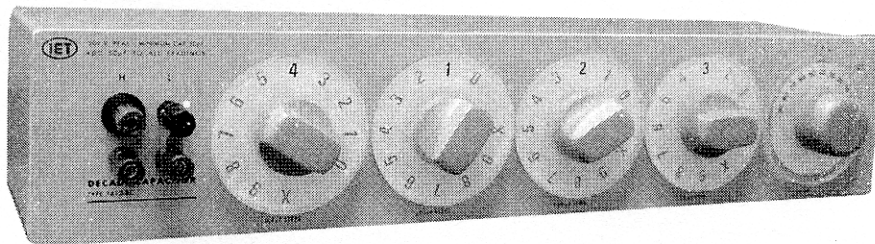


◆ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ◆

1412-BC

DecadeCapacitor

User and Service Manual



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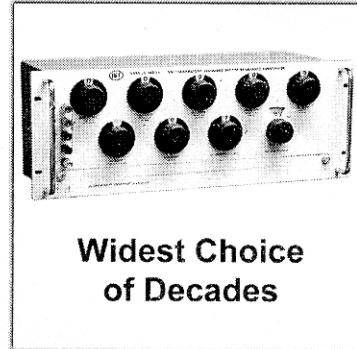
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Capabilities

- R: 20 $\mu\Omega$ -1 T Ω
- C: <1 pF - 1 F
- L: 100 μ H-100 H

- Accuracy to 1 ppm
- Resolution to 0.1 ppm
- Voltage to 20 kV
- Power to over 1000 W
- Programmable IEEE-488 or BCD



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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.



WARNING



OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

**Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qualified personnel**

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO
AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE
CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

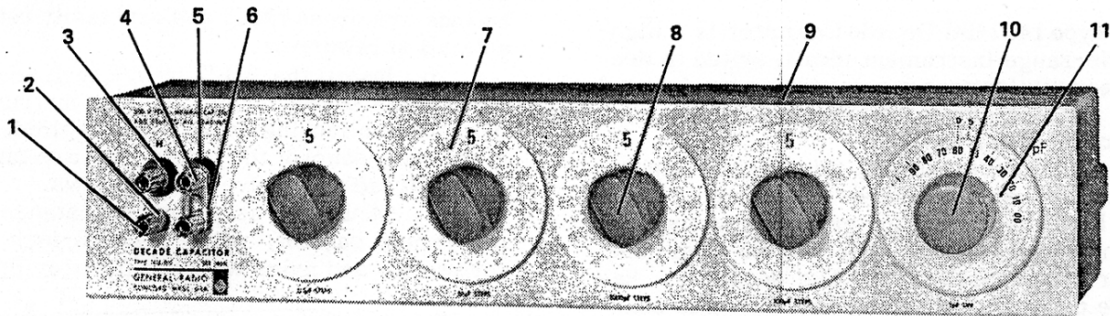
WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND
KEEP UNREQUIRED PERSONNEL SAFELY AWAY.



CAUTION



DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS
INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON
THE FRONT PANEL OR THE OPERATING GUIDE LABEL.



MECHANICAL PARTS LIST

Fig Ref	Qnt	Description	GR Part No.	Fig Ref	Qnt	Description	GR Part No.
1	2	Binding post asm.	0938-3022			Knob	5500-5404
2	2	Spacer	7800-0600			Retainer	5220-5401
3	1	Binding post asm.,	0938-3070	9	1	Cabinet asm	1412-1040
4	1	Binding post asm.,	0938-3058	10	1	Knob asm., 1 pF Div.	5520-5420
5	3	Bushing	0938-7130			includes:	
	1	Bushing	0938-7131			Knob	5520-5400
6	1	Shorting Links	5080-4800			Retainer	5520-5401
7	4	Dial asm.,	5120-2120	11	1	Dial asm., 1 pF Div.	5120-2121
8	4	Knob asm.,	5500-5420	4	4	Foot, rubber	5260-1200

ELECTRICAL PARTS LIST

Ref Des	Description	GR Part No.	Ref Des	Description	GR Part No.
CAPACITORS					
C1	Variable	0368-4100	C17	Poly, 0.50 μ F + .05% - .35% 500 V	1412-1100
C2	Poly, 99 pF \pm 0.6% 500 V	4872-1050	C18	Cer., 2.2 \pm 0.25 pF or Cer., 4.7 \pm 0.5 pF	4400-2450 4400-2700*
C3 and C4	Poly, 198.8 pF \pm 0.6% 500 V	4872-1051	CONNECTORS		
C5	Poly, 498 pF \pm 0.6% 500 V	4872-1052	J1	Binding post	0938-3070
C6	Poly, 997 pF \pm 0.5% - .45% 500 V	4872-1053	J2	Binding post	0938-3022
C7 and C8	Poly, 1995 pF \pm 0.5% - .45% 500 V	4872-1080	J3	Binding post	0938-3058
C9	Poly, 4987 pF \pm 0.5% - .35% 500 V	4872-1081	J4	Binding post	0938-3022
C10	Poly, .01 μ F \pm 0.5% - .35% 500 V	4872-1082	SWITCHES		
C11 and C12	Poly, .02 μ F \pm 0.5% - .35% 500 V	4872-1060	S1	Switch	7890-4140
C13	Poly, .05 μ F \pm 0.5% - .35% 500 V	4872-1070	S2 thru S4	Switch	7890-4150
C14	Poly, 0.1 μ F \pm 0.5% - .35% 500 V	4872-1171			
C15 and C16	Poly, 0.2 μ F \pm 0.5% - .35% 500 V	4872-1179			

*Selected by General Radio Company to produce a zero reading of 48-50 pF in individual instruments.

SPECIFICATIONS

Capacitance: 50 pF to 1.11115 μ F in steps of 100 pF with a 0- to 100-pF variable air capacitor providing continuous adjustment with divisions of 1 pF. Capacitances for 2- and 3-terminal connections differ by about 1 pF (C_{HE} in the drawing). C_{LE} is approx 125 pF.

Min Capacitance: 50 pF with all controls set at zero.

Dielectric: Polystyrene for decade steps.

Accuracy: \pm (0.5% + 5 pF) at 1 kHz for total capacitance including 50-pF minimum for the 3-terminal connection.

Temperature Coefficient: -140 ppm/°C (nominal).

Frequency Characteristics: Dc Cap/1-kHz Cap $<$ 1.001. At higher frequencies the increase is approx $\Delta C/C = (f/f_0)^2$. The resonant frequency, f_0 , varies from over 400 kHz for a capacitance of 1 μ F to about 27 MHz for a capacitance of 150 pF when connections are made to the front terminals. f_0 is about 300 kHz and 70 MHz for rear connections and the same capacitances.

Max Operating Temperature: 65°C.

Dielectric Absorption (Voltage Recovery): 0.1% max.

Dissipation Factor: 150 to 1000 pF, 0.001, max, at 1 kHz, at 23°C and relative humidity $<$ 50%; over 1000 pF, 0.0002, max, at 1 kHz.

Insulation Resistance: 10^{12} ohms, min.

Max Voltage: 500 V peak, up to 35 kHz.

Terminals: Four 938 Binding Posts with grounding link are provided on the panel. Two of the binding posts are connected to the case and located for convenient use with patch cords in 3-terminal applications. Access is also provided to rear terminals for relay-rack applications.

Mechanical: Lab-bench cabinet; brackets provided for rack mounting. DIMENSIONS (wxhxd): 17.25x3.5x6 in. (439x89x153 mm). WEIGHT: 8.5 lb (3.9 kg) net, 10 lb (4.6 kg) shipping.

Description	Catalog Number
1412-BC Decade Capacitor	1412-9410

1 INTRODUCTION

1.1 PURPOSE.

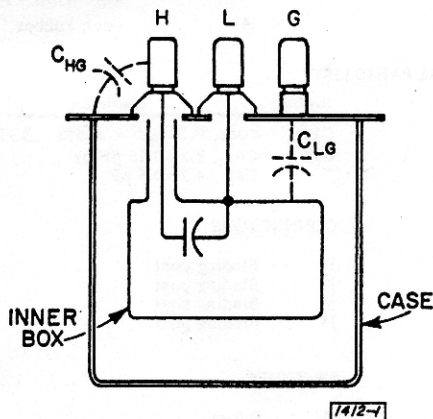
The Type 1412-BC Decade Capacitor is a high-quality, wide-range instrument ideally suited to decade capacitor applications ranging from experimental circuits on a laboratory bench to permanent installations in a relay rack.

Designed for versatility, this Decade Capacitor features fine adjustment over a wide range of capacitance, high resolution, and provision for two- or three-terminal connections on either the front panel or the rear of the instrument. The decade box has polystyrene capacitors with excellent dc and ac characteristics. Its low inductance permits use up into the supersonic frequency range with relatively little change in effective capacitance.

1.2 DESCRIPTION.

An air capacitor makes available a continuously variable range of 0 to 100 pF. In the four decades, polystyrene capacitors are used for steps of 100 pF, 1000 pF, 0.01 μ F, and 0.1 μ F. The capacitors are housed in a double-shielded inner box and case as shown in Figure 1.

Figure 1. The double shielding used in the Type 1412-BC Decade Capacitor keeps C_{HG} very small. This capacitance is the difference between the three-terminal and two-terminal capacitance of the box; C_{LG} is approximately 125 pF.



Ceramic-insulated switches, with solid-silver-alloy contacts, select parallel combinations of capacitors having values in the ratio of 1, 2, 2, and 5. The polystyrene capacitors are of extended foil construction for minimum inductance and low series resistance. This dielectric material is used for stability of capacitance, low dielectric losses, and high insulation resistance.

Mounting hardware is provided for installing the instrument in a relay rack.

2 OPERATING PROCEDURE

2.1 MOUNTING.

The Type 1412-BC Decade Capacitor is housed in a cabinet for convenient bench use. Additional mounting hardware is also supplied for installation

in a relay rack. To install the instrument in a relay rack:

a. Remove the black nylon buttons from the holes at the side panels of the instrument. These buttons are press fitted and are easily removed with a small screwdriver.

b. Install the 3 1/2 by 7/8 inch adaptor-panel assemblies (A) on each side of the instrument, using the 3/8-inch locking screws (B) supplied. The holes in the side-panel of the instrument are tapped with a 10-32 thread to receive these screws.

c. Mount the assembly in a standard 19-inch relay-rack cabinet, using the 5/8-inch No. 10-32 screws (C) and nylon washers (D) provided.

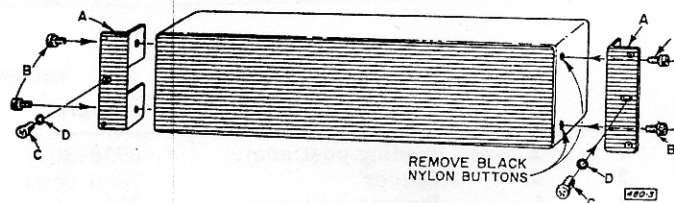
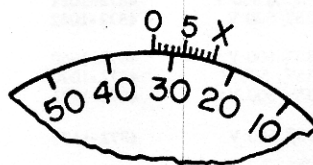


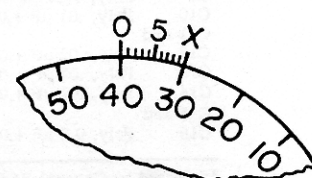
Figure 2. Relay-rack installation of Type 1412-BC.

2.2 READOUT.

The four decades of polystyrene capacitors have clear, easy-to-read dials with numbered steps from 0 to X (X=10). The dial provided with the continuously adjustable air capacitor has ten 10-pF divisions for a total range of 0 to 100 pF, plus additional readout to 1 pF per graduation. The dial is easy to read, simply add the number of graduations (counting from 0) on the fixed vernier scale to the corresponding numbered division on the dial. Sample settings are illustrated in the following examples:



Read:
 $30 + 3 = 33$ pF



Read:
 $30 + X(10) = 40$ pF
or
 $40 + 0 = 40$ pF

2.3 FRONT CONNECTIONS.

The four terminals on the front panel of the Type 1412-BC are arranged in a square with standard 3/4-inch spacing for either two-terminal or three-terminal connection. With this arrangement, a wide variety of connectors, in various combinations, can be used. Typical examples are shown in Figures 3 through 6.

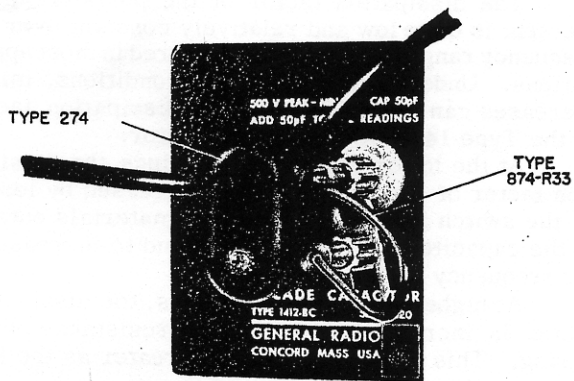


Figure 3. Front panel of Type 1412-BC showing three-terminal connection with both shields connected to the case.

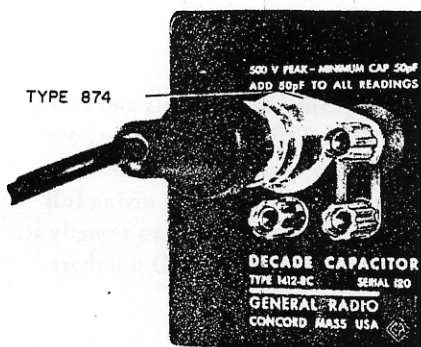


Figure 4. Type 1412-BC showing two-terminal (grounded) connection using Type 874

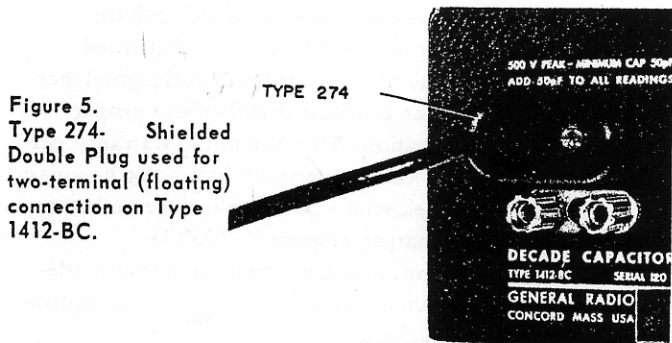


Figure 5. Type 274. Shielded Double Plug used for two-terminal (floating) connection on Type 1412-BC.



Figure 6. Type 1412-BC with two-terminal (grounded) connection using bus wire.

2.4 REAR CONNECTIONS.

To make connections at the rear of the instrument (see Figure 7):

a. Remove the two 6-32 screws (G) and the small rectangular plate from the rear panel. Thread the two screws (G) back into the panel after removing the plate.

b. Thread the spacer and then one of the 1/4 inch No. 6-32 screws (spacer and screws supplied) on the recessed terminal H.

c. Thread the remaining 1/4-inch No. 6-32 screw into terminal L.

NOTE

Lug terminals are supplied and can be installed with the terminal screws as desired.

Connections can now be made to terminals L, H, and G.

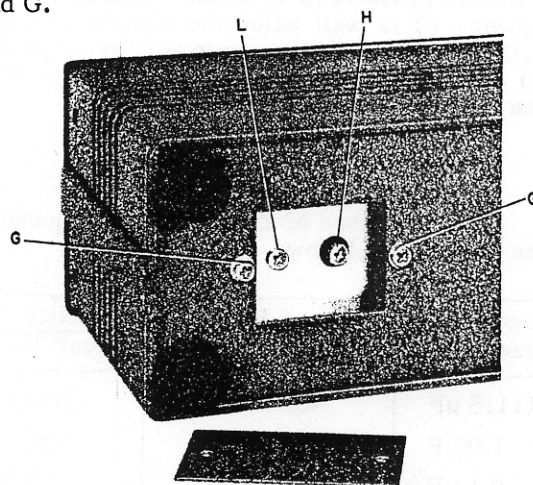


Figure 7. Rear panel view of Type 1412-BC showing terminals for rear connections.

3 PRINCIPLES OF OPERATION

3.1 GENERAL.

The following paragraphs briefly describe some of the more important principles of operation applicable to the Type 1412-BC Decade Capacitor. For a detailed discussion of the characteristics of standard capacitors, refer to the General Radio Catalog.

3.2 CONNECTIONS.

The Type 1412-BC is designed for either two-terminal or three-terminal connection. (See Figure 1 for a diagram of the shielding elements and connection terminals.) Because the inner box is connected to terminal L, the high side (H) of the decade capacitance is almost completely shielded from the outer case.

For general use, the two-terminal and three-terminal decade capacitances differ only by the small capacitance (C_{HG}) of the binding post H to the case. It is particularly desirable that this capacitance be as small as possible when using low values of decade capacitance with the Type 1654 Impedance Comparator and with many special bridges.

3.3 FREQUENCY CHARACTERISTICS.

Variations of capacitance with changes in frequency are principally a function of the dielectric material below 1 kHz and a function of the amount of series inductance above 1 kHz. Polystyrene dielectric ensures negligible variations of capacitance below 1 kHz and extended foil construction provides a minimum value of inductance above 1 kHz.

Most of the inductance in the Decade Capacitor is in the wiring. This inductance is low enough to keep the increase in effective capacitance to a reasonably low value over the frequency range in which the instrument is likely to be used. When the operating frequency (f) is well below the resonant frequency (f_r), the approximate increase in effective capacitance (ΔC) over the zero-frequency capacitance (C_0) is given by the expression:

$$\frac{\Delta C}{C_0} \approx \left(\frac{f}{f_r}\right)^2$$

Typical values of the resonant frequency are given in the table below.

Decade Capacitance	Resonant Frequency	
	Front Terminals	Rear Terminals
1.11115 μ F	430 kHz	310 kHz
1.0 μ F	440 kHz	320 kHz
0.1 μ F	1.25 MHz	1.2 MHz
0.01 μ F	3.5 MHz	4.3 MHz
1050 pF	10 MHz	17 MHz
150 pF	27 MHz	70 MHz

At frequencies up to 30 kHz, the effective capacitance at any setting will be less than 1% higher than the value of capacitance at 1 kHz. At most settings, the error will be much smaller.

3.4 DISSIPATION FACTOR.

The dissipation factor of the polystyrene dielectric is quite low and relatively constant over the frequency range ordinarily encountered in most applications. Under certain operating conditions, minor increases can be expected in the dissipation factor of the Type 1412-BC Decade Capacitor.

At the lower capacitance settings, the dissipation factor of the decade box is increased by losses in the switch insulation and other materials outside of the capacitors. These losses tend to increase as the frequency is lowered.

At higher capacitance settings, the dissipation factor is increased by the series resistance of the wiring. This effect will become greater as the frequency is increased.

4 SERVICE AND MAINTENANCE

4.1 WARRANTY.

Our warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. Please write or phone the nearest QT service facility, giving full information of the trouble and of steps taken to remedy it. Describe the instrument by type, serial, and ID numbers. (Refer to front and rear panels.)

4.2 SERVICE.

Before returning an instrument to QuadTech for service, please ask our nearest office for a "Returned Material" number. Use of this number in correspondence and on a tag tied to the instrument will ensure proper handling and identification. After the initial warranty period, please avoid unnecessary delay by indicating how payment will be made, i.e., send a purchase-order number or (for transportation charges) request "C.O.D."

For return shipment, please use packaging that is adequate to protect the instrument from damage, i.e., equivalent to the original packaging.



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