HP 4342A

OPERATING AND SERVICE MANUAL

Q METER

4342A

HEWLETT PACKARD

HP 4342A

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and the mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

The product related to this manual is no longer in production at Hewlett Packard Co., As a service to our customers, we are supplying you with a photocopy of the original document.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment, except that in the case of certain components listed in Section 1 of this manual, the warranty shall be for the specified period. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environment specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILTY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

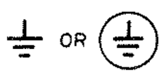
For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

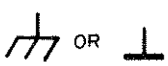
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

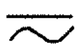
Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).



Alternating or direct current (power line).

WARNING

A **WARNING** denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

Note

A Note denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

GERÄUSCHEMISSION

Lpa < 70 dB
am Arbeitsplatz
normaler Betrieb
nach DIN 45635 T. 19

ACOUSTIC NOISE EMISSION

Lpa < 70 dB
operator position
normal operation
per ISO 7779

MANUAL CHANGES

4342A

Q METER

MANUAL IDENTIFICATION

Model Number: 4342A
Date Printed: MAR. 1983
Part Number: 04342-90009

This supplement contains important information for correcting manual errors and for adapting the manual to instruments containing improvements made after the printing of the manual.

To use this supplement:
Make all ERRATA corrections.
Make all appropriate serial number related changes indicated in the tables below.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES	SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
2451J04741 and above	1		
2451J05070 and above	2		

► NEW ITEM

ERRATA

Page 1-5, Table 1-1, Specifications,
Change the value of power consumption to 40VA max.

Page 6-19, Table 6-2, Reference Designation Index,
See Table 1, Parts Information.

Page 6-21, Table 6-2,
See Table 1, Parts Information.

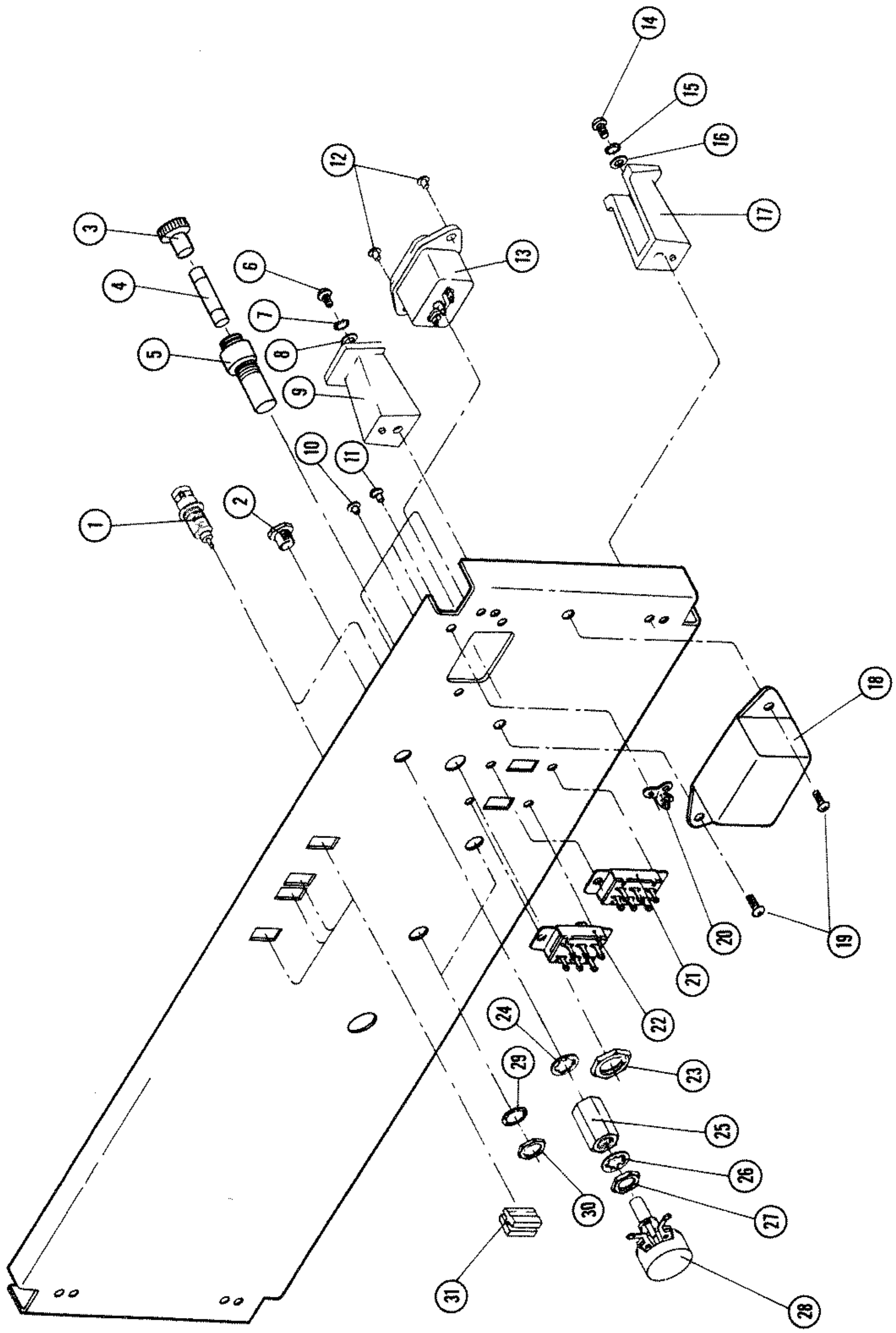
CHANGE 1

Page 6-30, Figure 6-7 (Sheet 1 of 2),
Change the Figure as shown on the next page.

NOTE

Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

HEWLETT PACKARD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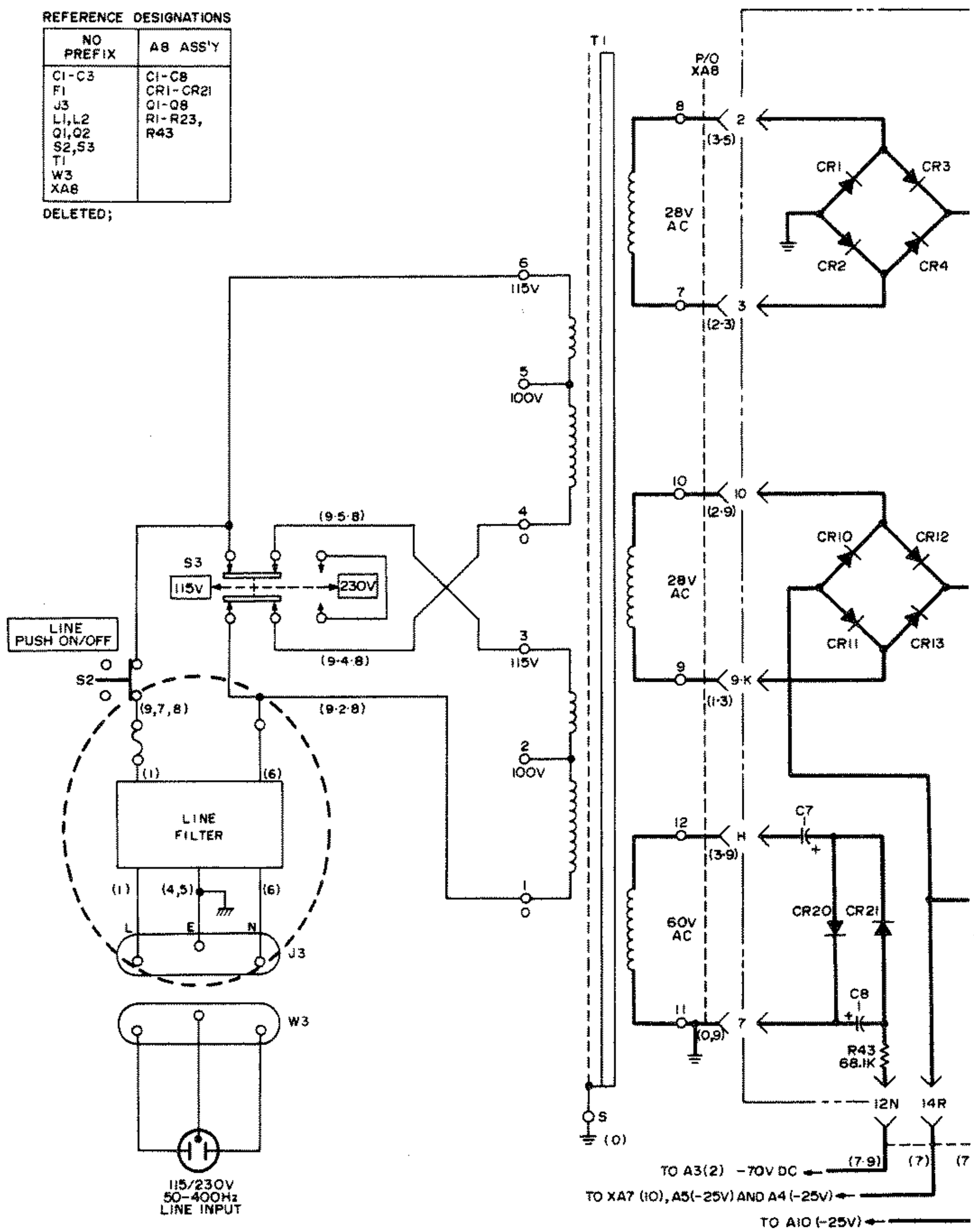
Page 6-31, Figure 6-7 (sheet 2 of 2);

Change the table in Figure as follows.

Item No.	Part No.	Q'ty	Description
1	1251-0083	2	CONNECTOR: BNC FEMALE
2	1410-0052	1	SCREW; BUSHING
3	2110-0565	1	FUSE CAP
4	2110-0016	1	FUSE: 0.6A 250V
5	2110-0564	1	FUSE HOLDER
6	2360-0199	2	SCREW-MACH 6-32
7	2190-0918	2	WASHER-LK HLCL
8	3050-0010	2	WASHER-FL MTLC
9	5040-0447	2	FOOT: REAR
10	0361-0008	4	RIVET SEMITUB ALUX 1/8 DIA
11	0360-0009	1	RIVET: TERM-SOLDER LUG
12	0361-0011	2	RIVET-SEMITUB
13	1251-8695	1	CONNECTOR: POWER
14	2360-0199	2	SCREW-MACH 6-32
15	2190-0918	2	WASHER-LK HLCL
16	3050-0010	2	WASHER-FL MTLC
17	5040-0447	2	FOOT: REAR
18	9135-0084	1	LINE FILTER
19	2360-0113	2	SCREW
20	0360-1859	1	TERMINAL STUD
21	3101-1234	1	SWITCH: SLIDE DPDT 115/230V
22	3101-0011	1	SWITCH: SLIDE DPDT 0.5 AMP 125 VDC
23	2110-0569	1	NUT: FUSE HOLDER
24	2190-0016	1	WASHER: LOCK INT 3/8 PH BRZ
25	2950-0039	1	WASHER: LOCK INT NO. 1/2. 789 OD STL CAD
26	2190-0016	1	WASHER: LOCK INT 3/8 PH BRZ
27	2950-0001	1	NUT: HEX BRS 3/8 X. 50 AF NI-F
28	2100-0732	1	R: VARIABLE COMP LIN 500 10 2W
29	2190-0016	2	WASHER: LOCK INT 3/8 PH BRZ
30	2950-0001	2	NUT: HEX BRS 3/8 X. 50 AF NI-P
31	0403-0131	4	GUIDE: PC BOARD

Page 8-13, Figure 8-7

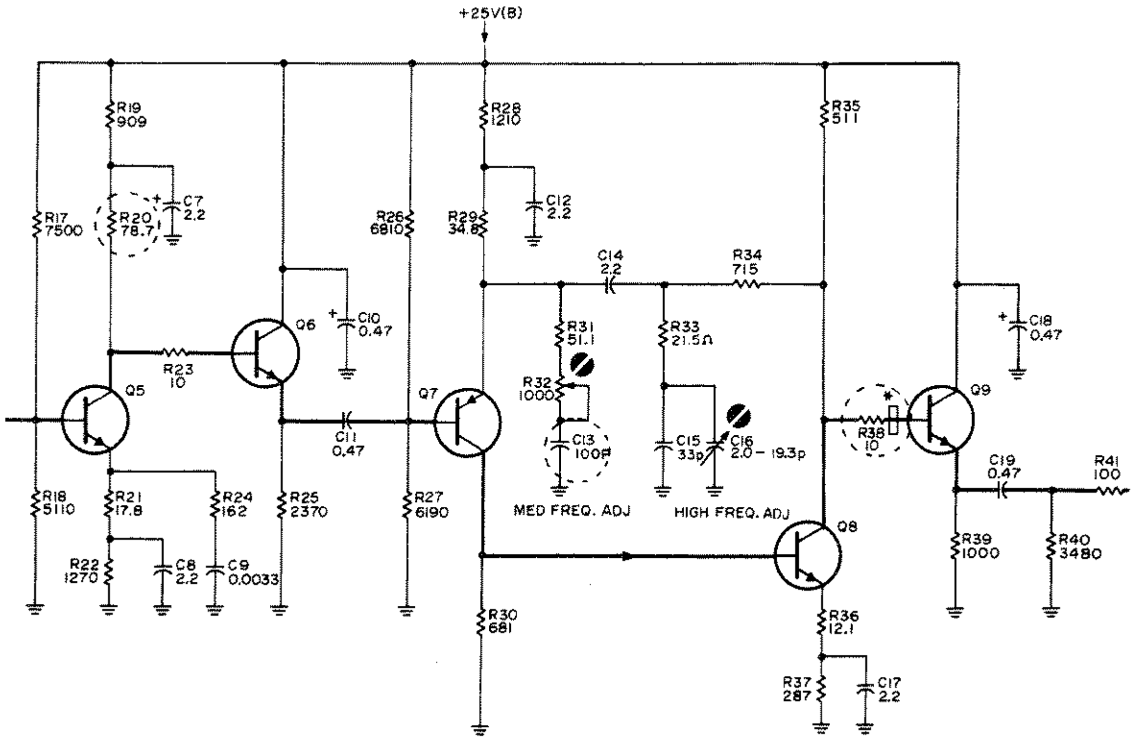
Correct the Figure as shown below;



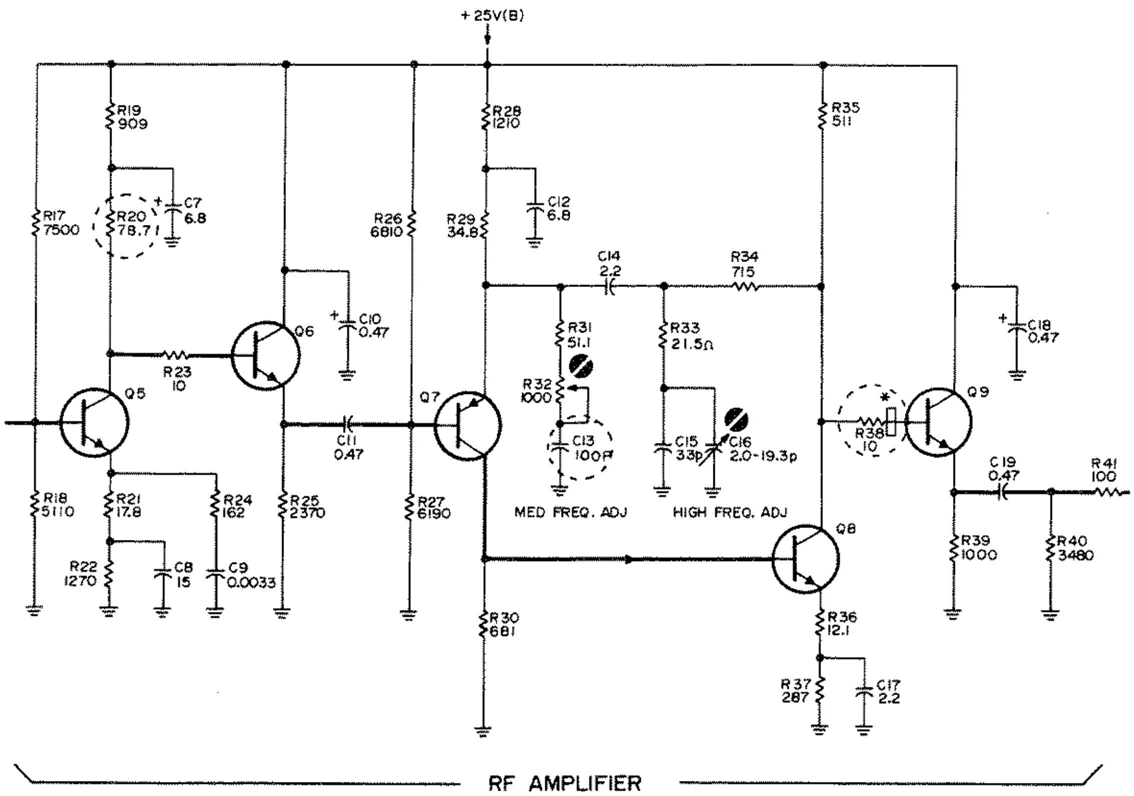
▶ CHANGE 2

Page 6-10, 6-11, Table 6-2, Reference Designation Index:
See Table 1, Parts Enformation.

Page 8-9, Figure 8-5, A3, A5, A6, All Ass'y:
Change the Figure as shown in Figure 1.



Page A9, Figure A2, A5 (OPTION 001) Ass'y:
Change the Figure as shown in Figure 2.



▶ CHANGE 3

Page 6-8, Table 6-2, Reference Designation Index:
See Table 1, Parts Information.

Table 1. Parts Information

CHANGE	PAGE	NOTE	Reference Designation	HP Part Number	Description
ERRATA	6-19	C	C2	0180-3409	C: FXD ELECT 1000μF 63VDCW
		C	C3	0180-3409	C: FXD ELECT 1000μF 63VDCW
		C	F1	2110-0016	NO CHANGE
	6-21	D		04342-3020	GLASS: FREQUENCY DIAL
		A		04342-7560	GLASS ASS'Y: FREQUENCY DIAL
2	6-10	C	A5C13	0160-2204	C: FXD MICA 100pF 5% 300VDC
	6-11	C	A5R20	0698-4395	R: FXD MET FLM 78.7Ω 1% 1/8W
	6-11	C		9170-0029	CORE-SHIELDING BEAD 2REQ'D
3	6-8	C	A3CR1	1901-0535	DIODE-SCHOTTKY SM SIG

▶ : New Item   A: Add   D: Delete   C: Change

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The HP Model 4342A Q Meter is designed to meet the requirements for making easy and accurate quality factor measurements in the laboratory, on the production line, or in QA incoming inspection areas. The direct reading, expanded scale of the 4342A permits measurement of Q from 5 to 1000 and the reading of very small changes in Q resulting from variation in test parameters. The long frequency dial scale and the pushbutton range selector continuously cover the frequency range of 22kHz to 70MHz (in seven - 1/3 decade steps) and permit setting the frequency to an accuracy of 1.5% with 1% resolution.

The calibrated long-scale capacitance dials permit reading the capacitance of the tuning capacitor at an accuracy of 1% and provides the capability for varying the capacitance with 0.1pF resolution on the vernier scale. Inductance of sample can be read directly from the inductance scale adjacent to the capacitance scale at seven specific frequencies by setting the frequency dial to the "L" point on each frequency range.

Flat oscillator output, automatically level-controlled over the entire frequency ranges, is a feature of the 4342A. This advantage obviates the necessity for frequent oscillator level adjustments to maintain the output level constant or the use of a specially matched fragile thermocouple level meter.

The high reliability of the instrument and ease of operation are the direct results of these measurement advancements in the 4342A.

For determing the resistance, reactance, or quality factor of capacitance and inductance samples in the high frequency region, the 4342A is a most versatile measuring instrument. The 4342A can measure the dissipation factor and dielectric constant of insulating materials, coefficient of coupling, mutual inductance, and the frequency characteristics of transformers. Accessories which extend the measurement capabilities, designed for

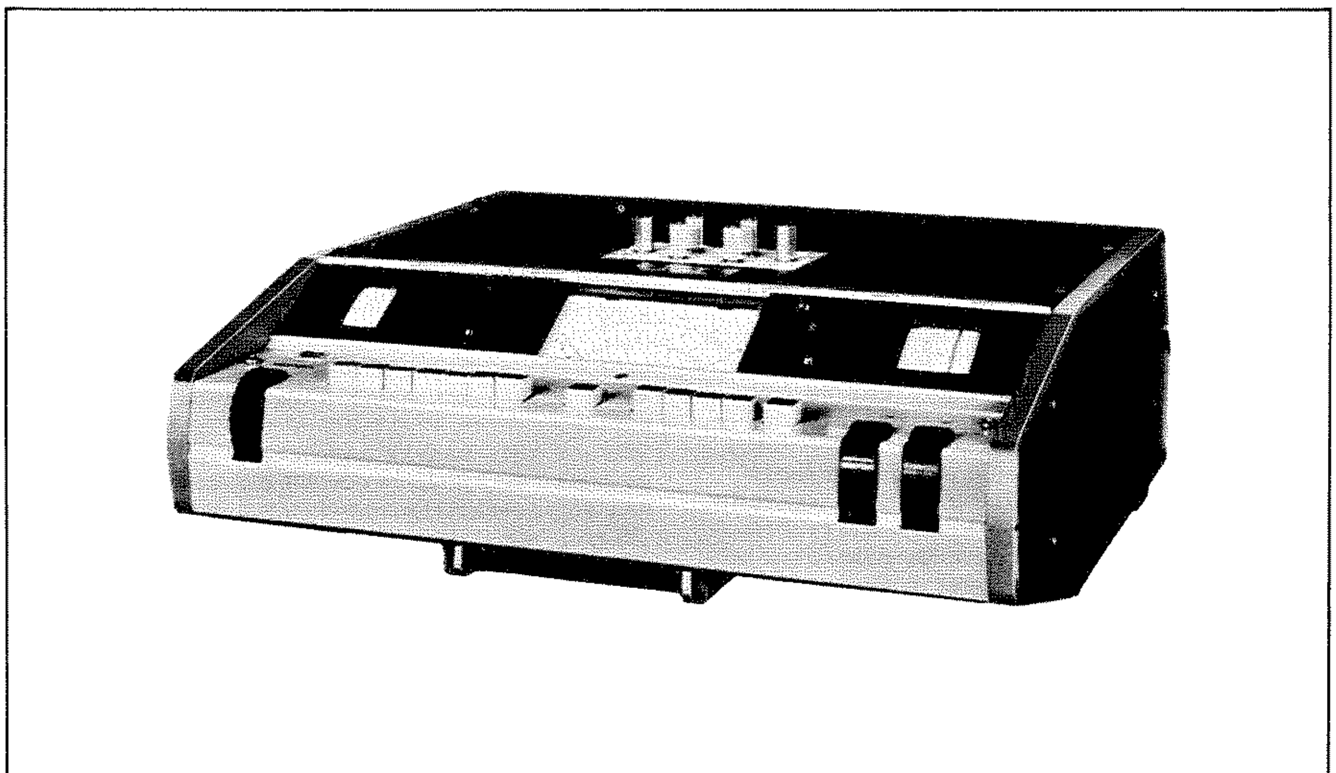


Figure 1-1. Model 4342A Q Meter.

user convenience, have broad applications in testing components and electronic materials, in physical and chemical research, and in related scientific fields.

Pushbutton operation of frequency range and Q/ΔQ range selection provides for straightforward measurement. Automatic indication of meter scales, frequency dials, and frequency multipliers are used, adding to the simplicity and reading speed.

1-3. How The 4342A Measures.

1-4. The Q Meter is basically composed of a stable, variable oscillator, a tuning circuit for taking resonance with an unknown sample, and a high input impedance RF voltmeter connected across the variable capacitor which is a section of the tuning circuit.

To measure the quality factor of a sample, a stable oscillator signal is injected into the series tuning circuit composed of the variable capacitor and the unknown (inductor). At the tuned frequency, the RF voltmeter (called Q voltmeter) indicates a peak value in the signal level increase (resonance) and is proportional to the quality factor of the sample measured. By injecting an oscillator signal with a low output impedance and by measuring the signal level of the series resonant circuit with a high impedance voltmeter, the quality factor of the unknown sample can be accurately determined at the resonant frequency. Additionally, various parameters of the sample can be measured (directly and indirectly) as factors of the resonant frequency and the tuning capacity which can be read from their respective dial scales.

1-5. For accurate measurements, the 4342A employs a unique constant voltage injection system and a low output impedance injection transformer. The oscillator signal is automatically leveled by an ALC loop to provide the constant injection voltage required by the Q range in use. This obviates the need of an oscillator level control or the fragile thermocouple level meter (as used in traditional Q Meters). The unique injection transformer along with the high quality low loss tuning capacitor contribute minimal additional loss to the measurement circuit (resonant circuit) and greatly improve the Q accuracy in high Q measurements.

1-6. High stability of the Q voltmeter virtually eliminates the need for Q-zero adjustments in routine measurements. Troublesome zero settings prior to each adjustment are thus eliminated, ensuring simple and rapid operation. Accurate determination of Q changes in delta-Q measurements can be obtained in all Q ranges by using the expanded resolution (X10) capability.

1-7. The unique Q Limit selector is especially useful in Go/No-Go checking on the production line. The high response speed of the Go/No-Go indicator (compared to using a meter pointer deflection method) permits faster Go/No-Go testing. For even easier testing, external indicating devices may be remotely controlled by the Go/No-Go output signal (on the rear panel).

1-8. INSTRUMENTS COVERED BY MANUAL.

1-9. Hewlett-Packard uses a two-section nine character serial number which is marked on the serial number plate (Figure 1-2) attached to the instrument rear panel. The first four digits and the letter are the serial prefix and the last five digits are the suffix. The letter placed between the two sections identifies country where instrument was manufactured. The prefix is the same for all identical instruments; it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

1-10. An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates that the instrument is different from those described in this manual. The manual for this new instrument may be accompanied by a yellow Manual Changes supplement or have a different manual part number. This supplement contains "change information" that explains how to adapt the manual to the newer instrument.

1-11. In addition to change information, the supplement may contain information for correcting errors (called Errata) in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is identified with this manual's title page. Complimentary copies of the supplement are available from Hewlett-Packard. If the serial prefix or number of an instrument is lower than that on title page of this manual, see Section VII Manual Changes.

1-12. For information concerning a serial number prefix that is not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-13. SPECIFICATIONS.

1-14. Complete specifications of the Model 4342A Q Meter are given in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. The test procedures for testing the instrument to determine if it meets its specifications are covered in Section V Maintenance Paragraph 5-9 Performance Checks. When the 4342A Q Meter is shipped from the factory, it meets the specifications listed in Table 1-1.

1-15. ACCESSORIES SUPPLIED.

1-16. Fuses (HP Part No. 2110-0339 and 2110-0044), the Operating and Service Manual, and a power cord are furnished with the 4342A. One of four types of power cords (HP Part No. 8120-1703, -0696, -1692 or -1521) is furnished depending on the instrument destination. All accessories supplied are packed in the instrument carton.

1-17. ACCESSORIES AVAIALABLE.

1-18. Accessories are specially designed devices which extend or enhance the measurement capabilities of the 4342A. The following accessories are available for use with the 4342A Q Meter:

16470 Series Supplemental Inductors:

A range of 20 inductors (model numbers 16471A to 16490A), which can be supplied separately or as a set, are available for use with the 4342A Q Meter. These inductors are useful as reference devices when measuring the RF characteristics of capacitors, resistors, or insulating materials. For 4342A option 001 instruments, the Model 16465A Inductor is additionally available. These inductors have three terminals including a guard terminal for stabilization of measurements.

16462A Auxiliary Capacitor:

The 16462A Auxiliary Capacitor is designed to extend the Q and L measurement capabilities of the 4342A. It is especially useful when measuring small inductors at low frequencies.

16014A Series Loss Test Adapter:

The 16014A Series Loss Test Adapter is a special terminal adapter designed for measuring low impedance components, low-value inductors and resistors, and also high value capacitors. The adapter adds convenience in connecting components in series with the test circuit of the 4342A Q Meter. It consists of a teflon printed-circuit base on which are mounted binding posts to accept the supplemental inductors, and a pair of low-inductance series terminals for the unknown.

16451A Dielectric Test Adapter (4342A-K01):

The 16451A Dielectric Test Adapter is a test fixture for measuring the dielectric constant or dielectric loss angle (tan δ) of insulating materials. The 16451A has a pair of precision variable electrodes (one side is fixed) which hold the sample and which operate similar to a micrometer to permit direct reading of electrode spacing. This test adapter is directly attached to 4342A measurement terminals.

Typical performance, characteristics, and additional information regarding these accessories are given in Table 1-2.

1-19. OPTIONS.

1-20. An option is a standard modification performed in the instrument to meet a special requirement desired by a user. When an instrument model is ordered with an option number, the corresponding optional parts are installed in/or packaged with instrument at the factory. An Option for obtaining a lower measurement frequency range is available for installation in the 4342A.

1-21. Option 001.

1-22. The 4342A Option 001 covers a lower frequency range, 10kHz to 32MHz, instead of the standard frequency range of 20kHz to 70MHz. All specifications that apply to Option 001 instruments are given in Table 1-1.

Table 1-1. Specifications (Sheet 1 of 2).

FREQUENCY CHARACTERISTICS

Measurement Frequency Range:
22kHz to 70MHz in 7 bands (22 to 70kHz, 70 to 220kHz, 220 to 700kHz, 700 to 2200kHz, 2.2 to 7MHz, 7 to 22MHz, and 22 to 70MHz).

Frequency Dial Accuracy:
±1.5% at 22kHz to 22MHz,
±2% at 22MHz to 70MHz,
±1% at "L" point on frequency dial.

Frequency Dial Resolution:
Approximately ±1%.

Q MEASUREMENT CHARACTERISTICS

Q Range:
5 to 1000 in 4 ranges (5 to 30, 20 to 100, 50 to 300, and 200 to 1000).

Q Tolerance: % of indicated value (at 25°C)

Q \ Frequency	22kHz - 30MHz	30MHz - 70MHz
5 - 300	±7%	±10%
300 - 600	±10%	±15%
600 - 1000	±15%	±20%

Q Resolution:
Upper scale: 1 from 20 to 100,
Lower scale: 0.5 from 5 to 30.

ΔQ Range:
0 to 100 in 4 ranges, 0 to 3, 0 to 10, 0 to 30, 0 to 100.

ΔQ Tolerance:
±10% of full scale.

ΔQ Resolution:
Upper scale: 0.1 from 0 to 10,
Lower scale: 0.05 from 0 to 3.

INDUCTANCE MEASUREMENT CHARACTERISTICS

L Range:
0.09μH to 1.2H, direct reading for seven specific frequencies as marked at the frequency dial "L" scale point and selected by the frequency range switches.

L Accuracy:
±3% after compensation for residual inductance (approx. 10nH).

TUNING CAPACITOR CHARACTERISTICS

Capacitance Range:
Main dial capacitor: 25 to 470pF
Vernier dial capacitor: -5 to +5pF

Capacitance Dial Accuracy:
Main dial: ±1% or 1pF whichever is greater.
Vernier dial: ±0.1pF.

Capacitance Resolution:
Main dial: 1pF from 25 to 30pF,
2pF from 30 to 200pF,
5pF from 200 to 470pF.
Vernier dial: 0.1pF.

Table 1-1. Specifications (Sheet 2 of 2).

REAR PANEL OUTPUTS

Frequency Monitor:
170mVrms min. into 50Ω.

Q Analog Output:
1V ±50mV dc at full scale, proportional to meter deflection, output impedance approx. 1kΩ.

Over Limit Signal Output:
Single pole relay contact output, one side grounded, relay contact capacity 0.5A/15VA.

Over Limit Display Time:
Switch-selectable, 1sec. or continuous.

GENERAL

Operating Temperature Range:
0°C to 50°C.

Warm-up Time: 30 minutes.

Power: 115 or 230V ±10%, 48 - 440Hz, approx. 25VA.

Weight: Approx. 31 lbs (14kg).

Accessories Furnished:
Power Cord

Accessories Available:
16471A through 16490A, and 16465A Supplemental Inductors.
16462A Auxiliary Capacitor.
16014A Series Loss Test Adapter.
16451A Dielectric Test Adapter.

Extender Board 15pin (Part No. 5060-4940).
Extender Board 6pin (Part No. 5060-0651).

OPTION 001:
This option covers a frequency range of 10kHz to 32MHz. Specifications are identical with those of the standard model except as noted below.

Oscillator Frequency Range:
10kHz to 32MHz in 7 bands (10 to 32kHz, 32 to 100kHz, 100 to 320kHz, 320 to 1000kHz, 1 to 3.2MHz, 3.2 to 10MHz, and 10 to 32MHz).

Frequency Accuracy:
±1.5% at 10kHz to 10MHz.
±2% at 10MHz to 32MHz.
±1% at "L" point on frequency dial.

Q Tolerance: % of indicated value (at 25°C)

Q		
5 - 300	300 - 600	600 - 1000
±7%	±10%	±15%

DIMENSIONS:

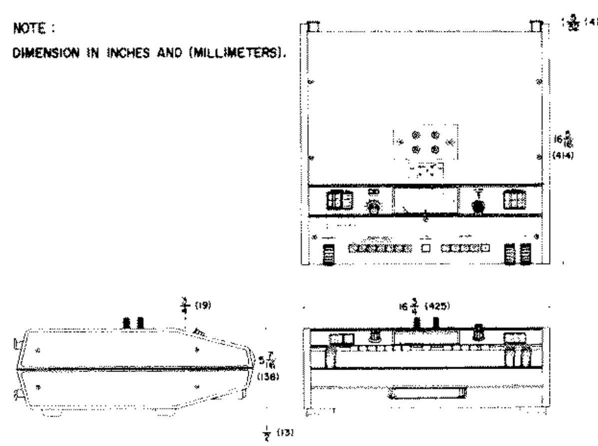


Table 1-2. Accessories - Typical Values.

16471A - 16490A, 16465A Supplemental Inductors

Model	Inductance	Approx. resonant frequency for tuning capacitance of 400pF	100pF	50pF	Q Limit	Capacitance (pF)
16471A	130 mH	22	40	62 kHz	below 300(30 kHz)*	8
16472A	52 mH	35	70	100 kHz	below 300(50 kHz)*	8
16473A	25 mH	50	100	140 kHz	below 300(70 kHz)*	8
16474A	10 mH	80	160	220 kHz	below 300(100 kHz)*	8
16475A	5.2mH	110	220	300 kHz	below 300(150 kHz)*	8
16476A	2.8mH	150	300	420 kHz	below 300(200 kHz)*	8
16477A	1 mH	250	500	700 kHz	below 300(300 kHz)*	8
16478A	520 μH	350	700	1000 kHz	below 300(500 kHz)*	8
16479A	250 μH	500	1000	1400 kHz	below 300(1MHz)*	7
16480A	100 μH	800	1600	2200 kHz	below 300(1MHz)*	7
16481A	56 μH	** 1	2.2	3.1MHz	below 300(1MHz)*	7
16482A	28 μH	1.5	3	4.2MHz	below 300(1.5MHz)*	7
16483A	10 μH	2.5	5	7 MHz	below 300(2.5MHz)*	6
16484A	5.2μH	3.5	7	10 MHz	below 300(10MHz)*	6
16485A	2.5μH	5	10	14 MHz	below 300(15MHz)*	6
16486A	1 μH	8	16	22 MHz	below 300(20MHz)*	6
		100pF	35pF			
16487A	0.52μH	22MHz	35MHz		below 300(35MHz)*	6
16488A	0.28μH	30MHz	50MHz		below 300(50MHz)*	4
16489A	0.1 μH	50MHz	70MHz		below 300(70MHz)*	3
16490A	0.07μH	60MHz	100MHz		below 300(70MHz)*	2
		400pF	100pF	50pF		
***16465A	630 mH	10	20	28 kHz	below 300(12 kHz)*	9

* The frequency in parentheses indicates frequency at which maximum Q factor is obtained (for the respective inductor).
** Approx. resonant frequency for tuning capacitance of 450pF.
*** For 4342A Option 001 use only.

16462A Auxilialy Capacitor

Capacitance Range: 300pF to 2700pF in steps of 300pF. 10 ranges including OFF position.

Capacitance Accuracy: ±1% on all ranges.

Q: 5000 at 20kHz on all ranges.

Residual inductance: approx. 0.1μH.

Residual capacitance at OFF position: approx. 23pF.

16014A Series Loss Test Adapter

Useable Frequency Range: 10kHz to 10MHz.

Measurable Capacitance Range: 450pF to 0.225μF.

Measurable Resistance Range: 10mΩ to 80Ω at 10MHz, 4Ω to 8kΩ at 10kHz.

Stray Capacitance Between Unknown Terminals: approx. 3pF.

Insulation Resistance between Unknown Terminals: approx. 10MΩ at 1MHz.

Residual Inductance: approx. 30nH

16451A Dierectric Test Adapter
(refer to Page 3-21 Table 3-2).

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information for unpacking, inspection, repacking, storage, and installation of the Model 4342A.

2-3. INITIAL INSPECTION

2-4. MECHANICAL CHECK

2-5. If damage to the shipping carton is evident, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for mechanical damage. Also check the cushioning material for signs of severe stress.

2-6. PERFORMANCE CHECKS

2-7. The electrical performance of the Model 4342A should be verified upon receipt. Performance checks suitable for incoming inspection are given in Section V, Maintenance.

2-8. DAMAGE CLAIMS

2-9. If the instrument is mechanically damaged in transit, notify the carrier and the nearest Hewlett-Packard field office immediately. A list of field offices is on the back of this manual. Retain the shipping carton and padding material for the carrier's inspection. The field office will arrange for replacement or repair of your instrument without waiting for claim settlements against the carrier.

2-10. Before shipment this instrument was inspected and found free of mechanical and electrical defects. If there is any deficiency, or if electrical performance is not within specifications, notify your nearest Hewlett-Packard Sales and Service Office.

2-11. STORAGE AND SHIPMENT

2-12. PACKAGING. To protect valuable electronic equipment during storage or shipment always use the best packaging methods available. Your Hewlett-Packard field office can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are a few recommended packaging methods:

a. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq in. bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit.

b. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq in. bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of the instrument.

2-13. ENVIRONMENT. Conditions during storage and shipment should normally be limited as follows:

a. Maximum altitude, 20,000 feet
b. Minimum temperature, -40°F (-40°C)
c. Maximum temperature, 167°F (75°C)

2-14. POWER CONNECTION

2-15. LINE VOLTAGE. The Model 4342A operates from either 115 or 230 volt (±10%) ac line voltage and Line frequency from 50 to 400Hz. A slide switch on the rear panel permits quick conversion for operating from either voltage. Insert a narrow-blade screwdriver in the switch slot and slide the switch to the right for 115-volt operation ("115" marking exposed) or to the left for 230-volt operation ("230" marking exposed). The Model 4342A is supplied with 115-volt fuse; for 230-volt operation, be sure to replace this fuse with that listed in Table 2-1.

Table 2-1. AC Line Fuse

Conversion	115-volt	230-volt
Slide Switch	Right ("115")	Left ("230")
AC Line Fuse	0.6 amperes Slow-Blow 2110-0339	0.3 amperes Slow-Blow 2110-0044

CAUTION

To avoid damage to the instrument, before connecting the power cable, set the 115/230-volt switch for the line voltage to be used.

2-16. POWER CABLE. To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that instrument panels and cabinets be grounded. Accordingly, the Model 4342A is equipped with a detachable three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin of the three-prong connector is the ground pin. Proceed as follows for power cable installation.

a. Connect flat plug (3-terminal connector) to LINE jack at rear of instrument.

b. Connect plug (2-blade with round grounding pin) to 3-wire (grounded) power outlet. Exposed portions of instrument are grounded through the round pin on the plug for safety; when only 2-blade outlet is available, use connector adapter (HP Part No. 1251-0048). Then connect short wire from slide of adapter to ground to preserve the protection feature.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The 4342A Q Meter can measure the quality factor of inductors from 5 to 1000 and, in addition, capacitance, inductance and resistance, and the dielectric constant of insulating materials over the frequency range of 22kHz to 70MHz. This section provides the instructions and information necessary for operating the 4342A Q Meter.

Fundamental operating procedures and general techniques for measuring various parameter values of the unknown directly and indirectly by using accessories appropriate to the characteristics of the unknown are also outlined in this section.

3-3. PANEL CONTROLS, CONNECTORS AND INDICATORS.

3-4. Control panel, top terminal deck, and rear panel features of the 4342A are described in Figures 3-1 and 3-2. The numbers in the illustrations are keyed to the descriptive items for each figure. Other detailed information about the functions of the panel controls and connectors is provided in paragraphs 3-8 through 3-11.

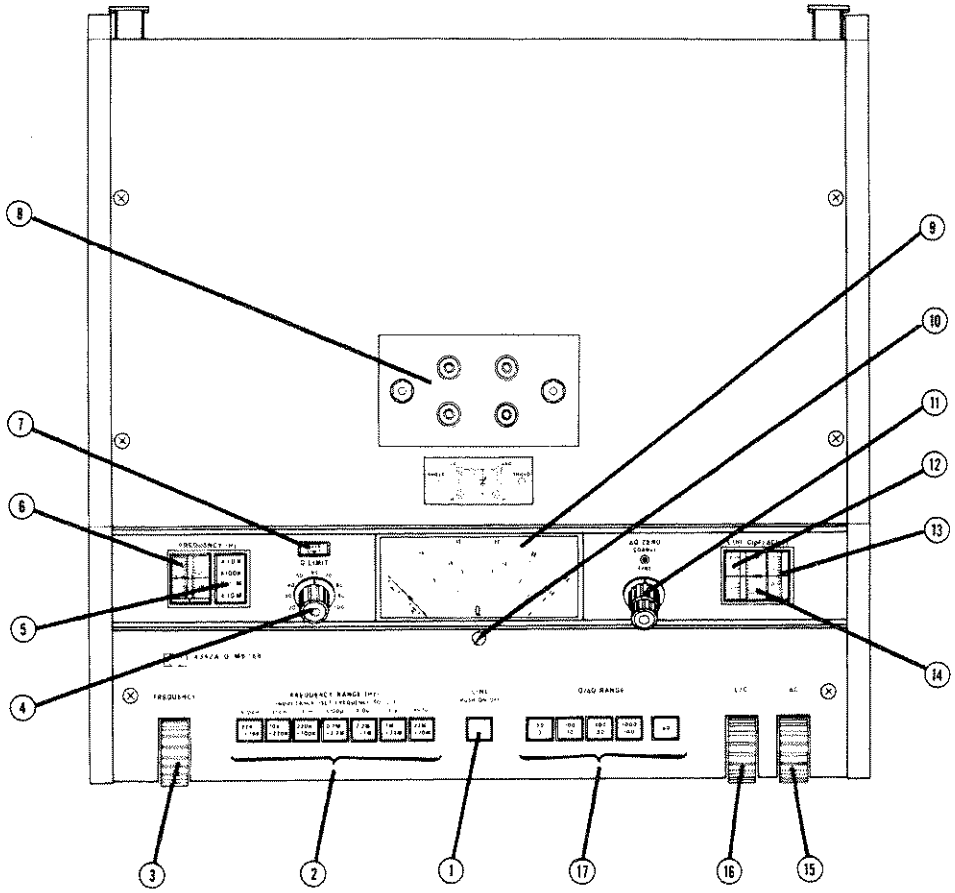
3-5. Q MEASUREMENT-GENERAL.

3-6. To complete the measuring circuit, the Model 4342A requires the connection of an inductor to the measurement COIL terminals. This circuit is then used to establish a resonance, either by setting the frequency controls to a predetermined frequency and varying the tuning capacitor, or by presetting the tuning capacitor to a desired value and adjusting the frequency controls. Resonance is indicated by maximum deflection of the panel Q meter. The Q value of the sample is proportional to Q meter deflection at the resonant frequency.

3-7. The "indicated Q" which is the Q meter reading at resonance is called the "circuit Q" because it includes all the additive losses inherent in the instrument including those in the tuning capacitor, the Q voltmeter input resistance, output resistance of the oscillator signal injection circuit, and contact resistances of the measurement terminals. To avoid ambiguity, the Q meter reading or "circuit Q" is called "indicated Q" throughout the balance of this manual. The "effective Q", which is dependent only on the inherent loss of the sample and can be measured only by an ideal measuring circuit, is somewhat greater than the "indicated Q". However, the "indicated Q" can approximate the "effective Q", by reducing instrument losses as much as is possible. So, in most instances, these Q values can be deemed to be the same. The 4342A employs a Constant Voltage Injection System obviating the use of a thermocouple level meter (the resistance of thermocouple device would contribute additional losses to the measuring circuit) and the coupling resistor used in traditional Q meters. The low output impedance of the injection transformer, the improved operating performance of the Q voltmeter, and the precision tuning capacitor which has extremely low loss over a wide frequency range minimize the difference between the "indicated Q" and "effective Q".

3-8. GO/NO-GO FUNCTION.

3-9. The 4342A Go/No-Go function provides an annunciation when the measured Q value exceeds a reference value. Two annunciation outputs, the OVER LIMIT lamp display and a relay contact output (rear panel) are available. The OVER LIMIT indicator lamp lights and the relay is energized when the measured Q value is over the reference value set by the front panel Q LIMIT control. Annunciation time can be selected to occur at either 1 second intervals or to be continuous by the rear panel OVER LIMIT DISPLAY TIME switch. When the switch is set to its 1 sec position and the Q meter indication goes over the preset Q limit control value, the OVER LIMIT lamp lights once for 1 second. In the contínous mode, the lamp stays continuously lit during the entire time that the Q value meter deflection exceeds the preset value. Relay contact output follows in the same manner.



1. LINE PUSH ON/OFF Switch: Instrument power on/off switch.

2. FREQUENCY RANGE Selector: These pushbuttons select the desired measurement frequency range from among the seven ranges covering 22kHz to 70MHz (10kHz to 32MHz for Option 001). The inductance range which may be measured directly at the "L" scale frequency point on the selected frequency range is labeled on the panel adjacent to the pushbuttons.

3. FREQUENCY Dial Control: This dial wheel varies the measurement frequency as well as the FREQUENCY dial scale ⑥. The frequency is read from FREQUENCY scale ⑥ and the multiplier indicator ⑤

4. Q LIMIT Control: This dial control sets the low limit of the Q value for Go/No-Go checks. The Q LIMIT setting dial scale numbers are related to meter deflection (% of full scale).

Figure 3-1. Front Panel Controls (Sheet 1 of 2).

5. Frequency Multiplier Indicator: The Frequency multiplier indicators, adjacent to the frequency dial scale, light and correspond with the settings of the frequency range selector ② pushbuttons.

6. FREQUENCY Scale: The Frequency scale comprises two scales with ranges of 2.2 to 7.0 and 7 to 22 (1.0 to 3.2 and 3.2 to 10 for Option 001). One or the other of the scales is automatically illuminated depending on the FREQUENCY RANGE selector ② setting.

7. OVER LIMIT Display: The letters "OVER LIMIT" are displayed when the measured Q value exceeds the limit value set by the Q LIMIT control ④.

8. Measurement Terminals: These binding post terminals facilitate connection of the unknown and the various measurement aid accessories. A simplified terminal circuit schematic is provided by the top panel label.

9. Q Meter: At maximum meter pointer deflection, this meter indicates the Q value of the sample or of the measuring circuit as well as the optimum tuning point. The outer two scales (0 to 100 and 0 to 30) are the Q readings. The inner two reverse scales (10 to 0 and 3 to 0) provide ΔQ readings when making ΔQ measurements. Meter scale indicators at the left end of scale automatically light to indicate the appropriate scale (to read) on the selected Q/ΔQ range.

10. Meter Pointer Adjustment Screw: This adjustment screw zero-sets the meter pointer so it is exactly over the zero calibration mark when the instrument is off.

11. ΔQ ZERO Controls: These coarse and fine controls adjust the meter indication for zero (reference) scale in ΔQ measurements. This function applies only to ΔQ measurements.

12. L Scale: This dial scale allows direct reading of inductance sample values at the "L" frequency. An "L" scale frequency point, common to and useable on all frequency ranges, is labeled with a blue letter on the FREQUENCY scale ⑥. The L scale indicates the inductance value of the unknown when resonated with the tuning capacitance at the "L" frequency.

13. ΔC Scale: This dial scale permits the reading of the capacitance of a vernier tuning capacitor from -5pF to +5pF in 0.1pF steps. The actual tuning capacitance is sum of the C Scale ⑭ and the ΔC Scale readings. A small change in the tuning capacitance adjustment point resulting from a variation in test parameters can be accurately read from the spread ΔC scale.

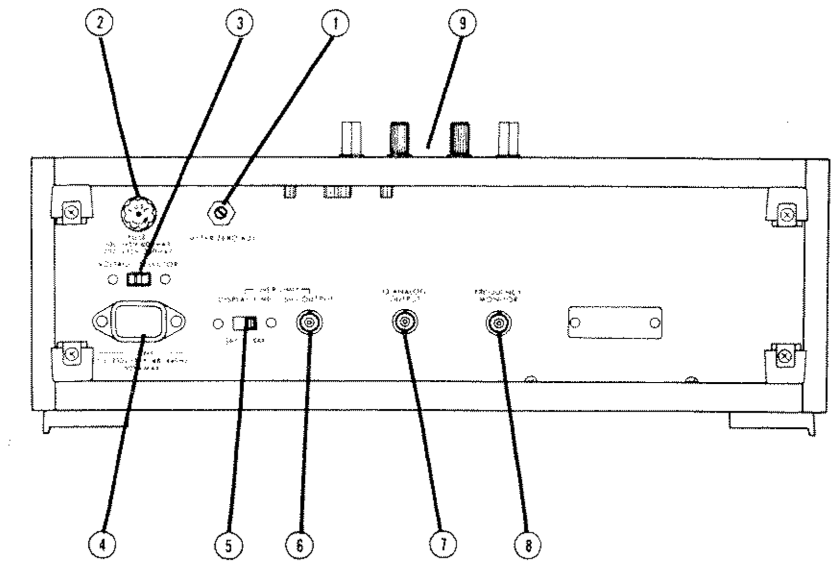
14. C Scale: This dial scale is for reading the capacitance of the main tuning capacitor which may be varied from 25pF to 470pF. A C scale reading is exact (calibrated) when the ΔC scale ⑬ is set to 0pF.

15. ΔC Dial Control: This dial wheel varies the vernier tuning capacitor and moves the ΔC Scale ⑬. The control employs a string drive mechanism which facilitates easy adjustment of vernier capacitor.

16. L/C Dial Control: This dial wheel varies the main tuning capacitor as well as moving the C scale ⑭ and L scale ⑫.

17. Q/ ΔQ RANGE Selector: These pushbuttons select the desired Q range (either 30, 100, 300 or 1000 full scale). ΔQ button enables ΔQ measurement and expands Q resolution by ten times (3, 10, 30 or 100 full scale).

Figure 3-1. Front Panel Controls (Sheet 2 of 2).



1. METER ZERO ADJ: This trimmer adjustment electrically zero-sets the meter pointer so that it is exactly over the zero calibration mark when the instrument is on.

2. FUSE: Instrument power fuse is installed in this fuse holder. Appropriate current rating for the fuse required is labeled on the rear panel.

3. VOLTAGE SELECTOR: This slide switch selects the appropriate ac operating power voltage (115V or 230V ±10%). Selection of the ac voltage must be made before the instrument is connected to power line.

4. LINE Receptacle: Male ac power line receptacle with center ground pin for powering the instrument from a 115V or 230V, 48 - 440Hz line. Before connecting power cord (furnished), VOLTAGE SELECTOR ③ should be properly set.

5. OVER LIMIT DISPLAY TIME Switch: This slide switch sets "OVER LIMIT" annunciation time for Go/No-Go checks to either 1 second (1 sec) or to continuous (∞).

6. OVER LIMIT SIG. OUTPUT Connector: Relay contact output for Go/No-Go checks. Center and outer conductors of this BNC connector are internally short-circuited when measured Q value exceeds the limit value set by the Q LIMIT control.

7. Q ANALOG OUTPUT Connector: 0 to 1V analog output proportional to meter deflection. Output impedance is approximately 1kΩ.

8. FREQUENCY MONITOR Connector: This BNC connector provides a portion of internal oscillator output for monitoring oscillator frequency with external equipment (such as a frequency counter). Output level is 170mVrms min. and output impedance is 50Ω.

9. Measurement Terminals: These six binding post terminals, including the two shield terminals, provide the connection capabilities for attaching the unknown sample as well as supplemental inductors, auxiliary capacitors, and other devices and accessories used in making measurements.

Figure 3-2. Rear Panel Controls and Connectors.

3-10. MEASUREMENT TERMINALS.

3-11. Six binding post terminals, including two shield terminals, mounted on the instrument top deck, facilitate connection of unknown samples and accessories to the measuring circuit. Figure 3-3 illustrates the measurement terminals circuit configuration. Shield terminals 3 and 6, and binding post 4 are directly connected to instrument chassis (grounded). Binding posts 1 and 2 are the LO and HI COIL terminals, respectively, to which an inductor is connected to compose the circuit to be resonated. Inductors can be measured by connecting them to the COIL terminals (1 and 2) and by taking resonance with the tuning capacitor. The oscillator signal is injected into the measuring circuit between LO COIL terminal 1 and GND terminal 4. Binding posts 4 and 5 are CAPACITOR terminals which are used for doing parallel connection measurements (outlined in paragraph 3-19). Shield terminals 3 and 6 are used for connection to the shield terminal of an inductor or to the guard terminal of the device connected between HI COIL terminal 5 and GND terminal 4.

3-12. HOW TO CONNECT UNKNOWN.

3-13. There are three basic methods of connecting unknown sample to the measuring circuit of the Q Meter. The characteristics of the unknown, the parameter value to be measured, and the measurement frequency are the factors which guide the selection of an appropriate connection method. The fundamental operating procedures for each individual connection method are outlined in Table 3-1.

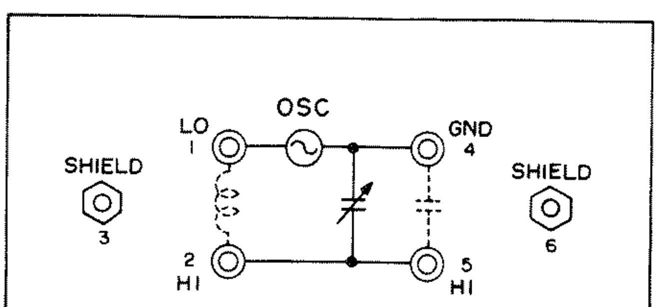


Figure 3-3. Measurement Terminal Circuit.

3-14. MEASUREMENT PARAMETERS AND CONNECTION METHODS.

3-15. The connection to the measuring circuit of the 4342A, when measuring quality factor, inductance, capacitance, resistance or dielectric constant, may be either a direct, parallel, or a series connection and depends upon the sample. As the sample values and measurement parameters are the guidelines for selecting an appropriate connection method, a discussion of the measurement capabilities unique to each connection method will help you to make straight-forward measurements. The measurement range limits of the individual connection methods and associated reasoning are outlined in the paragraphs which follow.

3-16. Direct Method Limitations.

3-17. When using the direct connection method in taking Q meter measurement parameters, only the quality factor, inductance, equivalent series resistance, and distributed capacitance of the inductor can be read from Q meter indications. In addition, the quality factor and the inductance measurement ranges covered by the direct connection method are dependent on sample inductance and measurement frequency. This is because the sample value and measuring frequency must satisfy the following mathematical relationship so as to resonate with the measuring circuit:

$$(2\pi f)^2 LC = 1 \quad \text{................} \quad \text{(eq. 3-1)}$$

Where, f: Measurement frequency
L: Inductance of sample
C: Tuning capacitance (read from C dial scale; 25pF to 470pF)

For example, if the measurement frequency is 1MHz, the inductance range of a sample which can be measured directly by the 4342A is approximately 54μH to 1.2mH. And, for a given inductance, the measurement frequency range is indicated. For example, a 10μH inductor can be measured over a frequency range of approximately 2.3MHz to 11MHz. Additionally, the quality factor of sample must be below 1000 (upper range limit). Figure 3-4 shows the relationships between the measurement frequency and the inductance limits measurable with the 4342A alone (without using any supplemental equipment). In Figure 3-4, the shaded area denotes the applicable inductances and useable frequencies. The seven bold lines in the shaded area indicate the "L" frequencies and the ranges of inductance which can be read from the L/C dial L scale at these particular L frequencies. The inductance at a measurement frequency other than the "L" frequency can be determined by substituting frequency and L/C dial (C scale) readings in equation 3-1.

3-18. Expansion of measurement ranges.

3-19. For higher or lower value inductances (above or below the shaded area in Figure 3-4), a parallel or series connection of the unknown to the measuring circuit enables the measurement to be made. To obtain the value of the desired parameter, these methods employ a comparison of the Q meter indications. The Q meter measuring circuit is first resonated with a reference inductor. Then the sample is connected in parallel or in series with the measuring circuit and the circuit again resonated. The sample value is calculated from the difference in Q meter indication measurements made before and after connecting the sample. In the equation from which the sample values are obtained, the values inherent in the reference inductor are subtracted from the measurement quantities. Consequently, the characteristics of the reference inductor do not (theoretically) affect measurement results.

In addition to their expanded measurement ranges, the parallel and series methods have some measurement capability advantages which do not appear when using direct methods. A detailed description of these advantages is given in the discussion in paragraph 3-58.

3-20. Capacitance Measurement.

3-21. For capacitor samples, either a parallel or series connection method may be used when measuring either the capacitance or the Q value. The criteria for selecting the appropriate connection method concerns only the sample value and is irrespective of the measurement frequency. Capacitances higher than approximately 450pF (up to approximately 0.2μF) are normally measured by the series method and lower capacitances are easily measured by the parallel method. Generally, capacitors can be measured at the desired frequency by using an appropriate inductor as a measurement aid.

3-22. Resistance Measurement.

3-23. Resistance values are fundamentally calculated from measured Q values. Thus, the connection method selected depends upon the sample value and the measurement frequency. Figure 3-5 shows approximate limits for both parallel and series measurements. The upper shaded area indicates the combinations of frequency and measurable resistance values for parallel measurements. Similarly, the lower shaded area indicates the values for series measurements. For sample values between the upper and lower shaded areas, it is difficult

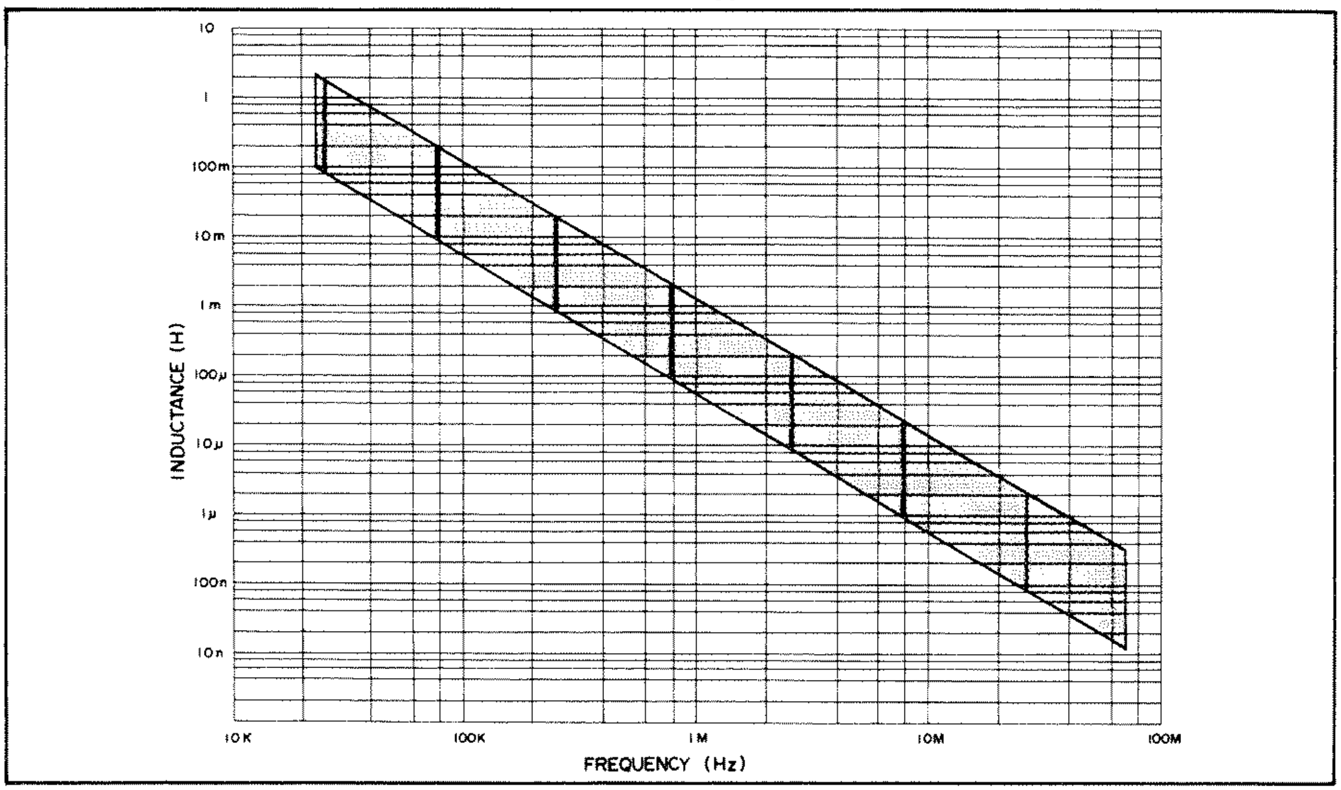


Figure 3-4. Inductance Measurement Ranges vs. Frequency (direct method).

to measure with either connection method. These limits are based on the use of a reference inductor having a Q value of 280. Parallel measurement low limits can be extended by using an external capacitor connected to the measurement CAPACITOR (HI and GND) terminals.

3-24. High Q Measurement.

3-25. Measurement of high quality factors up to 10000 can also be made by the parallel or series connection methods. These methods enable the measurement of low loss samples and are especially useful in the measurement of high Q capacitors. As inherent losses in the instrument will cause larger incremental measurement errors in higher Q measurements, these residual loss factors should be taken into consideration in the accuracies of measured values. In high Q measurements, the measured Q should be deemed to be only a rough approximation of the sample Q value. A detailed discussion on parallel and series connection measurement errors is provided in paragraph 3-60 and those which follow.

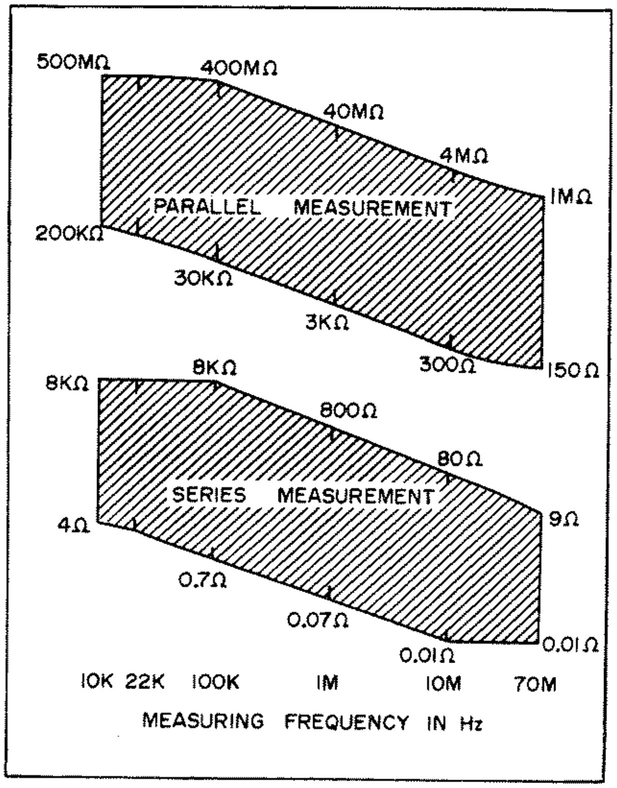


Figure 3-5. Ranges of Measurable Resistance.

3-26. Supplemental Equipment Used in Parallel and Series Methods.

3-27. For use with the 4342A as reference inductors, the Model 16470A series supplemental inductors are available. The 16470A series inductors have various inductances (from 0.07μH to 630mH) and totally cover the frequency range of 10kHz to 70MHz when used with the 4342A as measurement aids. The reference inductor must be resonated alone (before connecting unknown) at the desired measurement frequency to take its inherent values for reference. And, of course, the useable frequency range of each individual supplemental inductor depends upon the inductance of the individual coil. This frequency range is indicated on a label attached to the case of each inductor. Detailed data and information on the supplemental inductors is tabulated in Table 1-2.

3-28. Inductor samples whose inductance is somewhat lower than the low limits of the measurement range of the 4342A may be measured by using an external high Q capacitor to extend the available tuning capacitance range. The external capacitor is connected between HI and GND measurement terminals; its capacitance, thereby, adds to the tuning capacitance. For this special purpose, the HP 16462A Auxiliary Capacitor is available. This capacitor module combines nine capacitors from 300pF to 2700pF (in 300pF steps) and, when used with the 4342A, allows measurement of low inductances to approximately 1/6.7 of the measurement low limit of the instrument.

3-29. Dielectric constant of an insulating material is calculated from the capacitance value of the sample held between a pair of electrodes whose dimensions are accurately known. Model 16451A Dielectric Test Adapter is the test fixture which is specially designed for measuring dielectric constant (ε) and dielectric loss angle (tan δ) and is directly attached to the 4342A measurement terminals. The 16451A has a pair of variable precision electrodes which can hold materials measuring up to a maximum of 10mm in thickness. The electrodes operate similar to a micrometer permitting direct reading of electrode spacing (0 to 10mm) with 0.02mm resolution. The diameter of the electrodes has been designed so as to simplify the associated calculations. Measurement time is thus greatly shortened.

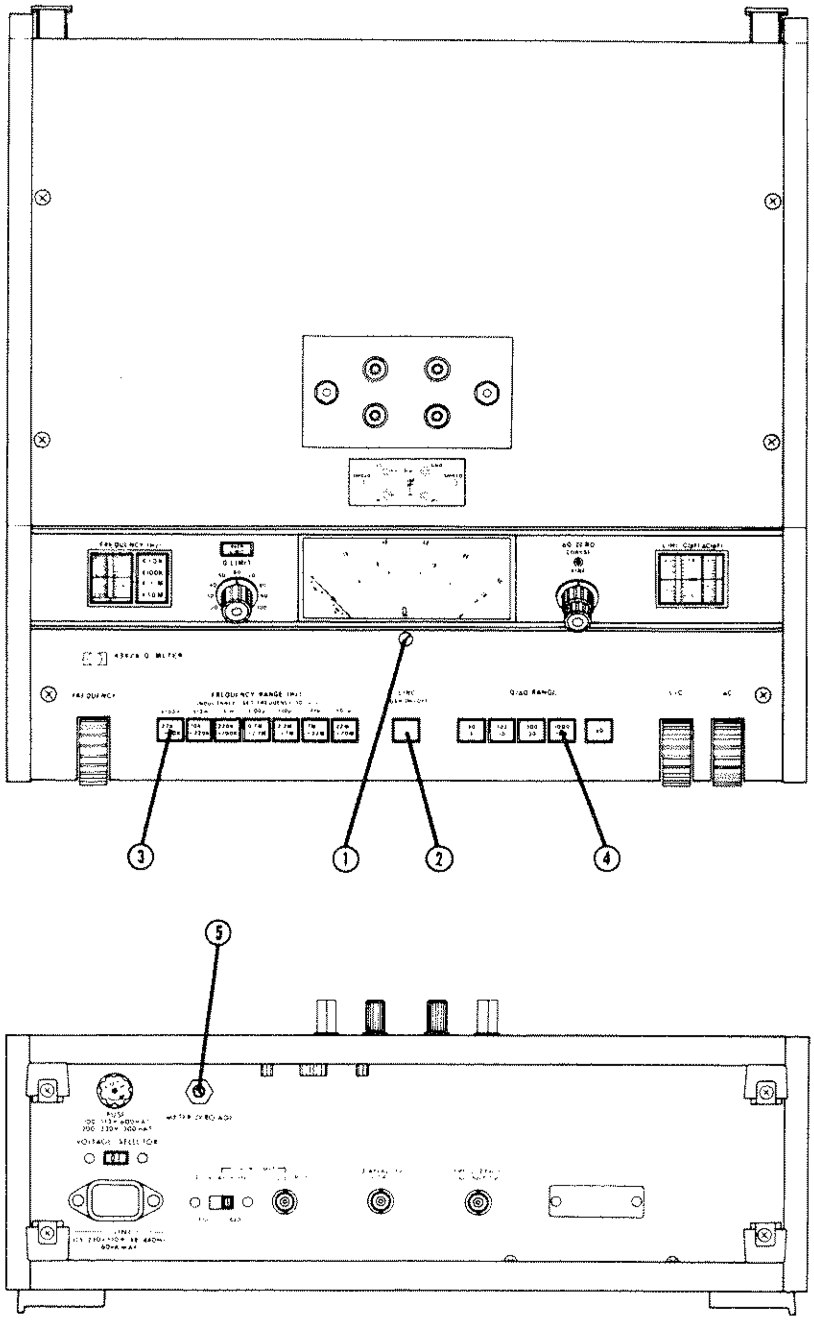


Figure 3-6. Zeroing Procedure (sheet 1 of 2).

Mechanical zero adjustment

The meter is properly zero-set when the pointer sets exactly over the zero calibration scale mark and the instrument is in its normal operating environment. To check the meter mechanical zero, turn the instrument off and allow 30 seconds to completely deenergize the instrument. To obtain maximum accuracy and mechanical stability, if the meter is not over zero, zero-set the meter as follows:

a. Rotate meter pointer adjustment screw ① clockwise until meter is moving toward zero in an upscale direction.

b. Continue rotating screw clockwise and stop when pointer is exactly at zero. If the pointer overshoots, continue rotating the adjustment screw clockwise to do steps a and b once again.

c. When the pointer is exactly over zero, rotate adjustment screw slightly counterclockwise to relieve tension on pointer suspension. If pointer moves off zero, repeat steps a, b and c, but rotate less counterclockwise.

Electrical zero adjustment

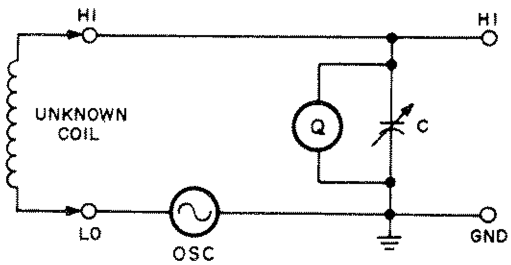
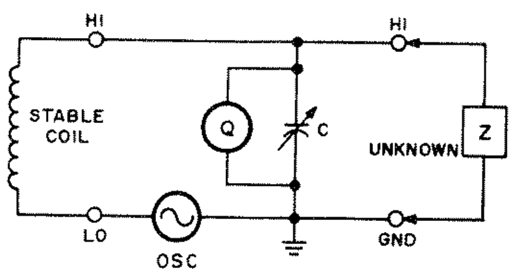
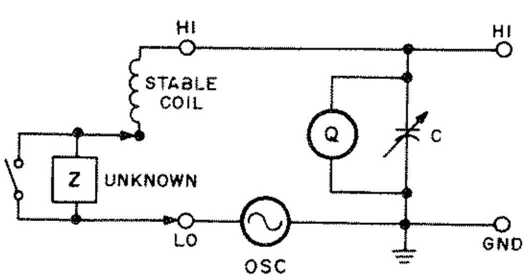
The meter pointer should set exactly over the zero scale mark when instrument is turned on and nothing is connected to measurement terminals. Turn the instrument on and allow at least 15 minuts warm-up time to let the instrument reach a stable operating condition. If meter pointer is not over zero, zero-set the meter as follows:

a. Set FREQUENCY RANGE selector ③ to 22k - 70k (10k - 32k for Option 001) and Q RANGE ④ to 1000.

b. Adjust rear panel METER ZERO ADJ control ⑤ so that the meter pointer is exactly over zero.

Figure 3-6. Zeroing Procedure (sheet 2 of 2).

Table 3-1. Methods of Connecting Unknown.

Direct Connection.  (A)	Inductors can usually be measured by connecting them directly to the COIL terminals as shown in Figure A. The measuring circuit is resonated by adjusting either the L/C dial or the FREQUENCY dial controls. The quality factor (indicated Q) of the sample is read at maximum deflection of the Q Meter. Setting the FREQUENCY dial to the "L" scale point and taking resonance with the L/C dial control permits reading the inductance of the sample directly from the inductance scale (adjacent to the tuning capacitor scale). Otherwise the inductance can be calculated from the frequency and capacitance dial readings at the desired resonant frequency.
Parallel Connection.  (B)	The parallel connection is suitable for high impedance measurements. High inductances, high resistances, and small capacitances can be measured by connecting the samples to the CAPACITOR terminals as shown in Figure B. Before connecting a sample, the measuring circuit is resonated with a stable inductor (such as a 16470 series supplemental inductor) connected to the HI and LO COIL terminals to obtain a reference Q reading and a capacitance dial reading. The measuring circuit is again resonated with the sample connected to the CAPACITOR terminals by re-adjusting the L/C dial for maximum Q meter deflection. The parameter values of the sample are derived from the Q meter readings and the L/C dial readings obtained before and after connecting the unknown sample. The derivation of parameter values related to the unknown are detailed in paragraphs 3-64 through 3-72.
Series Connection.  (C)	The Series connection is suitable for low impedance measurements. Low inductances, low resistances and high capacitances can be measured by connecting the sample in series with a stable inductor as shown in Figure C. The 16014A Test Adapter is useful for making the series connection to the unknown sample. First, a shorting strap is attached to the unknown connection terminals in parallel with the sample and the measuring circuit resonated with the L/C control. For reference, the Q meter and capacitance dial readings are noted. The shorting strap is then disconnected (or removed) and resonance of the measuring cicuit is again taken by adjusting the L/C dial. The parameter values of the unknown can be derived from the Q meter and capacitance dial readings obtained before and after disconnecting the shorting strap. The derivation of the parameter values related to the unknown are described in paragraphs 3-73 through 3-81.

3-30. BASIC Q METER MEASUREMENTS.

3-31. QUALITY FACTOR AND INDUCTANCE MEASUREMENTS (DIRECT CONNECTION).

3-32. This paragraph and those which follow describe the fundamental operating procedures for quality factor and inductance measurements which are typical applications of the Q Meter. An inductor usually has some distributed capacitance (Cd). The self-resonant frequency (fo) of the inductor is determined by its self-inductance and the Cd. The 4342A measuring circuit consideration of distributed capacitance is shown in Figure 3-7. If the Q meter indication is Qt when Cd is zero, then the presence of Cd will influence the voltage across the resonating inductor such that the Q meter will actually indicate a Q value lower than Qt. The indicated Q value (Qi) and the Qt can be correlated by a correction factor (which is a function of Cd and the tuning capacitance) each with the other. A similar correction factor also applies to difference of inductance readings resulting from the presence of Cd. A detailed discussion of correction factors is given in paragraph 3-50. When the Cd is less than 1/20 of the tuning capacitance, the difference between Qi and Qt (Li and Lt are similar in meaning) is within 5%.

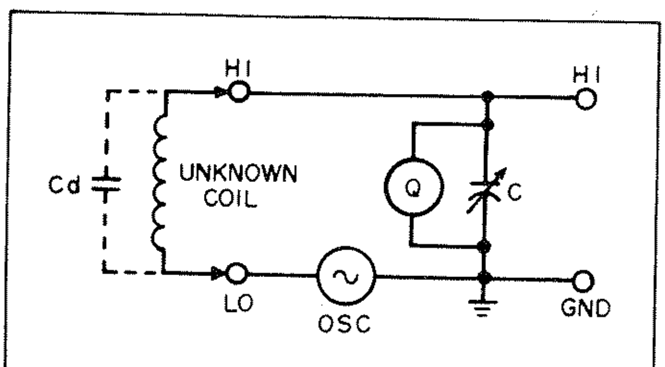


Figure 3-7. Distributed Capacitance in Direct Connection.

3-33. Q Measurement.

3-34. To read the quality factor of an inductance sample directly from the Q meter indication, proceed as follows:

a. Connect unknown to measurement COIL (HI and LO) terminals.

b. Depress an appropriate FREQUENCY RANGE button and set FREQUENCY dial control to the desired frequency.

c. Adjust L/C dial control for maximum panel Q meter deflection on the instrument.

Note

Alternatively, the resonance may be taken by setting the L/C dial to a desired position and adjusting the FREQUENCY dial for maximum Q meter deflection.

d. Depress Q RANGE button as appropriate for obtaining a Q meter deflection more than one-third of full scale and less than full scale.

e. Re-adjust L/C dial (or FREQUENCY dial) control for maximum deflection. If panel meter deflection exceeds full scale, up-range the Q RANGE and continue the adjustment. For easily obtaining a precise resonance, use the ΔC dial control.

Note

The ΔC dial control facilitates accurate adjustment for establishing resonance especially in high Q measurements.

f. Read panel Q meter indication on the meter scale designated by the appropriate scale lamp indicator lit.

Note

The measured Q value corresponds to the "indicated Q" of the sample.

g. To derive series equivalent resistance of the sample, substitute the Q meter FREQUENCY, C dial, ΔC dial, and Q readings in the following equation:

$$Rs = 1/\omega CQ \approx 0.159/fCQ \quad ..... \quad (eq.\ 3\text{-}2)$$

Where, Rs: equivalent series resistance in ohms.
f: frequency dial reading in hertz.
ω: 2π times the frequncy (2πf).
C: sum of C and ΔC dial readings in farads.
Q: panel Q meter reading.

3-35. ΔQ Measurement.

3-36. When two Q values are nearly identical, the difference is difficult to read accurately on the normal Q scale. The ΔQ feature of the 4342A provides accurate readings for changes in Q on all Q ranges by providing ten times resolution, namely: 0 to 3, 0 to 10, 0 to 30, and 0 to 100. To make a ΔQ measurement, proceed as follows:

a. Connect the sample inductor to the measurement COIL (HI and LO) terminals.

b. Resonate the inductor using the same procedure as described in Q Measurement (para. 3-34) steps b, c, d and e.

c. Note panel Q meter reading.

d. Depress ΔQ button and set ΔQ COARSE and FINE controls so that meter pointer indicates zero (full scale) on ΔQ scale.

e. Check for correct resonance by slightly rotating ΔC dial control. If Q meter deflection is not at peak, readjust ΔC dial and ΔQ controls.

f. Make the desired change in the sample or in the measuring circuit.

g. Adjust L/C dial control for maximum Q meter deflection. Use ΔC dial control for easily taking a precise resonance. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement and skip steps h and i.

h. Read panel Q meter indication on ΔQ scale. The ΔQ reading is the difference in Q resulting from the change made in step f.

i. The differential Q value (after change) is given by the following equation:

$$Q_2 = Q_1 - \Delta Q \quad \text{(eq. 3-3)}$$

where, Q_1: Q meter reading in step c (before change).
Q_2: present Q value (after change).
ΔQ: Q meter reading from ΔQ scale in step h.

j. When the change in Q exceeds ΔQ full scale, the difference is given by the following equation:

$$\Delta Q = Q_1 - Q_2 \quad \text{(eq. 3-4)}$$

3-37. Inductance Measurement.

3-38. The inductance of a coil can be measured directly from the Q meter inductance scale at specific "L" frequencies. The inductance range which may be measured directly at the "L" scale frequency point on the selected frequency range is labeled on the panel adjacent to the FREQUENCY RANGE pushbuttons. To measure inductance at the "L" frequency, proceed as follows:

a. Connect unknown to measurement COIL (HI and LO) terminals.

b. If the approximate value of inductance is known, select an appropriate measuring frequency range. Refer to the chart in Figure 3-4 or the inductance multiplier label adjacent to the FREQUENCY RANGE pushbuttons. For the samples whose values are quite unknown, select a trial frequency range. Depress the selected frequency range pushbutton.

c. Set FREQUENCY dial control for the "L" scale frequency designated by the mark "-L-" (shown in blue) on the FREQUENCY scale.

d. Set Q RANGE to 100. Rotate L/C dial control and verify that panel Q meter indicates peak deflection. If a peak meter deflection can not be recognized, change to another trial FREQUENCY RANGE setting and repeat the procedure until a peak is verified.

e. Set ΔC dial to zero scale (0pF).

f. Adjust L/C dial control for maximum Q meter deflection (change Q RANGE setting as necessary).

g. Read L/C dial L scale indicated by the fixed scale pointer. To calculate the inductance value, multiply the L scale reading by the factor for the selected inductance range.

Note

The measured value corresponds to the "indicated L" including measuring circuit residual factors (similar to "indicated Q" value).

3-39. Inductance Measurement (at a desired frequency).

3-40. Occasionally it may be necessary to measure inductance at frequencies other than the specific "L" frequencies. The frequency characteristic measurements of an inductor or of an inductor core are representative examples. In such instances, the inductance may be measured as follows:

a. Connect unknown inductor and resonate it using the procedure same as described in Q Measurement (para. 3-34) steps a through e.

b. Note FREQUENCY dial, L/C dial C scale and ΔC dial readings. Substitute these values in the following equation:

$$L = 1/\omega^2 C \approx 0.0253/f^2 C \quad \text{..... (eq. 3-5)}$$

Where, L: inductance value (indicated L) of sample in henries.
f: measurement frequency in hertz.
ω: 2π times the measurement frequency.
C: sum of C and ΔC dial readings in farads.

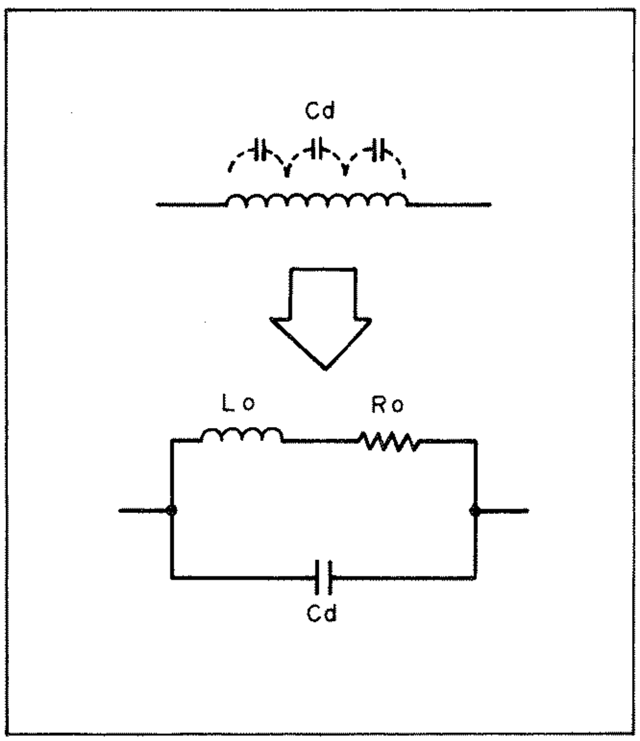


Figure 3-8. Distributed Capacitance Circuit Model.

3-41. MEASUREMENTS REQUIRING CORRECTIONS.

3-42. Effects of Distributed Capacitance.

3-43. The presence of distributed capacitances in a sample influences Q meter indications with a factor that is related to both its capacity and the measurement frequency. Considerations for the distributed capacitances in an inductor may be equivalently expressed as shown in Figure 3-8. In the low frequency region, the impedance of the distributed capacitance Cd is extremely high and has negligible effect on the resonating circuit. Thus, the sample measured has an inductance of Lo, an equivalent series resistance of Ro, and a Q value of ωLo/Ro (where, ω is 2π times the measurement frequency). In the high frequency region, the inductor develops a parallel resonance with the distributed capacitance and the impedance of the sample increases at frequencies near the resonant frequency. Therefore, readings for measured inductances will be higher as the measurement frequency gets closer to the self-resonant frequency. Additionally, at parallel resonance, the equivalent series resistance is substantially increased (this is because, at resonance, the impedance of the sample changes from reactive to resistive because of the phase shift in the measurement current) and the measured Q value reading is lower than that determined by ωLo/Ro. Typical variations of Q and inductance values under these conditions are given in Figure 3-9.

3-44. Ratio of the measurement frequency and the self-resonant frequency can be converted to a distributed capacitance and tuning capacitance relationship with the following equation:

$$f_1/fo = \sqrt{Cd/(C + Cd)} \quad \text{....... (eq. 3-6)}$$

Where, f_1: measurement frequency.
fo: self-resonant frequency of sample.
Cd: distributed capacitance of sample.
C: tuning capacitance of Q meter.

Figure 3-10 graphically shows the variation of measured Q and inductance as capacitance is taken for the parameter. The ideal inductance and Q values in the presence of no distributed capacitance (or when it is negligible) are correlated with the actually measured values by correction factors which correspond to readings along the vertical axis scales in Figures 3-9 and 3-10.

3-45. Measuring Distributed Capacitance (Preferred Method).

3-46. The impedance of a coil at its self-resonant frequency is resistive and usually high. This characteristic may be utilized for measuring distributed capacitance. Proceed as follows:

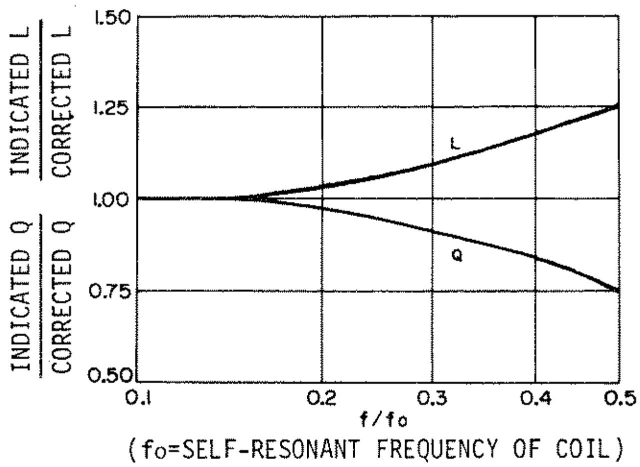


Figure 3-9. Typical Variation of Effective Q and Inductance with Frequency.

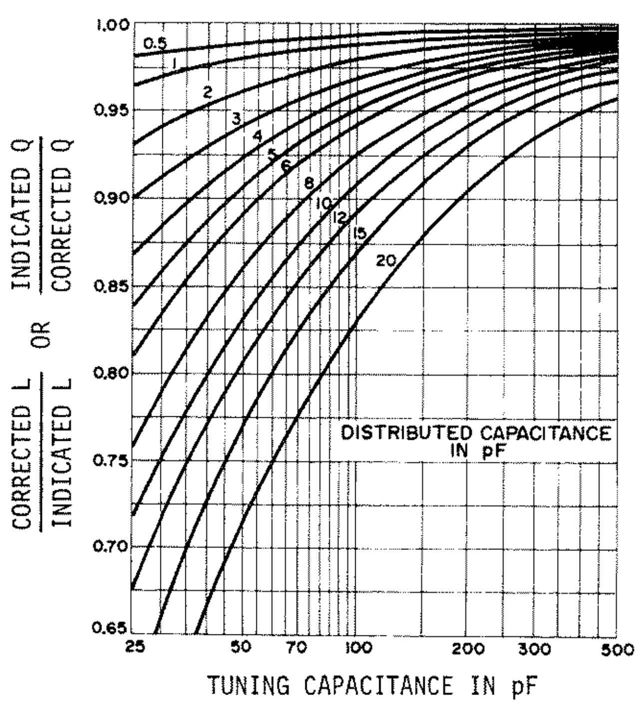


Figure 3-10. Correction Chart for Distributed Capacitance.

a. Connect inductor sample to be tested to the 4342A measurement COIL (HI and LO) terminals.

b. Set L/C dial control to approximately 400pF and ΔC dial control to 0pF. Note C dial reading as C_1.

c. Depress a trial FREQUENCY RANGE button and rotate FREQUENCY dial to search for the frequency at which panel Q meter shows a maximum deflection. If no peak deflection can be observed, change FREQUENCY RANGE setting and repeat the procedure.

d. Adjust FREQUENCY dial control for maximum Q meter deflection. Note the dial frequency reading as f_1.

e. Set measurement frequency to approximately ten times the frequency f_1 noted in step d.

f. Replace the inductor sample with a stable coil (16470 series supplemental inductor) capable of resonating in the measuring circuit at this higher frequency.

g. Adjust the L/C dial control for maximum Q meter deflection.

h. Connect the test inductor to the measurement CAPACITOR (HI and GND) terminals.

i. Adjust the L/C dial control for again obtaining maximum Q meter deflection. If the L/C dial control has to be rotated in the direction of higher capacitance, increase the measurement frequency. If it has to be rotated towards a lower capacitance, decrease the frequency.

j. Alternately connect and disconnect the test inductor to/from the CAPACITOR terminals and adjust the FREQUENCY dial control (if necessary, change FREQUENCY RANGE setting) until the influence of the test inductor to tuning conditions is non-existent (indicated Q value may change). Note dial frequency reading as fo. This frequency is identical with the self resonant frequency of the inductor.

k. Distributed capacitance of the inductor sample is given by the following equation. Substitute measured values of C_1, fo, and f_1 in the equation:

$$Cd = \frac{C_1}{\left(\frac{f_0}{f_1}\right)^2 - 1} \quad \text{.......... (eq. 3-7)}$$

Where, Cd: distributed capacitance in farads.
C_1: C dial reading (farads) noted in step b.
f_0: measurement frequency (hertz) noted in step j.
f_1: measurement frequency (hertz) noted in step d.

Note

If $f_0 \gg f_1$, the eq. 3-7 is simplified as follows:

$$Cd = \left(\frac{f_1}{f_0}\right)^2 C_1 \quad \text{........... (eq. 3-7)}$$

3-47. Measuring Distributed Capacitance (Approximate Method, Cd≥10pF).

3-48. A distributed capacitance more than approximately 10pF may be measured with the simplified procedure described below (this procedure is useful for obtaining approximate values of distributed capacitance with an accuracy which serves practical purposes):

a. Connect inductor sample to the measurement COIL (HI and LO) terminals.

b. Set L/C dial control to approximately 50pF and ΔC dial control to 0pF. Note the C dial reading as C_1.

c. Depress a trial FREQUENCY RANGE button and rotate FREQUENCY dial control to search for the frequency at which panel Q meter shows a maximum deflection. If no peak deflection can be observed, change FREQUENCY RANGE setting and repeat the procedure.

d. Adjust FREQUENCY dial control for maximum panel Q meter deflection. Note this frequency as f_1.

e. Change FREQUENCY dial setting to f_2 equal to f_1/n (n should be a selected integer, e.g. 2 or 3).

f. Adjust L/C dial and ΔC dial controls for again obtaining maximum meter deflection. Note the sum of C dial and ΔC dial readings as C_2.

g. Distributed capacitance is given by the following equation. Substitute measured values of C_1, C_2, f_1 and f_2 in the equation:

$$Cd = \frac{(C_2 - n^2 C_1)}{n^2 - 1} \quad \text{........ (eq. 3-9)}$$

$$n = \frac{f_1}{f_2}$$

Where, Cd: distributed capacitance in farads.
C_1: C dial reading (farads) noted in step b.
C_2: C dial reading (farads) noted in step f.
f_1: measurement frequency (hertz) noted in step d.
f_2: measurement frequency (hertz) given in step e.

Note

If f_2 is exactly one half of f_1, then

$$Cd = \frac{C_2 - 4C_1}{3} \quad \text{........... (eq. 3-10)}$$

An average of several measurements using different values of C_1 will improve the results of this measurement. The best accuracy to be expected with this method, however, is in the range of ±2pF.

3-49. CORRECTION FOR Q.

3-50. To use the indicated Q for the purpose of calculating L and Rs (in determining the actual equivalent circuit), it must be corrected for the effects of the distributed capacitance. The corrected Q and the Q value measured by the Q meter can be obtained from the following equation:

$$Qt = Qi \frac{C + Cd}{C} \quad \text{........... (eq. 3-11)}$$

Then,

$$\text{Correction factor} = \frac{C + Cd}{C} = 1 + \frac{Cd}{C} \quad \text{........... (eq. 3-12)}$$

Where, Qt: corrected Q value.
Qi: indicated Q value.
C: sum of C and ΔC dial readings.
Cd: distributed capacitance of sample.

Figure 3-10 is a graphical solution to equation 3-11. The corrected Q value Qt may be deemed the quality factor calculated as ωLo/Ro from inductance Lo, equivalent series resistance Ro, and the measurement frequency (refer to paragraph 3-43). However, Qt is not identical to "effective Q". The corrected Q is also a "circuit Q" which includes the additional losses of the measuring circuit.

3-51. By substituting equation 3-6 in equation 3-11, the correction factor in equation 3-11 can be converted into a relationship of measurement frequency and self resonant frequency of sample. And the corrected quality factor may be expressed as follows:

$$Qt = Qi \frac{1}{1 - \left(\frac{f_1}{f_0}\right)^2} \quad \text{......... (eq. 3-13)}$$

Where, f_1: measurement frequency.
f_0: self resonant frequency of sample.

A graphic expression of the above equation is shown in Figure 3-9. When f_1 is greater than f_0, equation 3-13 produces a negative Qt. However, this negative Q has no meaning and should not be used. A negative Q is obtained when the reactance of the sample becomes capacitive (effect of distributed capacitance) instead of inductive at frequencies above f_0.

3-52. CORRECTION FOR INDUCTANCE.

3-53. The residual inductance of the measuring circuit is included in the measured inductance of sample. When the sample value is in the vicinity of 0.5μH or less, the measured inductance should be compensated for such residual inductance. This compensation can be made simply by subtraction as follows:

$$Lm = Li - Lres \quad \text{........... (eq. 3-14)}$$

Where, Lm: measured value excluding residual inductance.
Li: measured inductance.
Lres: residual inductance of measuring circuit.

The Lres in the 4342A is approximately 0.01μH.

3-54. Correction of the measured inductance to arrive at a true model of the equivalent circuit of the sample also requires a correction for the distributed capacitance (similar to the correction in para. 3-50 for indicated Q). The corrected inductance value is given by the following equation:

$$Lt = Li \frac{C}{C + Cd} \quad \text{.......... (eq. 3-15)}$$

Where, Lt: corrected inductance value.
Li: indicated inductance value.
C: sum of C and ΔC dial readings.
Cd: distributed capacitance of sample.

Equation 3-15 may be converted into a frequency form as follows:

$$Lt = Li \left\{1 - \left(\frac{f_1}{f_0}\right)^2\right\} \quad \text{...... (eq. 3-16)}$$

Where, f_1: measurement frequency
f_0: self resonant frequency of sample.

Graphic solutions of equations 3-15 and 3-16 are shown in Figures 3-10 and 3-9, respectively.

3-55. PARALLEL AND SERIES CONNECTION MEASUREMENT METHODS.

3-56. GENERAL.

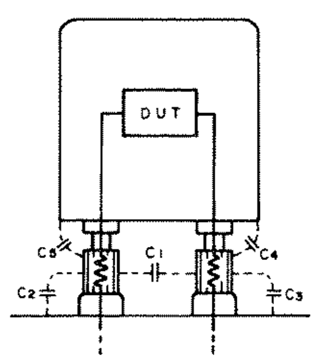
3-57. In practical applications of the Q meter, the expanded measurement capabilities of parallel and series connection measurements yield various advantages. For example, the parallel method permits measuring inductor samples at frequencies about its self-resonant frequency (f_0). In addition, inductance just below resonance, impedance at resonance, and apparent capacitance above fo can be measured. This is especially useful for measurement of inductors which are designed to resonate with tuning capacitors less than 20pF at their respective nominal working frequencies. A great number of coils known as "peaking coils" fall into this category. If there is no requirement for particular measurement conditions, the coil can be measured using the direct connection method. Here, the measurement parameter values may be read directly from Q meter indications. However, if the sample requires measurement with a tuning capacitance of less than 20pF, a direct measurement is impossible (due to the minimum capacitance of the tuning capacitor). A parallel measurement will provide the desired data eliminating the limitations of the direct connection method.

3-58. Sometimes parallel or series connection measurements offer improved measurement accuracies. At first glance, these measurement configurations appear to be incompatible with the stray capacitance, residual inductance and other unwanted additional factors incident in the use of supplemental equipment such as reference inductors and the test terminal adapter. Actually, these residual factors do not contribute additional errors in the measurement results. In quality factor measurements, the "indicated Q" values obtained by parallel or series methods are usually a better approximation of "effective Q" than those obtained by direct methods. As the differences between the measured values and the effective values decrease further to small orders of magnitude, parallel and series methods are sometimes also used for samples which can be measured by direct methods.

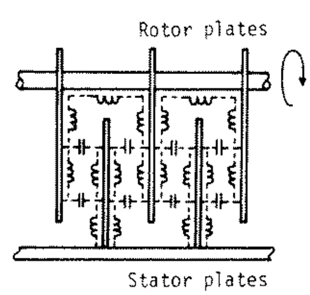
3-59. Measured values in parallel and series methods are theoretically given only by the variable quantities which yield to differences in tuning conditions before and after connecting the sample. The constant quantities in the measuring circuit, which do not vary for the duration of measurement, are not factors in the results of the calculations for the individual measurement parameters. Since residual impedances in measuring circuit as well as inherent values of reference inductors are almost constant, these values are mathematically eliminated and also do not influence the measurement results. So, what additional measurement errors are contributed by the parallel and series methods? Let's discuss them in detail.

3-60. Additional Error Discussion.

3-61. Certain residual impedance elements change with the method of connection of the sample; in addition, the residual impedance also depends upon the mutual distances between the sample and the individual components of the measurement apparatus. Typical circuit models showing such residual factors are illustrated in Figure 3-11. C_4 and C_5 in



Stray Capacitances about Measurement Terminals
(A)



Distributed Inductances In Tuning Capacitor
(B)

Figure 3-11. Residual Parameters.

Figure 3-11 (A) exhibit the stray capacities added by connecting a sample with a shielded case. This capacitance increase adds to the stray capacitances (C_1, C_2 and C_3) around the measurement terminals. In a series measurement, the shorting strap, for initially short-circuiting the unknown connection terminals, has its own residual impedance. Additionally, its contact resistances differ from those of samples. Small changes in the loss and the distributed inductance of the tuning capacitor affect measurement accuracies. Figure 3-11(B) graphically shows an electrical model of a variable capacitor. The distributed inductance and the loss varies depending on the position of the capacitor rotor. In the 4342A, these residual factors are minimum because specially designed, high quality variable capacitors are employed in the tuning circuit.

Actually, the residual impedances present in the measuring circuit do not cause significant errors except when measurements of extremely high or extremely low impedance samples are taken at high frequency. A full consideration of the factors of additional errors is not practical except in cases where the experiment requires improved accuracies. However, it is difficult to make an accurate Q measurement above 1000 (effective Q) at a frequency higher than about 1MHz.

3-62. In parallel and series measurements, Q meter indications are read twice as often as those in direct method measurements; thus, the accumulation of reading errors and instrumental errors should be taken into consideration. In addition, a more accurate tuning operation is required to minimize these additional errors. To improve frequency accuracy, the oscillator frequency may be monitored with a frequency counter (using FREQUENCY MONITOR output at rear panel).

3-63. When a low Q sample is measured, the Q meter deflection increases and decreases broadly during the tuning operation. Because of this low resonance sharpness, it is usually difficult to do exact tuning (to get a resonant peak) and to obtain correct indications. This limits the resistance value measurable with parallel and series methods, respectively, as shown in Figure 3-5. As high series resistance and low parallel resistance make for very low Q resonance circuits (below 10), the measurement accuracies for such samples are thus much lower.

3-64. PARALLEL MEASUREMENTS.

Note

In the following parallel connection measurement procedures, set 4342A Q RANGE as appropriate unless specially instructed otherwise.

3-65. High Inductance Measurement.

3-66. When the measuring circuit is resonated using a reference inductor and then the sample (unknown) inductor placed in parallel with the tuning capacitor, the tuning frequency will increase. To restore resonance at the measurement frequency, the tuning capacitance must be increased. The inductance of the unknown inductor can be determined from relationship of the tuning capacitances at the same measurement frequency. After the sample is connected, quality factor and equivalent parallel resistance can also be calculated from a reduction of the panel Q meter indication.

To measure an inductance sample by the parallel method, proceed as follows:

a. Depress appropriate FREQUENCY RANGE pushbutton and set FREQUENCY dial control for desired measurement frequency.

b. Select a reference inductor which allows the measuring circuit to resonate with a tuning capacitance of 30pF to 70pF at this frequency. Connect it to measurement COIL (HI and LO) terminals.

c. Adjust L/C dial and ΔC dial controls for a maximum Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading as Q_1.

d. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

e. Connect unknown inductor to measurement CAPACITOR (HI and GND) terminals.

f. Restore resonance by adjusting the L/C and ΔC dial controls. Note sum of the C dial and ΔC dial readings as C_2 and panel meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function for normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

g. Inductance of the unknown inductor is:

$$L = \frac{1}{\omega^2 (C_2 - C_1)} \text{ (H) ..... (eq. 3-17)}$$

Where, $\omega = 2\pi$ times the measurement frequency.

Q value of the unknown is:

$$Q = \frac{Q_1 Q_2 (C_2 - C_1)}{\Delta Q C_1} \text{ .... (eq. 3-18)}$$

Where, $\Delta Q = Q_1 - Q_2$

Equivalent parallel resistance is:

$$Rp = \frac{Q_1 Q_2}{\omega C_1 \Delta Q} \ (\Omega) \text{ .... (eq. 3-19)}$$

h. The capacitance required to tune the coil at the measuring frequency is simply,

$$C = C_2 - C_1 \text{ .... (eq. 3-20)}$$

Note

If the measurement frequency is higher than the self-resonant frequency of the unknown inductor, the unknown will not appear inductive but capacitive, and C_2 will be less than C_1. Apparent capacitance of the unknown in such frequency region is:

$$Ca = C_1 - C_2 \text{ .... (eq. 3-21)}$$

and equivalent parallel conductance is

$$Ga = \frac{\omega C_1 \Delta Q}{Q_1 Q_2} \text{ .... (eq. 3-22)}$$

3-67. Low Capacitance Measurement (<450pF)

3-68. When the measuring circuit is resonated using a reference inductor, a capacitor placed in parallel with the tuning capacitor will lower the tuning frequency. To restore resonance at the measurement frequency, the tuning capacitance must be reduced as much as the capacitance of the sample. Hence, the sample value can be determined by noting the difference between the tuning capacitor dial readings. After the sample is connected, quality factor and equivalent parallel resistance can be calculated from a reduction of panel Q meter indication.

To measure a capacitance sample, proceed as follows:

a. Select a reference inductor which can resonate at the desired measurement frequency and connect it to measurement COIL (HI and LO) terminals.

b. Set L/C dial control to desired tuning capacitance and ΔC dial to zero. Note the tuning capacitance C_1.

Note

If the approximate value of the capacitor sample is known, select a value for C_1 such that the difference between C_1 and the sample value is 30 to 100pF.

c. Depress appropriate FREQUENCY RANGE button and adjust FREQUENCY dial control for a maximum Q meter deflection. Note frequency f_1 and panel Q meter reading Q_1.

d. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

e. Connect the unknown capacitor to measurement CAPACITOR (HI and GND) terminals.

f. Restore resonance by adjusting the L/C and ΔC dial controls. Note sum of the L/C dial and ΔC dial readings as C_2 and panel meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

g. Capacitance value of the unknown capacitor is:

$$Cp = C_1 - C_2 \quad \text{.............. (eq. 3-23)}$$

Q value of the unknown is:

$$Q = \frac{Q_1 Q_2 (C_1 - C_2)}{\Delta Q C_1} \quad \text{........ (eq. 3-24)}$$

where, $\Delta Q = Q_1 - Q_2$

and equivalent parallel resistance of the unknown is:

$$Rp = \frac{Q_1 Q_2}{\omega C_1 \Delta Q} \ (\Omega) \quad \text{.......... (eq. 3-25)}$$

where, $\omega = 2\pi f_1$.

3-69. High Resistance Measurement.

3-70. When the measuring circuit is resonated using a reference inductor, a resistor placed in parallel with the tuning capacitor will lower the indicated Q in inverse proportion to the sample value. This reduction of Q is utilized to measure the resistance. To avoid a significant increment of measurement error, the measurement should be made for resistors within a reasonable range. For high resistances, the change in the indicated Q should be greater than the Q meter resolution, that is, 0.1 on ΔQ = 3 range, 0.3 on 10 range, 1 on 30 range and 3 on 100 range, respectively. For relatively low resistances, the indicated Q should be higher than 10 when the sample is connected. See Figure 3-5 for suitable sample value ranges.

To measure high resistances, proceed as follows:

a. Depress appropriate FREQUENCY RANGE button and set FREQUENCY dial control to the desired frequency.

b. Connect a suitable reference inductor to measurement COIL (HI and LO) terminals.

c. Adjust L/C dial and ΔC dial controls for maximum panel Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading Q_1.

Note

The reference inductor should be selected so that high resistances are measured with a low tuning capacitance and relatively low resistances are measured with a high tuning capacitance.

d. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

e. Connect the unknown resistor to measurement CAPACITOR (HI and GND) terminals.

f. Restore resonance by adjusting the L/C and ΔC dial controls. Note sum of the C dial and ΔC dial readings as C_2 and panel meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

g. The resistance of the unknown resistor is:

$$Rp = \frac{Q_1 Q_2}{\omega C_1 \Delta Q} \ (\Omega) \quad \text{.......... (eq. 3-26)}$$

Where, $\omega = 2\pi$ times the measurement frequency.

If the sample is also reactive, its reactance is:

$$Xp = \frac{1}{\omega (C_2 - C_1)} \quad (\Omega) \quad \text{.... (eq. 3-27)}$$

(usually capacitive)

and its capacitance is:

$$Cp = C_1 - C_2 \quad \text{.............. (eq. 3-28)}$$

If the sample appears inductive, C_2 is larger than C_1.

Parallel Connection Measurements

3-71. Dielectric Measurement.

3-72. The dielectric constant and dielectric loss of insulating materials can be measured by a method similar to and is basically a capacitance measurement. When a pair of parallel electrodes (air capacitor) connected to 4342A (in air) and an insulating material placed between the electrodes, the electrode capacitance increases in proportional to the specific inductive capacity (ε_s) of the sample material. The dielectric constant of the sample material is calculated as the product of ε_s and the vacuum dielectric constant ε_0. Accordingly, the dielectric constant can be determined from the capacitance measurements made before and after placing the sample between the elecrodes. Additionally, after the sample is mounted in the holder, the conductance of the sample can also be calculated from a reduction of the Q meter indication. To make easy and accurate dielectric measurements, it is recommended that the 16451A Dielectric Test Adapter be used with the 4342A. Typical characteristics of the 16451A are described in Table 3-2.

Materials to be measured with the 16451A should be less than 10mm in thickness and from 38 to 55mm in diameter. When measuring materials with a high dielectric constant or a large loss, it is usually best to prepare material in thicknesses greater than 3mm. On the other hand, when low loss material is to be measured, the material thickness should be less than 3mm. Materials measuring less than 0.5mm in thickness are usually difficult to measure.

To make dielectric measurements using the 16451A, proceed as follows:

a. Depress the appropriate FREQUENCY RANGE button and set FREQUENCY dial control for the desired measurement frequency.

b. Select a reference inductor which can resonate at the measurement frequency. Connect it to 4342A measurement COIL (HI and LO) terminals.

c. Adjust L/C dial and ΔC dial controls for a maximum Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading as Q_1.

d. Let the reference inductor remain in place (as is) and attach the 16451A to 4342A measurement CAPACITOR (HI and GND) terminals.

e. Set 16451A electrode spacing as desired. However, if possible, it is best to set the electrode spacing dimension to about the same as the thickness of the material to be measured.

f. Again resonate the measurement circuit by adjusting the L/C and ΔC dial controls. Note C dial and ΔC dial readings as C_2 and panel meter reading Q_2.

Table 3-2. 16451A (4342A-K01) Typical Characteristics.

Electrode Diameter: 38mm

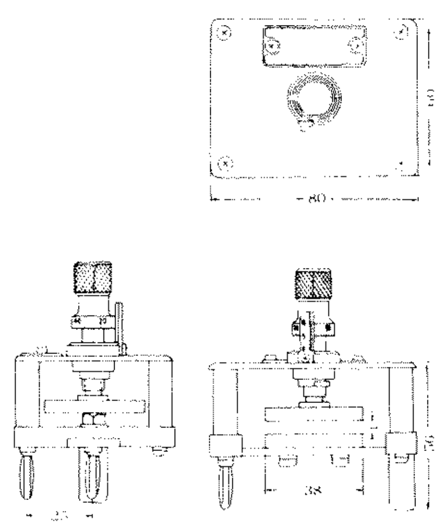
Electrode Spacing: 0 ∿10mm variable

Minimum vernier division: 0.02mm

Residual Parameters: Co≈5pF
Go<0.4µS (at 10MHz)
Lo≈40nH

Minimum measurable loss angle (tan δ):

Approximately 1×10^{-4}



Parallel Connection Measurements

g. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for current resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

h. Place the sample material between 16451A electrodes. The sample material should be in close contact with electrodes. Note 16451A micrometer reading Tx (as thickness of the sample).

i. Again adjust the L/C and ΔC dial controls for resonance. Note sum of the C dial and ΔC dial readings as C_3 and panel meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function for normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_2 - Q_3$.

j. Remove the sample material from between the 16451A electrodes.

k. Let the L/C and ΔC dial settings remain as is, and reduce space between the 16451A electrodes until resonance again occurs. Note the micrometer reading as To.

Note

If this procedure is a little difficult, let the distance between the 16451A electrodes remain the same as the thickness of the sample being measured and take resonance again by adjusting the L/C and ΔC dial controls. Note sum of the C and ΔC dial readings as C_4.

l. Calculation formulas of the dielectric constant, dielectric loss, and associated measurement parameter values are summarized below:
Specific inductive capacity of the sample material is:

$$\varepsilon_s = \frac{Tx}{To} \quad \text{............... (eq. 3-29)}$$

Dielectric constant of the sample material is:

$$\varepsilon = \varepsilon_0 \cdot \varepsilon_s$$

$$= \frac{Tx}{To} \times 8.85 \times 10^{-12} \ (F/m) \quad \text{............... (eq. 3-30)}$$

Electrode capacitance with the sample material is:

$$Cx = \frac{1}{To} \ (pF)$$

$$= C_4 - C_3 + \frac{1}{Tx} \ (pF) \quad \text{..(eq. 3-31)}$$

Where, the unit for Tx and To is cm.

Equivalent parallel conductance of the sample material is:

$$Gx = 2\pi f C_1 \frac{\Delta Q}{Q_2(Q_2 - \Delta Q)}$$

$$= 2\pi f C_1 \left(\frac{Q_2 - Q_3}{Q_2 Q_3} \right) (pS) \quad \text{..(eq. 3-32)}$$

Dielectric loss angle (dissipation factor) of the sample material is:

$$\tan\delta = C_1 \cdot To \frac{\Delta Q}{Q_2(Q_2 - \Delta Q)}$$

$$= \frac{C_1}{Cx} \cdot \frac{\Delta Q}{Q_2(Q_2 - \Delta Q)}$$

$$= Gx/2\pi f Cx \quad \text{........... (eq. 3-33)}$$

Where, f is measurement frequency.

Note

$\frac{Q_2 - Q_3}{Q_2 Q_3}$ may be used instead of $\frac{\Delta Q}{Q_2(Q_2 - \Delta Q)}$ in equation 3-33.

Q value of the sample material is:

$$Qx = 1/\tan\delta \quad \text{.............. (eq. 3-34)}$$

Note

The theoretical formula for 16451A electrode capacitance is:

$$C = \frac{S \times 10^{-2}}{36\pi \times 10^9 \times To} (F) = \frac{S}{3.6\pi \ To} (pF)$$

where S is area of electrode (cm^2).

Since the size of the electrode is 3.8cm in diameter, C above can be shown to be 1/To (pF).

3-73. SERIES MEASUREMENTS.

Note

In the following series connection measurement procedures, set 4342A Q RANGE as appropriate unless specifically instructed otherwise.

3-74. Low Inductance Measurement.

3-75. Measurement of small inductors at relatively low frequencies can not be made directly at the measurement COIL terminals. However, by using an external high Q capacitor (such as the 16462A Auxiliary Capacitor) connected in parallel with the tuning capacitor, resonance can be obtained at the desired frequency. A second method, which is explained here, is the series method. This method is recommended for measuring low value inductors without using an external capacitor (but with an external inductor).

When the measuring circuit is resonated using a reference inductor, the test inductor placed in series with the reference inductor will lower the tuning frequency. To restore resonance at the measurement frequency, the tuning capacitance must be reduced. The inductance of the unknown inductor can be determined from the relationship between the tuning capacitances at the same frequency. After the sample is connected, quality factor and equivalent series resistance can also be calculated from a reduction of panel Q meter indication. Proceed as follows:

a. Depress the appropriate FREQUENCY RANGE button and set FREQUENCY dial control for the desired measurement frequency.

b. Select a reference inductor which allows the measuring circuit to resonate with a tuning capacitance of approximately 400pF. Connect unknown inductor in series with the reference inductor (between measurement LO terminal and low potential end of the reference inductor) and to measurement COIL (HI and LO) terminals.

Note

If 16014A Series Loss Test Adapter is available, attach it to measurement COIL terminals. Connect the reference inductor to appropriate terminals of the 16014A and unknown inductor to 16014A series connection terminals.

c. Short-circuit the unknown (series connection terminals) with a heavy (low impedance) shorting strap.

d. Adjust L/C dial and ΔC dial controls for a maximum Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading as Q_1.

e. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

f. Disconnect the shorting strap. Again resonate the measuring circuit by adjusting L/C dial and ΔC dial controls. Note sum of the C dial and ΔC dial readings as C_2 and panel Q meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

Note

This procedure (steps c, d and f) permits the unknown component to be physically connected even through it is electrically out of the circuit, and eliminates possible errors by maintaining the relative positions of the reference inductor and unknown component.

g. Inductance of the unknown inductor is:

$$Ls = \frac{(C_1 - C_2)}{\omega^2 C_1 C_2} \quad (H) \;\ldots\ldots\; (\text{eq. } 3\text{-}35)$$

Where, $\omega = 2\pi$ times the measurement frequency.

Q value of the unknown is:

$$Q = \frac{Q_1 Q_2 (C_1 - C_2)}{C_1 Q_1 - C_2 Q_2} \;\ldots\ldots\ldots\; (\text{eq. } 3\text{-}36)$$

Where, $Q_2 = Q_1 - \Delta Q$

Equivalent series resistance is:

$$Rs = \frac{\left(\frac{C_1}{C_2}\right) Q_1 - Q_2}{\omega C_1 Q_1 Q_2} \quad (\Omega) \;\ldots\ldots\; (\text{eq. } 3\text{-}37)$$

3-76. High Capacitance Measurement (≥450pF).

3-77. When the measuring circuit is resoated using a reference inductor, a test capacitor placed in series with the reference inductor will raise the tuning frequency. To restore resonance at the measurement frequency, the tuning capacitance must be increased. The capacitance of the unknown can be determined from the relationship between the tuning capacitances at the same frequency. After the sample is connected, quality factor and equivalent series resistance can be calculated from a reduction of panel Q meter indication.

To measure a capacitance sample, proceed as follows:

a. Depress the appropriate FREQUENCY RANGE button and set FREQUENCY dial control for desired measurement frequency.

b. Select a reference inductor which allows the measuring circuit to resonate with a tuning capacitance of approximately 200pF.

Note

If the sample value is higher than about 3600pF, it is recommended that the initial tuning capacitance setting be in the vicinity of 400pF to obtain better measurement accuracy.

Connect unknown capacitor in series with the reference inductor (between measurement LO terminal and low potential end of the reference inductor) and to measurement COIL (HI and LO) terminals.

Note

If 16014A Series Loss Test Adapter is available, attach it to measurement COIL terminals. Connect the reference inductor to appropriate terminals of the 16014A and unknown capacitor to 16014A series connection terminals.

c. Short-circuit the unknown (series connection terminals) with a heavy (low impedance) shorting strap.

d. Adjust L/C dial and ΔC dial controls for a maximum Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading as Q_1.

e. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

f. Disconnct the shorting strap. Again resonate the measuring circuit by adjusting L/C dial and ΔC dial controls. Note sum of the C dial and ΔC dial readings as C_2 and panel meter indication as ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

Note

This procedure (steps c, d and f) permits the unknown component to be physically connected even through it is electrically out of the circuit, and eliminates possible errors by maintaining the relative positions of the reference inductor and unknown component.

g. The capacitance of the unknown capacitor is:

$$Cs = \frac{C_1 C_2}{(C_2 - C_1)} \quad \text{.......... (eq. 3-38)}$$

Q value of the unknown is:

$$Q = \frac{Q_1 Q_2 (C_1 - C_2)}{C_1 Q_1 - C_2 Q_2} \quad \text{...... (eq. 3-39)}$$

Where, $Q_2 = Q_1 - \Delta Q$

Equivalent series resistance is:

$$Rs = \frac{Q_2 - \left(\frac{C_1}{C_2}\right) Q_1}{\omega C_1 Q_1 Q_2} \ (\Omega) \quad \text{.. (eq. 3-40)}$$

Where, $\omega = 2\pi$ times the measurement frequency.

3-78. Self-resonant Frequency Measurement of High Capacitors.

3-79. Capacitors have a residual inductance which is dependent on the capacitor lead

Series Connection Measurements

length and electrode structure. This inductance resonates with the capacitance of the capacitor at a high frequency. At this self-resonant frequency, the impedance of the capacitor is minimum owing to the series resonance which occurs in the capacitor itself. Hence, its self-resonant frequency determines the upper limit of the useable frequency for the capacitor. Usually the self-resonant frequency of electrolytic, tantalum, film, mylar capacitors and others which are within a capacitance range of about 5nF to 1μF can be measured with a Q meter.

When the capacitor self-resonates, the impedance is minimum and purely resistive. This characteristic is utilized to determine the self-resonant frequency and the equivalent series resistance at this frequency. The measurement procedure to determine the self-resonant frequency of a capacitor is similar to that for an inductor (described in paragraph 3-46). Proceed as follows:

a. Depress a trial FREQUENCY RANGE button.

Note

For high capacitance samples, select either the 22k - 70k or the 70k - 220k range and, for a relatively low capacitance samples, select the 220k - 700k or the 0.7M - 2.2M range, respectively.

b. Select a reference inductor which allows the measuring circuit to resonate with a tuning capacitance of approximately 400pF. Connect unknown capacitor in series with the reference inductor (between measurement LO terminal and low potential end of the reference inductor) and to measurement COIL (HI and LO) terminals.

Note

If 16014A Series Loss Test Adapter is available, attach it to measurement COIL terminals. Connect the reference inductor to appropriate terminals of the 16014A and unknown capacitor to 16014A series connection terminals.

c. Short-circuit the unknown (series connection terminals) with a heavy (low impedance) shorting strap.

d. Adjust FREQUENCY dial control for a maximum panel Q meter deflection.

e. Disconnect the shorting strap. Again resonate the measuring circuit by adjusting the L/C dial control. If L/C dial control has to be rotated in the direction of higher capacitance, increase the measurement frequency. If it has to be rotated towards a lower capacitance, decrease the frequency.

f. Repeat steps c, d, and e until the influence of the test capacitor to tuning condition is non-existent (indicated Q value may change).

Note

If such condition can not be obtained on the selected frequency range even though the L/C dial control is set to maximum, change FREQUENCY RANGE setting to upper range. If the L/C dial control must be reduced to less than 200pF, change FREQUENCY RANGE setting to a lower range. Replace reference inductor with another trial inductor and repeat steps a through f until the adjustment in step f succeeds.

g. Note sum of C dial and ΔC dial readings as C_1 and dial frequency reading as f_0. <u>This frequency is identical with the self-resonant frequency</u> of the unknown capacitor.

h. Connect the shorting strap (if not already connected). Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

i. Disconnect the shorting strap. Note panel Q meter ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

j. Equivalent resistance of the capacitor at the resonant frequency is:

$$Rs = \frac{\Delta Q}{\omega C_1 Q_1 Q_2} \ (\Omega) \ \ldots\ldots\ (\text{eq. } 3\text{-}41)$$

Where, $\omega = 2\pi f_0$.

3-80. Low Resistance Measurement.

3-81. When measuring circuit is resonated using a reference inductor, a resistor placed in series with the reference inductor will lower the indicated Q in proportion to the resistance value of the sample. This reduction of Q is utilized to measure the resistance. To avoid a significant increment of measurement error, the measurement should be made for resistors within a reasonable range. For low resistance, the change in the indicated Q should be greater than the Q meter resolution, that is, 0.1 on ΔQ = 3 range, 0.3 on 10 range, 1 on 30 range and 3 on 100 range, respectively. For high resistance, the indicated Q should be higher than 10 when the sample is connected. See Figure 3-5 for the suitable sample value range.

To measure low resistances, proceed as follows:

a. Depress the appropriate FREQUENCY RANGE button and set FREQUENCY dial control for the desired measurement frequency.

b. Select a suitable reference inductor so that relatively high resistances are measured with a low tuning capacitance and low resistances are measured with a high tuning capacitance. Connect unknown resistor in series with the reference inductor (between measurement LO terminal and low potential end of the reference inductor) and to measurement COIL (HI and LO) terminals.

Note

If 16014A Series Loss Test Adapter is available, attach it to measurement COIL terminals. Connect the reference inductor to appropriate terminals of the 16014A and unknown resistor to 16014A series connection terminals.

c. Short-circuit the unknown (series connection terminals) with a heavy (low impedance) shorting strap.

d. Adjust L/C dial and ΔC dial controls for a maximum Q meter deflection. Note sum of the C dial and ΔC dial readings as C_1 and panel meter reading as Q_1.

e. Depress ΔQ button and adjust ΔQ ZERO (COARSE and FINE) controls so that meter pointer indicates zero (full scale) on ΔQ scale.

Note

Press ΔQ button to release ΔQ function and recheck for correct resonance. Again depress the ΔQ button and recheck for ΔQ zero indication.

f. Disconnect the shorting strap. Again resonate the measuring circuit by adjusting L/C dial and ΔC dial controls. Note sum of the C dial and ΔC dial readings as C_2 and panel meter as ΔQ reading. If meter pointer scales out at the left end of the scale (ΔQ full scale), reset the function to normal Q measurement. The difference in Q is calculated from the two Q values as $\Delta Q = Q_1 - Q_2$.

Note

This procedure (steps c, d and f) permits the unknown component to be physically connected even though it is electrically out of the circuit, and eliminates possible errors by maintaining the relative positions of the reference inductor and unknown component.

g. The resistance of unknown resistor is:

$$Rs = \frac{\left(\frac{C_1}{C_2}\right) Q_1 - Q_2}{\omega C_1 Q_1 Q_2} \quad (\Omega) \text{ .. (eq. 3-42)}$$

Where, $\omega = 2\pi$ times the measurement frequency.

$Q_2 = Q_1 - \Delta Q$

If the unknown is purely resistive ($C_2 = C_1$), the equation for resistance reduces to:

$$Rs = \frac{\Delta Q}{\omega C_1 Q_1 Q_2} \quad (\Omega) \text{ .... (eq. 3-43)}$$

If the unknown is also reactive, the reactance is:

$$Xs = \frac{(C_1 - C_2)}{\omega C_1 C_2} \quad (\Omega) \text{ ..... (eq. 3-44)}$$

Table 3-3. Formulas for Calculating Q and Impedance Parameters from Parallel and Series Measurements.

Parallel Measurements	Series Measurements
Effective Q of Unknown $Q = \frac{Q_1 Q_2 (C_2 - C_1)}{\Delta Q C_1}$	Effective Q of Unknown $Q = \frac{Q_1 Q_2 (C_1 - C_2)}{C_1 Q_1 - C_2 Q_2}$
Effective Parallel Resistance of Unknown $R_p = \frac{Q_1 Q_2}{\omega C_1 \Delta Q}$	Effective Series Resistance of Unknown $R_s = \frac{\left(\frac{C_1}{C_2}\right) Q_1 - Q_2}{\omega C_1 Q_1 Q_2}$
Effective Parallel Reactance of Unknown $X_p = \frac{1}{\omega (C_2 - C_1)}$	Effective Series Reactance of Unknown $X_s = \frac{C_1 - C_2}{\omega C_1 C_2}$
Effective Parallel Inductance of Unknown $L_p = \frac{1}{\omega^2 (C_2 - C_1)}$	Effective Series Inductance of Unknown $L_s = \frac{C_1 - C_2}{\omega^2 C_1 C_2}$
Effective Parallel Capacitance of Unknown $C_p = C_1 - C_2$	Effective Series Capacitance of Unknown $C_s = \frac{C_1 C_2}{C_2 - C_1}$
Note In the equation for Xp, the polarity (sign) of the quantity (C2-C1) indicates the effective reactance, a positive quantity indicates an inductive reactance and a negative quantity indicate a capacitive result. Disregard the sign of the quantity (C2-C1) in the equation above for Q.	Note In the equation for Xs, the polarity (sign) of the quantity (C1-C2) indicates the effective reactance, a positive quantity indicates an inductive reactance and a negative quantity indicate a capacitive result. Disregard the sign of the quantity (C1-C2) in the equation above for Q.

Table 3-4. Formulas Relating Series and Parallel Components.

$$Q = \frac{X_s}{R_s} = \frac{\omega L_s}{R_s} = \frac{1}{\omega C_s R_s} = \frac{R_p}{X_p} = \frac{R_p}{\omega L_p} = R_p \omega C_p = \frac{\sqrt{\frac{L}{C}}}{R_s} = \frac{R_p}{\sqrt{\frac{L}{C}}}$$

PARALLEL TO SERIES CONVERSION	Formulas for Q greater than 10	Formulas for Q less than 0.1	SERIES TO PARALLEL CONVERSION	Formulas for Q greater than 10	Formulas for Q less than 0.1
$R_s = \frac{R_p}{1 + Q^2}$	$R_s = \frac{R_p}{Q^2}$	$R_s = R_p$	$R_p = R_s (1 + Q^2)$	$R_p = R_s Q^2$	$R_p = R_s$
$X_s = X_p \frac{Q^2}{1 + Q^2}$	$X_s = X_p$	$X_s = X_p Q^2$	$X_p = X_s \frac{1 + Q^2}{Q^2}$	$X_p = X_s$	$X_p = \frac{X_s}{Q^2}$
$L_s = L_p \frac{Q^2}{1 + Q^2}$	$L_s = L_p$	$L_s = L_p Q^2$	$L_p = L_s \frac{1 + Q^2}{Q^2}$	$L_p = L_s$	$L_p = \frac{L_s}{Q^2}$
$C_s = C_p \frac{1 + Q^2}{Q^2}$	$C_s = C_p$	$C_s = \frac{C_p}{Q^2}$	$C_p = C_s \frac{Q^2}{1 + Q^2}$	$C_p = C_s$	$C_p = C_s Q^2$

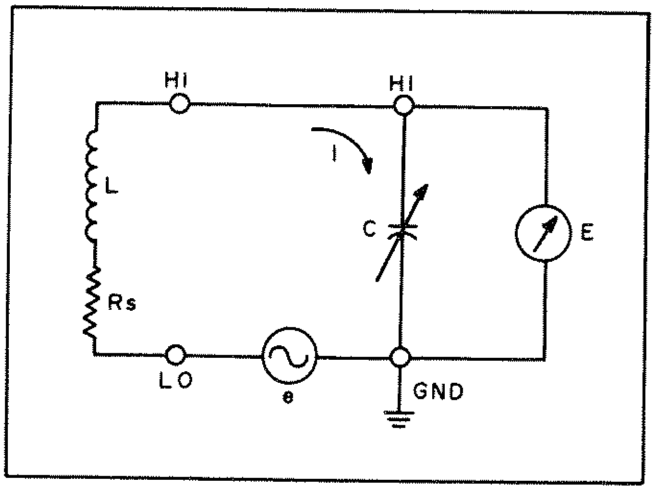


Figure 4-1. Series Resonant Circuit

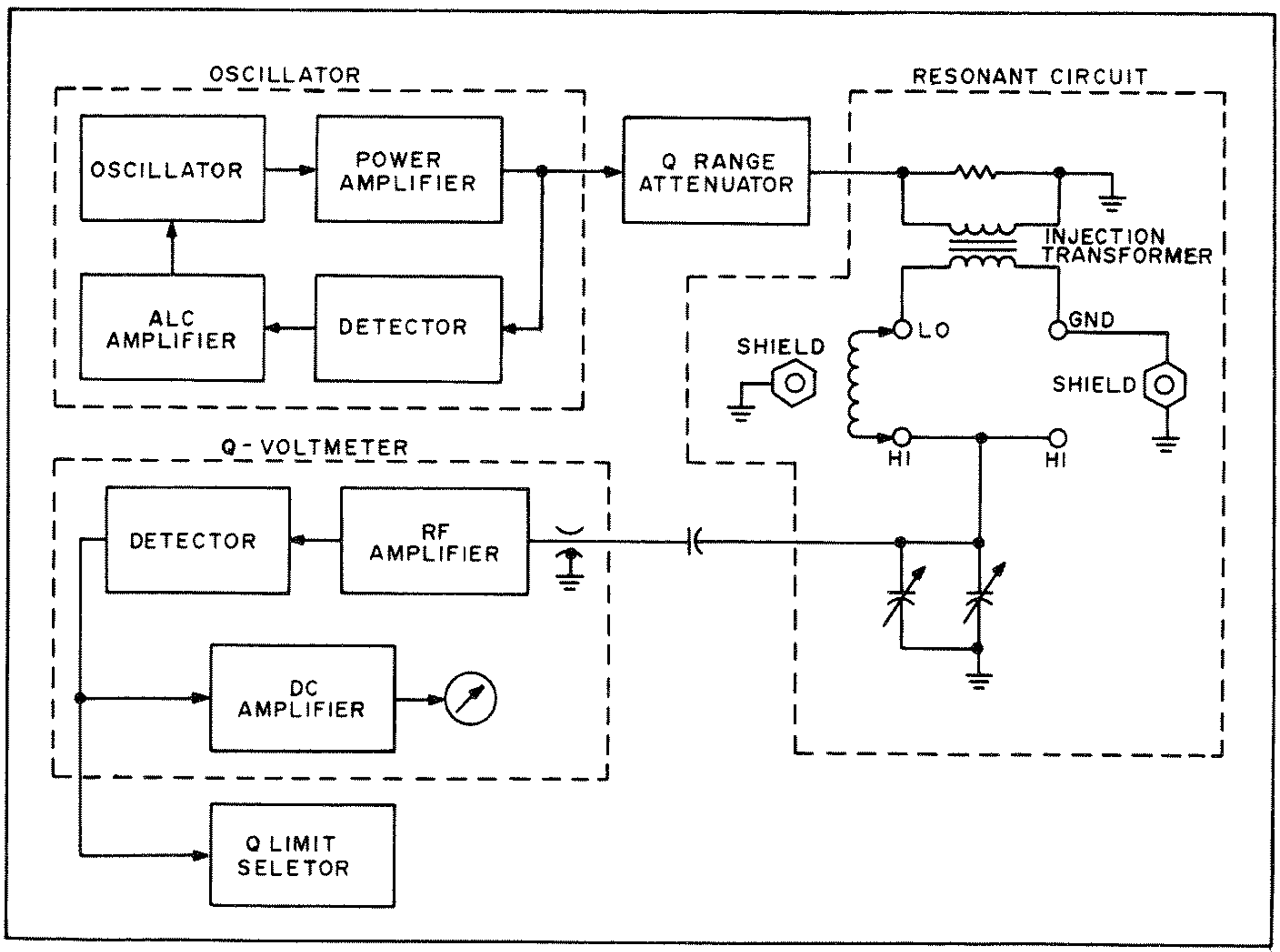


Figure 4-2. Model 4342A Simplified Block Diagram

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This discussion of the HP Model 4342A Q Meter internal operation is divided into two parts: Block diagram description and circuit description. The block diagram section discusses the functions of the major circuits within the instrument, using the overall block diagram. The circuit description provides a detailed description of all the major circuits within the instrument. It is suggested that the block diagram and schematics which have been included in this manual be referred to while reading the circuit description. A Functional Overall Block Diagram of the instrument, showing all the major circuits and associated relevant information is provided in Section VIII at the back of the manual. Also in Section VIII, there are complete schematics of all the circuitry within the Model 4342A which include components, reference designators, and values.

4-3. Q DETERMINATION AND MEASUREMENT.

4-4. The ratio of a component's reactance to its resistance is measured by the Q meter. The magnitude of Q is usually considered a figure of merit expressing the ability of component to store energy compared to the energy it dissipates. A measure of Q is important to determine the RF resistance of components, the loss angle of capacitors, dielectric constants, transmission line parameters and antenna characteristics, etc. Q is a dimensionless number. In a circuit at resonance, Q can be defined as the ratio of total energy stored to the average power dissipated per cycle. For a single reactance component:

$$Q = Xs/Rs = Rp/Xp$$

Where Xs and Xp are series and parallel reactance and Rs and Rp are series and parallel resistance. The most common form of Q meter uses a series resonant circuit to measure Q, as shown in Figure 4-1.

4-5. When the variable air capacitor C is adjusted so that $X_C = X_L$, the only remaining impedance in the loop is Rs. The current that flows then is;

$$i = \frac{e}{Rs}$$

and the voltage E across capacitor C is;

$$E = \frac{e}{Rs} \cdot Xc \text{ and } \frac{E}{e} = \frac{Xc}{Rs} = \frac{X_L}{Rs} = Q$$

This equation is correct for values of $Q \geqq 10$, for it can be shown that the true Q value being measured by the Q meter is equal to $\sqrt{1 + Q^2}$. Therefore, if e is held at a constant and known level, a voltmeter with high input impedance can be connected across the capacitor and calibrated directly in terms of Q. The e values in the above equations are functions of selected Q ranges. Rs is a function of the unknown inductor or Q reference coils. A detailed explanation for the measurement of unknowns is provided in SECTION III.

4-6. SIMPLIFIED BLOCK DIAGRAM

4-7. The measurement principle used in the Model 4342A is the series resonant circuit. A simplified block diagram of the Q Meter is shown in Figure 4-2. The oscillator which covers 22kHz to 70MHz (10kHz to 32MHz in Option 001), is automatically leveled by a loop consisting of the detector and the ALC amplifier. The oscillator output is controlled automatically by comparing it to a fixed dc level. Thus, constant voltage is supplied to the Q-range attenuator. The attenuator adjusts the signal level according to the Q range settings. This signal is fed into the resonant circuit by a transformer (sometimes called an injection transformer). Resonance is acheived by adjusting the variable capacitor, and this level is read by the high-impedance voltmeter. Thus the Q value of the resonant circuit is indicated on the meter.

4-8. BLOCK DIAGRAM DESCRIPTION

4-9. The Model 4342A Q Meter performs Q measurement in the range of 5 to 1000 on coils in seven bands covering a frequency range from 22kHz to 70MHz (10kHz to 32MHz in Option 001). The following paragraphs contain a brief outline of function of the major circuit groups in the Q Meter. Reference is made to the Functional Overall Block Diagram in SECTION VIII.

4-10. <u>OSCILLATOR AND IMPEDANCE CONVERTER (A1A1)</u>

4-11. The Oscillator circuit Q1-Q2 is a seven-band variable frequency oscillator covering a frequency range from 22kHz to 70MHz (10kHz to 32MHz in Option 001). The instrument utilizes a Hartley type circuit which operates from 22kHz to 22MHz (10kHz to 10MHz in Option 001) and a Colpitts type circuit from 22MHz to 70MHz (10MHz to 32MHz in Option 001). The FREQUENCY RANGE switch provides for the selection of the desired band of operation. The output amplitude of the oscillator is automatically controlled by an ALC loop Q9-Q13 (P/O A8) to provide the injection voltages required by the Q ranges used. The oscillator output is further coupled to a high impedance circuit Q3-Q6 which provides a buffer stage between the oscillator and the RF power amplifier assembly.

4-12. <u>RF POWER AMPLIFIER (A1A2)</u>

4-13. The RF Power Amplifier assembly consists of a cascode amplifier circuit Q1-Q2 with a gain of about 18dB and an impedance converter Q3-Q4. Commonly called a cascode, the circuit uses an emitter grounded amplifier followed by a grounded base stage. The circuit has excellent noise figure, broadband characteristics, and is very stable. The impedance converter Q3-Q4 consists of a pair of emitter followers connected in series which provides a higher input impedance and lower output impedance.

4-14. ALC AMPLIFIER(P/O A8)

4-15. The ALC Amplifier circuit Q9-Q13 provides the appropriate correction signal to the Oscillator assembly(A1A1) in order to control the oscillator output in accordance with the fixed reference dc level set by the OSC LEVEL control.

4-16. Q/ΔQ RANGE ATTENUATOR(A3)

4-17. The Q RANGE Attenuator consists of four switches which provide a total attenuation of 30.4dB. An additional switch is used for the ΔQ measurement. The Meter Scale Indicator (A11) ganged with Q RANGE switches, utilizes four lamps, two of these lamps are used for the Q scale display and the other two for the ΔQ scale. The attenuator output is fed to an Impedance Converter(A4) which consists of transistors Q1 and Q2 and which is similar in operation to the one described in paragraph 4-13.

4-18. TUNING CAPACITOR AND INJECTION TRANSFORMER(A2)

4-19. The Tuning Capacitor sometimes referred to as the Q Capacitor is an important part of the Q Meter. It is the reactance standard in the Q measurement. Because the Q Capacitor can be calibrated precisely, the Q Meter provides direct reading of inductance in addition to Q. To achieve this high accuracy, the capacitor is designed with low loss and low residual inductance. Minimum capacitance is low to maintain accuracy at high frequencies. The Q Capacitor covers a range of 20pF to 475pF. Residual inductance is less than 10nH.

4-20. The Model 4342A uses a new method of injecting a constant voltage through a transformer as shown in Figure 4-3, which has very low output impedance. The transformer has a toroidal core and nearly flat frequency reaponse from 10kHz to 70MHz. The LO terminal consists of a one-turn secondary winding which has an output impedance of approximately 1 milliohm. High measurement accuracy is thus achieved.

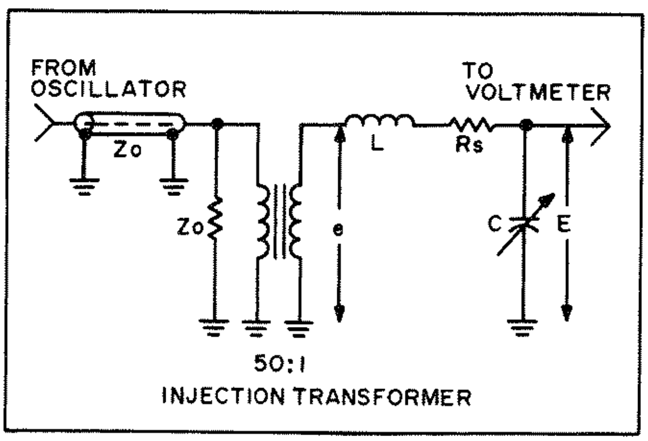


Figure 4-3. Constant Voltage Injection System

4-21. RF AMPLIFIER AND DETECTOR(A5)

4-22. The RF Amplifier and Detector assembly includes the Impedance Converter, the RF Amplifier, and the Detector circuits. The impedance converter Q1-Q4 is a "unity" gain buffer stage amplifier between the Tuning Capacitor assembly A2 and the RF Amplifier Q5-Q9. It provides a high input impedance and a low output impedance similar to what has been described in paragraph 4-13.

4-23. The RF Amplifier circuit Q5-Q9 is a high gain and broad band amplifier. The frequency response of the amplifier is flat and covers the entire spectrum range given in the specifications, while broad band RF transistors supply power gain. The approximate gain is about 34dB. The amplified signal is detected by diodes CR2-CR5 and coupled to the DC Amplifier assembly A6.

4-24. DC AMPLIFIER(A6)

4-25. The DC Amplifier Q1-Q5 provides a gain from 0 to 20dB. It is used to drive linearly the meter. Various gain adjustment, balance control, ΔQ COARSE AND FINE adjustments, METER ZERO ADJUST, and ΔQ function are provided for in this assembly. A Q ANALOG OUTPUT is also supplied which can be interfaced with other instruments. Frequency signals down to and including dc can be handled by the amplifier. By combining direct coupling with a resistive feedback circuit, good stability is obtained.

4-26. Q LIMIT SELECTOR(A7)

4-27. The Q Limit Selector assembly includes a comparator circuit Q1-Q3, a Schmitt trigger Q4-Q5, a monostable multivibrator Q6-Q7 and a driver Q8-Q9. The comparator compares the output of the detected RF signal with the Q LIMIT setting. The comparator output is then coupled via an emitter follower to the Schmitt trigger which generates a fast rise pulse output. This signal is coupled to the monostable multivibrator which has a fixed time constant of 1 second, and also supplies the necessary drive signal to the driver stage. An OVER LIMIT SIGNAL OUTPUT and DISPLAY TIME(1 sec or ∞) are provided.

4-28. CIRCUIT DETAILS

4-29. LC OSCILLATOR(P/O A1A1)

4-30. FREQUENCY RANGE switches select the appropriate LC circuit, setting the operating frequencies of the oscillator Q1-Q2. In the Hartley configuration, when an RF current flows in the tuned circuit, there is a voltage drop across L. The tap on the L coil will be at an intermediate potential with respect to the two ends of the coil. The amplified current in the Q2 collector circuit, which flows through the bottom section of L, is in phase with the current already flowing in the circuit and thus in the proper relationship for positive feedback. The Colpitts arrangement uses the voltage drops across the two capacitors C18 and C19 in series in the tuned circuit to supply the feedback. Other than this, the Colpitts operation is the same as just described for the Hartley configuration.

4-31. IMPEDANCE CONVERTER(P/O A1A1) AND RF POWER AMPLIFIER(A1A2)

4-32. FET Q3 provides a high input impedance for the impedance Converter circuit. Transistor Q5 is used as a current source and Q4 provides positive feedback to make Q3 gain equal to unity. Emitter follower Q6 provides low impedance output signals to the RF Amplifier stage. Inductor L8 acts as a parasitic oscillation suppressor and C30 is a dc blocking capacitor. The signal from the Impedance Converter is ac coupled to RF Power Amplifier Q2 via C2. Transistors Q1 and Q2 form a cascode stage as previously described in paragraph 4-12. Resistor R11 and C6 form a frequency compensation network and C5 is a bypass capacitor. Transistors Q3 and Q4 form an Impedance Converter as described in paragraph 4-12. Inductor L1 and L4 are parasitic oscillation suppressors.

4-33. ALC AMPLIFIER(P/O A8)

4-34. Transistor Q9 thru Q13 form the ALC Amplifier assembly. FET Q9A and Q9B form a differential amplifier with Q11 as its current source. A portion of the rectified RF Amplifier signal is taken across diode A3CR1 and coupled to FET Q9B. Transistors Q10 and Q12 form another differential amplifier with Q13 as its current source. The drain output signal of FET Q9B turns on transistor Q12. The current flowing through the collectors of transistors A1A1Q1 and A1A1Q2 is caused to vary by the setting of the OSC LEVEL control R26. This variation in A1A1Q1 collector current causes a change in the tuned circuit current and the gain of the Oscillator is thereby controlled. C10 provides ac feedback and circuit stabilization.

4-35. Q RANGE ATTENUATOR(A3)

4-36. The Q Range Attenuator with a total attenuation of 30.4dB covers the entire frequency range. The following steps of 10.4dB, 9.6dB, and 10.4dB are provided to correlate the meter reading with the Q Ranges used in the proper ratio (ie. 30/3, 100/10, etc.). The maximum insertion loss is 0.1dB and the impedance is 50Ω nominal. The Q Attenuator output is coupled to Impedance Converter A4 which is arranged in a Darlington pair configuration.

4-37. IMPEDANCE CONVERTER, RF AMPLIFIER AND DETECTOR(A5)

4-38. The Impedance Converter Q1-Q4 is identical in operation to the description given in paragraph 4-32. Diode CR1 protects Q4 from initial current surge. Transistors Q5-Q9 provide RF amplification for the broad band RF fraquencies with a total gain of approximate 34dB. Variable resistor R32 and variable capacitor C16 provide for the adjustment of medium and high frquency response of the amplifier respectively. A flat response is obtained through out the entire frequency band. The signal is ac coupled to detector diode CR2 via C19. Capacitor C20 provides filtering action. Diodes CR3 thru CR5 in conjunction with R42 and R43 cancel the non-linearities of diode CR2. A linear reading is provided to the meter circuit.

4-39. DC AMPLIFIER(A6)

4-40. FET Q1 supplies Q ANALOG OUTPUT proportional to the meter deflection to J1 connector. Variable resistors R4 and R6 are used for the settings of the Q ANALOG OUTPUT-BALANCE and GAIN respectively. FET Q2A and Q2B form a differential amplifier with transistor Q4 as a current source. Diode CR1 compensates for temperature changes. Q3 and Q5 supply current drive to the meter. Resistors R2 and R21 provide for X1 GAIN and X10 GAIN adjustments respectively. Zenor diode CR2 and CR3 are used to regulate for the +25V and -25V supplies, inductors L1, L2 and capacitors C2, C3 are used to obtain additional filtering of meter circuit supply voltages. Resistor R2(mounted on chassis) provides for METER ZERO adjustment. Resistors R3 and R4(mounted on chassis) are used for the ΔQ ZERO FINE and COARSE adjustments respectively.

4-41. Q LIMIT SELECTOR(A7)

4-42. High impedance FETs Q1 and Q2 form a comparator circuit. Emitter follower Q3 dc couples the comparator output to the Schmitt trigger Q4 and Q5. Capacitor C2 is used as a negative feedback path to reduce the ripple voltage at Q3 emitter. Transistors Q4 and Q5 provide Schmitt trigger action. When Q4 base voltage reaches 9V, the transistor will turn on and Q5 which is normally on will turn off. A positive going pulse will be generated and coupled via capacitor C3 and diode CR3 to the one-shot multivibrator Q6 and Q7. Normally, transistor Q7 is on and Q6 is cut off by the voltage drop across the common bias resistor R19. The pulse from Q5 turns on Q6 which in turn switches off Q7 for one second. Capacitor C6, resistors R20, R21, and R22 determine the constant of the circuit. Transistor Q8 turned on by the rise in Q7 collector voltage operates K1 the OVER LIMIT DISPLAY relay. Transistor Q9(normally on) is used for ∞ OVER LIMIT DISPLAY TIME. Diodes CR5 and CR6 protect Q8 and Q9 against initial line transient when the instrument is turned on.

4-43. POWER SUPPLY(P/O A8)

4-44. Description of the Power Supply operation will pertain to the +25 volt supply. For the negative supply, operation will be identical but with reversed polarities. Rectifiers CR1 thru CR4 form a fullwave bridge rectifier for the +25 volt supply. In this arrangement two rectifiers operate in series on each half of the cycle, one rectifier being in the lead to the load; the other being in the return lead.

4-45. Pulsating(rectified) dc at the output of the four-diode rectifier bridge is applied to the collector of the series regulator Q1. Closely matched transistors Q2, Q5 and Q3, Q4 form differential amplifier with high common mode signal rejection. The output voltage is applied across R11, R12, and R13 a voltage divider, such that some fraction of this voltage will be applied to the base of Q5. Should the voltage at the base of Q5 increase, its collector will go more negative. This negative going signal will be applied through emitter follower Q4 and cause Q3 collector to go negative. The negative going signal from Q3 is coupled through emitter follower Q1 and series regulator Q1(mounted on chassis). Subsequently the signal at the base of Q1 will increase the effective resistance of series regulator.

4-46. The rectifier output is continually changing, as it is a pulsating current. Thus the amplifier chain feeding the series regulator is continually compensating for this pulsation, effectively smoothing the rectifiers output. Capacitor C2 (mounted on chassis) sets ac output impedance. Zenor diode CR5 provides constant base voltage to Q2. Diode CR6 protects transistor Q3 against transients. Diodes CR7, CR8, and CR9 provide current limiting in the event of a grounded output. As stated earlier the operation for the negative supply is identical to the positive supply, except that only one differential amplifier is used in the circuit.

Table 5-1. Recommended Test Equipment.

Instrument Type	Required Performance	Recommended Model
AC Voltmeter	Frequency Range: 10kHz to 1MHz Voltage Range: 1mV to 1V Accuracy: 1% at 200kHz.	HP 400E
RF Voltmeter	Frequency Range: 500kHz to 100MHz Voltage Range: 10mV to 1V Frequency Flatness: ±1%	HP 3406A (with known frequency flatness)
Digital Voltmeter	Voltage Range: 0.1V to 100V dc DC Voltage Accuracy: 0.1% of reading AC Frequency Range: ≤100kHz AC Voltage Accuracy: 1% of reading	HP 3456A
Frequency Counter	Frequency Range: 10kHz to 80MHz Sensitivity: 50mV	HP 5381A
Test Oscillator	Frequency Range: 10kHz to 100kHz Output Voltage: 1.0V max. Distortion: less than 1%.	HP 651B
RF Oscillator	Frequency Range: 100kHz to 70MHz Output: 1.0V max.	HP 8601A
Oscilloscope	Bandwidth: 50MHz Sensitivity: 5mV/cm Input Impedance: 1MΩ	HP 180C with 1801A and 1821A Plug-ins
Impedance Meter	Frequency: 100kHz Full Scale Range: 500pF Accuracy: 0.3%	HP 4192A
Reference Inductor	Frequency Range: 110kHz to 300kHz Q: higher than 100	HP 16475A
50Ω Resistor	Metal Film 0.5% 1/4W	HP P/N 0698-5965

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides the instructions and information required to maintain the HP Model 4342A Q Meter. Included are Performance Checks, Adjustment and Calibration Procedures, Servicing and Troubleshooting guides.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The equipment required to maintain the Model 4342A are listed in Table 5-1. The table lists the type of equipment to be used, the performance requirements and recommended model. If the recommended model is not available, equipment which meets or exceeds the critical performance may be substituted.

5-5. Q ACCURACY CONSIDERATIONS.

5-6. A Q Meter theoretically measures the comprehensive Q of a circuit. In practice, residual circuit parameters, which do not exist in ideal circuits, contribute to measured Q values. Insertion resistance, residual inductance in series with the COIL terminals, Q voltmeter input conductance, and tuning capacitor loss are some of the factors that contribute to measurement errors in the practical measurement of Q in a typical circuit.

These errors can be minimized by the use of a low output impedance injection transformer system, a low loss tuning capacitor, and a Q voltmeter which has a low input conductance, as in the Model 4342A. Consequently, the 4342A will indicate higher Q values than other currently available Q meters.

By assuming that no internal circuit loss exists in the Q Meter, the specified Q accuracy can be guaranteed by performing the adjustment and calibration procedures in this section. If a Q calibration, which takes the actual internal loss of the instrument into account is required, a Q value reading check with Q standards (inductors) should be done in addition to the adjustment and calibration procedures described in paragraphs 5-9 and those which follow.

At the present time, no Q standards are available for users, thus a Q accuracy check with Q standards can not be performed at the facility where the instrument is used. Since, Hewlett-Packard, however, maintains Q standards traceable to NBS (National Bureau of Standards) in its major service offices, a calibration service with authorized Q standards for the 4342A is always available. If a Q accuracy check is needed, contact your nearest Hewlett-Packard office. If HP Models 513A/518A Q standards are owned and maintained, a Q accuracy check for the 4342A can be done at the user's location. Refer to Table 5-2 for Q Correction Factors.

Table 5-2. Q Correlation Factors.

Q Standard	Frequency	Correlation Factor*
518-A5	50 kHz	1.04
	100 kHz	1.07
	150 kHz	1.13
518-A4	150 kHz	1.05
	300 kHz	1.08
	450 kHz	1.12
513-A	500 kHz	1.01
	1 MHz	1.04
	1.5MHz	1.12
518-A3	1.5MHz	1.05
	3 MHz	1.03
	4.5MHz	1.05
518-A2	5 MHz	1.07
	10 MHz	1.09
	15 MHz	1.23
518-A1	15 MHz	1.27
	30 MHz	1.17
	45 MHz	1.37

* Correlation Factor x Indicated Q - Value on 513/518 = 4342A Indicated Q-Value.

5-7. OPTION.

5-8. The calibration and adjustment procedures for Option 001 instruments (that differ from the standard Model 4342A) are provided in paragraphs 5-25 and below.

Table 5-3. Frequency Accuracy Check.

Frequency Range	Frequency Dial Setting	Measured Accuracy	Counter Reading
22k - 70k	2.2 L 5.0 7.0	±1.5% ±1.0% ±1.5% ±1.5%	21.670 - 22.330 kHz 24.922 - 25.424 kHz 49.250 - 50.750 kHz 68.950 - 71.050 kHz
70k - 220k	7.0 L 15 22	±1.5% ±1.0% ±1.5% ±1.5%	68.950 - 71.050 kHz 78.822 - 80.413 kHz 147.75 - 152.25 kHz 216.70 - 223.30 kHz
220k - 700k	2.2 L 5.0 7.0	±1.5% ±1.0% ±1.5% ±1.5%	216.70 - 223.30 kHz 249.22 - 254.24 kHz 492.50 - 507.50 kHz 689.50 - 710.50 kHz
700k - 2.2M	7.0 L 15 22	±1.5% ±1.0% ±1.5% ±1.5%	689.50 - 710.50 kHz 788.22 - 804.13 kHz 1477.5 - 1522.5 kHz 2167.0 - 2233.0 kHz
2.2M - 7M	2.2 L 5.0 7.0	±1.5% ±1.0% ±1.5% ±1.5%	2167.0 - 2233.0 kHz 2492.2 - 2542.4 kHz 4925.0 - 5075.0 kHz 6895.0 - 7105.0 kHz
7M - 22M	7.0 L 15 22	±1.5% ±1.0% ±1.5% ±1.5%	6895.0 - 7105.0 kHz 7882.2 - 8041.3 kHz 14.775 - 15.225 MHz 21.670 - 22.330 MHz
22M - 70M	2.2 L 5.0 7.0	±2.0% ±1.0% ±2.0% ±2.0%	21.560 - 22.440 MHz 24.922 - 25.424 MHz 49.000 - 51.000 MHz 68.600 - 71.400 MHz

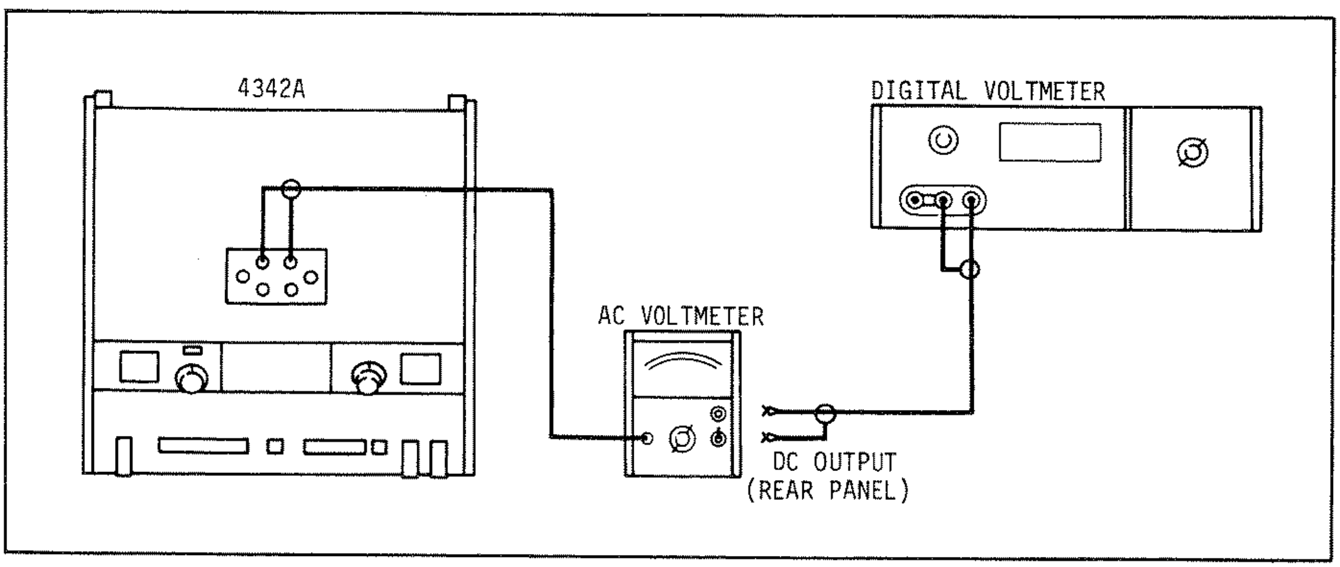


Figure 5-1. Q Range Check.

5-9. PERFORMANCE CHECKS.

5-10. The Performance Checks compare the 4342A instrument with its specifications. These checks are used in incoming inspection, periodic maintenance, and after a repair. Before beginning the Performance Checks, do mechanical and electrical meter zero adjustments using the procedure in Figure 3-6.

5-11. FREQUENCY ACCURACY CHECK.

An electronic frequency counter is required for this check.

a. Connect frequency counter to 4342A rear panel FREQUENCY MONITOR connector.

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 22k to 70k
FREQUENCY dial 2.2
Other controls .... any settings

c. Frequency counter reading should be within 21,678kHz to 22,320kHz.

d. Check frequency at each frequency setting in accord with Table 5-3. Counter readings should be within the tolerance limits given in Table 5-3.

5-12. Q RANGE CHECK.

An AC Voltmeter and a Digital Voltmeter are required for this check.

a. Connect an AC Voltmeter to 4342A LO and GND terminals as shown in Figure 5-1. Connect Digital Voltmeter to AC Voltmeter dc output terminals.

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 70k - 220k
FREQUENCY dial 20
Q RANGE 30
Q LIMIT .... CW
L/C dial .... 25(pF)
ΔC dial 0

c. Set AC Voltmeter range to 30mV and Digital Voltmeter to 1V. Digital Voltmeter reading should be between 920.6 and 977.4mV.

d. Set Q RANGE and AC Voltmeter range in accord with Table 5-4. Digital Voltmeter reading should be within the tolerance limits given in Table 5-4.

Table 5-4. Q Range Check.

Q Range	AC Voltmeter Range	Digital Voltmeter Reading
30	30 mV	920.6 - 977.4 mV
100	10 mV	873.0 - 927.0 mV
300	3 mV	920.6 - 977.4 mV
1000	1 mV	873.0 - 927.0 mV

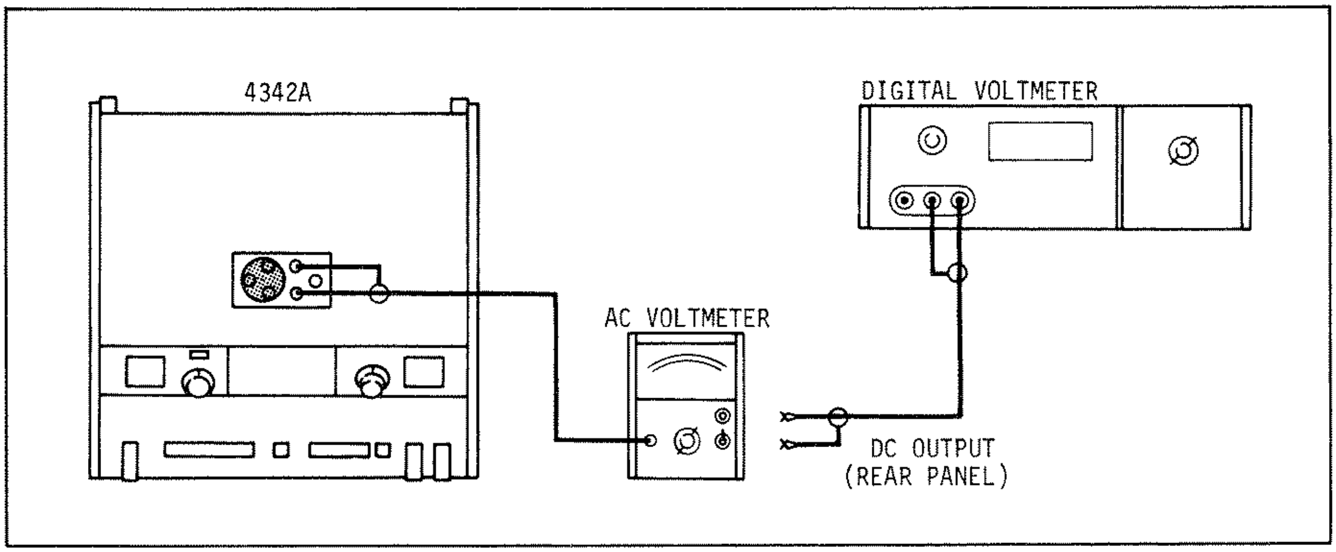


Figure 5-2. ΔQ Range Check.

5-13. ΔQ RANGE CHECK.

An AC Voltmeter, a Digital Voltmeter, and a Reference Inductor are required for this check.

a. Connect the AC Voltmeter to 4342A HI and GND terminals and place the Reference Inductor in the HI and LO terminals as shown in Figure 5-2. Monitor DC voltage at AC Voltmeter dc output terminals with Digital Voltmeter.

b. Set 4342A controls as follows:

FREQUENCY RANGE	70k - 220k
FREQUENCY dial	20
Q RANGE	100
Q LIMIT	CW
L/C dial	25(pF)
ΔC dial	0

c. Set AC Voltmeter range to 1V.

d. Adjust L/C dial so that 4342A meter pointer indicates 100 (need not indicate a peak value). Adjust to exactly 100 with the ΔC dial.

e. Digital Voltmeter reading should be within 873mV to 927mV.

f. Adjust L/C dial for 900.0mV on Digital Voltmeter display. Use ΔC dial for accurate adjustment.

g. Set Q/ΔQ RANGE to ΔQ10 and adjust ΔQ ZERO control (coarse and fine) so that Q meter indicates 0 (full scale) on ΔQ scale.

h. Adjust ΔC dial so that Q meter indicates 10 on ΔQ scale and note Digital Voltmeter reading. It should be within 801.9mV to 818.1mV.

5-14. CAPACITANCE ACCURACY CHECK.

An Impedance Meter is required for this check.

a. Connect Impedance Meter to 4342A HI and GND terminals as shown in Figure 5-3.

Note

When the Model 4192A is used for this check, set panel controls as follows:

DISPLAY A	C
ZY RANGE	AUTO
CIRCUIT MODE	AUTO
FREQUENCY	100kHz
OSC LEVEL	1V
CABLE LENGTH	1m

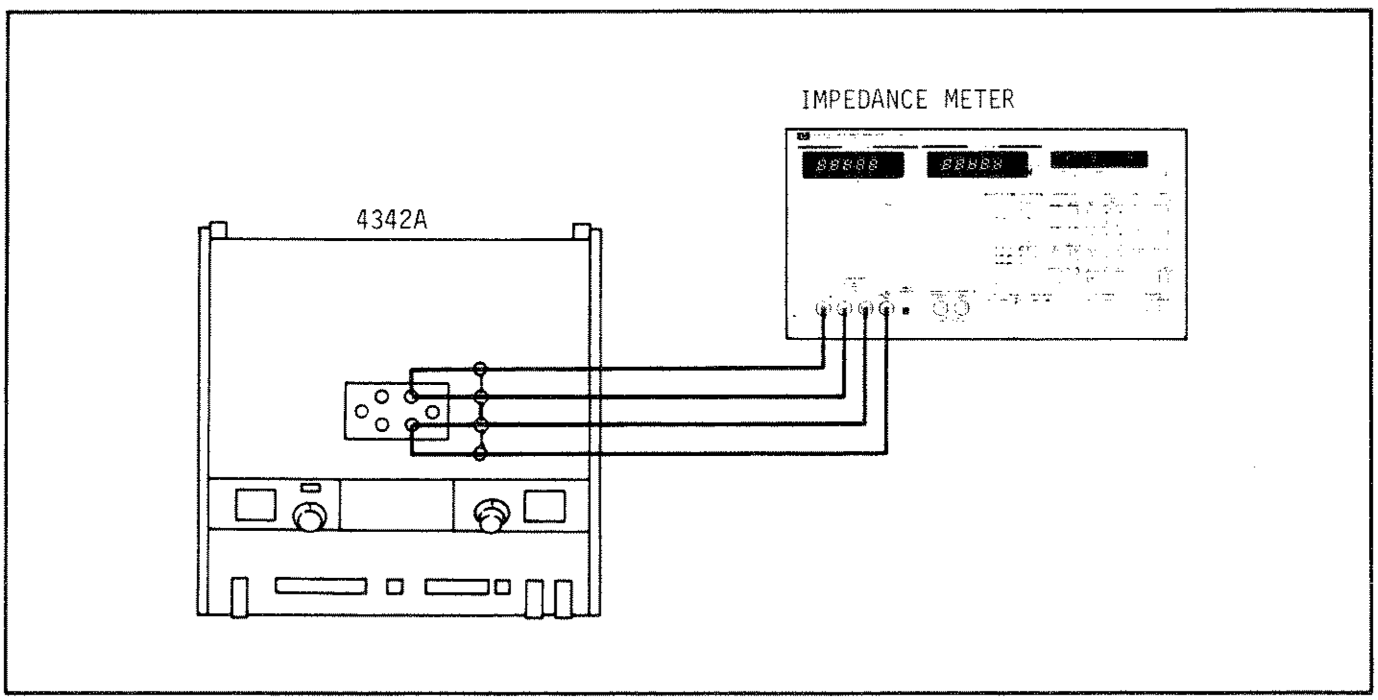


Figure 5-3. Capacitance Accuracy Check.

b. Set 4342A controls as follows:

L/C dial .... 25(pF)
ΔC dial 0
Other controls .... any settings

c. Capacitance Bridge reading should be between 23.9 and 26.1pF.

d. Check capacitance on each L/C dial and ΔC dial setting in accord with Table 5-5. Capacitance Bridge readings should be within the specified tolerance limits given in Table 5-5.

Table 5-5. Capacitance Accuracy Check.

C Dial	ΔC Dial	C-Bridge Reading
25	0	23.9 - 26.1
25	-5	(0 Reading)* - 5±0.1
25	+5	(0 Reading)* + 5±0.1
100	0	98.9 - 101.1
200	0	197.9 - 202.1
300	0	296.9 - 303.1
400	0	395.9 - 404.1
470	0	465.2 - 474.8
470	+5	(0 Reading)* + 5±0.1

* Note: 0 Reading is the readout on the Capacitance Bridge when ΔC Dial is set to 0.

5-15. Q LIMIT OPERATION CHECK.

A Reference Inductor is required for this check.

a. Connect a Reference Inductor to 4342A HI and LO terminals.

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 70k - 220k
FREQUENCY dial 20
Q RANGE 100
Q LIMIT .... CW
L/C dial .... 25(pF)
ΔC dial 0

c. Set OVER LIMIT DISPLAY TIME switch on 4342A rear panel to ∞ position.

d. Rotate L/C dial until Q meter pointer deflection exceeds full scale and scales out.

e. Set Q LIMIT control dial to 60. OVER LIMIT lamp should light.

f. Adjust L/C dial so that Q meter pointer indicates approximately 50. OVER LIMIT lamp should be extinguished.

g. Rotate L/C dial so that Q meter indication increases slowly as it approaches 60. The OVER LIMIT lamp should light at or near a Q meter indication of 60.

Table 5-6. Adjustable Components.

Reference Designator	Name of Control	Purpose
A1A1C1, -C3, -C5, -C7, -C9, -C11, -C13	FREQ. ADJ C	To adjust oscillator frequency of upper range limits of individual frequency ranges to maximize frequency accuracies.
A1A1L1 thru A1A1L7	FREQ. ADJ L	To adjust oscillator frequency of lower range limits of individual frequency ranges to maximize frequency accuracies.
A5C16	HIGH FREQ. ADJ	To adjust Q meter sensitivity in high frequency (70MHz) region to obtain optimum frequency flatness.
A5R32	MED FREQ. ADJ	To adjust Q meter sensitivity in high frequency (20MHz) region to obtain optimum frequency flatness.
A5R43	LINEARITY ADJ	To adjust Q meter linearity to maximize measurement accuracy.
A6R2	X1 GAIN	To set Q meter full scale sensitivity to maximize measurement accuracy.
A6R4	REC BAL	To set Q ANALOG OUTPUT dc voltage at rear panel to zero volts at Q meter zero scale deflection.
A6R6	REC GAIN	To set Q ANALOG OUTPUT dc voltage at rear panel (to 1 volt) at Q meter full scale deflection.
A6R21	X10 GAIN	To adjust ΔQ measurement full scale sensitivity to maximize ΔQ measurement accuracy.
A7R3	Q-PRESET	To properly set Q limit selector sensitivity at Q LIMIT dial full scale setting to maximize the dial scale accuracy.
A7R7	Q-PRESET VERNIER	To properly set Q limit selector sensitivity at Q LIMIT dial center scale setting to maximize the dial scale accuracy.
A8R12 -R21	+25V ADJ -25V ADJ	To set +25V and -25V output voltages of dc power supply.
A8R26	OSC LEVEL	To adjust oscillator output voltage to maximize measurement accuracy.

5-16. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-17. These paragraphs describe complete adjustment and calibration procedures for the Model 4342A. The procedures should be performed when any performance test fails or when it is known that the instrument does not meet the specifications or may be necessary after certain repairs. Table 5-6 is a summary of the purpose of each adjustment and its effect on instrument performance. Adjustment and assembly locations are shown in Figure 5-4 and 5-5, respectively.

WARNING

ADJUSTMENTS DESCRIBED IN THIS SECTION ARE ALLOWED FOR QUALIFIED TECHNICAL PERSONNEL ONLY.

WARNING

ADJUSTMENTS DESCRIBED HEREIN ARE PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT AFTER PROTECTIVE COVERS HAVE BEEN REMOVED. ENERGY EXISTING AT MANY POINTS MAY, IF CONTACTED, RESULT IN PERSONAL INJURY.

Preparatory to beginning adjustments, remove top cover by removing the four retaining screws near side frames (both sides). Remove bottom cover with similar procedure.

5-18. POWER SUPPLY ADJUSTMENT.

A DC Voltmeter (or a DMM) is required for this adjustment.

a. Turn 4342A power off. Take out A8 Power Supply Assembly. Reinstall it with an extender board.

b. Turn instrument on. Connect DC Voltmeter plus input lead to plus terminal of capacitor A8C3 and minus input lead of voltmeter to chassis.

c. Adjust A8R12 (+25V ADJ) for a reading of +25 ±0.025V on DC Voltmeter.

d. Connect DC Voltmeter minus input lead to minus terminal of capacitor A8C6 and plus input lead of voltmeter to chassis.

e. Adjust A8R21 (-25V ADJ) for a reading of -25V ±0.025V on DC Voltmeter.

Note

Voltage ripple should be less than 0.35mVrms for both +25V and -25V power supplies.

5-19. OSCILLATOR LEVEL ADJUSTMENT.

An AC Voltmeter and a Digital Voltmeter are required for this adjustment.

a. Connect AC Voltmeter to 4342A LO and GND terminals as shown in Figure 5-1. Monitor dc voltage at AC Voltmater dc output terminals with Digital Voltmeter.

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 22k - 70k
FREQUENCY dial 5.0
Q RANGE 30
Q LIMIT .... CW
L/C dial .... 25(pF)
ΔC dial 0

c. Set AC Voltmeter range to 30mV and Digital Voltmeter range to 1V.

d. Adjust A8R26 (OSC LEVEL adj.) for 949.0mV ±5mV on Digital Voltmeter display.

5-20. OSCILLATOR FREQUENCY ADJUSTMENT.

A Frequency Counter is required for this adjustment.

a. Connect a frequency counter to 4342A rear panel FREQUENCY MONITOR connector.

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 22k - 70k
FREQUENCY dial 2.2
Other controls .... any settings

c. Remove instrument bottom cover and oscillator shield cover labeled with names of FREQ ADJ potentiometers and trimmer capacitors.

d. Loosen all oscillator coil locking nuts. Replace oscillator shield cover.

e. Adjust A1A1L1 (see Figure 5-5, instrument bottom view) for 22.000kHz ±0.330kHz on frequency counter display.

f. Set FREQUENCY dial to 7.0.

g. Adjust A1A1C1 for 70.000kHz ±1.050kHz on frequency counter display.

h. Set FREQUENCY dial to "L" point.

i. Frequency counter reading should be within 24.922kHz to 25.420kHz. If not, repeat steps b through g.

j. Check dial tracking throughout the 22 - 70kHz frequency range. A compromise adjustment may improve tracking. Compare with Table 5-3.

k. Set FREQUENCY RANGE and FREQUENCY dial in accord with Table 5-7 and adjust each individual adjustment control (A1A1L2 through L7, C3, C5, C7, C9, C11 and C13) for correct frequency with procedures similar to steps b through j.

l. Remove oscillator shield cover and carefully tighten all oscillator coil locking nuts. Take care that potentiometer does not rotate with nut. Replace oscillator cover.

m. Recheck instrument against Table 5-7.

5-21. Q VOLTMETER ADJUSTMENT.

A Test Oscillator and a Digital Volemeter are required for this adjustment.

Note

Before proceeding with this adjustment, check meter mechanical and electrical zero using the procedure given in Figure 3-6.

1) X1 Gain and meter linearity adjustments.

a. Connect the Test Oscillator and the Digital Volemeter to 4342A as shown in Figure 5-6.

Table 5-7. Frequency Adjustment.

Frequency Range	Frequency Dial Setting	Measured Frequency	Adjustment
22k - 70k	2.2 7.0 "L"	22.000 ±0.330 kHz 70.000 ±1.050 kHz 25.173 ±0.251 kHz	A1A1L1 A1A1C1 NONE
220k - 700k	2.2 7.0 "L"	220.00 ±3.30 kHz 700.00 ±10.50 kHz 251.73 ±2.51 kHz	A1A1L3 A1A1C5 NONE
2.2M - 7.0M	2.2 7.0 "L"	2200.0 ±33.0 kHz 7000.0 ±105.0 kHz 2517.3 ±25.1 kHz	A1A1L5 A1A1C9 NONE
22M - 70M	2.2 7.0 "L"	22.000 ± 0.440MHz 70.000 ± 1.400MHz 25.173 ± 0.251MHz	A1A1L7 A1A1C13 NONE
70k - 220k	7.0 22 "L"	70.000 ±1.050 kHz 220.00 ±3.30 kHz 79.618 ±0.796 kHz	A1A1L2 A1A1C3 NONE
0.7M - 2.2M	7.0 22 "L"	700.00 ±10.50 kHz 2200.0 ±33.0 kHz 796.18 ±7.96 kHz	A1A1L4 A1A1C7 NONE
7.0M - 22M	7.0 22 "L"	7000.0 ± 105.0kHz 22.000 ± 0.330MHz 7961.8 ± 79.6kHz	A1A1L6 A1A1C11 NONE

b. Set 4342A controls as follows:

FREQUENCY RANGE .... 22k - 70k
FREQUENCY dial 2.2
L/C dial .... 25(pF)
ΔC dial .... -5

c. Set the Test Oscillator frequency to 100kHz and adjust the signal level until the Digital Voltmeter reads 900.0mV.

d. Adjust A6R2 (X1 GAIN adj.) for full scale Q meter reading.

e. Adjust the Test Oscillator's signal level until the DVM reads 450.0mV.

f. Q meter should indicate exactly 1/2 full scale. If Q meter deflection is insufficient, rotate A5R43 (LINEARITY ADJ) CCW until meter reads correctly. If deflection is excessive, rotate A5-R43 slightly CW.

g. Repeat steps c through f until meter indicates 1/2 full scale within ±0.5/100 full scale (1/2 minor division) in step f.

h. Adjust the Test Oscillator's signal level until the DVM reads 300.0mV.

i. Q meter should indicate within 1/3 full scale ±1/100 of full scale (1 minor division). If not, repeat steps c through f.

2) X10 GAIN adjustment.

j. Adjust the Test Oscillator's signal level until the DVM reads 810.0mV.

k. Depress 4342A ΔQ button and set ΔQ RANGE to 10.

l. Adjust ΔQ ZERO control for 10 (zero scale deflection) on ΔQ scale.

m. Adjust the Test Oscillator's signal level until the DVM reads 900.0mV.

n. Q meter should indicate 0 (full scale) on ΔQ scale. If Q meter reading is not zero, adjust A6R21 (X10 GAIN adj.) for correct reading. Repeat steps j through n because both adjustments interact.

5-22. Q ANALOG OUTPUT ADJUSTMENT.

A Test Oscillator and a Digital Voltmeter are required for this adjustment.

a. Set 4342A controls as follows:

Q RANGE 30
other controls .... any settings

b. Connect Digital Voltmeter to 4342A rear panel Q ANALOG OUTPUT connector.

c. Adjust A6R4 (REC BAL adj.) for 0V ±0.01V on Digital Voltmeter display.

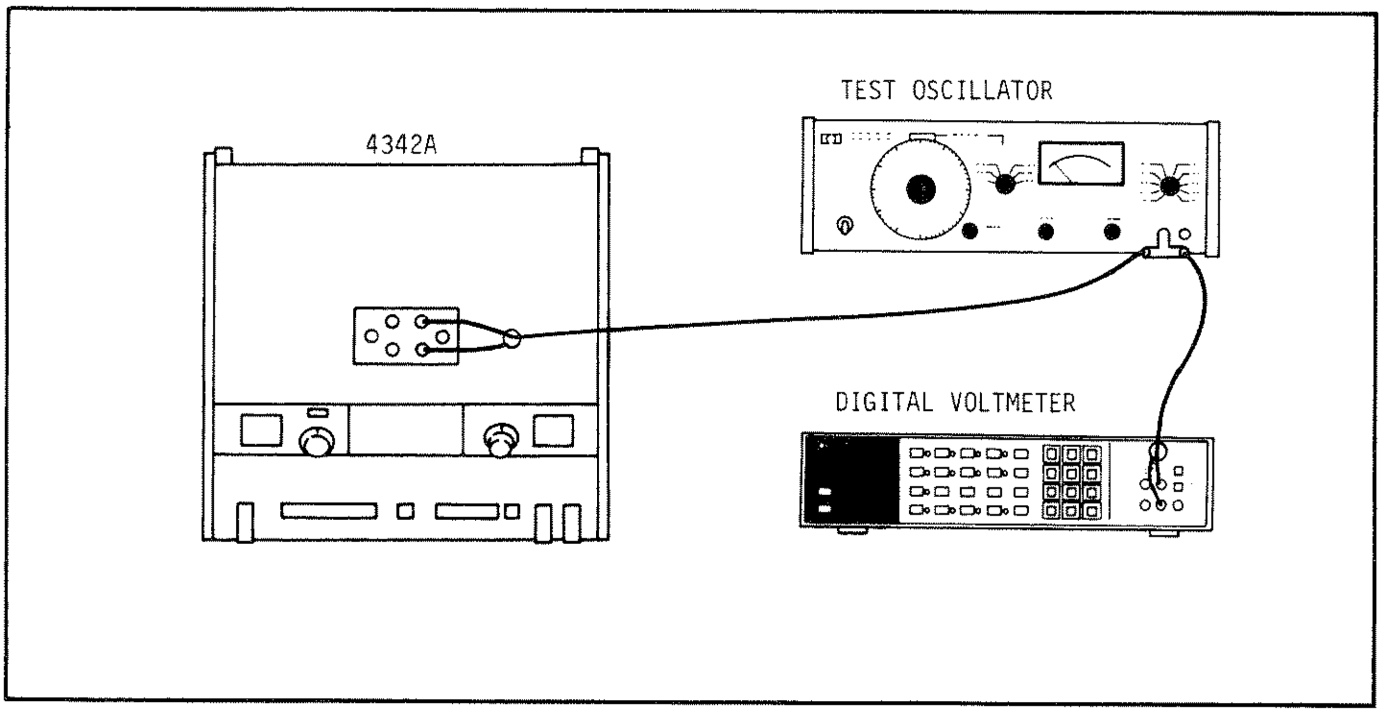


Figure 5-6. Voltmeter Adjustment.

d. Connect the Test Oscillator to the 4342A as shown in Figure 5-6.

e. Set the Test Oscillator frequency to 100kHz and output for full scale reading (approx. 900mVrms) on 4342A Q meter.

f. Adjust A6R6 (REC GAIN adj.) for 1V ±0.01V on Digital Voltmeter display.

g. Repeat steps c through f because both adjustments interact.

5-23. FREQUENCY RESPONSE ADJUSTMENT.

An RF Oscillator and an RF Voltmeter (with known frequency flatness) are required for this adjustment.

a. Connect RF Oscillator and RF Voltmeter as shown in Figure 5-7.

b. Set 4342A C and ΔC dials to minimum.

c. Set RF Oscillator frequency to 10MHz and its output for full scale meter deflection (approx. 900mVrms) on 4342A Q meter.

d. Note RF Voltmeter reading.

e. Set RF Oscillator frequency to 20MHz and its output for the same RF Voltmeter reading as that noted in step d.

f. Adjust A5R32 (MED. FREQ. ADJ) for full scale reading on 4342A Q meter.

g. Set RF Oscillator frequency to 70MHz and its output for the same RF Voltmeter reading as that noted in step d.

h. Adjust A5C16 (HIGH FREQ. ADJ) for full scale reading on 4342A Q meter.

i. Repeat steps c through h until both difference (from full scale) Q meter readings obtained in steps f and h are within ±2% of full scale.

5-24. Q LIMIT SELECTOR ADJUSTMENT.

An RF Oscillator is required for this adjustment.

a. Set 4342A rear panel OVER LIMIT DISPLAY TIME switch to ∞ position.

b. Connect RF Oscillator between HI and GND terminals.

c. Set 4342A Q LIMIT control to 100.

d. Set RF Oscillator to desired frequency (100kHz to 1MHz) and adjust its output for full scale reading on 4342A Q meter.

e. Rotate A7R3 (Q-PRESET adj.) CCW until front panel OVER LIMIT indicator lights.

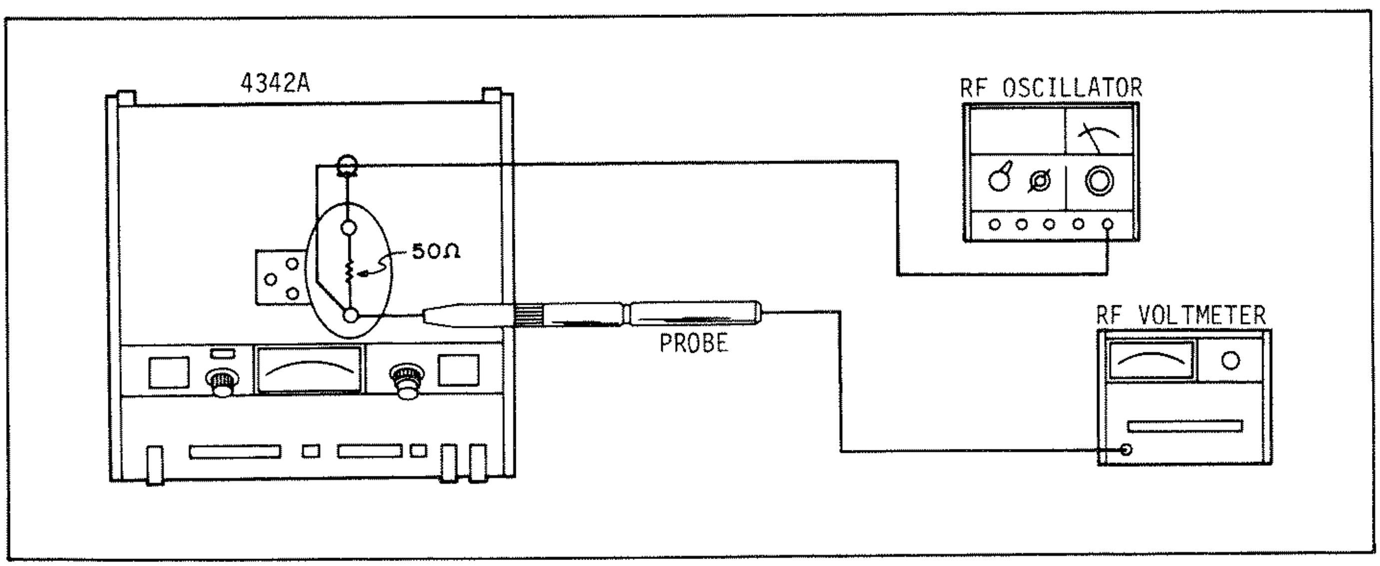


Figure 5-7. Frequency Response Adjustment.

f. Rotate A7R3 very slowly CW until OVER LIMIT indicator is extinguished.

g. Set Q LIMIT control to 50. OVER LIMIT indicator should light.

h. Decrease RF Oscillator output level and note 4342A Q meter reading at which OVER LIMIT indicator just extinguishes. Q Meter reading should be approx. 1/2 full scale (50 ±5 divisions on meter top scale).

i. If Q Meter reading is low, rotate A7R7 (Q-PRESET VERNIER) slightly CW and repeat steps c through h.

j. If Q Meter reading is high, rotate A7R7 slightly CCW and repeat steps c through h.

5-25. OPTION 001 MAINTENANCE INSTRUCTIONS.

5-26. This paragraph and those below describe the changes necessary for applying the Performance Checks and Adjustment and Calibration Procedures in this section (V) to Option 001 instruments.

5-27. OPTION 001 PERFORMANCE CHECKS.

5-28. To apply the Performance Check procedure in paragraphs 5-9 and below to option 001 instruments, make the following changes in standard procedures:

a. Para. 5-11 b. Change the FREQUENCY RANGE and FREQUENCY dial settings to 10k - 32k and 1.0, respectively.

Para. 5-11 c. Change the upper and

Table 5-8. Frequency Accuracy Check (Option 001).

Frequency Range	Frequency Dial Setting	Specified Accuracy	Counter Reading
10k - 32k	1.0 1.5 L 3.2	±1.5% ±1.5% ±1.0% ±1.5%	9.8500 - 10.150 kHz 14.775 - 15.225 kHz 24.922 - 25.424 kHz 31.520 - 32.480 kHz
32k - 100k	3.2 5.0 L 10	±1.5% ±1.5% ±1.0% ±1.5%	31.520 - 32.480 kHz 49.250 - 50.750 kHz 78.822 - 80.413 kHz 98.500 - 101.50 kHz
100k - 320k	1.0 1.5 L 3.2	±1.5% ±1.5% ±1.0% ±1.5%	98.500 - 101.50 kHz 147.75 - 152.25 kHz 249.22 - 254.24 kHz 315.20 - 324.80 kHz
320k - 1M	3.2 5.0 L 10	±1.5% ±1.5% ±1.0% ±1.5%	315.20 - 324.80 kHz 492.50 - 507.50 kHz 788.22 - 804.13 kHz 985.00 - 1015.0 kHz
1M - 3.2M	1.0 1.5 L 3.2	±1.5% ±1.5% ±1.0% ±1.5%	985.00 - 1015.0 kHz 1477.5 - 1522.5 kHz 2492.2 - 2542.4 kHz 3152.0 - 3248.0 kHz
3.2M - 10M	3.2 5.0 L 10	±1.5% ±1.5% ±1.0% ±1.5%	3152.0 - 3248.0 kHz 4925.0 - 5075.0 kHz 7882.2 - 8041.3 kHz 9.8500 - 10.150 MHz
10M - 32M	1.0 1.5 L 3.2	±2.0% ±2.0% ±1.0% ±2.0%	9.8000 - 10.200 MHz 14.700 - 15.300 MHz 24.922 - 25.424 MHz 31.360 - 32.640 MHz

lower frequency limits to 9.850kHz and 10.150kHz, respectively.

Para. 5-11 d. Use Table 5-8 for option 001 instead of Table 5-3.

b. Para. 5-12 b, 5-13 b, and 5-15 b. Change FREQUENCY RANGE and FREQUENCY dial settings to 100k - 320k and 2.0, respectively.

5-29. OPTION 001 CALIBRATION AND ADJUSTMENT PROCEDURES.

5-30. To apply the Calibration and Adjustment Procedures in paragraphs 5-16 and those below to option 001 instruments, partially make the following changes in standard procedures:

a. Para. 5-19 b. Change the FREQUENCY RANGE and FREQUENCY dial settings to 10k - 32k and 2.0, respectively.

b. Para. 5-20 b. Change the FREQUENCY RANGE and FREQUENCY dial settings to 10k - 32k and 1.0, respectively.

Para. 5-20 e. Change frequency tolerance limits to 10.000kHz ± 0.150kHz.

Para. 5-20 f. Change FREQUENCY dial setting to 3.2.

Para. 5-20 g. Change frequency tolerance limits to 32.000kHz ± 0.480kHz.

Para. 5-20 j. Change frequency range to 10 - 32kHz (from 22 - 70kHz).

Para. 5-20k. Use Table 5-9 instead of Table 5-7.

c. Para. 5-21 b. Change FREQUENCY RANGE and FREQUENCY dial settings to 10k - 32k and 1.0, respectively.

d. Para. 5-23 g. Change RF Oscillator frequency setting to 32MHz.

Table 5-9. Frequency Adjustment (Option 001).

Frequency Range	Frequency Dial Setting	Measured Frequency	Adjustment
10k - 32k	1.0 3.2 L	10.000 ±0.150 kHz 32.000 ±0.480 kHz 25.173 ±0.251 kHz	A1A1L1 A1A1C1 NONE
100k - 320k	1.0 3.2 L	100.00 ±1.50 kHz 320.00 ±4.80 kHz 251.73 ±2.51 kHz	A1A1L3 A1A1C5 NONE
1M - 3.2M	1.0 3.2 L	1000.0 ±15.0 kHz 3200.0 ±48.0 kHz 2517.3 ±25.1 kHz	A1A1L5 A1A1C9 NONE
10M - 32M	1.0 3.2 L	10.000 ±0.200 MHz 32.000 ±0.640 MHz 25.173 ±0.251 MHz	A1A1L7 A1A1C13 NONE
32k - 100k	3.2 10 L1	32.000 ±0.480 kHz 100.00 ±1.50 kHz 79.618 ±0.796 kHz	A1A1L2 A1A1C3 NONE
320k - 1M	3.2 10 L	320.00 ±4.80 kHz 1000.0 ±15.0 kHz 796.18 ±7.96 kHz	A1A1L4 A1A1C7 NONE
3.2M - 10M	3.2 10 L	3200.0 ±48.0 kHz 10.000 ±0.150 MHz 7961.8 ±79.6 kHz	A1A1L6 A1A1C11 NONE

5-31. DIAL RE-STRINGING INSTRUCTIONS.

5-32. This paragraph explains how to re-string and set the dial drive strings which move FREQUENCY, L/C, and C dials which rotate the internal variable capacitors. To maintain dial scale accuracy and smooth dial operation, the dial string must be correctly wound on and attached to the drum scale pulley and dial or capacitor pulley and its tension set properly. If a dial string is off or loose, repair the string in accord with the following instructions which outline the procedures for correctly interlocking dial and capacitor.

5-33. For access to internal dial interlocking mechanism, remove control panel, top, bottom, and side covers, and side frames as follows:

a. Turn instrument off and remove power cord.

b. Unscrew the four retaining screws and remove top cover. Remove bottom cover with like procedure.

c. Remove the four retaining screws located at the left and right (top and bottom) sides of the control panel.

d. Lift control panel front edge up and remove the panel.

e. Remove both side panels by removing the four screws on each side.

f. Remove both side-casting-frames by removing the eight screws on each side.

5-34. FREQUENCY DIAL.

The parts required for stringing frequecy dial are:

1) String I: HP Part No. 04342-8541
2) String II: HP Part No. 04342-8542
3) Belt: HP Part No. 04342-1051
4) Screws (2): HP Part No. 0520-0127

Frequency dial re-stringing procedure is illustrated in Figure 5-8.

5-35. L/C DIAL.

To re-string tuning capacitor dial, the following parts are required:

1) String I: HP Part No. 04342-8541
2) String II: HP Part No. 04342-8544
3) Belt: HP Part No. 04342-1052
4) Screws (2): HP Part No. 0520-0127

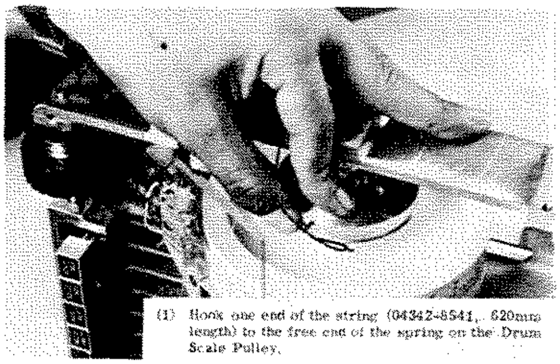
L/C dial re-stringing procedure is illustratd in Figure 5-9.

5-36. ΔC DIAL.

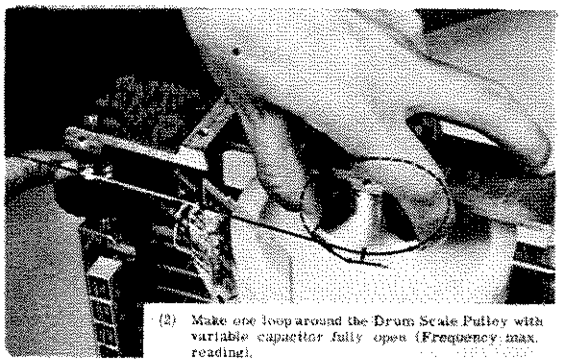
To re-string ΔC dial, the following parts are required:

1) String I: HP Part No. 04342-8541
2) String II: HP Part No. 04342-8543
3) Belt: HP Part No. 04342-1053
4) Screws (2): HP Part No. 0520-0127

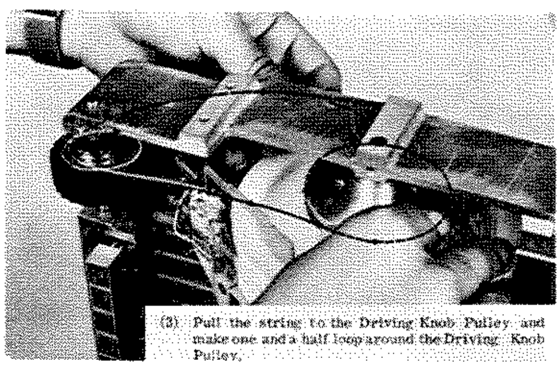
ΔC dial re-stringing procedure is illustrated in Figure 5-10.



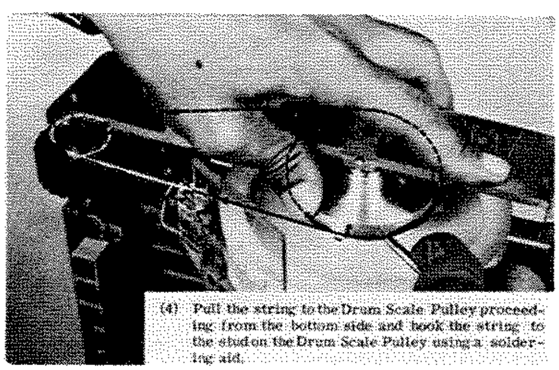
(1) Hook one end of the string (04342-8541, 620mm length) to the free end of the spring on the Drum Scale Pulley.



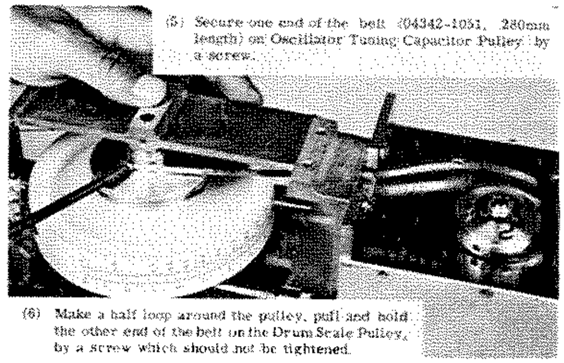
(2) Make one loop around the Drum Scale Pulley with variable capacitor fully open (Frequency max. reading).



(3) Pull the string to the Driving Knob Pulley and make one and a half loop around the Driving Knob Pulley.

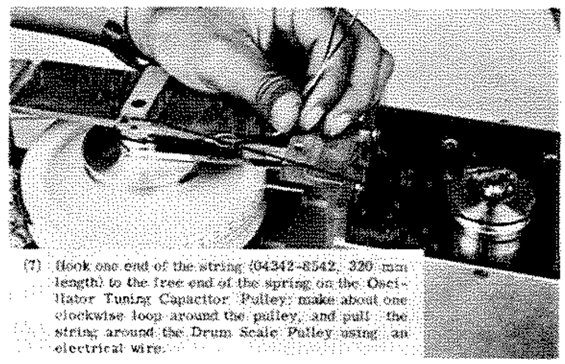


(4) Pull the string to the Drum Scale Pulley proceeding from the bottom side and hook the string to the stud on the Drum Scale Pulley using a soldering aid.

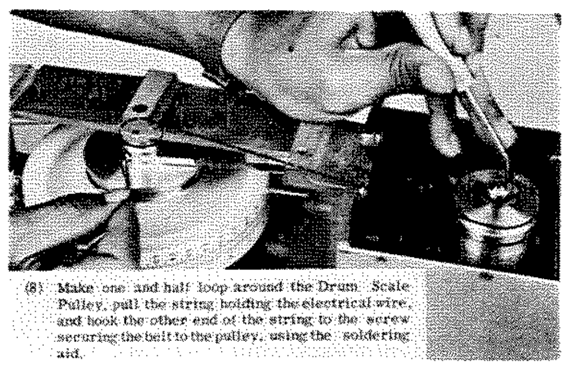


(5) Secure one end of the belt (04342-1051, 280mm length) on Oscillator Tuning Capacitor Pulley by a screw.

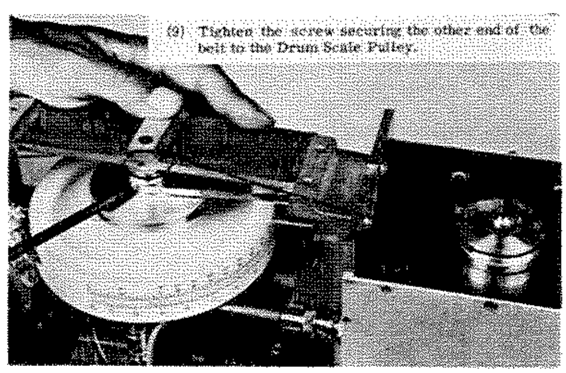
(6) Make a half loop around the pulley, pull and hold the other end of the belt on the Drum Scale Pulley, by a screw which should not be tightened.



(7) Hook one end of the string (04342-8542, 320 mm length) to the free end of the spring on the Oscillator Tuning Capacitor Pulley; make about one clockwise loop around the pulley, and pull the string around the Drum Scale Pulley using an electrical wire.

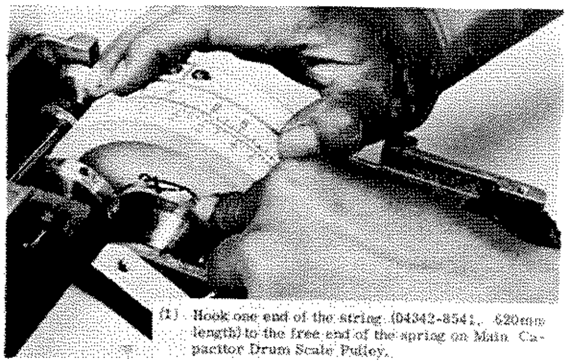


(8) Make one and half loop around the Drum Scale Pulley, pull the string holding the electrical wire, and hook the other end of the string to the screw securing the belt to the pulley, using the soldering aid.



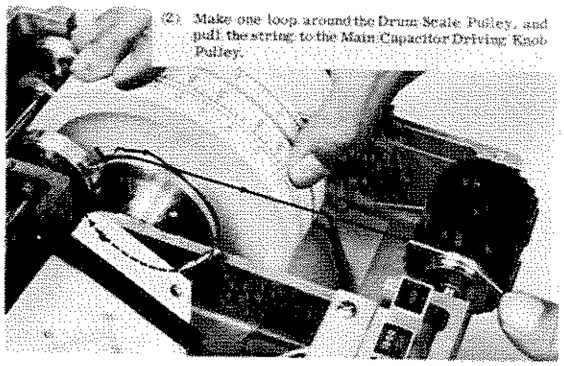
(9) Tighten the screw securing the other end of the belt to the Drum Scale Pulley.

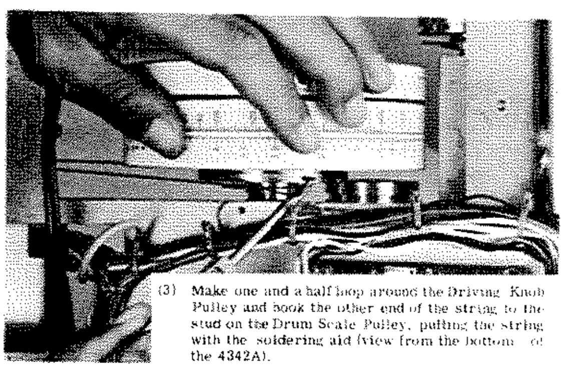
Figure 5-8. Frequency Dial Restringing.



(1) Hook one end of the string (04342-8541, 620mm length) to the free end of the spring on Main Capacitor Drum Scale Pulley.

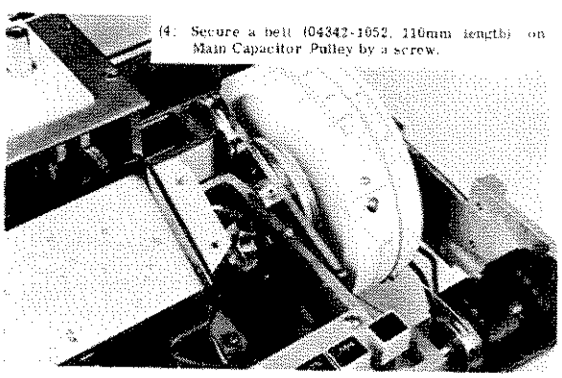
(2) Make one loop around the Drum Scale Pulley, and pull the string to the Main Capacitor Driving Knob Pulley.

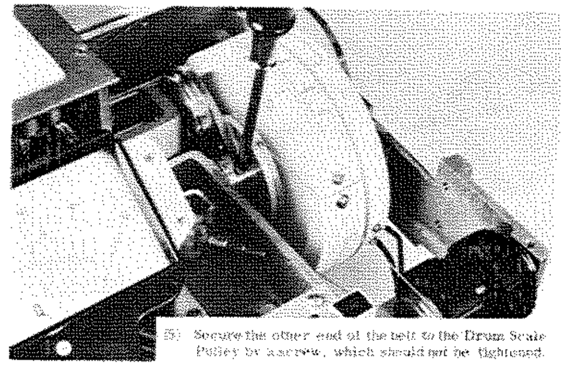




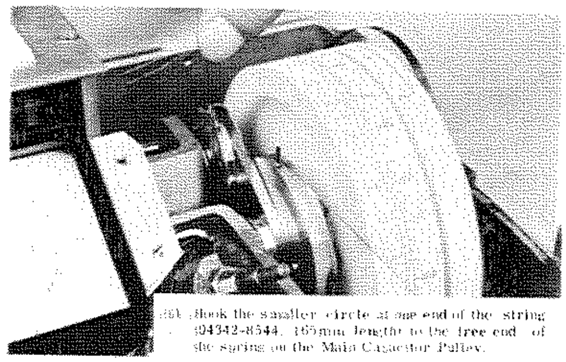
(3) Make one and a half loop around the Driving Knob Pulley and hook the other end of the string to the stud on the Drum Scale Pulley, pulling the string with the soldering aid (view from the bottom of the 4342A).

(4) Secure a belt (04342-1052, 110mm length) on Main Capacitor Pulley by a screw.

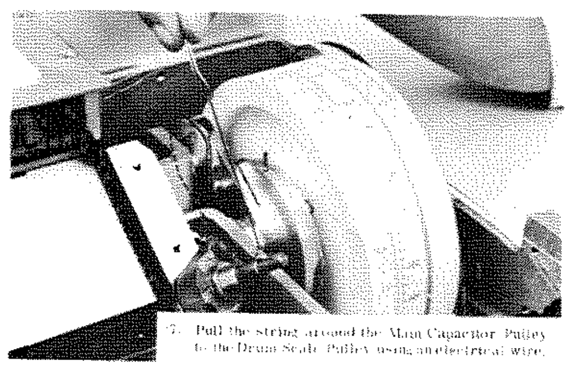




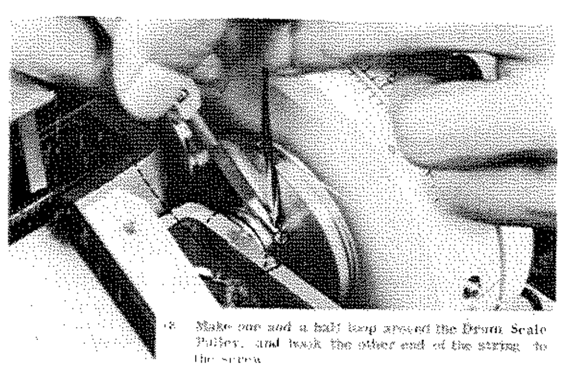
(5) Secure the other end of the belt to the Drum Scale Pulley by a screw, which should not be tightened.



(6) Hook the smaller circle at one end of the string (04342-8544, 165mm length) to the free end of the spring on the Main Capacitor Pulley.

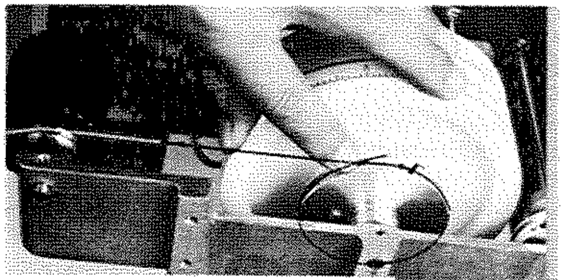


(7) Pull the string around the Main Capacitor Pulley to the Drum Scale Pulley using an electrical wire.

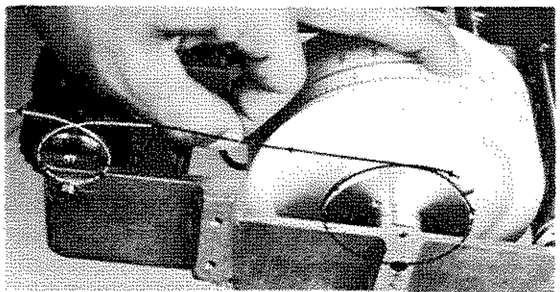


(8) Make one and a half loop around the Drum Scale Pulley, and hook the other end of the string to the screw.

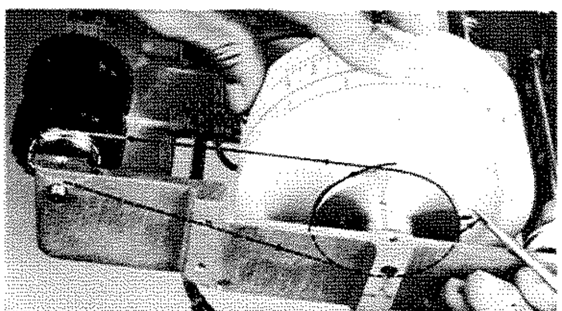
Figure 5-9. Main C Dial Restringing.



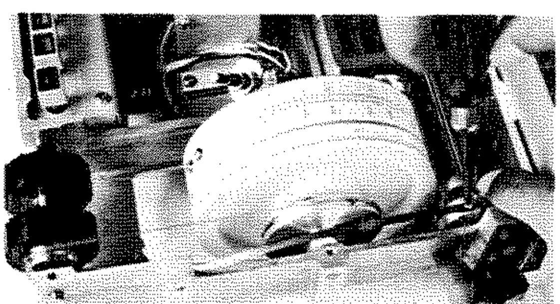
(1) Hook one end of the string (04342-8541, 620mm length) to the free end of the string on the ΔC Drum Scale Pulley and make one loop around the Drum Scale Pulley.



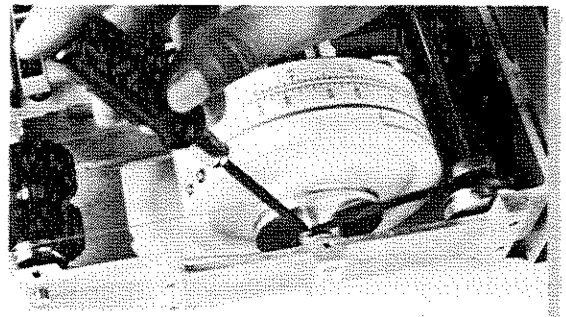
(2) Pull the string to the ΔC Driving Knob Pulley and make one and a half loop around the Driving Knob Pulley.



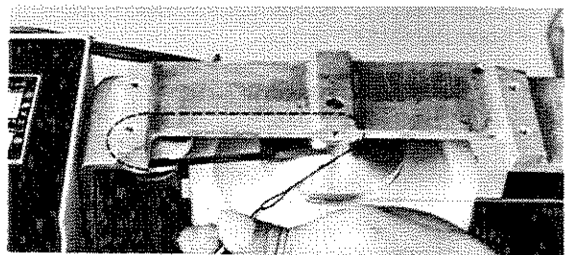
(3) Hook the other end of the string to the stud on the Drum Scale Pulley.



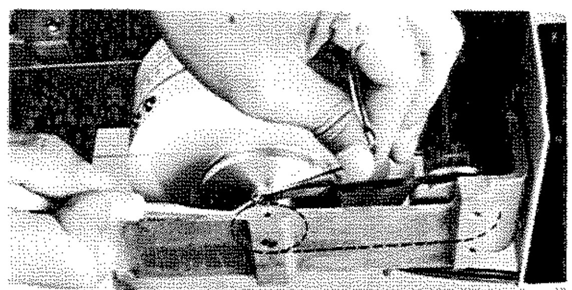
(4) Secure a belt (04342-1053, 142mm length) on ΔC pulley by a screw.



(5) Secure the other end of the belt to the Drum Scale Pulley by a screw which should not be tightened.



(6) Hook the smaller circle at the end of the string (04342-8543, 200mm length) to the free end of the spring on the ΔC Capacitor Pulley, and pull the string around the ΔC Pulley to the Drum Scale Pulley.



(7) Make one and a half loop around the Drum Scale Pulley and hook the other end of the string to the screw using a wire and soldering aid.

Figure 5-10. ΔC Dial Restringing.

5-37. TROUBLESHOOTING GUIDES.

5-38. This paragraph and those below provide information helpful to isolating a faulty circuit in a defective unit and the appropriate remedy for the trouble. Component level troubleshooting procedures are provided in Figures 5-13 and 5-14 in the form of flow diagrams [however, for simple circuits composed of only a few (active) components, these figures treat the breakdown only to circuit block level and component level troubleshooting procedure is omitted]. Before proceeding with troubleshooting, verify whether any external factor relating to the instrument operating environment is contributing to the trouble symptoms. The following paragraphs outline some considerations for such external troubles:

5-39. High Frequency Line Noise.

High frequency noise superposed on the AC power line may possibily cause an abnormal deflection of the Q meter regardless of the sample measured. If meter pointer shows almost the same deflection on any FREQUENCY and Q RANGE setting, check quality of operating power line. To isolate trouble, proceed as follows:

1) Operate the instrument from another ac power line and attempt measurement.

2) Securely ground the instrument chassis to earth.

If the symptom disappears or is different, use the same procedures on actual measurements or use a line filter in the power line.

5-40. Operating in a Strong Electromagnetic Field.

When the instrument is operated in a strong RF electromagnetic field, two (or more) resonant frequency points are sometimes observed on the Q meter indication. This symptom arises from the fact that the Q-measuring circuit resonates with the oscillator signal injected into the circuit and additionally with the RF signal induced by the electromagnetic field as well. In practice, this trouble sometimes occurs when the instrument is located near a high power transmitting station (such as a broadcasting station). The meter "true" tuning deflection can be easily distinguished from the "false" behavior because the amplitude of any meter deflection caused by such external electromagnetic field is irrespective of the Q range. One solution to this trouble is to enclose the instrument in a grounded wire net shield. Securely ground the instrument.

5-41. Operation in High Humidity Environment.

The Q factor of a high Q inductor is generally sensitive to atmospheric humidity. Usually, ordinary high Q inductors tend to show a pronounced decrease in Q factor when they are located in a high humidity environment (more than 80%). If Q meter indicates a lower Q value (different from a nominal value of the sample), compare instrument reading by using a Q reference coil or a stable inductor (hermetically sealed).

5-42. ELEMENTARY TROUBLESHOOTING GUIDE.

5-43. Meter Zeroing Troubles.

If Q meter does not indicate zero after the instrument is turned on and if meter zero adjustment (Figure 3-6) is not successful, A6 DC Amplifier Assembly is probably faulty. Check differential meter amplifier (A6Q2, Q3, Q4 and Q5) and dc power supply voltages on the circuit board.

5-44. Incorrect Q Meter Indication.

If indicated Q values of Q measurements are incorrect (compared with a known sample), the trouble is probably located in either the oscillator section or the Q voltmeter section. (If no deflection at all can be obtained, first check power supply voltages). To isolate the trouble, proceed as follows:

a. Connect a RF Voltmeter to 4342A LO and GND terminals.

b. Set 4342A Q RANGE to 30.

c. Rotate FREQUENCY dial from lowest to highest frequency on each FREQUENCY RANGE setting and check RF voltmeter reading.

d. RF Voltmeter reading should be within 30mV ±0.9mVrms at any frequency setting. If this check fails, troubleshoot oscillator section and follow Figure 5-12 Troubleshooting Tree. If OK, troubleshoot voltmeter section and follow Figure 5-13 Troubleshooting Tree.

5-45. Low Q indication in high frequency measurements.

If the Q meter shows lower Q indication at higher frequencies (above approx. 10MHz), it is conceivable that the symptom is being caused by a drop in Q of the tuning capacitor. The tuning capacitor has a spring contact brush for grounding the capacitor rotor plates with minimal residual impedance to maintain the inherent loss of the capacitor at minimum in the high frequency region. A contact brush in service for a long period may possibly cause an increase in contact resistance and resultant increase in capacitor loss. The remedy for this trouble is to clean the contact brush. Clean with a cloth moistened with alcohol. To take out the contact brush, proceed as follows:

a. Remove top cover.

b. Remove white plastic top plate on measurement terminal deck.

c. Unsolder center conductor (1) of coaxial module connected to A4 Impedance Converter (see Figure 5-11).

d. Remove nut (2) retaining the coaxial assembly module.

e. Remove the six terminal deck retaining screws (3).

f. Lift terminal deck up and out. The contact brush is located on bottom side of terminal deck.

5-46. Faulty Q Limit Operation.

If 4342A operates normally in Q measurements but Q OVER LIMIT indication malfunctions, A7 Q Limit Selector assembly is probably faulty. If OVER LIMIT lamp does not light, first check lamp A10DS5.

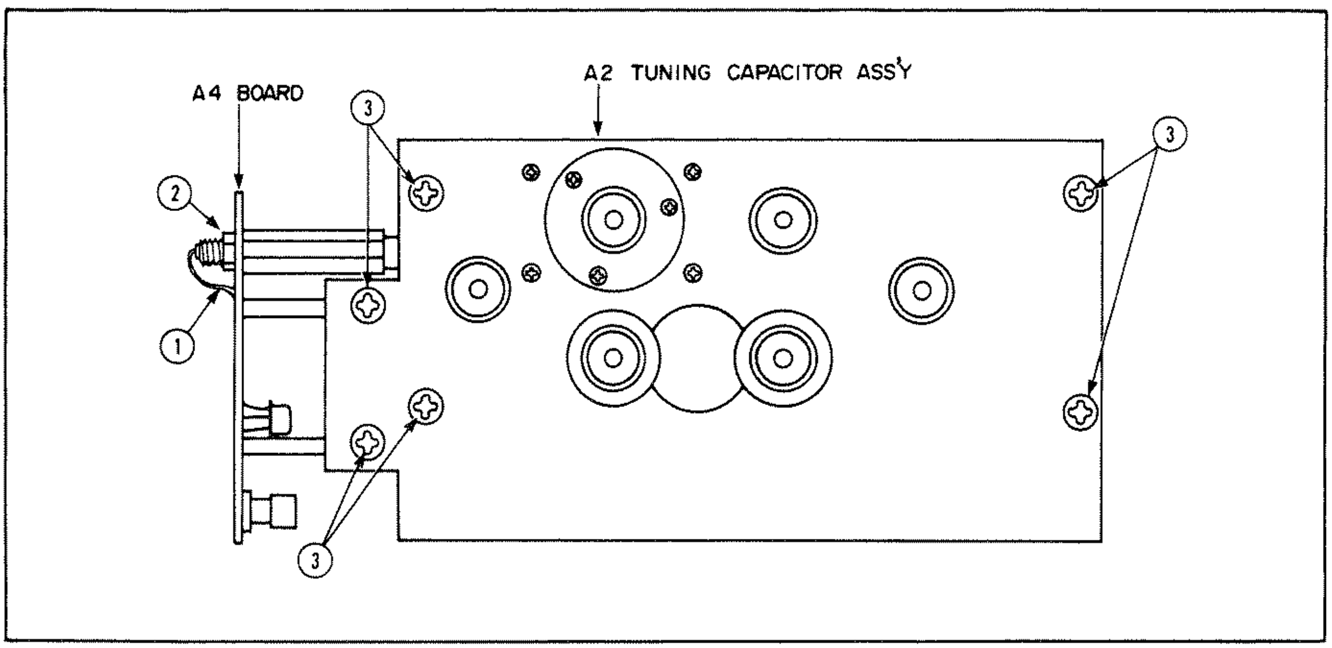


Figure 5-11. Tuning Capacitor Disassembly (top view).

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 4342A
Q Meter
Serial No. ____________

Test Performed by ____________

Date ____________

DESCRIPTION		CHECK
1. FREQUENCY ACCURACY: STANDARD		Counter Reading
22 kHz - 70 kHz Range	22 kHz	21.670 kHz < ________ < 22.330 kHz
	L	24.922 kHz < ________ < 25.424 kHz
	50 kHz	49.250 kHz < ________ < 50.750 kHz
	70 kHz	68.950 kHz < ________ < 71.050 kHz
70 kHz - 220 kHz Range	70 kHz	68.950 kHz < ________ < 71.050 kHz
	L	78.822 kHz < ________ < 80.413 kHz
	150 kHz	147.75 kHz < ________ < 152.25 kHz
	220 kHz	216.70 kHz < ________ < 223.30 kHz
220 kHz - 700 kHz Range	220 kHz	216.70 kHz < ________ < 223.30 kHz
	L	249.22 kHz < ________ < 254.24 kHz
	500 kHz	492.50 kHz < ________ < 507.50 kHz
	700 kHz	689.50 kHz < ________ < 710.50 kHz
700 kHz - 2.2 MHz Range	700 kHz	689.50 kHz < ________ < 710.50 kHz
	L	788.22 kHz < ________ < 804.13 kHz
	1.5 MHz	1477.5 kHz < ________ < 1522.5 kHz
	2.2 MHz	2167.0 kHz < ________ < 2233.0 kHz
2.2 MHz - 7.0 MHz Range	2.2 MHz	2167.0 kHz < ________ < 2233.0 kHz
	L	2492.2 kHz < ________ < 2542.4 kHz
	5.0 MHz	4925.0 kHz < ________ < 5075.0 kHz
	7.0 MHz	6895.0 kHz < ________ < 7105.0 kHz
7.0 MHz - 22 MHz Range	7.0 MHz	6895.0 kHz < ________ < 7105.0 kHz
	L	7882.2 kHz < ________ < 8041.3 kHz
	15 MHz	14.775 MHz < ________ < 15.225 MHz
	22 MHz	21.670 MHz < ________ < 22.330 MHz
22 MHz - 70 MHz Range	22 MHz	21.560 MHz < ________ < 22.440 MHz
	L	24.922 MHz < ________ < 25.424 MHz
	50 MHz	49.000 MHz < ________ < 51.000 MHz
	70 MHz	68.600 MHz < ________ < 71.400 MHz

DESCRIPTION		CHECK
1'. FREQUENCY ACCURACY: OPTION 001		Counter Reading
10 kHz - 32 kHz Range	10 kHz	9.8500 kHz < ________ < 10.150 kHz
	15 kHz	14.775 kHz < ________ < 15.225 kHz
	L	24.922 kHz < ________ < 25.424 kHz
	32 kHz	31.520 kHz < ________ < 32.480 kHz
32 kHz - 100 kHz Range	32 kHz	31.520 kHz < ________ < 32.480 kHz
	50 kHz	49.250 kHz < ________ < 50.750 kHz
	L	78.822 kHz < ________ < 80.413 kHz
	100 kHz	98.500 kHz < ________ < 101.50 kHz
100 kHz - 320 kHz Range	100 kHz	98.500 kHz < ________ < 101.50 kHz
	150 kHz	147.75 kHz < ________ < 152.25 kHz
	L	249.22 kHz < ________ < 254.24 kHz
	320 kHz	315.20 kHz < ________ < 324.80 kHz

PERFORMANCE CHECK TEST CARD

1'. FREQUENCY ACCURACY: OPTION 001 (Cont'd)		Counter Reading
320 kHz - 1.0 MHz Range	320 kHz	315.20 kHz < ______ < 324.80 kHz
	500 kHz	492.50 kHz < ______ < 507.50 kHz
	L	788.22 kHz < ______ < 804.13 kHz
	1.0 MHz	985.00 kHz < ______ < 1015.0 kHz
1.0 MHz - 3.2 MHz Range	1.0 MHz	985.00 kHz < ______ < 1015.0 kHz
	1.5 MHz	1477.5 kHz < ______ < 1522.5 kHz
	L	2492.2 kHz < ______ < 2542.4 kHz
	3.2 MHz	3152.0 kHz < ______ < 3248.0 kHz
3.2 MHz - 10 MHz Range	3.2 MHz	3152.0 kHz < ______ < 3248.0 kHz
	5.0 MHz	4925.0 kHz < ______ < 5075.0 kHz
	L	7882.2 kHz < ______ < 8041.3 kHz
	10 MHz	9.8500 MHz < ______ < 10.150 MHz
10 MHz - 32 MHz Range	10 MHz	9.8000 MHz < ______ < 10.200 MHz
	15 MHz	14.700 MHz < ______ < 15.300 MHz
	L	24.922 MHz < ______ < 25.424 MHz
	32 MHz	31.360 MHz < ______ < 32.640 MHz

2. Q RANGE		Digital Voltmeter Reading
Q Range	30	920.6 mV < ______ < 977.4 mV
	100	873.0 mV < ______ < 927.0 mV
	300	920.6 mV < ______ < 977.4 mV
	1000	873.0 mV < ______ < 927.0 mV

3. ΔQ RANGE		Digital Voltmeter Reading
Q Range	100	873.0 mV < ______ < 927.0 mV
ΔQ Range	10	801.9mV < ______ < 818.1mV

4. CAPACITANCE ACCURACY C Dial	ΔC Dial	Capacitance Bridge Reading
25 pF	0	23.9pF < ______ < 26.1pF
25 pF	-5 pF	(0 Reading)* -5.1pF < ______ < (0 Reading)* -4.9pF
25 pF	+5 pF	(0 Reading)* +4.9pF < ______ < (0 Reading)* +5.1pF
100 pF	0	98.9pF < ______ < 101.1pF
200 pF	0	197.9pF < ______ < 202.1pF
300 pF	0	296.9pF < ______ < 303.1pF
400 pF	0	395.9pF < ______ < 404.1pF
470 pF	0	465.2pF < ______ < 474.8pF
470 pF	+5 pF	(0 Reading)* +4.9pF < ______ < (0 Reading)* +5.1pF

* Note: 0 Reading is the readout of the Capacitance Bridge when C Dial is set to 0.

5. Q OVER LIMIT OPERATION		Over Limit Lamp
Q Limit Setting	60	On ☐
Meter Indication	50	Off ☐
Meter Indication	≥ 60	On ☐