1710 LCR Digibridge
Instruction Manual
Form 150390/A5

"1710 DISCONTINUED"
REPLACED BY 1715

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The material in this manual is for informational purposes only and is subject to change, without notice. QuadTech assumes no responsibility for any error or for consequential damages that may result from the misinterpretation of any procedures in this publication.

WARNING

Potentially dangerous voltages may be present on front and rear panel terminals. Follow all warnings in this manual when operating or servicing this instrument. Dangerous levels of energy may be stored in capacitive devices tested by this unit.

Always make sure the high voltage indicator is **not** on when connecting or disconnecting the device under test.

Product will be marked with this symbol (ISO#3684) when it is necessary for the user to refer to the instruction manual in order to prevent injury or equipment damage.

Product marked with this symbol (IEC417) indicates presence of direct current.

Product will be marked with this symbol (ISO#3684) when voltages in excess of 1000V are present.

Contents

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Warranty

QuadTech warrants that Products are free from defects in material and workmanship and, when properly used, will perform in accordance with QuadTech's applicable published specifications. If within one (1) year after original shipment it is found not to meet this standard, it will be repaired, or at the option of QuadTech, replaced at no charge when returned to a QuadTech service facility.

Changes in the Product not approved by QuadTech shall void this warranty.

QuadTech shall not be liable for any indirect, special or consequential damages, even if notice has been given of 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 or merchantability or fitness for a particular purpose.

SERVICE POLICY

QuadTech's service policy is to maintain product repair capability for a period of at least five (5) years after original shipment and to make this capability available at the then prevailing schedule of charges.

Specifications

LCR Features

		120Hz	1KHz
Primary Display:	R	0.0001Ω - 99.999MΩ	0.0001Ω - 9.9999MΩ
	L	0.0001mH – 9999.9H	0.1µH – 999.99H
	C	0.001nF - 99999µF	0.1pF – 999.99µF

Secondary Display:	D (with C)	.0001 – 9.999
	Q (with R)	.0001 – 9.999
	Q (with L)	00.01 – 999.9
	R (with C, L)	.0001Ω - 99.999MΩ

Frequency: 120Hz or 1KHz

Measurement Rate: 3 measurements/second

Accuracy:

For D < 0.05 or Q > 20:

R, L, C	± 0.2%
Q (with R)	± 0.001
Q (with L)	± 0.01
D (with C)	± 0.0005

For D > 0.05 or Q < 20:

	LCR Accuracy	D, Q Accuracy (Typ)
ZL ≤ Zx ≤ ZH	0.2%	0.25%
Zx < ZL	(ZL/Zx) x 0.2%	(ZL/Zx) x 0.25%
Zx > ZH	(Zx/ZH) x 0.2%	(Zx/ZH) x 0.25%

Zx: DUT
ZL: Lower edge of ranges in best accuracy
ZH: Upper edge of ranges in best accuracy

ZL, ZH	R	L	C
120Hz	2Ω, 2MΩ	2mH, 2000H	2nF, 650µF
1kHz	2Ω, 2MΩ	0.2mH, 200H	.2nF, 75µF

Specifications (Continued)

General Features

Bias Voltage:	External DC Bias:	0-35VDC, Applied Current: < 200mA	
	Ripple:	< 1mV peak to peak.	
Test Signal:	RMS Test Voltage:	1.0V	0.25V
	Current Limits:	10µA - 40mA, (Range Dependent)	2.5µA - 25mA, (Range Dependent)

Circuit: Equivalent Series or Parallel

Mechanical: Bench Mount
Dimensions: (w x h x d): 10.50x4.0x13.0 inches (262.5x100.0x325.0mm)

Weight: 7.5lbs (3.45kg) net, 11lbs (5.06kg) shipping

Environmental: Operating: 0°C to + 50°C
Storage: -40° to + 75°C
Humidity: <85%
Warm-up Time: 15 minutes

Power:
- 90 - 125V AC
- 180 - 250V AC
- 50 or 60Hz
- 50W max, 40W typical

Supplied:
- Instruction Manual
- Calibration Certificate
- AC Power Cable
- 4 BNC to 2 Kelvin Clip Lead Set

Ordering Information:

Description	Catalog No.
1710 LCR Digibridge	1710

Accessories

Accessories Included

Item	Quantity	QuadTech P/N
AC Power Cord	1	4200-0300
0.6A Slow Blow Screw Cap Fuse 115V Operation	1	520023
0.3A Slow Blow Screw Cap Fuse 230V Operation	1	520025
4-BNC Connectors to 2-Kelvin Clips Lead Set	1	1700-03
Instruction Manual	1	150390
Calibration Certificate	1	N/A

Accessories/Options Available

Item	Quantity	QuadTech P/N
Axial/Radial Component Test Fixture	1	1700-01
Axial/Radial Remote Test Fixture	1	1700-02
4-BNC Connectors to 2-Kelvin Clips Lead Set	1	1700-03
4-BNC Connectors to 4-Banana Plugs Lead Set	1	1700-04
4-BNC Connectors to Chip Component Tweezers	1	1700-05

Safety Precautions

The 1710 LCR Digibridge can provide an output voltage as high as 1.0VDC (35VDC external Bias Voltage) to the device under test (DUT). Although the Digibridge unit is designed with full attention to operator safety, serious hazards could occur if the instrument is used improperly and these safety instructions are not followed.

1. The 1710 Digibridge unit is designed to be operated with its chassis connected to earth ground. The instrument is shipped with a three-prong power cord to provide this connection to ground. This power cord should only be plugged in to a receptacle that provides earth ground. Serious injury can result if the 1710 Digibridge is not connected to earth ground.
2. Tightly connect BNC cable(s) to the (silver) **HIGH (-)** terminal. If this is not done, the DUT's casing can be charged to the high voltage test level and serious injury or electrical shock hazards could result if the DUT is touched.
3. Never touch the metal of the High Voltage probe directly. Touch only the insulated parts of the lead(s).
4. Never touch the test leads, test fixture or DUT in any manner (this includes insulation on all wires and clips) when the bias voltage is applied and the red **BIAS ON** light is on.
5. Before turning on the 1710 Digibridge unit, make sure there is no device (DUT) or fixture connected to the test leads.
6. When the red **BIAS ON** LED is lit or flashing, NEVER touch the device under test, the lead wires or the output terminals.
7. Before touching the test lead wires or output terminals make sure:
   a) Any capacitive device has had enough discharge time.
   b) The red **BIAS ON** LED is NOT lit.
8. **In the case of an emergency**, turn OFF the POWER switch using a "hot stick" and disconnect the AC power cord from the wall. DO NOT TOUCH THE 1710 Digibridge INSTRUMENT.
9. When the 1710 Digibridge instrument is used in remote control mode, be extremely careful. The High Voltage Output is being turned on and off with an external signal.

Condensed Operating Instructions

General Information

The 1710 LCR Digibridge is an instrument for measuring primary parameters of inductance (L), capacitance (C) and resistance (R) and secondary parameters of dissipation factor (D) and quality factor (Q).

Start-Up

The 1710 LCR Digibridge unit can be operated from a power source between 95 - 125VAC or 150 – 250VAC at a power line frequency of 50 or 60Hz. The standard 1710 unit is shipped from QuadTech with a 0.6A fuse in place for AC 115V operation. A 0.3A fuse is included in the accessories package for 230V operation. The 1710 unit is shipped with the line voltage selector set for 115V. Refer to paragraph 1.4.3 to change a fuse and to change the line voltage selector.

Connect the 1710 instrument's AC power cord to the source of proper voltage. The instrument is to be used only with 3-wire grounded outlets.

Press the [POWER] button on the front panel to apply power. To switch the power off press the [POWER] button again or if measurements are to be made proceed with Test Parameter Set-Up below. Note: the 1710 unit should warm-up for a minimum of 15 minutes prior to use.

Test Parameter Set-up

The Test Parameter Table illustrates the parameters that can be set prior to test. Refer to ¶ 2.7 for the correct connection to device under test. Refer to ¶ 2.3.6 for the correct zeroing function. Read this instruction manual in full prior to using the 1710 LCR Digibridge.

Test Parameter Table

NAME	FUNCTION	SELECTION		
LCR%	Primary Parameter	L	C	R
FREQ	Frequency	120Hz	1kHz	
SER/PAR	Equivalent Circuit	Series	Parallel	
0.25V/1.0V	Test Voltage	0.25V	1.0V	
ZERO	Zero Function	Enable	Disable	
DQR NOM%	Secondary Parameter	Q	D	R
RANGE	Range	AUTO	DOWN	UP
SAVE NOMINAL	Comparison	Enable	Disable	

Measurement Mode

1. Turn [POWER] ON.
2. Allow the 1710 instrument to warm-up for 15 minutes.
3. Select Primary Parameter.
4. Select Frequency.
5. Select Test Voltage.
6. Select Secondary Measurement.
7. Select Range.
8. Connect Test Cables or Test Fixture.
9. Enable Zero Function.
10. Connect Device Under Test (DUT).

Figure COI-1 illustrates the connection of a device under test (DUT) to the 1710 instrument using the BNC to Kelvin Clip Lead Set provided with the unit.

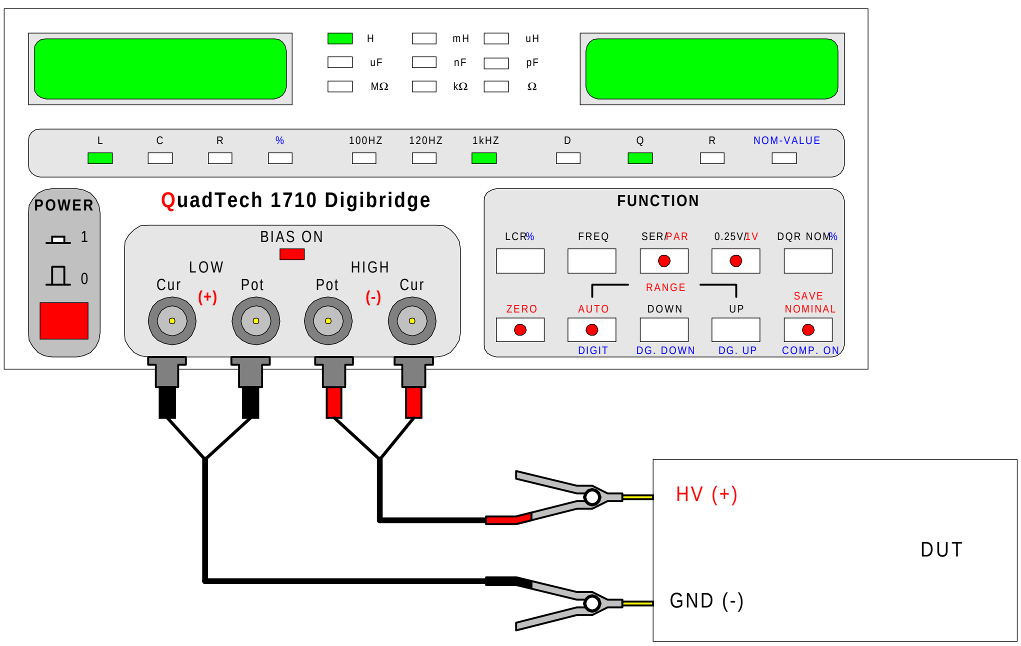


Figure COI-1: Connection to DUT using Kelvin Clip Lead Set

Section 1: Introduction

1.1 Unpacking and Inspection

Inspect the shipping container before opening if it is damaged contact the carrier's agent immediately. Inspect the 1710 LCR Digibridge unit for any damage. If the instrument appears damaged or fails to meet specifications, notify QuadTech (refer to instruction manual front cover) or its local representative. Retain the shipping carton and packing material for future use such as returning for recalibration or service.

1.2 Product Overview

The 1710 LCR Digibridge is an economical, user-friendly meter for production testing of inductors, capacitors and other LCR components. The 1710 Digibridge makes primary measurements of L, C, and R and secondary measurements of D and Q. L, C & R measurements are made at a frequency of 120Hz or 1kHz with a basic accuracy of ±0.2%. The accuracy of the secondary parameters for D or Q <1 is ± 0.001 for Q (with R), ±0.01 for Q (with L), and ± 0.0005 for D (with C). Refer to the Specifications list for the accuracy of D and Q when D or Q > 1. Bias Voltage can be applied to capacitors by connection of an external voltage source and sliding an internal switch accessible through hole on the bottom panel (refer to ¶ 2.7). Bias levels from 0V to 35VDC are attainable. The test voltage level is programmable at 0.25V or 1.0V RMS. An internal zeroing function is provided and selectable from the front panel. Auto/Manual ranging is selectable for the five measurement ranges. Connection to the device under test (DUT) is through 4 BNC terminals on the front panel of the 1710 Digibridge unit.

External DC Bias Voltage Limitation

When using the External DC Bias Voltage mode of the 1710 instrument, the 1710 unit will NOT Auto-Range. The range resistor is fixed at 25Ω. With the source resistor fixed at 25Ω, the useful capacitance measurement range is that above 1-2µF.

1.3 Controls and Indicators

1.3.1 Front Panel Controls and Indicators

Figures 1-1 and 1-2 illustrate the controls and indicators on the front panel of the 1710 LCR Digibridge unit. Table 1-1 identifies them with description and function.

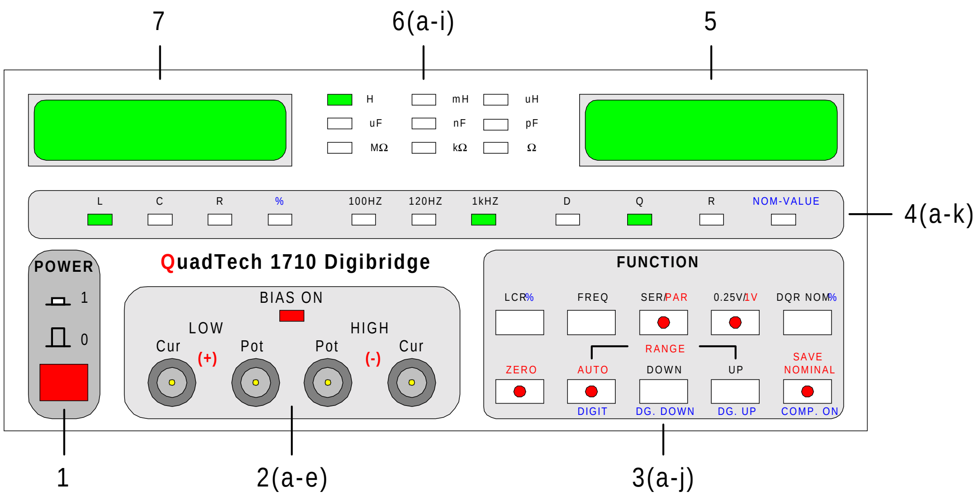


Figure 1-1: 1710 Front Panel Controls and Indicators

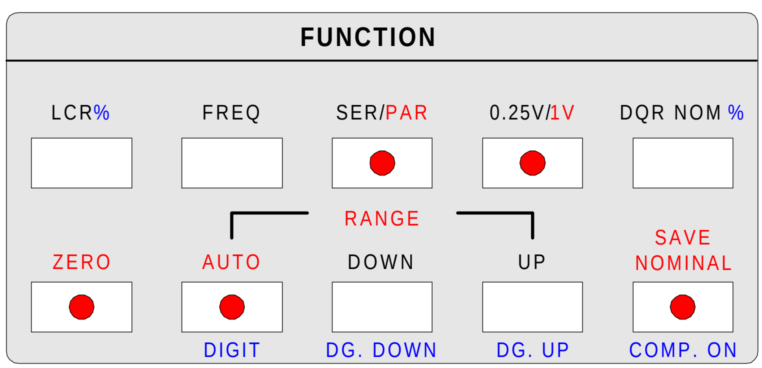


Figure 1-2: Close Up 1710 Front Panel FUNCTION Keys

Table 1-1: 1710 Front Panel Controls and Indicators

Reference Number Figure 1-1	Name	Type	Function
1	**POWER**	Red Push Button Switch	Apply power: 1 (ON) 0 (OFF)
2	**UNKNOWN**		
2a	Cur (+)	Silver BNC Connector	Low current connection
2b	Pot (+)	Silver BNC Connector	Low potential connection
2c	BIAS ON	Red LED	When lit, Bias voltage at output terminals
2d	Pot (–)	Silver BNC Connector	High potential connection
2e	Cur (–)	Silver BNC Connector	High current connection
3	**FUNCTION**		
3a	LCR %	Black Push Button Switch	Select L, C or R measurement (Primary)
3b	FREQ	Black Push Button Switch	Select Test Frequency=120Hz or 1kHz
3c	SER/PAR	Black Push Button Switch	Select Series or Parallel equivalent circuit
3d	0.25V/1.0V	Black Push Button Switch	Select Test Voltage=0.25V or 1.0V
3e	DQR NOM %	Black Push Button Switch	Select D, Q or R measurement (Secondary)
3f	ZERO	Black Push Button Switch	Enable Zero Function
3g	AUTO/DIGIT	Black Push Button Switch	Select Auto Range/Select place value
3h	DOWN/DG DOWN	Black Push Button Switch	Move Down a Range/Decrease place value
3I	UP/DG UP	Black Push Button Switch	Move Up a Range/Increase place value
3j	SAVE NOMINAL/COMP. ON	Black Push Button Switch	Enable Comparison Function
4	**INDICATORS**		
4a	L	Green LED	When Lit, primary measurement = L
4b	C	Green LED	When Lit, primary measurement = C
4c	R	Green LED	When Lit, primary measurement = R
4d	%	Green LED	When Lit, value displayed = % Value
4e	100Hz	Green LED	When Lit, Test Frequency=100Hz
4f	120Hz	Green LED	When Lit, Test Frequency=120Hz
4g	1kHz	Green LED	When Lit, Test Frequency=1kHz
4h	D	Green LED	When Lit, secondary measurement = D
4I	Q	Green LED	When Lit, secondary measurement = Q
4j	R	Green LED	When Lit, secondary measurement = R
4k	NOM VALUE	Green LED	When Lit, value displayed=Nominal value
5	DQR & NOM. VALUE DISPLAY	6 Digit LCD	Display D, Q & R (Secondary) Values
6	**UNIT INDICATORS**		
6a	H	Green LED	When Lit, unit = Henry
6b	mH	Green LED	When Lit, unit = milli-Henry
6c	μH	Green LED	When Lit, unit = micro-Henry
6d	μF	Green LED	When Lit, unit = micro-Farad
6e	nF	Green LED	When Lit, unit = nano-Farad
6f	pF	Green LED	When Lit, unit = pico-Farad
6g	MΩ	Green LED	When Lit, unit = Mega-Ohm
6h	kΩ	Green LED	When Lit, unit = kilo-Ohm
6i	Ω	Green LED	When Lit, unit = Ohm
7	LCR & % DISPLAY	6 Digit LCD	Display L, C & R (Primary) Values

1.3.2 Rear Panel Controls and Connectors

Figure 1-3 illustrates the controls and connectors on the rear panel of the 1710 LCR Digibridge unit. Table 1-2 identifies them with description and function.

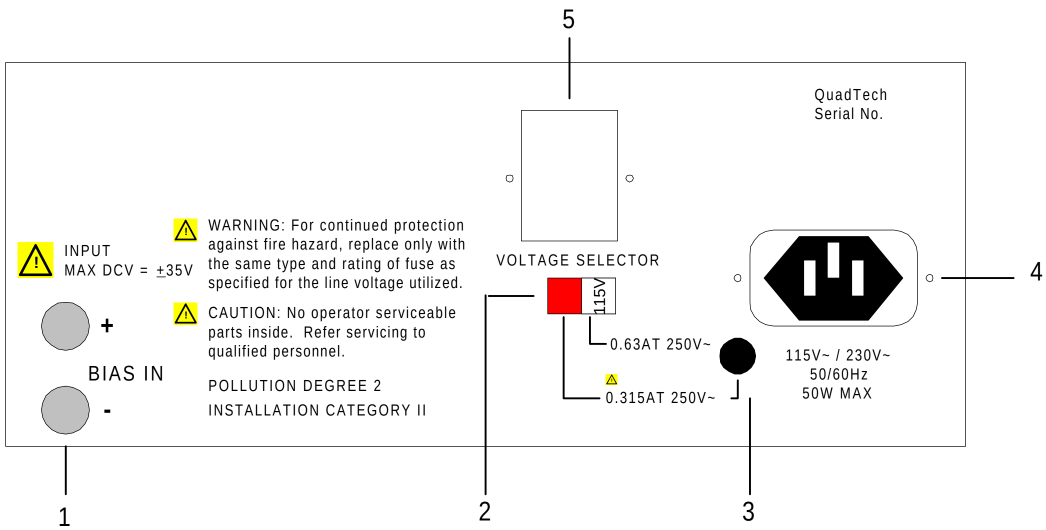


Figure 1-3: 1710 Rear Panel Controls and Connectors

Table 1-2: 1710 Rear Panel Controls and Connectors

Reference Number Figure 1-3	**Name**	**Type**	**Function**
1	Bias In	2 Silver BNC 35V, 200mA max.	Connection External Voltage Source
2	Line	Red 2-position slide switch	Select 115V or 230V operation
3	Fuse	Black Screw Cap Slow Blow Fuse	Short circuit protection 0.6A for 115V Operation 0.3A for 230V Operation
4	AC Input	Black 3-wire AC receptacle	Input for AC power
5			No connection

1.4 Installation

1.4.1 Dimensions

The 1710 LCR Digibridge unit is supplied in bench configuration (a cabinet with resilient feet for placement on a table). A front bail is provided so that the unit can be tilted back for convenient operator viewing. Figure 1-4 illustrates the 1710 instrument dimensions.

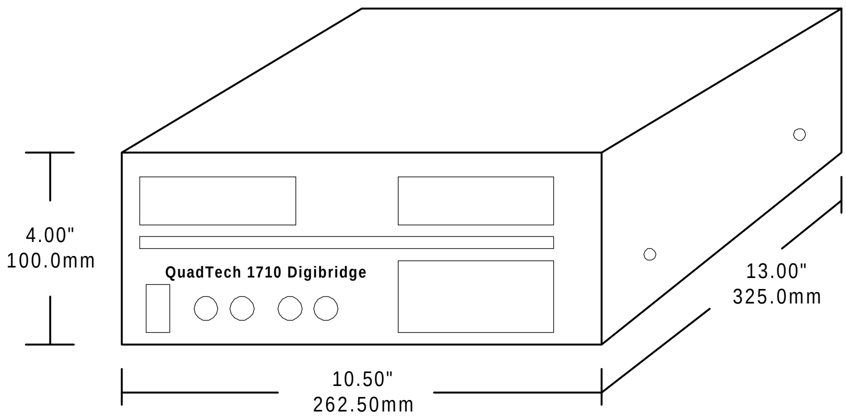


Figure 1-4: 1710 Instrument Dimensions

1.4.2 Instrument Positioning

The 1710 LCR Digibridge instrument contains two LCD displays, a primary display with 6-digit resolution and a secondary with 6-digit resolution for convenient viewing. The optimum angle for viewing is slightly down and about 10° either side of center. For bench operation the front bail should be used to angle the instrument up. In bench or rack mount applications the instrument should be positioned with consideration for ample air flow around the rear panel. An open space of at least 3 inches (75mm) is recommended behind the rear panel.

1.4.3 Power Requirements

⚠ The 1710 LCR Digibridge can be operated from a power source of 90 to 125VAC or 180 to 250VAC. Power connection is via the rear panel through a standard receptacle. Before connecting the 3-wire power cord between the unit and AC power source make sure the voltage selection switch and fuse on the rear panel (Figure 1-5) are in accordance with the power source being used. Use a 0.6A, 250V SB fuse for 115V operation and a 0.3A, 250V SB fuse for 230V operation. Always use an outlet that has a properly connected protection ground.

Procedure for Changing A 1710 Digibridge Fuse

WARNING
MAKE SURE THE UNIT HAS BEEN DISCONNECTED FROM ITS AC POWER SOURCE FOR AT LEAST 5 MINUTES BEFORE PROCEEDING.

Figure 1-5 illustrates a close up of the rear panel. Remove the black screw cap fuse on the rear panel of the 1710 instrument.

- Make sure the power switch is OFF and the power cord is disconnected from the unit and the AC power source.
- Inspect if the fuse is functional by measuring resistance (< 15Ω) with an ohmmeter.
- Using a flat head screwdriver, turn the screw cap about 60° counterclockwise. The screw cap should protrude about 3.0 cm from the socket.
- Remove screw cap. Replace with new, same rated 0.6A, 250V SB or 0.3A 250V SB fuse.
- Using a flat head screwdriver, turn the screw cap about 60°clockwise.
- Make sure the voltage selector switch is in accordance with the power source being used.

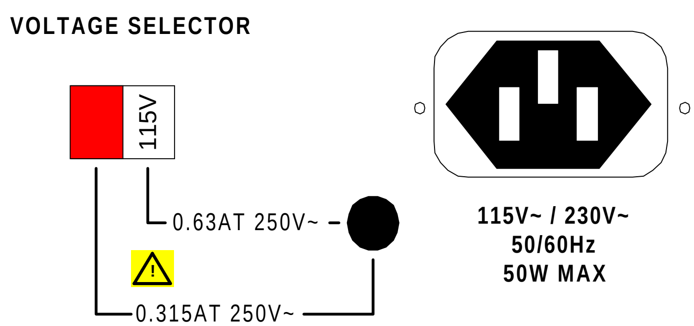


Figure 1-5: 1710 Fuse & Voltage Selector (Rear Panel)

1.4.4 Safety Inspection

⚠ Before operating the instrument inspect the screw cap fuse receptacle on the rear panel of the 1710 unit to ensure that the **properly rated fuse is in place**, otherwise damage to the unit is possible. Refer to paragraph 1.4.3.

The 1710 LCR Digibridge unit is shipped with a standard U.S. power cord, QuadTech P/N 4200-0300 (with Belden SPH-386 socket or equivalent and a 3-wire plug conforming to IEC 320). CE units are shipped with an approved international cord set. Make sure the instrument is only used with these cables (or other approved international cord set) to ensure the instrument is provided with **connection to protective earth ground**.
The surrounding environment should be free from excessive dust to prevent contamination of electronic circuits. The surrounding environment should also be free from excessive vibration. Do not expose the 1710 instrument to direct sunlight, extreme temperature or humidity variations or corrosive chemicals.

WARNING
If this instrument is used in a manner not specified in this manual protection to the operator and equipment may be impaired.

Section 2: Operation

2.1 Terms and Conventions

Table 2-1: Measurement Unit Prefixes

Multiple	Scientific	Engineering	Symbol
1000000000000000	10^{15}	Peta	P
1000000000000	10^{12}	Tera	T
1000000000	10^{9}	Giga	G
1000000	10^{6}	Mega	M
1000	10^{3}	Kilo	k
.001	10^{-3}	milli	m
.000001	10^{-6}	micro	u
.000000001	10^{-9}	nano	n
.000000000001	10^{-12}	pico	p
.000000000000001	10^{-15}	femto	f

Dielectric Absorption: The physical phenomenon in which insulation appears to absorb and retain an electrical charge slowly over time. Apply a voltage to a capacitor for an extended period of time then quickly discharge it to zero voltage. Leave the capacitor open circuited for a period of time then connect a voltmeter to it and measure the residual voltage. The residual voltage is caused by the dielectric absorption of the capacitor.

Charging Current: An insulated product exhibits the basic characteristics of a capacitor. Application of a voltage across the insulation causes a current to flow as the capacitor charges. This current instantaneously rises to a high value as voltage is applied then exponentially decays to zero as the DUT becomes fully charged. Charging current decays to zero much faster than dielectric absorption.

Leakage Current: The steady state current that flows through the insulation. Leakage current is equal to the applied voltage divided by the insulation resistance. Leakage current is the main measured value for AC hipot and DC hipot.

Discharge:	The act of draining off an electrical charge to ground. Devices that retain charge should be discharged after an IR or DC hipot test.
Frequency:	The rate at which current or voltage reverses polarity and then back again completing a Full cycle, measured in Hertz (Hz) or cycles/second. AC Line Frequency = 50/60 Hz.
Ground:	The base reference from which voltages are measured, nominally the same potential as the earth. Ground is also the side of a circuit that is at the same potential as the base reference.
Inductance:	Inductance is the property of a coil to oppose any change in current through it. The inductance of a coil varies by the number of turns squared (N^2). If the turns are stretched out, the field intensity will be less and the inductance will be less. The larger the radius or diameter of the coil, the longer the wire used and the greater the inductance.
Inductive Reactance:	A measure of how much the counter electro-magnetic force (EMF) of the coil will oppose current variations. The amount of reactance is directly proportional to the frequency of the current variation. $X_L = 2\pi fL$
Quality Factor:	Quality factor is a measurement of the quality of an inductor: how tight the wire is wrapped (wound). The higher the Q, the better the inductor. Q is equal to reactance divided by resistance. $Q = X_S / R_S$
Capacitance:	The ratio of charge on either plate of a capacitor to the potential difference (voltage) across the plates. When a voltage is applied, current flows immediately at a high rate then exponentially decays toward zero as the charge builds up. If an AC voltage is applied, an AC current appears to flow continuously because the polarity of the voltage is reversed at the frequency of the applied voltage. The wave form of this current however is displaced in time from the applied voltage by 90°.
Capacitive Reactance:	A measurement of the actual AC resistance of a capacitor. How effective a capacitor may be in allowing AC to flow depends upon its capacitance and the frequency used. $X_C = 1/ 2\pi fC$.

Dissipation Factor: Dissipation factor is a measurement of the quality of a capacitor: how well it dissipates charge. The lower the D_f, the better the capacitor. Dissipation factor is equal to resistance divided by reactance. $D_f = R_S / X_S = 1/Q = \tan(90° - \theta) = \tan\delta$.

Impedance: In AC circuits, impedance is the “AC resistance” to the flow of current through a circuit when an AC voltage is applied across the terminals of that circuit. Impedance is composed of real (in phase with voltage) and reactive (out of phase by 90°) components. $Z = E/I = R + jX$
Impedance = resistance + reactance.

Series Circuit: Designated with a subscript S in equations and Figure 2-1.

Parallel Circuit: Designated with a subscript P in equations and Figure 2-1.

Nominal Value: Value inputted by operator. Devices connected to 1710 unit. If SAVE NOMINAL button is pressed, the display will show the % difference of the DUT to the Nominal Value.

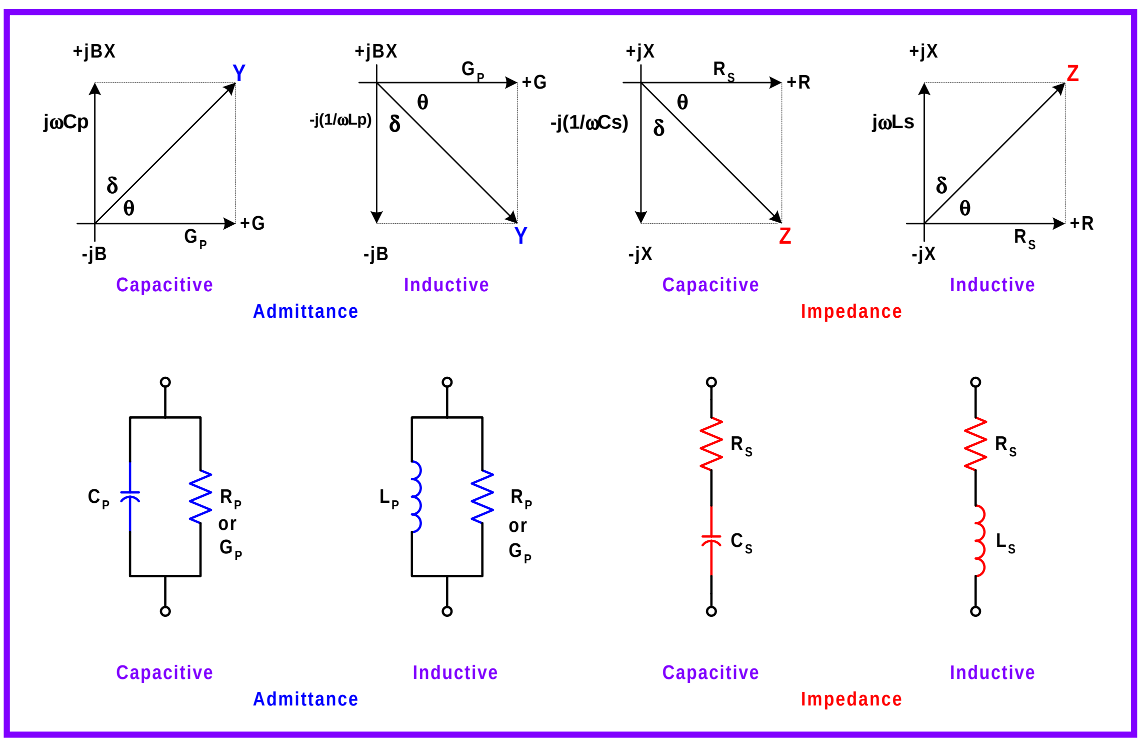


Figure 2-1: Impedance and Admittance Phase Diagrams & Equivalent Circuits

2.2 Startup

Check to make sure the line voltage selector on the rear panel of the 1710 LCR Digibridge instrument agrees with the AC power source available, if not refer to paragraph 1.4.3.

Connect the 1710 instrument AC power cord to the source of proper voltage. The instrument is to be used only with 3-wire grounded outlets.

WARNING
When the BIAS ON LED is lit or flashing, there is high voltage outputting at the UNKNOWN Terminals [POT. (+) and CUR. (-)]

2.3 FUNCTION Keys

Figure 2-2 illustrates the FUNCTION keys on the front panel of the 1710 instrument. Paragraphs 2.3.1 through 2.3.10 describe the function of each key. Table 2-2 lists the Function keys by color. The red labeled functions are selected when the red LED is lit on the corresponding button (key). The blue labeled functions are activated when the [SAVE NOMINAL] button is first pressed and the Nominal Value is being inputted.

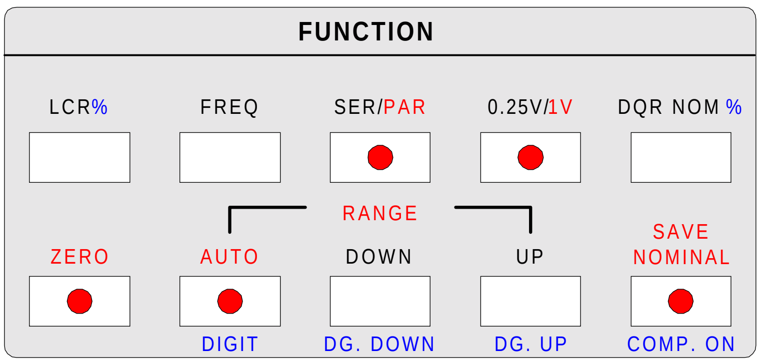


Figure 2-2: FUNCTION Keys

Table 2-2: Function Keys

Table 1-1 Ref. #	Black Keys	Red Keys	Blue Keys
3a	LCR		%
3b	FREQ.		
3c	SER.	PAR.	
3d	0.25V	1.0V	
3e	DQR NOM.		%
3f		ZERO	
3g		AUTO	DIGIT
3h	DOWN		DG. DOWN
3I	UP		DG. UP
3j		SAVE NOMINAL	COMP. ON

2.3.1 LCR % (Primary Parameter)

The [LCR %] button permits the user to specify the primary measurement parameter as L (inductance), C (capacitance) or R (resistance). The [%] function is accessed when the [SAVE NOMINAL] function has been activated first (¶2.3.10). The primary display will then show the measurement result as a % value of the nominal value.

2.3.2 FREQ. (Test Frequency)

The [FREQ.] button permits the user to select the test frequency as 120Hz or 1kHz. The instrument default value is 1kHz. The corresponding frequency LED will light indicating test frequency.

2.3.3 SER. / PAR. (Equivalent Circuit)

The [SER. / PAR.] button permits the user to select the equivalent circuit representation as Series [SER.] or Parallel [PAR.]. The instrument default value is Series [SER.]. Parallel circuit representation is selected when the red LED is lit on the [SER. / PAR.] button.

2.3.4 0.25V / 1.0V (Test Voltage)

The [0.25V / 1.0V] button permits the user to select the test voltage equal to 0.25V or 1.0V RMS. The instrument default value is 0.25V. A test voltage equal to 1.0V is selected when the red LED is lit on the [0.25V / 1.0V] button.

2.3.5 DQR NOM. / % (Secondary Parameter)

The [DQR NOM. / %] button permits the user to select the secondary measurement parameter as D (dissipation factor), Q (quality factor) or R (resistance). The [%] function is accessed when the [SAVE NOMINAL] function has been activated first (¶2.3.10). The secondary display will then show the measurement result as a % value of the nominal value.

2.3.6 ZERO

The [ZERO] button permits the user to enable the instrument automatic Zero Function. The red LED on the [ZERO] button will light to indicate the zero function is enabled. For R or L measurements, connect the test cables or fixture in "short" configuration then press the [ZERO] button. For C measurements, connect the test cables or fixture in "open" configuration then press the [ZERO] button. Figure 2-3 illustrates how to connect the Kelvin Clip leads for a short or open configuration.

When enabled in R or L measurements, the Zero function removes the effects of any series resistance or inductance of the test cabling or fixture. When enabled in C measurements, the Zero function removes the effects of any stray capacitance or conductance of the test cabling or fixture.

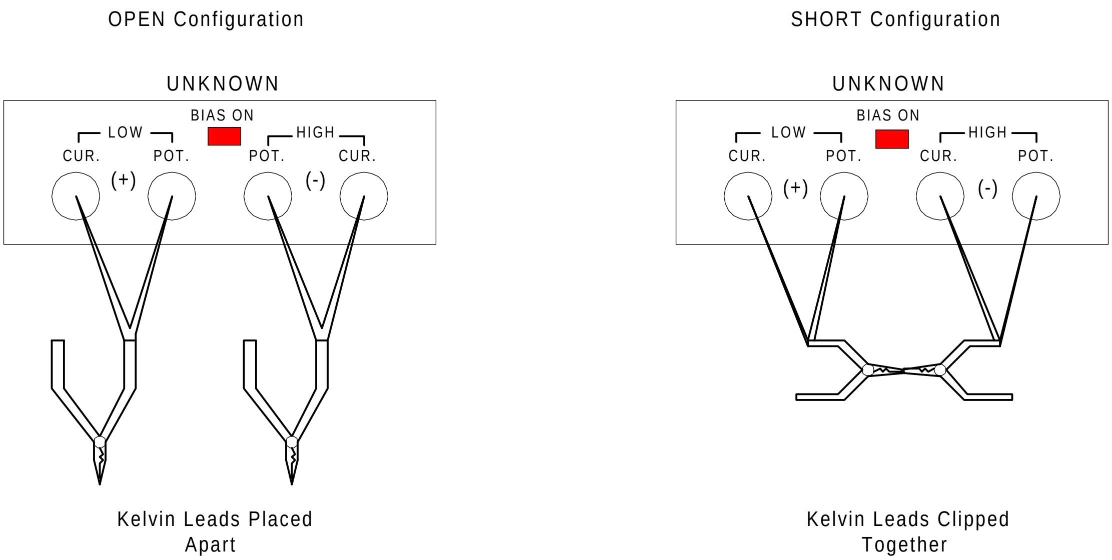


Figure 2-3: Kelvin Clip Leads Short & Open Configuration

Very low capacitance shielded wire should be used for cables to minimize any resonance effects in the measurement of large inductance. Test fixture extension cable can add some capacitance in parallel with the DUT due to imperfect shielding of the leads. The Zero Function will compensate for capacitance between cables under normal test conditions.

NOTE
Anytime the test cables or test fixture are changed, the 1710 instrument should be re-zeroed.

2.3.7 AUTO / DIGIT

The [AUTO / DIGIT] button permits the user to select auto range or change the digit. The instrument range default is AUTO. The red LED on the [AUTO / DIGIT] button will light indicating AUTO ranging selected. The DIGIT function refers to place value and is used when SAVE NOMINAL is activated. Refer to example in ¶2.3.10.

2.3.8 DOWN / DG. DOWN

The [DOWN/ DG. DOWN] button permits the user to manually decrease the instrument measurement range ([DOWN]) or to decrease the value of the standard ([DG. DOWN]), when SAVE NOMINAL is activated. [DG. DOWN] is functional when SAVE NOMINAL is selected and the standard value is being inputted. [DOWN] is functional in normal measurement mode.

2.3.9 UP / DG. UP

The [UP / DG. UP] button permits the user to manually increase the instrument measurement range ([UP]) or to increase the value of the standard ([DG. UP]), when SAVE NOMINAL is activated. [DG. UP] is functional when SAVE NOMINAL is selected and the standard value is being inputted. [UP] is functional in normal measurement mode.

2.3.10 SAVE NOMINAL / COMP. ON

The [SAVE NOMINAL / COMP. ON] button permits the user to input a standard value (nominal value) against which future DUT measurement results will be compared. The SAVE NOMINAL function is selected when the red LED is lit on the [SAVE NOMINAL / COMP. ON] button. The 'Comparator On' function is selected when the [SAVE NOMINAL / COMP. ON] button is first pressed. The blue labeled buttons are then activated and used to input the 'Nominal Value'. The NOM-VALUE LED will light indicating the blue-labeled buttons are operative. An example follows on how to set the Nominal Value.

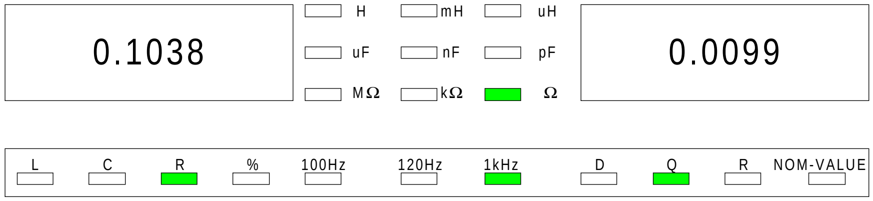
NOTE
To disable the Comparator Function press the [SAVE NOMINAL / COMP. ON] button TWO times. The instrument will return to normal measurement mode.

Example: Setting the Nominal Value

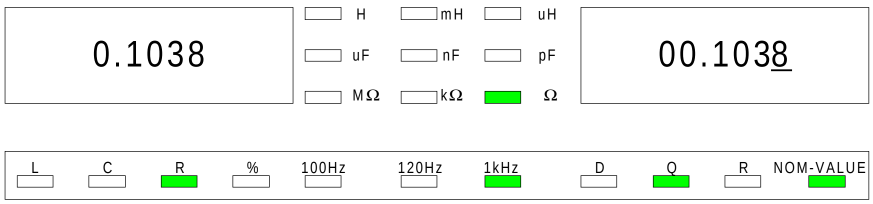
100mΩ resistor
1700-02 Axial/Radial Remote Component Test Fixture

Attach BNC connectors of 1700-02 Remote Test Fixture to 1710 BNC Terminals.
Place 100mΩ resistor in 1700-02 Test Fixture
Turn on 1710 instrument
Press [LCR%] to select Primary Parameter = R (Resistance)
Press [DOWN / DG. DOWN] to select unit = Ω

Primary Display shows R value.   Secondary Display shows Q value.

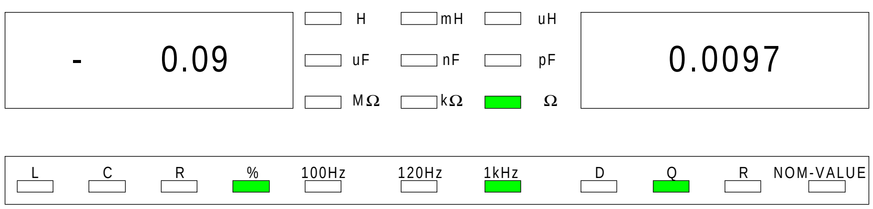


Press [SAVE NOMINAL / COMP ON] to initiate Save Nominal function.
Primary Display shows R Value.   Secondary Display shows same R value and right most digit is flashing.



Press [DG. DOWN] to decrease value of flashing digit.
Press [DG. UP] to increase value of flashing digit.
Press [DIGIT] to move left in place value (to the next digit).

Press [DQR NOM %] to accept inputted Nominal Value.
Primary Display now shows % difference from Nominal Value.
Secondary Display shows Q value.



Press [SAVE NOMINAL / COMP ON] two times to exit comparator mode and return to normal measurement mode.

2.4 Frequency and Equivalent Circuits

The user can select a measurement frequency of 1kHz or 120Hz. The exception is when the principle (primary) measurement (L, C or R) has a very large value. Use the lower frequency (120Hz) when the primary measurement of R ≥ 10MΩ, L ≥ 1000H or C ≥ 1000μF.

The value of the principle measurement (L, C or R) of the DUT depends on the choice of equivalent circuit (series or parallel). The more 'pure' the resistance or reactance, the more identical the series and parallel values will be. However for D and Q near unity, the difference in the series and parallel values is substantial.

The value of the principle measurement (L, C or R) of the DUT also depends on the choice of frequency (1kHz or 120Hz). The more 'pure' the resistance or reactance, the less frequency selection is a factor. However for D and Q near unity and/or the measuring frequency near the self-resonating frequency of the DUT, frequency selection is an important factor.

The manufacturer usually specifies the parameters for measuring a DUT. A series equivalent circuit is usually specified for L, C and low values of R. Frequency is usually specified as 120Hz or 1kHz.

Resistors ≤ 1kΩ: Series Equivalent Circuit and 120Hz Frequency
If specification calls for DC Resistance select lower frequency (120Hz) to minimize AC Loss.

Resistors > 1kΩ: Parallel Equivalent Circuit and 120Hz Frequency
Parallel selected to compensate for reactive components present in a high resistance resistor acting as shunt capacitance. If the Q< 0.1, the measures Rp will be close to the DC resistance.

Capacitors ≤ 2nF: Series Equivalent Circuit and 1kHz Frequency
Unless otherwise specified, select Series for capacitors and inductors. High measurement frequency (1kHz) will provide better accuracy.

Capacitors > 200μF: Series Equivalent Circuit and 120Hz Frequency
Low measurement frequency provides better accuracy in this case and enables the measurement of capacitors ≥ 1000F.

Inductors ≤ 2mH: Series Equivalent Circuit and 1kHz Frequency
Higher measurement frequency provides better accuracy in this case.

Inductors > 200H: Series Equivalent Circuit and 120Hz Frequency
Low measurement frequency provides better accuracy in this case and enables the measurement of inductors ≥ 1000H.

2.4.1 Series and Parallel Circuits

An impedance (Z) that is neither pure reactance (X) nor resistance (R) can be represented at any specific frequency by either a series or a parallel combination of resistance and reactance. The value of resistance and reactance used in an equivalent circuit depend on whether a series or parallel combination is used. If the user selects [SER] (series equivalent circuit), then the 1710 instrument measures Ls, Cs or Rs. If the user selects [PAR] (parallel equivalent circuit), then the 1710 instrument measures Lp, Cp or Rp. Figure 2-4 illustrates Series and Parallel Equivalent circuits and corresponding Impedance and Admittance phase diagrams. Table 2-3 displays LCR parameters, their unit and formula from which they are derived. The 1710 instrument measures the primary parameters L, C and R and secondary parameters Q, D and R. The other LCR parameters can be calculated from these measurements using the equations in Table 2-3.

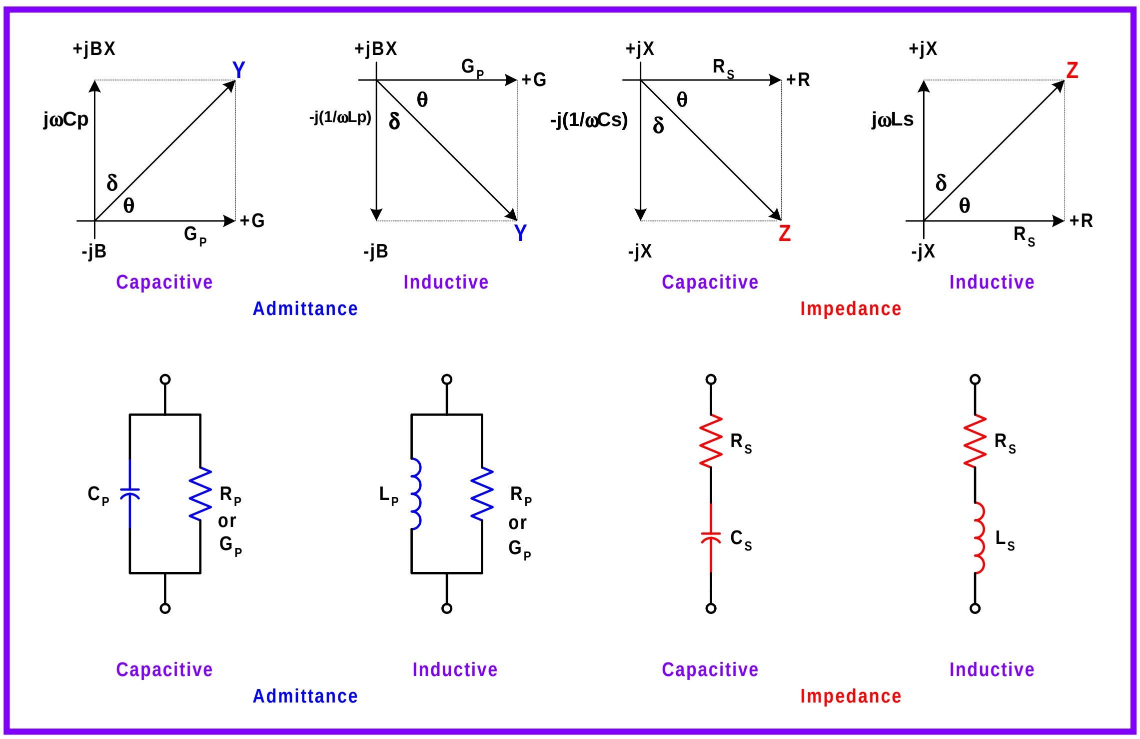


Figure 2-4: Series and Parallel Equivalent Circuits and Phase Diagrams

Table 2-3: LCR Parameters

Parameter	Quantity	Unit Symbol	Formula
Z	Impedance	Ohm, Ω	$Z = R_S + jX_S = \frac{1}{Y} = \|Z\|\varepsilon^{j\theta}$
|Z|	Magnitude of Z	Ohm, Ω	$\|Z\| = \sqrt{R_S^2 + X_S^2} = \frac{1}{\|Y\|}$
R_S or ESR	Resistance, Real part of Z	Ohm, Ω	$R_S = \frac{G_P}{G_P^2 + B_P^2}$
X_S	Reactance, Imaginary part of Z	ohm, Ω	$X_S = -\frac{B_P}{G_P^2 + B_P^2}$
Y	Admittance	siemen, S	$Y = G_P + jB_P = \frac{1}{Z} = \|Y\|\varepsilon^{j\phi}$
|Y|	Magnitude of Y	siemen, S (was mho)	$\|Y\| = \sqrt{G_P^2 + B_P^2} = \frac{1}{\|Z\|}$
G_P	Real part of Y	siemen, S	$G_P = \frac{R_S}{R_S^2 + X_S^2}$
B_P	Susceptance	siemen, S	$B_P = -\frac{X_S}{R_S^2 + X_S^2}$
C_S	Series capacitance	farad, F	$C_S = -\frac{1}{\omega X_S} = C_P(1 + D^2)$
C_P	Parallel capacitance	farad, F	$C_P = \frac{B}{\omega} = \frac{C_S}{1 + D^2}$
L_S	Series inductance	henry, H	$L_S = \frac{X}{\omega} = L_p \frac{Q^2}{1 + Q^2}$
L_P	Parallel inductance	henry, H	$L_P = -\frac{1}{\omega B_P} = L_S(1 + \frac{1}{Q^2})$
R_P	Parallel resistance	ohm, Ω	$R_P = \frac{1}{G_P} = R_S(1 + Q^2)$
Q	Quality factor	None	$Q = \frac{1}{D} = \frac{X_S}{R_S} = \frac{G_P}{B_P} = \tan\theta$
D, DF or tan δ	Dissipation factor	None	$D = \frac{1}{Q} = \frac{R_S}{X_S} = \frac{G_P}{B_P} = \tan(90^0 - \theta) = \tan\delta$
θ	Phase angle of Z	degree or radian	$\theta = -\phi$
ϕ	Phase angle of Y	degree or radian	$\phi = -\theta$

2.4.2 Equivalent Series Resistance (ESR) for Capacitors and Inductors

The total loss of a capacitor can be expressed in several ways including D and ESR (Equivalent Series Resistance). The 1710 instrument has the capacity to measure C and ESR or L and ESR. C and L are shown on the primary display and ESR is shown on the secondary display. The equivalent circuit must be selected as Series. If the ESR measurement is of primary importance, select [LCR]. Select [SER] (Series). Measure [L] or [C]. Hold the range by pressing [AUTO] until the AUTO LED is OFF. Select [LCR]. Select [SER] (Series). Measure [R]. Note: L (or C) should be measured on the same range.

2.4.3 Parallel Equivalent Circuits for Inductors

Although it is customary to measure series inductance of inductors, in some cases the parallel circuit better represents the physical properties of the DUT. At low frequencies, the significant loss mechanism is commonly ‘ohmic’ or ‘copper loss’ in the wire and the series equivalent circuit compensates for this. At higher frequencies with a DUT that has an iron core, the significant loss may be ‘core loss’ related to eddy currents and hysteresis and the parallel equivalent circuit better compensates for this. Whether this is true at 1kHz depends on the physical properties of the DUT. If the measurement of Lp at 1kHz and 120Hz is more closely the same than the measurement of Ls at the same two frequencies, then the parallel equivalent circuit is better representation of the DUT.

2.4 Parameter and Range Holding

The 1710 instrument has 5 measurement ranges at 1.0V and 3 measurement ranges at 0.25V. Range can be selected as AUTO or MANUAL. When AUTO is selected the UP and DOWN Function keys act as count-UP and count-DOWN adapters.

To select the primary and secondary measurement parameters, press [LCR] then [DQR] to choose L/Q, L/R, C/D, C/R or R. The 1710 instrument will tolerate a poor choice of parameter but accuracy will be reduced as shown in Figure 2-5. The appearance of a DUT can be misleading. For example, a faulty inductor can be essentially capacitive or resistive or a component part may be labeled incorrectly.

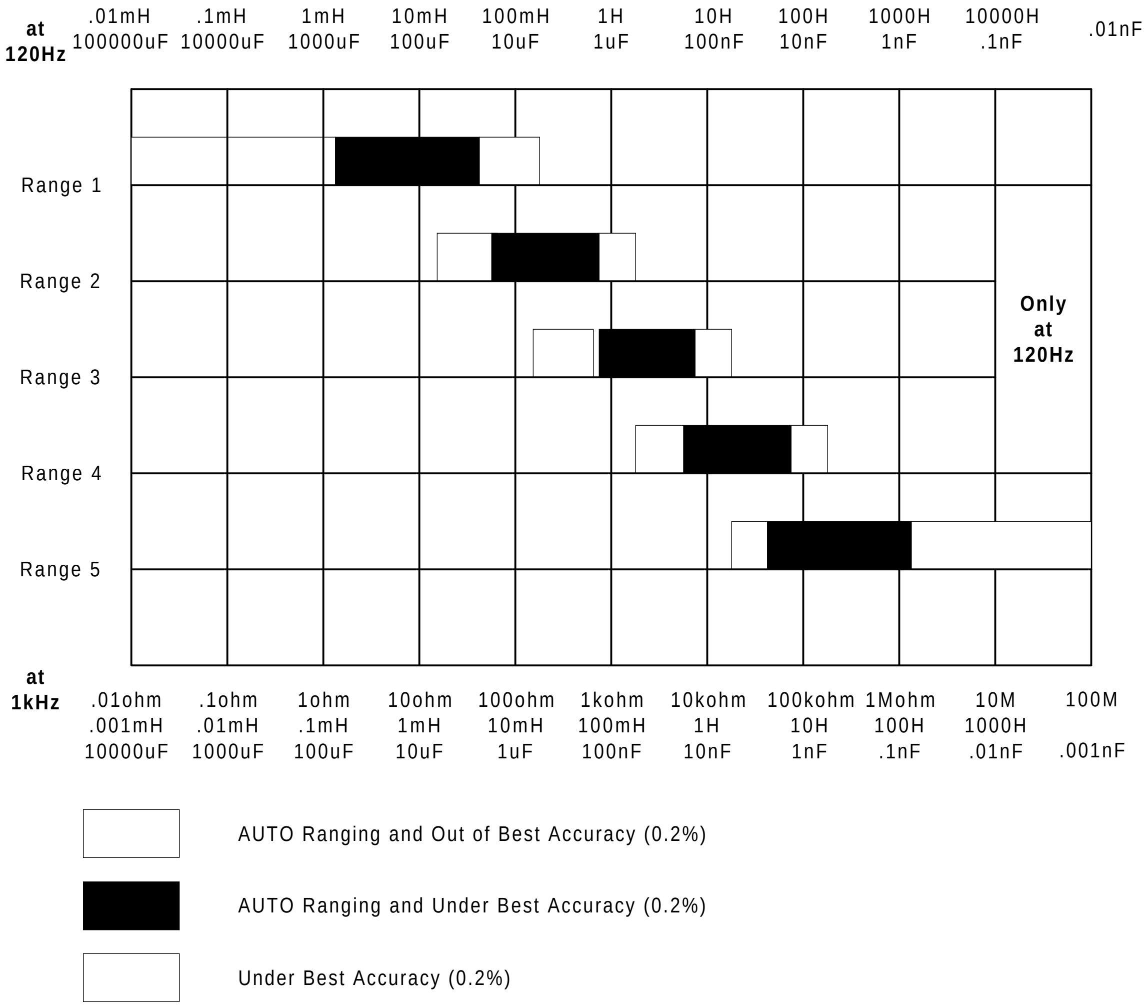


Figure 2-5: 1710 LCR Digibridge Test Range Distribution

2.6 External Bias Voltage Source

An external Bias Voltage source may be connected to the 1710 instrument via the silver BNC connectors labeled “BIAS IN” on the rear panel. Maximum attainable bias is 35V and 200mA. To turn the bias source ON, slide the white switch (SW1) on board # 48-01001-012. To access the switch, turn 1710 instrument over and carefully place a small screw driver through the hole in the bottom panel. Slide the white switch to the ON position (Figure 2-6). Figure 2-7 illustrates the location of SW1. Turn 1710 right side up. Connect external source to rear panel “BIAS IN” terminals. Push [POWER] button ON. The BIAS ON LED will light indicating there is bias voltage present at 1710 front panel BNC terminals.

External DC Bias Voltage Limitation

When using the External DC Bias Voltage mode of the 1710 instrument, the 1710 unit will NOT Auto-Range. The range resistor is fixed at 25Ω. With the source resistor fixed at 25Ω, the useful capacitance measurement range is that above 1-2µF.

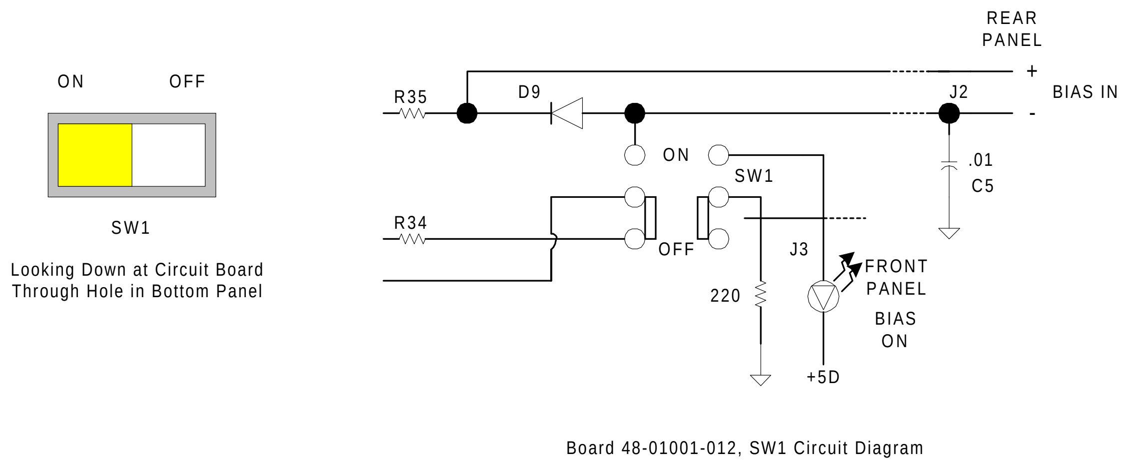
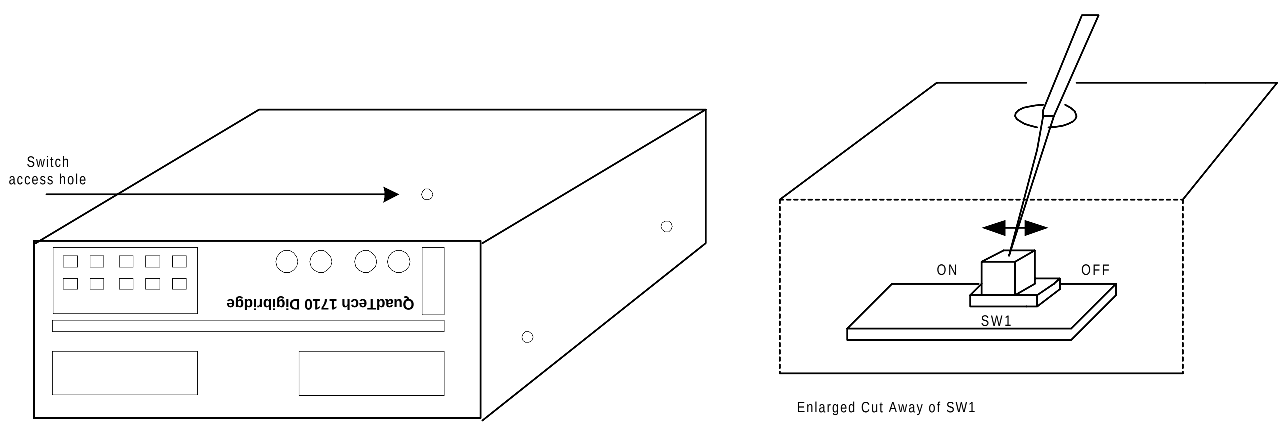


Figure 2-6: Bias Voltage Switch



Turn 1710 Instrument so Bottom Panel Faces Up. Place screw driver through hole. Slide switch to Left to Enable. Slide switch to Right to Di

Figure 2-7: 3-D View Bias Source Switch

2.7 Connection to Device Under Test

Figure 2-8 illustrates the connection of a device under test to the 1710 instrument using the BNC to Kelvin Clip cable set. This cable set (QuadTech P/N 1700-03) is supplied with the unit.

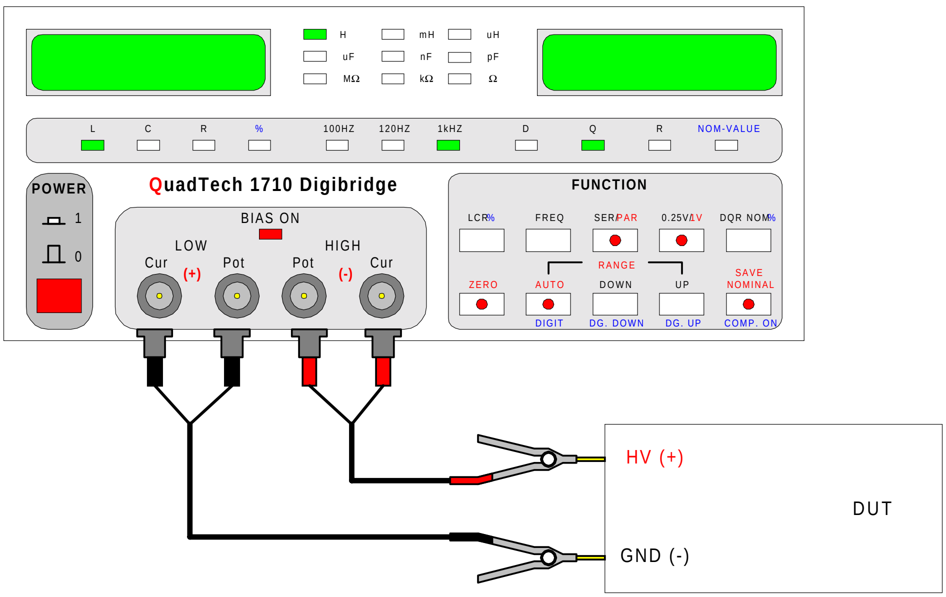


Figure 2-8: Connection to Device Under Test (DUT)

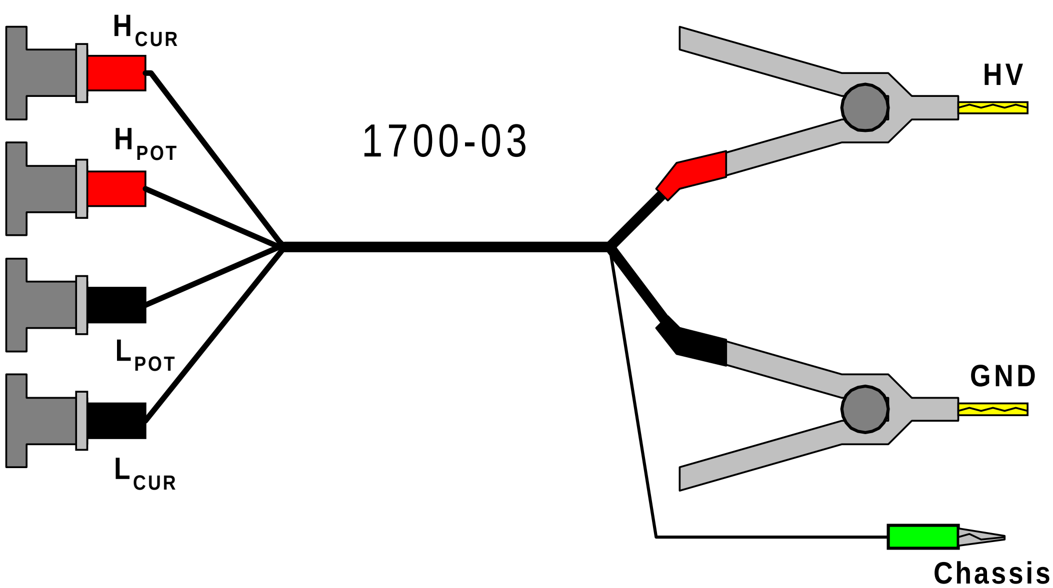


Figure 2-9: BNC to Kelvin Clip Leads (1700-03)

Other connectors are available as optional accessories for the 1710 LCR Digibridge and are listed in Table 2-4.

Table 2-4: 1700 Series Digibridge Accessories

Accessory	QuadTech P/N	Figure #
Axial/Radial Component Test Fixture	1700-01	2-10
Axial/Radial Remote Component Test Fixture	1700-02	2-11
4-BNC to 2-Kelvin Clip(s) Lead Set	1700-03	2-9
4-BNC to 4-Banana Plug(s) Lead Set	1700-04	2-12
4-BNC to Chip Component Tweezers	1700-05	2-13

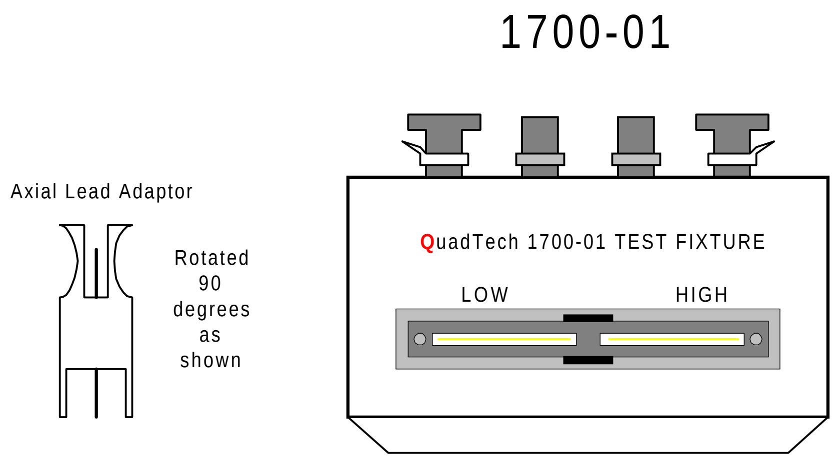


Figure 2-10: Axial/Radial Component Test Fixture

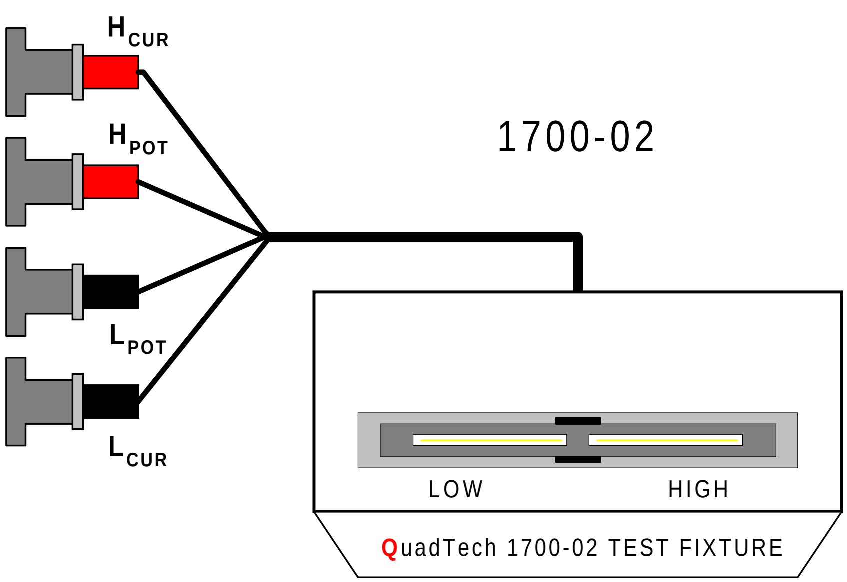


Figure 2-11: Axial/Radial Remote Test Fixture

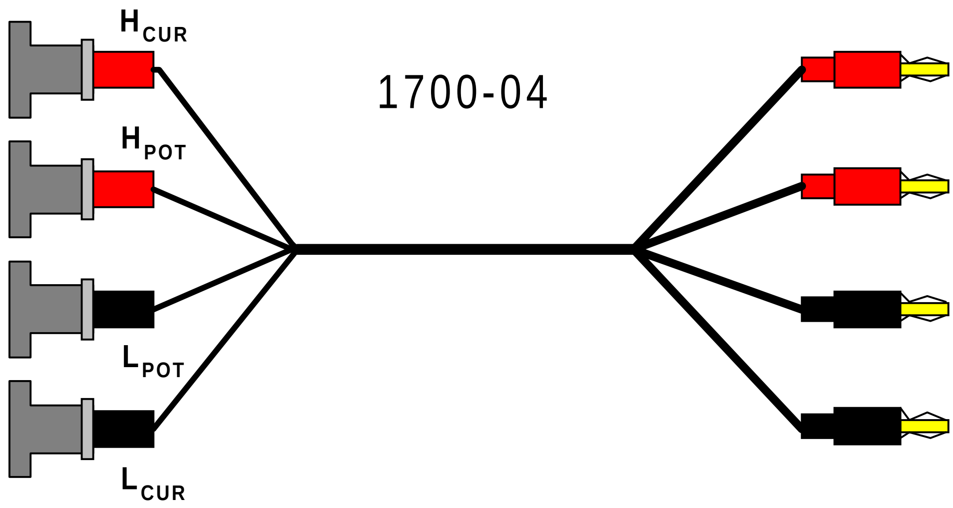


Figure 2-12: 4 BNC to 4 Banana Plug Lead Set

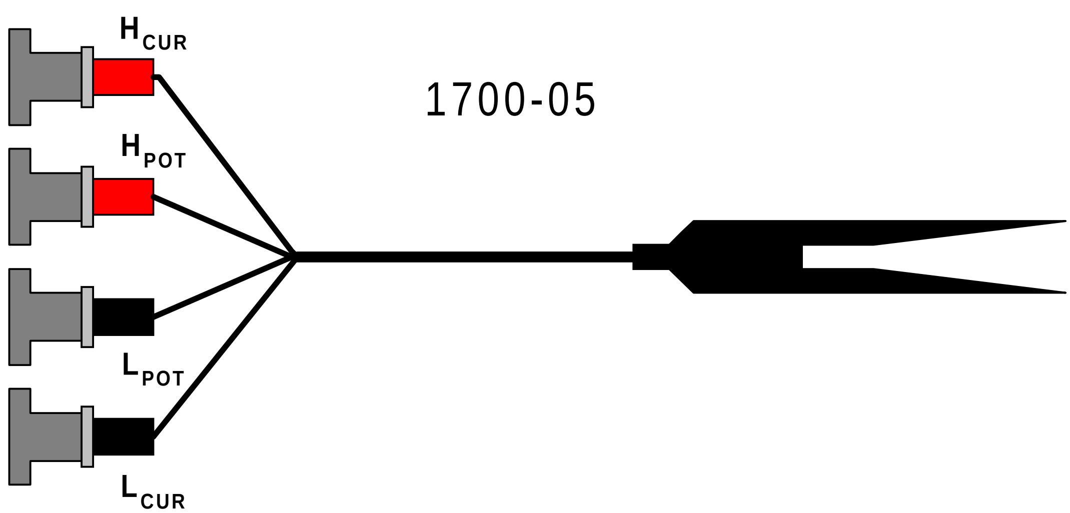


Figure 2-13: 4 BNC to Chip Component Tweezers

2.8 Measurement Procedure

Table 2-5 details the Test Parameters that can be set prior to test. Accuracy for the primary and secondary parameters is detailed in the Specifications section.

Table 2-5: Test Parameters

NAME	FUNCTION	SELECTION		
LCR%	Primary Parameter	L	C	R
FREQ	Frequency	120Hz	1kHz	
SER/PAR	Equivalent Circuit	Series	Parallel	
0.25V/1.0V	Test Voltage	0.25V	1.0V	
ZERO	Zero Function	Enable	Disable	
DQR NOM%	Secondary Parameter	Q	D	R
RANGE	Range	AUTO	DOWN	UP
SAVE NOMINAL	Comparison	Enable	Disable	

Measurement Mode

1. Turn POWER ON.
2. Allow the 1710 instrument to warm-up for 15 minutes.
3. Select Primary Parameter.
4. Select Frequency.
5. Select Test Voltage.
6. Select Secondary Measurement.
7. Select Range.
8. Connect Test Cables or Test Fixture (¶2.7).
9. Enable Zero Function (¶2.3.6).
10. Connect Device Under Test (DUT) (¶2.7).

The 1710 LCR Digibridge will **continually** test until the DUT is disconnected. When the test lead or test fixture is changed, enable the Zero Function to compensate for series resistance and inductance or stray capacitance and conductance.

CAUTION

When testing capacitive devices using a Bias Voltage applied at the rear panel input terminals, use extreme caution. The charge stored in the capacitor can be lethal if the device is not allowed enough discharge time.

Section 3: Theory

3.1 Description of 1710 LCR Digibridge

The 1710 LCR Digibridge incorporates a new measurement technique in which the microprocessor calculates the specified impedance parameters from a series of 8 voltage measurements. The measurement includes quadrature (90°) and inverse (180°) vector components of the voltage across a standard resistor (Rx) carrying the same current as Zx. The measurement is meaningless by itself because the current through Zx is not controlled. The set of voltage measurements is made in fast sequence with the same phase-sensitive detector and analog to digital converter. Therefore differences between these measurements subtract out fixed offset errors and ratios between the differences cancel out the value of the common current and the scale factor of the detector-converter.

The phase-sensitive detector uses 8 reference signals, precisely 45° apart that have exactly the same frequency as the test signal, but whose phase relationship to any analog voltage or current (such as current through Zx and Rx) is incidental. No precise analog phase shifter or waveform squaring circuit is therefore required. Correct phase relationships are maintained by generating the test signal and reference signal from the same high frequency source.

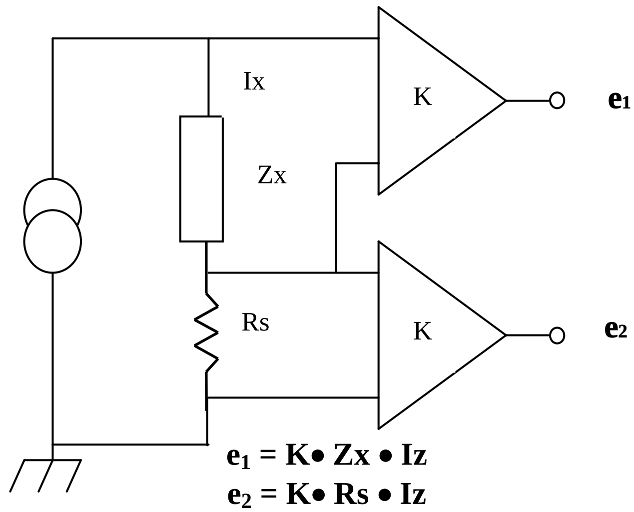
Calibration adjustments are unnecessary for the 1710 instrument. The only precision components in the instrument are five standard resistors and a quartz crystal stabilized oscillator. There is no reactance standard incorporated in the instrument. C and D values are calculated by the microprocessor from the set of voltage measurements and predetermined values of frequency and the applicable standard resistance.

Test Frequencies are within ±2% of the front panel displayed value. The actual frequencies are accurate to ±0.01% due to the rejection of power line frequency stray signals that could be picked up by the DUT.

3.2 Principal Functions

3.2.1 Primary Measurement Circuit

Figure 3-1 illustrates the primary measurement circuit. A sine-wave generator drives current (Ix) through the DUT (Zx) and the standard resistor (Rs) in series with the DUT. Two differential amplifiers with the same gain (K) produce voltages e_1 and e_2. The impedance (Zx) is calculated by multiplying the resistance (Rs) by the potential difference between e_1 and e_2 . This ratio is complex. Both a magnitude and a loss are automatically calculated from Zx and frequency.



$$e_1 = K \bullet Zx \bullet Iz$$
$$e_2 = K \bullet Rs \bullet Iz$$
$$e_1 / e_2 = Zx / Rs$$

Figure 3-1: Primary Measurement Circuit

3.2.2 Frequency and Time Source

A necessary component of the accuracy of the instrument is the frequency of the test signal. Equally important is the generation of the eight phase references for detection and clocks for the microprocessor. Frequency and timing requirements are derived from a single highly accurate oscillator operating at approximately 25 MHz. Digital dividers and logic circuitry provide the clocks and triggers and drive the sine-wave generator (described in ¶ 3.2.3).

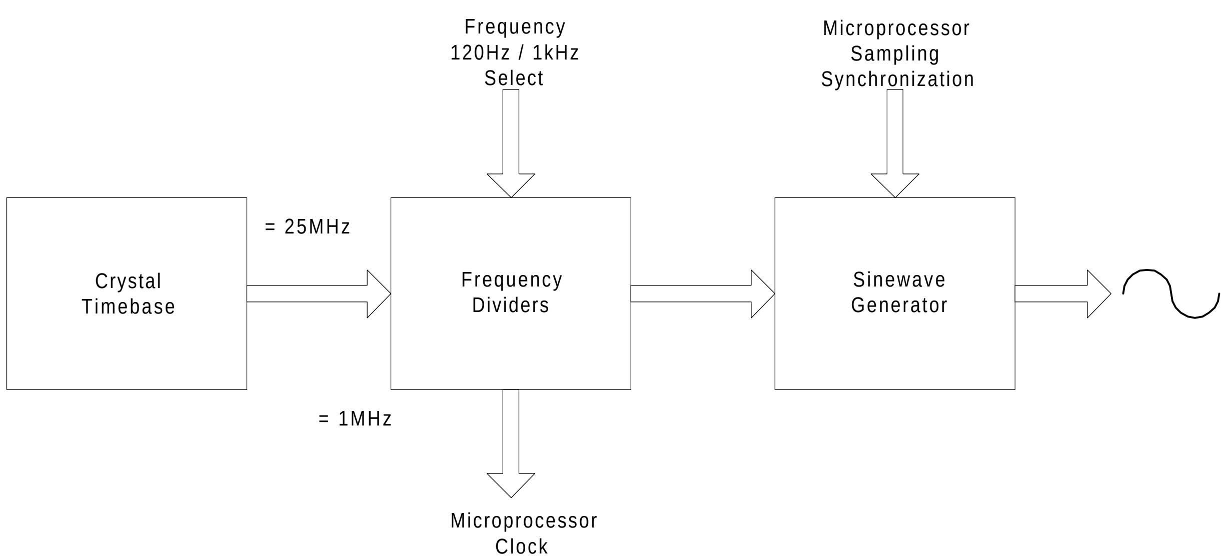


Figure 3-2: 1710 Frequency and Time Source

3.2.3 Sine-wave Generator

The sine-wave generator uses a digital signal 256 times the selected test frequency to provide the test signal that drives the current through the DUT. Binary dividers count down from 256F, providing 128F, 64F, … 2F and F. This set of signals is used to address a read-only memory that contains a 256-step approximation of a sine function. The ROM output (an 8-bit binary number) is transformed by a D/A converter to a slightly 'noisy' sine-wave which is then filtered before used in the measurement of the DUT. The filter is switched according to the selected test frequency.

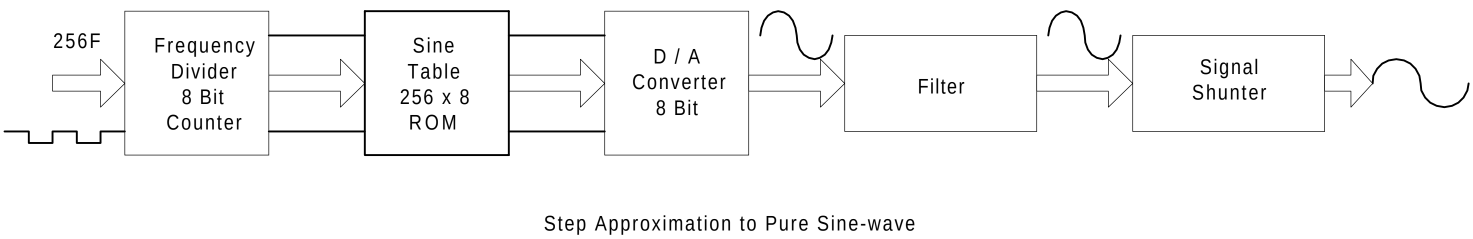


Figure 3-3: 1710 Sine-wave Generator

3.2.4 Analog Block Diagram

Figure 3-4 illustrates the Analog Circuitry of the 1710 instrument in block diagram form.

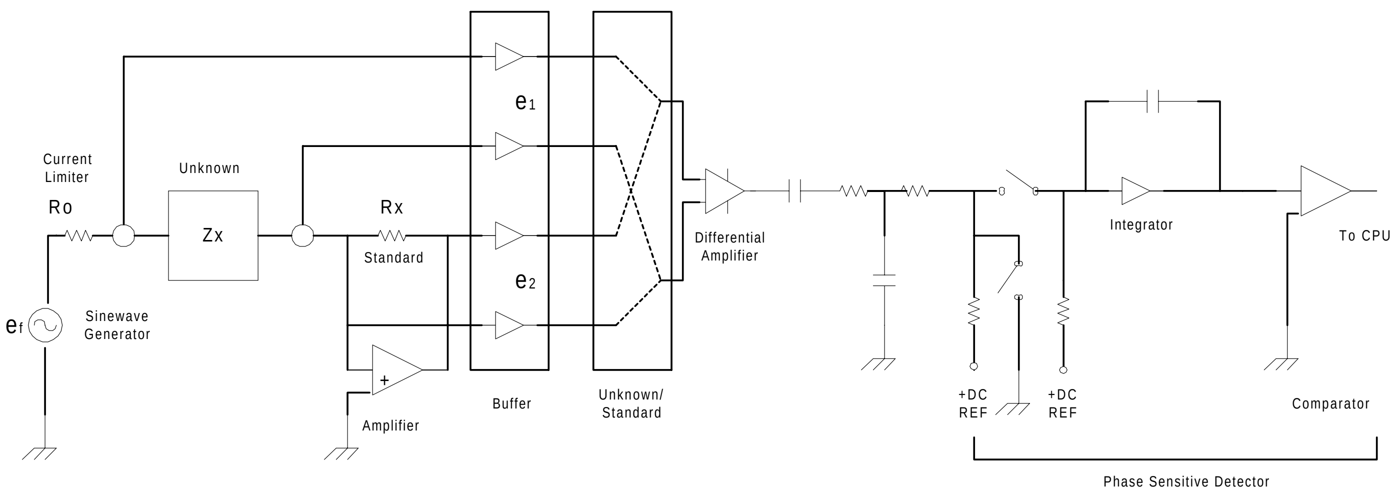


Figure 3-4: Analog Block Diagram

3.2.5 Digital Block Diagram

Figure 3-5 illustrates the digital section of the 1710 LCR instrument in block diagram form.

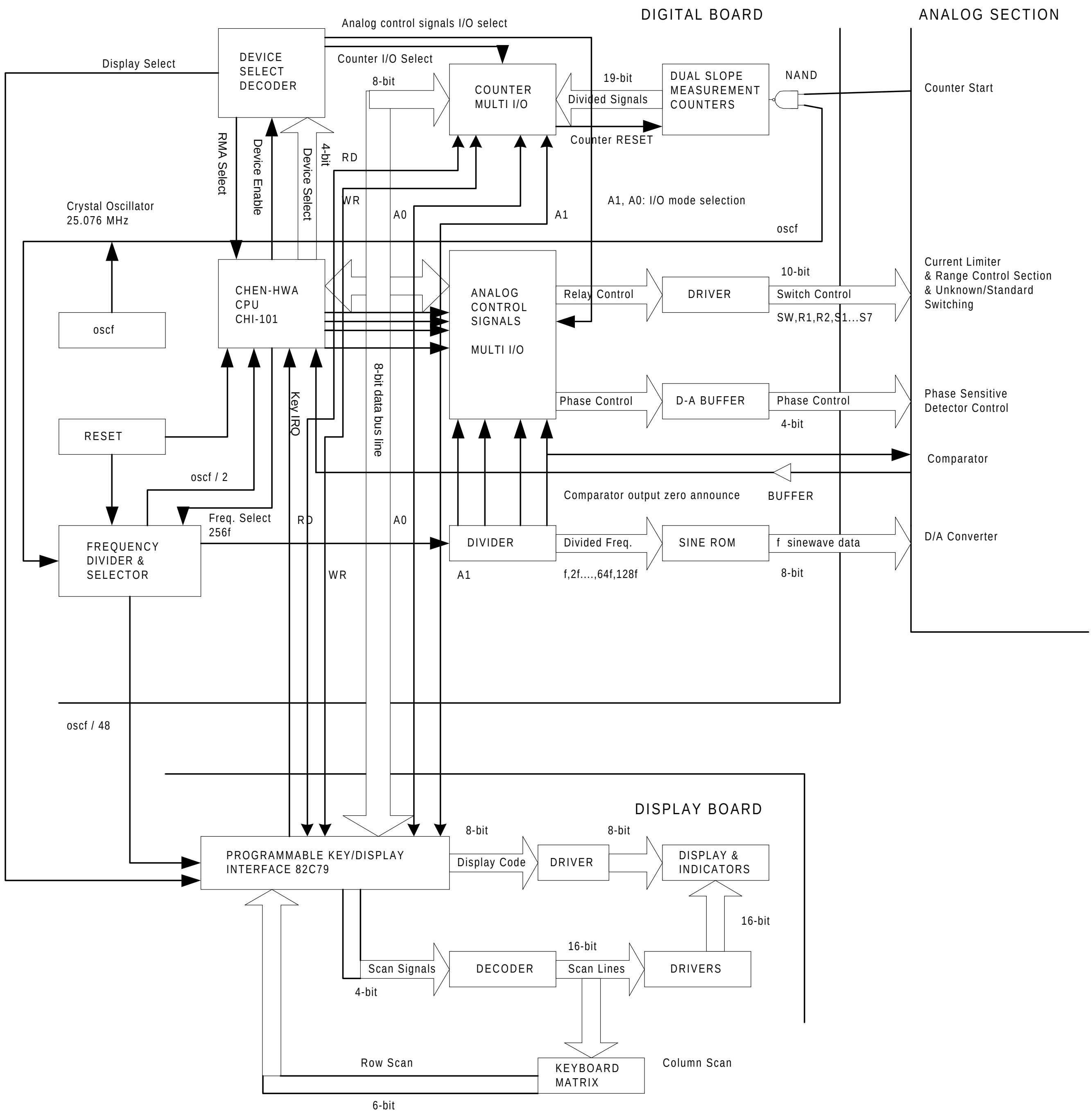


Figure 3-5: Digital Block Diagram

Section 4: Service & Calibration

4.1 General

Our warranty (at the front of the manual) attests the quality of materials and workmanship in our products. If malfunction should be suspected, or other information be desired applications engineers are available for technical assistance. Application assistance is available in the U.S. by calling 978-461-2100 and asking for Applications Support. For support outside of the United States please contact your local QuadTech distributor.

4.2 Instrument Return

Before returning an instrument to QuadTech for service please call our **Customer Care Center** (**CCC**) at **800-253-1230** for Return Material Authorization (RMA). It will be necessary to include a Purchase Order Number to insure expedient processing, although units found to be in warranty will be repaired at no-charge. For any questions on repair costs or shipment instructions please contact our **CCC** Department at the above number. To safeguard an instrument during storage and shipping please use packaging that is adequate to protect it from damage, i.e., equivalent to the original packaging and mark the box "Delicate Electronic Instrument". Return material should be sent freight prepaid, to:

QuadTech, Inc.
5 Clock Tower Place, 210 East
Maynard, MA 01754

Attention: RMA #

Shipments sent collect can not be accepted.

4.3 Calibration

4.3.1 General

There are no calibration adjustments available on the 1710 LCR Digibridge. The following procedure is recommended for verification that the 1710 is performing within stated accuracy and functionality.

Table 4-1: Component/Equipment Recommended for Performance Verification

Description	Requirements
Capacitance Standards 10pF to 1000µF (See Table 4-2 below)	Calibration value and accuracy known
Resistance Standards 0.1Ω to 9.9MΩ (See Table 4-4 below)	Calibration value and accuracy known
Inductance Standards 1H and 16H	Calibration value and accuracy known
DF Standards 0.001, 0.01, and 0.1 (Capacitor/Resistor combinations)	Calibration value and accuracy known

4.3.2 Test Setup

Allow the 1710 instrument to warm-up for at least 15 minutes.

Connect the test fixture or Kelvin test leads (that will be used for connection to the standards) to the 1710 four-terminal connection.

Select the following parameters:

a. Primary Parameter for C
b. Secondary Parameter for D
c. Frequency for 1kHz
d. Test Voltage for 1V
e. Range to Auto

Enable the zero function

a. Test cables in “open” configuration
b. Press ZERO

Limits in the tables below are based on a nominal value for each standard. Limits need to be calculated for the actual calibrated value of each standard.

4.3.3 Capacitance Check

Table 4-2: Capacitance Accuracy

Connect Standard Capacitor For Measurement	Accuracy	Measured Limits Based on Nominal Value
10 pF	2.0%	9.8 pF – 10.2 pF
100 pF	0.2%	99.8 pF – 100.2 pF
400 pF	0.2%	399.2 pF – 400.8 pF
1.6 nF	0.2%	1.597 nF – 1.603 nF
6.4 nF	0.2%	6.387 nF – 6.413 nF
25 nF	0.2%	24.95 nF – 25.05 nF
100 nF	0.2%	99.8 nF – 100.2 nF
400 nF	0.2%	399.2 nF – 400.8 nF
1.6 μF	0.2%	1.597 μF – 1.603 μF
6 μF	0.2%	5.988 μF – 6.012 μF
25 μF	0.2%	24.95 μF – 25.05 μF
100 μF	0.25%	99.75 μF – 100.25 μF
1000 μF	2.5%	975.0 μF – 1025 μF

4.3.4 Dissipation Factor Check

Table 4-3: Dissipation Factor Accuracy

Connect Standard D For Measurement	Accuracy	Measured Limits Based on Nominal Value
0.001	+/-0.0005	0.0005 – 0.0015
0.01	+/-0.0005	0.0095 – 0.0105
0.1	+/-0.0025	0.0975 – 0.1025

Select the following parameters:

f. Primary Parameter for R
g. Secondary Parameter for Q
h. Frequency for 1kHz
i. Test Voltage for 1V
j. Range to Auto

Enable the zero function

c. Test cables in “short” configuration
d. Press ZERO

4.3.5 Resistance Check

Table 4-4: Resistance Accuracy

Connect Standard Resitors For Measurement	**Accuracy**	**Measured Limits Based on Nominal Value**
0.1 Ω	4.0%	0.096 Ω - 0.104 Ω
25 Ω	0.2%	24.95 Ω - 25.05 Ω
400 Ω	0.2%	399.2 Ω - 400.8 Ω
6.4 kΩ	0.2%	6.387 Ω - 6.413 Ω
100 kΩ	0.2%	99.8 Ω - 100.2 Ω
9.9 MΩ	1.0%	9.801 Ω - 9.999 Ω

4.3.6 Inductance Check

Table 4-5: Inductance Accuracy

Connect Standard Inductors For Measurement	**Accuracy**	**Measured Limits Based on Nominal Value**
1 H	+/-0.2%	0.998 H – 1.002 H
16 H	+/-0.2%	15.968 H – 16.032 H