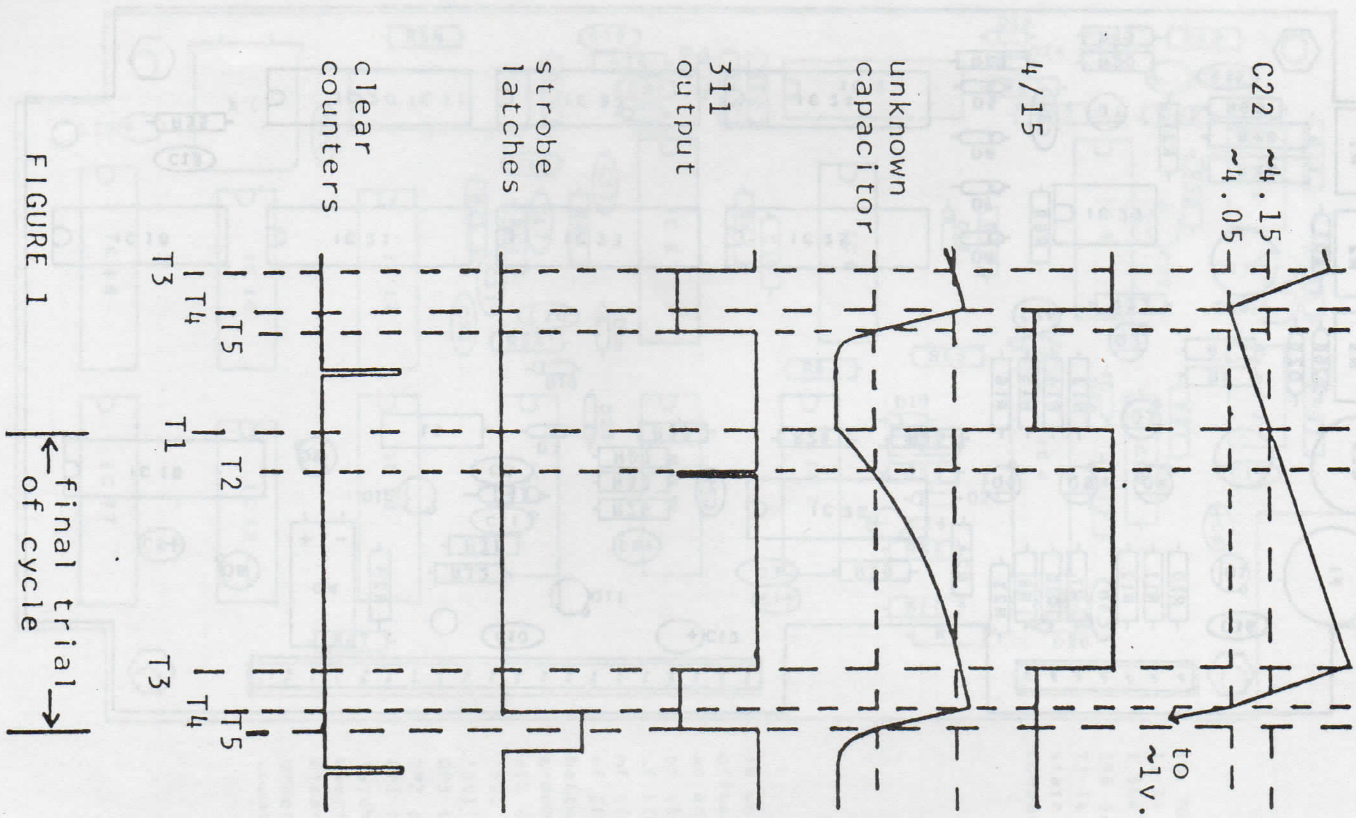


FIGURE 1

Table 1

State	Range	Charging resistor	Counting frequency	Voltage V2
A	20-200mf	200 ohms	500hz	.42
B	2-20mf	200 ohms	500hz	2.7
C	200-2000uf	200 ohms	5khz	2.7
D	20-200uf	2k	5khz	2.7
E	2-20uf	2k	50khz	2.7
F	200-2000nf	2k	500khz	2.7
G	20-200nf	2k	5mhz	2.7
H	2-20nf	2M	50khz	2.7
I	200-2000pf	2M	500khz	2.7
J	0-200pf	2M	5mhz	2.7

PARTS LIST

R1	100k pot	R38	10k*
R2	100 pot	R39	3.48k 1%
R3	10 pot	R40	1k pot
R4	1.96M, 1%	R41	3.48k 1%
R5	1.96k, 1%	R42	51k
R6	196 1%	R43	51k
R7	4.7k	R44	51k
R8	4.7k	R45	51k
R9	4.7k	R46	1M
R10	1k	R47	1M
R11	10k	R48	27k
R12	51k	R49	4.7k
R13	9.76k, 1%	R50	1.5M
R14	1.02k, 1%	R51	2.2M
R15	2.10k, 1%	R52	10k
R16	110 1%	R53	100k*
R17	27k	R54	51k
R18	10k	R55	51k
R19	10k 1%	R56	470k
R20	10k 1%	R57	27k
R21	4.7M	R58	22M
R22	10k	R59	51k
R23	10k	R60	51k
R24	13k	R61	200
R25	100	R62	3k
R26	27k	R63	100
R27	22k	R64	51k
R28	150	R65	100k
R29	4.7k	R66	390k
R30	22	R67	100k
R31	1k	R68	100k
R32	51k	R69	3k
R33	1k		
R34	4.7k	C1	10uf 15v
R35	100k	C2	10uf 15v
R36	1M	C3	120pf
R37	10k	C4	47uf 15v

C5	2.2uf 15v	D10	5082-4684
C6	10uf 15v	D11	5082-4684
C7	10uf 15v	D12	5082-4684
C8	10uf 15v	D13	1N4148
C9	120pf	D14	1N4148
C10	1nf	D15	1N4148
C11	10nf	D16	1N4148
C12	10uf 15v	D17	1N4148
C13	.01uf	D18	1N4148
C14	.1uf	D19	1N4148
C15	6.8nf	D20	1N4148
C16	27pf	D21	1N4148
C17	220pf	D22	1N4148
C18	22pf	D23	1N4148
C19	120pf	D24	1N4148
C20	220pf	D25	1N4148
C21	22pf	D26	1N4742 zener
C22	1.0uf		
C23	120pf		
C24	1.5uf 15v	Q1	2N2222*
C25	10pf	Q2	2N2222*
C26	5-40pf	Q3	2N2222*
C27	10uf 15v	Q4	2N2222
C28	10uf 15v	Q5	2N2222
C29	10uf 15v	Q6	2N2222
C30	1.8nf	Q7	E411
C31	510pf	Q8	2N2907
C32	220pf	Q9	2N2907
C33	2.2uf 15v	Q10	2N2222
C34	220pf	Q11	2N2222
C35	47pf	Q12	2N2222
C36	47pf		
D1	1N457A	IC1	CA3080E
D2	1N457A	IC2	CA3080E
D3	1N4148	IC3	4030
D4	1N964B zener	IC4	4449
D5	1N4148	IC5	4011
D6	1N4148	IC6	4001
D7	1N4148	IC7	4075
D8	1N4148	IC8	4044
D9	5082-4684 LED	IC9	4071

IC10	4075
IC11	4011*
IC12	4071
IC13	4017
IC14	4016
IC15	4016
IC16	4518
IC17	4518
IC18	4047
IC19	4054
IC20	4518
IC21	4056
IC22	4518*
IC23	4056
IC24	4042
IC25	4056
IC26	723
IC27	LM311

X1	5.0 mhz
F1	Type 112 bulb
L1	390 uh
LCD	Hamlin 3601
B1	4-'AA' cells
S1	Oak 415

* Selected

MAINTAINANCE

In the event that the Model 100 is connected across a large value charged capacitor, fuse F1 (= a type 112 light bulb) will blow to protect the meter. The symptom of a blown fuse is a displayed value independent of the test capacitor. This value will be approximately minus (leftmost decimal point on) 75 pf, and can be altered by the 'cap. offset' control. Fuse F1 is socketed **and accessible by removing the box back.** Do not replace it with anything other than a 112 bulb.

Other repairs should not be attempted unless the repairman is accustomed with the precautions necessary for working with CMOS ic's. The two p.c. boards should not be seperated unless both the boards and workman are grounded. Use only a grounded soldering iron when making repairs.

If the display board is removed from the box, be sure to reposition the grounding pin to the front panel (between the banana jacks) when reassembling.

CALIBRATION

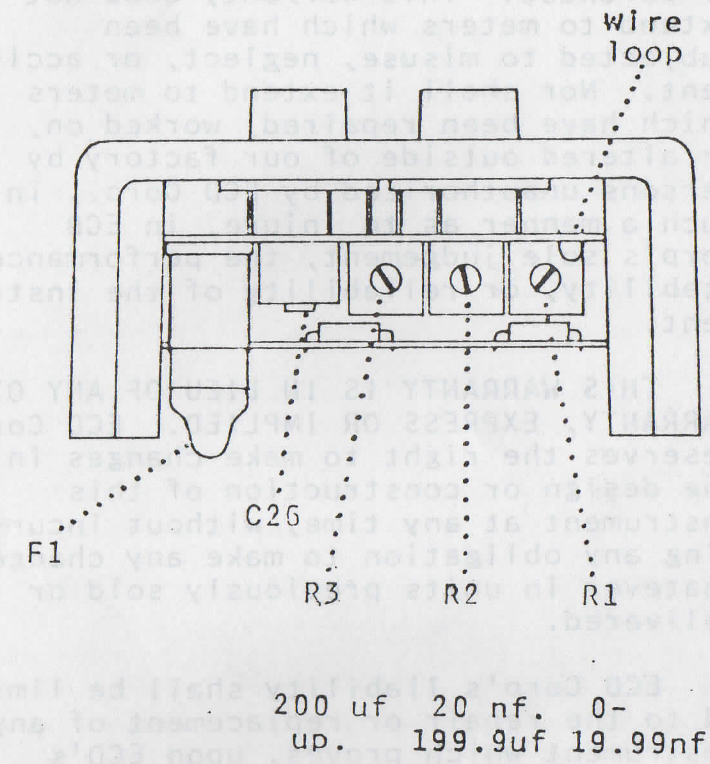
The Model 100 comes fully calibrated from the factory. Recalibration should be done semi-annually, if deemed necessary by the application.

The calibration procedure is very simple. A screwdriver and 3 precision capacitors are necessary. The first capacitor should be somewhere between 100 pf and 19.99 nf. The second should lie between 100 nf and 199.9 uf. The last capacitor should be over 200 uf. The values of the first two capacitors should be known to at least 0.1% (.01% recommended) and the last to 1% (0.1% recommended). Values just under a multiple of 2 will give the best resolution for the adjustments. Either good quality film capacitors measured accurately on a precision bridge, or commercial standard capacitors, can be used for the calibration.

The first step is to zero the capacitance offset via the front panel control, as outlined in the operating instructions section. The three adjustments to be made are non-interactive, and can thus be performed in any order. With the capacitor between 100 pf and 19.99 nf inserted, adjust R1 for the correct value on the display. Repeat with the 100 nf to 199.9 uf capacitor and R2. Repeat with the capacitor

greater than 200 ufd and R3. This completes the calibration.

Lift edge of shield to access R1, R2, R3, and wire loop.



WARRANTY

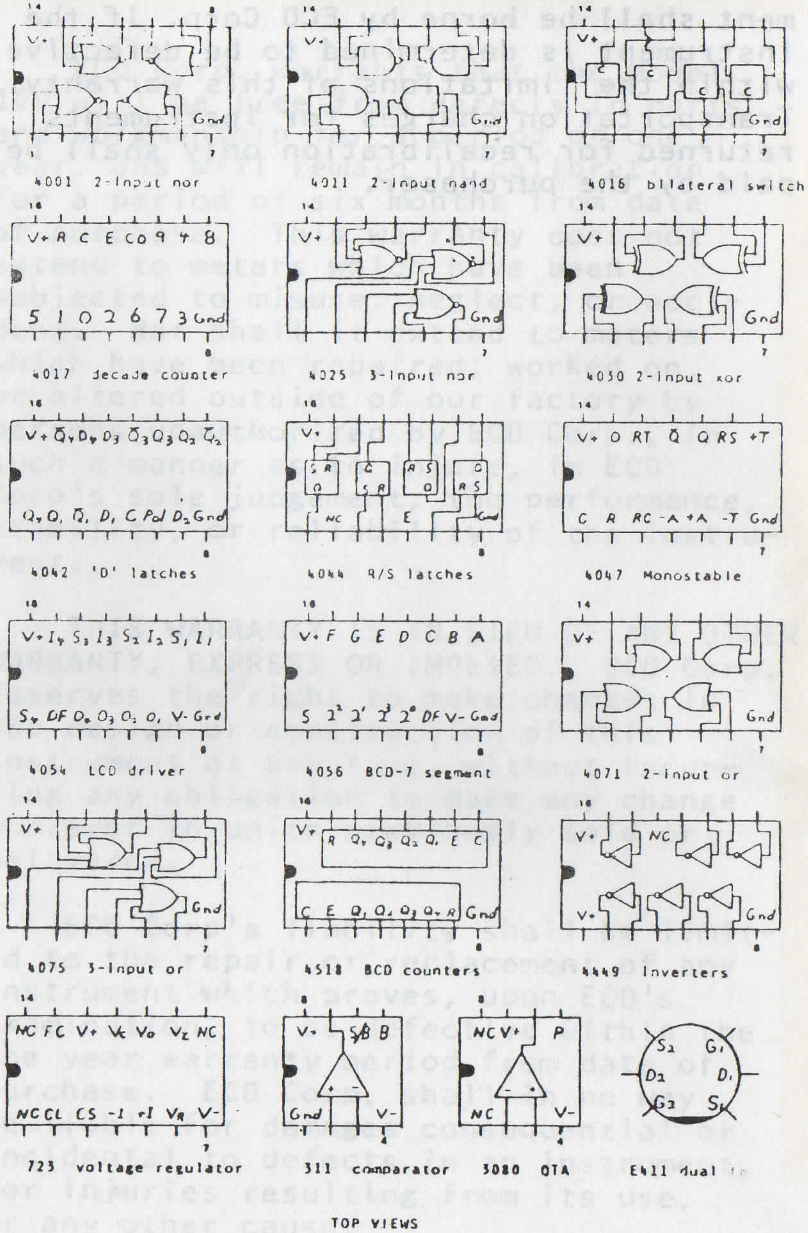
ECD Corp. warrants that the Model 100 will be free from defects in parts and workmanship for a period of one year, and will remain in calibration for a period of six months from date of purchase. This warranty does not extend to meters which have been subjected to misuse, neglect, or accident. Nor shall it extend to meters which have been repaired, worked on, or altered outside of our factory by persons unauthorized by ECD Corp., in such a manner as to injure, in ECD Corp's sole judgement, the performance, stability, or reliability of the instrument.

THIS WARRANTY IS IN LIEU OF ANY OTHER WARRANTY, EXPRESS OR IMPLIED. ECD Corp. reserves the right to make changes in the design or construction of this instrument at any time, without incurring any obligation to make any change whatever in units previously sold or delivered.

ECD Corp's liability shall be limited to the repair or replacement of any instrument which proves, upon ECD's examination, to be defective within the one year warranty period from date of purchase. ECD Corp. shall in no way be liable for damages consequential or incidental to defects in an instrument, for injuries resulting from its use, or any other cause.

For service under this warranty, please advise the factory promptly of all

details. Domestic surface transportation charges for return of a defective instrument shall be borne by ECD Corp. If the instrument is determined to be defective within the limitations of this warranty. Transportation charges for instruments returned for recalibration only shall be paid by the purchaser.


4001 2-input nor
4011 2-input nand
4016 bilateral switch
4017 decade counter
4025 3-input nor
4030 2-input xor
4042 'D' latches
4044 R/S latches
4047 Monostable
4054 LCD driver
4056 BCD-7 segment
4071 2-input or
4075 3-input or
4518 BCD counters
4049 inverters
723 voltage regulator
311 comparator
3080 OTA
TOP VIEWS

I.C. Pin-outs