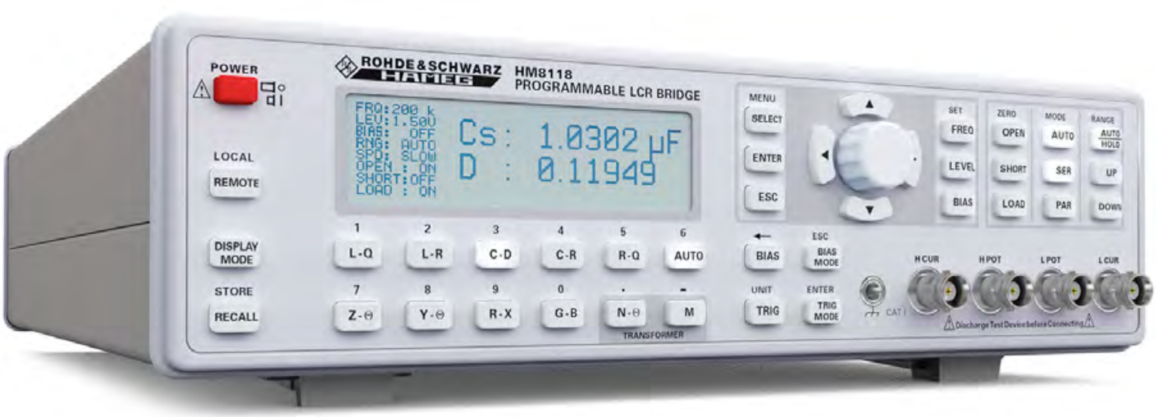
HM8118
Programmable LCR-Bridge
User Manual

HAMEG® Instruments
A Rohde & Schwarz Company



北京海洋兴业科技股份有限公司
北京市西三旗东黄平路 19 号龙旗广场 4 号楼(E座)906 室
邮编：100096
电　话：010-62176775　62178811　62176785
传真：010-62176619
企业 QQ：800057747
邮箱：info.oi@oitek.com.cn
企业官网：www.hyxyyq.com
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DECLARATION OF CONFORMITY

HAMEG Instruments GmbH
Industriestraße 6 · D-63533 Mainhausen

The HAMEG Instruments GmbH herewith declares conformity of the product:

Product name: Programmable LCR-Bridge
Type: HM8118
with: HO820
Option: HO880

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (2006/95/EC) [LVD]
- relating to electromagnetic compatibility (2004/108/EC) [EMCD]
- relating to restriction of the use of hazardous substances in electrical and electronic equipment (2011/65/EC) [RoHS].

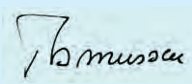
Conformity with LVD and EMCD is proven by compliance with the following standards:

EN 61010-1: 04/2015
EN 61326-1: 07/2013
EN 55011: 11/2014
EN 61000-4-2: 12/2009
EN 61000-4-3: 04/2011
EN 61000-4-4: 04/2013
EN 61000-4-5: 03/2015
EN 61000-4-6: 08/2014
EN 61000-4-11: 02/2005
EN 61000-6-3: 11/2012

For the assessment of electromagnetic compatibility, the limits of radio interference for Class B equipment as well as the immunity to interference for operation in industry have been used as a basis.

Date: 8.6.2015

Signature:



Holger Asmussen
General Manager

General remarks regarding the CE marking

Hameg measuring instruments comply with the EMI norms. Our tests for conformity are based upon the relevant norms. Whenever different maximum limits are optional Hameg will select the most stringent ones. As regards emissions class 1B limits for small business will be applied. As regards susceptibility the limits for industrial environments will be applied. All connecting cables will influence emissions as well as susceptability considerably. The cables used will differ substantially depending on the application. During practical operation the following guidelines should be absolutely observed in order to minimize emi:

1. Data connections

Measuring instruments may only be connected to external associated equipment (printers, computers etc.) by using well shielded cables. Unless shorter lengths are prescribed a maximum length of 3m must not be exceeded for all data interconnections (input, output, signals, control). In case an instrument interface would allow connecting several cables only one may be connected. In general, data connections should be made using double-shielded cables. For IEEE-bus purposes the double screened cable HZ72 from HAMEG is suitable.

2. Signal connections

In general, all connections between a measuring instrument and the device under test should be made as short as possible. Unless a shorter length is prescribed a maximum length of 1m must not be exceeded, also, such connections must not leave the premises. All signal connections must be shielded (e.g. coax such as RG58/U). With signal generators double-shielded cables are mandatory. It is especially important to establish good ground connections.

3. External influences

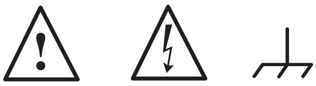
In the vicinity of strong magnetic or/and electric fields even a careful measuring set-up may not be sufficient to guard against the intrusion of undesired signals. This will not cause destruction or malfunction of Hameg instruments, however, small deviations from the guaranteed specifications may occur under such conditions.

HAMEG Instruments GmbH

Content

1 Important Notes

1.1 Symbols



(1) (2) (3)

Symbol 1: Caution, general danger zone –
Refer to product documentation
Symbol 2: Risk of electric shock
Symbol 3: Ground terminal

1.2 Unpacking

While unpacking, check the package contents for completeness (measuring instrument, power cable, product CD, possibly optional accessories). After unpacking, check the instrument for mechanical damage occurred during transport and for loose parts inside. In case of transport damage, please inform the supplier immediately. The instrument must not be operated in this case.

1.3 Setting Up the Instrument

Two positions are possible: .

Fig. 1

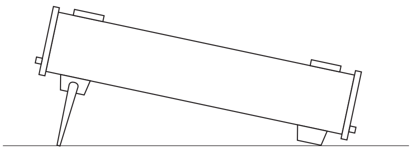


Fig. 2

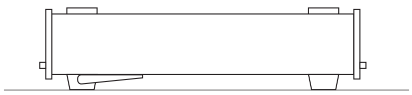
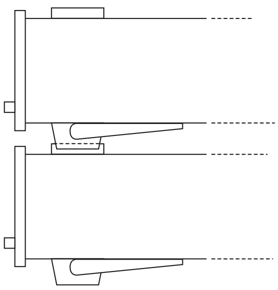


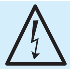
Fig. 3



According to Fig. 1 the front feet are folded down and are used to lift the instrument so its front points slightly upward (approx. 10 degrees). If the feet are not used (Fig. 2) the instrument can be stacked safely with many other HAMEG instruments. In case several instruments are stakked (Fig. 3) the feet rest in the recesses of the instrument below so the instruments can not be inadvertently moved. Please do not stack more than 3 instruments. A higher stack will become unstable, also heat dissipation may be impaired.

1.4 Safety

This instrument was built in compliance with VDE 0411 part 1, safety regulations for electrical measuring instruments, control units and laboratory equipment. It has been tested and shipped from the plant in safe condition. It is in compliance with the regulations of the European standard EN 61010-1 and the international standard IEC 61010-1. To maintain this condition and to ensure safe operation, the user must observe all instructions and warnings given in this operating manual. Casing, chassis and all measuring ports are connected to a protective earth conductor. The instrument is designed in compliance with the regulations of protection class 0.



It is prohibited to disconnect the earthed protective connection inside or outside the instrument!

For safety reasons, the instrument may only be operated with authorized safety sockets. The power cord must be plugged in before signal circuits may be connected. Never use the product if the power cable is damaged. Check regularly if the power cables are in perfect condition. Choose suitable protective measures and installation types to ensure that the power cord cannot be damaged and that no harm is caused by tripping hazards or from electric shock, for instance.

If it is assumed that a safe operation is no longer possible, the instrument must be shut down and secured against any unintended operation.

Safe operation can no longer be assumed:

- If the measuring instrument shows visible damage
- If the measuring instrument no longer functions properly
- After an extended period of storage under unfavorable conditions (e.g. outdoors or in damp rooms)
- After rough handling during transport (e.g. packaging that does not meet the minimum requirements by post office, railway or forwarding agency).

In case of doubt the power connector should be checked according to DIN VDE 0100/610:

- Only qualified personnel may open the instrument
- Prior to opening the instrument must be disconnected from the line and all other inputs/outputs.

1.5 Intended Operation

The measuring instrument is intended only for use by personnel familiar with the potential risks of measuring electrical quantities. For safety reasons, the measuring instrument may only be connected to properly installed safety socket outlets. Separating the grounds is prohibited. The power plug must be inserted before signal circuits may be connected. The product may be operated only under the operating conditions and in the positions specified by the manufacturer, without the product's ventilation being obstructed. If the manufacturer's specifications are not observed, this can result in electric shock, fire and/or serious personal injury, and in some cases, death. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

Use the measuring instrument only with original HAMEG measuring equipment, measuring cables and power cord. Never use inadequately measured power cords. Before each measurement, measuring cables must be inspected for damage and replaced if necessary. Damaged or worn components can damage the instrument or cause injury.

The measuring instrument is designed for use in the following sectors: Industry, residential, business and commercial areas and small businesses.

The measuring instrument is designed for indoor use only. Before each measurement, you need to verify at a known source if the measuring instrument functions properly.

To disconnect from the mains, the low-heat device socket on the back panel has to be unplugged.

1.6 Ambient Conditions

The allowed operating temperature ranges from +5°C to +40°C (pollution category 2). The maximum relative humidity (without condensation) is at 80%. During storage and transport, the temperature must be between -20°C and +70°C. In case of condensation during transportation or storage, the instrument will require approximately two hours to dry and reach the appropriate temperature prior to operation. The measuring instrument is designed for use in a clean and dry indoor environment. Do not operate with high dust and humidity levels, if danger of explosion exists or with aggressive chemical agents. Any operating position may be used; however adequate air circulation must be maintained. For continuous operation, a horizontal or inclined position (integrated stand) is preferable.

The maximum operating altitude for the instrument is 2000 m. Specifications with tolerance data apply after a warm up period of at least 30 minutes at a temperature of 23°C (tolerance ±2°C). Specifications without tolerance data are average values.

1.7 Warranty and Repair

Our instruments are subject to strict quality controls. Prior to leaving the manufacturing site, each instrument undergoes a 10-hour burn-in test. This is followed by extensive functional quality testing to examine all operating modes and to guarantee compliance with the specified technical data. The testing is performed with testing equipment that is calibrated to national standards. The statutory warranty provisions shall be governed by the laws of the country in which the product was purchased. In case of any complaints, please contact your supplier.

The product may only be opened by authorized and qualified personnel. Prior to working on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.

Any adjustments, replacements of parts, maintenance and repair may be carried out only by authorized technical personnel. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, PE conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

1.8 Maintenance

Clean the outer case of the measuring instrument at regular intervals, using a soft, lint-free dust cloth.

The display may only be cleaned with water or an appropriate glass cleaner (not with alcohol or other cleaning agents). Follow this step by rubbing the display down with a dry, clean and lint-free cloth. Do not allow cleaning fluid to enter the instrument. The use of other cleaning agents may damage the labeling or plastic and lacquered surfaces.

Before cleaning the measuring instrument, please make sure that it has been switched off and disconnected from all power supplies (e.g. AC supply network).

No parts of the instruments may be cleaned with chemical cleaning agents (such as alcohol, acetone or cellulose thinner)!

1.9 Line fuse

The instrument has 2 internal line fuses: T 0.8 A. In case of a blown fuse the instrument has to be sent in for repair. A change of the line fuse by the customer is not permitted.

1.10 Power switch

The instrument has a wide range power supply from 105 V to 253 V, 50 Hz or 60 Hz ±10 %. There is hence no line voltage selector.

Fuse type:
Size 5 x 20 mm; 250V~, C; IEC 127, Bl. III; DIN 41 662 (possibly DIN 41 571, Bl. 3). Slow-blow (T) 0,8A.

1.11 Batteries and Rechargeable Batteries/Cells

If the information regarding batteries and rechargeable batteries/cells is not observed either at all or to the extent necessary, product users may be exposed to the risk of explosions, fire and/or serious personal injury, and, in some cases, death. Batteries and rechargeable batteries with alkaline electrolytes (e.g. lithium cells) must be handled in accordance with the EN 62133 standard.

1. Cells must not be disassembled, opened or crushed.
2. Cells and batteries may not be exposed to heat or fire. Storage in direct sunlight must be avoided. Keep cells and batteries clean and dry. Clean soiled connectors using a dry, clean cloth.

3. Cells or batteries must not be short-circuited. Cells or batteries must not be stored in a box or in a drawer where they can short-circuit each other, or where they can be short-circuited by other conductive materials. Cells and batteries must not be removed from their original packaging until they are ready to be used.
4. Keep cells and batteries out of reach of children. Seek medical assistance immediately if a cell or battery was swallowed.
5. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
6. If a cell develops a leak, the fluid must not be allowed to come into contact with the skin or eyes. If contact occurs, wash the affected area with plenty of water and seek medical assistance.
7. Improperly replacing or charging cells or batteries can cause explosions. Replace cells or batteries only with the matching type in order to ensure the safety of the product.
8. Cells and batteries must be recycled and kept separate from residual waste. Cells and batteries must be recycled and kept separate from residual waste. Rechargeable batteries and normal batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.

1.12 Product Disposal

Fig. 1.4: Product labeling in accordance with EN 50419

The Electrical and Electronic Equipment Act implements the following EG directives:

- 2002/96/EG (WEEE) for electrical and electronic equipment waste and
- 2002/95/EG to restrict the use of certain hazardous substances iin electronic equipment (RoHS directive).

Once its lifetime has ended, this product should be disposed of separately from your household waste. The disposal at municipal collection sites for electronic equipment is also not permitted. As mandated for all manufacturers by the Electrical and Electronic Equipment Act (ElektroG), ROHDE & SCHWARZ assumes full responsibility for the ecological disposal or the recycling at the end-of-life of their products.

Please contact your local service partner to dispose of the product.

2 Description of the Operating Elements

Front panel of HM8118

1 POWER – Turning on/off the instrument
2 DISPLAY (LCD) – Display of measurement results and units, ranges, frequencies, level, equivalent circuit, functions and parameters

MENU

3 SELECT – Opening the submenus SETUP, CORR, SYST and BIN (only with installed Binning Interface HO118)
4 ENTER – Confirmation of input values
5 ESC – Cancel the menu function
6 Rotary knob (Knob/Pushbutton) – Selection of functions and parameters
7 Arrow buttons ▲▼◀▶ – Pushbuttons for parameter selection

SET

8 FREQ – Setting of the test signal frequency with rotary knob 6 or arrow buttons ▲▼◀▶ 7
9 LEVEL – Setting of the test signal level with rotary knob 6 and cursor position with arrow buttons ▲▼◀▶ 7
10 BIAS – Setting of the bias voltage or current with rotary knob 6 and cursor position with arrow buttons ▲▼◀▶ 7

ZERO

11 OPEN – Activating the OPEN calibration
12 SHORT – Activating the SHORT calibration
13 LOAD – Activating the LOAD calibration

MODE

14 AUTO – Activating the automatic selection of equivalent circuit
15 SER – Activating the series equivalent circuit
16 PAR – Activating the parallel equivalent circuit

RANGE

17 AUTO/HOLD – Activating the automatic measurement range (LED lights up) or the range HOLD function
18 UP – Range up
19 DOWN – Range down

Connectors

20 L CUR (BNC socket) – Low Current; signal output for series measurements (signal generator)
21 L POT (BNC socket) – Low Potential; signal input for parallel measurement (voltage measurements)
22 H POT (BNC socket) – High Potential; signal input / output for parallel measurements (measurement bridge)
23 H CUR (BNC socket) – High Current; signal input for series measurements (current measurements)

Instrument functions

24 BIAS MODE/ESC – Activating of internal / external bias voltage resp. cancelling the editing mode (ESC)
25 TRIG MODE/ENTER – Changing the trigger mode resp. confirming an input value
26 BIAS / ⟵ – Activating the bias voltage resp. erasing the last character of an numeric input
27 TRIG / UNIT – Single trigger in manual trigger mode resp. selection of a parameter unit
28 AUTO / 6 – Activating the automatic measurement function resp. entering numeric value 6
29 M / – – Selection of the measurement function „Mutual Inductance“ resp. parameter input of the character „-“.
30 R-Q / 5 – Selection of the measurement function ‘Resistance’ R und ‘Quality factor’ Q resp. entering numeric value 5

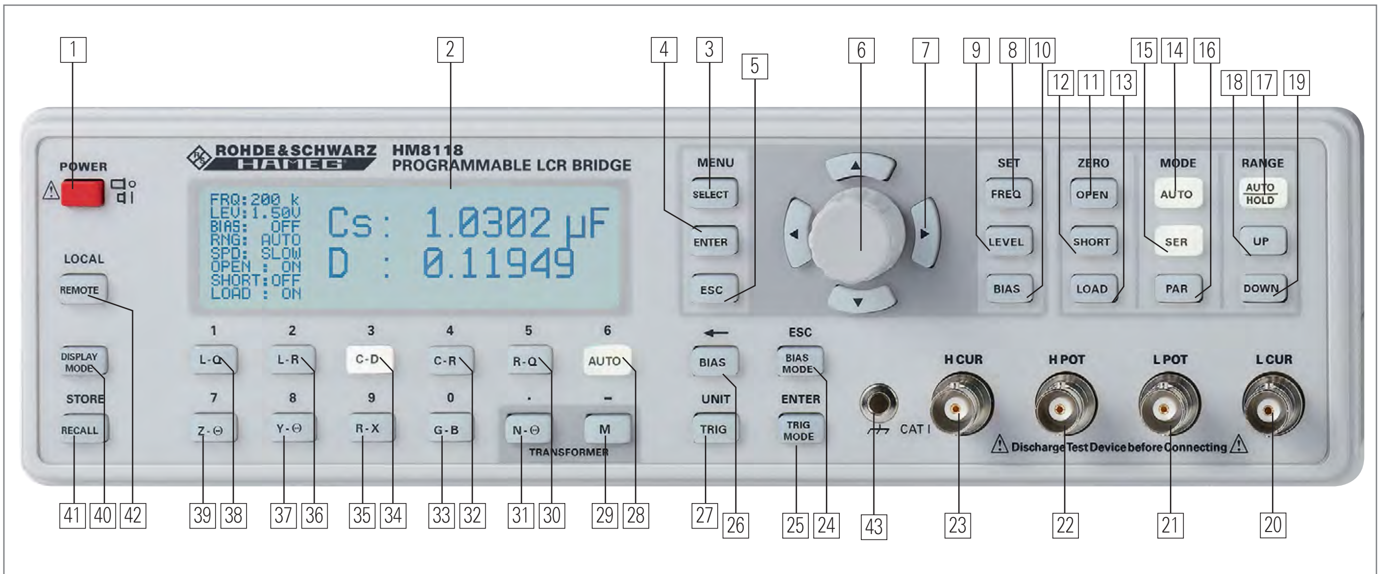


Fig. 2.1: Front panel of HM8118

31 N-Θ / . – Selection of the measurement function 'Turns ratio' N and 'Phase angle' Θ resp. parameter input of the character ". "
32 C-R / 4 – Selection of the measurement function 'Capacitance' C and 'Resistance' R resp. entering numeric value 4
33 G-B / 0 (Pushbutton)
Selection of the measurement function 'Conductance' G and 'Susceptance' B resp. entering numeric value 0
34 C-D / 3 – Selection of the measurement function 'Capacitance' C and 'Dissipation factor' D resp. entering numeric value 3
35 R-X / 9 – Selection of the measurement function 'Resistance' R and 'Reactance' X resp. entering numeric value 9
36 L-R / 2 – Selection of the measurement function 'Inductance' L and 'Resistance' R resp. entering numeric value 2
37 Y-Θ / 8 – Selection of the measurement function 'Admittance' Y and 'Phase angle' Θ resp. entering numeric value 8
38 L-Q / 1 – Selection of the measurement function 'Inductance' and 'Quality factor' Q resp. entering numeric value 1
39 Z-Θ / 7 – Selection of the measurement function 'Impedance' Z and 'Phase angle' Θ resp. entering numeric value 7
40 DISPLAY MODE – Toggling the display of measurement values with / without parameters
41 RECALL / STORE – Loading/storing of instrument settings
42 REMOTE / LOCAL – Toggling between front panel (LOCAL) or remote operation (LED lights up); if local lockout was activated, the instrument can not be operated from the front panel.
43 Ground (4 mm socket) – Ground connector (⊥). The socket is directly connected to the mains safety ground!

Back panel of HM8118

44 TRIG. INPUT (BNC socket) –
Trigger input for external trigger
45 BIAS FUSE (Fuse holder) –
Fuse for external voltage input ext. BIAS
46 EXT. BIAS (4 mm safety sockets) –
External bias input (+, –)
47 INTERFACE – HO820 Dual Interface USB/RS-232 (galvanically isolated) is provided as standard
48 BINNING INTERFACE (25 pin D-Sub socket) –
Output to control external binning sorters for components (option HO118)
49 POWER INPUT (Power Cord Receptacle)

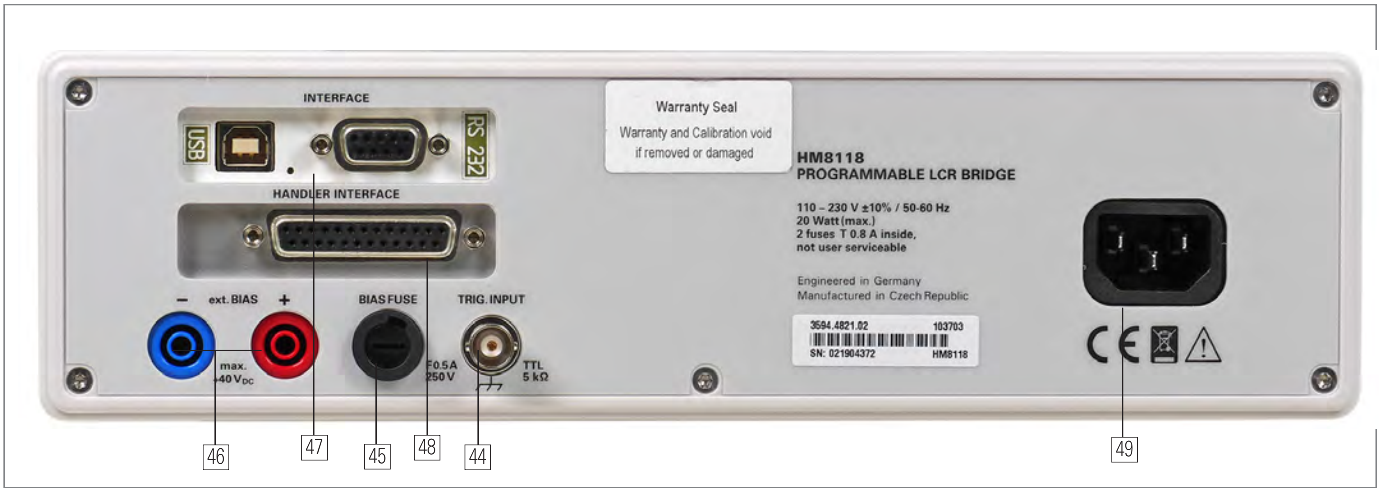


Fig. 2.2: Back panel of HM8118

3 Introduction

3.1 Requirements

The following components are only intended to be used as an example for a quick introduction to the instrument.

- HAMEG HM8118 LCR measuring bridge with firmware from 1.37 upwards.
- HZ184 Kelvin measurement cables
- 1 x HAMEG 1,000 µF capacitor (not contained in shipment)
- 1 x HAMEG 280 µH inductor (not contained in shipment)
- 1 x HAMEG 100 kΩ resistor (not contained in shipment).

First connect the HZ184 cables supplied to the HM8118. The two plugs of the black cable are connected to the terminals LCUR and LPOT, the plugs of the red cable to the terminals HCUR and HPOT.

After turning the instrument on, the first steps are the open circuit and the short circuit calibration procedures at the preselected frequency of 1.0 kHz because the measurement cables HZ184, in conjunction with the terminals, due to their design, show a stray capacity, a residual inductance and a residual resistance which impair the accuracy of the measurement results. In order to minimize these influences, the compensation of impedance measurement errors caused by adapters and cables is necessary.

For the open circuit calibration, position the two clips apart from each other. For the short circuit calibration connect both clips as shown in Fig. 3.1.

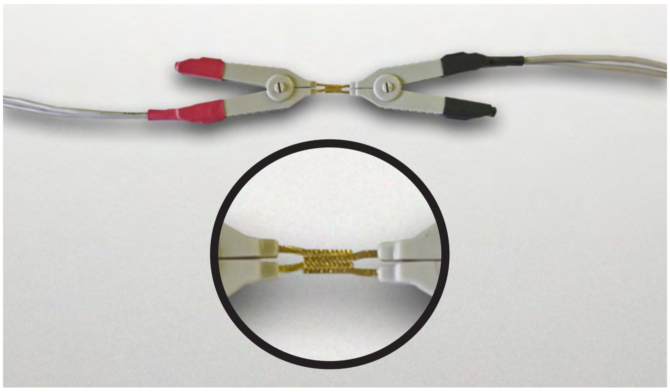


Fig. 3.1: Short circuit calibration with HZ184.

Push the button MENU/SELECT [3] and then the button C-D [34] in order to enter the CORR menu. Select the menu item MODE and use the knob [6] to change the menu entry from SGL to ALL in order to automatically perform the calibration at all 69 frequency steps provided. Leave the menu by pushing the button MENU/ESC [5].

The mode SGL is used to only calibrate at the presently selected frequency; this procedure takes just a few seconds and is destined for measurements in one or a few frequency ranges only.

Now start the open and short circuit calibrations by pushing the buttons ZERO/OPEN [11] resp. ZERO/SHORT [12]. The instrument will now determine correction factors at all 69 frequency steps valid for the presently connected measurement cables and store them until the instrument is switched off. This procedure will last appr. 2 minutes.

3.2 Measurement of a capacitor

Now connect the capacitor to the terminals of the HZ184. Please observe the polarity of the capacitor and connect the black terminal to the negative terminal of the capacitor, marked with a – (minus).

As the instrument is set to automatic mode, the measurement function will be automatically switched to function no. 3 (C-D). Because the measuring frequency of 1.0 kHz was preselected, the capacitor will not be measured in its regular operating mode, so the value displayed of appr. 900 µF will not equal the specified value of 1,000 µF.

Change the measuring frequency to 50 Hz by pushing the button SET/FREQ [8] and turning the knob until 50 Hz are shown on the display. Now the value displayed will change to appr.1,000 µF depending on its tolerance. The dissipation factor „D" will be very low at this setting.

The smaller the loss angle, the more the real world components will come close to the ideal. An ideal inductor has a loss angle of zero degrees. An ideal capacitor also has a loss angle of zero degrees. An ideal electrical resistor, however, has a loss angle of 90 degrees, it has no capacitive or inductive components.

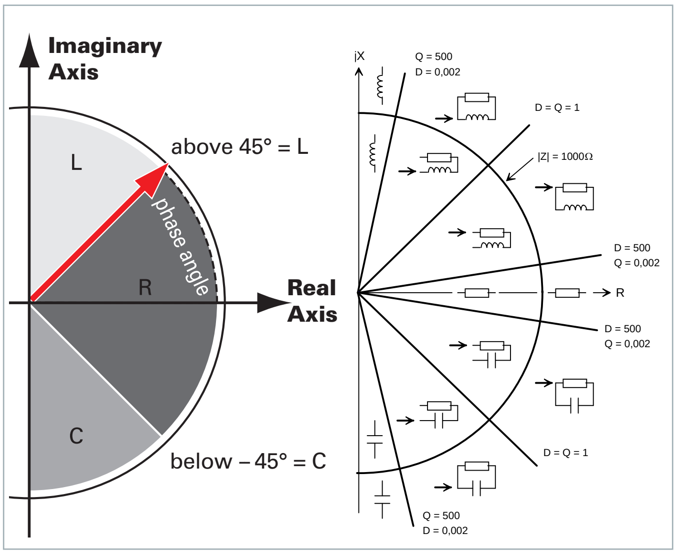


Fig. 3.2: HM8118 measurement principle, left: schematic, right: detailled presentation.

3.3 Measurement of an inductor

Before you connect the choke, increase the measuring frequency by one decade to 500 Hz by pushing the arrow button ▲ [7] above the knob. Disconnect the capacitor and connect the choke to the terminals of the HZ184.
The instrument will now automatically switch to the function no. 1 (L-Q) and the inductance of the choke will be dis-

played. The value should be appr. 280 µH. As shown in Fig. 3.2, the phase angle of an inductor must be in the range of + 45 to 90°. In order to prove this, leave the automatic mode by pushing the button „Z-Θ [39]. The phase angle displayed will be appr. +70° and depends on the measuring frequency set.
For comparison: the phase angle of the capacitor measured before is appr. -87° at 50 Hz.

3.4 Measurement of a resistor

Disconnect the choke and connect the 100 kΩ resistor supplied. As the instrument was previously set manually to the function Z-Θ, the value of its impedance can be directly read (appr. 100 kΩ). As decribed on the page before, an ideal resistor has no capacitive or inductive components. Hence the phase resp. loss angle of the component connected is close to zero degrees.

The HM8118, upon connection of the resistor, automatically changed the internal equivalent circuit from series connection SER to parallel connection PAR (LED pushbuttons [15] and [16]). If the automatic selection of the equivalent circuit was chosen (pushbutton AUTO [14]), the LCR measuring bridge will automatically select the equivalent circuit which, depending on the component connected, is best suited to yield a precise measurement result. The equivalent circuit represents the measurement circuit. Usually, components with a low impedance (capacitors, chokes) will be measured using the series connection equivalent circuit while components with a high impedance (e.g. resistors) will be measured using the parallel equivalent circuit.

4 First-Time Operation

4.1 Connecting the instrument

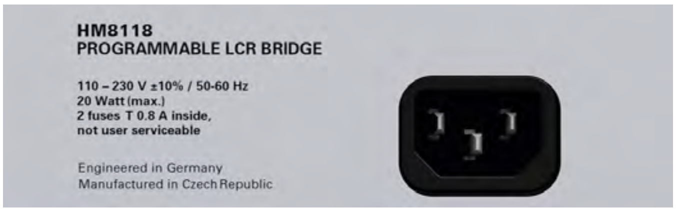


Fig. 4.1: Power Input

Prior to connecting the instrument to the mains, check whether the mains voltage conforms to the mains voltage range specified on the rear panel. This instrument has a wide-range power supply and hence requires no manual setting of the mains voltage.

The fuse holder of the BIAS FUSE [45], i.e. the external BIAS input, is accessible on the rear panel. Prior to exchanging a fuse the instrument must be disconnected from the mains. Then the fuse holder may be removed with a suitable screw driver, using the slot provided. Afterwards the fuse can be removed from the holder and exchanged. The holder is spring-loaded and has to be pushed in and turned. It is prohibited to use „repaired" fuses or to short-circuit the fuse. Any damages incurred by such manipulations will void the warranty. The fuse may only be exchanged by this type:

Fuse with ceramic body, filled with fire extinguishing material:
Size 6.3 x 32 mm; 400 V_{AC}, C; IEC 127, Bl. III; DIN 41 662 (alternatively DIN 41 571, p. 3), (F) 0,5 A

Fig. 4.2: Rear panel with fuse

4.2 Turning on the instrument

Prior to operating the instrument for the first time, please be sure to observe the safety instructions mentioned previously!

The LCR bridge is switched on by using the power switch [1]. Once all keys have briefly been illuminated, the bridge can be operated via keys and the knob on the front panel. If the keys and the display do not light up, either the mains voltage is switched off or the internal input line fuses are defective. The current measurement results are shown in the right panel and the essential parameters in the left panel of the display. The four BNC sockets located on the front panel can be connected to the component to be measured with the appropriate measuring accessories. Additionally, it is also possible to connect the measuring instrument via ground socket on the front panel [43] with ground potential. The socket is suitable for a banana plug with a 4 mm diameter.

The front panel ground connector and the ground contact of the trigger input are directly connected to the mains safety ground potential through the line cord. The outer contacts of the front panel BNC connectors [20] – [23] (as well as the shields of any coaxial cables attached) are connected to the GUARD potential which has no connection to the safety ground! No external voltages may be applied to the BNC connectors! The rear panel interfaces [47] and [48] are galvanically isolated (no connection to ground)!

If there are undefined messages on the display or if the instrument fails to react to operation of its controls turn it off, wait a minute and turn it on again in order to trigger a reset operation. If the display remains unchanged or operation impossible, turn it off and take it to a qualified service point (see Safety Instructions).

4.3 Line frequency

Prior to first measurements, the line frequency setting must be set to the applied line frequency, 50 or 60 Hz. If the line frequency is not set properly, depending on the measurement range and the line frequency value, instabilities may occur e.g. on the display. In order to set the line frequency press the SELECT button [3], use the SYST menu for accessing MAINS FRQ, use the knob [6] for selecting the correct value.

4.4 Measurement Principle

The LCR meter HM8118 is not a traditional Wien, Maxwell or Thomson measurement bridge. Rather, when connecting a test object, the impedance |Z| and the corresponding phase angle Θ (phase between current and voltage) are always determined (see fig. 4.3). These measurement values are frequency dependent and will be determined by means of an AC test signal (which can be set manually between 50mV and 1.5V). The test signal is induced in the test item. This distinguishes a LCR bridge from a multimeter (DC measurement). Based on the measurement principle, the measured impedance is always essential. Based on the impedance (X axis) and the phase angel (angle), the instrument is able to determine the missing value of the Y axis. This means that it is not the DC component that is being measured but rather the AC value. The issued values are calculated digitally. This measurement of impedance and phase angle is subject to a certain measurement inaccuracy which will be described on the following pages.

In general, the HM8118 bridge can only determine the ESR, ESC or ESL (= Equivalent Series Resistance / Capacity / Inductivity) according to the equivalent circuit diagram of the component and is primarily used to measure individual components. If a circuit with multiple components is connected to the bridge, the instrument will always determine the ESR, ESC or ESL of the entire circuit / component group. This can potentially skew the measurement result. The connected component / circuit is assumed to be the „Black Box". These values are available for each component; however, please keep in mind that these always describe the result of multiple, possibly overlapping individual capacities, inductances and impedances. This can easily cause some misunderstandings especially with coils (magnetic field, eddy currents, hysteresis, etc.)

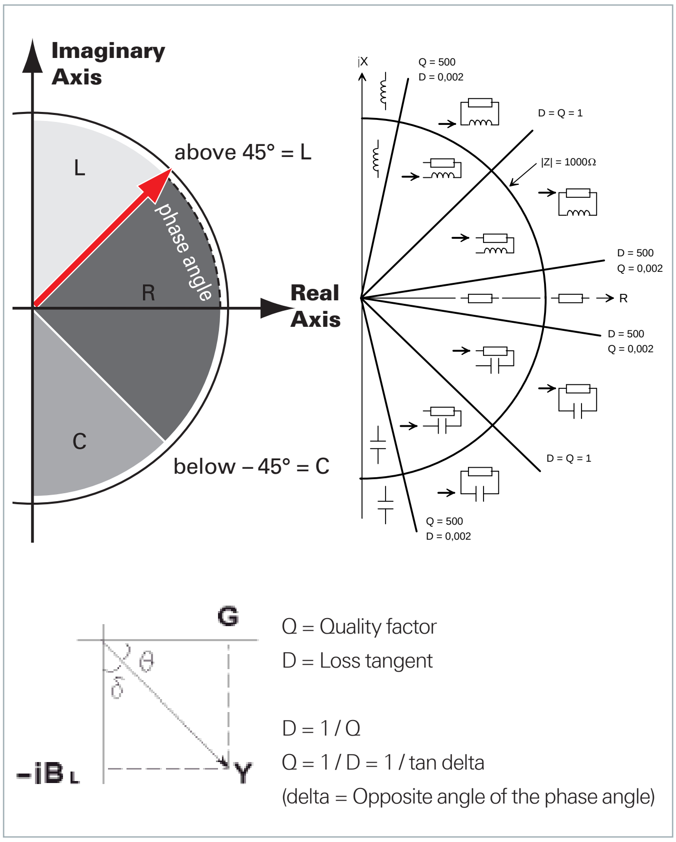


Fig. 4.3: Measurement principle

The LCR bridge HM8118 is primarily intended to determine passive components. Therefore, it is not possible to determine test objects which are externally supplied with power.

Fig. 4.4 shows the link between capacity C_S (or resistance R_S) and various test voltages that can be selected with the bridge ($0.2V_{eff}$ to $1.5V_{eff}$). As can be seen in the figure, the measurement values of C_S or R_S are highly dependent on the selected test voltage. Point A shows the test point of the instrument during the measurement of a single component, point B shows the test point during the measurement of a component group (in this case two capacities connected in parallel). In contrast to test point A, with point B the bridge switches the measurement range due to the impedance of the entire component group. As a result, the measurement results for point A and point B are different.

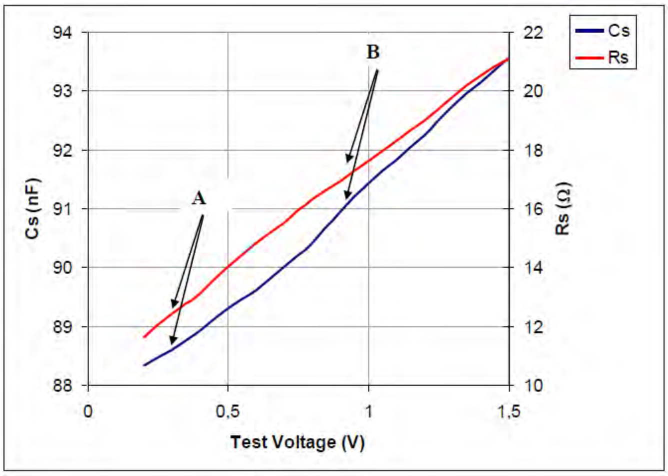


Fig. 4.4: Example correlation Cs (or Rs) and test voltage

The actual measured series resistance includes all series resistances such as the component leads and the resistance of series-connected foils in capacitors as well as dielectric losses; it is expressed by the dissipation factor DF. The equivalent series resistance (ESR) is frequency-dependent according to the formula:

$$ESR = Rs = D/\omega Cs$$

where ω „Omega" = 2 π f (circular frequency) represents. Traditionally, the inductance of coils is measured in a series circuit; however there are cases where a parallel circuit will yield a better representation of the component. In small „air" coils mostly the ohmic or copper losses are predominant , hence the series circuit is the proper representation. The core of coils with an iron or ferrite core may contribute most of the losses, the parallel circuit is to prefer here.

The resistance measurement always occurs in compliance with the method to apply voltage (AC) and measure the resulting current. The only difference to L or C is that the phase angle is nearly 0° (real resistance). A resistance measurement with DC is not intended.

4.5 Measurement Accuracy

The measurement of impedance and phase angle is prone to a certain amount of inaccuracy. The measurement accuracy of a specific test point can be calculated based on the accuracy table in the data sheet (see fig. 4.5). Make sure you know the impedance of the corresponding component at the respective test point. No further information is required to calculate the accuracy. The base accuracy of 0.05% as indicated in the data sheet pertains only to the base accuracy of the HM8118 bridge. The base accuracy only indicates the general measurement uncertainty of the instrument. The accuracy table describes the measurement accuracy that additionally has be taken into account.

The highest accuracy is ensured when the DUT value (= Device Under Test) is approximately centered in the measurement range. If the next highest measurement range is selected for this DUT, it will display in the center of the selected range. Since the measurement error is defined as a percentage of the measurement range final value, the measurement error in the higher range goes up nearly by a factor of 2. Typically, the measurement error is increased accordingly in the nearest higher measurement range. If a component is removed from the test lead or measurement adapter during a measuring process in the continuous measurement mode, the automatically selected measurement range and the automatically selected measurement function can be adopted by switching to the manual measurement range selection (RANGE HOLD). This allows the measurement time during the measurement of many similar components to be reduced.

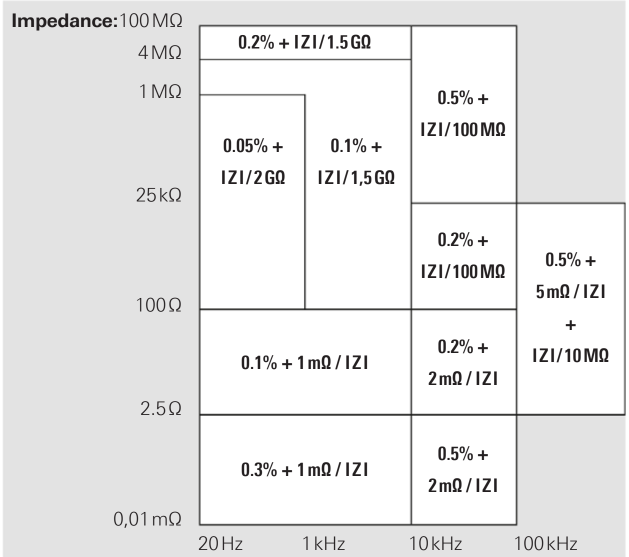


Fig. 4.5: Table to determine the accuracy

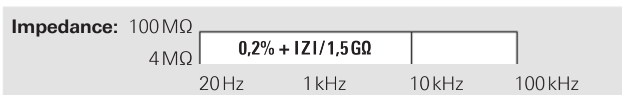
The accuracy decreases with the measurement voltage (test voltage) because the signal / noise ratio decreases. Consequently, this leads to additional instabilities. The accuracy decreases at the same rate. If 0.5V is used as measurement voltage, for instance, the base accuracy is one half.

4.5.1 Example of determining the measurement accuracy

The accuracy calculation is always based on the data sheet table (see fig. 4.5). To calculate the corresponding measurement accuracy, the following component parameters are required (component operating point):

- Component impedance at corresponding measurement frequency
- The measurement frequency.

As an example, a 10 pF capacitor with an impedance of 15 MΩ at 1 kHz will be measured. In this case, the top row of the accuracy table is valid:



The values of the component set in into the formula:

$$\text{Accuracy}_{@1kHz} = 0{,}2\% + \frac{15\ \text{M}\Omega}{1{,}5\ \text{G}\Omega}$$

$$\text{Accuracy}_{@1kHz} = 0{,}2\% + \frac{15 \times 10^{6}\ \Omega}{1{,}5 \times 10^{9}\ \Omega}$$

$$= 0{,}2\% + \frac{15\ \Omega}{1{,}5 \times 10^{3}\ \Omega}$$

$$= 0{,}2\% + \frac{15\ \Omega}{1500\ \Omega}$$

$$= 0{,}2\% + 0{,}01$$

The units will be adjusted once the component values have been entered and the formula has been calculated because the second addend is without unit:

$$\text{Accuracy}_{@1kHz} = 0{,}2\% + 0{,}01 = 0{,}2 + (0{,}01 \times 100\%) = 0{,}2\% + 1\% = 1{,}2\%$$

For the 10pF component this leads to:
1.2% of 10pF is 0.12pF.

Based on the calculation the displayed value will be between 10pF - 0.12pF = 9.88pF and 10pF + 0.12pF = 10.12pF.

5 Setting of Parameters

5.1 Selecting Values /Parameters

Each function and operating mode of the measuring instrument can be selected with the keys on the front panel of the instrument. Use the respective function key to select the measurement function. An active measurement function is highlighted by an illuminated white LED. Subsequent settings refer to the selected measurement function. To set parameters, three options are available:

- Numeric keypad
- Knob
- Arrow keys

You can set the measuring instrument parameters by pressing the SELECT key [3] and by using the menu functions SETUP, CORR, SYST and BIN (will only be displayed with an integrated binning interface HO118). Use the keys L-R/2 [36], C-D/3 [34], C-R/4 [32], R-Q/5 [30] to select the sub menus associated with the menu functions. Depending on the function, you can set the respective measuring instrument parameters by using the arrow keys ▲▼◀▶ [7] and the knob [6]. Pressing the knob allows the user to modify the corresponding measuring instrument parameters. This will be indicated in the display by a blinking „E" (Edit).

5.1.1 Knob with Arrow Keys

If you select the respective menu via arrow keys, you can press the knob to activate the editing mode. If the editing mode is active (blinking „E" on the display), you can use the knob to select the parameter or the input value. The value input will be modified gradually, and the respective input parameter will be set instantly. The nominal value is increased by turning the knob to the right, and it is decreased by turning it to the left. Press the knob again to deactivate the editing mode and to confirm the function slection. Use the arrow keys to select the respective menu function.

5.1.2 Numeric Keypad

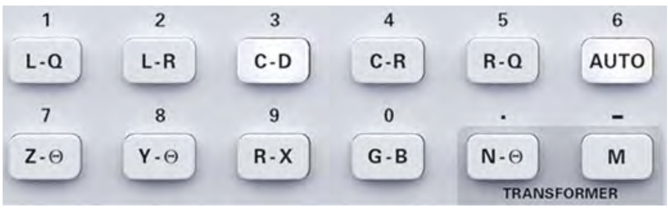


Fig. 5.1: Numeric keypad with function keys

The easiest way to enter a value precisely and promptly is to use the numeric keypad with numeric keys (0...9) and the decimal point key. Once you have pressed the knob to activate the editing mode, you can use the SELECT key [3], the ENTER key [25] or press the knob again to reactivate the manual value input via numeric keypad. This opens a value entry window where you can enter the respective value by means of number pads (in addition to the corresponding unit, depending on the measuring instrument parameter). After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again. Before confirming the parameter, you can delete the value that has been entered incorrectly by pressing the ← key. The ESC key allows you to cancel the operation to enter parameters. This will close the editing window.

5.2 Selecting the Measurement Function

Out of nine measurement functions, the LCR bridge HM8118 allows you to measure two parameters simultaneously and display them as measurement values. The first parameter refers to the „main measurement value display" and the second parameter to the „secondary measurement value display". Depending on the connected component, the following main and secondary measurement value displays can be shown:

L-Q	Inductance L and quality factor (quality) Q
L-R	Inductance L and resistance R
C-D	Capacity C and dissipation factor D
C-R	Capacity C and resistance R
R-Q	Resistance R and quality factor (quality) Q
Z-Θ	Apparent impedance (impedance) Z and phase angle Θ
Y-Θ	Admittance Y and phase angle Θ
R-X	Resistance R and reactance X
G-B	Conductance G and susceptance B
N-Θ	Transformer ratio N and Phase difference Θ
M	Transformer mutual inductance M

You can select the desired measurement function by pressing the keys 29 to 39.

In the automatic mode (key AUTO), the bridge switches both the measurement function (key 28 - 39) as well as the internal equivalent circuit diagram of the measurement circuit appropriately to the measured values to serial (for inductive loads) or to parallel (for capacitive loads).

6 Measurement Value Display

The values measured with the LCR bridge HM8118 can be shown on the LCD display in three different versions:

- Measurement value
- absolute measurement value deviation Δ ABS or
- relative measurement value deviation Δ % (in percent).

Press the SELECT key 3 to use the SETUP and the setting DEV_M (for the main measurement value display) and DEV_S (for the secondary measurement value display) to switch the measurement value display. If you select the function DEV_M or DEV_S via arrow keys, you can press the knob to activate the editing mode. If the editing mode is active (blinking „E" on the display), you can use the knob to select the respective measurement value display. Press the knob again to deactivate the editing mode and to confirm the function selection.

The main measurement value and the secondary measurement value will be shown on the display including the decimal point and the associated units. The resolution of the main measurement value display (L, C, R, G, Z or Y) consists of one, or two or three digits before the decimal point and four, or three or five digits after the decimal point. The resolution of the secondary measurement value display (D, Q, R, B, X or Θ) consists of one, or two or three digits before the decimal point and four, or three or five digits after the decimal point. The depiction OVERRANGE will be shown on the display if the measurement value is located outside the set measurement range.

If the bridge shows a negative value on the display, make sure to check the measurement frequency, the measurement voltage and possibly the phase angle of the component. For instance, if the phase angle of a capacitor is close to 90°, it could result in a negative display value due to the measurement accuracy. For instance, negative values may occur for coils with cores (erroneous measurement due to magnetization).

6.1 Relative Measurement Value Deviation Δ % (#, %)

The # symbol in front of a measurement value and the % symbol following a measurement value indicate that the relative measurement value deviation Δ % (in percent) of the measured L, C, R, G, Z or Y measurement value, or of the D, Q, R, B, X or Θ measurement value of a stored measurement value (reference value) is displayed.

6.2 Absolute Measurement Value Deviation Δ ABS (#)

The # symbol in front of a measurement value indicates that the absolute measurement value deviation Δ ABS of the measured value, similarly to Δ %, of the stored measurement value (reference value) is displayed. The measurement value deviation is shown in the appropriate units (Ohm, Henry, etc.).

6.3 Reference Value (REF_M, REF_S)

The menu function REF_M or REF_S enables the user to enter a reference value which will be used as a basis for the measurement result Δ % or Δ ABS. Press the SELECT key 3 to use the SETUP menu function and the setting REF_M (for the main measurement value display) and REF_S (for the secondary measurement value display) to enter a reference value each. The applicable units will be selected automatically depending on the selected measurement function for the main measurement value display (H, F, Ω or S) or for the secondary measurement value display (Ω, S or °). You can enter a reference value numerically with up to five digits after the decimal point. Alternatively, you can press the TRIG key 27 to perform a measurement, and the resulting measurement value will be adopted as reference value.

6.4 Selecting the Measurement Range

The measurement range can be selected automatically or manually. In some cases, it is useful to lock the automatic measurement range function as it can take a complete measurement cycle to determine the appropriate measurement range. This can also be useful when switching similar components. The bridge HM8118 automatically switches to the measurement range 6 and subsequently back to the adequate measurement range if a component has been connected to the instrument. If the automatic measurement range function has been locked and the impedance of a component equals more than 100 times the nominal value of the measurement range, the bridge will display an OVERRANGE measurement error. In this case, it is necessary to select a suitable measurement range for the measurement. Press the AUTO/HOLD key 17 to switch between the automatic and the manual measurement range selection.

6.4.1 Automatic range selection (AUTO)

If the automatic measurement range function is activated, the bridge automatically selects the most suitable measurement range for an exact measurement in accordance with the connected component. The instrument will switch to the next measurement range level below if the measurement value is smaller than 22.5% of the selected measurement range or 90% higher than the end value of the measurement range. An integrated switching hysteresis of approximately 10% prevents the instrument from constantly switching the measurement range if the measurement value is close to the switching threshold of a measurement range. The following table shows the switching thresholds for switching the measurement range (if the constant voltage CST V is switched off):

Measurement Range	Component Impedance
1 to 2	Z > 3.00 Ω
2 to 3	Z > 100.00 Ω
3 to 4	Z > 1.60 kΩ
4 to 5	Z > 25.00 kΩ
5 to 6	Z > 1.00 MΩ
2 to 1	Z < 2.70 Ω
3 to 2	Z < 90.00 Ω
4 to 3	Z < 1.44 kΩ
5 to 4	Z < 22.50 kΩ
6 to 5	Z < 900.00 kΩ

During the measurement of an inductance in the AUTO mode, it may occur that the HM8118 is constantly changing the measurement range. This is based on the fact that the source impedance is dependent on the selected measurement range so that after switching the measurement range, the newly measured value is outside the range of the 10% hysteresis. In this case, it is recommended to use the manual measurement range selection.

6.4.2 Manual Measurement Range Selection

The bridge HM8118 includes 6 measurement ranges (1–6). The measurement ranges can be preselected manually or automatically. The following table indicates the source resistance and the impedance of the connected component for each measurement range. The specified ranges are impedance ranges, not resistance ranges. Capacitors or inductances are frequency-dependent components.

Measurement range	Source Impedance	Component Impedance
1	25.0 Ω	10.0 μΩ bis 3.0 Ω
2	25.0 Ω	3.0 Ω bis 100.0 Ω
3	400.0 Ω	100.0 Ω bis 1.6 kΩ
4	6.4 kΩ	1.6 kΩ bis 25.0 kΩ
5	100.0 kΩ	25.0 kΩ bis 2.0 MΩ
6	100.0 kΩ	2.0 MΩ bis 100.0 MΩ

Additionally, the impedance of capacitors is inversely proportionate to the frequency. Therefore, larger capacitators will be measured in the lower impedance measurement ranges. Consequently, the measurement range for any given component may change as the measurement frequency changes. If you wish to measure multiple similar components, it is possible to shorten the measurement time by using the AUTO/HOLD 17 key to switch from the automatic measurement range selection to the manual measurement range selection with the DUT (= Device Under Test) connected. The AUTO/HOLD key will no longer be illuminated. It is recommended to primarily use the ma-

The LCR bridge HM8118 does not create a 50Ω system. Instead, it changes its internal resistance dependent on measurement function and measurement range. Every cable shows losses and distorts the original measurement result because of inductive and capacitive properties (particularly because of its length).
The input impedance changes dependent on the selected measurement range and the connect load impedance between 25Ω and 100kΩ.

nual measurement range selection for high-precision measurements to prevent potential measurement errors due to incorrect use and other uncertainties. Whenever possible, make sure to perform measurements with the automatic measurement range selection activated.

Use the function RNG in the SETUP menu to activate the manual measurement range selection. Press the knob to activate the editing mode. You can then press the knob to select the manual measurement range. If the manual measurement range selection is activated, you can use the UP [18] key to manually switch to a higher measurement range. Press the DOWN [19] key to manually switch to a lower measurement range.

6.5 Circuit Type

If the automatic circuit type selection is activated (by pressing the AUTO [14] key), the LCR bridge HM8118 will automatically select the circuit type (serial or parallel) that is best suited for the precise measurement, according to the connected component. It is also possible to select the circuit type manually (by pressing the SER [15] key for serial, or by pressing the PAR [16] key for parallel).

The circuit type displays the equivalent circuit diagram of the measurement circuit. Typically, the inductance of coils is measured in serial mode. However, for certain situations the parallel equivalent circuit diagram may be better suited to measure physical components. For instance, this is the case for coils with iron core which most significantly experience core losses. If the most significant losses are ohmic losses or losses in the connecting wires of wired components, a serial circuit would be better suited as equivalent circuit diagram for the measurement circuit. In the automatic mode, the bridge selects the serial equivalent circuit diagram for impedances below 1kΩ and the parallel equivalent circuit diagram for impedance above 1kΩ.

7 Instrument Functions

Press the SELECT key to open the main menu. The main menu enables you to access the submenus SETUP, CORR and SYST via numeric keypad.

7.1 SETUP Menu

Fig. 7.1: Menu function SETUP display

7.1.1 Measurement Frequency FRQ

The LCR bridge HM8118 includes a measurement frequency range from 20 Hz to 200 kHz (in 69 increments) with a base accuracy of 100 ppm. The 69 increments of the measurement frequency range are as follows:

Measurement Frequencies					
20Hz	90Hz	500Hz	2.5kHz	12kHz	72kHz
24Hz	100Hz	600Hz	3.0kHz	15kHz	75kHz
25Hz	120Hz	720Hz	3.6kHz	18kHz	80kHz
30Hz	150Hz	750Hz	4.0kHz	20kHz	90kHz
36Hz	180Hz	800Hz	4.5kHz	24kHz	100kHz
40Hz	200Hz	900Hz	5.0kHz	25kHz	120kHz
45Hz	240Hz	1.0kHz	6.0kHz	30kHz	150kHz
50Hz	250Hz	1.2kHz	7.2kHz	36kHz	180kHz
60Hz	300Hz	1.5kHz	7.5kHz	40kHz	200kHz
72Hz	360Hz	1.8kHz	8.0kHz	45kHz	
75Hz	400Hz	2.0kHz	9.0kHz	50kHz	
80Hz	450Hz	2.4kHz	10kHz	60kHz	

You can set the measurement frequency either in the SETUP menu via FRQ or via FREQ [8] key by means of the knob [6] or the ▲▼◀▶ keys [7]. If the automatic measurement range selection is activated (AUTO [17]) and the impedance exceeds a value of 1000 Ω, a change in the measurement frequency may result in a change in circuit type (serial or parallel). In case of high impedances and a power frequency of 50 Hz/60 Hz, a measurement frequency of 100 Hz/120 Hz may result in an instable measurement value display due to interferences with the power frequency. Therefore, depending on the power frequency, it will be necessary to select a different measurement frequency.

7.1.2 Voltage LEV

The LCR bridge HM8118 generates a sinusoidal measurement AC voltage between 50 mV_{eff} and 1.5 V_{eff} with a resolution of 10 mV_{eff}. You can set the measurement AC voltage either in the SETUP menu via LEV or via LEVEL [9] key by means of the knob [6] or the arrow keys ▲▼◀▶ [7]. You can select the decimal point to be changed via arrow keys. Using the SETUP menu additionally provides you with the option to select the measurement AC voltage by means of the numeric keypad. The amplitude accuracy is ±5%. This voltage is applied to the component through a source resistance. Depending on the impedance of the connected component, the source resistance may automatically be selected in accordance with the following table. The source resistance is dependent on the selected measurement range.

Component Impedance	Source Resistance
10.0µΩ to 3.0Ω	25.0Ω
3.0Ω to 100.0Ω	25.0Ω
100.0Ω to 1.6kΩ	400.0Ω
1.6kΩ to 25.0kΩ	6.4kΩ
25.0kΩ to 2.0MΩ	100.0kΩ
2.0MΩ to 100.0MΩ	100.0kΩ

7.1.3 Preload/ Bias Current BIAS

The constant voltage (CST V function) must be switched on for measurements with bias current or external preload.

To permit a forecast on how a component will behave in the circuit at a later point, you can preset a DC BIAS which corresponds to the subsequent supply voltage (current).

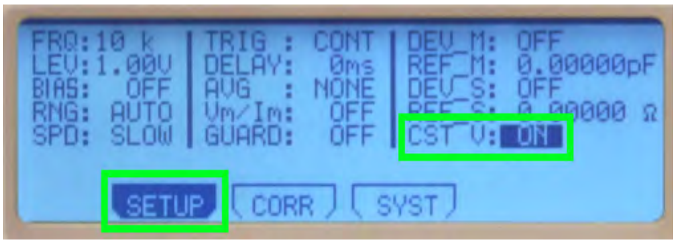


Fig. 7.2: Constant voltage CST_V activated

The BIAS function offers the option to overlap a DC with the AC measurement range voltage. Components such as electrolytic or tantalum capacitors require a positive preload for an accurate measurement. An internal preload of 0 to +5 V_{DC} with a resolution of 10 mV or an external preload of 0 up to +40 V_{DC} / 0.5A through an external power supply (instrument back panel) allow reality-oriented measurements (function C-R / C-D). Additionally, the internal preload helps measurements on semiconductor components.

Is is necessary to unload coils before removing them, i.e.after switching off the bias current, it is required to wait for the coils to discharge before the component is disconnected from the measuring instrument. During the discharge, "Please wait..." is shown in the LCD display. The bias current (BIAS) is only available for the inductance measurement.

For measurements of inductances, (function L-R / L-Q), only an internal bias current is available which can be set from 0 to +200 mA (DC) with a resolution of 1mA. An external bias current is not possible in this case.

Use the BIAS [10] key to select the value for the preload or the bias current. Press the BIAS key again after entering the value to complete the process. You can use the knob [6] and the arrow keys ▲▼◀▶ [7] (decimal point) to select the amount of the preload / bias current. You can activate the internal preload or bias current (BIAS) by pressing the BIAS / ◀— [26] key. If the preload or bias current is activated, the BIAS / ◀— key will be illuminated. By pressing the BIAS / ◀— key again, the preload / bias current will be deactivated and the key will no longer be illuminated.

The error message "DCR too high" indicates that the resistance of the connected DUT is too high for the selected bias current. In this case, the bias current cannot be activated.

Example for internal BIAS preload:

Unipolar capacitators must be connected with the correct polarity, i.e. the positive capacitator pole must be connected to the left contact and the negative pole to the right contact. The preload (BIAS) is only available for the capacity measurement.

In this example, a 1000µF (20V) electrolytic capacitator was measured with a measurement voltage of 5kHz. The C-R mode is activated as function and the BIAS [10] key is used via knob [6] or arrow keys ▲▼◀▶ [7] (decimal point) to select the value for the internal preload. The BIAS / ◀— [26] is used to activate the internal BIAS preload.

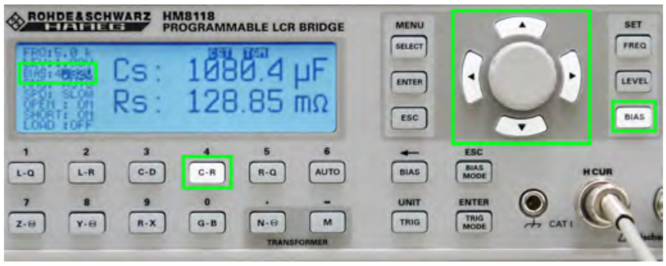


Fig. 7.3: Internal BIAS preload

Example for external BIAS preload:

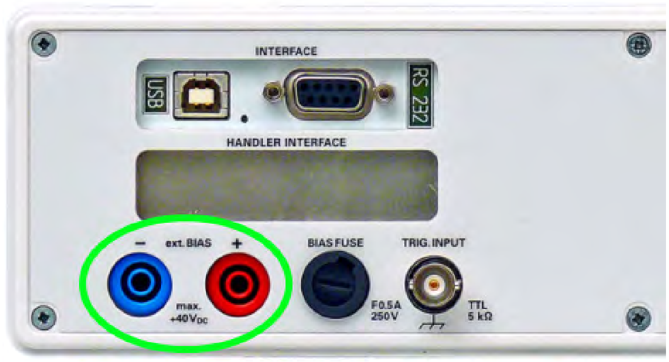


Fig. 7.4: Connectors for external BIAS preload

Contrary to the internal preload, in this example an external DC preload is generated on the HM8118 back panel. Component and measurement mode are identical to the example with the internal preload. The external DC preload is generated for the HM8118 by a power supply unit (here: Hameg HMP2020) in this example. The voltage is applied to the power supply unit at 20V and the current is limited to 250mA.

Fig. 7.5: Activate external BIAS preload

The C-R mode is also activated as function and the BIAS 10 key is used via knob 6 or arrow keys ▲▼◀▶ 7 (decimal point) to select the voltage value. Press the BIAS MODE 24 key to select the EXT (= external) function via knob. Use the BIAS / ⟵ 26 key to activate the external BIAS preload.

Fig. 7.6: Activate external BIAS preload

Example for internal bias current BIAS:

The process for an internal bias current is similar to that for an internal preload. In this case, the L-R or L-Q function is selected and any given inductance is connected to the bridge. Use the BIAS 10 key via knob 6 or the arrow keys ▲▼◀▶ 7 (decimal point) to select the value for the internal bias current. The BIAS / ⟵ 26 key is used to activate the internal BIAS bias current.
Fig. 7.7 shows an example for a typical waveform of a bias current that is adjustable to a maximum value in connection with a connected load.

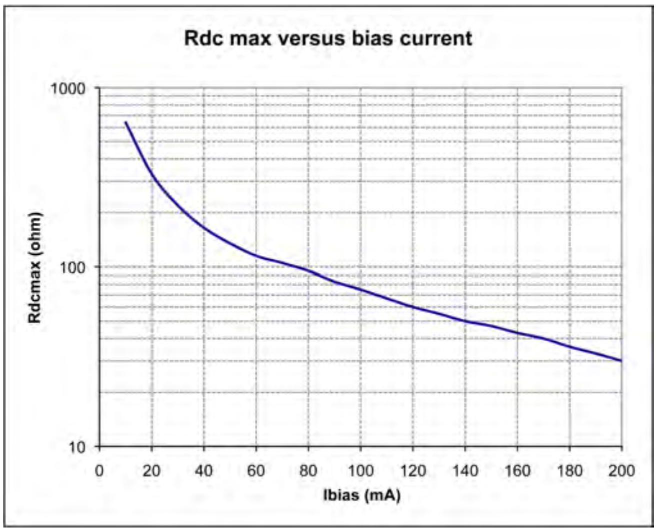


Fig. 7.7: Maximum setting for bias current in connection with the connected load (typical waveform)

7.1.4 Measurement Range RNG

The measurement range can be selected automatically or manually. If the measurement range is changed, the internal measurement circuit (replacement circuit) will be modified and internal relays will be switched. Therefore, a change in the measurement range depends on multiple factors, such as phase angle, impedance, measured value, etc.

The measurement range can be set manually via knob 6 in the range of 3 Ω to 500 kΩ. In the SETUP menu, use the arrow keys ▲▼◀▶ 7 to select the RNG function, press the knob (editing mode) and select the desired measurement range via knob. Press the knob again to confirm the selected value. Use the AUTO/HOLD key to then switch between automatic (AUTO/HOLD key is illuminated) and manual measurement range selection.

If the measuring instrument permanently toggles between two measurement ranges (limit of the automatic measurement range) or if the component to be measured is known, select the manual measurement range selection (see chapter 6).

7.1.5 Measurement Speed SPD

The measurement speed can be set in three increments:
- **SLOW** (slow),
- **MED** (medium)
- **FAST** (fast).

In the SETUP menu, use the arrow keys ▲▼◀▶ 7 to select the SPD function to set the measurement speed, press the knob 6 (editing mode) and select the measurement speed via knob. Press the knob again to confirm the selection.

The number of measurements for a continuous triggering (CONT) is approximately 1.5 per second at the SLOW setting, 8 per second at MED or 14 per second at FAST. The setting is a compromise between measurement accuracy and measurement speed. A low measurement speed (SLOW) implies a higher measurement accuracy, correspondingly a high measurement speed (FAST) implies a low measurement accuracy. For very low measurement frequencies, the measurement speed is automatically reduced.

7.1.6 Triggering TRIG

The trigger source and trigger operating mode can be selected here. The following trigger operating modes and trigger sources are available:

- **CONT** (continuous trigger):
  A new measurement is automatically performed at the end of a previous measurement.
- **MAN** (manual trigger):
  A measurement is performed when the TRIG / UNIT key [27] is pressed. The activated manual trigger function will be marked as TGM on the screen.
- **EXT** (external trigger):
  A measurement is performed when a rising slope is applied to the external trigger input (TTL level +5V). During a measurement, all potential signals at the trigger input will be ignored until the current measurement has been fully completed. If a measurement is triggered, the TRIG key [27] will be illuminated. The activated external trigger function will be marked as TGE on the screen. A single measurement will be performed for each tirggered triggering.

If the measuring instrument shows a blank screen (i.e. lines "- - -") without measurement values, no trigger event / measurement has been triggered or the selected measurement function has been selected incorrectly.

7.1.7 DELAY Function

The DELAY function defines the trigger delay time. It can be set anywhere between 0ms and 40000ms (40s). In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the DELAY function to set the trigger delay time, press the knob [6] (editing mode) and select the desired trigger delay time via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again.

7.1.8 Average Value AVG

When the function AVG Average Value is activated, several individual measurements will be used to form a mean value according to the set period. To determine the number of measurement periods to form the mean value, in the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the AVG function, press the knob [6] (editing mode) and select the desired average by mean. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again. The number of measurement periods for the averaging measurement can be set between 2 and 99 or to MED (medium). The MED (medium) setting is the medium averaging mode. The bridge HM8118 performs 6 consecutive measurements, rejects the lowest and highest measurement values and generates an average based on the four remaining measurements. This type of averaging hides individual erroneous measurements. If the averaging function is activated, the symbol „AVG" will be shown in the display. The averaging function can also be used for a manual or external triggering. However, the number of measurements per triggered triggering will be determined by the set number of averages (periods).

For instance, if a component is integrated in a measurement adapter, the first measurement generally is erroneous and differs greatly from all subsequent measurements. Therefore, the first erroneous measurement is rejected to prevent an erroneous display of measurement values by measuring transient processes.

7.1.9 Display of Test Signal Level V_m (Measurement Voltage) / I_m (Measurement Current):

Use the function V_m/I_m to turn the display for the voltage that is measured at the connected component as well as the display of the measured current that flows through the connected component on (ON) and off (OFF). In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the V_m/I_m function, press the knob (editing mode) and activate or deactivate the function via knob. Press the knob again to confirm the selection.

7.1.10 Guarding GUARD

It the GUARD function is activated, the shield covers for the BNC connectors [20] ... [23] will be connected to an internal generator and supplied with a reproduction of the measurement voltage. Within certain limits, this eliminates the cable capacity which would otherwise result in erroneous capacity measurements. The GUARD function is applied for low voltages.
The following settings options are available:

- **OFF** (off)**:**
  Guarding is not used; the shield cover for the BNC connectors will be connected with ground potential.
- **DRIVE** (controlled):
  The shield cover for the BNC connectors will be connected to the LOW DRIVE potential via internal generator.
- **AUTO** (automatic):
  For frequencies below 100 kHz and for measurement ranges 1 to 4, the external contacts of the BNC connectors are connected with ground potential; for frequencies above 100 kHz and measurement ranges 5 or 6, the external contacts of the BNC connectors are connected with an active protective voltage source (for the potential control).

It is recommended to use the GUARD function if measurement adapters with high capacity (e.g. HZ184) are used. If the DUT exhibits impedances of more than 25kΩ at frequencies of more than 100kHz, is is also recommended to use the GUARD function.

In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the GUARD function, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection.

The HM8118 GUARD function is not comparable to the 4TP function (= Four Terminal Pair) of other measuring instrument manufacturers. For the 4TP function, the measurement current is returned through the test lead shield. The electromagnetic radiation of the supply and return conductor nearly override each other which for the most part resolves the issue of electromagnetic coupling. This does not work for the Kelvin test lead provided with the HM8118, as this is not properly converted (the shields would have to be short-circuited preferably close to the test point). The HM8118 uses a 5 terminal configuration / 5T and does not support the 4TP function.

7.1.11 Deviation DEV_M

You can use the DEV_M function to turn on or off (OFF) the display of the measurement deviation of the main display (Main) in Δ % (percent) or Δ ABS (absolute) as applied to the reference value REF_M. In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the DEV_M function to set the display for the measurement deviation, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection. For more information about the measurement value deviation, see chapter 6.

7.1.12 Reference REF_M

You can use the REF_M function to save the measurement value as a reference value in the reference memory M (Main). You can choose one of the following as unit for the measurement value: H, mH, μH, nH, F, mF, μF, nF, pF, Ω, mΩ, kΩ, MΩ, or S, kS, mS, μS, nS, pS. In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the REF_M function to set the reference value, press the knob [6] (editing mode) and select the desired reference value via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again. As long as this field is activated, you can also use the TRIG key [27] to accept the value of the DUT (= Device Under Test). For more information about the reference value, see chapter 6.

7.1.13 Deviation DEV_S

You can use the DEV_S function to turn on or off (OFF) the display of the secondary value display (Sub) in Δ % (percent) or Δ ABS (absolute) as applied to the reference value REF_S. In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the DEV_S function to set the display for the measurement deviation, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection. For more information about the measurement value deviation, see chapter 6.

7.1.14 Reference REF_S

You can save a measurement value of the dissipation factor or the quality factor (quality) as reference value in the reference memory S. You can choose one of the following as unit for the measurement value: Ω, mΩ, kΩ, MΩ, S, kS, mS, μS, nS, pS or °. In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the REF_M function to set the reference value, press the knob [6] (editing mode) and select the desired reference value via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again. As long as this field is activated, you can also use the TRIG key [27] to accept the value of the DUT (= Device Under Test). For more information about the reference value, see chapter 6.

7.1.15 CONSTANT VOLTAGE CST V

The CST V function allows you to turn the constant voltage (AC) on (ON) or off (OFF). Due to the source resistance, some test require the use of a specific measurement voltage which is not possible with the regular source resistance of the respective measurement range. In the SETUP menu, use the arrow keys ▲▼◀▶ [7] to select the CST V function to activate the constant voltage, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection.

The constant voltage (CST V function) must be switched on for measurements with BIAS bias current or external BIAS preload.

If the constant voltage is activated (ON), the source resistance is preset to 25 Ω. The voltage applied to the component will be nearly constant for all components whose impedance is substantially greater than 25 Ω. If the constant voltage mode is activated for the bridge, the measurement range changes (depending on the impedance of the connected component) to prevent overloading the bridge. However, the accuracy is reduced by the factor of 2 in the constant voltage mode. The following table shows the impedance measurement ranges when the constant voltage mode is activated (CST V ON):

Measurement Range	Source Resistance	Component Impedance
1	25 Ω	10.0 μΩ to 3.0 Ω
2	25 Ω	3.0 Ω to 100.0 Ω
3	25 Ω	100.0 Ω to 1.6 kΩ
4	25 Ω	1.6 kΩ to 25.0 kΩ
5	25 Ω	25.0 kΩ to 2.0 MΩ
6	25 Ω	2.0 MΩ to 100.0 MΩ

The following table shows the change in the impedance ranges when the constant voltage mode is deactivated (CST V OFF):

Measurement Range	Component Impedance
1 to 2	Z > 3.33 Ω
2 to 3	Z > 400.00 Ω
3 to 4	Z > 6.67 kΩ
4 to 5	Z > 100.00 kΩ
5 to 6	Z > 2.22 MΩ
2 to 1	Z < 2.7 Ω
3 to 2	Z < 324.0 Ω
4 to 3	Z < 5.4 kΩ
5 to 4	Z < 81.0 kΩ
6 to 5	Z < 1.8 MΩ

Under certain circumstances, the display shows the label „OVERRANGE". This may occur when the constant voltage mode is activated for the bridge and the manual measurement range selection is activated. To bypass this, change into a higher measurement range or select the automatic measurement range selection.

7.2 CORR Menu

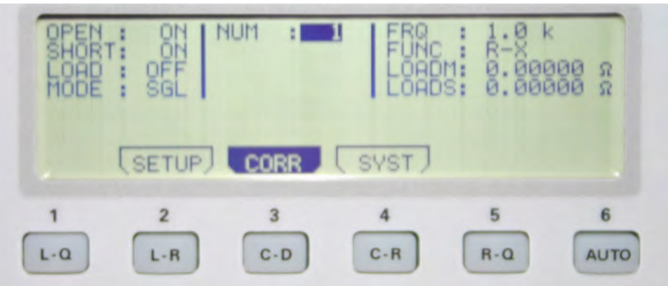


Fig. 7.8: Menu function CORR display

7.2.1 Compensation

It is recommended to perform a compensation prior to the measurement beginning with measurement equipment to prevent measurement errors caused by the system. You can also compensate test leads and other parasitic effects (capacitative impedances) with a compensation. To attain the highest possible measurement accuracy, it is recommended to perform the compensation under the same conditions as the later measurement of the component (for instance, the sequence of the test leads should not be changed after the compensation). Also, the test leads should not be restricted, i.e. no hands or metallic items should be nearby as these could impact the measurement.

The following compensation options can be selected in the CORR menu:

- **OPEN**:
  An open compensation is performed to compensate for parasitic effects (impedances) caused by connections between measurement accessories and component. To perform the open compensation, it is essential to only have the open-end test leads without components connected. The open compensation is possible for impedances greater than 10kΩ.
- **SHORT**:
  A short compensation is performed to compensate for parasitic effects (impedances) caused by connections between measurement accessories and component. To perform the short compensation, it is essential to only have the open-end, short-circuited test leads without components connected. The short compensation is possible for impedances of up to 15Ω and resistances of up to 10Ω.
- **LOAD**:
  A compensation with adjustment (compensation of a known load impedance) is suitable to calibrate measured impedances before the actual measurement. If the load is known, the compensation is entered after selecting the measurement function [28] ... [39] (e.g. L-Q) separate for the main display LOADM (Main) and secondary display LOADS (Sub), and it should be as close as possible to the expected measurement value of the DUT (= Device Under Test). It is possible to compensate known loads for impedances and resistances within the measurement range.

In the CORR menu, use the arrow keys ▲▼◀▶ [7] to select the respective compensation function to perform a compensation, press the knob [6] (editing mode) and select the desired setting (ON/OFF) via knob. Press the knob again to confirm the selection. The MODE function allows you to determine if the OPEN or SHORT compensation should be performed only for the currently selected measurement frequency (SGL) or for all 69 frequency increments (ALL) (available with firmware version 1.35 and higher).

If the corresponding compensation function is activated in the CORR menu (ON) and the frequency levels are selected, the compensation can be started via OPEN [11], SHORT [12] or LOAD [13] key. A compensation of all 69 frequency increments takes approximately 90 seconds. If the compensation was successful, a short signal will sound. If the compensation was unsuccessful, an error message will be shown in the display.

For a compensation with a known load, a value is entered in both reference memories (LOADM and LOADS) (e.g. the value for the expected inductance in LOADM and the expected quality value in LOADS). This only applies to each selected measurement frequency.

7.2.2 NUM

You can use the NUM function to select one of 5 possible load impedances (LOAD). In the CORR menu, use the arrow keys ▲▼◀▶ [7] to select the NUM function to choose the load impedance, press the knob [6] (editing mode) and select the desired load impedance via knob. Press the knob again to confirm the selection.

7.2.3 Measurement Frequency FRQ

You can use the FRQ function to select the measurement frequency of the load impedance (LOAD) between

20Hz and 200kHz. In the CORR menu, use the arrow keys ▲▼◀▶ 7 to select the FRQ function to choose the measurement frequency, press the knob 6 (editing mode) and select the desired measurement frequency via knob. Press the knob again to confirm the selection.

7.2.4 FUNC Function

You can use the FUNC function to select the measurement function for the load impedance LOADM and LOADS. You can choose from the following functions:

Ls-Q,	**Lp-Q,**	**Ls-Rs,**
Lp-Rp,	**Cs-D,**	**Cp-D,**
Cs-Rs,	**Cp-Rp,**	**Rs-Q,**
Rp-Q,	**Z-Θ,**	**Y-Θ,**
R-X	**G-B**	

In the CORR menu, use the arrow keys ▲▼◀▶ 7 to select the FUNC function to choose the measurement function, press the knob 6 (editing mode) and select the desired function via knob. Press the knob again to confirm the selection.

7.2.5 Correction Factors LOADM / LOADS

You can use the LOADM function (main measurement value display) to save a reference value for the load impedance LOAD in the reference memory LOADM. Depending on the parameter FUNC H, you can choose one of the following as unit for the measurement value: mH, µH, nH, F, mF, µF, nF, pF, Ω, mΩ, kΩ, MΩ, or S, kS, mS, µS, nS, pS. In the CORR menu, use the arrow keys ▲▼◀▶ 7 to select the LOADM function to set the reference value, press the knob 6 (editing mode) and select the desired reference value via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again.

The LOADM or LOADS function is not necessary for Hameg accessories. In this case, the regular OPEN /SHORT compensation is sufficient.

You can use the LOADS function (secondary measurement value display) to save a reference value for the load impedance LOAD in the reference memory LOADS. Depending on the parameter FUNC, you can choose one of the following as unit for the measurement value: Ω, mΩ, kΩ, MΩ, S, kS, mS, µS, nS, pS or °. In the CORR menu, use the arrow keys ▲▼◀▶ 7 to select the LOADS function to set the reference value, press the knob 6 (editing mode) and select the desired reference value via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again.

For a compensation with adjustment, a value is entered in both reference memories (LOADM and LOADS) (e.g. for a real resistance for LOADM the resistance value and the value "0" for LOADS).

You can use the parameters LOADM and LOADS if it is difficult to align a connect measurement adapter or if it is connected to the bridge via long test leads. In this case, a complete open or short circuit compensation is not possible because the bridge cannot compensate the actual equivalent circuit diagram of the measurement adapter with a simple equivalent circuit. This places the bridge in a state that cannot be compensated. The user can compensate the measurement error by means of a known impedance with a given frequency.

If the compensation with a known load (LOAD) is activated, the bridge corrects the measurement value of the connected impedance in relation to three impedances:
- Short circuit impedance,
- Idle time impedance
- Load impedance

It is possible to use up to 5 different reference values for the load impedance which can be selected by means of NUM parameter. An impedance always corresponds to a group of parameters: a number, a frequency, a function and naturally the known parameters of the impedance.

After the compensation with adjustment (LOAD), the impedance is connected to the measured impedance to measure with the load impedance correction. Correcting with a load impedance is most effective if the load impedance is near the measured impedance. If the compensation with adjustment (LOAD) is switched on (parameter LOAD set to „ON"), the load impedance correction is automatically activated when the set measurement frequency is equal to the measurement frequency of the load impedance LOAD which is saved for the load impedance corrections within the 5 parameter groups. Therefore, it is important that the 5 parameter groups have different frequencies for the load impedance correction.

7.3 Menu Function SYST

Fig. 7.9: Menu function SYST display

7.3.1 CONTRAST Function

You can use the CONTRAST function to set the display contrast from 35 to 55. In the SYST menu, use the arrow keys ▲▼◀▶ [7] to select the CONTRAST function to choose the screen contrast, press the knob [6] (editing mode) and select the desired contrast setting via knob. By pressing the knob again, you can activate the manual value input via numeric keypad. A value input window will be opened. You can use the numeric keys to enter a value. After entering the value via keypad, confirm the entry by pressing the ENTER key or by pressing the knob again.

7.3.2 Acoustic key signal KEY BEEP

The KEY BEEP function allows you to turn the key beep on (ON) or off (OFF). In the SYST menu, use the arrow keys ▲▼◀▶ [7] to select the KEY BEEP function to activate or deactivate the key beep, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection.

7.3.3 TALK ONLY

The TALK ONLY function allows you to activate (ON) or deactivate (OFF) the „Talk Only" interface mode. In the SYST menu, use the arrow keys ▲▼◀▶ [7] to select the TALK ONLY function to activate or deactivate the „Talk only" mode, press the knob [6] (editing mode) and select the desired setting via knob. Press the knob again to confirm the selection. The interface can only send, not respond, when TALK ONLY is activated.

7.3.4 Data Transfer Speed BAUDS

The BAUDS function shows the data transfer speed of the serial RS-232 interface. The baud rate is not variable and is 9600 bit/s.

7.3.5 Line Frequency MAINS FRQ

The MAINS FRQ function allows you to select the existing line frequency of 50 Hz or 60 Hz for the internal frequency suppression. In the SYST menu, use the arrow keys ▲▼◀▶ [7] to select the MAINS FRQ function to choose the line frequency, press the knob [6] (editing mode) and select the desired line frequency (50Hz / 60Hz) via knob. Press the knob again to confirm the selection.

7.3.6 Instrument Information INFO

The INFO function shows information about the firmware version, the FPGA hardware version and the compensation date as well as the bridge serial number. To select the menu item, use the arrow keys in the SYST menu ▲▼◀▶ [7] to select the INFO function.

7.4 Saving / Loading of Settings

By pressing the RECALL/STORE key [41], you can load the current measuring instrument parameters (settings) from memory spaces 0 to 8, or alternatively, store them to memory spaces 0 to 8. If the memory space 9 is selected, the factory settings will be loaded (reset). However, this will not impact the stored parameters in the memory spaces 0 to 8. After the measuring instrument has been switched on, the parameters will be loaded from memory space 0. Repetitively press the RECALL/STORE key [41] to toggle between storing and loading measuring instrument parameters. Use ESC or press the RECALL/STORE key [41] again to close the menu.

7.5 Factory Settings

Frequency FRQ	1.0 kHz
Level LEV	1.00 V
Preload BIAS	OFF
Measurement range RNG	AUTO
Measurement speed SPD	SLOW
NUM	1
FUNC	AUTO
Compensation OPEN	ON
Compensation SHORT	ON
Compensation LOAD	OFF
Triggering TRIG	CONT
Delay DELAY	0ms
Average AVG	1
Voltage / current Vm/Im	OFF
Guarding GUARD	OFF
Deviation DEV_M	OFF
Reference REF_M	0.00000 H / mH / µH / nH / F mF / µF / nF / pF / Ω / mΩ kΩ / MΩ / S / kS / mS / µS / nS / pS
Deviation DEV_S	OFF
Reference REF_S	0.00000 Ω / mΩ / kΩ / MΩ / S kS / mS / µS / nS / pS / °
Constant voltage CST V	OFF
NUM	1
Function FUNC	AUTO
Reference LOADM	0.00000 Ω
Reference LOADS	0.00000 Ω
Contrast CONTRAST	49 (dependent on the LCD)
Key beep KEY BEEP	ON
TALK ONLY	OFF
Baud rate BAUDS	9600
MAINS FRQ	50 Hz

8 Measuring Equipment

Measuring components requires the use of suitable measurement adapters. This will be connected firmly with the LCR HM8118 via the four front panel BNC connectors:

- **H_{Pot}** (High Potential)
- **H_{Cur}** (High Current)
- **L_{Pot}** (Low Potential)
- **L_{Cur}** (Low Current)

Fig. 8.1: Front panel BNC connectors

For measurements of wired components, it is recommended to use the test adapter HZ181 whereas for SMD components, it is recommended to use the test adapter HZ188 that is included in delivery.

It is essential to discharge all components before connecting them. Do not apply external voltages to the measurement inputs (BNC sockets on the instrument front panel). During a measurement, do not touch the component directly with hands or indirectly with objects as this may distort the measurement results. Always remove measurement accessories, such as test adapter for component measurements, by pulling it forward.

For precision measurements, it is recommended to use measurement adapters for 4-wire measurements. A 2-wire measurement is not as accurate as a 4-wire measurement. It is possible to minimize parasitic impedances by using the appropriate measurement adapter. To maximize the accuracy, it is recommended to perform an OPEN/SHORT/LOAD compensation following each change to the measurement configuration. This is also recommended for any change to the measurement frequency. Alternatively, you can use test leads instead of a measurement adapter. The component to be measured can be connected to the LCR bridge HM8118 by means of a suitable test lead. The test lead will be connected with the bridge via the four front panel BNC connectors. Please also note here that a 2-wire measurement is not as accurate as a 4-wire measurement. Since any cable is likely to see individual losses which ultimately distorts the original measurement result due to inductive and capacitive properties (especially due to the length), it is recommended to measure a component with Hameg HM8118 accessories.

Connecting a conventional coaxial cable is not recommended since the measurement result may be modified by other cable types, changed cable length etc. Additionally, due to the OPEN or SHORT calibration, the bridge cannot fully compensate such impacts.

8.1 4-Wire Test Adapter HZ181 (Including Short Circuit Board)

Fig. 8.2: 4-wire test adapter HZ181

The 4-wire test adapter (including the short circuit board) is used to qualify wired components. The measurement adapter converts the configuration of a 4-wire measurement to a 2-wire measurement. The measurement adapter is directly connected to the front panel BNC connectors via the four front panel BNC sockets of the LCR bridge HM8118. Insert the component to be measured with its connection wires in the two provided contact slots (measurement contacts). The following figure shows the connection of this test adapter. This equipment is optional and not included in delivery.

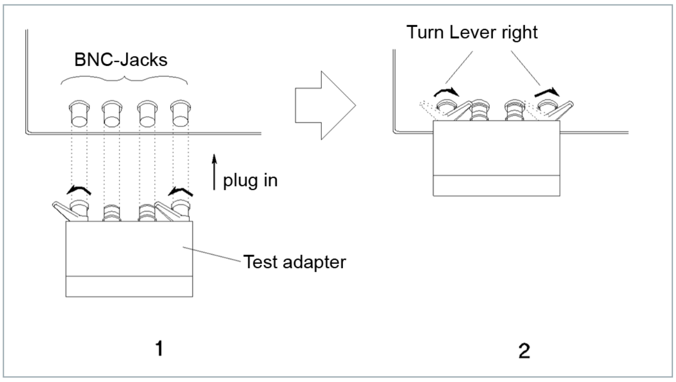


Fig. 8.3: Connecting a measurement adapter

Technical Data HZ181	
Function:	Measurement adapter to operate (via 4-wire connection) with LCR bridge HM8118
Measurable components:	Resistances, coils or capacitators with axial or radial connecting wires
Frequency range:	20 Hz to 200 kHz
Maximum voltage:	± 40 V maximum value (AC+DC)
Connectors:	BNC sockets (4), measurement contacts (2)
Safety standards:	EN61010-1; IEC61010-1; EN61010-031; IEC61010-031
Environmental conditions:	Contamination Class 2, internal use
Operating temperature:	+5 °C ... +40 °C
Temperature limits:	–20 °C … +70 °C
Weight:	approximately 200 g

8.1.1 Compensation HZ181

Due to its design, the measurement adapter HZ181 has a fringing capacitance, a residual inductance and a residual resistance which impacts the accuracy of the measured values. To minimize these impacts, the compensation of impedance errors caused by adapters and leads becomes necessary.

For frequency dependent components, make sure to perform an OPEN and SHORT compensation for each of the 69 test frequencies.

To compensate or eliminate this measurement error, it is recommended to perform an open and short compensation (OPEN/SHORT compensation) with the LCR bridge HM8118. For the open compensation, the measurement adapter is connected without component. For the short compensation, insert the enclosed short circuit board into the two adapter contact slots (measurement contacts). The compensation values that are measured during the compensation process will be stored in the memory of the LCR bridge HM8118 and are valid until another compensation is performed. If any changes to the measurement setup are implemented, it becomes necessary to perform a new compensation. For more information about the OPEN/SHORT compensation, see chapter 7.2.

8.2 Kelvin-Test Lead HZ184

Fig. 8.4: Kelvin test lead HZ184

The Kelvin test lead with Kelvin clamps allows for the 4-wire measurement of components that could otherwise not be tested by means of conventional test adapters (for instance, due to their size). The test lead is directly connected to the front panel BNC connectors via the four front panel BNC sockets of the LCR bridge HM8118. The leads of the red clamp are connected to H_{CUR} and H_{POT}, the leads of the black clamp to L_{POT} and L_{CUR}. This equipment is included in delivery.

Technical Data HZ184	
Function:	Kelvin test lead to operate (via 4-wire connection) with LCR bridge HM8118
Measurable components:	Resistances, coils or capacitators
Frequency range:	20 Hz to 200 kHz
Test lead length	approximately 35 cm
Connectors	BNC sockets (4), clamps (2)
Safety standards:	EN61010-1; IEC61010-1; EN61010-031; IEC61010-031
Environmental conditions:	Contamination Class 2, internal use
Operating temperature:	+5 °C to +40 °C
Temperature limits:	-20 °C to +70 °C
Weight:	approximately 170 g

8.2.1 Compensation HZ184

Due to their design, the test lead HZ184 and the terminal clamps have a fringing capacitance, a residual inductance and a residual resistance which impacts the accuracy of the measured values. To minimize these impacts, the compensation of impedance errors caused by adapters and leads becomes necessary.

For frequency dependent components, make sure to perform an OPEN and SHORT compensation for each of the 69 test frequencies.

To compensate or eliminate this measurement error, it is recommended to perform an open and short compensation (OPEN/SHORT compensation) with the LCR bridge HM8118. For the open compensation, the test lead without component and without the measurement clamps are attached without being connected to each other (separate arrangement).

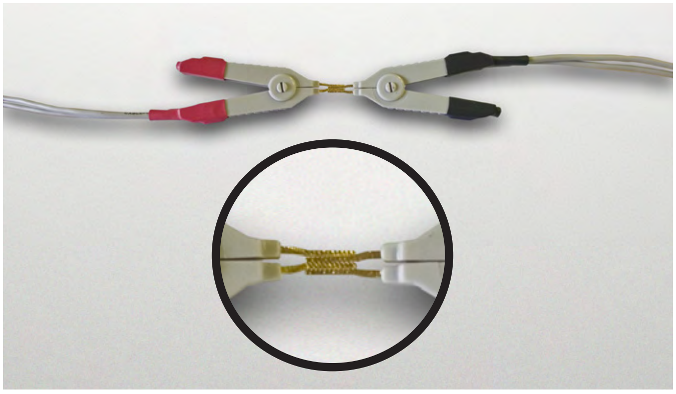


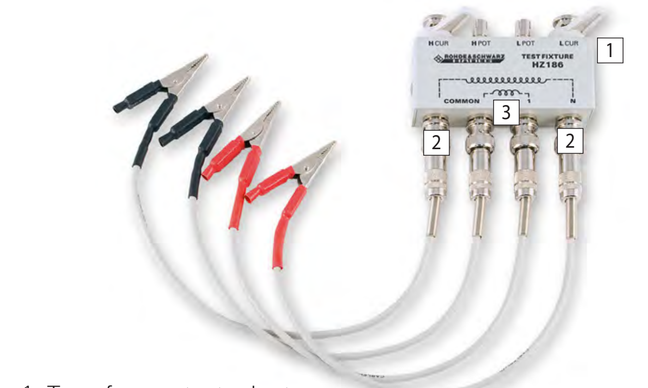
Fig. 8.5: Short compensation HZ184

For the short compensation, the two connecting clamps are connected to each other. The compensation values that are measured during the compensation process will be stored in the memory of the LCR bridge HM8118 and are valid until another compensation is performed. If any changes to the measurement setup are implemented, it becomes necessary to perform a new compensation. For more information about the OPEN/SHORT compensation, see chapter 7.2.

8.3 4-wire Transformer Test Lead HZ186

Fig. 8.6: Connecting the measurement adapter to the LCR bridge

The measurement adapter HZ186 is designed for measurements of transformers or transmitters in combination with transformer measurement functions of the LCR bridge HM8118. The measurement adapter is directly connected to the front panel BNC connectors of the LCR bridge via the four BNC sockets.



1 Transformer test adapter
2 Test lead for high number of windings
3 Test lead for low number of windings

Fig. 8.7: 4-wire transformer test lead

In case of a faulty measurement, the LCR bridge does not display any value for N.

The 4-wire transformer test lead is a convenient tool to measure the mutual inductance (M), the transformer ratio (N) and the phase difference Θ in a frequency range between 20Hz and 200kHz of a transformer or transmitter. The measurement adapter serves as interface between the LCR bridge and the four included test leads. For the measurement, the transformer / transmitter to be measured is connected to the measurement adapter via test lead, according to the imprinted wiring on the primary and the secondary side. This equipment is optional and is not included in delivery.

Technical Data HZ186	
Function:	Measurement adapter to operate (via 4-wire connection) with LCR bridge HM8118
Measurable components:	Transformers, transmitters
Measurable parameters:	Mutual inductance M (1 µH...100 H), Transformer ratio N (0,95...500), phase difference φ between primary and secondary winding (-180° to +180°)
Frequency range:	20 Hz to 200 kHz
Test lead length:	approximately 35 cm
Connectors:	BNC sockets (4), BNC connectors (4)
Safety standards:	EN61010-1; IEC61010-1; EN61010-031; IEC61010-031
Environmental conditions:	Contamination Class 2, internal use
Operating temperature:	+5° C to +40 °C
Storage temperature:	-20 °C to +70 °C
Weight:	approximately 240 g

8.3.1 Compensation HZ186

Due to their design, the test lead HZ186 and the connected test leads have a fringing capacitance, self inductance and self-resistance which impacts the accuracy of the measured values. To minimize these impacts, the compensation of impedance errors caused by adapters and leads becomes necessary.

For frequency dependent components, make sure to perform an OPEN and SHORT compensation for each of the 69 test frequencies.

To compensate or eliminate this measurement error, it is recommended to perform an open and short compensation (OPEN/SHORT compensation) with the LCR bridge HM8118. For the open compensation, the four test leads are connected to the measurement adapter HZ186. Before starting the open compensation, the two black test leads (which are connected to the „COMMON" BNC connectors) are connected. It is also necessary to connect the two red test leads that are connected to the BNC connectors „N" and „1".

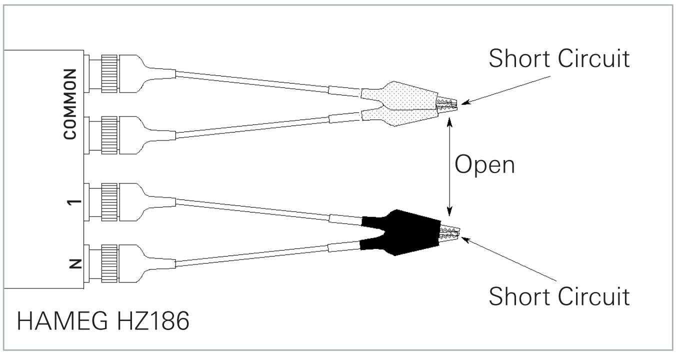


Fig. 8.8: OPEN / SHORT calibration with HZ186

For the short compensation, the two red test leads and the two black test leads are connected to each other.

8.3.2 Transformer Measurement

The measurement of a transformer can always result in varying measurement results. This is related both to the iron core losses as well as to the unknown state of the premagnetized core. The component to be measured is dependent on the frequency as well as on the applied measurement voltage. The measuring instrument determines the values for L, R and C by measuring the impedance and the related phase angle. The angle determines an inductive, capacitive or real value (L,C,R). Consequently, the amount of the impedance increases as the voltage increases, and the phase angle is heavily dependent on the measurement frequency (due to change in magnetization and iron core loss and visible in the „Z-Theta" mode [7]). If a transformer is measured as „open", the measurement values are plausible. However, if the secondary side is short-circuited, it is only possible to measure considerably fewer measurement values. The values in case of a short-circuited secondary page correspond nearly precisely to the core losses.

8.3.3 Mutual Inductance

To measure the mutual inductance, the HM8118 applies the same procedure as for the regular inductance. Instead of measuring the voltage via primary winding, the voltage will be measured at the secondary transformer winding.

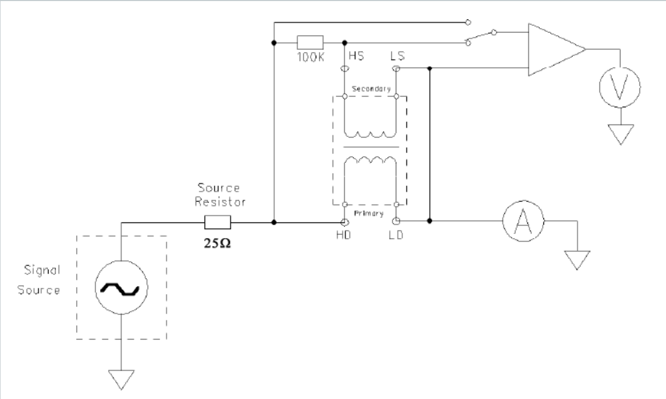


Fig. 8.9: Measuring the mutual inductance

The HM8118 calculates a „virtual" impedance $\mathbf{Z = V_S / I_P}$. V_S is the secondary voltage, I_P is the primary current (all complex values). The mutual inductance is calculated using the mutual inductance definition:

$$V_S = R_S * I_S + L_S\, dI_S/dt + M\, dI_P/dt$$

If no current is applied to the secondary winding ($I_S = 0$), the following is true:

$V_S = M\, dIp/dt$ or $M = Im\{Z\}/w$.

In this case, the value for M can also be negative. It is possible to use a BIAS current if necessary. However, BIAS is not used to improve the accuracy. Some coils may be subjected to a strong bias current BIAS. In this case, the measurement must be performed under the same conditions as they are to be used for the circuit.

8.3.4 Determining the Leakage Inductance

The short circuit principle is applied to determine the leakage inductance for the HM8118 bridge. The wiring to determine the leakage inductance does not differ from a conventional inductance measurement. The component / transformer is connected to the instrument via BNC connectors on the HM8118 instrument front panel. The HZ186 is not mandatory for this purpose. You can also use the included standard cable which is suitable for inductance measurements.
Before determining the leakage inductance, it is re-

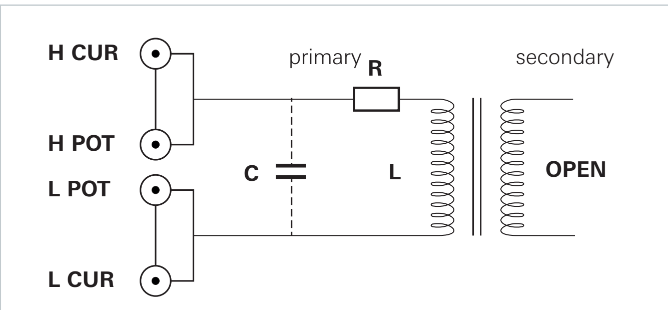


Fig. 8.10: Primary inductance measurement

commended to first perform a conventional inductance measurement of the primary transformer winding. In this case, the secondary side remains open (see fig. 8.10).

Contrary to a conventional inductance measurement, determining the leakage inductance requires the secondary transformer side to be short-circuited (see fig. 8.11). If the secondary side is short-circuited, the measured values of the primary side correspond to the leakage inductance.

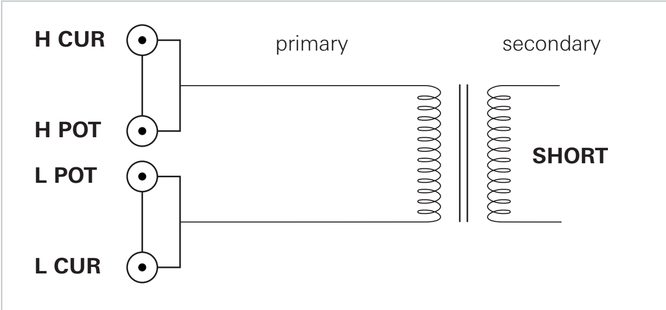


Abb. 8.11: Leakage inductance measurement

8.4 4-Wire SMD Test Adapter HZ188

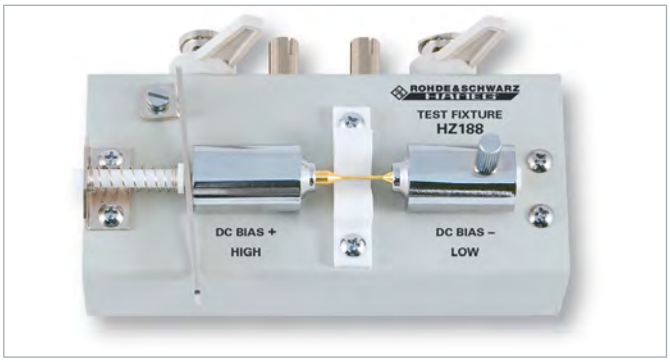


Fig. 8.12: 4-wire-SMD test adapter HZ188

The SMD test adapter HZ188 is suitable to qualify SMD components. The test adapter converts the configuration of a 4-wire measurement to a 2-wire measurement. Due to its net weight, it is recommended to mount the measurement adapter and bridge to a flat surface (e.g. a table). The test adapter is directly connected to the front panel BNC connectors of the bridge via the four BNC sockets. For the measurement, insert the SMD component to be measured with its connectors between the two provided contact pins (measurement contacts). This equipment is included in delivery.

8.4.1 Compensation HZ188

Technical Data HZ188	
Function:	Test adapter to operate (via 4-wire connection) with LCR bridge HM8118
Measurable components:	SMD resistances, coils or capacitators
Frequency range:	20 Hz to 200 kHz
Maximum voltage:	± 40 V maximum value (AC+DC)
Connectors:	BNC sockets (4), measurement contacts (2)
Safety standards:	EN61010-1; IEC61010-1; EN61010-031; IEC61010-031
Environmental conditions:	Contamination Class 2, internal use
Operating temperature:	+5 °C to +40 °C
Temperature limits:	-20 °C to +70 °C
Weight:	approximately 300 g

Due to its design, the measurement adapter HZ188 has a fringing capacitance, a residual inductance and a residual resistance which impact the accuracy of the measured values. To minimize these impacts, the compensation of impedance errors caused by adapters becomes necessary.

For frequency dependent components, make sure to perform an OPEN and SHORT compensation for each of the 69 test frequencies.

To compensate or eliminate this measurement error, it is recommended to perform an open and short compensation (OPEN/SHORT compensation) with the LCR bridge HM8118. For the open compensation, for the test adapter HZ188 you must loosen the screw on the right side counterclockwise and then push the right contact pin to the right until both contact pins are electrically open. The resulting gap between the contact pins must correspond to the dimensions of the SMD component to be measured. Fixate the right contact pin by turning the screw clockwise.

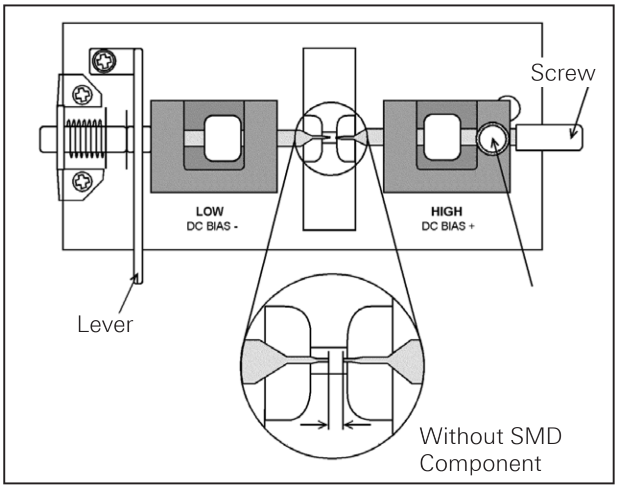


Fig. 8.13: Open compensation with HZ188

For the short compensation, for the test adapter HZ188 you must loosen the screw on the right side counterclockwise and then push the right contact pin to the left until both contact pins are electrically connected. Fixate the right contact pin by turning the screw counterclockwise.

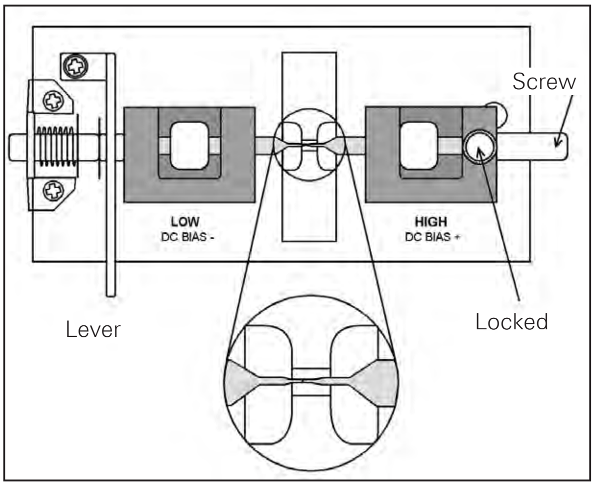


Fig. 8.14: Short compensation with HZ188

The compensation values that are measured during the compensation process will be stored in the memory of the LCR bridge HM8118 and are valid until another compensation is performed. If any changes to the measurement setup are implemented, it becomes necessary to perform a new compensation. For more information about the OPEN/SHORT compensation, see chapter 7.2.

The test adapter HZ188 allows SMD components of up to a size of 0603 to 1812 (in inches) to be tested. This corresponds to a size of approximately 1.6mm to 4.5mm.

8.5 Sorting Components with Option HO118 Binning Interface

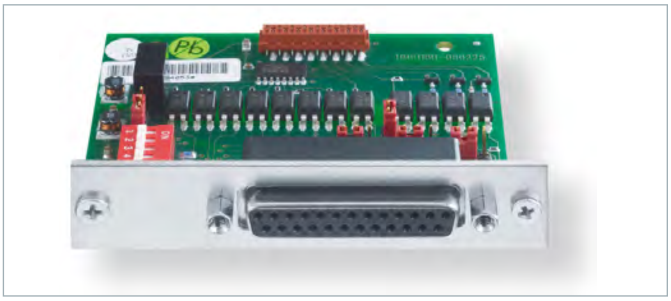


Fig. 8.15: Optional equipment HO118 (binning interface)

A binning interface (25 pol. interface) is particularly useful for a production environment:

- To test incoming components, e.g. for incoming goods,
- To select components by limit,
- To test multiple components with similar values

We recommended the factory-installed option HO118. Otherwise, it becomes necessary to open the instrument which would break the warranty seal which in turn would void the warranty.

The HO118 binning interface enables the use with external hardware which sorts components by physical type after the HM8118 measurement. Data lines for eight sorting containers and control lines are intended (ALARM, INDEX, EOM,TRIG).

8.5.1 HO118 Circuit

The HM8118 with integrated HO118 binning interface is always delivered in a condition that allows for an external power supply to be connected. Specifically, this means that jumper J1 is on position 2-3, jumper J3 on position 1-2 and the DIP switch set to „OFF". These settings deactivate the internal pull-ups.

The following conditions must be be met to operate the binning interface:

- Use external pull-ups.
- Provide external power supply between 5V and 40V.

The circuit is „active low", i.e.the voltage drops to 0V as soon as the criterion for the respective BIN (set in the instrument) is met. The function of the binning interface can

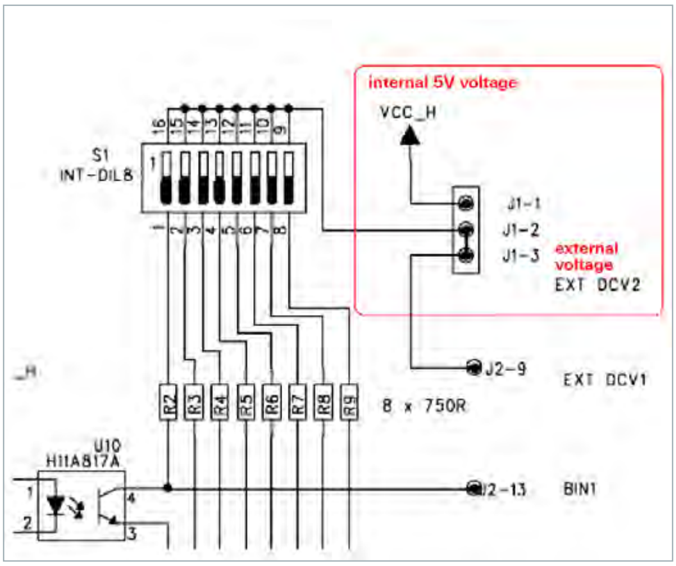


Fig. 8.16: HO118 internal circuitry

be tested by connecting a simple, passive component (e.g. 1kOhm resistance) to the instrument. In the BIN menu, set a generous pass/fail criterion and measure the voltage of PIN 25 (BIN2 on the circuit, BIN1 in the instrument) for the 25-pole plug to PIN 1 (GND). In case of „Pass", the voltage should be 0V, in the case of „Fail", it should correspond to the external voltage which must be applied to PIN 9.

For detailed information on the binning interface in the context of the PIN and jumper assignment, refer to the HO118 manual at www.hameg.com.

8.5.2 HO118 Description

BIN	Type	Description
0...5	Pass BIN	This sorting bin is used if the measured value is within the user-defined bin limit. If the measured value is within this limit, it will be assigned to bin 0 (BIN 0). Outside the limit that is defined for bin 0, the assignment within the limit for bin 1 (BIN 1) is performed. This process is repeated until the limit for bin 5 (BIN 5) is exceeded. If the measured value exceeds the defined range limits for bins 1 to 5, it will be assigned to the General-Failure bin.
6	Secondary Parameter Failure BIN	This sorting bin is used if the primary value is within the range for the sorting bins 0 ... 5 and only the secondary parameters exceed the limit for sorting bin 6.
7	General Fai-lure BIN	This sorting bin output is activated if the sorting does not apply to one of the first 7 bins.

The Store/Recall feature enables you to determine a maximum of 9 binning configurations. Binning configurations can also be operated via remote control interface. The bridge HM8118 can sort components in up to 8 separate bins: six pass sorting bins, one secondary parameter sorting bin and one general sorting bin for errors. At any given time, only one sorting bin (BIN) is activated.

Output signal:
Negative TRUE, open collector, opto-isolated, selectable pull-ups.

Measurement types:
Since the HM8118 is used for classification, the number of measurement types is limited to the modes needed for the characterization of components.
- R-Q: Resistance value and quality
- C-D: Capacitance value and loss angle
- L-Q: Inductance and quality

Sorting bins (BINs):
- Pass bin: Bin 0...5 for primary parameters
- Fail bin: Bin 6 for secondary parameters, bin 7 for general errors (General Failure BIN).
- Maximum current for an output voltage of 1 V is 15 mA.

Index:
Analog measurement completed.

Measurement completed:
Complete measurement completed.

Alarm:
Notification about a known bug.

External trigger:
Opto-isolated, selectable pull-up, pulse width >10µs.

8.5.3 Sorting Bin Preferences (BINs)

The HM8118 must be in manual mode. Select the respective function of the parameter to be sorted. As mentioned in the section „Measurement Types", all functions can be used. To be able to enter binning parameters, press the MENU key and select the option BIN. A binning interfact must be integrated to be able to access the binning menu.

Example:	Binning:	ON
	BIN Number:	0
	BIN:	Open
	Nominal:	100.0
	Low limit:	-4.0%
	High limit:	+5.0%

Binning ON/OFF:
- ON: Binning function activated
- OFF: Binning function deactivated

BIN Number:
- Selecting the BIN number
- Bins 0 to 5 correspond to the primary pass bins
- Bin 6 corresponds to the secondary parameter failure bin
- Bin 7 (General Failure BIN 7) does not have a menu entry.

BIN OPEN or CLOSED:
- OPEN: The respective BIN is activated.
- CLOSED: The respective BIN is deactivated.
- At least the first bin must be activated.

Nominal value of the classification:
- Enter the nominal value with the number keys and confirm with the Enter key.
- The new value and the associated units will be displayed. A nominal value for bin 6 is not applicable.

LOW LIMIT (as a percentage of Low Limit):
- The bin 6 does not have a relative limit but an absolute limit instead.

HIGH LIMIT (as a percentage of High Limit):
- Automatically, the low limit is set symmetrically.
- If an asymmetrical low limit is required, you must first define the high limit , followed by the low limit.
- For the symmetrical limits, only the high limit value must be selected. The low limit acts as the counterpart to the upper limit.

8.5.4 Binning Example

PASS/FAIL for a resistance (1 kΩ ±1%, Q < 0.0001)

1. Select RQ to measure the resistance in the automatic range selection mode.
2. Press AUTO/HOLD to freeze the range. Press MENU and BIN. Activate the binning function now (Binning Feature).
3. Enter the nominal value (1.000 k) and 1.0 as high limit value for bin 0. The negative limit will automatically be set to -1%. Press BIN.
4. Select BIN 6 and enter the range limit (0.0001). Open the bin (BIN).

Make sure that no other bins are open.
- Partial measurements within the defined range will be moved to bin 0 (Pass BIN).
- Partial measurements that do not correspond to the primary parameters will be moved to bin 7 (General-Failure BIN).
- Partial measurements that do not correspond to the secondary parameters will be moved to bin 6 (Secondary Parameter Failure BIN).

Control lines for the output are included in the binning interface to receive information about the classification of the measured components and to allow status requests for the bridge. A trigger input exists to start the measurement process. The interface includes 8 control lines for process sorting bins, sorting bin for failures, general sorting bin for failures, active measurement and sorting bin data. The interface control lines are open collector outputs and are voltage proof for up to 40 volts. The trigger input responds to TTL level and triggers with falling slopes. It is protected against voltages of up to ±15 volts.

For more information on the binning interface in the context of the PIN and jumper assignment, refer to the HO118 manual at www.hameg.com.

9 Remote Control

By default, the LCR bridge HM8118 includes a galvanically isolated RS-232 and USB interface (HO820). The instrument can optionally be fitted with a GPIB interface (HO880) at the factory.

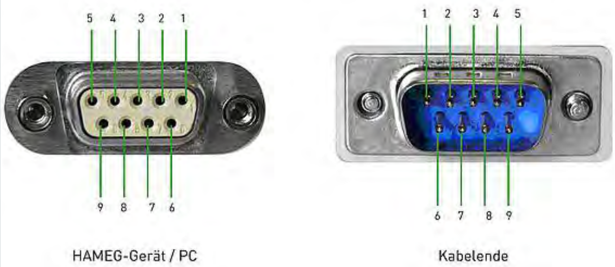
We recommend the installation of or an upgrade to a HO820 / HO880 installation via factory installation or the Hameg service since the measuring instrument has to be opened and the warranty seal must be broken.

All data and signal cables of the instruments galvanically isolated by mass.

9.1 RS-232

The RS-232 interface is built with a 9-pin D-SUB connector. This bidirectional interface allows measuring instrument parameters to be sent from an external instrument (DTE, e.g. a PC with measurement software) to the HM8118 bridge (DCE), or to be read by the external instrument. It is also possible to send commands and read measurement data via this interface. Please find an overview of available commands in chapter "Command Reference“. It is possible to establish a direct connection from the PC (serial port) to the RS-232 interface of the HM8118 bridge via 9-pin shielded cable (1:1 wired). Only shielded cables that do not exceed a maximum length of 3m may be used.

RS-232 Pin Assignment (9 Pin)



2 Tx Data (data from HAMEG instrument to PC)
3 Rx Data (data from PC to HAMEG instrument)
7 CTS Clear to Send
8 RTS Request to Send
5 Ground (reference potential connected to the conductor via HAMEG instrument
(safety class 1) and power cord

Fig. 9.1: Pin assignment RS-232

The baud rate is set to 9600 baud and cannot be modified. The maximum voltage variation at the TX, RX, RTS and CTS connections is ±12 volts.
The RS-232 standard parameters for the interface are as follows:
- **8-N-1** (8 data bits, no parity bit, 1 stop bit)
- RTS/CTS hardware protocol: None.

9.2 USB / VCP

The interface includes a type B connector. To establish a direct connection with a host controller or an indirect connection via USB hub requires a USB cable with a type B socket on the one end and a type A socket on the other end. It is not necessary to configure the measuring instrument.

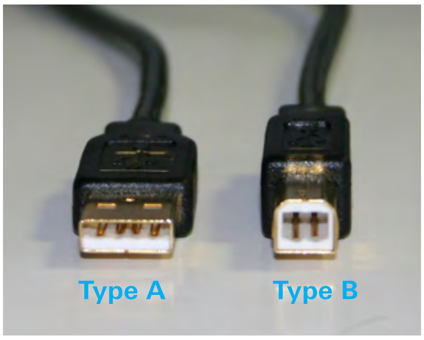


Fig. 9.2: Type A and type B of the USB interface

The HO820 driver ZIP file contains a native USB and a virtual COM port driver. The traditional version of the VCP (virtual COM port) allows the user to communicate with the measuring instrument using any terminal program via remote commands once the corresponding Windows drivers have been installed. The latest USB (VCP driver can be downloaded from the Hameg website www.hameg.com and unpacked into an appropriate directory. If you do not have a driver for the HM8118 bridge installed on the PC, the operation system issues the message "New hardware found" once the connection between the bridge and the PC has been established. Additionally, the Found New Hardware Wizard will be displayed. Installing the USB driver is only necessary if this occurs. For more information on the USB (VCP) driver installation, please read the installation guide within the driver file.

9.3 IEEE-488 (GPIB)

The HO820 USB driver can only be installed on the PC if the following minimum requirements are met:

1. **A measuring instrument with integrated HO820 interface.**
2. **A PC with operating system Windows XP™, VISTA™, Windows 7™, Windows 8™ or Windows 10™ (32 or 64Bit).**
3. **Administrator rights are imperative for the driver installation. If an error message or a write error are displayed it typically means the required rights have not been assigned for the driver installation. If this is the case, please contact your IT department to obtain the necessary rights.**

The GPIB address is set at the GPIB interface on the instrument back panel and is connected to the PC with a GPIB cable. The cable establishes a connection to a IEEE-488 controller (control unit of a IEEE-488 bus system). Any PC equipped with the corresponding plug-in card can function as IEEE-488 controller. If a IEC-625 cable must be used, an appropriate plug-in adapter is required.

The HO880 interface works in the Device mode, i.e. commands are received by the controller and transmitted to the measuring instrument, and signal data is sent to the controller if applicable. It is only possible to select settings

The optional IEEE 488 interface (GPIB) can only be factory-fitted as it is necessary for this purpose to open the instrument and break the guarantee seal.

prior to starting the instrument. Once operation has started, it is no longer possible to do so. Technical data as well as how to address the interface is described in the manual of the HO880 interface (on the CD included in delivery or at our website www.hameg.com).

We recommend using a National Instruments Adapter (NI-USB-GPIB HS) as GPIB-USB adapter.

10 Command Reference

The REMOTE/LOCAL key is illuminated if communication to the instrument has been established via interface (Remote Control). To return to the local operating mode (Local Control), press the REMOTE/LOCAL key, provided that the instrument has not been locked out from local operation via interface (Local lockout). If local operation is locked, the instrument cannot be operated via front panel keys.

No remote PC software is available for the HM8118 bridge. The supported commands can be embedded in any software environment that is able to send ASCII characters.

10.1 Setting Up the Command Structure

A syntax with four letters in a command string specifies a command. The remaining command string consists of parameters (variables). Multiple parameters in a command string are separated by a comma. Parameters in brackets **{}** can optionally be used or queried whereas parameters that are not in brackets are requested or queried. Commands that can be queried include a question mark in parentheses **(?)** following the syntax. Commands that can only be queried include a question mark **?** following the syntax. Do not send **()** or **{}** as part of a command. Certain variables must be expressed as integers and others as floating point or exponentially. Normally, the variables **i** and **j** are integers whereas the variable **x** is a real number.

To prevent communication errors, it is recommended to avoid command strings. Each remote command ends with CR (carriage return) or CR+LF (carriage return + line feed) (no individual LF).

10.2 Supported Command and Data Formats

The HM8118 bridge does not support parallel processing of commands.

***IDN?**
The query *IDN? queries the bridge HM8118 identification string. The queried string has the following format:
HAMEG Instruments,‹instrument type›,‹serial number›,‹firmware›
(Example: HAMEG Instruments, HM8118,013206727,1.54).

***RST**
The *RST command resets all measuring instrument parameters to the bridge factory settings (Reset).

***OPC?**
The query *OPC? (= Operation Complete) is used to synchronize the sequence of a measurement. The *OPC? query returns the value 1 if all measurement values of a measurement sequence were completely captured by the measuring instrument and if the instrument is ready to perform another measurement.

***WAI**
The *WAI command is a synchronization command that stops every subsequent command before its execution until all running measurements are completed. The commands STRT followed by *WAI and XALL? would start a measurement . However it would block the processing of further commands until the measurement has been completed. The XALL? command issues the measurement result.

***SAV i**
The *SAV command saves the current measuring instrument parameters in the memory location. You can select a memory location between 0 and 9. The measuring instrument always starts with the parameters that are stored in memory location 0.

***RCL i**
The *RCL command activates the stored measuring instrument configuration i and uses it as the current setting. You can select a memory location between 0 and 9. If the saved settings (measuring instrument parameters) are incomplete or have not been saved (e.g. due to an empty memory location), an error message is displayed when the command is executed. The *RCL 9 command resets all measuring instrument parameters to the factory settings.

LOCK 1
The LOCK 1 command allows you to lock the instrument front panel operation. You can unlock this by pressing the REMOTE key or by using the LOCK 0 command.

LOCK 0
The LOCK 0 command allows you to unlock an existing instrument lock.

$STL(?) {i}
The $STL command sets the trigger delay time (DELAY) to i milliseconds. The trigger delay time i can be set anywhere between 0ms and 40000ms. The query $STL? queries the set trigger delay time.

AVGM(?) {i}
The AVGM command activates or deactivates the calculation of the average (AVG). The function AVG Average Value is activated, several individual measurements will be used to form a mean value according to the set period. i=0 deactivates the calculation of the average (NONE), i=2 sets the calculation of the average to MED. The MED (medium) setting is the medium averaging mode. The bridge HM8118 performs 6 consecutive measurements, rejects the lowest and highest measurement values and generates an average based on the four remaining measurements. This type of averaging hides individual erroneous measurements. If the calculation of the average is set to i=1, you can use the NAVG command to select the number of

measurement values to be used for the calculation of the average. The AVGM? query queries the status of the calculation of the average.

NAVG(?) {i}
If you use the AVGM command to set the calculation of the average to i=1, you can use the NAVG command to set the number of measurement values to be used for the calculation of the average anywhere between 2 and 99.
The NAVG? query queries the number of measurement values to be used for the calculation of the average.

The constant voltage (CST V function) must be switched on for measurements with bias current or external preload.

VBIA(?) {x}
The VBIA command sets one internal DC preload anywhere between 0V and 5V. This command returns an error message (ERROR) if the HM8118 is not set to a measurement mode C-D, C-R, R-X or Z-Θ which would be suitable for a preload. Use the BIAS 1 (= internal) command to activate the preload which was previously activated via VBIA and to show it on the display. The VBIA? query queries the current value of the applied DC preload.

IBIA(?) {x}
The IBIA command defines the DC bias current between 0.001A and 0.200A. This command returns an error message (ERROR) if the HM8118 is not set to perform an inductance measurement or a transformer measurement (L-Q, L-R, N-Θ or M). Use the BIAS 1 (= internal) command to activate the bias current which was previously activated via IBIA and to show it on the display. The IBIA? query queries the current DC bias current.

The error message "DCR too high" indicates that the resistance of the connected DUT is too high for the selected bias current. In this case, the bias current cannot be activated.

BIAS(?) {i}
The BIAS command activates or deactivates the DC preload or DC bias current defined in the HM8118. Use i=0 to deactivate the DC preload that is selected via VBIA, or deactivate the DC bias current that is selected via IBIA. Use i=1 to activate the internal BIAS and to show the value that was previously selected via VBIA or IBIA on the display. Use i=2 to select the external BIAS which is only possible with a DC preload. The internal BIAS preload can only be selected if the instrument is set to the appropriate measurement function (see VBIA command). The internal BIAS bias current can only be selected if the instrument is set to the appropriate measurement function (see IBIA command). The external BIAS function behaves correspondingly. The BIAS? query queries the current BIAS status.

CIRC(?) {i}
Use the CIRC command to select the circuit type of the equivalent circuit diagram (measurement circuit). By default, the automatic circuit type (i=2) is selected. Use i=0 to set the series circuit, use i=1 to set the parallel circuit of the equivalent circuit diagram. The CIRC? query queries the current status of the equivalent circuit diagram setting.

CONV(?) {i}
The CONV command activates (i=1) or deactivates (i=0) the constant voltage (function CST V). The CONV? query queries the current status of the constant voltage.

FREQ(?) {x}
Use the FREQ command to select the measurement frequency in Hz. The 69 available measurement frequency intervals are as follows:

Measurement Frequencies					
20Hz	90Hz	500Hz	2.5kHz	12kHz	72kHz
24Hz	100Hz	600Hz	3.0kHz	15kHz	75kHz
25Hz	120Hz	720Hz	3.6kHz	18kHz	80kHz
30Hz	150Hz	750Hz	4.0kHz	20kHz	90kHz
36Hz	180Hz	800Hz	4.5kHz	24kHz	100kHz
40Hz	200Hz	900Hz	5.0kHz	25kHz	120kHz
45Hz	240Hz	1.0kHz	6.0kHz	30kHz	150kHz
50Hz	250Hz	1.2kHz	7.2kHz	36kHz	180kHz
60Hz	300Hz	1.5kHz	7.5kHz	40kHz	200kHz
72Hz	360Hz	1.8kHz	8.0kHz	45kHz	
75Hz	400Hz	2.0kHz	9.0kHz	50kHz	
80Hz	450Hz	2.4kHz	10kHz	60kHz	

The FREQ? query queries the set measurement frequency in Hz.

MMOD(?) {i}
Use the MMOD command to select the trigger type. Use i=0 to select the continuous trigger, i.e. a new measurement will automatically be performed upon completion of the previous measurement. Use i=1 to select the manual trigger (TGM). In this case, a measurement will be performed only after the *TRG command was sent. Use i=2 to select the external trigger (TGE). A measurement is performed when a rising slope is applied to the external trigger input (TTL level +5V). The MMOD? query queries the current status of the triggering.

If the measuring instrument shows a blank screen (i.e. lines "- -") without measurement values, no trigger event / measurement has been triggered or the selected measurement function has been selected incorrectly.

***TRG / STRT**
Use the *TRG or STRT command to start a measurement if the manual trigger mode was previously selected (see MMOD).

RATE(?) {i}
Use the RATE command to set the measurement speed (SPD function) in the increments FAST (i=0), MED (i=1) or SLOW (i=2). The number of measurements for a continuous triggering (CONT) is approximately 1.5 per se-

cond at the SLOW setting, 8 per second at MED or 14 per second at FAST. The RATE? query queries the selected measurement speed.

RNGE(?) {i}
The RNGE command sets the measurement range and the related source resistance:
i = 1: between 1 and 25 Ω;
i = 2: between 2 and 25 Ω;
i = 3: between 3 and 400 Ω;
i = 4: between 4 and 6.4 kΩ;
i = 5: between 5 and 100 kΩ;
i = 6: between 6 and 100 kΩ.

The RNGE? query queries the selected measurement range.

RNGH(?) {i}
The RNGH command deactivates (i=0) or activates (i=1) the manual measurement range selection. If the manual measurement range selection is deactivated, the automatic HM8118 measurement range selection is activated (AUTO). The RNGH? query queries the status of the manual measurement range selection.

PMOD(?) {i}
Use the PMOD command and the parameter to select the measurement function:
i=0 : AUTO
i=1 : L-Q
i=2 : L-R
i=3 : C-D
i=4 : C-R
i=5 : R-Q
i=6 : Z-Θ
i=7 : Y+Θ
i=8 : R+X
i=9 : G+B
i=10 : N+Θ
i=11 : M

The PMOD? query queries the selected measurement function.

If the automatic measurement range selection is activated, it is not possible to perform relative measurements and measurements with integrated binning interface.

VOLT(?) {x}
The VOLT command sets the measurement voltage to x volts. You can select any value between 0.05 V and 1.5 V for x. Interim values will be rounded by 0.01 V to the nearest figure. The VOLT? query queries the selected measurement voltage.

OUTP(?) {i}
The OUTP command sets the main measurement value display for the measurement values to
Normal (i=0),
relative measurement value deviation % (i=1) or
absolute measurement value deviation (i=2).

The OUTP? query queries the status of the main measurement value display.

PREL(?) {x}
The PREL command sets the parameter x to determine the relative measurement value deviation (REF_M) for the main measurement value display, if the measurement value deviation of the main measurement value display was previously activated via OUTP 1 or OUTP 2 command (DEV_M). The PREL command generates an error message (ERROR), if the automatic HM8118 measurement range selection (AUTO) is activated. The unit for x is:
Ohm: For R+Q, Z+Θ and R+X measurements,
Henry: For L+Q, L+R and M measurements,
Farad: For C+D and C+R measurements and
Siemens: For Y+Θ and G+B measurements.

The PREL? query queries the set value of the relative measurement deviation (REF_M) of the main measurement value display.

OUTS(?) {i}
The OUTS command sets the secondary measurement value display for the measurement values to
Normal (i=0),
relative measurement value deviation % (i=1) or
absolute measurement value deviation (i=2).

The OUTS? query queries the status of the secondary measurement value display.

SREL(?) {x}
The SREL command sets the parameter x to determine the relative measurement value display for the secondary measurement value display (REF_S), if the secondary measurement value display was previously activated via OUTS 1 or OUTS 2 command (DEV_S). This command generates an error message (ERROR), if the automatic HM8118 measurement range selection (AUTO) or the M measurement is activated (by means of the interference of mutual inductance). The unit for x is:
Ohm: For L+R, C+R and R+X measurements,
Degree: For Z+Θ, Y+Θ and N+Θ measurements and
Without unit: For all other measurements.
The SREL? query queries the set value of the measurement deviation (REF_S) of the secondary measurement value display.

CALL 0
The CALL 0 command determines the bridge settings and ensures that the subsequent command (CROP or CRSH) performs an open or short compensation for the frequency that is currently set for the instrument. It is necessary to first send CROP or CRSH before the compensation is performed.

CALL 1
The CALL 1 command determines the bridge settings and ensures that the subsequent command (CROP or CRSH) performs an open or short compensation for all 69 test frequencies. It is necessary to first send CROP or CRSH before the compensation is performed.

CROP
The CROP command performs an open compensation. The HM8118 automatically reports immediately if a compensation was successful (0) or if it failed (-1).

CRSH
The CRSH command performs a short compensation. The HM8118 automatically reports immediately if a compensation was successful (0) or if it failed (-1).

XALL?
The XALL? query queries the measurement values of the main measurement value display, the secondary measurement value display and the number of sorting bins. The measurement values are issued separated by a comma. If the binning interface is not activated / not integrated or if the current measurement is invalid, the sorting bin value 99 issued.

XMAJ?
The XMAJ? query queries the measurement value of the main measurement value display. If the measurement value display is set to percentage deviation and if the nominal measurement value is „0", an error message will be issued.

XMIN?
The XMIN? query queries the measurement value of the secondary measurement value display. If the measurement value display is set to percentage deviation and if the nominal measurement value is „0", an error message will be issued.

XDLT?
The XDLT? query queries the absolute deviation between the measurement value and the nominal measurement value (see also PREL command). If the automatic measurement mode (AUTO) is selected, an error message is issued.

XDMT?
The XDMT? query queries the relative deviation between the measurement value and the nominal measurement value (see also PREL command). If the nominal measurement value is set to „0" or if the automatic measurement mode (AUTO) is selected, an error message is issued.

10.3 Command List Binning Interface

(only with integrated binning interface HO118)

XBIN?
The XBIN? query queries the number of sorting bins for the current measurement. If the binning interface is not switched on / not activated or if the current measurement is invalid, the sorting bin value 99 issued.

BBUZ(?) i
The BBUZ command activates (i=1) or deactivates (i=0) the alarm function of the binning interface. The BBUZ? query queries the current status of the alarm function.

BCLR
The BCLR command deletes the nominal values and limits for all sorting bins. It also deactivates the binning interface.

BING(?) {i}
The BING command locks (i=0) and enables (i=1) the binning. If no sorting bin is opened or if the measurement mode „AUTO" is selected for the HM8118 , an error message is issued.

BLIH j,(?) {x}
The BLIH command sets the maximum limit (i = 0) of a sorting bin j to x % between 0 and 7. The BLIH? query queries the maximum limit (i = 0) of the sorting bin.

BLIL j,(?) {x}
The BLIL command sets the lower limit (i = 1) for a sorting bin j x % between 0 and 7. The lower limit must be less than or equal to the upper limit. If no lower limit has been set, the HM8118 applies the negative value of the upper limit as lower limit. The query BLIL? queries the lower limit (i = 1) of the sorting bin.

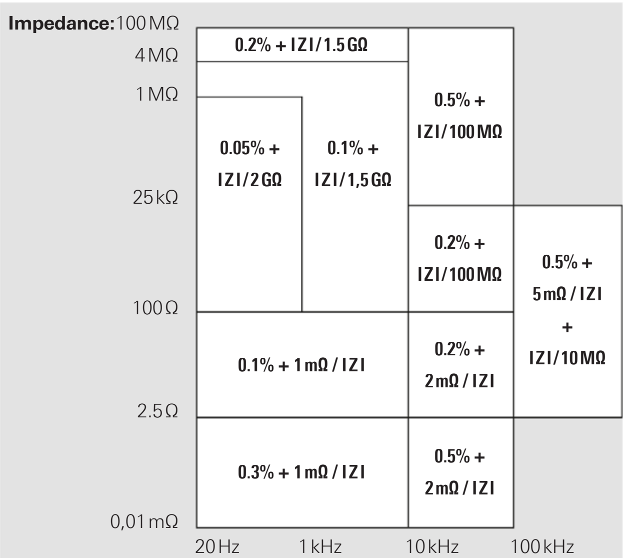
BNOM i,(?) {x}
The BNOM command set sets the nominal value of the sorting bin i to the value x. The value i can be anywhere between 0 and 8 (sorting bin 8 is the QDR sorting bin for failures). If no nominal value has been set for the sorting bin, the HM8118 applies the nominal value of the subsequent lowest numbered sorting bin with a nominal value of unequal 0 (multiple sorting bins can have the identical nominal value without having a value entered for each sorting bin). The lowest numbered active sorting bin must have a selected nominal value. The sorting bin 0 must always be set for the binning to work. The query BNOM? queries the nominal value of the sorting bin.

11 Technical Data

200 kHz LCR-Bridge HM8118

All data valid at 23 °C after 30 minutes warm-up.

Conditions	
Test signal voltage	1 V
Open and short corrections performed	
Measurement time	SLOW
Display	
Measurement modes	Auto, L-Q, L-R, C-D, C-R, R-Q, Z-Θ, Y-Θ, R-X, G-B, N-Θ, M
Equivalent circuits	auto, series or parallel
Parameters displayed	Value, deviation or % deviation
Averaging	2 to 99 measurements
Accuracy	
Primary parameters	Basic accuracy (Test voltage: 1.0 V, measurement SLOW/MEDIUM, autoranging mode, constant voltage OFF, bias off). For FAST mode double the basic accuracy values



Secondary parameters	
Basic accuracy D, Q	±0,0001 if f = 1 kHz
Phase angle	±0,005° if f = 1 kHz
Ranges	
|Z|, R, X	0,01 mΩ to 100 MΩ
|Y|, G, B	10 nS to 1.000 S
C	0,01 pF to 100 mF
L	10 nH to 100 kH
D	0,0001 to 9,9999
Q	0,1 to 9.999,9
ϑ	-180 to +180°
Δ	-999,99 to 999,99 %
M	1 µH to 100 H
N	0,95 to 500
Measurement conditions and functions	
Test frequency	20 Hz to 200 kHz (69 steps)
Frequency accuracy	±100 ppm
AC test signal level	50 mVrms to 1.5 Vrms
Resolution	10 mV_{rms}
Drive level accuracy	±(5% + 5 mV)
Internal bias voltage	0 to +5,00 V_{DC}
Resolution	10 mV
External bias voltage	0 to +40 Vdc (fused 0.5 A)
Internal bias current	0 to +200 mA
Resolution	1 mA
Range selection	Auto and Hold
Trigger	Continuous, manual or external via interface, binning interface or trigger input
Trigger delay time	0 to 999 ms in 1 ms steps
Measurement time (f ≥1 kHz)	
FAST	70 ms
MEDIUM	125 ms
SLOW	0,7 s
Miscellaneous	
Test signal level monitor	Voltage, current
Error correction	Open, short, load
Save/Recall	9 instrument settings
Front-end protection	$V_{max} < \sqrt{2/C}$ @ V_{max} <200 V, C in Farads (1 Joule of stored energy)
Low potential and low current guarding	Ground, driven guard or auto (fused)
Constant voltage mode (25 Ω source)	
Temperature effects R, L or C	±5 ppm/°C
Interface	Dual interface USB/RS-232 (HO820), IEEE-488 (GPIB) (optional)
Safety	Safety class I (EN61010-1)
Power supply	110 to 230 V ±10%, 50 to 60 Hz, CAT II
Power consumption	approx. 20 W
Operating temperature	+5 to +40 °C
Storage temperature	-20 to +70 °C
Rel. humidity	5 to 80% (non condensing)
Dimensions (W x H x D)	285 x 75 x 365 mm
Weight	approx. 4 kg

Accessories supplied: Line cord, operating manual, HZ184 4-terminal kelvin test cable and HZ188 4-terminal SMD component test fixture, CD

Recommended accessories:

HO118	Binning interface
HO880	Interface IEEE-488 (GPIB), galvanically isolated
HZ13	Interface cable (USB) 1.8 m
HZ14	Interface cable (serial) 1:1
HZ33	Test cable 50 Ω, BNC/BNC, 0.5 m
HZ34	Test cable 50 Ω, BNC/BNC, 1.0 m
HZ42	19" rackmount kit 2RU
HZ72	GPIB-cable 2 m
HZ181	4-terminal test fixture including shorting plate
HZ186	4-terminal transformer test cable