HIOKI

3520

LCR Hi TESTER

INSTRUCTION MANUAL

HIOKI E.E. CORPORATION

WARNING

This instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurement. Failure to follow directions can result in a serious or fatal accident.

Contents

INTRODUCTION

Thank you for purchasing this HIOKI 3520 LCR Hi−Tester. In order to utilize your device to the maximum and maintain high performance levels for the longest period of time, please read this manual thoroughly before use.

NOTES FOR OPERATION

To ensure the safe use of this device and full performance of the many functions, please observe the following precautions.

INSPECTION

Once the 3520 has been delivered, first inspect it to make sure it has not been damaged in transit. In particular, check the panel switches and terminals closely.

If there is any damage, or if the unit does not function normally, contact your vendor immediately.

PRECAUTIONS IN TRANSPORT

When transporting the 3520, please use the original packing materials. If the original packing materials are not available, use the following procedure:

(1) Wrap all equipment in plastic.

(2) Place at least 100mm of cushioning material in a corrugated cardboard box at least 7mm in thickness, and nestle the 3520 inside.

(3) After wrapping the 3520 in cushioning material, insert the accessories, place an additional layer of cushioning material on top, close the box and seal with tape. If required, the box may be secured with twine.

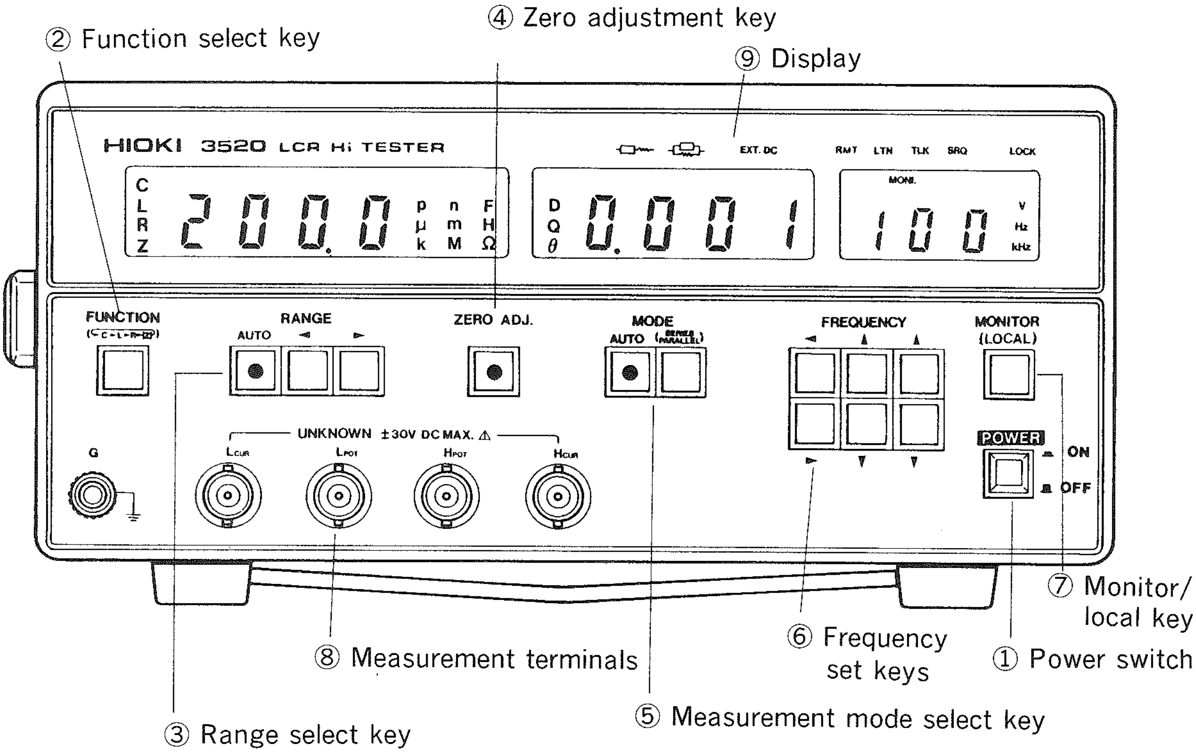
PRECAUTIONS IN USE

⚠ **WARNING**

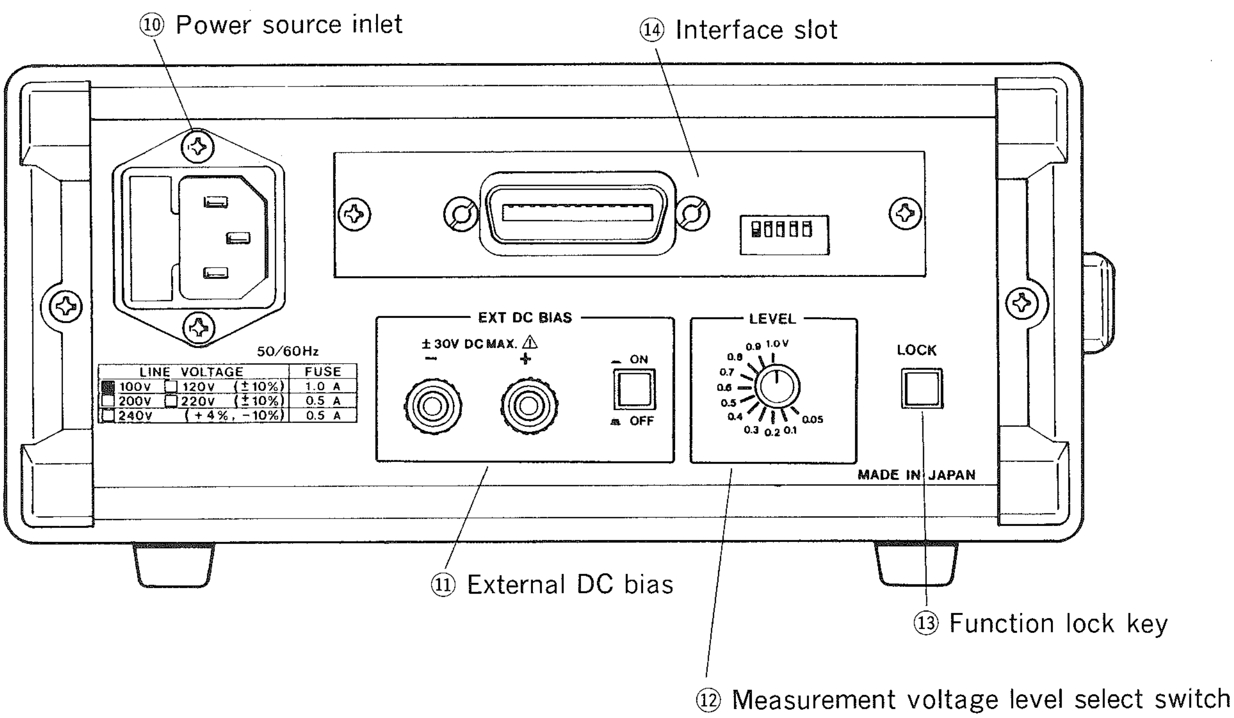
1. **Specific precautions are given for each section of this manual as required. Always use the 3520 only after reading these sections completely.**
2. **In measurement of components such as coils and capacitors with inherent voltage and current dependence, measure under precise measurement conditions.**
3. **Take care of charged capacitors. Connection of the 3520 to highly−charged capacitors could cause damage to or destruction of the unit.**
4. **When the power is turned on all of the LED displays on the panel will light for a moment. If any of them does not light, contact your vendor or service representative.**
5. **If an abnormal display is given during operation, or if function is abnormal, turn off the power for a momènt and then turn it back on again.**
6. **Be sure to prevent dust and oil from adhering to the clip end of the 9140 4-terminal probe.**

PART NAMES AND FUNCTIONS

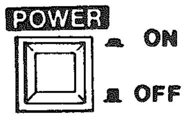
Front panel



Rear panel



① **Power switch**

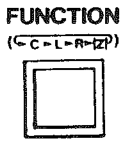


- Switches between on and off with pushbutton operation. When power is turned on all LEDs will light. Initial settings are:

  Function: C−D measurement
  Range: Automatic
  Measurement mode: Automatic
  Measurement frequency: 1 kHz
  Monitor: Frequency monitor
  Measurement voltage: As per rear panel setting

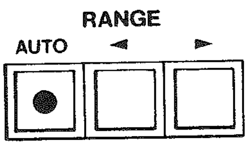
  If the function lock key is activated, however, then the 3520 will start with all settings as previously selected (see ⑬ below).

② **Function select key**



- Measurement functions are selected each time the key is pressed, sequentially from C−D, L−Q, R, |Z| −θ, C−D. If the function is changed, the measurement range and mode are changed to automatic.

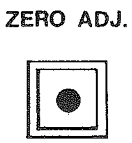
③ **Range select key**



- Each time the AUTO key is pressed the system changes between manual and automatic ranging. When the switch LED is on the system is in automatic ranging, and off indicates manual ranging.
  In automatic ranging, the range will be shifted up at a count of 2021, and down at a count of 179. With the exception of the lowest ranges (2ohm, 200pF, 200μH), the display range for each measurement range is from 180 to 2020.
- The 「◀」 and 「▶」 switches are for manual, with 「◀」 shifting the range up and 「▶」 shifting the range down. The display range for each manual measurement range is the same as for automatic ranges, from 180 to 2020 counts. When this range is exceeded the display will flash with the exception of the lowest ranges.
- The measurement range is determined through the combination of range and measurement frequency. If measurement frequency and range have been set and the measured value is not displayed, it means that the value is outside the specified range. Recheck the specifications in this case.

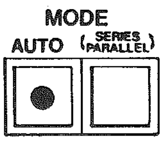
⚠ COUTION

- **If measurement is made at a low measurement signal level, please use manual ranging. Automatic ranging can cause range instability in certain situations.**
- **Ranging processing within the 3520 measurement circuits is handled based on impedance |Z|. For this reason, changing the measurement frequency within a single range will switch the detection circuit and may change the measured value (see section 2−3).**
- **If the manual range is selected during operation in automatic range the system will switch to manual range and at the same time change the range being used.**



④ Zero adjustment key

- Pressing the zero adjust key will cause the key LED to flash, after which the system will perform in sequence the probe residual component short test and open test (see Section 3−3).
- After residual component measurement is completed, the key LED will remain lit to indicate the system is performing zero adjustment (residual component compensation).
- Pressing the key a second time will turn off the LED and cancel zero adjustment operation. If zero adjustment is required a second time, the process must be started again from measurement.



⑤ Measurement mode select key (serial/parallel equivalent)

- This key selects whether measurement is handled with a serial equivalent or a parallel equivalent circuit. Each time the AUTO key is pressed the system will switch between automatic and manual. When the LED is lit the system in automatic operation, and when off the system is in manual operation.
- When in manual operation, the system will switch between series and parallel equivalent circuits each time the SERIES−PARALLEL switch is pressed.
- In the automatic mode the display (see item 9) will indicate which mode the system is in with an icon.

- When in the automatic mode, switching between serial and parallel equivalent circuits is handled based on impedance |Z|

  |Z| ≧ 2kohm: parallel equivalent circuit
  |Z| < 2kohm: series equivalent circuit

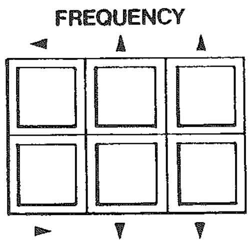
- The measurement mode will not operate when in the impedance |Z| measurement mode.

⚠ COUTION

- **In general the measured values for electrolytic capacitors and low−Q coils will differ between measurement on series equivalent and parallel equivalent circuits.**
  This is because the larger the material loss factor (larger D in capacitors and smaller Q in coils) is, the larger the difference in the measured values will be. For example, measurements for a capacitor of the same capacity by series and parallel equivalent circuits for different values for D are given below.

	Series equivalent circuit	Parallel equivalent circuit
D=0	C	C
D=0.1	1.005C	0.995C
D=0.5	1.118C	0.8944C

  For this reason, effective evaluation of materials requires care in selection of measurement mode.
- **In general film and ceramic capacitors and other devices with small capacity and high impedance are measured with the parallel equivalent circuit because parallel resistance is a loss factor, while the series equivalent circuit is used to measure large capacity low impedance electrolytic capacitors because lead resistance equivalent parallel resistance is a loss factor.**



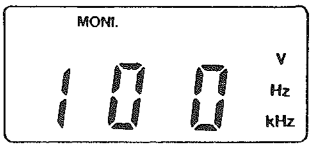
⑥ **Frequency set keys**

- These keys are used to set the measurement frequency. The key pad is composed of two keys with horizontal arrows, and four keys with vertical arrows.

- **Horizontal arrows**

  ◀ key: Increases the power of 10, jumping the frequency to 10 times the display value.
  For example, 100Hz → 1kHz → 10kHz → 100kHz.

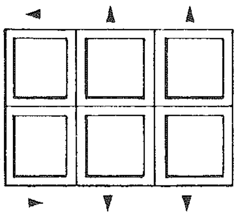
  ▶ key: Reduces the power of 10, cutting the frequency to 1/10th of the displayed value.
  For example, 100kHz → 10kHz → 1kHz → 100Hz.



- **Vertical arrows**

  ▲ key: Raises the digit corresponding to the position of the arrow.

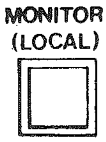
  ▼ key: Lowers the digit corresponding to the position of the arrow.



> ⚠ **NOTE**
>
> - **Switches operate once each time they are pressed.**

- Frequency resolution that can be set from the front panel is:
  40～990Hz ····················10Hz steps
  1.00kHz～9.90kHz············100Hz steps
  10.0kHz～100kHz ············1kHz steps

⑦ Monitor/local key



- This key switches the monitor display between the set frequency and the voltage between the material terminals.
- When monitoring the voltage between the material terminals the resolution is 0.1V.
- GP−IB use

  When the GP−IB interface is used and control passed to an external computer, the RMT display will light and the system will be in the remote operation mode. In this mode the front panel switches are disabled.

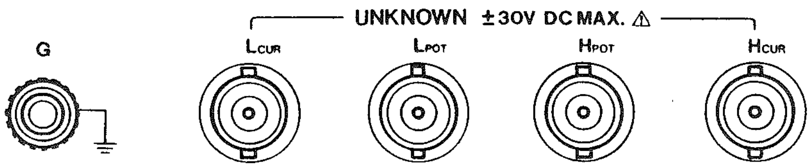
  For this reason, when the monitor/local key is pressed GP−IB control is cancelled to extinguish the RMT display and enable front panel controls again (see item ⑨).

  However, if a local lockout command has been sent by the external controller the local key is disabled.

⚠ COUTION

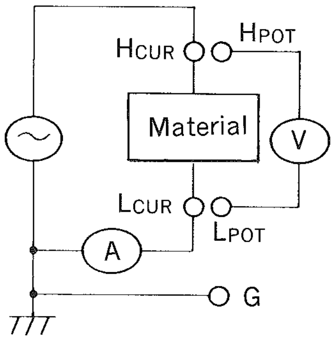
- **When displaying the voltage between the material terminals, do not change the frequency setting.**
- **The displayed monitor voltage will be abnormal unless the probe is connected.**

⑧ Measurement terminals



- There are five terminals used.

  H_{CUR} ······Measurement current supply
  H_{POT} ······Voltage detect for measurement current supply
  L_{POT} ······Voltage detect for current measurement
  L_{CUR} ······Current measurement
  G ·········Guard terminal



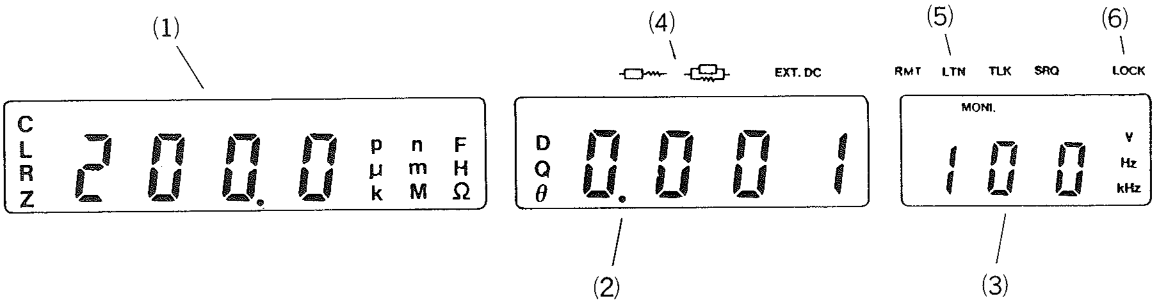
- Cable connection to the material to be measured should be as indicated to the left. When using the 9140 4-terminal probe, be sure to match prove connector colors with the front panel label colors.
- For materials with high impedance, such as resistance of 100kohm or higher or capacitors of 1nF or lower, measurement may be unstable due to external noise effects. In this situation use the guard terminal for stabilized measurement (see Section 3−4).

⚠ **COUTION**

- **This system is designed to use a 75ohm coaxial cable of 1 meter in length. When using dedicated fixtures except of 9140 probe, please match cable type and length.**

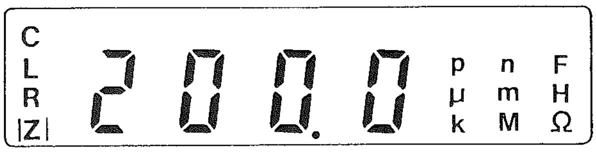
⑨ Display

The display is composed of the following portions:



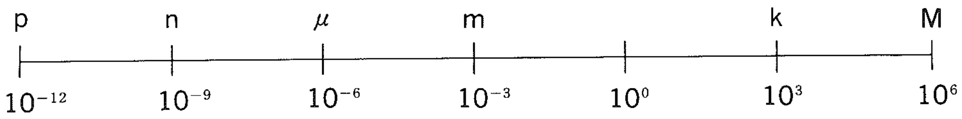
(1) C, L, R, |Z| display
(2) D, Q, θ display
(3) Monitor display
(4) Measurement mode display
(5) GP—IB display
(6) Other

(1) C, L, R, |Z| display

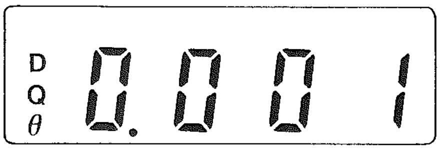


- The measurement function, measured value and units are displayed for C, L, R and |Z| measurements. When the valid measurement range is exceeded the range will be changed in automatic ranging and the display will flash in manual ranging. For ranges that cannot be measured due to the selected combination of frequency and range, the display will be blank. Units are as follows:

C ……capacitance …… F ……Farad
L ……inductance……… H ……Henries
R ……resistance ………Ω ……ohms
|Z| impedance………Ω ……ohms



(2) **D, Q, θ display**



- Displays values for capacitor measurement loss factor D, coil measurement Q (inverse of loss factor D), and current—voltage angle θ in impedance measurement.

D……loss factor, often expressed as tanX.

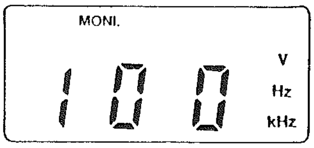
$$D = \frac{\text{resistance component}}{\text{capacitor component}} = \tan\delta$$

Q……inverse of loss factor D

$$Q = \frac{\text{coil component}}{\text{resistance component}} = 1/D$$

θ……phase angle of voltage in reference to current phase, with delays represented by 「−」 and advances by 「+」.

(3) Monitor display

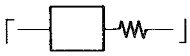
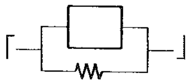


- Displays the voltage potential between the material terminals and the measurement frequency. Frequency is shown as xxxHz or xxxkHz, and material terminal voltage as MONI. x.xxV.

⚠ **CAUTION**

Monitor voltage display is abnormal unless probe is connected.

(4) Measurement mode display

- Displays whether the measurement mode is series equivalent or parallel equivalent. In addition, the  icon indicates series equivalent and the  diagram indicates parallel equivalent.

(5) GP—IB display

RMT LTN TLK SRQ LOCK

- This indicates the current status of the unit when it is controlled externally through the GP—IB interface (see Section ⑤).
  RMT ……remote control
  LTN………Listener
  TLK………Talker
  SRQ ……Service request

(6) Other

- Other displays include EXT.DC and LOCK. EXT.DC lights when the rear panel external DC bias voltage switch is on, and the LOCK display lights when the rear—panel lock function key is activated.

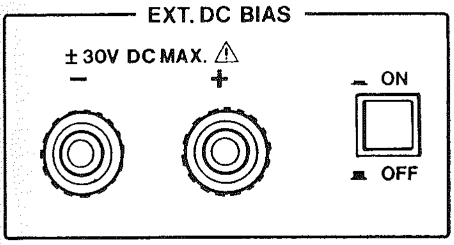
⑩ **Power source inlet**
(with fuse holder)

- This power source inlet includes a ground terminal and a fuse holder.

⚠ WARNING

- **The power supply voltage and fuse rating used by the unit are printed here. Never use power supply voltages or fuse ratings other than as specified.**

⑪ **External DC bias**

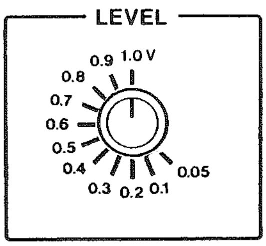


- This key turns on and off the DC bias to the DC bias terminal, material and internal measurement circuit. The push−button switch will remain on until pushed off again, and when on the 「EXT.DC」 display will light.
- The 「+」 voltage for the input terminal is present at the 「HCUR」 terminal of the probe. To generate a minus DC bias, apply a minus voltage to the 「+」 input terminal.
- When using DC bias, measurement will be unstable until the material is charged after switching on the DC bias function or changing materials. Wait sufficient time.
- When the switch is turned off, the material will be discharged through about a 50ohm resistor.

⚠ COUTION

- **The DC bias function should only be used as a voltage bias for capacitance measurement. See Section 3−9 for details on DC current bias in coil measurement.**
- **When applying a DC bias to polar materials (electrolytic capacitors), be sure to check**
  (1) **the polarity of the DC bias input terminal connection,**
  (2) **the color marks of the 9140 4-terminal probe and the panel connectors, and**
  (3) **the color marks of the 9140 4-terminal probe material clip and the material polarity.**

  The material may be damaged is polarity is incorrect.
- **The maximum DC bias is 30V.**
- **If DC bias is not used, be sure to switch the function off.**

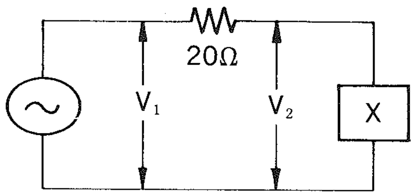


⑫ **Measurement voltage level select switch**

- The measurement voltage level is variable. It can be varied from 1V rms in 0.1V steps to a minimum of 0.05V.
- The switch rotates the full 360 .°Settings that are not marked are 1V.

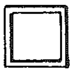
⚠ **NOTE**

- **The voltage that is set is the voltage of the measurement signal generation circuit, and not the voltage applied between the material measurement terminals.**
- **The 3520 generates measurement voltage with a fixed voltage output circuit, but to prevent shorts when material impedance is close to 0, it is fitted with an about 20ohm current control resistor as indicated below.**



- **Set voltage is output as V_1, and voltage V_2 to the current control resistor becomes the material measurement terminal voltage potential.**
- **Verify the material terminal voltage V_2 with the voltage level monitor.**
- **When the measurement signal level is set very low please use manual ranging. Automatic ranging may have unstable ranging in some situations.**

LOCK



⑬ **Function lock key**

- This key disables the front panel controls and preserves current settings. It is a push-button switch, and the LOCK display lights when it is activated. The settings preserved are those that existed when the lock key was pressed.
- The power switch, DC bias on/off key and monitor key cannot be locked.
- The lock is not freed even when the power is turned off. When power is turned on again, the unit will start from the locked settings.
- Residual component data used in zero adjustment is also saved.

⚠ COUTION

- **When the function lock is turned off the normal panel settings will be enabled. If the measurement voltage select was set, the the measurement voltage will also be set as specified. Be sure to check the voltage level when releasing the lock.**
- **If the function lock is on when the 3520 is turned on, "8888" is displayed as an error code. Press the function lock key again to turn off the function lock, restore the former settings, and clear the error code.**

⑭ **Interface slot**

- In the 3520 this is a blank slot cover.
  In the 3520−01 there is a GP−IB interface mounted.
  In the 3520−02 there is a 9200 digital printer interface printed.
  Refer to Section 5 and 6 of the manual.

1. Outline

1—1 Product introduction

The 3520 LCR Hi-Tester is an LCR meter capable of measuring resistance, impedance—θ, inductance—Q and capacitance—D for a frequency range from 40Hz through 100kHz. To ensure stability in measurement conditions, measurement voltage is variable and a monitor is provided for the voltage between the material measurement terminals.

As options a GP—IB interface and a printer interface (options:9200 digital printer) are available.

1—2 Special features

1. In addition to C—D, L—Q and R measurement, |Z| —θmeasurement is also possible.
2. Frequency is variable from 40Hz to 100kHz.
3. Material measurement signal voltage is variable from 0.05V to 1V rms.
4. The voltage between the material measurement terminals can be monitored to stabilize measurement conditions.
5. The function lock prevents misoperation and erroneous measurement, and makes parameter set after power on unnecessary.

1–3 Measurement items and equations

This unit measures the voltage applied between the terminals of the material being measured, current flowing through the material I, the phase angle θ between current and voltage, and the frequency angle speed ω, and uses these values in the following equations.

Parallel equivalent mode	Z	$Z=R+j\frac{1}{\omega C}$ or $R+j\omega L$
	$\lvert Z\rvert$	$\lvert Z\rvert=\sqrt{R^2+(1/\omega C)^2}$ or $\sqrt{R^2+(\omega L)^2}$
	L	$\omega L=\lvert Z\rvert\cdot\sin\theta$, $L=\frac{\lvert Z\rvert\cdot\sin\theta}{\omega}$
	C	$\frac{1}{\omega C}=\lvert Z\rvert\cdot\sin\theta$, $C=\frac{1}{\omega\cdot\lvert Z\rvert\sin\theta}$
	R	$R=\lvert Z\rvert\cdot\cos\theta$
	D	$D=\omega C\cdot R=1/\tan\theta$
	Q	$Q=\frac{\omega L}{R}=\tan\theta$

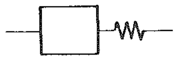
Series equivalent mode	Z	$Z=\frac{1}{1/R+j\omega C}$ or $\frac{R\cdot j\omega L}{R+j\omega L}$
	$\lvert Z\rvert$	$\lvert Z\rvert=\frac{1}{\sqrt{(1/R)^2+(\omega C)^2}}$ or $\frac{R\cdot\omega L}{\sqrt{R^2+(\omega L)^2}}$
	L	$\frac{1}{\omega L}=1/\lvert Z\rvert\cdot\sin\theta$, $L=\frac{\lvert Z\rvert}{(\omega\cdot\sin\theta)}$
	C	$\omega C=1/\lvert Z\rvert\cdot\sin\theta$, $C=\frac{\sin\theta}{(\omega\cdot\lvert Z\rvert)}$
	R	$R=\lvert Z\rvert/\cos\theta$
	D	$D=1/(\omega C\cdot R)=1/\tan\theta$
	Q	$Q=R/\omega L=\tan\theta$

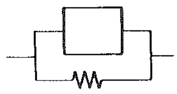
2. Specifications

2-1 General

1) Measurement items : (1) C (capacitance), D (loss factor),
(2) L (inductance), Q (=1/D),
(3) R (resistance),
(4) |Z| (impedance), θ (phase angle)

2) Measurement circuit modes : automatic or manual


(serial equivalent)


(parallel equivalent)

3) Measurement frequency :

40~990Hz (variable in 10Hz steps)
1.00~9.90kHz (variable in 0.1kHz steps)
10.0~100kHz (variable in 1kHz steps)
(See 21 below for GP-IB use)

4) Measurement signal level :

0.05~1.0V rms (switchable to 11 ranges)
Maximum 50mA rms, voltage division with 20 ohm current controller

5) Signal level monitor : Monitoring of voltage between material measurement terminals possible. Resolution 0.01V.

6) Ranging : Automatic or manual

7) Display : 3½ digits, maximum display 2020 (θ and measurement frequency are 3 digits).

8) Measurement terminals :

Five terminals: voltage, current (BNC terminal), and guard. (Useing the 9140 4-terminals.)

9) Residual charge protection :

Maximum 50VDC

10) DC bias : Maximum external input during capacitance measurement is DC30V.

11) Zero adjust function : Automatic compensation for measurement terminal residual component

C max. 10pF
L max. 10μH
R max. 0.1 ohm

12) Lock function : Allows settings of all control switches to be locked and stored in memory.

13) Temperature coefficient :

500 ppm/°C.

14) Operating temperature and humidty :

0~40 °C, 80%RH max. (non condensation)

15) **Strage temperature and humidity :**

−10∼50°C, 80%RH max. (non condensation)

16) **Power supply :** AC100V/120V/200V/220V ±10%, 240V +4%/−10%
Maximum 250V 50/60Hz

17) **Power consumption :** Approx. 25VA

18) **Dimensions :** Approx. 96H×218W×429D (mm),(not including protrusions)

19) **Weight :** Approx. 3.8kg.

20) **Accessories :** Power cord (1)
9140 4-terminal probe (1)
Instruction manual (1)
Spare fuse (1) (100/120V···1A/250V ϕ5.2×20)
(200/220/240V···0.5A/250V ϕ5.2×20)

21) **Options :** GP−IB interface
Front panel switch set possible
Frequency set 40Hz∼9.99kHz (10Hz steps)
10.0∼100kHz (100Hz steps)
Measurement signal level 0.05∼1V rms (5mV steps)
Printer interface (9200 digital printer sold separately)
Printout of R, |Z| −θ, C−D, L−Q, frequency and comparison.

2−2 Measurement range

Accuracy is assured for 25±5°C, 80%RH max. and 30 minutes of warmup time.

Function	Set ranges	Measurement range	Accuracy	Remarks
C	8	0.1pF∼2020μF	±0.3%rdg+2dgt+α	
D	1	0.001∼1.999	±1%rdg+0.005α+5dgt	
Q	1	0.5∼999	———	Remarks As per 1/D
L	7	0.1μH∼202.0H	±0.3%rdg+2dgt+α	
R, |Z|	7	0.001Ω∼2.020MΩ	±0.3%rdg+2dgt+α	
θ	1	-90.0° ∼ 90.0°	±(1+α/10)° +β+5dgt	

* Measurement range and accuracy change with measurement frequency and measurement signal level. Refer to the accuracy table (Fig. 1, 4, and 6).

* α and β represent equation deviation. Refer to Fig. 2, 3, 5 and 7.

2—3 Accuracy

The 3520 LCR meter takes voltage V applied to the test material, current I, current/voltage phase signal voltage V_θ and set frequency f as primary parameters, and uses them to determine secondary parameters |Z| , θ, D and Q, from which tertiary parameters L, C and R are determined.
Refer to the individual explanations given below.

⚠ NOTE

Accuracy figures given for L, C and R in the accuracy tables are:

L ······phase angle +84°C minimum (Q ≧ 10)

C ······phase angle −84°C minimum (D ≦ 0.105)

R ······phase angle 0~±6°C

with 1V measurement signal level, zero adjust function on and using the dedicated probe. Other use conditions will further increase deviation.

(1) Accuracy for measured values is expressed in the following manner:

● L, C, and R measured value accuracy

A%rdg+B+Cα

A = material actual value

B = digit (count deviation)

C = operation deviation coefficient

α = operation deviation

● θ (phase angle) measured value accuracy

$(A+\alpha/C)^\circ + B + \beta$

A = basic accuracy of phase angle detection

C = operation deviation coefficient

B = digit (count deviation)

α = operation deviation

β = operation deviation

● D measured value accuracy

A% +Cα + B

A = actual value of D

C = D operation resolution (expressed as D)

B = digit (count deviation)

α = operation deviation

(2) Ranging processing within the 3520 measurement circuits is handled based on impedance |Z| . For this reason, changing the measurement frequency within a single range will switch the detection circuit and may change the measured value.

(3) Accuracy of measured voltage level

- The measurement voltage level is variable from 1V to 0.05V, but as voltage and current signals become extremely small, it becomes impossible to measure phase angle θ, L, C, R and |Z| . The range of values that can be measured is given in accuracy table Fig. 6 (per measurement signal level). The measurable range is given in impedance |Z| . For measurement of L and C, first measure impedance |Z| and then measure is a range that will cover it.

- Add the deviations given in Fig. 9 (deviation variable K dependent on signal level) to the accuracy listed in the accuracy table.

Example : The accuracies for a 1kohm resistance measured at 1kHz are given below for 1.0V and 0.1V.

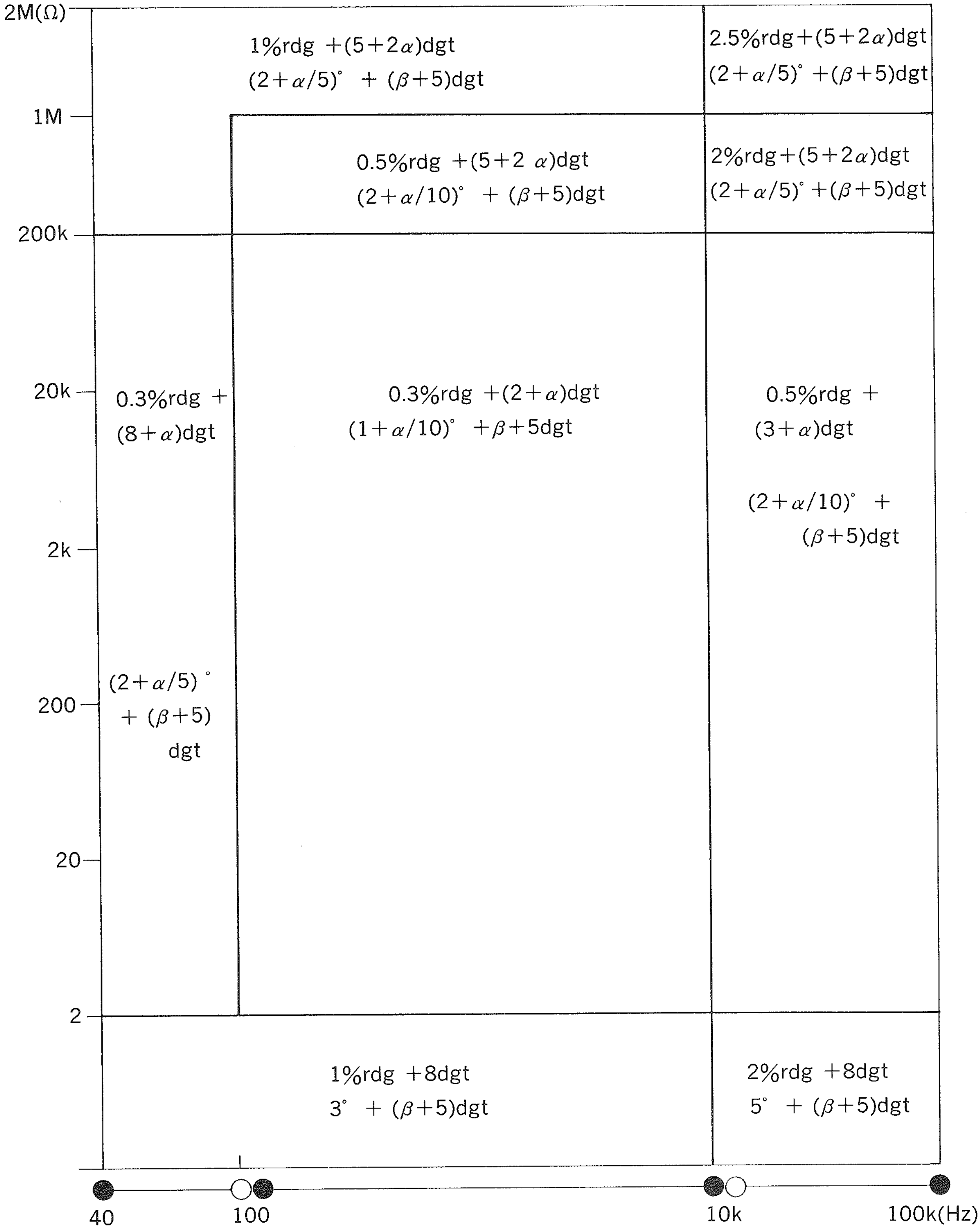
	1.0V	0.1V
From Fig. 1	Basic accuracy from R accuracy table is ±(0.3%+2+α). For a count of 1000, a variation is 3 digit (from Fig. 4), and therefore the total variation is ±(0.3% + 5 dgt)	Same as the left
From Fig. 1 and Fig. 7	For measurement at 1.0V, the deviation per measurement signal level is K=0%, and therefore 992 ≦ measured value ≦ 1008, in other words, within the range of 1kohm ±0.8%	For measurement at 0.1V, the deviation per measurement signal level is K=3%, and therefore the deviation is ±(3.3%+ 5 digits). 962 ≦ measured value ≦ 1038, in other words, within the range of 1kohm ±3.8%

2−3−1 R, Z | −θ accuracy table (Fig. 1)

(signal level 1V rms, zero adjustment on, using dedicated probe)

Resistance range allowable phase angle : 0∼±6 °

Accuracy assured environment: 23±5°C, 80%RH max, no condensation.



Accuracy upper line: R, |Z| accuracy. α is operation deviation

Accuracy lower line: θ accuracy. (°) is absolute value (including operation deviation, β is operation deviation

● Including marked frequency

○ Not including marked frequency

Fig. 2—R, |Z| operation deviation (α) diagram

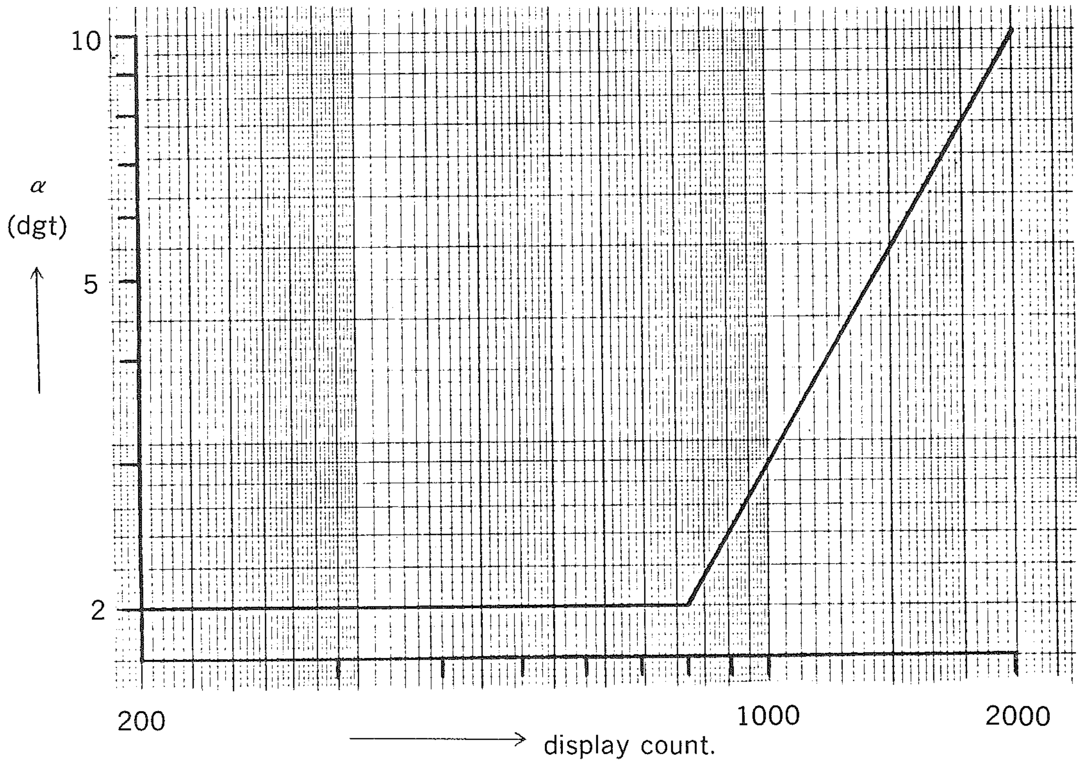
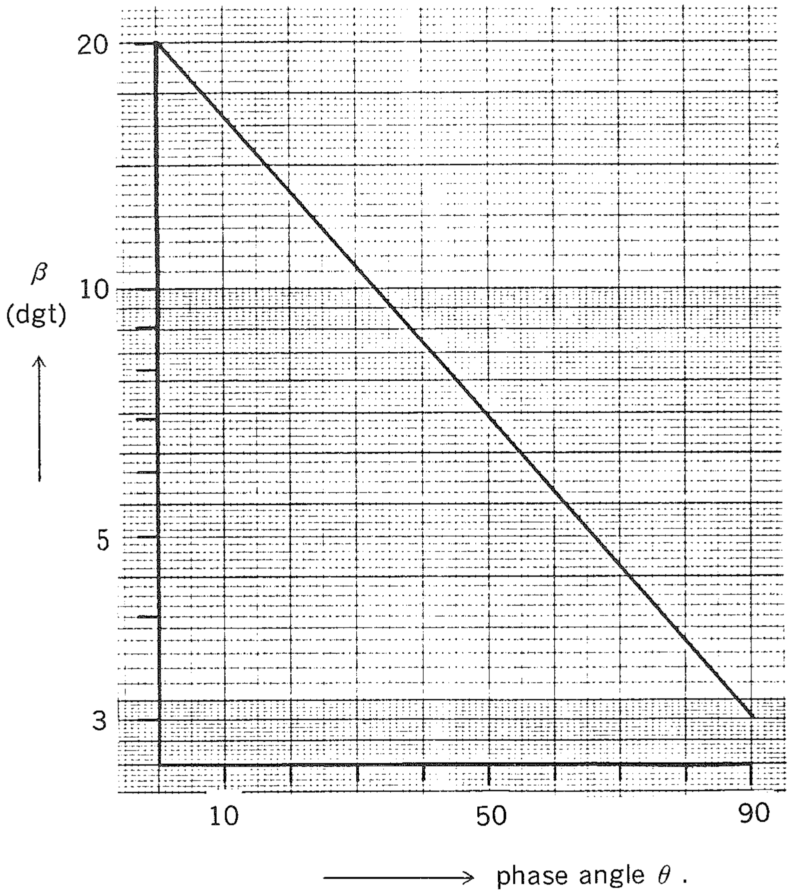


Fig. 3—Phase angle θ operation deviation (β) diagram

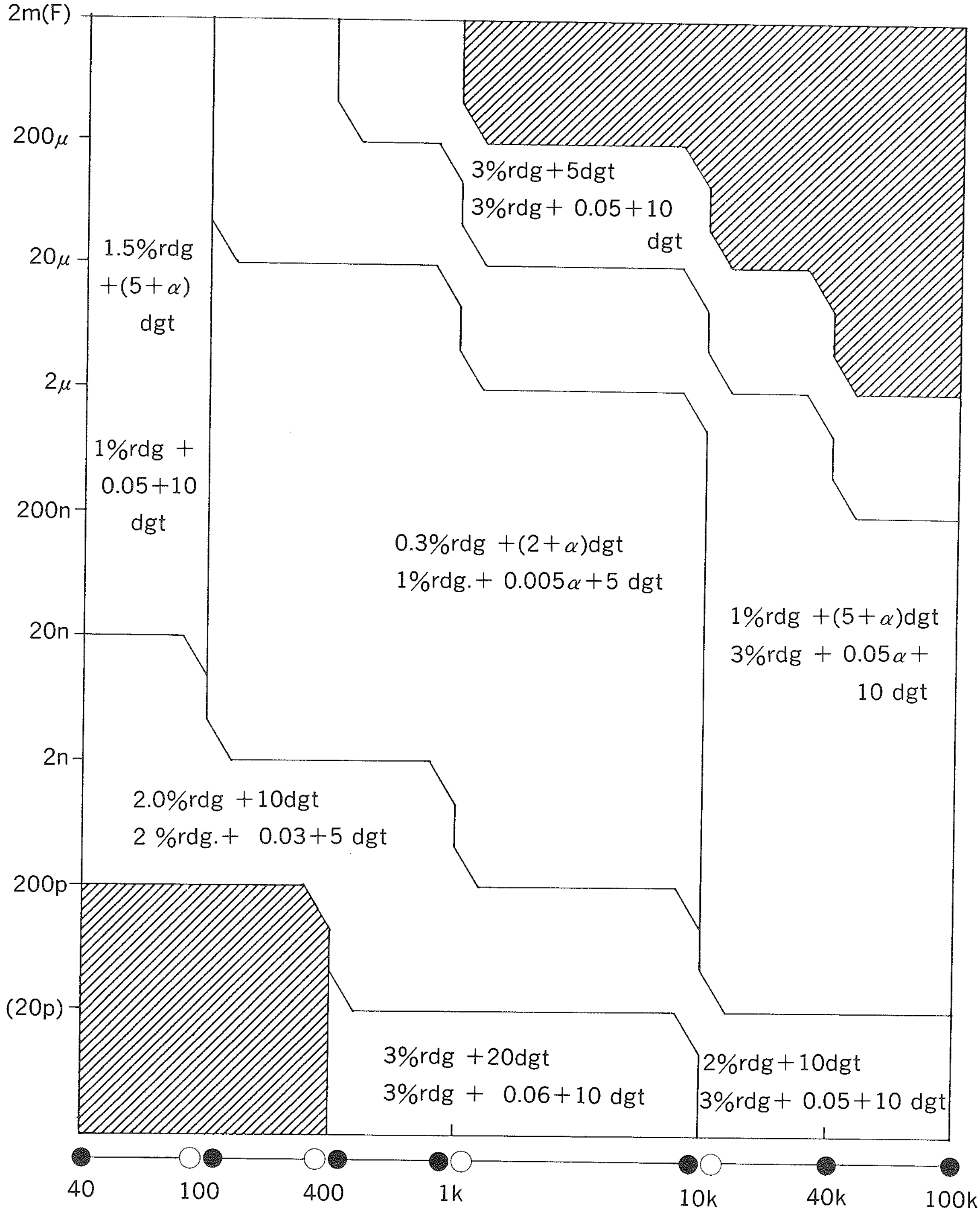


2−3−2 **C−D accuracy table (Fig. 4)**

C range allowable phase angle −84° min.(D≦0.1)

▨ Shaded areas cannot be measured.

Accuracy assured environment: 23±5°C, 80%RH max, no condensation.



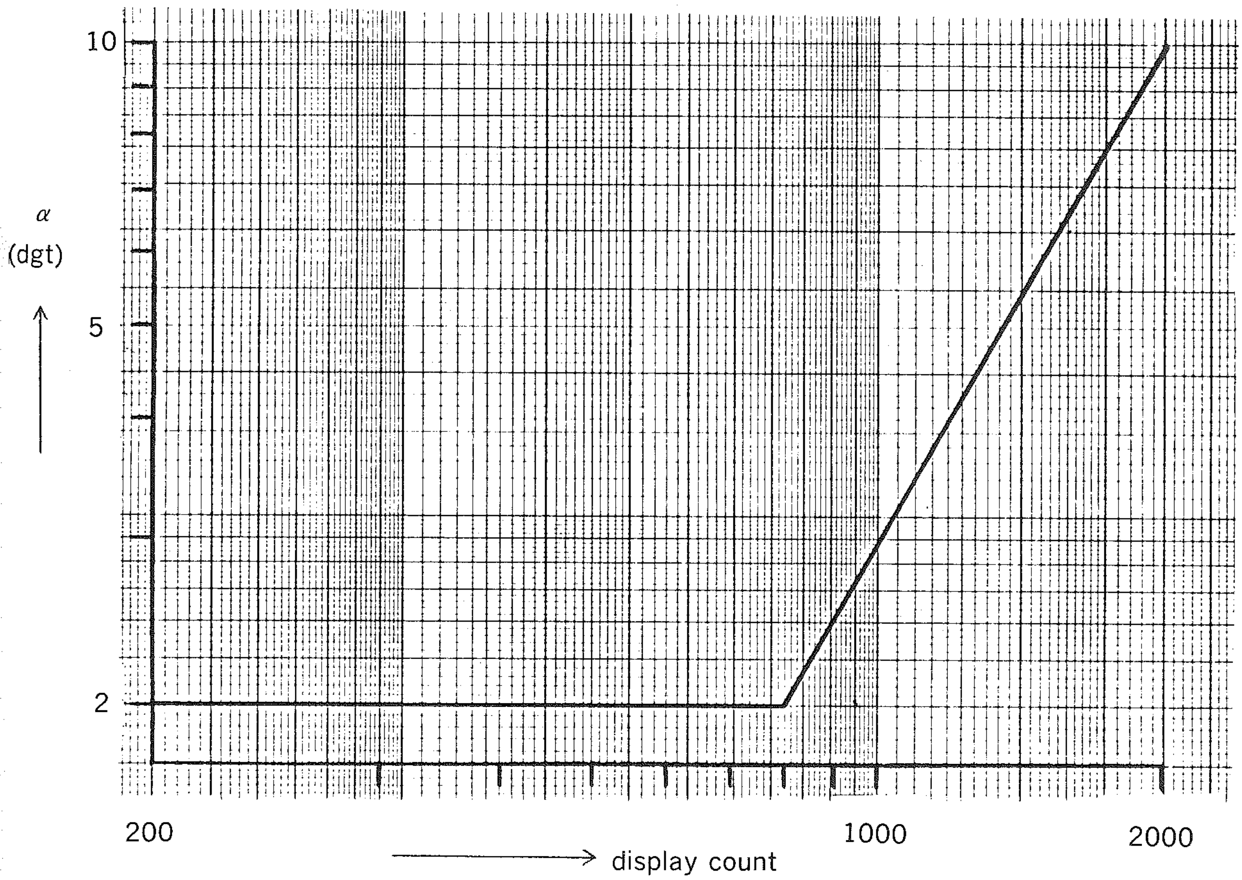
Accuracy upper line: C accuracy. α is operation deviation

Accuracy lower line: D accuracy. %rdg plus absolute value or operation coefficient

● Including marked frequency

○ Not including marked frequency

Fig. 5 C—D operation deviation (α) diagram

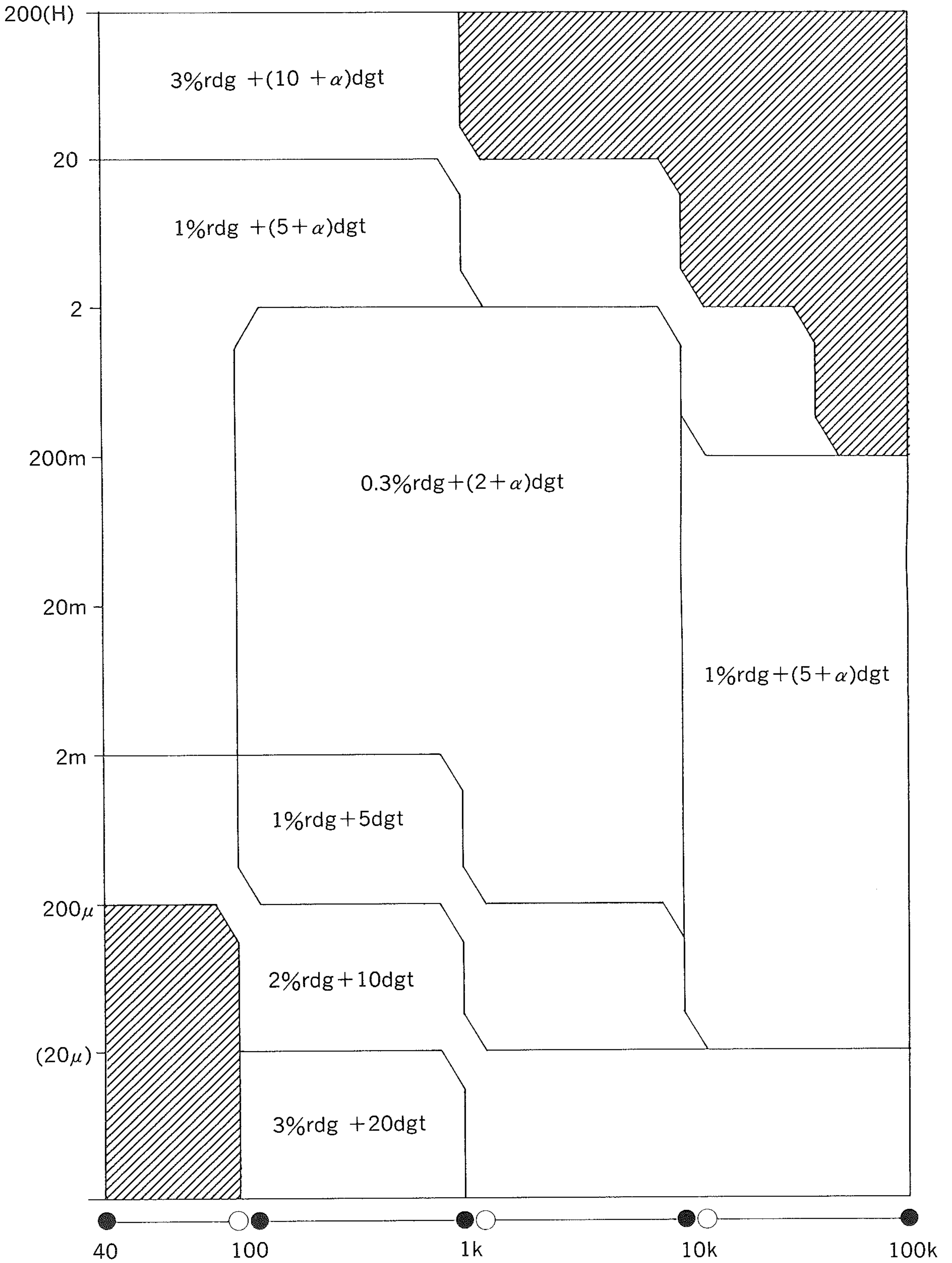


2-3-3 L-Q accuracy table (Fig. 6)

Q is calculated as 1/D

L range allowable phase angle 84 °min, Q≧10.Shaded areas cannot be measured.

Accuracy assured environment: 23±5°C, 80%RH max, no condensation.



L accuracy: α is operation deviation.

● Including marked frequency

○ Not including marked frequency

Fig. 7 D−Q operation deviation (α) diagram
(where Q is calculated as 1/D)

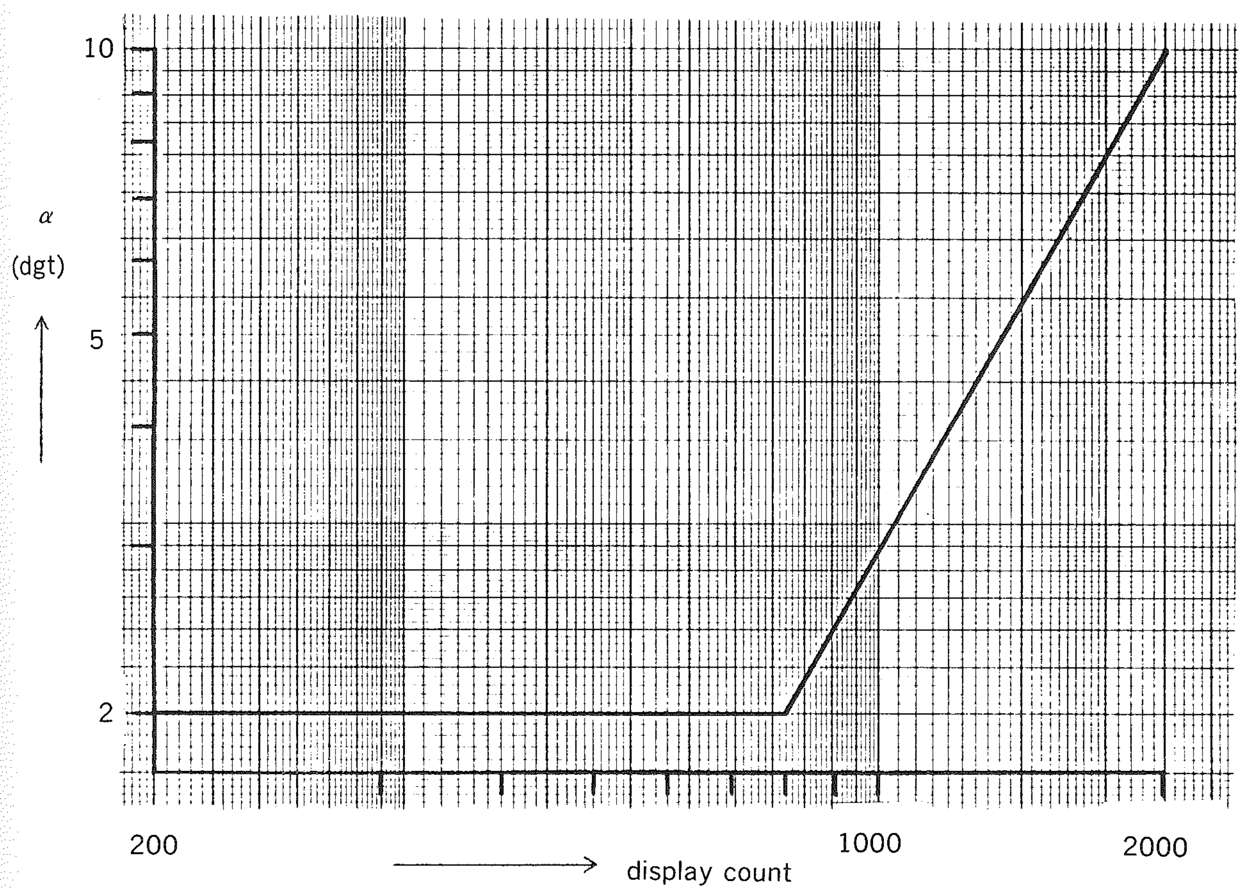
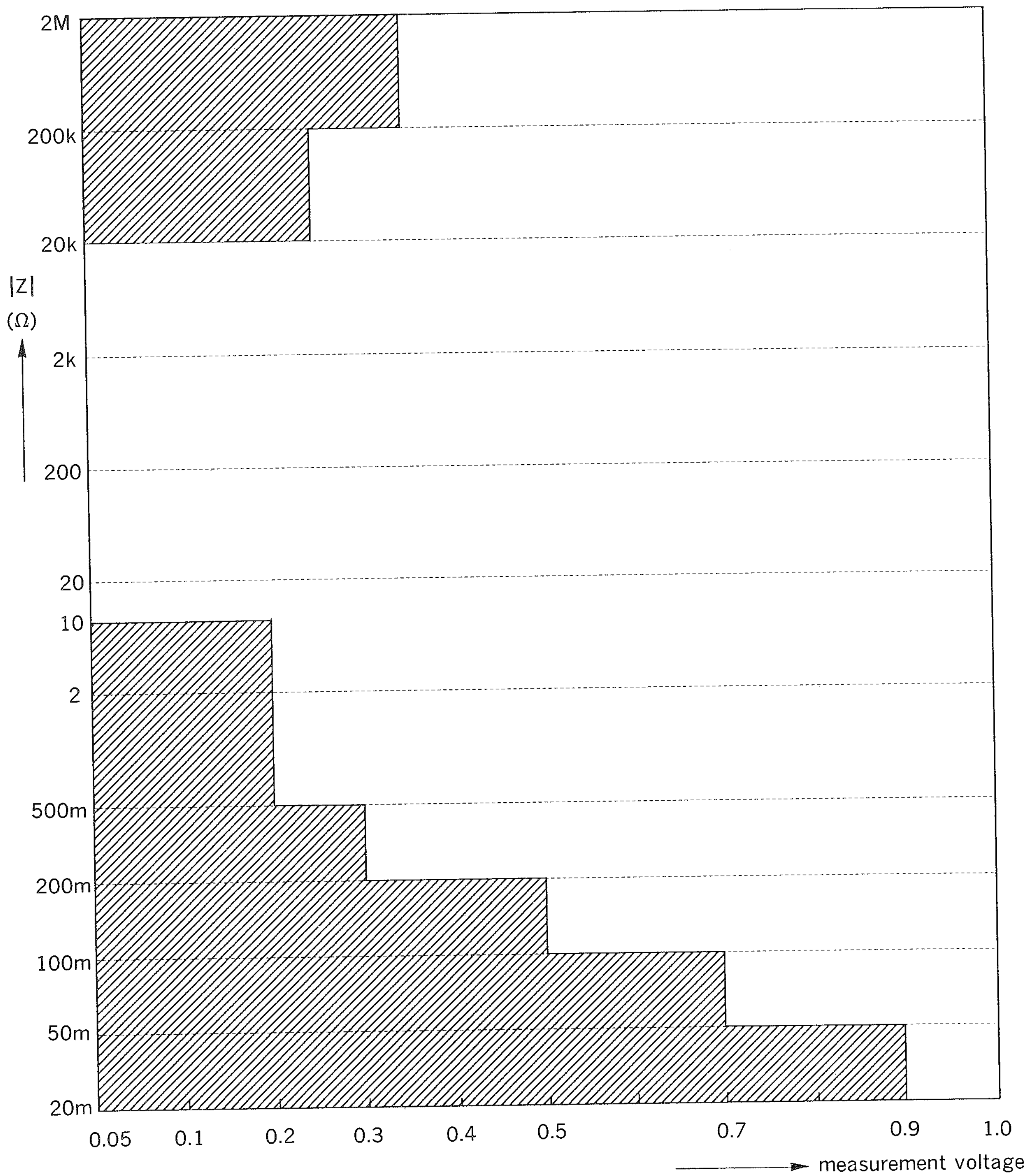


Fig. 8 (measurable ranges by signal level)

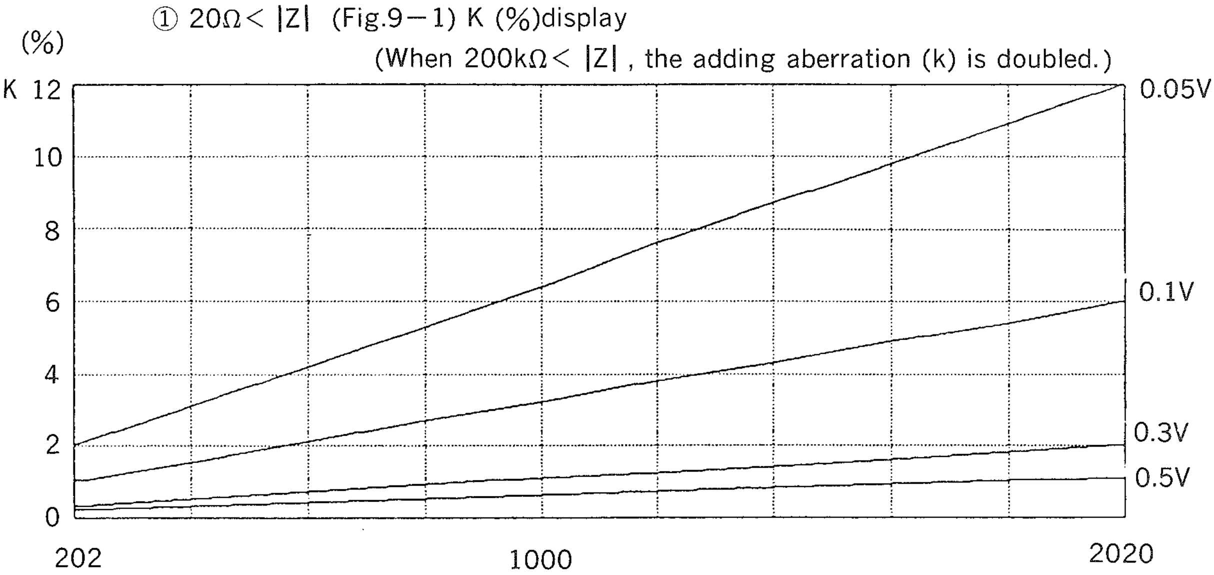
Shaded areas cannot be measured.



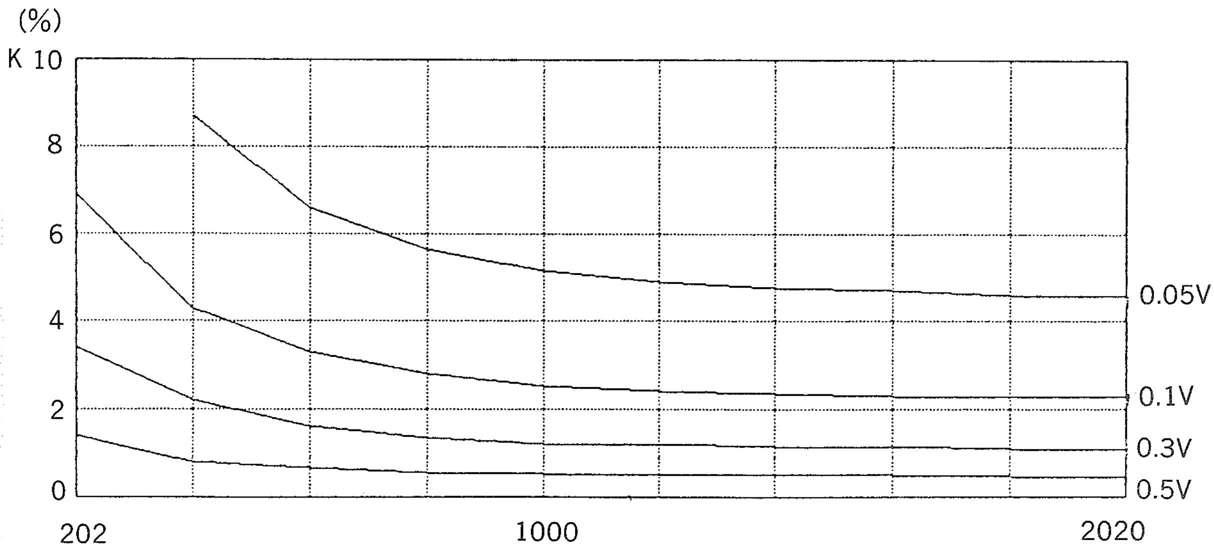
Added deviation for measurement signal level (K)

① 20Ω< |Z| (Fig.9−1) K (%)display

(When 200kΩ< |Z| , the adding aberration (k) is doubled.)

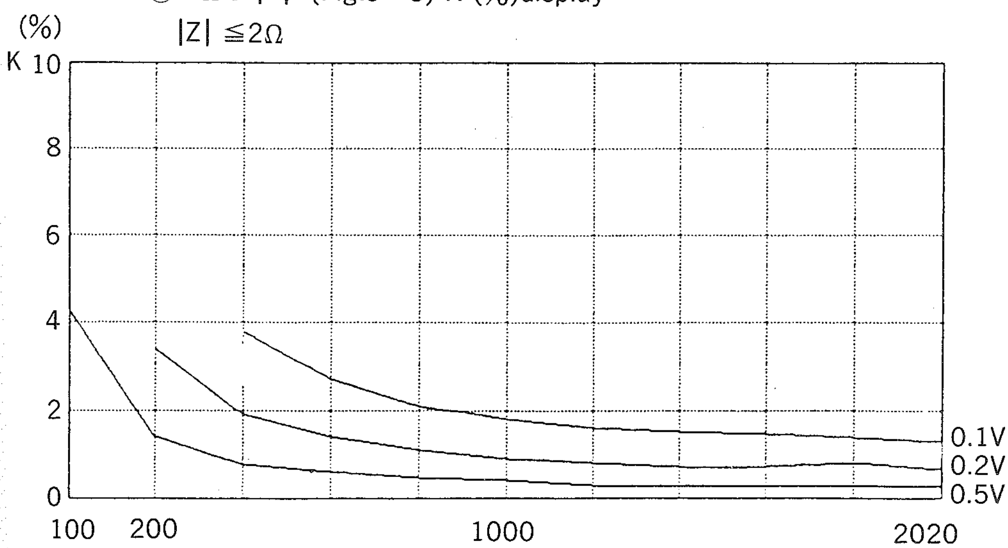


② 2Ω< |Z| ≦20Ω (Fig.9−2)K (%)display



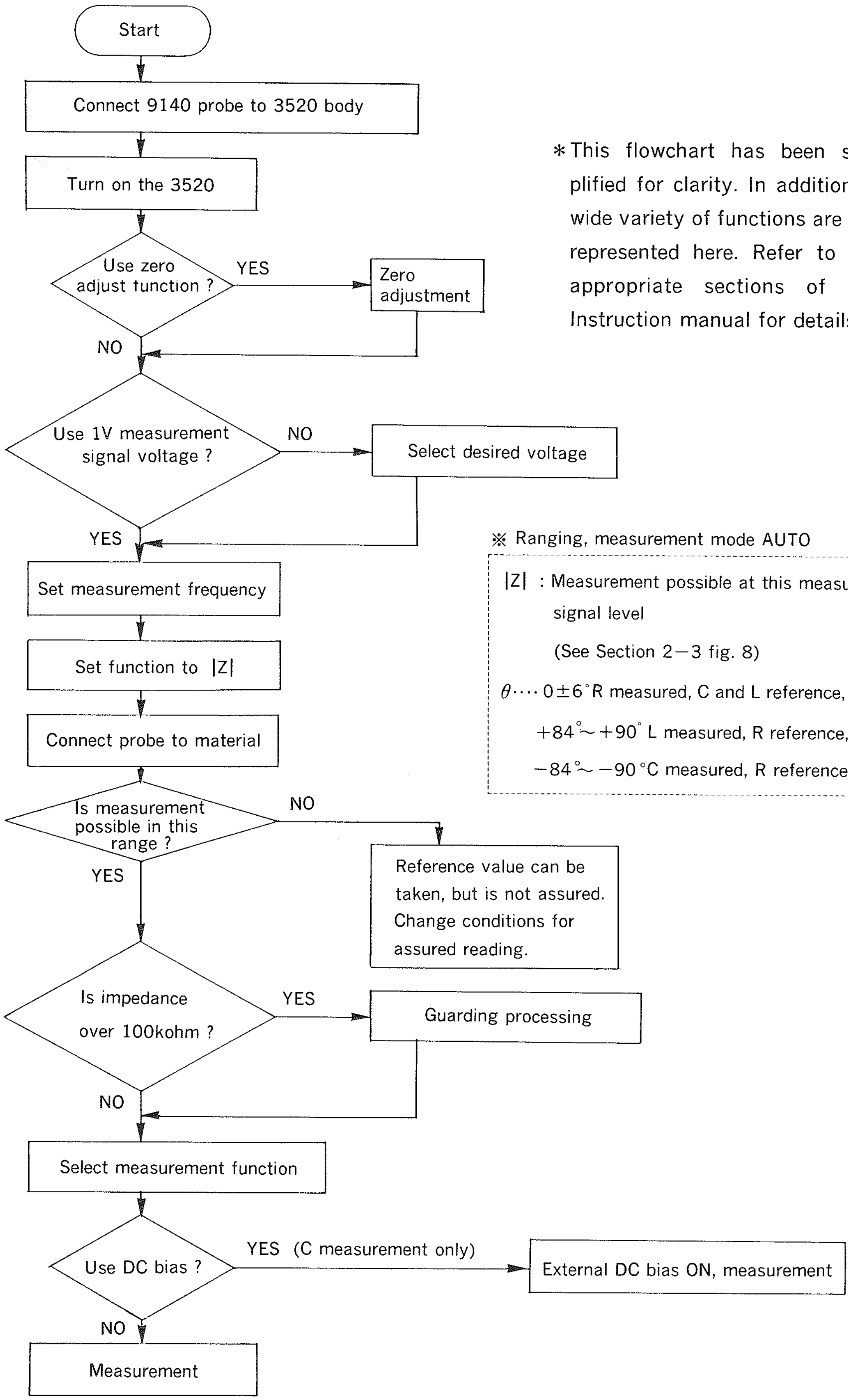
③ 2Ω≧ |Z| (Fig.9−3) K (%)display

|Z| ≦2Ω



3. Operation

General use of the 3520



* This flowchart has been simplified for clarity. In addition, a wide variety of functions are not represented here. Refer to the appropriate sections of the Instruction manual for details.

※ Ranging, measurement mode AUTO

|Z| : Measurement possible at this measurement signal level

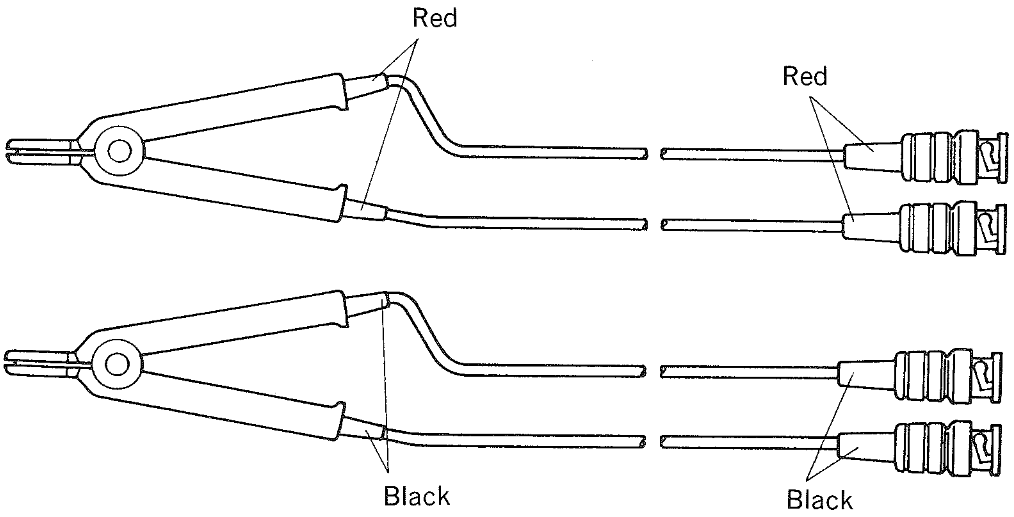
(See Section 2−3 fig. 8)

θ···· $0 \pm 6^\circ$ R measured, C and L reference,

$+84^\circ \sim +90^\circ$ L measured, R reference,

$-84^\circ \sim -90^\circ$ C measured, R reference

3–1 9140 4-terminal probe



- ○ The general probe used with the 3520 consists of a pair of clips, four leads and four BNC plugs.
- ○ The BNC plugs and the panel connectors are color-coded:

  Red: HCUR or HPOT terminals

  Black: LCUR or LPOT terminals

  Be sure to connect matching colors together.
- ○ Clips connected to red plugs are marked in red on the cable near the clip end.

⚠ **CAUTION**

- **When a DC bias is applied to polar materials for measurement, check the component polarity and red cable marks carefully to ensure polarity connections are correct.**
- **The system is designed to use a 75ohm coaxial cable 1 meter in length. Observe this fact carefully when redesigning applications.**
- **When the clips are shorted to each other, short them with a short metal lead between the jaws. Connecting the jaws to each other directly may result in poor connection.**
- **Never short the clips to each other when connected to a charged material or when DC bias is being applied, as this will damage the clip contact section. Damage in this location will effect measurement accuracy at high frequencies.**

3—2 Turning on the power

Connect the power cable to the AC power source inlet on the rear panel, and then press the power switch on the lower right corner of the front panel. When power is turned on all LEDs will light for a moment, and then assume the initial settings given below (if the lock function is engaged, the locked settings will be used).

Function: C—D measurement
Range: automatic
Measurement mode: automatic
Measurement frequency: 1kHz
Monitor: frequency monitor
Measurement voltage: as set the measurement voltage level select switch

⚠ NOTE

Always allow the system to warm up for at least 10 minutes before starting measurement.

3—3 Zero adjust

Where the probe is used without material for direct short or open tests, use the following procedure.

(1) Press the zero adjust key. The LED in the key face will flash.

(2) At the same time the measurement display for L, C, R and |Z| will display the numeral "5" (representing the S of Short), and the numeral will move to the left.

(3) Connect the clips of the 9140 4-terminal probe with a metal lead and press the zero adjust key. The short test will be started, and the residual components (inductance and resistance) of the probe will be measured. During this period, the zero adjust LED will flash, and nothing is displayed on the display panel.

⚠ NOTE

- **When the clips of the 9140 4-terminal probe are shorted to each other, short them with a short metal lead between the jaws. The lead should be as thick as possible. Connecting the jaws to each other directly may result in poor connection.**

(4) When the short test is completed the numeral "0" will be displayed (representing the O of Open) will be displayed in the L, C, R, |Z| display, and move to the left.

(5) Without connecting anything to the 9140 4-terminal probe, press the zero adjust key. The open test will be started and residual capacitance will be measured. When measurement is completed the zero adjust LED will stop flashing. (Nothing is displayed on the display panel during this period.)

(6) When the test is completed measurement with the zero adjust function operating is possible.

⚠ **NOTE**

- **When the result of the short test is not within the zero-adjustable range (L: 10μH, R: 0.1ohm max), the display will flash "5555". Press the zero adjust key again to stop the alarm display and return to the initial state. Check the probe short and try again.**
- **When the result of the open test is not within the zero-adjustable range (C: 10pF max), the display will flash "0000". Press the zero adjust key again to stop the alarm display and return to the initial state. Check the probe short and try again from the short test.**
- **The open test is easily affected by external stray radiation. Performance of this test on a metal sheet connected to the guard terminal is strongly recommended.**

(7) Pressing the zero adjust key will turn off the key face LED and disengage the zero adjust function. To turn this function back on again, the procedure must be started over again from the start.

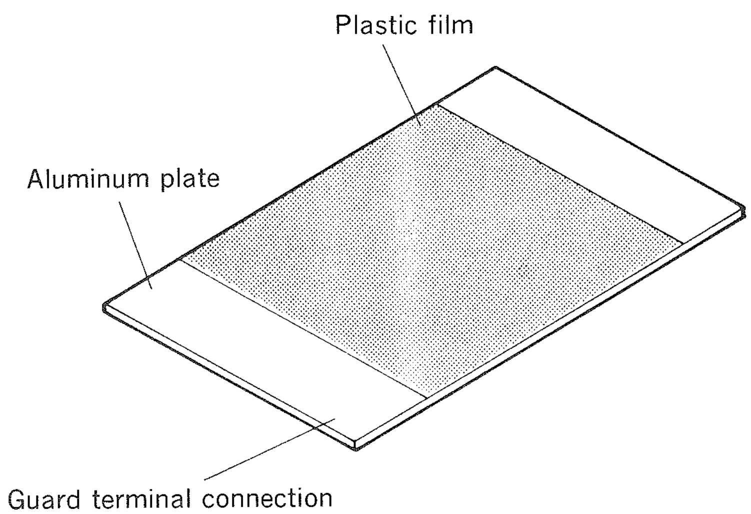
(8) After zero adjustment, if the function lock key is pressed and the lock function engaged, zero adjust data will also be saved.

3–4 Guarding processing

(1) Using the guard terminal for guarding processing will enhance precision in the measurement of high-impedance devices and in-circuit components.

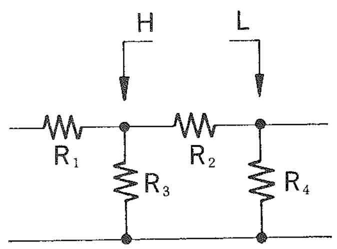
(2) Measurement of high-impedance devices

- High-impedance devices (e.g. resistors of 100kohm or higher, capacitors of 1nF or lower) are susceptible to the effects of external radiation and often suffer from instability in measurement. In these situations, measurement stability will be enhanced by measuring on an aluminum plate as indicated below. We recommend covering the top of the plate with a plastic film for insulation.



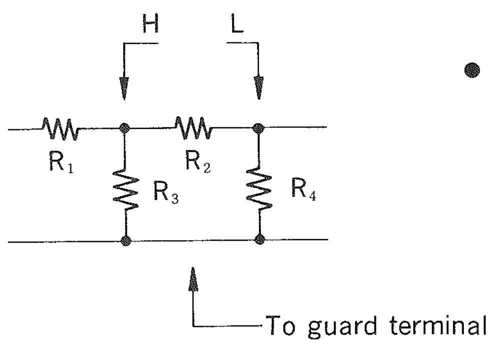
(3) Measurement of devices in-circuit

- Devices cannot be measured in-circuit unless guarding processing is used.



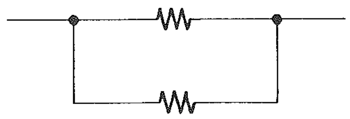
- In the circuit indicated to the left, measurement of resistance R_2 requires the probe tips to be connected on either end of R_2. The current flowing through resistor R_2 is added to the current passing through R_3 and R_4, and resistance measured is actually parallel resistance:

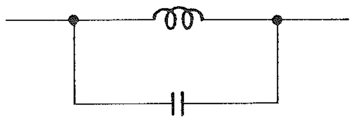
$$R = \frac{R_2(R_3 + R_4)}{R_2 + R_3 + R_4}$$



- In the circuit indicated to the left, the current passing through R_3 and R_4 is absorbed by the guard terminal, and measurement of resistance R_2 is possible. However, where $R_2 > R_3$, and R_3 is close to 0, there will be little improvement in precision.

⚠ COUTION





● Note that circuits as indicated to the left, composed of two resistors or a resistor and a coil, cannot be measured.

● Observe the following precautions when measuring a circuit in operation (charged).

○ Turn on the external DC bias.

○ When the probe is connected a charging current will flow into the 3520. Measurement will be impossible for this period, and the operation of the measured circuit may be abnormal for the same period.

○ After a single measurement is completed, always short the clips to each other through a resistor, or turn off the DC bias and discharge the 3520 internal charge. Where the voltage distribution of the measured circuit is different, performing the next measurement without discharging first could destroy the material (device) being measured through the charge.

3−5 R measurement

(1) Connect the probe and turn on the power.

(2) Set the following items:

①	Function: R
②	Range: auto or manual
③	Measurement mode: auto or manual
④	Measurement frequency
⑤	Measurement signal level

(3) Connect the probe to the material and the resistance will be displayed. The value displayed will be determined from the impedance $|Z|$ and the phase angle of current and voltage θ, as:

parallel equivalent circuit Rohm = $|Z| / \cos\theta$

series equivalent circuit Rohm = $|Z| \cdot \cos\theta$

⚠ NOTE

- **Where the material has high L or C components and the phase angle θ is large, $\cos\theta$ will approach zero, generating a large error. The allowable phase angle for resistance measurement is ±6° maximum, and measurements outside this range should be taken as reference only.**

(4) For zero adjustment, refer to Section 3−3.

(5) For measurement of materials with high resistance (100kohm or higher), refer to Section 3−4. The 3520 can measure from 40Hz, and therefore it may be affected by noise from AC lines and other sources, resulting in an unstable reading. Use guarding in these cases.

⚠ NOTE

- **When the L component of resistor leads or the stray capacitance is measured, be sure to use a frequency that is capable of measurement, and check the measurements for impedance $|Z|$ and phase angle θ.**
- **L and C measurement has a maximum allowable phase angle of ±84°～±90°, and measurements outside this range should be taken as reference.**

3–6 |Z| – θ measurement

(1) Connect the probe and turn on the power.

(2) Set the following four items:

①	Function: |Z|
②	Range: auto or manual
③	Measurement frequency
④	Measurement signal level
⑤	Measurement signal level

(3) Connect the probe to the material. The impedance |Z| and the phase angle θ between the measured current and voltage will be displayed.

Impedance |Z| is determined from measured current and voltage as:

$$|Z| = \frac{|V|}{|I|}$$

|Z| can be developed into the individual R, C and L components as:

Parallel equivalent circuits

$$|Z| = \frac{1}{\sqrt{(1/R)^2 + (\omega C)^2}}$$

$$|Z| = \frac{R \cdot \omega L}{\sqrt{R^2 + (\omega L)^2}}$$

Series equivalent circuits

$$|Z| = \sqrt{R^2 + (1/\omega C)^2}$$

$$|Z| = \sqrt{R^2 + (\omega L)^2}$$

(4) Phase angle θ is based on measured current, with the delay/advance of voltage to current expressed as polarity.

「+」 (no display): advance

「–」 : delay

Capacitance measurement will result in a 「–」 display, and inductance measurement in no display 「+」.

⚠ **NOTE**

- **When measuring coil impedance |Z|, there are situations where the phase angle may invert from 「+」 to 「−」, depending on the frequency.**
- **In coil measurement there are situations where a series resonant circuit may be formed with the capacitor used in the 3520 DC bias circuit. If there is no possibility that the coil phase would invert (resonate) at that frequency, it may be resonating with the internal capacitor, and the measurement frequency should be changed.**

(5) Refer to Section 「3−3 for zero adjustment.」

(6) Refer to Section 「3−4 for measurement of high-impedance」 (over about 100kohm) devices.

3−7 C, D measurement (capacitance-loss factor)

(1) Connect the probe and turn on the power.

(2) Set the following items:

①	Function: C
②	Range: auto or manual
③	Measurement mode: auto or manual
④	Measurement frequency
⑤	Measurement signal level

(3) Connect the probe to the material. The capacitance C and the loss factor D will be displayed. The displayed values will be:

parallel equivalent circuit,

$$\cdots\cdots\cdots C=\sin\theta/(\omega\cdot|Z|)$$
$$D=1/\tan\theta$$

series equivalent circuit,

$$\cdots\cdots\cdots C=1/(\omega\cdot|Z|\cdot\sin\theta)$$
$$D=1/\tan\theta$$

△ **NOTE**

- **If there is a large parallel or series resistance component in the material, the loss factor D will grow, the phase angle may exceed 90°. If this happens, θ will approach 0, sinθ will approach 0, and deviation will increase. L and C measurement has a maximum allowable phase angle of ±84°～±90°, and measurements outside this range (D≧0.1 or Q≦10) should be taken as reference.**

(4) When applying a DC bias to a polar capacitor use the following procedure:

(See part names and function at 3 page, ⑪ external DC bias below)

- Connect the DC bias input terminal to the DC voltage source.
- The input terminal 「+」 voltage will be input to the probe H_{CUR} terminal. For minus DC biasing, apply a minus voltage to the 「+」 input terminal.
- Connect the 9140 4-terminal probe to the material.
- Turn on the DC bias.
- When measurement is completed, turn off the DC bias. The material will be discharged through about a 50ohm resistance.
- Be sure to use a DC bias DC voltage power supply with a sufficiently low output impedance. If output impedance is too high the DC supply ripple will increase with the measurement signal and affect measurement.
- Under JIS C 5102, DC bias power supplies are specified as:

	Ripple		DC stability
	50～60Hz	100～120Hz	
A	2% Max.	1% Max.	±3%
B	0.1% Max.	0.1% Max.	±0.1%

(Source: JIS C 5102, Capacitance Testing for Electronic Equipment)

△ **COUTION**

- **Always double-check polarity. If polarity is reversed the material may be damaged.**
- **Measurement will be unstable while the material and the internal detection circuit capacitor are charging.**
- **The maximum DC bias is 30VDC. Never use higher voltages as device circuits will be damaged.**
- **After measurement either turn off the DC bias and discharge, or remove from the circuit and discharge thoroughly.**
- **Never short the 9140 4-terminal probe clips to each other the the DC bias on, as it will damage the clip connectors.**

(5) See Section 3−3 for zero adjustment.

(6) See Section 3−4 for measurement of capacitors under 1nF in capacity.

(7) Other

- For C measurement where the material is connected to a coil the phase angle will be reversed, but it will be converted to normal capacitance for display. This display has no meaning in real terms.
- It is impossible to measure coil or capacitor components individually in a parallel circuit with at both.
- Where it is unclear if the material content is a coil or a capacitor, determine the phase angle θ polarity and angle from impedance $|Z|$ measurement and use the following guide:

θ		Measurement item
Polarity	Angle	
+	≒90°	L measurement, R reference
+	≒ 0	R measurement, L reference
−	≒ 0	R measurement, C reference
−	≒90°	C measurement, R reference

3−8 L, Q measurement (inductance − Q(1/D) measurement)

(1) Connect the probe and turn on the power.

(2) Set the following five items:

①	Function: L
②	Range: auto or manual
③	Measurement mode: auto or manual
④	Measurement frequency
⑤	Measurement signal level

(3) Connect the probe to the material. The inductance L and the loss factor D will be displayed. The displayed values will be:

parallel equivalent circuit,

$L = |Z| / (\omega \cdot \sin\theta)$

$Q = \tan\theta$

series equivalent circuit,

$L = (|Z| \cdot \sin\theta) / \omega$

$Q = \tan\theta$

⚠ **NOTE**

- **If there is a large parallel or series resistance component in the material, the loss factor D will grow, and the phase angle will change from 90°. If this happens, θ will approach 0, sinθ will approach 0, and deviation will increase. L and C measurement has a maximum allowable phase angle of ±84°～±90°, and measurements outside this range (D≧0.1 or Q≦10) should be taken as reference.**
- **In inductance measurement where the frequency is changed and the measured value becomes unstable, verify the phase angle through |Z| −θ measurement. If frequency is changed and phase polarity inverts from 「+」 to 「−」, it is possible that series resonation has been generated with the measurement circuit internal capacitor. In this case, use a different frequency.**

(4) For measurement of current-dependent components such as choke coils, use the material terminal voltage monitor to check measurement conditions and ensure reproducability.

(5) See Section 3−9 for DC bias.

⚠ **NOTE**

- **The external DC bias terminal on the rear panel of the 3520 can only be used for DC voltage bias for capacitor measurement, and not as a DC bias for coil measurement.**

(6) See Section 3−3 for zero adjustment.

(7) See Section 3−4 for high-impedance coil measurement.

(8) Other

- For L measurement where the material is connected to a coil the phase angle will be reversed, but it will be converted to normal inductance for display. This display has no meaning in real terms.
- It is impossible to measure coil or capacitor components individually in a parallel circuit with at both.
- Where it is unclear if the material content is a coil or a capacitor, determine the phase angle θ polarity and angle from impedance |Z| measurement and use the following guide:

θ		Measurement item
Polarity	Angle	
+	≒90°	L measurement, R reference
+	≒ 0	R measurement, L reference
−	≒ 0	R measurement, C reference
−	≒90°	C measurement, R reference

3—9 DC bias

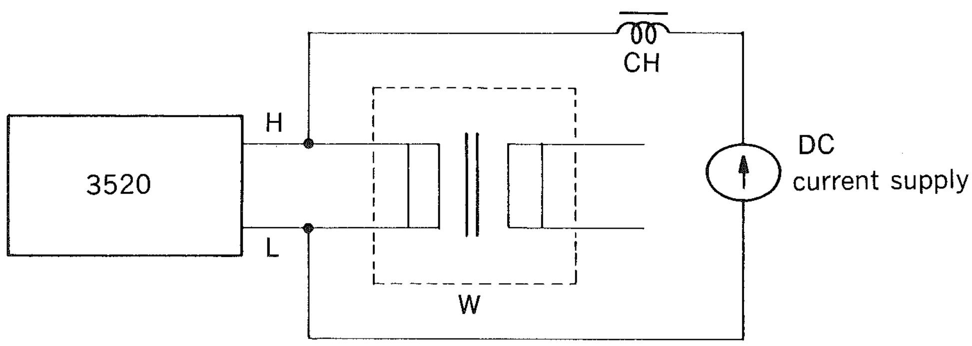
(1) DC bias is used to apply a DC voltage to voltage-dependent components such as electrolytic capacitors and ceramic capacitors.
For current-dependent devices such as choke coils, bias is applied as a DC current. The 3520 external DC bias terminal is a voltage bias terminal, and can only be used for DC voltage bias for capacitors.

(2) DC voltage bias for capacitors

- Take care of the polarity for connections between external DC bias input terminal and power supply, probe and panel plugs, and probe and material.
- Never use a DC bias over 30VDC.
- Measurement will be unstable when a DC bias is applied to a capacitor, for the period while the measured capacitor and the internal capacitor are charging.
- After measurement turn off the DC bias and disconnect the probe only after full discharge, or disconnect the probe with the DC bias on and then discharge completely.
- Never short the clips of the 9140 4-terminal probe together with the DC bias on. The clip contacts will be damaged.
- If a voltage is applied to the external DC bias terminal but there is no DC voltage applied to the material even when the DC bias switch is turned on, the internal fuse may be blown. Please contact your service representative.

(3) DC current bias for transformers and choke coils

- The 3520 external DC bias input terminal cannot use DC current bias.
- For DC current bias for transformers and choke coils, construct an external bias circuit as indicated below (as per JIS C—6435):



- Turn the 3520 DC bias switch on, as measurement is not possible when off.
- Ensure that the impedance of choke coil CH is sufficiently larger than the impedance of the material W.
- Do not magnetically saturate the choke coil with the DC bias current.

3–10 Measurement time

(1) The basic measurement times are:

40~990Hz	approx. 960msec
1~100kHz	approx. 360msec

(2) This time is the time required for measurement itself, and does not include time required for computation or auto-ranging.

(3) In the manual range detection circuits are switched to measured impedance. For this reason, this switching time must be added whenever the probe is disconnected and reconnected.

3–11 Measurement voltage

(1) The 3520 can vary the voltage applied to the material to test voltage dependence of current/voltage-dependent materials.

(2) The 3520 is suited to materials requiring low-voltage measurement, such as semiconductors.

(3) Measurement voltage can be varied from 1V rms to 0.5V rms. This voltage is the voltage generated by the 3520 measurement signal generator, and not the potential between the probe terminals. Check the voltage between the probe terminals with the level monitor.

(4) If the current flowing in the material is required, measure the impedance and at the same time monitor the voltage between the probe terminals, and then convert as:

$$|I| = |V| / |Z|$$

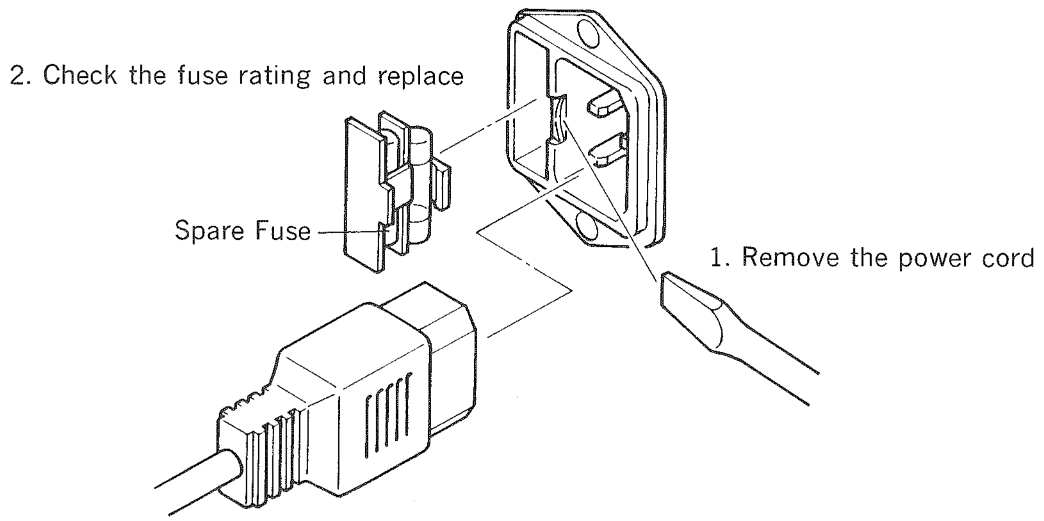
This operation can be performed with the GP–IB interface (see Section 5).

(5) Accuracy drops as measurement voltage is decreased (see Section 2–3 (3)).

4. Inspection and maintenance

1. Fuse replacement

Disconnect the power cord. Use a blade screwdriver to open the cover of the fuse holder, and remove the damaged fuse. Check that the new fuse is of the correct rating before inserting it. A spare fuse is mounted inside the fuse holder.



2. When the machine does not work correctly.

Before calling a service technician.

● LEDs don't light	● Check fuse
● Display doesn't change even when connected to material	● Check 9140 4-terminal probe for damage or bad connection
● DC voltage not output even when DC bias applied	● Check cable for damage

※If the cause of the problem is not clear, please consult your service representative.

5. GP−IB interface

(3520−01 Instruction Manual)

Contents

5−1 Outline

This device can be controlled through an IEEE488−1978 instrumentation bus (GP−IB: General Purpose Interface Bus).

5−2 General specifications

Compatible standard: IEEE Std. 488−1978
Interface function

Table 6−1 Interface Functions

Code	Function
SH1	All source handshake functions
AH1	All acceptor handshake functions
T6	Basic talker function Serial poll function Listener-specified talker release function No talk only mode
L4	Basic listener function Talker-specified listener release function No listen only mode function
SR1	All service request functions
RL1	All remote/local functions
PP0	No parallel port functions
DC1	All device clear functions
DT1	All device trigger functions
C0	No controller functions

Code used: ASCII

5−3 Panel explanation

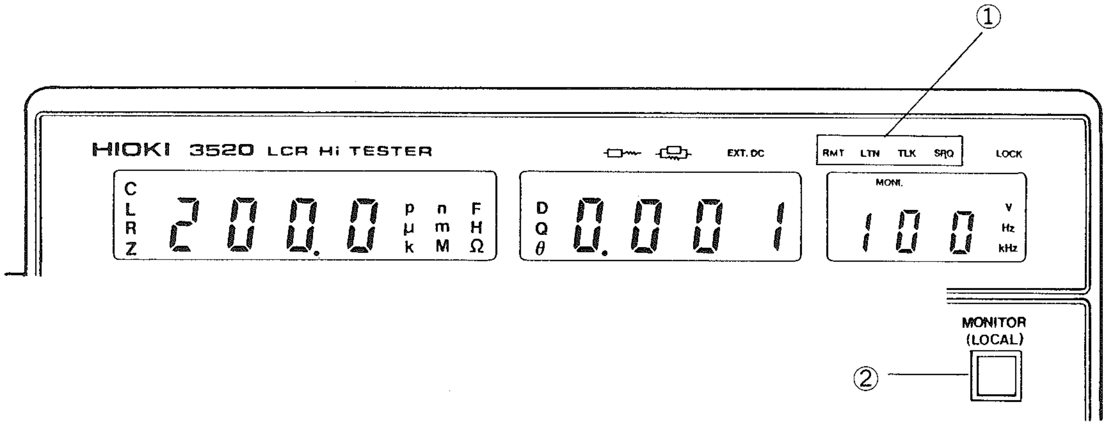


Fig. 5−1 3520 Front Panel Display

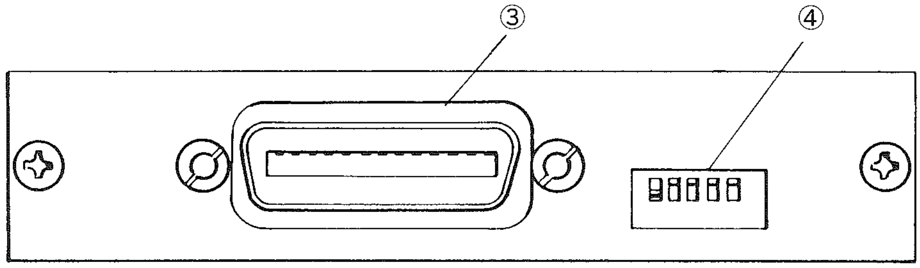


Fig. 5−2 3520 Rear Panel Expansion Slot

① GP−IB interface status

This indicates the status of the system when controlled by an external computer through the GP−IB interface.

RMT : Lights when system in remote status
LTN : Lights when system is receiving data
TLK : Lights when system is transmitting data
SRQ : Lights for a service request

② Local key

Pressing this key cancels the GP−IB remote status and returns the system to local control. However, if a local lockout command has been issued by the controller this key is disabled.

③ **GP—IB connector**

④ **Address switch**

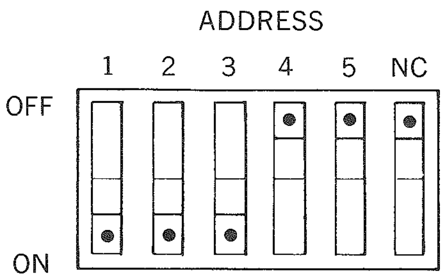


Fig. 5—3 Address Switch

1) Address setting

The GP—IB address is set by the address switches on the back Panel. The address-consists of 5 bit (ADDRESS 1—5), so there are 31 different addresses that can be set.

For example. Fig. 5—3 shows an address setting of 11100, covresponding to a decimal value of 7. (Note that ADDRESS 1 is the LSB).

⚠ NOTES

- **GP—IB addresses for the 3520 are set with the switch on the back panel. The five slide switches set a 5—bit number, which may be any of the possible 31 combinations.**
- **The only combinations which cannot be used is address 31, where all switches are on.**
- **The switch setting is read in when the power is turned on, or when an interface clear signal is received. As a result, one of these two triggers must be activated when the switch setting is changed.**
- **Unless one of these two triggers is activated, the current switch setting will not change.**
- **When connecting the 3520 to a controller through a GP—IB cable, the two cases will be shorted together.**

5–4 Listener function

Measurement parameters can be set externally, from the controller. The program codes for this are listed below.

(1) **Function "Fn" (n is a numeral, default is F1)**

F 1 : C (capacitance)
F 2 : L (inductance)
F 3 : R (resistance)
F 4 : |Z| (impedance)

(2) **Range "Rn" (n is 0 to 8 numeral, default is R0)**

Table 5–2 Range codes for each function

range code \ function	C	L	R	|Z|
R0	auto	auto	auto	auto
R1	2000μF	200μH	2Ω	2Ω
R2	200μF	2mH	20Ω	20Ω
R3	20μF	20mH	200Ω	200Ω
R4	2μF	200mH	2kΩ	2kΩ
R5	200nF	2H	20kΩ	20kΩ
R6	20nF	20H	200kΩ	200kΩ
R7	2nF	200H	2MΩ	2MΩ
R8	200pF	—	—	—

(3) **Mode "Mn" (n is a 0, 1, and 2 numeral, default is M0)**

- M 0 : Automatic mode
- M 1 : Series equivalent circuit mode
- M 2 : Parallel equivalent circuit mode

(4) **Frequency (3-digit maximum)**

- H Z n n 0 (nn is a number from 4~99)
- k H Z n. n. n 〔(n. n. n is a number from 0.04 to 100, default setting is kHZ1.00)〕

⚠ **NOTE**

- **Insert the decimal point where needed, and never use more than 3 digits.**

(5) **Level**

V n. n n n 〔(default is V1.000. n is a number from 0.050 to 1.000, in 0.005 steps)〕

⚠ **NOTE**

- **Codes 1 through 5 above can be sent together. Codes 6 through 10 must be sent individually. If they are sent with other codes a sensing error will occur and all codes will be ignored.**
- **Code 1 will automatically set range and mode to automatic (R0, M0).**

(6) **Zero adjust "ZAn" (n is 0, 1, and 2 numeral, default is ZA0)**

Z A 0 : Off

Z A 1 : Short test

Z A 2 : Open test

⚠ **NOTE**

- **Refer to Section 5–5 for zero adjustment.**

(7) **Function lock "Ln" (n is 0 and 1 numeral, default is L0)**

L 0 : off

L 1 : on

(8) **Frequency/level display "Dn" (n is 0 or 1 numeral, default is D0)**

D 0 : frequency display

D 1 : level display

(9) **Service request mask**

S M K n n n (n is a numeral, default is SMK0)

[nnn is a number from 0 to 127, and is used to select factors for SRQ transmission and status byte contents.]

⚠ **NOTE**

- **Refer to 5−7 (2) for setting method.**

(10) **Output format specification**

O F M n n n (n is a numeral, default is OFM31)

[nnn is a number from 2~127, with other numbers resulting in the default setting.]

⚠ **NOTE**

- **Refer to 5−9 (2) for setting method.**

5−5 Zero adjustment

During zero adjustment, all commands other than zero adjustment commands are ignored.

(1) Short out the probe.
(2) Transmit the ZA1 command. The display will go out and the short test begin. The LED in the ZERO ADJ. key will flash.
(3) When the short test is completed the completion signal SRQ "ZA" will be sent, and a single 0 will be displayed in the CLRZ display. This 0 will move to the left across the display. Start the open test next, without connecting anything to the probe.
(4) Transmit the ZA2 command. The display will clear and the open test start.
(5) When the open test is completed the system will generate the SRQ "ZA" and the display will light. The LED in the ZERO.ADJ key will stay on indicating that the zero adjust is engaged.
(6) After zero adjustment, sending the ZA0 command will turn off the LED of ZERO. ADJ key and cancel zero adjustment.

⚠ **NOTE**

- **If the result of the short or open test is outside the correctable range, an error SRQ will be generated, and the display will flash "5555" (for short) or "0000" (for open). Sending a ZA0 command will return the system to non−adjusted operation.**

5−6 Talker function

(1)

Data format

① ② ③ ④ ⑤ ⑥ XX

Table 5−3 Output Format by Data Type

Order	Data type	Output format
①	CLRZ	ADDDDDE±NNx
②	DQθ	AADDDDDx
③	MODE	ADx
④	Frequency	ADDDDE+NNx
⑤	Voltage monitor	ADDDDDx
⑥	Current monitor	ADDDDDE−NN

x: " , " can be used as the secondary delimiter

XX: primary delimiter is CR/LF (see (2) below)

① C, L, R and |Z| values

- **A portion: header**

Header	Content
C	Capacitance
L	Inductance
R	Resistance
Z	Impedance

- D portion: mantissa (5 digits including decimal point)
- E±NN portion: ordinate

  E−12 through E+06, in 10E+03 steps

② **D, Q and θ values**

- A portion: header (only PH is two characters)

Header	Content
D	Loss factor
Q	Inverse of loss factor
PH	Phase angle

- D portion: data (digits vary with header)

Header	Content
D	4 digits with decimal point
Q	3 digits with decimal point
PH	3 digits with decimal point

③ **Measurement mode**

- A portion: Header is "M"
- D portion: Indicates parallel or series mode

D portion	Content
1	Series equivalent circuit
2	Parallel equivalent circuit

④ **Frequency**

- A portion: Header is "F"
- D portion: mantissa (4 digits including decimal point)
- E+NN portion: ordinate, E+00 or E+03

⑤ **Voltage monitor**

- A portion: header is "V"
- D portion: Data (5 digits including decimal point), units are V (volts)

⑥ **Current monitor**

- A portion: Header is "A"
- D portion: mantissa (5 digits including decimal point)
- E−NN portion: ordinate, E−03, E−06 or E−09

⚠ **NOTE**

- **Separate data with the secondary delimiter " , ".**
- **Output is in the order given in Table 5−3.**
- **Output will be from 1 to 4 unless the output format program is set.**

(2) **CR LF delimiter**

The primary delimiter is CR/LF, and EOI is output at the same time as the LF.

5−7 Service requests (SRQ)

(1) SRQ status byte

Fig. 5−4 Status Byte

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0	SRQ	ZA	ERR	UND	OVR	END	SE

Fig. 5−5 Bit Significance in Status Byte

bit	Value	Code	Status	Meaning
0	1	SE	Setting error	Error in program code
1	2	END	Measurement complete	Measurement was completed
2	4	OVR	Overrange	Measurement data exceeded the present range
3	8	UND	Underrange	Measurement data was too small for the present range
4	16	ERR	Error	Memory back−up error, zero adjustment error, etc.
5	32	ZA	Zero adjust complete	Set when zero adjustment short test and open test completed
6	64	SRQ	SRQ	Requesting service
7	128	0	Unused	Always set to 0

In response to a serial poll from the controller the status bytes given above are output. The output value is the total of the values assigned to the individual bits.
However, where bits corresponding to the SRQ mask are set to 0, they are output as 0.

(2) **SRQ mask setting**

It is possible to designate conditions which will generate SRQ.

○ Mask setting method

Mask set in the unit is handled by bits 0 through 6 of the status byte. Masking bit 6 specifies whether a service request is sent or not. For example, to generate an SQR for OVR, END or SE, set 1 to bits 0, 1, 2 and 6 as indicated in Fig. 6—5, and set the other bits to 0. The 3520 can be set in decimal notation, making the masking number is this case 71 (base 10). The set can be accomplished with the mask program code SMK. The default setting for all bits is 0.

6	5	4	3	2	1	0	← Bit
0	0	0	0	0	0	0	← Bit value

(a) SRQ mask bit pattern default settings

⇩

6	5	4	3	2	1	0	← Bit
1	0	0	0	1	1	1	← Bit value
64	32	16	8	4	2	1	← Value (decimal)

Mask set value

$64+2+1=(71)_{10}$

(b) Mask bit pattern for SRQ transmission for OVR, END and SE

Fig. 5—5 Mask Set Method

5—8 Enquiry codes

Table 5—6 Enquiry Codes

Code	Content
Q0	Reads content of output format program
Q1	Reads voltage level set value
Q2	Reads zero adjust on/off
Q3	Reads if function lock is on/off
Q4	Reads if DC bias is on/off
Q5	Reads SRQ mask setting

This system can read the above six function settings with these enquiry codes. The output format is output only once, as indicated below, in the first talker following the code transmission.

Table 5—7 Output Formats for Enquiry Codes

Code	Output format
Q0	OFMddd (d is a value, see note 1)
Q1	d.dddV (d is a value)
Q2	Z.ADJ ON or Z.ADJ OFF
Q3	LOCK ON or LOCK OFF
Q4	BIAS ON or BIAS OFF
Q5	SMKddd (d is a value, see note 2)

⚠ **NOTE**

1. **ddd is the value set in the output format program (Section 5—9).**
2. **ddd is the value set in Section 5—7.**

5−9 Output format program

(1) Output format register

Fig. 5−6 Output Format Register

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0	A MONI	V MONI	f	MODE	DQθ	CLRZ	header

Fig. 5−8 Output Format Register Bit Meanings

bit	val-ue	code	meaning
0	1	header	header on/off setting
1	2	CLRZ	function
2	4	DQθ	loss factor, inverse of loss factor, phase angle
3	8	MODE	mode type
4	16	f	frequency
5	32	V MONI	voltage monitor
6	64	A MONI	current monitor
7	128	0	unused

(2) **Output format setting**

Setting output format conditions allows only desired data to be output. The set value is the total of the values assigned to individual bits.

○ Output format set method

For example, with the ON header, directing an output of CLRZ, DQθ, MODE, f, and V_{MONI} would require setting bits 0 through 5 to 1 as indicated in Fig. 5−7, and other bits to 0. The 3520 can be set in decimal notation, making the masking number is this case 63 (base 10). The set can be accomplished with the mask program code OFM. The default is 31 (decimal), which is header ON, CLRZ, DQθ, MODE and f output).

7	6	5	4	3	2	1	0	← Bit
0	0	0	1	1	1	1	1	← Bit value

(a) Default setting for output format code

⇩

7	6	5	4	3	2	1	0	← Bit
0	0	1	1	1	1	1	1	← Bit value
24	64	32	16	8	4	2	1	← Value (decimal)

Coad set value

$32+16+8+4+2+1=(63)_{10}$

(b) Bit pattern for header ON, XLRZ, DQθ, MODE, F and V_{MONI}.

Fig. 5−7 Output format Set Method

⚠ **NOTE**

- For function Z, setting OFM8 or OFM9 will result in output data "ERROR".

5—10 GP—IB commands

(1) **GET (Group Execute Trigger)**

Start measurement command

- When measurement is completed the values are held. This hold is released when a value for C—L—R— |Z| , or for D—Q—θ is output.

(2) **DCL (Device Clear)**

SDC (Selected Device Clear)

The following default settings are used:

Function	C—D
Range	auto
Mode	auto
Frequency	1kHz
Level	1.000V
Zero adjust	OFF
Lock	OFF

5−11 Sample program library

This sample program library was constructed in HP−9000 series 300 BASIC4.0 and PC−9801VM N88−BASIC (86). The 3520 GP−IB address is 1.

(1) Set output format, function, range and frequency and display measured data.

```
10     CLEAR 701
20     OUTPUT 701;"OFM127"
30     DIM A$[50]
40     OUTPUT 701;"F1R4KHZ1"
50     WAIT 1.5
60     ENTER 701;A$
70     PRINT A$
80     END
```

○ Program points

10: Device clear

The 3520 is initialized, and set the initial status indicated in Section 5−10 (2) DCL command.

50: Wait

When the initial state and the set (line 40) differ, leave sufficient relay time.

Run results

```
C0.218E-06,D0.008,M1,F1.00E+03,V0.991,A1.36E-03
```

● The same program for the PC−9801 is:

```
10 CMD DELIM=0
20 ISET IFC
30 ISET REN
40 WBYTE &H40,&H3F,&H21,
&H4;
50 PRINT @1;"OFM127"
60 PRINT @1;"F1R4KHZ1"
70 FOR I=1 TO 4000
80 NEXT I
90 LINE INPUT @1;A$
100 PRINT A$
110 END
```

(2) When many of the same type of capacitor are to be measured, measurement will start when a 1 is input, and complete when a 2 is input. Measurement time is determined with an SRQ.

```
10     CLEAR 701
20     N=0
30     DIM A$[50]
40     OUTPUT 701;"F1R7KHZ1"
50     OUTPUT 701;"OFM127"
60     OUTPUT 701;"SMK78"
70     A=0
80     INPUT "ｿｸﾃｲ......1,  ｼｭｳﾘｮｳ......2",A
90     IF A<=0 THEN 80
100    IF A>=3 THEN 80
110    IF A=2 THEN 340
120    OUTPUT 701;"F1R7KHZ1"
130    P=SPOLL(701)
140    TRIGGER 701
150    ON INTR 7 GOTO Pri
160    ENABLE INTR 7;78
170    GOTO 170
180    !
190    !
200 Pri:   P=SPOLL(701)
210        IF P=66 THEN
220        IF N=1 THEN
230        ENTER 701;A$
240        PRINT A$
250        GOTO 70
260        END IF
270        N=1
280        GOTO 300
290        END IF
300        ENTER 701;A$
310        GOTO 120
320    !
330    !
340    END
```

○Program points

120: Each time measurement starts the system is reset, in case the system has been switched to local.

130: Serial polling is handled before the trigger (GET) to reset SRQ output.

200~310:
Triggered measurement is repeated until SRQ content is P=66 (measurement completed). The first data received when P=66 is discarded, and the result for the next data displayed. Line 300 is a trigger to reset the held values through a dummy read.

Run results

```
C1.536E-09,D0.008,M2,F1.00E+03,V0.992,A09.6E-06
C1.493E-09,D0.008,M2,F1.00E+03,V0.992,A09.3E-06
C1.501E-09,D0.008,M2,F1.00E+03,V0.992,A09.4E-06
C1.430E-09,D0.008,M2,F1.00E+03,V0.992,A08.9E-06
C1.348E-09,D0.008,M2,F1.00E+03,V0.992,A08.4E-06
```

● The same program as written for the PC−9801:

```
10 CMD DELIM=0
20 ISET IFC
30 ISET REN
40 WBYTE &H40,&H3F,&H21,
&H4;
50 N=0
60 PRINT @1;"F1R7KHZ1"
70 PRINT @1;"OFM127"
80 PRINT @1;"SMK78"
90 A=0
100 INPUT "ｿｸﾃｲ......1,
 ｼｭｳﾘｮｳ......2    ",A
110 IF A<=0 THEN 100
120 IF A>=3 THEN 100
130 IF A=2 THEN 360
140 PRINT @1;"F1R7KHZ1"
150 POLL 1,P
160 WBYTE &H40,&H3F,&H21
,&H8;
170 ON SRQ GOSUB 220
180 SRQ ON
190 GOTO 190
200 '
210 '
220 POLL 1,P
230 IF P=66 THEN
240 IF N=1 THEN
250 LINE INPUT @1;A$
260 PRINT A$
270 GOTO 90
280 END IF
290 N=1
300 GOTO 320
310 END IF
320 LINE INPUT @1;A$
330 GOTO 140
340 '
350 '
360 END
```

(3) The frequency is varied from 1kHz to 100kHz in 1 kHz steps to measure resonant point, resonant impedance and phase angle for an L—C circuit. The results are displayed in a graph (|Z| MAX ≦ 1 kohm).

```
10    GCLEAR
20    PLOTTER IS CRT,"INTERNAL"
30    GRAPHICS ON
40    WINDOW 0,3.5,0,4.1
50    MOVE 1,1
60    PLOT 1,1
70    PLOT 3,1
80    PLOT 3,4
90    MOVE 1,1
100   PLOT 1,1
110   PLOT 1,4
120   PENUP
130   FOR I=1 TO 4
140   PLOT 1,I
150   PLOT 1.03,I
160   PENUP
170   PLOT 3,1+I*3/4
180   PLOT 2.97,1+I*3/4
190   PENUP
200   NEXT I
210   FOR I=1 TO 3
220   PLOT I,1
230   PLOT I,1.1
240   PENUP
250   NEXT I
260   MOVE .7,2.5
270   LABEL "Z"
280   MOVE .65,1
290   LABEL "1"
300   MOVE .65,2
310   LABEL "10"
320   MOVE .65,3
330   LABEL "100"
340   MOVE .65,3.9
350   LABEL "1k"
360   MOVE 1,.8
370   LABEL "1k"
380   MOVE 1.9,.8
390   LABEL "10k"
400   MOVE 2.8,.8
410   LABEL "100k"
420   MOVE 1.5,.8
430   LABEL "f"
440   MOVE 3.1,1
450   LABEL "-90"
460   MOVE 3.1,1+3/4
470   LABEL "-45"
480   MOVE 3.1,1+3/2
```

○ Program points

10～570:

Graph scaling and label generation

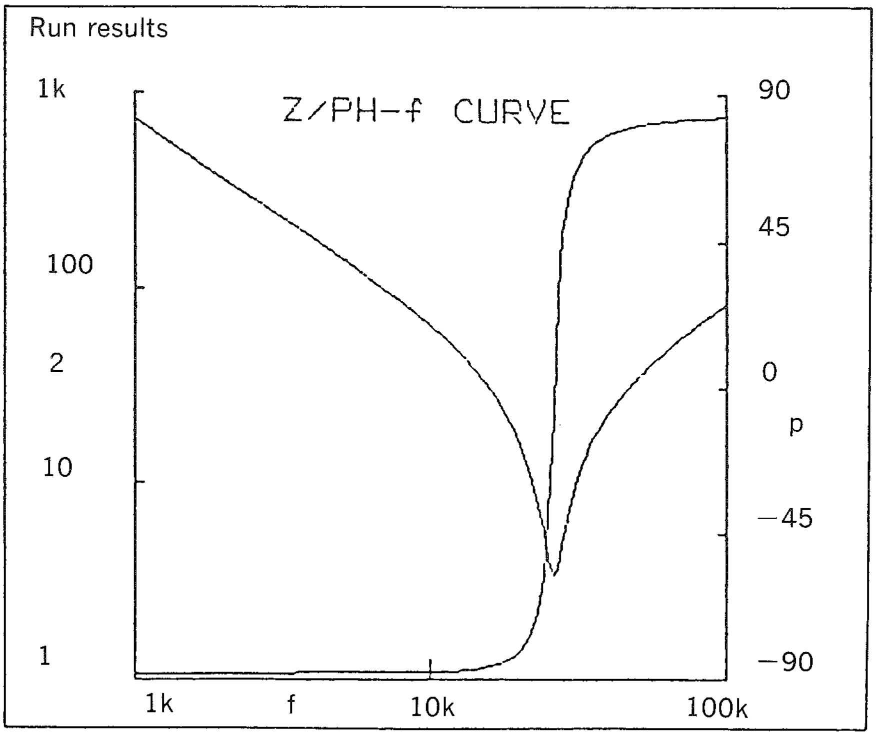
740～780:

Autoranging is used and therefore remeasurement is needed for over-range and underrange results.

830～1090:

Graph points are determined through logarithm operations and plotted.

```
490    LABEL "0"
500    MOVE 3.1,1+9/4
510    LABEL "45"
520    MOVE 3.1,3.9
530    LABEL "90"
540    MOVE 3.2,2.2
550    LABEL "PH"
560    MOVE 1.5,3.8
570    LABEL "Z/PH-f CURVE"
580    !
590    !
600    CLEAR 701
610    DIM A$[10]
620    DIM B$[10]
630    X=0
640    OUTPUT 701;"F4R0M0KHZ1V1"
650    OUTPUT 701;"SMK78"
660    FOR F=1 TO 100 STEP 1
670    P=SPOLL(701)
680    OUTPUT 701;"KHZ"&VAL$(F)
690    TRIGGER 701
700    ON INTR 7 GOTO Cek
710    ENABLE INTR 7;78
720    GOTO 720
730    !
740 Cek:    P=SPOLL(701)
750         IF P=66 THEN 780
760         ENTER 701;A$
770         GOTO 700
780         GOSUB Glph
790    !
800    NEXT F
810    STOP
820    !
830 Glph:   OUTPUT 701;"OFM2"
840         ENTER 701;A$
850         OUTPUT 701;"OFM4"
860         ENTER 701;B$
870         R=VAL(A$)
880         R=1+LOG(R)/LOG(10)
890         Fz=1+LOG(F)/LOG(10)
900         Ph=VAL(B$)
910         Ph=2.5+1.48/90*Ph
920         IF X=1 THEN 960
930         R1=R
940         Fz1=Fz
950         Ph1=Ph
960         R2=R
970         Fz2=Fz
980         Ph2=Ph
990         MOVE Fz1,R1
1000        PLOT Fz1,R1
1010        PLOT Fz2,R2
1020        MOVE Fz1,Ph1
1030        PLOT Fz1,Ph1
1040        PLOT Fz2,Ph2
1050        R1=R2
1060        Fz1=Fz2
1070        Ph1=Ph2
1080        X=1
1090        RETURN
1100   !
1110   END
```



6. PRINTER INTERFACE

(3520-02 OINSTRUCTION MANUAL)

CONTENTS

6—1. Outline

The 3520-02 printer interface is designed to be used with the 9200 printer. By using the 9200 printer, data can be printed out, bad/good determination using the conparator function can be made, and stastical processing such as standard deviation, histgram, etc., can be performed.

6—2. Specifications

Output data format : Bit parallel/digit serial
(Refer to "4. Data Output Format" for details.)

Applicable modem : 9200

6—3. Operation Procedure

(1) Turn off the power switches of 3520 and 9200.

(2) Conect the 3520 to the 9200 with the 9161 connection cable.

Note: When connecting the cable, the power switches of both the 3520 and the 9200 must be turned off.

(3) Turn on the power switch of the 9200.

(4) Turn on the power switch of the 3520.

(5) Set the device selection of the 9200 to the 3520.

Note1 : When turning on the 9200 and 3520, turn on the power switch of the 9200 first, then turn on the power switch of the 3520.

Note2 : When turning off the power of the 9200 and 3520, turn off the power switch of the 3520, then turn off the power switch of the 9200.

Note3 : Whenever the 3520 is turned on, the 9200 must always be turned on.

Note4 : It is recommended to use the 3520 in the manual range (fixed range).

⚠ **NOTE**

● **Refer to the 9200 printer operation manual for the print format specification procedure. Read the 9200 printer operation manual before using the 3520.**

6–4. Data Output Format

(1) 3520-02 rear panel connector pin assignment

(Viewd from back)

CLOCK	1	2	4	8	C	D. P.	GND	B	+/−
BUSY	10^3	10^2	10^1	10^0	A	B	Zero	A	PARA/SERI
	Digit				DATA SELECT			FUNCTION	

(All signal lines are output lines. 5V CMOS)

(2) Contents of signal

○ DATA SELECT lines A to C……Indicates the contents of BCD data.

C	B	A	Data
0	0	1	CLRZ
0	1	0	DQθ
0	1	1	Units
1	0	0	Frequency
1	0	1	Voltage monitor

For the table above, when outputting units is selected, BCD code v.s. units are corresponded as shown in the table below.

BCD	Units
0	None
1	P
2	n
3	μ
4	m
5	k
6	M

● FUNCTION

B A	Function
0 0	C
0 1	L
1 0	R
1 1	Z

○ D. P. ············Decimal point

○ +/− ············± for θ 0 —— ⊖, 1 —— ⊕

○ P/S ················Mode 0 —— SERIAL, 1 —— PARALLEL

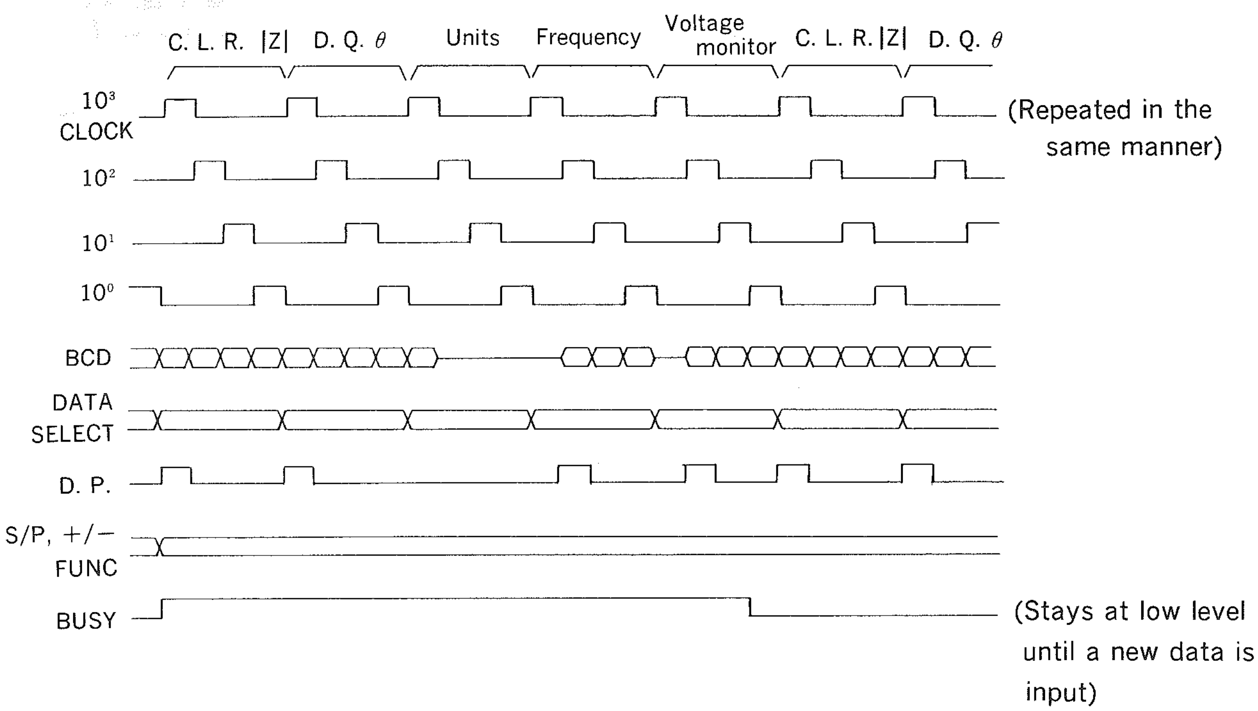
○ Zero ············Zero ADJ, 0 —— OFF, 1 —— ON

○ CLOCK ·········Same as 10^3 signal of digit signal lines

○ BUSY ············Indicates new data output

(3) Timing chart

The following chart shows the operation timing of the 3520.



6—5. Typical Print Out Example

```
No.
 1  S102.3 nFI
   D = 0.022
  1.00kHz 0.99V
 2  S100.2 nFL
   D = 0.026
  10.0kHz 0.98V
 3  P105.6 nFH
   D = 0.027
  0.10kHz 0.99V
 4  P102.1 nFI
   D = 0.022
  1.00kHz 0.99V
 5 ZP101.7 nFI
   D = 0.022
  1.00kHz 0.99V
           END
N =   5
x̄ = 102.380 F
MIN=  100.2 nF
 (No.     2)
MAX=  105.6 nF
 (No.     3)
σn = 1.77020 F
```

(Data select: CLRZ, Print enable: CLRZ)

L : Indicates that comparison result is Lo.

H : Indicates that comparison result is Hi.

I : Indicates that comparison result is IN.

S : Indicates that measurement is performed with a series equivalent circuit.

P : Indicates that measurement is performed with a parallel equivalent circuit.

Z : Indicates that Zero adjust is used.

```
No.
 1    ERROR
 R = 10.17 kΩ
  1.00kHz 0.87V
 2    ERROR
 R = 101.7 kΩ
  1.00kHz 0.99V
 3    ERROR
 R =  4.15  Ω
  10.0kHz 0.98V
           END
N =    3(*   0)
```

(Data select: DQPH, Print enable: CLRZ, DQPH)

ERROR : Word "ERROR" is printed if DQPH is selected as data when measuring a resistance (R).

```
No.
 1 ZP16.56 kΩ
  * * * * * *
  10.0kHz 0.99V
 2 ZP19.21 kΩ
  * * * * * *
  10.0kHz 0.99V
 3 ZP14.27 kΩ
  * * * * * *
  10.0kHz 0.99V
           END
N =    3
x̄ = 16.6800kΩ
MIN=  14.27 kΩ
 (No.     3)
MAX=  19.21 kΩ
 (No.     2)
σn = 2.01853kΩ
```

(Data select: CLRZ), Print enable: CLRZ, DQPH, F, V)

* * * * * * : Six asterisks are printed when print enable is selected for DQPH for measuring a resistance (R).

```
No.
 1   0.022
  C = 101.7 nF
   1.00kHz 0.99V
 2   0.022
  C = 101.7 nF
   1.00kHz 0.99V
 3   0.022
  C = 101.7 nF
   1.00kHz 0.99V
              END
 N =   3
 x̄ = 22.0000m
MIN=  0.022
  (No.    3)
MAX=  0.022
  (No.    1)
σn = 0.00000
```

(Data select: DQPH, Print enable: CLRZ, DQPH, F, V)
0.022: D (loss factor)

```
No.
 1   -88.7
  Z = 1.558 kΩ
   1.00kHz 0.99V
 2   -88.5
  Z = 159.6  Ω
  10.0kHz 0.98V
 3   -88.5
  Z = 159.6  Ω
  10.0kHz 0.98V
              END
 N =   3
 x̄ =-88.5667
MIN=  -88.7
  (No.    1)
MAX=  -88.5
  (No.    3)
σn = 94.2825m
```

(Data select: DQPH, Print enable: CLRZ, DQPH, F, V)
−88.7: phase angle

HIOKI E.E. CORPORATION

81 Koizumi, Ueda, Nagano 386-11, Japan

TEL:0268-28-0562 FAX:0268-28-0568

TLX:3327508 HIOKI J CABLE: HEWLOV, Ueda

3520A981-01 90-06-002U 78320039 Printed in Japan