TEGAM Inc.

Model 3550
42.0Hz-5.00MHz
Fully Programmable
LCR Meter

MODEL 3550

Instruction Manual
PN# 3550-900-01CD
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REV. E

NOTE: This user's manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. Because of this, some differences may occur between the descriptions in this manual and the product received. Please refer to www.tegam.com for future updates of this manual.

INSTRUMENT DESCRIPTION
PREPARATION FOR USE
QUICK START INSTRUCTIONS
OPERATING INSTRUCTIONS
PROGRAMMING & INTERFACING
SERVICE INFORMATION
APPENDIX

Instrument Description

The Model, 3550, is a high-speed LCR Meter capable of measuring Inductance (L), Capacitance(C), Resistance (R), Absolute Impedance (|Z|), Absolute Admittance (|Y|), Dissipation factor (D), Quality (Q), Serial Equivalent Resistance (Rs), Parallel Equivalent Resistance (Rp), Conductance (G), Reactance (X), Susceptance (B), and Phase Angle (θ). It has a wide measurement range, and includes full adjustability of Measurement Frequency and Measurement Signal Level. It also features Automatic adjustment for Zero Correction, Range Switching, and Series and Parallel Mode Switching.

The basic comparator function of the 3550 is extended to allow sorting of components to up to 10 different bins. Up to 9 panels worth of measurement settings can be stored in the instrument's non-volatile memory for convenient recall. The instrument can perform a complete measurement including a comparator judgment in as little as 40ms.

The 3550 has standard RS-232C and Control I/O Connector Interfaces with the availability of an optional GPIB Interface. The Control I/Os are optically isolated thus making the instrument ideal for noise immunity.

Feature Overview

The 3550 Programmable LCR Meter offers a complete solution for a wide variety of specialized LCR measurement applications. Listed below are some of the features.

High Speed
The measurement time, including data display, zero correction, and comparator function is approximately 40 milliseconds.

Extended Frequency Range
The Measurement Frequency can be adjusted between 42.0Hz - 5.00MHz.

Programmable Test Voltage and Current
The test signal level can be adjusted between 10mV to 5.00V in the constant voltage mode and from 10μA to 99.99mA in the constant current mode.

Voltage & Current Monitor
The voltage at the test piece terminals and the current, which is flowing through the test piece, can be displayed up to 3 significant digits.

Feature Overview cont'd:

$4^1/_2$ Digits Resolution
"DISPLAY A" (L, C, R, |Z|, |Y|), and "DISPLAY B" (D, Q, R_S, R_P, G, X, B, θ) can both display up to $4^1/_2$ digits.

GO / NO-GO COMPARATOR
For L, C, R, |Z|, |Y|, D, Q, R_S, R_P, G, X, B, and θ, upper and lower limit values can be set for 9 items (10 categories), for up to 9 panels of settings.

Series or Parallel Equivalent Circuit Mode
When in "Auto" mode, Parallel or Series Equivalent Circuit measurements are automatically determined by the active measurement range. In manual range, the Parallel or Series Equivalent Circuit mode are user selectable.

Front Panel Key Lock
The Key Switch on the front panel can be set to lock the instrument settings for protection against accidental changes.

Automatic Zero Correction of Parasitic Impedance
Performing Open and Short Circuit Zeroing cancel the offset errors caused by Stray Capacitance, Stray Conductance, Residual Inductance, and Residual Resistance.

Non-Volatile Memory
All measurement settings such as the Zero Correction Values, Comparator Limits, Panel Settings etc. are stored in non-volatile memory and are retained in the event of power loss.

Remote Operation
The TEGAM Model 3550 provides standard RS-232C and I/O Control Connector interfaces for remote operation. There is an optional GPIB (IEEE-488) interface available for purchase.

3550 Options and Accessories

2005B - Chip Tweezers (5ft)

This four-terminal tweezer set makes solid connections to chip components in manual sorting applications. Capacity of jaws is 12.7mm (0.5 in.). The 2005B Chip Component Tweezer Set includes a 1.5m (5 ft) cable for connection to the 2150/2160. Contact tips are replaceable. P/N 47422.

47422 Chip Tweezer Replacement Kit

Tweezer tips are intended to last 100,000 to 500,000 operations. An optional tip replacement kit includes 12 replacement tips, 2 screws and 1 wrench.

3511 - SMD Test Fixture

Available for performing three terminal measurements on surface mount devices. Connects directly to the front panel of the 3550. Use the 3511 for medium and high impedance measurements.

3510-Radial Lead Adapter

This sorting fixture allows for efficient four-wire measurement of leaded parts. The test fixture features spring action contacts for easy insertion and removal of test components.

47454 – Kelvin Klips

Kelvin Klips allow solid four-terminal, Kelvin connections to leaded components. The jaws are assembled with hardened gold-plated, beryllium copper, which ensures low contact resistance, low thermal emf to copper, high corrosion resistance, and long service life. An alligator clip is provided allowing connection of a passive guard. The assembly includes a 5 ft (1.5m) cable for connection to the 3525.

NOTE: Under certain measurement conditions, Kelvin Klips can cause a loss of measurement accuracy. Fixtures 3510, 3511, or 2005B chip tweezers are recommended for the following component values:

C<100pF; L < 100µH; R > 1MΩ

KK100- Kelvin Klip™ Rebuild Kit

Kelvin Klip™ replacements for construction or repair of Kelvin Klip leads.

GPIB (IEEE-488) Cables

1583-3 – 1-meter GPIB buss cable
1583-6 – 2-meter GPIB buss cable
1583-9 – 3-meter GPIB buss cable

3505 – GPIB Interface

3550-900-01 – User's Manual-Hard Copy

CABLE NULL 9PIN – 25 PIN

3740570-6 - 6' Cable null 9 pin – 25pin
3740570-10 - 10' Cable null 9 pin – 25 pin

Performance Specifications

The advertised specifications of the model 3550 are valid under the following conditions:

1. The instrument must be verified and/or adjusted using the methods and intervals as described in the calibration section of this user's manual.

2. The instrument must be in an environment, which does not exceed the limitations as defined under "Environmental" in the Miscellaneous Specifications section.

3. The unit is allowed to warm up for a period of at least 30 minutes before measurements are taken. A warm-up period of 60 minutes is recommended after exposure to or storage in a high humidity, (non-condensing), environment.

4. Only TEGAM-manufactured Kelvin Klips™, Tweezers and other test fixtures are used with this device during measurements.

Measurement Parameters:

Inductance (L), Capacitance(C), Resistance(R), Impedance (|Z|), Admittance (|Y|), Dissipation Factor (D), Quality (Q), Equivalent Series Resistance (R_S), Equivalent Parallel Resistance (R_P), Conductance (G), Reactance (X), Susceptance (B), and Phase Angle (θ).

Measurement Ranges

Table 1.1 – Model 3550 Measurement Range Limits

Parameter	Low Limit	High Limit
L	320.0nH (At: 10Ω 5MHz)	0.7500MH(At: 199.99MΩ 42Hz) (θ=90°)
C	0.160pF (At: 100kΩ 5MHz)	0.037F(At: 100mΩ 42Hz) (θ=-90°)
R	0.01mΩ	199.99MΩ
|Z|	0.01mΩ	199.99MΩ
|Y|	5.000nS(199.99MΩ)	100.00S(100mΩ)
D	0.0001	9.999
Q	0.1	1999.9
R_S	0.01mΩ	199.99MΩ
R_P	0.01mΩ	199.99MΩ
G	5.000nS(199.99MΩ)	100.00S(100mΩ)
X	0.01mΩ	199.99MΩ
B	5.000nS(199.99MΩ)	100.00S(100mΩ)
θ	-180.00°	180.00°

***NOTE**: The Measurement Range is dependent on the Measurement Frequency. The figures in parentheses are DUT impedance values.*

Performance Specifications cont'd:

Basic Accuracy

0.1%

Display Specifications:

- Numeric Display (DISPLAY A)
  L, C, R, |Z|, |Y| ($4^1/_2$ digits)

- Numeric Display (DISPLAY B)
  D, Q, R_S, R_P, G, X, B, θ ($4^1/_2$ digits)

- Numeric Display (DISPLAY C)
  Frequency, Voltage, Current, Terminal Voltage, Terminal Current, PANEL (3 digits)

- Unit Prefix Display (DISPLAY A)
  p, n, µ, m, k, M

- Unit Prefix Display (DISPLAY B)
  n, µ, m, k, M

- Unit Display (DISPLAY A)
  F, H, Ω, S

- Unit Display (DISPLAY B)
  Ω, S, deg

- Unit Display (DISPLAY C)
  Hz, kHz, MHz, V, mA

Switch Indicator Lamps

- RANGE – AUTO; UP; DOWN
- CIRCUIT MODE – AUTO; SER; PRL
- SHIFT
- DISPLAY C – V; I; CV/CC
- TRIGGER - INT; MAN/EXT
- SAMPLE

Performance Specifications cont'd:

Measurement Frequency

Table 1.2 – Model 3550 Measurement Frequencies

Frequency Range	Resolution
42.0Hz ~99.9Hz	0.1Hz Steps
100Hz~999Hz	1Hz Steps
1.00kHz~9.99kHz	10Hz Steps
10.0kHz~99.9kHz	100Hz Steps
100kHz~999kHz	1kHz Steps
1.00MHz~5.00MHz	10kHz Steps

Measurement Frequency Accuracy

±0.01%

Measurement Signal Level

Table 1.3 – Model 3550 Measurement Amplitudes

Frequency Range	Test Voltage Range	Test Current Range
42.0Hz~1.00MHz	0.01~5.00Vrms	0.01~99.99mArms
1.01MHz~5.00MHz	0.05~1.00Vrms	0.05~20.00mArms

Open Terminal Voltage Mode

- Increment/Resolution 0.01V Steps
- Max. Shorting Current 99.99mA (Dependent on Measurement Frequency)

Fixed Voltage Mode

- Increment/Resolution 0.01V Steps
- Max. Shorting Current 99.99mA(Dependent on Measurement Frequency)

Fixed Current Mode

- Increment/Resolution 0.01mA Steps
- Max. Shorting Current 99.99mA(Dependent on Measurement Frequency)

Performance Specifications cont'd:

Monitor Functions

Voltage Monitor 0.00V~5.00V
Current Monitor 0.00mA~99.99mA

Settings and Monitor Accuracy

Table 1.4 – Model 3550 Amplitude Accuracies

Frequency Range	Test Voltage Accuracy	Test Current Accuracy
42.0Hz~4.00MHz	±(10%+10mV)	±(10%+10μA)
4.01MHz~5.00MHz	±(20%+10mV)	±(20%+10μA)

Signal Source Impedance

50Ω ±10%

Measurement Circuit Modes

- Auto/Manual Circuit Selection
- Parallel Equivalent Circuit Mode
- Series Equivalent Circuit Mode

Range

Measurement Range is determined by the DUT's absolute impedance |Z|. There are 9 total ranges selectable in either AUTO or MANUAL modes. Measurement parameters (L, C, R, etc.) are calculated from actual test voltage and current values.

Table 1.5 – Model 3550 Measurement Ranges

Range	1	2	3	4	5	6	7	8	9	AUTO
Upper Limit |Z|	100mΩ	1Ω	10Ω	100Ω	1kΩ	10kΩ	100kΩ	1MΩ	10MΩ	100mΩ~10MΩ

Performance Specifications cont'd:

Measurement Time

Open Terminal Voltage Mode

When the Measurement Frequency is 10kHz, no averaging, the range is held constant, RS-232C is OFF and the Comparator is ON, the shortest measurement time is 18ms.

Typical Analog Measurement Times

Conditions: Averaging= 1, range held, RS-232C is OFF, and Comparator ON:

Table 1.6 – Typical Analog Measurement Times

Test Frequency	Typical Analog Measurement Time
42Hz	624ms Max.
120Hz	221ms Max.
1kHz	31ms Max.
10kHz	18ms Max.
100kHz	30ms Max.
1MHz	25ms Max.
5MHz	21ms Max.

About the Typical Analog Measurement Time

The Typical Analog Measurement Time is dependent upon the Measurement Frequency. For ranges 42.0Hz~750Hz, and 10.1kHz~19.0kHz, Typical Analog Measurement Time will exceed 40 ms.
For other frequencies, 40ms will not be exceeded.
(Conditions: Averaging = 1, range held, RS-232C is OFF, and Comparator ON)
With the RS-232C turned on and set to a baud rate of 9600 BPS, the additional time needed for RS-232C communication is 100ms at any frequency setting.

Fixed Voltage/Fixed Current Mode

The measurement time can be up to 4X the time of the Open Terminal Voltage Mode.

Average Mode

The user can define from 1~100 averages.

Performance Specifications cont'd:

Measurement Terminals

- 2 – BNC Source Terminals
- 2 – BNC Detect Terminals
- 1 – Guard Banana/Binding Post

Parasitic Impedance Correction

Open Correction	1kΩ or higher Impedance
Short Correction	Less than 1kΩ Impedance

Programmable Delay Time

Measurements will be started after a trigger is detected from the front panel, Control I/O Connector or RS232C interface. The delay time setting is user-definable and ranges from 0~10 seconds in 1ms increments.

GO / NO-GO Limits Comparator / Binning

Absolute Value

- Absolute Settings must fall within the Measurement Ranges of DISPLAY A and DISPLAY B.
- Comparator Settings must be applied to existing preset panels.
- Up to 9 programmable bins (1-9) may be defined. Bin 0 is reserved for measured values that fall outside of the limits.
- User may program the High or Low limits of DISPLAY A and DISPLAY B to be ignored.

Percent Value

- Percent Settings must fall within the Measurement Ranges of DISPLAY A and DISPLAY B.
- Limit Values of 00000~999.99 % for both DISPLAY A and DISPLAY B
- Comparator Settings must be applied to existing panels.
- Up to 9 programmable bins (1-9) may be defined. Bin 0 is reserved for measured values that fall outside of the limits.
- User may program the High or Low limits of DISPLAY A and DISPLAY B to be ignored.

Performance Specifications cont'd:

Comparator/Binning: Absolute Limits Operation

Table 1.7a – Absolute Comparator Operation

Operation	Function
Bins 1~9	"LOW LIMIT"≤ Measurement Value ≤"HIGH LIMIT"
LO	Measurement Value < "LOW LIMIT"
HI	"HIGH LIMIT" < Measurement Value
TOTAL GO	When both DISPLAY A and DISPLAY B are not LO or HI

Comparator/Binning: Percent Limits Operation

*The location of the decimal point affects the % comparator/binning values.

Table 1.7b – Percentage Comparator Operation

Operation	Function
Bins 1~9	"LOW LIMIT"≤ Measurement Value ≤"HIGH LIMIT"
LO	Measurement Value < "LOW LIMIT"
HI	"HIGH LIMIT" < Measurement Value
TOTAL GO	When both DISPLAY A and DISPLAY B are not LO or HI

Displays

Table 1.8 – Numeric Displays and Annunciators

Display	Display Description & Range
Numeric DISPLAY A	-19999 ~ 19999 (4-1/2 digits)
Numeric DISPLAY B	-19999 ~19999 (4-1/2 digits)
Unit Prefix Annunciators for DISPLAY A	p, n, µ, m, k, M
Unit Prefix Annunciators for DISPLAY B	n, µ, m, k, M
Unit Annunciators for DISPLAY A	F, H, Ω, S
Unit Annunciators for DISPLAY B	Ω, S, deg
Comparator Limit	LOW & HIGH Pushbuttons
Comparator Enabled	ON Pushbutton
Comparator State	LO-HI (For DISPLAY A & B)
Comparator Total GO	TOTAL GO LED
BIN	0-9 Seven Segment LED Display
PANEL	0-9 Seven Segment LED Display
GPIB Status	SRQ, LTN, TLK, RMT

Performance Specifications cont'd:

Digital Interfaces

RS-232C Standard interface
GPIB Optional Interface
Control I/O Standard Interface Connector

External Control Signals
CONTROL PANEL/EXT, EXT TRIGGER, PANEL No. (Isolated)
External Output Signals
MEASURE END, ERROR, DISPLAY A HI, DISPLAY A LO, DISPLAY A GO, DISPLAY B LO, DISPLAY B HI, DISPLAY B GO, TOTAL GO, TOTAL NO-GO, BIN (Optically Isolated)

Audible Buzzer

Can be set to turn ON with GO or NO-GO comparator state; or it can be disabled.

Panel Presets

9 panel presets including comparator settings can be programmed into non-volatile memory.

Front Panel Key Lock

Protects accidental changing of front panel settings all panel keys except the Manual Trigger are disabled.

Environmental

Operating Temperature = 5°C~40°C (41°F~104°F) <80%RH Non-Condensing

- o Accuracy specifications are based on temperature conditions within 23°C±5°C (73.4°F±9°F).
- o For temperatures exceeding 23°C±5°C and still within the operating temperature, the margin of error will be 2 times larger.

Power Source

- Operating Voltage=100/120/220/240V AC ±10%(MAX250V)
- Power Frequency=50/60Hz
- Maximum Power Usage=40VA

Dimensions

Width: 9.84" (250mm)
Height: 5.83" (148mm)
Depth: 15.74" (400mm)

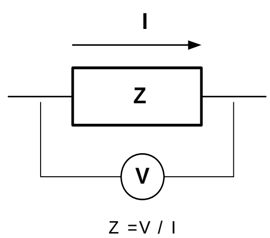
Weight

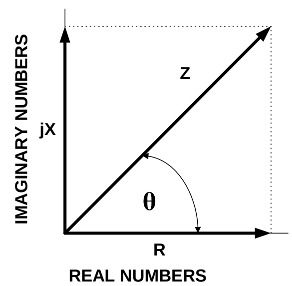
Approximately 15.4lb (7kg)

Formulas and Measurement Accuracy

Parameters and Formulas

Generally speaking, the characteristics of circuit components can be evaluated in terms of impedance (Z).
The 3550 LCR Meter measures the voltage and current components of the circuit in relation to the alternating signal of the measurement frequency, and uses these values to calculate impedance (Z) and phase angle (θ).
Displaying impedance (Z) in a complex notation as below allows us to determine the following values.

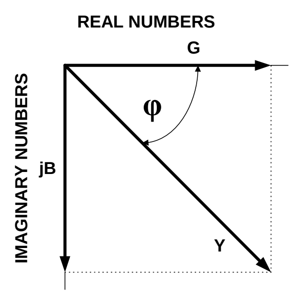




$Z = R + jX$
$\theta = TAN^{-1}\ X/R$
$|Z| = \sqrt{R^2 + X^2}$
Z: Impedance (Ω)
θ: Phase Angle (deg)
R: Resistance (Ω)
X: Reactance (Ω)
|Z|: Absolute Value of Impedance (Ω)

Depending on the properties of the DUT, Admittance (Y), which is the inverse of Impedance (Z), may be used to calculate parameter values instead. Admittance (Y), like Impedance (Z) can be represented in complex notation in order to calculate the following values.

$Y = G + jB$
$\Phi = TAN^{-1}\ (B*G)$
$|Y| = \sqrt{G^2 + B^2}$
Y: Admittance (S)
G: Conductance (S)
B: Susceptance (S)
|Y|: Absolute value of Admittance (S)



Formulas and Measurement Accuracy cont'd:

The 3550 calculates the various measurement values using the inter-terminal voltage (V) applied to the DUT (device under test) terminals, the current (I) that occurs in relation to the voltage, the Phase Angle (θ) of (V) and (I), and the Angular Velocity (ω) of the measurement frequency. These factors are used in the formulas below to determine values for the measurements made by the TEGAM 3550.

Note: The Phase Angle is based on Impedance (Z). In order to base the Phase Angle on Admittance (Y), add a "-" sign to the Impedance value to negate it.
Thus, φ for Admittance will be φ=-θ.

Table 1.9 – Series and Parallel Equivalent Circuit Measurements

Item	Series Equivalent Circuits	Parallel Equivalent Circuits
Z	$\lvert Z\rvert = V/I(\sqrt{R^2+X^2})$	
Y	$\lvert Y\rvert = 1/\lvert Z\rvert(\sqrt{G^2+B^2})$	
R	R_S = ESR = $\lvert\,\lvert Z\rvert\cos\theta\,\rvert$	R_P = EPR = $\lvert 1/(\lvert Y\rvert\cos\theta)\rvert = 1/G$
X	$X = \lvert Z\rvert \sin\theta$	————————
G	————————	$\lvert Y\rvert\cos\theta$ ***
B	————————	$B = \lvert Y\rvert\sin\theta$ ***
L	$L_S = X/\omega$	$L_P = 1/(\omega * B)$
C	$C_S = 1/(\omega * X)$	$C_P = B/\omega$
D	$D = 1/\tan\theta = 1/Q$	
Q	$Q = \tan\theta = 1/D$	

*** φ is the Phase Angle of Admittance: φ = -θ

L_S, C_S, R_S represent the L, C, R measurements for series equivalent circuits.
L_P, C_P, R_P represent the L, C, R measurements for parallel equivalent circuits.

Measurement Accuracy

The impedance of the DUT is either the actual measured value or a value, which is derived from the formulas below:

$$\text{If } \theta = 90° \rightarrow |Z| = \omega L$$
$$\text{If } \theta = -90° \rightarrow |Z| = 1/\omega C$$
$$\text{If } \theta = 0° \rightarrow |Z| = R$$

Voltage Level Accuracy Limit

See the Measurement Accuracy Tables located in the Appendix. The tables contain formulas for calculating the Voltage Level Accuracies.

Unpacking & Inspection:

Each 3550 is put through a series of electrical and mechanical inspections before shipment to the customer. Upon receipt of your instrument unpack all of the items from the shipping carton and inspect for any damage that may have occurred during transit. Report any damaged items to the shipping agent. Retain and use the original packing material for reshipment if necessary.

Upon Receipt, inspect the carton for the following items:

Model 3550 General Purpose, Programmable LCR Meter
Model 3550 User's Manual CD
Power Cord

⚠ Safety Information & Precautions:

The following safety information applies to both operation and service personnel. Safety precautions and warnings may be found throughout this instruction manual and the equipment. These warnings may be in the form of a symbol or a written statement. Below is a summary of these precautions.

Terms in This Manual:

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements apply conditions or practices that could result in personal injury or loss of life.

Terms as Marked on Equipment:

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

⚠ Safety Information & Precautions Cont'd:

Symbols:

As Marked in This Manual:

⚠	This symbol denotes where precautionary information may be found.

As Marked on Equipment:

⚠	Caution – Risk of Danger
ϟ	Danger – Risk of Electric Shock
⏚	Earth Ground Terminal-
I	On
O	Off
⊥	Chassis Terminal
∿	Alternating Current
⊥	Earth Ground Terminal / Guard

Grounding the Equipment

This product is grounded through the grounding conductor of the power cord.
WARNING: To avoid electrical shock or other potential safety hazards, plug the power cord into a properly wired receptacle before using this instrument. The proper grounding of this instrument is essential for safety and optimizing instrument operation.

Danger Arising from Loss of Ground

WARNING: If the connection to ground is lost or compromised, a floating potential could develop in the instrument. Under these conditions all accessible parts, including insulating parts such as keypads and buttons could develop a hazardous voltage and put the user at risk.

⚠

Use the Proper Fuse
To avoid fire hazard, use only the correct fuse type as specified for the AC power supply in the "Preparation for Use"" or "Service" sections of this manual. Please note that the fuse rating for 100 & 120-volt operation is different than the rating for 200 & 240-volt operation. Information about the proper fuse type is also printed on the rear panel of the instrument.

Refer fuse replacement to qualified service personnel.

Do Not Use in Explosive Environments
WARNING: The 3550 is not designed for operation in explosive environments.

Do not Operate Without Covers
WARNING: This device should be operated with all panels and covers in place. Operation with missing panels or covers could result in personal injury.

FOR QUALIFIED SERVICE PERSONNEL ONLY

⚠ Servicing Safety Summary:

Do Not Service Alone
Do not perform service or adjustment on this product unless another person capable of rendering first aid is present.

Use Care When Servicing with Power On or Off
Dangerous voltages may exist at several points in this product. To avoid personal injury or damage to this equipment, avoid touching exposed connections or components while the power is on. Assure that the power is off by unplugging the instrument when removing panels, soldering, or replacing components.
WARNING: The instrument power source is electronically controlled meaning that there is power present throughout the instrument even when the instrument is in the OFF state.
Always unplug the instrument and wait 5 minutes before accessing internal components.

Power Source
This product is intended to connect to a power source that will not apply more than 250V RMS between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

⚠ Line Voltage & Fuse Selection:

CAUTION: DO NOT APPLY POWER TO THE INSTRUMENT BEFORE READING THIS SECTION:

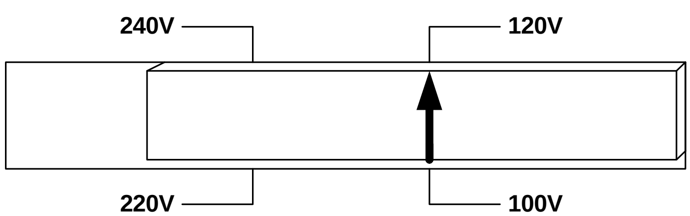
Unless other wise specified, the Model 3550 is delivered from TEGAM with its power supply set for 120V, 60 Hz operation. However, the 3550 design allows it to operate under 100, 120V, 220 or 240V @ 50/60 operation. It is strongly recommended that the line voltage and fuse size be verified before powering the unit.

First, determine the supply voltage that the instrument will be operating under and verify that the supply voltage does not fall outside of the allowable ranges in the table below:

LINE VOLTAGE RANGE		FUSE SIZE
100/120V	90~132VAC	1A
220/240V	198~250VAC	0.5A

Make sure that the proper fuse size is installed.

Next, verify that the jumper block in the rear panel of the instrument is securely plugged into the correct position. There are four positions that the block may be set to. Set the jumper block to point to one of the four voltage settings. You can remove the jumper block by pulling it from the jumper socket.



Unit set for 120VAC Operation 50/60Hz

The instrument is ready for power up. Proceed to “Quick Start Instructions” for continued operation.

The Model 3550 is a versatile product, which can be used in many different configurations. Because of its ability to measure a large number of impedance parameters under a dynamic range of test frequencies, amplitudes, and configurations, its is highly recommended that the entire "Operating Instructions" Section of this manual be reviewed to insure proper use of this equipment.

This Quick Start section is designed to give the user a general instruction set for the speedy setup and measurement of impedance values where arbitrary measured values are needed and accuracy is not critical. Whenever additional information is applicable, a reference will be made to other parts of this manual so that the user, at their discretion, can decide whether or not to pursue additional information.

Power the Unit

The power supply of the Model 3550 is designed for 50-60 Hz operations and a voltage range of 90-250 VAC. It is assumed that the "Preparation for Use" section of this manual has been read an understood and the line voltage and fuse settings have been verified to be correct.

Power the unit by depressing the pushbutton located on the lower right corner of the front panel. Allow at least 30 minutes for the unit to warm up and verify that the unit will be operated in its specified operating environment described on page 1-12.

Instrument Settings

Factory Default Settings

Before performing an actual impedance measurement, there are a number of test parameters, which must be defined. The factory default settings can be used for most general-purpose measurements.

The 3550 is shipped from the factory with default settings as follows:

Table 3.1 – Factory Default Settings

	Parameter	Setting		Parameter	Setting
1	DISPLAY A	Capacitance	**9**	Communications	*RS232
2	DISPLAY B	Dissipation Factor	**10**	Trigger	INT
3	DISPLAY C	Frequency	**11**	PANEL	0
4	Comparator	Data Cleared	**12**	Circuit Mode	AUTO
5	Comparator	OFF	**13**	Range	AUTO
6	Zero Correction	Data Cleared	**14**	LOCK	OFF
7	Test Frequency	1kHz	**15**	Test Voltage	1.00 V
8	Measurement Mode	Open Terminal Voltage			

** not storable in a setup location.*

At any time during use, you may recall these default settings by pressing the [MAN/EXT] key while powering the unit.

NOTE: When the unit is reset to factory defaults, user-defined comparator settings and zero correction factors will be lost.

Table 3.2a – Control Command Summary

Display Commands	1	Change measure item of DISPLAY A	A
	2	Change measure item of DISPLAY B	B
	3	Show measure frequency on DISPLAY C	FREQ
	4	Show terminal voltage on DISPLAY C	V
	5	Show measure. current on DISPLAY C	I
Basic Commands	6	Change panel number	0-9
	7	Change measurement frequency	FREQ → DISPLAY C's UP and DOWN
	8	Change measurement voltage	V → DISPLAY C's UP and DOWN
	9	Carry out open correction	OPEN
	10	Carry out short correction	SHORT
	11	Change to auto range	RANGE's AUTO
	12	Change to auto circuit mode	CIRCUIT MODE's AUTO
Applied Commands	13	Change to fixed voltage mode	V → CV/CC
	14	Change the fixed voltage setting	When V and CV/CC LED are flashing, DISPLAY C's UP and DOWN
	15	Change to fixed current mode	I → CV/CC
	16	Change the fixed current setting	When I and CV/CC LED are flashing DISPLAY C's UP and DOWN
	17	Raise the range	RANGE's UP
	18	Lower the range	RANGE's DOWN
	19	Parallel equivalent circuits mode	PRL
	20	Serial equivalent circuits mode	SER
	21	Measure with continuous trigger	INT
	22	Measure with manual (single shot) trigger	MAN/EXT → MAN/EXT → MAN/EXT →
	23	Set comparator lower limit	LOW
	24	Set comparator upper limit	HIGH
	25	Turn comparator on	ON
	26	Move cursor forward in setting mode	◁
	27	Move cursor backward in setting mode	▷
Shift Commands	28	Set measurement frequency	SHIFT → 0 → Frequency Value → ENTER
	29	Set voltage for measurement or fixed voltage mode	SHIFT → 1 → Voltage Value (V) → ENTER
	30	Set current for fixed current mode	SHIFT → 2 → Current Value (mA) → ENTER
	31	Set number of measurements	SHIFT → 3 → Number Setting → ENTER

Table 3.2b – Control Command Summary cont'd

Shift Commands	32	Release Key Lock	SHIFT → 4 → 0 → ENTER
	33	Lock Key	SHIFT → 4 → 1 → ENTER
	34	No buzzer for decision	SHIFT → 5 → 0 → ENTER
	35	Buzzer for GO decision ON	SHIFT → 5 → 1 → ENTER
	36	Buzzer for NO GO decision ON	SHIFT → 5 → 2 → ENTER
	37	Set start delay time	SHIFT → 6 → delay time (ms) → ENTER
	38	To use absolute value comparator	SHIFT → 7 → 0 → ENTER
	39	To use percent comparator	SHIFT → 7 → 1 → ENTER
	40	Set 1st spot correction frequency	SHIFT → 8 → 1 → frequency value → ENTER
	41	Set 2nd spot correction frequency	SHIFT → 8 → 2 → frequency value → ENTER
	42	Set 3rd spot correction frequency	SHIFT → 8 → 3 → frequency value → ENTER
	43	Set low frequency of correction	SHIFT → - → 1 → frequency value → ENTER
	44	Set high frequency of correction	SHIFT → - → 2 → frequency value → ENTER
	45	Do spot or open correction	SHIFT → OPEN
	46	Do spot or open correction	SHIFT → SHORT
	47	Change RS-232C baud rate	SHIFT → 9 → 1 → Setting → ENTER
	48	Change RS-232C data length setting	SHIFT → 9 → 2 → Setting → ENTER
	49	Change RS-232C parity setting	SHIFT → 9 → 3 → Setting → ENTER
	50	Change RS-232C stop bit setting	SHIFT → 9 → 4 → Setting → ENTER

Table 3.3 - Shift Function Summary

SHIFT 0	Set measurement frequency
SHIFT 1	Set voltage for measure voltage/fixed voltage mode
SHIFT 2	Set current for fixed current mode
SHIFT 3	Set number of measurements
SHIFT 4	Set key lock
SHIFT 5	Set buzzer
SHIFT 6	Set start delay time
SHIFT 7	Set comparator mode
SHIFT 8	Set spot correction frequency
SHIFT 9	Set RS-232C communication parameters
SHIFT -	Set correction frequency limits
SHIFT OPEN	Do spot open correction
SHIFT SHORT	Do spot short correction

Instrument Setup for Basic Measurements

To perform basic measurements with the Model 3550, perform the steps below: Refer to "Operating Instructions" for more details about specific commands or functions of the 3550.
NOTE: The numerals in parentheses reference the Control Command Tables on the previous pages. The letters in parentheses reference the Settings Summary below:

- ❖ Perform an open and closed circuit zero correction {Normal correction (9,10), Frequency limit correction (F), or Spot correction (E)} on the test leads or fixture.
- ❖ Set DISPLAY A measurement parameters (1)
- ❖ Set DISPLAY B measurement parameters (2)
- ❖ Set measurement frequency (7 or 28)
- ❖ Set measurement mode {Voltage (8 or 29), Constant Voltage (A), or Constant Current (B)}
- ❖ Set the comparator limits and operation if necessary {Absolute Comparator (C) or Percent Comparator (D)}
- ❖ Set the trigger mode {Continuous (21) or One-Shot (22) trigger}

Table 3.4 - Settings Summary

A	To use fixed voltage mode	❖ Set voltage for fixed voltage mode (14 or 29) ❖ Change to fixed voltage mode (13)
B	To use fixed current mode	❖ Set current for fixed current mode (16 or 30) ❖ Change to fixed current mode (15)
C	To use absolute value comparator	❖ Select absolute value comparator (38) ❖ Set comparator lower limit value (23) ❖ Set comparator upper limit value (24) ❖ Turn comparator ON (25) ❖ For comparator setting details, see absolute value comparator setting instructions.
D	To use percent comparator	❖ Select percent comparator (39) ❖ Set comparator lower limit value (23) ❖ Set comparator upper limit value (24) ❖ Turn comparator ON (25) ❖ For comparator setting details, see percent comparator setting instructions.
E	To use spot correction	❖ Set spot correction frequency (40~42) ❖ Carry out spot-open correction (45) ❖ Carry out spot-short correction (46)
F	To use frequency limit correction	❖ Set upper frequency limit for correction (44) ❖ Set lower frequency limit for correction (43) ❖ Carry out open correction (9) ❖ Carry out short correction (10)

Setting the Absolute Comparator

To set the Absolute Value Comparator, following the procedure below:

1. ***Select either the upper or lower comparator limit.***
   To input an upper limit, press [HIGH]
   To input a lower limit, press [LOW]

2. ***Input the BIN No.***
   After the [HIGH] or [LOW] key is pressed, the BIN LED will begin to flash. Use keys [1]~[9] to designate the number.

3. ***Input a limit value for DISPLAY A***
   After selecting the bin number, use the cursor to highlight DISPLAY A.
   Enter the 5-digit upper or lower value using the keys [1]~[9]. When this is complete, the decimal point will flash.
   Press [DP] to move the decimal point to the position of the setting value.
   Use the cursor [►] to highlight the unit. Here, each time [UNIT] is pressed, the unit will change. Designate the unit for the Nominal value.

4. ***Input a limit value for DISPLAY B***
   When the setting for DISPLAY A is complete, use the cursor [►] to highlight DISPLAY B.
   Enter the 5 digits, decimal point and unit as done for DISPLAY A.
   If the setting is a negative value, use the cursors keys, [►] or [◄] to highlight the 1st digit of DISPLAY B.
   Press [-] to negate the value.

5. ***Finalize the Comparator Settings***
   If defining an upper limit, press [HIGH] to complete the setting.
   If defining a lower limit, press [LOW] to complete the setting.

   To input settings for other bins, repeat the steps above.

6. ***Invalidating the DISPLAY A or DISPLAY B Comparator settings.***
   To invalidate the settings, take the cursor, [►] or [◄], to any digit location in DISPLAY A or DISPLAY B. Then press [IGNORE] to invalidate the settings of DISPLAY A or DISPLAY B.

NOTES:

- ❖ The comparator can only be set using panels [1]~[9]. [0] is not used.
- ❖ The above procedure applies only to the Absolute Value Comparator. The procedure for setting the Percent Comparator is different. Before attempting to set the Absolute Comparator limits, verify that the 3550 is in the Absolute Comparator Mode.
- ❖ After setting the limit values for the comparator, the measurement parameters for DISPLAY A and DISPLAY B cannot be changed. The measurement parameters must be defined before the comparator is set.
- ❖ For DISPLAY B, there are no units for D,Q, or θ.

Setting the Percent Comparator

To set the Percent Comparator, follow the procedure below.

The upper and lower limit for the nominal value are the same. For the threshold values, different values for the upper and lower limit must be set. In order to proceed, the 3550 must be in the percent comparator mode.

1. ***Select the Upper or Lower Limit to Enter the % Comparator Mode***
   To input the Nominal value, press the [HIGH] key. (The [LOW] key may also be pressed to enter the % Comparator Set Mode)

2. ***Select the Nominal Value Input Mode***
   To input the Nominal Value, press [0] when the first digit of DISPLAY C is flashing.

3. ***Input the BIN No.***
   After selecting the Nominal Value Input Mode, use the cursor [►] to highlight the bin number, and then press [1]~[9] to select the desired bin.

4. **Set the Nominal Value for DISPLAY A**
   After inputting the bin number, use the cursor, [►] to highlight DISPLAY A. Enter a 5 digit Nominal Value for DISPLAY A using keys [0]~[9]. (NOTE: The 1st digit, is restricted to only a "1" or "0" setting.)
   When this is complete, the decimal point will flash. Press [D.P] to move the decimal point to the desired position. Then, use the cursor [►] to highlight the unit. Press the [UNIT] key until the required unit annunciator is lit. This designates the measurement unit for the Nominal value.

5. **Input the Nominal Value for DISPLAY B**
   When the setting for DISPLAY A is complete, use the cursor [►] to highlight DISPLAY B. Enter the 5 digits, decimal point and unit just as in DISPLAY A.
   If the setting is to be a negative value, use cursors [►] or [◄] to highlight the 1st digit of DISPLAY B then press [-] to negate the value.

6. **Completing the Nominal Value Setting**
   Press the [HIGH] key to finalize the Nominal Value Setting for the % Comparator.
   (*If the [LOW] key was pressed to enter into the % Comparator Mode then press it instead of the [HIGH] key to exit the mode and finalize the settings.*)

7. ***Set an Upper or Lower Limit for the % Threshold Values***
   To input an upper limit threshold value, press the [HIGH] key. Press the [LOW] key to set the lower limit threshold value. Then, highlight the first digit of DISPLAY C and press [1].

Setting the Percent Comparator

8. ***Input the BIN No.***
   After selecting the threshold value input mode, use the cursor key, [►] to highlight the bin LED, and then press [1]~[9] to select the desired bin.

9. ***Input the Threshold Value for DISPLAY A***
   After entering the bin number, use the cursor key [►] to highlight DISPLAY A.
   Enter the 5-digit threshold value for DISPLAY A using keys [0]~[9]. (The setting range is from 000.00%~199.99%)

10. ***Input the Threshold Value for DISPLAY B***
    Enter the 5-digit threshold value for DISPLAY B using keys [0]~[9]. (The setting range is 000.00%~199.99%)

11. ***Finalizing the Setting***
    To finalize an upper limit, press [HIGH] or press [LOW] to finalize a low limit setting.
    NOTE: Whether a high or low limit %comparator setting is defined is determined in step 7.

    To input settings for other bins, return to Step 1 and repeat the process.

12. ***Invalidating the DISPLAY A or DISPLAY B Percent Comparator settings***
    To invalidate the settings, for threshold values, simply enter the Threshold Percent Comparator Set Mode and move the cursor to any segment in DISPLAY A or DISPLAY B. Then press [IGNORE] to invalidate the % comparator settings for that DISPLAY.

NOTES:

- The comparator can only be set using panels 1~9. 0 cannot be used.
- This procedure is only for the percent comparator setting. Note that the procedure for the absolute value comparator is different.
- Make sure the comparator mode is set for "Percent Mode" otherwise the procedure will not work correctly.
- After setting the limit values for the comparator, the measurement parameters for DISPLAY A and DISPLAY B cannot be changed. This means that the measurement parameters must be defined before the comparator settings.
- For DISPLAY B, there are no units for D,Q, or θ.

Basic Operation

The Model 3550 is a fully programmable LCR meter, designed for use in many different low and high frequency applications. There are ideal configurations of the 3550 for each type of measurement. These configurations optimize test conditions while enhancing accuracy and measurement speed. In order to maximize the effectiveness the 3550, the user should have a thorough understanding of the instrument's operation along with a basic knowledge of LCR measurement techniques. This section will provide the user with the necessary information to make accurate and repeatable measurements.

Default Parameters

Each unit is delivered from the factory with predefined settings intended for general-purpose LCR measurement and ease of use. Chapter III, Quick Start Instructions, contains information on factory default settings.

⚠ **CAUTION:**

NEVER APPLY DIRECT CURRENT TO THE MEASUREMENT TERMINALS

Never apply direct voltage to the measuring terminals. When testing capacitors, always make sure that they are fully discharged otherwise damage to the instrument will result.

NEVER MEASURE COMPONENTS IN A POWERED CIRCUIT

If you are measuring components, which are integrated into circuit boards, always check that power is disconnected from the circuit before taking measurements. When measuring transformers, always verify that no induced voltage is present before making connections.

Measurement Tips

Making Measurements that are Sensitive to Voltage and Current

The measured values of many components such as core-filled coils, layered ceramic capacitors etc. are dependent upon the applied level of test current or voltage. In applications where the test signal must remain constant, it is recommended that the range of the 3550 be manually set.

In the event that AUTO Range must be used, then operation of the 3550 in the “Constant Current” or “Constant Voltage” Mode will maintain signal levels while allowing range adjustments.

Measuring Earth-Grounded Test Pieces

The L-side (L_{FORCE} & L_{SENSE}) of the measurement terminals is set up to be the virtual grounding point of the internal amplifiers. The L-side is a high-impedance point with zero electrical potential. These terminals cannot be directly connected to Earth Ground. Measurement of devices with one lead tied to earth ground is not recommended.

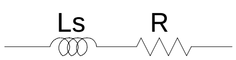
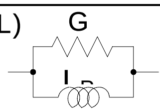
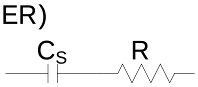
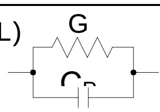
Measurement Tips cont'd:

Measurement Circuit Modes

When the Measurement Circuit Mode is set to "AUTO", the Parallel Mode (PRL) or the Serial Mode (SER) is automatically selected by the instrument based on the Measurement Range. The measurement range is determined by the instrument by the magnitude of |Z| with no regards to D or Q of the DUT.

Thus, the measured values of a component will vary depending on whether series or parallel equivalent circuit modes are used. The relationship between series and parallel equivalent circuit measurements is illustrated in Table 4.1.

Table 4.1: Relationship Between Series and Parallel Equivalent Circuit Values

Equivalent Circuit Mode		Dissipation Factor: D	Conversion Formula	
L	(SER) 	$D = \frac{R}{\omega L_S} = \frac{1}{Q}$	$L_P = (1+D^2) \cdot L_S$	$G = \frac{D^2}{1+D^2} \cdot \frac{1}{R}$
	(PRL) 	$D = \omega L_P G = \frac{1}{Q}$	$L_S = \frac{1}{1+D^2} \cdot L_P$	$R = \frac{D^2}{1+D^2} \cdot \frac{1}{G}$
C	(SER) 	$D = \omega C_S R = \frac{1}{Q}$	$C_P = \frac{1}{1+D^2} \cdot C_S$	$G = \frac{D^2}{1+D^2} \cdot \frac{1}{R}$
	(PRL) 	$D = \frac{G}{\omega C_P} = \frac{1}{Q}$	$C_S = (1+D^2) \cdot C_P$	$R = \frac{D^2}{1+D^2} \cdot \frac{1}{G}$

As a general rule, when measuring components where the reactive component is high, >10kΩ then the parallel equivalent mode should be used as parallel leakage becomes more significant to the measurement.
For low reactance components, <10Ω the series equivalent mode should be used since lead resistance becomes more significant to the reading than parallel leakage.
For measurements of component values that fall somewhere in between, follow the manufacturer's recommendations.

Measurement Tips cont'd:

Negative Capacitance or Inductance Readings

If a capacitor is connected to the 3550 while in the inductance measurement mode or if an inductor is connected to the 3550 while in the capacitance mode, a negative sign will appear in the display. The negative sign in the capacitance mode indicates an inductive measurement. The negative sign in the inductance mode indicates a capacitive measurement.

If the resonant frequency of a DUT is reached, a "-" sign will appear in the display.

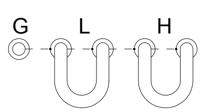
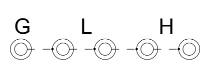
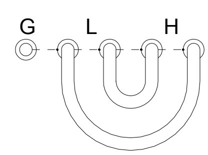
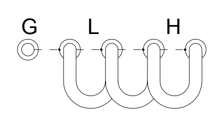
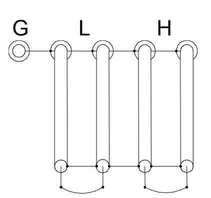
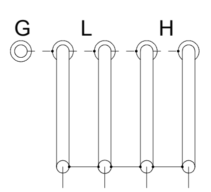
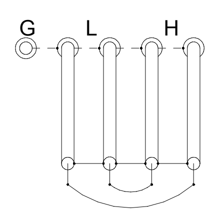
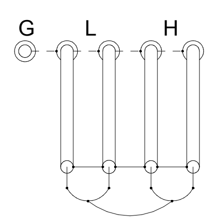
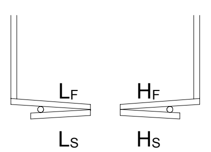
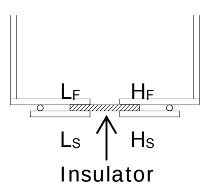
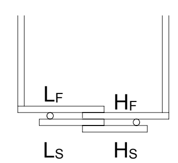
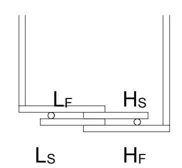
Zero Correction of Parasitic Impedance

"Open Correction" is for the purpose of compensating for the stray capacitance and stray conductance of cables or test fixtures. Executing an "Open Correction" procedure on the test leads of fixture before measurement of high impedance DUTs improves measurement accuracy.

"Short Correction" compensates for the residual inductance and resistance of cables or test fixtures. Performing a "Short Correction" procedure on cables or test fixture before measurement of low impedance DUTs improves measurement accuracy.

If the condition or position of a cable or test fixture changes, you MUST carry out Zero Correction to compensate for the change. When performing a Zero Correction, keep hands and metallic objects away from the cable or fixture.

Table 4.2: Short and Open Null Connections

Connection	Open Correction		Short Correction	
	Correct	Incorrect	Correct	Incorrect
Terminal Only				
5-Terminal				
Kelvin Klips™				

Measurement Tips cont'd:

Test Lead Requirements

Four-wire Kelvin-type cables or fixtures must be used with the 3550 in order to obtain accurate impedance measurements. The Kelvin measurement technique allows significant accuracy advantage over the two-wire method. This is because it virtually eliminates lead resistance and inductance and reduces stray capacitance between the source and sense leads.
Two of the four conductors are designated as source leads. These source leads provide the precision test current that will be referenced in making the resistance measurement. Since current is the same throughout a series circuit, the lead resistance of the test leads will not have any effect on the level of reference current.

The other two conductors are designated as voltage sense leads. These leads originate from a high impedance, volt measurement circuit. When these leads are terminated at the points of contact, an exact resistance reading is calculated by the 3550's microprocessor. The series lead resistance of the voltage sense leads is negligible due to the high impedance of the voltage measurement circuitry within the 3550.

Figure 4.1a: Four-Wire Kelvin Measurement

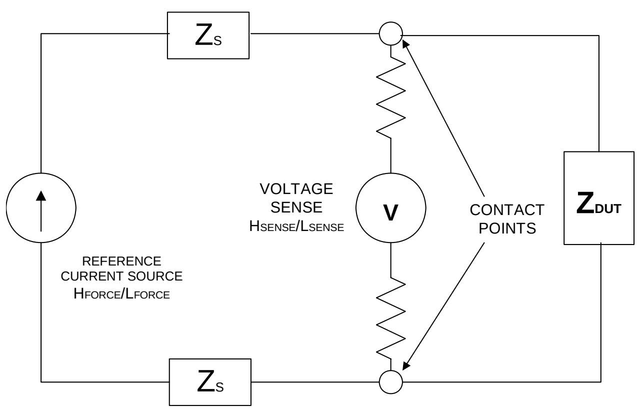
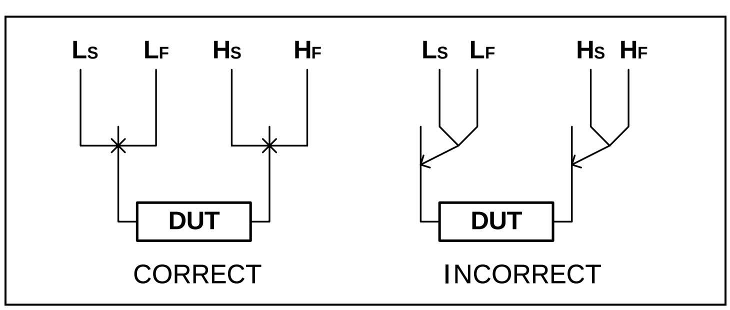


Figure 4.1b: Proper Application of Four Wire Kelvin Measurement



Measurement Tips cont'd:

Measurement Signal Levels

Measurement signal levels are adjustable between 0.01V~5.00V. It is recommended that the voltage level be kept at a high value (usually 1V or larger) to avoid potential stability problems associated with test frequency, device impedance and noise.

Series or Parallel Circuit Modes

The "CIRCUIT MODE" should always be "AUTO" mode, unless there is a special circumstance that requires otherwise. The 3550 is in the AUTO circuit mode when the pushbutton's LED is illuminated. Manually setting the circuit mode should only be done in special circumstances where series or parallel measurement is necessary even if some discrepancy is known to occur.

Auto Range Switching Threshold

When using Auto Range for measurement, the relationship between the switching direction and indicated switching values are as follows: (When Dissipation Factor: D=0)

Range UP	When $|Z| \geq 19999$ counts
Range DOWN	When $|Z| \leq 17999$ counts

As the dissipation factor, D increases then these threshold values will change.

Display Resolution

The absolute impedance, |Z| of the DUT determines the range of the 3550. All subsequent measurements will display with a resolution that is consistent with the instrument's current range setting.

AC Resistance of Coils with Cores

In most cases the AC resistance of a coil with no core at low frequencies is the same as the DC resistance. This is not the case for coils with high permeability cores such as ferrite or iron. Higher permeability will promote core losses from an AC signal causing the resistance measurement to appear larger than it would be for a DC measured resistance value. Therefore, an inductance measurement taken at 42Hz (the lowest frequency setting of the 3550) will not necessarily reflect a DC equivalent resistance value.

Front Panel Description

Front Panel Layout

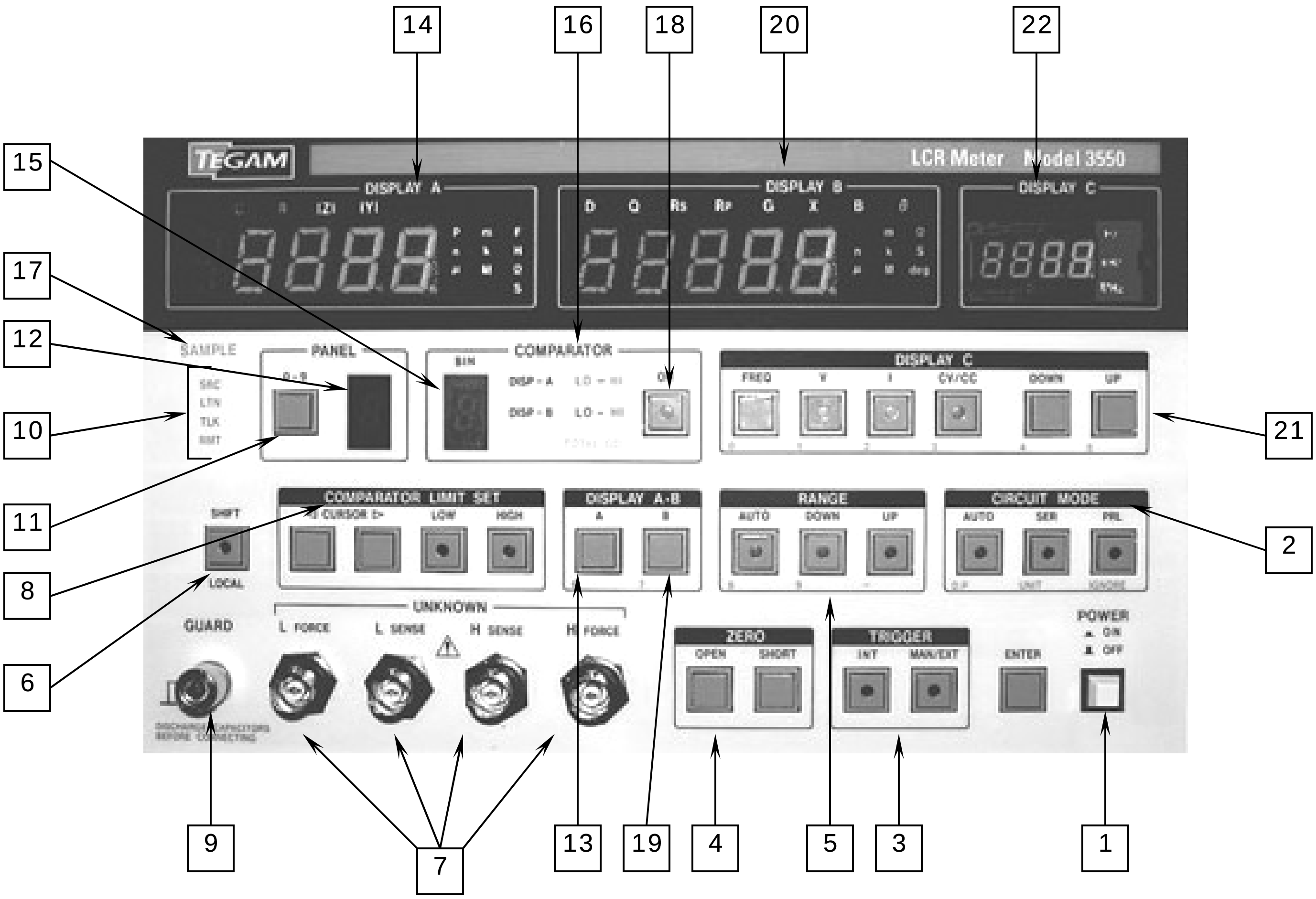


Figure 4.2: Front Panel layout

Except for the "POWER" switch, a buzzer will be sounded whenever the function of a switch is changed.

Front Panel Description cont'd:

1 - [POWER] Switch – [POWER]
With the power switch in the down state, power is applied to the 3550 and in the up state power is off. When the power is turned on, the remaining operational switches will retain the same status as they had before the power was previously turned off.
If the power is turned on while simultaneously pushing the [MAN/EXT] Key, the machine will return to its factory default settings.

2 "CIRCUIT MODE" Panel - [AUTO] [SER] [PRL]
This panel contains the keys used for setting the Series or Parallel Equivalent Circuit Mode. When verifying incoming component values it is usually good practice to consult the manufacturer for the recommended test mode.
In general, parallel mode is used when the reactance of a device is large. Parallel mode should be used when a capacitor's leakage or an inductor's core losses significantly affects the reading. Series mode is recommended for small reactance measurements in capacitors and inductors where series lead resistance must be considered and leakage and core losses become negligible.

- [AUTO] – When this key is illuminated, the instrument is in AUTO equivalent circuit mode. This means that the 3550 will automatically select either series or parallel equivalent circuit mode based on the impedance of the DUT. It does not necessarily mean that the correct equivalent circuit mode will be selected.
- [SER] – Series equivalent circuit mode is typically desirable for low reactance measurements. This is because Rs or series resistance becomes more significant than parallel resistance to the measured value.
- [PRL] – Parallel equivalent circuit mode is often more effective for measurement of impedances with high reactive components. This is because in a capacitor or inductor with a high reactance, the parallel leakage is more significant to the measured value.

3 "TRIGGER" Panel - [INT] [MAN/EXT]
Select either an internal or external trigger by pressing either the [INT] or [MAN/EXT] key. The active trigger mode of the 3550 is indicated by an illuminated pushbutton.

- [INT] - When the [INT] key is pressed, the 3550 operates in the continuous trigger mode. The instrument automatically takes readings at regular intervals.
- [MAN/EXT] – Depressing the [MAN/EXT] key will put the 3550 into manual one-shot trigger mode, which requires the [MAN/EXT] key to be pressed for each reading.

Front Panel Description cont'd:

4 "ZERO" Panel – [OPEN] [SHORT]
Performing OPEN and SHORT corrections before making an impedance reading greatly improves measurement accuracy. Refer to page *4-4, "Zero Correction of Parasitic Impedance"* for connection diagrams and other details regarding these procedures.

- [OPEN] - The OPEN circuit zero correction procedure compensates for stray capacitance and conductance between test leads/fixture. Pressing the [OPEN] key initiates the open circuit zero correction procedure. Make sure that the test fixture is in the *open* state before performing the OPEN circuit zero correction procedure.
- [SHORT] – The SHORT circuit zero correction procedure compensates for residual resistance and inductance in the test leads/fixture. Pressing the [SHORT] key initiates this procedure. Make sure that the test fixture is *shorted* before performing the SHORT circuit zero correction procedure.

There are three variations of zero correction procedures:

1) Standard Zero Correction: corrects all frequencies. This process requires several minutes to step through all of the test frequencies. See 4 (*p. 4-9*) for details.
2) Spot Zero Correction, allows up to three user-defined frequencies to be corrected: see [SHIFT]→[8] (*p. 4-14*) to define spot frequencies; [SHIFT] →[OPEN] (*p. 4-16*) for Open circuit spot correction; & [SHIFT] →[SHORT] (*p. 4-16*) for short circuit spot correction.
3) Correction Frequency Limit Mode: allows the user to define a range of test frequencies to be zero corrected during a standard zero correction.
   Refer to [SHIFT] →[-] (*p. 4-16*) and 4 (*p. 4-9*) for more details.

5 "RANGE" Selection Panel – [AUTO] [DOWN] [UP]
The Range panel is used to select either automatic or manual measurement ranges. If AUTO range is used to find the correct measurement range and the 3550 is then switched to MANUAL range, the 3550 will retain the current measurement range.

- [AUTO] – Pressing the [AUTO] key will toggle between Auto and Manual Range Modes. When the 3550 is in the AUTO mode, the pushbutton will be illuminated. When the instrument is in the manual mode the AUTO pushbutton is not illuminated.
- [DOWN] – In the manual mode, pressing the [DOWN] key will lower the range of the instrument. The [DOWN] key will flash to indicate when the current range is under ranged and needs to be lowered for a reading to take place. When the [DOWN] key is pressed, then an audible beeper will sound to indicate that the range has been lowered.
- [UP] - In the manual mode, pressing the [UP] key will raise the current range of the 3550. The [UP] key will flash to indicate when the current range is over ranged and needs to be raised in order for a reading to take place. When the [UP] key is pressed, then an audible beeper will sound to indicate that the range has been raised.

Front Panel Description cont'd:

6 [SHIFT] Key

The [SHIFT] key has dual functionality. Its primary purpose is to allow access to the secondary functions of the numeric keys. Its secondary function allows the user to switch from Remote communications Mode (GPIB or RS-232C Operation) to Local (Front Panel) Operation.

Below is a summary of the secondary functions accessible by pressing the [SHIFT] key and then a corresponding function key. The secondary function keys are [0]~[9], [OPEN], [SHORT] and [-]. For descriptive convenience, notation such as [SHIFT] → [0] etc will be used to indicate that first the [SHIFT] Key should be pushed, and then the [0]" Key.

[SHIFT] → [0]: Frequency Set Mode

The 3550 test frequency settings may be programmed from 42.0Hz to 5.00 MHz with a resolution of three significant digits. If DISPLAY C is set to indicate test frequency and the 3550 is in the Measurement mode, the frequency can be adjusted changed by pressing the [UP] and [DOWN] keys in the DISPLAY C panel.
Pressing [SHIFT] → [*0*] will cause the 3550 to enter the frequency set mode.

Entering the Frequency Values

The most significant digit in DISPLAY C will flash indicating that a new value must be entered. Press a key from [*0*]~[*9*] to set the value of the first digit and to proceed to set the next digit value. Once again, press a key from [*0*]~[*9*] and proceed to the next digit.

Set the Decimal Point Location

Once values for all of the three digits have been defined, the decimal point will start to blink indicating that the decimal point needs to be positioned. Press the [*DP*] key and notice that the position of the decimal point will change. Continue to press the [*DP*] key until the decimal point is positioned correctly.

Select the Frequency Units

Press either the [CURSOR ►] or [CURSOR ◄] keys repeatedly until one of the frequency units annunciators (Hz, kHz, or MHz) begins to blink. This indicates that the frequency units mode is now active. Press the [*UNIT*] key until the desired frequency units annunciator starts to blink.

Verify and Set the Frequency

The user can go back and edit any of the previous settings by pressing the [CURSOR ►] or [CURSOR ◄] keys to access the settings. Verify that all frequency settings are correct and then press the [ENTER] key. This will store the new frequency settings and return the instrument back to measurement mode.

Front Panel Description cont'd:

[SHIFT] → [*1*]: Test Voltage Set Mode

**See the Appendix for detailed information concerning the measurement ranges for constant current or constant voltage modes and for instructions for setting either of these modes.*

The 3550 test voltage values may be modified if the open circuit voltage or constant voltage setting is displayed on DISPLAY C. Constant voltage mode is indicated when the [CV/CC] and [V] pushbuttons are illuminated. The 3550 is in open circuit voltage mode when only the [V] key is lit.

The Model 3550 has programmable test voltages from 0.01V~5.00V for test frequencies of 42.0Hz~1.00MHz. For test frequencies above 1.00MHz, the voltage can be adjusted between 0.01V and 1.00V. Test voltages are adjustable in steps of 0.01V and are displayed in DISPLAY C to three significant digits. Refer to the Appendix to calculate the maximum voltage range of the constant voltage mode.

If DISPLAY C is set to indicate test voltage and the 3550 is in the Measurement mode, the voltage amplitude can be incremented or decremented by pressing the [UP] and [DOWN] keys in the DISPLAY C panel. If the [UP] and [DOWN] keys are held down the 3550 will increase the speed at which the voltage is incremented or decremented.

If more dramatic changes are required, then the test voltage must be manually entered by accessing the 3550's voltage set mode.

Pressing [SHIFT] → [*1*] will cause the 3550 to enter the voltage set mode. Below are instructions to set the test voltage.

Enter the Voltage Values

The most significant digit in DISPLAY C will flash indicating that a new value must be entered. Press a key from [*0*]~[*9*] to set the value of the first digit and to proceed to set the next digit value. Once again, press a key from [*0*]~[*9*] and proceed to the next digit.

Verify and Set the Test Voltage

Once all three digits have been entered, double-check the final voltage value. The values are changed by pressing the [CURSOR ►] or [CURSOR ◄] keys and entering a new value. Press the [ENTER] key to save the voltage setting and to return back to the measurement mode.

If a programmed voltage exceeds the instrument's sourcing capability, the 3550 will beep three times and not allow the illegal value to be saved if the [ENTER] key is pressed.

[SHIFT] → [*2*]: Test Current Set Mode

**See the Appendix for detailed information concerning the measurement ranges for constant current or constant voltage modes and for instructions for setting either of these modes.*

The 3550 test current values may be modified if the open circuit current or constant current setting is displayed on DISPLAY C. Constant current mode is indicated when the [CV/CC] and [I] pushbuttons are illuminated. The 3550 is in open circuit current mode when only the [I] key is lit.

Programmable test currents are available from 0.01mA~99.99mA for test frequencies of 42.0Hz~1.00MHz. For test frequencies above 1.00MHz, the current can be adjusted between 0.01mA and 20.00mA. The 3550's test current is adjustable in 0.01mA steps and is displayed to three significant digits. Refer to the Appendix for instructions to calculate the maximum test current available in the constant current mode for a given impedance.

Front Panel Description cont'd:

[SHIFT] → [*2*]: Test Current Set Mode cont'd:
If DISPLAY C is set to indicate test current and the 3550 is in the Measurement mode, the current amplitude can be incremented or decremented by pressing the [UP] and [DOWN] keys in the DISPLAY C panel. If the [UP] and [DOWN] keys are held down the instrument will increase the speed at which the current is incremented or decremented.
The test current can be manually entered by accessing the instrument's current set mode. Below are instructions to manually set the test current.

Enter the Current Values
Press [SHIFT] → [2] to enter the current set mode. The most significant digit in DISPLAY C will flash indicating that a new value must be entered. Press a key from [*0*]~[*9*] to set the value of the first digit and to proceed to set the next digit value. Once again, press a key from [*0*]~[*9*] and proceed to the next digit.

Verify and Set the Test Current
Once all three digits have been entered, double-check the final current value. Any of the digits may be accessed and modified by pressing the [CURSOR ►] or [CURSOR ◄] keys and entering a new value. Press the [ENTER] key to save the current setting and to return back to the measurement mode. The 3550 will beep three times and will not return to measurement mode if a programmed test current exceeds the instrument's sourcing capability.

[SHIFT] → [*3*]: Averaging Set Mode
You can define the number of measurements the 3550 makes before it produces a readable measurement. Averaging is used to stabilize the output reading and to increase the accuracy of a reading. To set the number of averages per reading, press [SHIFT] → [*3*]. The active average setting will be displayed on DISPLAY B. The first digit will flash indicating that one of the numeric keys, [*0*]~[*9*] must be pressed to set the value of the first digit. Once a value has been entered then the next digit will flash. Enter the desired values for the three digits and press the [ENTER] key to store the new setting. The number of averages may be set from 1~100 readings. If an illegal value is attempted the instrument will beep three times when the [ENTER] key is pressed to indicate that the attempted value is outside of the instrument's acceptable range.

[SHIFT] → [*4*]: Key Lock Mode
In the Key Lock mode, all front panel keys except the [SHIFT]" Key, [*4*] Key, and (in the case that the Measurement Trigger is set to Manual) the [MAN/EXT] Key will be locked. The Key lock mode is used to protect the 3550 settings from unintentional changes.
To access the Key Lock Mode settings, press the [SHIFT] →[4] keys. A single digit, either a "1" or a "0" will be displayed in DISPLAY B. Set the digit to "1" to lock the front panel or to "0' to unlock the front panel keys. Press the [ENTER] key to finalize the setting.

Front Panel Description cont'd:

[SHIFT] → [*5*]: Comparator Buzzer Function
Press the [SHIFT] →[*5*] keys to enter the Buzzer Settings Mode. The active setting, 0~2 will blink in DISPLAY B.

Buzzer Function	Value
Buzzer OFF	0
GO = Buzzer ON	1
NO-GO = Buzzer ON	2

Press either [0], [1] or [2]. The new entry will appear in DISPLAY B. Press [ENTER] to finalize the setting and to return to the measurement mode.

[SHIFT] → [*6*]: Trigger Delay Time
The trigger delay time is programmable from 0~10,000 milliseconds (10s). It is used to add a time delay immediately after the detection of a trigger signal from either the [MAN/EXT] key, external control device (I/O Control Connector), RS-232C or GPIB Interfaces.
In the Trigger Delay Time Settings Mode, the active setting for the trigger delay time will appear flashing on DISPLAY B. The default setting for the Trigger Delay Time is "00000 ms" The active flashing number can be changed by highlighting the active digits by pressing the [CURSOR ►] or [CURSOR ◄] keys and entering a new value by pressing the [*0*]~[*9*] keys. When all the necessary digits have been changed press the [ENTER] Key to finalize the settings and return to Measurement mode.

Front Panel Description cont'd:

[SHIFT] → [*7*]: Comparator Functions Mode
Press [SHIFT] →[*7*] to access the Comparator Functions Mode. Either a flashing "0" or a "1" will appear on DISPLAY B. The meaning of the numbers is as follows:

0: Absolute Value Comparator Function
1: Percent Comparator Function

To change the flashing digit, press either [*0*] or [*1*] and press [ENTER] to store the new setting and return to the measurement mode.

[SHIFT] → [*8*]: Defining Spot-Correction Frequencies for Zero Adjustments
The spot-correction frequency mode allows the user to identify up to three specific test frequencies where open and short-circuit, zero adjustments may be performed. This feature condenses the default zero adjustment procedure by limiting the zero adjustments to user-defined frequency points instead of stepping through the entire range of test frequencies (42Hz~5MHz). Performing spot-correction frequency zero adjustment saves time by eliminating the zero adjustment of unused test frequencies.

Select the Spot Frequency Number
Press [SHIFT] →[*8*] to enter the spot-correction frequency editing mode. The BIN LED will display a flashing "1", "2", or "3". Press either the [*1*], [*2*], or [*3*] keys to select the spot frequency you would like to set.
Entering the Spot Frequency Value
Once a key is pressed, DISPLAY C will display "---" indicating that a spot frequency must be defined. Press the [*0*]~[*9*] keys to enter the spot frequency digits. Next, press the [*DP*] key to position the decimal point. Press either of the [CURSOR ►] or [CURSOR ◄] keys to highlight the frequency units. Press the [*UNIT*] key until the desired frequency units annunciator starts to blink. Press the [ENTER] key to finalize the spot frequency setting.

To disable the Spot Correction Frequency, make sure that you are in the spot frequency editing mode (press [SHIFT] →[*8*]) use the [CURSOR] keys to highlight DISPLAY C. When this is done, press the [*IGNORE*] key to erase the current spot frequency setting.

Front Panel Description cont'd:

[SHIFT] → [9]: RS-232C Settings Mode

For the RS-232C, the baud rate, data length, parity and stop bit can be defined by the user. Press the [SHIFT] → [9] key to enter into the RS-232C setup mode.

After entering the RS-232C setup mode, you will notice that the BIN LED will begin to blink. Press a key from [1] ~[4] to select the RS-232C parameter that you wish to set.

[1]: Set the Baud Rate	Default=5, 9600BPS
[2]: Set the Data Length	Default=1, 8 Bits
[3]: Set the Parity	Default=0, No Parity
[4]: Set the Stop Bit	Default=0, 1 Stop Bit

Notice that after selecting a parameter from 1-4, DISPLAY B will show a number that corresponds to the parameter setting as summarized in the tables below: Use the tables to determine the appropriate setting for the RS-232C communications. Use the [CURSOR ►] or [CURSOR ◄] keys to navigate between the RS-232C parameter and the setting on DISPLAY B.
Press the [ENTER] key to finalize the settings and return to measurement mode.

BIN Display "1" Baud Rate Settings

DISPLAY B Settings	RS-232C Settings
0	300bps
1	600bps
2	1200bps
3	2400bps
4	4800bps
5	9600bps
6	19.2kbps
7	38.4kbps

BIN Display "2" Data Length Settings

DISPLAY B Settings	RS-232C Settings
0	7bits
1	8bits

BIN Display "3" Parity Settings

DISPLAY B Settings	RS-232C Settings
0	No parity
1	Odd parity
2	Even parity

BIN Display "4" Stop Bit Settings

DISPLAY B Settings	RS-232C Settings
0	1bit
1	2bit

Front Panel Description cont'd:

[SHIFT] → [-]: Correction Frequency Limit Setting Mode

As an alternative to zero correcting the entire frequency range 42Hz~5MHz, this function allows the user to set the correction frequency range in terms of upper and lower limits. Press [SHIFT] → [-] to enter the Correction Frequency Setting Mode. The "BIN" LED will be flashing. Press either [*1*] to edit the low limit correction frequency or [*2*] to edit the high limit correction frequency.
Use the [CURSOR ►] or [CURSOR ◄] keys to navigate between the "BIN" LED, DISPLAY C Digits, Decimal Point and Frequency Units. To change the frequency value indicated on DISPLAY C, simply press the [*0*]~[*9*] keys.
Press the [DP] key to change the position of the decimal point and use the [*UNIT*] key to select Hz, kHz, or MHz units.
Press the [ENTER] key in order to finalize the new setting and to return to measurement mode.

NOTE: While in the Spot Correction Frequency Mode, the Spot Correction Frequency high or low limit setting can be enabled or disabled. This is done by pressing the [IGNORE] key.

[SHIFT] → [*OPEN*]: Spot Correction Mode (Open Correction)

The spot correction Mode is used for making open and short-circuit frequency corrections. Pressing the [SHIFT] → [*OPEN*] keys will allow an open circuit, spot frequency correction to take place. The open circuit correction is performed only on the three spot frequencies that are defined by pressing [SHIFT] → [*8*], (*see Defining Spot-Correction Frequencies for Zero Adjustments*).
Note that Spot Frequency Zero Corrections have precedence over Normal Zero Corrections. This means that the open and closed-circuit, zero correction factors for the spot frequencies will be stored and retained in the instrument's memory and will be written over unless an additional spot frequency correction procedure is performed. Performing a standard zero correction procedure will write over the zero adjustment factors of all test frequencies except the three user-defined, spot correction frequencies.

[SHIFT] → [*SHORT*]: Spot Correction Mode (Short Correction)

Pressing [SHIFT] → [*SHORT*] initiates the Short-Circuit, Spot Frequency Correction process. The offset adjustment affects only the three user-defined Spot Correction Frequencies discussed in the, *Defining Spot-Correction Frequencies for Zero Adjustments* section ([SHIFT] → [*8*]).
Like the Open Circuit Spot Frequency Correction Mode, Short Circuit Spot Corrections have precedence over Normal Short Circuit Zero Corrections. Closed circuit, spot correction factors will be stored and retained in the instrument's memory and cannot be written over unless an additional spot frequency correction procedure is performed. Performing a standard zero correction procedure will write over the zero adjustment factors of all test frequencies except the three user-defined, spot correction frequencies.

Front Panel Description cont'd:

7 "UNKNOWN" Terminals Panel

Four BNC-type terminals plus one GUARD are available for making shielded or unshielded Kelvin-type measurement connections to the DUT. Their designations and functions are summarized below:

Table 4.3 – Unknown Terminals

Connection Type / Description	Measurement Function
BNC L_{FORCE}	Low Side Current Source
BNC L_{SENSE}	Low Side Voltage Sense
BNC H_{FORCE}	High Side Current Source
BNC H_{SENSE}	High Side Voltage Sense
Binding Post GUARD	Five-wire shielded measurements

8 "COMPARATOR LIMIT SET" Panel - [CURSOR ►] [CURSOR ◄] [LOW] [HIGH]

When programming comparator settings, the keys in the Comparator Limit Set Panel are used to define the DISPLAY A & DISPLAY B Comparator values. The two left most keys are the [CURSOR ►] or [CURSOR ◄] keys. In the comparator set mode, these cursor keys allow navigation between the present BIN number (1-9) and DISPLAY A and DISPLAY B comparator value settings.

If a value is defined for either DISPLAY A or DISPLAY B (by pressing digits [0]~[9] while the DISPLAY digits are blinking.) then the functionality of the [CURSOR ►] or [CURSOR ◄] keys extends to allow navigation of the comparator value's decimal point location and selection of the DISPLAY A and DISPLAY B units of measure.

The Comparator's High and Low Limit Values for DISPLAY A and DISPLAY B can be set by pressing the [LOW] and [HIGH] Keys while in the measurement mode. Pressing either of these keys will put the 3550 into the Comparator Limits Set Mode.
Once in the Comparator Limits Set Mode, the BIN# and values for DISPLAY A and DISPLAY B comparator settings can be defined by using the secondary functions (blue text) of the keys located in the CIRCUIT MODE, RANGE, DISPLAY C, and DISPLAY A-B Panels. These secondary functions include [*0*]~[*9*], [-], [*D.P.*], [*UNIT*], and [*IGNORE*] commands.

NOTE: Only panels 1~9 can have comparator limit values assigned to them.

9 The "GUARD" Terminal

This terminal is connected to the chassis of the 3550. When measuring High-Impedance devices, connect the device's shield to this binding post.

Front Panel Description cont'd:

10 **Remote Interface Status LEDs** – "SRQ" "LTN" "TLK" "RMT"
These LEDs indicate the status of remote communications using the 3550's standard RS-232C and optional GPIB (IEEE-488.2) interfaces
All four annunciators are used for GPIB communications. If the RS-232C is the controller, then only the "RMT" LED is used.

11 **"PANEL" Selector Switch**
Pressing the [0-9] key in the Panel section allows the user to select a preset panel setting from 0-9. Each consequent press of the [0-9] key will increment to the next preset panel number. The active instrument settings are automatically updated to the panel number indicated on the seven segment LED (Panel Display LED). If the instrument settings are changed while a panel number (0-9) is active and the panel key is pressed then the existing settings will be stored into the panel location indicated by the Panel Display LED.
Only panels 1~9 can have comparator limit values assigned to them.

12 **"PANEL" Display LED**
The PANEL Display LED is a seven segment LED that displays the active panel setting.
Press the [0-9] key located in the Panel Section to increment through panel settings 0-9.

13 **"DISPLAY A" Parameter Selection Key -** [A]
Press this key to select the measurement parameter of DISPLAY A. Measurements of L, C, R, |Z| and |Y| are available.

14 **"DISPLAY A"**
Measured values of L, C, R, |Z|, and |Y| are shown in this panel. The measurements values range from 0000 to 19999 and are displayed with $4^1/_2$ - digit resolution. In addition, units of measure are annunciated above and beside the display for reading convenience.
To change the parameters shown by DISPLAY A, press the [A] key located in the DISPLAY A-B instrument panel until the desired measurements are shown.

15 **"BIN" Display LED**
The BIN Display LED is a seven segment LED that displays the active sorting bin number of the Comparator. When the Comparator is ON, this LED displays which BIN Number the present measurement is associated with. "1" through "9" are for OK products, while "0" is reserved for defects such as open circuit conditions.

Front Panel Description cont'd:

16 Comparator State Annunciators

Located in the Comparator Panel there are three total comparator state annunciators. The annunciators become active when the comparator is on. The comparator is turned on by pressing the [ON] key in the Comparator Panel. See below for a summary of the annunciator functions.

Annunciator	Functional Description
DISP-A LO-HI	*Indicates when the measured value of DISPLAY A is equal to or outside of the Low or High Comparator setting.*
DISP-B LO-HI	*Indicates when the measured value of DISPLAY B is equal to or outside of the Low or High Comparator setting.*
TOTAL GO	*Indicates when the measured value of DISPLAY A and DISPLAY B are within the High and Low limits of the Low or High Comparator setting. If DISPLAY A comparator is disabled then the TOTAL GO DISPLAY B determines condition only. If DISPLAY B comparator is disabled then the TOTAL GO condition is determined by DISPLAY A only.*

17 Sample LED (Trigger Status)

This LED displays the measurement status. When the TRIGGER mode is set to "INT", this LED will flash continuously. When the TRIGGER mode is set to "MAN/EXT", this LED will flash every time a measurement is made.

18 "COMPARATOR ON/OFF" Switch – [ON]

This switch enables or disables the Comparator. When the switch is in the ON state (LED on), the BIN Display LED, Comparator State Annunciators, and Comparator functions are enabled.

19 "DISPLAY B" Parameter Selection Key - [B]

Press this key to select the measurement parameter of DISPLAY B. Measurements of D, Q, RS, RP, G, X, B and θ are available.

20 "DISPLAY B"

Measured values of D, Q, RS, RP, G, X, B and θ are shown in this panel. The measurements values are displayed with $4^1/_2$ - digit resolution. In addition, units of measure are annunciated above and beside the display for reading convenience.
To change the parameters shown by DISPLAY B, press the [B] key located in the DISPLAY A-B instrument panel until the desired annunciator is lit.

Front Panel Description cont'd:

21 **DISPLAY C Measurement Panel** – [FREQ] [V] [I] [CV/CC] [DOWN] [UP]
The keys on the DISPLAY C Measurement panel are used to set the measurement frequency, constant voltage, voltage or constant current mode, test signal amplitude and the measurement that will be shown on DISPLAY C.

[FREQ] – Test Frequency Select Key
When [FREQ] is pressed, the test frequency will be shown on DISPLAY C. The displayed test frequency setting can be adjusted using the [DOWN] and [UP] Keys to increment or decrement the existing test frequency setting. To define the test frequency value, decimal point location and units refer to the [SHIFT] → [0]: Frequency Set Mode section.

[V] – Show Test Voltage on DISPLAY C
When the [V] key is pressed the test voltage will be shown on DISPLAY C. Pressing either the [UP] or [DOWN] keys will adjust the test voltage. The test voltage, decimal point and units can be set by using the [SHIFT] → [V] key sequence.

The Model 3550 has programmable test voltages from 0.01V~5.00V for test frequencies of 42.0Hz~1.00MHz. For test frequencies above 1.00MHz, the voltage can be adjusted between 0.01V and 1.00V. Test voltages are adjustable in steps of 0.01V and are displayed in DISPLAY C to three significant digits.

When in the constant voltage mode, and the [UP] or [DOWN] keys are pressed, DISPLAY C will momentarily show the open circuit test voltage setting before displaying the constant voltage applied to the actual test device terminals. If either the [UP] or [DOWN] key is pressed and held, the voltage setting will display and the setting will either scroll up or down (depending on whether the [UP] or [DOWN] key is pressed.

[I] – Show Test Current on DISPLAY C
When [I] is pressed, the test current flowing through the DUT will be displayed. Pressing either the [UP] or [DOWN] keys will adjust the test current level. The test current, decimal point and units can be set by using the [SHIFT] → [I] key sequence.

Programmable test currents are available from 0.01mA~99.99mA for test frequencies of 42.0Hz~1.00MHz. For test frequencies above 1.00MHz, the current can be set between 0.01mA and 20.00mA. The 3550's test current is adjustable in 0.01mA steps and is displayed to three significant digits.

When in the constant current mode, and the [UP] or [DOWN] keys are pressed, DISPLAY C will momentarily show the open circuit test voltage setting before displaying the actual current flowing through the test device. If either the [UP] or [DOWN] key is pressed and held, the voltage setting will display and the setting will either scroll up or down (depending on whether the [UP] or [DOWN] key is pressed.

Front Panel Description cont'd:

Test Signal Modes - [CV/CC]

Model 3550 is capable of three different measurement modes. These are Open Circuit Test Voltage Mode, Constant Voltage Mode, and Constant Current Mode. The active measurement mode can be confirmed by looking at the [V], [I], and [CV/CC] LED Keys in the DISPLAY C panel.
The relationship between the operation modes and the LED displays are as follows:

Table 4.4 – CV/CC Indicators

Measurement Mode	**[V] LED**	**[I] LED**	**[CC/CV] LED**
Open Circuit Test Voltage Mode	ON	OFF	OFF
Constant Voltage Mode	ON	OFF	ON
Constant Current Mode	OFF	ON	ON

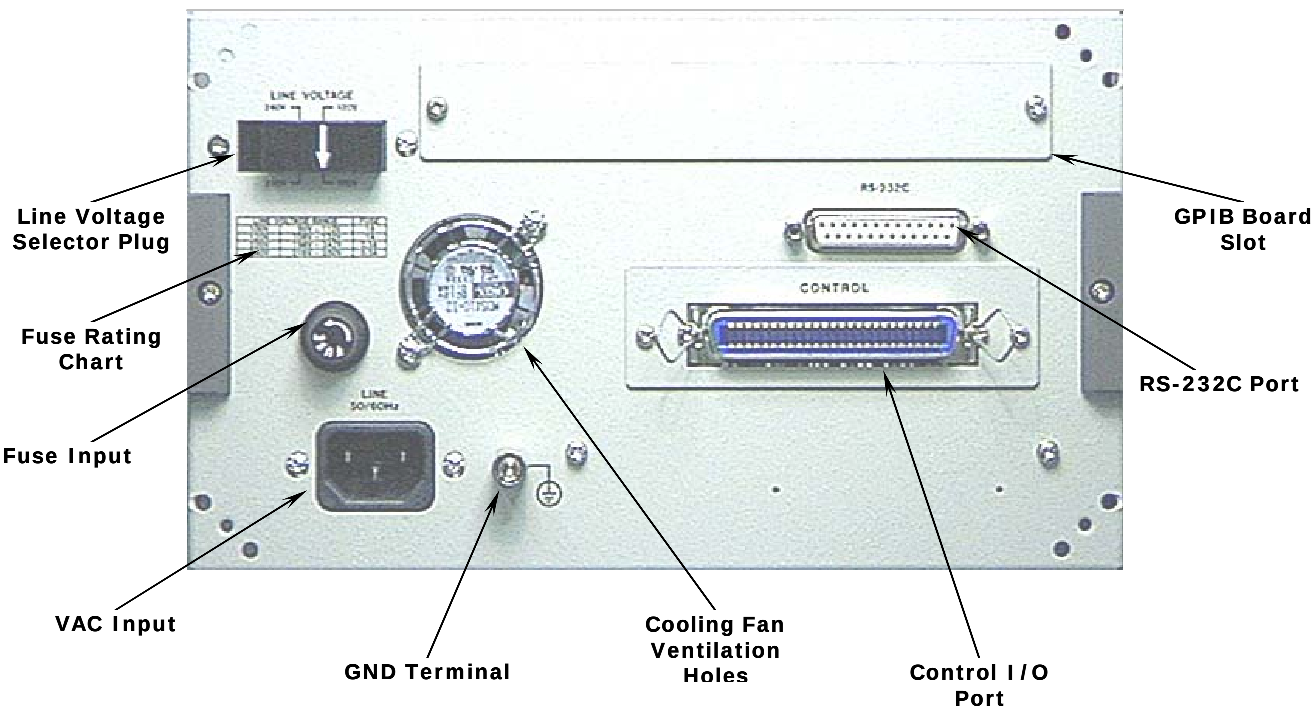
Set Voltage Mode
Measurements are taken using the open circuit Test Voltage. The test voltage varies with current. Use this mode for ordinary test objects that possess an overall impedance value with real and imaginary components.
Constant Voltage Measurement Mode
This makes the measurement while keeping the voltage of the measurement terminals at a fixed level. For example, this mode can be used for testing inductors where terminal voltage will vary. Using Constant Voltage mode can help stabilize a reading.
Constant Current Measurement" Mode
This makes the measurement stable by keeping the current passing through the DUT at a fixed level. For example, this mode can be used for testing capacitors where test current continuously varies with applied voltage.

22 "DISPLAY C"
Displays Frequency (Hz, kHz, and MHz), Open Circuit Test Voltage (V), Terminal Voltage (Constant V), and DUT Test Current (Constant mA) based on the settings of the DISPLAY C Measurement Panel. The measurement values are displayed with $4^1/_2$ - digit resolution. Units of measure are annunciated beside the display for reading convenience.

23 ENTER Key – [ENTER]
Used in the various programming modes to finalize user-defined instrument settings. For example, the [ENTER] key is pressed to finalize any of the [SHIFT] → [0~9] commands and to return back to the measurement mode.

Rear Panel Description

Figure 4.3 - Rear Panel Layout



Line Voltage Selector Plug – The Model 3550 is capable of 100/120/220/240 VAC 50/60 Hz Operation. To change the line voltage, remove the plug by pulling it from the rear panel. Put the plug back in to the socket with the arrow pointing to one of four supply voltage settings.

Fuse Input – Use 3AG Type Fuses, ¼" X 1¼" (6.35X31.75mm)

Fuse Rating Chart - See Rear Panel or Preparation for Use Section for fuse ampere ratings. Use fast acting fuses only.

VAC Input – 100/120/220/240, power input. An internal line filter is included in this input.

GND Terminal – The GND binding post provides a direct connection to the instrument's chassis and the grounded connector of the VAC input plug.

Cooling Fan Ventilation Holes – To prevent overheating, keep these ventilation holes free of obstructions. Periodically inspect these holes to assure they are free of obstructions.

Control I/O Port – The Control I/O Port has optically isolated TTL inputs and outputs used for remote operation. Inputs include BCD Panel Selection and trigger inputs. Outputs include A, B and total Comparator outputs, End of measurement, BIN, Busy and Error Outputs. The control connector also includes pins for external power connections.

RS-232C Port – Standard RS-232C Port.

GPIB Board Slot – Slot provided for factory installed GPIB (IEEE-488.2) option PN# 3505.

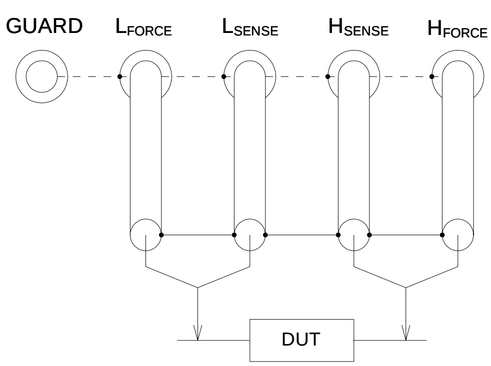
Making Accurate Measurements:

Connections to the Device Under Test (DUT)

The relationship between the connections schemes and impedance, |Z| ranges are shown in Table 5-1. It is extremely important, for measurement accuracy purposes, to observe appropriate connection methods for the subject test piece and measurement range.

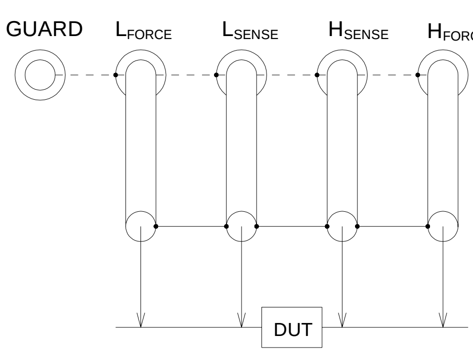
Range	1	2	3	4	5	6	7	8	9
Impedance Mode	Low Impedance (Series Equivalent Mode)					High Impedance (Parallel Equivalent Mode)			
Connection Type						**3 Terminal Connection**			
	← **5 Terminal Connection** →								

3-Terminal Measurement



This measurement method is used for testing devices having high impedance. In general, components with large inductance, low capacitance, or high resistance fall into this category.
The major advantage to 3-terminal measurements is that the influence of stray capacitance and conductance between the test leads and nearby conductors becomes negligible.

4 or 5-Terminal Measurements



The 5-terminal measurement method can be used for all impedance ranges and has significant advantage over the 3-terminal measurement method. The advantage is that in addition to canceling the effects of stray capacitance and conductance between the measurement leads and close proximity conductors, the residual inductance and resistance of the test lead are bypassed by placing the voltage sense points of contact directly at the DUT terminals.
A four-terminal measurement is the same as a five-terminal measurement except that the guard connection is not used.

Making Accurate Measurements:

Test Fixture Selection

Model 3510 Radial/Axial Lead Adapter

The Model 3510 Radial/Axial Lead adapter is a general-purpose accessory used for testing components with radial or axial leads. Components are tested by plugging the leads directly into the adapter sockets.
The Model 3510 is designed for 5-terminal measurements and is capable of measuring a wide range of impedances.

Model 47454 Kelvin Klips™

Model 47454 Kelvin Klip Leads are designed for 5-wire, Kelvin measurement of all types of component styles. They may be used for both low and high impedance measurements.
Kelvin Klips are particularly convenient for low impedance test devices or components with short leads, however, the measurement frequency and impedance range are limited as shown in Table 4.4. Exceeding the recommended measurement ranges may result in erroneous and inaccurate readings.

Table 4.4 - Impedance and Frequency Limitations of Kelvin Klip Leads

Frequency	Measurement Range
42Hz ~ 10kHz	100mΩ ~ 1MΩ
10.1kHz ~100kHz	1Ω ~ 100kΩ
101kHz ~ 1.00MHz	10Ω ~ 10kΩ

NOTE: Additional test voltage and current restrictions of the 3550 unrelated to test fixtures apply for measurements exceeding 1MHz.

Making Accurate Measurements cont'd:

Test Fixture Selection cont'd

Model 3511 Surface Mount Device (SMD) Test Fixture

The 3511 is a test fixture designed to perform 3-wire impedance measurements of surface mount devices. This adapter is suitable for measurement of chip components with middle to high impedance ranges. The measurement frequency and range limitations are summarized in table 4.5 below
Exceeding the recommended measurement ranges may result in erroneous and inaccurate readings. The signal level limitations of the instrument must also be considered when making measurements above 1MHz.

Table 4.5 - Impedance and Frequency Limitations of the SMD Test Fixture

Frequency	Measurement Range
42Hz ~ 100kHz	10Ω ~ 1MΩ
101kHz ~1.00MHz	10Ω ~ 10kΩ
1.01MHz ~ 5.00MHz	10Ω ~ 10kΩ (10Ω Minimum)

Model 2005B Chip Component Tweezers

2005B is designed for manual sorting of chip components from DC to 1MHz. Four-terminal tweezers make solid connections on chips up to 0.50 in. (12.7mm) long. The set includes a 5 ft. (1.5m) cable for connection to the 3550

47422 – Chip Tweezer Rebuild Kit
Tweezer tips are intended to last from 100,000 to 500,000 operations. This tip replacement kit includes 12 replacement tips, 2 screws, and 1 wrench.

Making Accurate Measurements cont'd:

Zero Corrections

Residual Impedance and Leakage of test fixtures exists for all types of test fixtures. To maintain the performance accuracy of the 3550 it is highly recommended that a zero correction be performed whenever a change in test fixture takes place. For test fixtures such as Kelvin Klip Leads where the positioning may vary, extra effort must be made to perform the zero correction while positioning the leads in the exact location, as the measurement will be taken.

When performing a standard zero correction, the instrument will step through frequencies from 42Hz to 5MHz. This takes a considerable amount of time and may not be desired in certain applications especially when the actual component test will take place at a single frequency point. To overcome this, the 3550 has the ability to perform spot frequency corrections where zero corrections are performed on up to three user defined frequency set points. The spot frequency zero correction data is stored in the instrument's non-volatile RAM and will overwrite any correction data obtained from a standard zero correction procedure. A standard zero correction cannot write over data from a spot frequency zero correction. The spot frequency setting must be disabled in order for the standard zero correction to be able to write over all frequency points. Refer to "Defining Spot-Correction Frequencies for Zero Adjustments", [SHIFT] → [*8*] in the front panel description to learn how to enable or disable the spot frequency settings.

Table 4.6 - Zero Correction Limits

Zero Correction	Correction		Correction Limit
Open	Stray Capacitance & Stray Conductance	(C0)&(G0)	>1kΩ
Short	Residual Inductance & Residual Resistance	(L0)&(R0)	< 1kΩ

If during OPEN correction the Impedance is less than 1kΩ, or during SHORT correction the Impedance is 1kΩ or higher, a buzzer will go off to warn that correction cannot be made, and the system will reset without making the correction.

There are three methods of defining what frequencies a zero correction will be performed on. They are Standard, Frequency Limit, and Spot Frequency Zero Correction.

Standard Zero Correction

Refer to Section [4], "ZERO" Panel – for instructions to perform a standard open and short circuit correction. This procedure will perform a zero correction on all test frequencies, 42Hz~5MHz except for those designated as spot correction frequencies.

Frequency Limit Zero Correction

For zero correction, [SHIFT] → [-], Correction Frequency Limit Setting Mode allows the user to define the upper and lower frequency limits instead of using the default 42Hz~5MHz range.

Spot Frequency Zero Correction

Refer to [SHIFT] → [OPEN] and [SHIFT] → [SHORT] sections for instructions to perform a spot frequency open and short zero correction procedure.

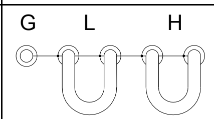
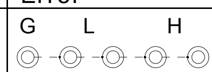
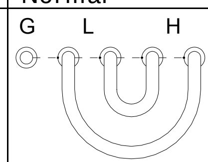
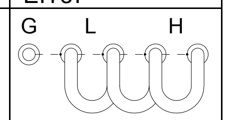
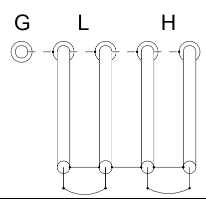
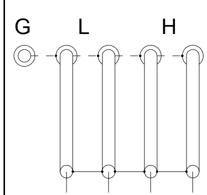
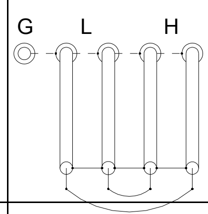
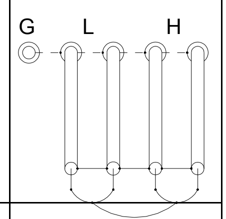
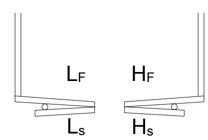
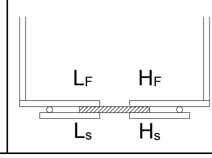
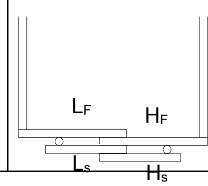
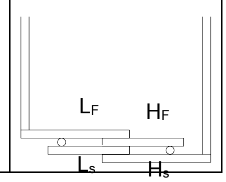
After performing the zero correction procedure, perform a "before and after" measurement on a component with an accurately known value to confirm that a zero correction has taken place. A calibrated capacitance or inductance standard would be ideal (but not required) for this type of verification.

Making Accurate Measurements cont'd:

Zero Corrections cont'd

NOTE: The parasitic impedance of test adaptors and measurement cables differ from cable to cable. Whenever a test adaptor or cable is changed, make sure that zero correction is performed again.

Figure 4.4 - Terminal Connections for Zero Correction

Connection	**Open Correction**		**Short Correction**	
	Normal	Error	Normal	Error
BNC Terminals				
5-Terminal Correction				
Kelvin Klip™ Correction				

Use Figure 4.4 as a reference when performing short-circuit and open-circuit zero corrections.

Making Accurate Measurements cont'd:

Equivalent Circuits

The DUT can be described in terms of Impedance (Z) or Admittance (Y). The relationships of the various characteristics are as follows:

$$Z = R + jX$$

$$Y = G - jB = \frac{1}{Z}$$

$$D = \frac{R}{X} = \frac{G}{B}$$

$$Q = \frac{1}{D}$$

$$X_L = \omega L = 2\pi f L$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$\theta = \tan^{-1}\frac{X}{R} = \tan^{-1}\frac{B}{G}$$

Z : Impedance
R : Equivalent Resistance
X : Reactance (jX)
Y : Admittance
G : Conductance
B : Susceptance (jB)
D : Loss Coefficient
Q : Quality
θ : Phase Angle
f : Measurement Frequency Hz
ω : Measurement Frequency rad/s

The measurable quantities of the 3550 are L, C, R, Z, Y, D, Q, G, Rp, Rs, X, B, and θ. The measured value of these parameters will change in value as the test frequency is increased or decreased. These measured parameters are said to be dependent upon test frequency.* Two examples are capacitive reactance, which is inversely proportional to frequency and inductive reactance, which is inversely proportional to frequency. Because of the direct relationship to test frequency, related quantities such as Dissipation Factor and Quality Factor is also frequency dependent.

**In measurement applications, the measured R and G values will change with frequency. True R and G are not theoretically dependent to frequency but in LCR measurement applications, parallel leakage and series losses can affect the measured R and G value of the component. Compensation for these errors is the reason for Series and Parallel Equivalent Circuit Measurement Modes.*

In general, parallel leakage becomes significant in highly reactive (*small capacitors or large inductors*) measurements and series resistance is more significant in low reactance (*large capacitors and small inductors*) measurements. This is the reasoning behind the use of series or parallel equivalent circuit measurement modes.

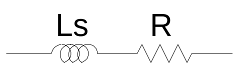
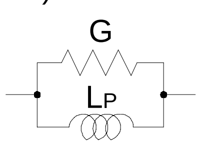
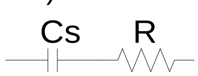
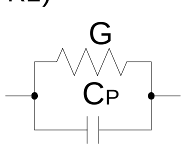
If the dissipation factor, D is small then the difference between Series Equivalent and Parallel Equivalent Circuit Measurement Mode measurement will be small. As the dissipation factor increases, the difference between parallel and series equivalent measurements will increase. Thus, precautions must be taken when performing measurements on components with high dissipation factors.

Making Accurate Measurements cont'd:

Equivalent Circuits cont'd

Table 4.7 Illustrates the effects of leakage and series resistance on component measurements. It also provides some additional formulae to illustrate the relationship that dissipation factor has on a device's impedance measurement.

Table 4.7 – Equivalent Circuit Relationships

Equivalent Circuit Mode		Dissipation Factor (D)	Conversion Formula	
L	(SER) 	$D = \frac{R}{\omega L_S} = \frac{1}{Q}$	$L_P = (1 + D^2) \cdot L_S$	$G = \frac{D^2}{1+D^2} \cdot \frac{1}{R}$
L	(PRL) 	$D = \omega L_P G = \frac{1}{Q}$	$L_S = \frac{1}{1+D^2} \cdot L_P$	$R = \frac{D^2}{1+D^2} \cdot \frac{1}{G}$
C	(SER) 	$D = \omega C_S R = \frac{1}{Q}$	$C_P = \frac{1}{1+D^2} \cdot C_S$	$G = \frac{D^2}{1+D^2} \cdot \frac{1}{R}$
C	(PRL) 	$D = \frac{G}{\omega C_P} = \frac{1}{Q}$	$C_S = (1 + D^2) \cdot C_P$	$R = \frac{D^2}{1+D^2} \cdot \frac{1}{G}$

The Series Equivalent Circuit Mode of the 3550 can be used for testing devices where series impedance has a great effect on the measurement. Parallel Equivalent Circuit Mode is used for testing devices with high reactance where parallel leakage becomes more significant. The formulae in Table 4.7 can be used to convert readings in one equivalent circuit mode to the other.

Note that the measured value of D (or Q) will not be different whether it is measured in Series or Parallel Equivalent circuit mode.

Operating the 3550

Preparation

Check the Power Source Voltage. The voltage range of this machine is displayed on the rear of the machine. The power voltage may be selected using the switching plug on the rear panel. See “Preparation for Use” for more setup details.

When the [POWER] Switch is turned ON the settings of the machine will be same as when the power was previously turned off. In order to reset the 3550, simply press [MAN/EXT] at the same time the [POWER] key is pressed. Resetting will clear the zero correction factors and return the instrument settings to factory defaults. A table summarizing the factory default settings can be found in Chapter 3, Quick Start Instructions.

How to Perform a Zero Correction

Determine whether test leads, an adapter or some other fixture will be used to make measurements and connect it to the front panel BNC terminals. Perform a Standard, Frequency Limit, or Spot Frequency Zero Correction for both open and closed circuit conditions. To perform a standard zero correction, follow the instructions below:

a) With the tips of the test leads or the adapter in an "open" condition, push the [OPEN] switch. DISPLAY A will show “OP–57” to indicate that an open correction is being performed and “57” will indicate what step frequency the instrument is adjusting for. The instrument will count down from “57” to “1”. Do not touch or adjust the test leads/fixture while the zero correction procedure is taking place.
b) Once the “OPEN” correction is completed the unit will return to the measurement mode. Connect the test leads/fixture in the "shorted" position (see Figure 4.X) and press the [SHORT] key. The instrument will execute the short circuit correction procedure.

During the Open or Short Circuit Zero Correction process, if the Correction Value min/max threshold is exceeded, a warning buzzer will sound 3 times to warn that the correction could not be done. If this happens, lower the parasitic Impedance, and re-do the correction. If the test leads/fixture continue to fail the zero correction, double check that the operating frequency range of the leads/fixture have not been exceeded. See “Test Fixture Selection” to determine whether the test frequency range of your test leads/fixture have been exceeded and whether a Frequency Limit or Spot Frequency Zero Correction need to be performed instead of a Standard Zero Correction. Frequency Limit and Spot Frequency Zero Corrections allow the user to define the specific frequencies to be open and short compensated. Frequency Limit and Spot Frequency Corrections can also be used to shorten the total zero correction time by ignoring unused test frequencies.

If the proper frequency correction has been performed and the test leads/fixture continues to fail zero correction, have the leads/fixture tested by an authorized service person.

⚠

Detailed instructions for performing "open " or "short” circuit zero corrections are found in the “Measurement Tips” and in “Front panel Description” sections of this manual. Make sure that front panel operation and LCR measurement technique is thoroughly understood before proceeding further. LCR measurement can be quite complex and the slightest overlooked detail could greatly affect measurement accuracy. To maximize measurement accuracy it is highly recommended that this chapter be understood in its entirety.

Operating the 3550 cont'd:

Measuring Inductance (L), Capacitance (C) and Resistance (R)

1) Always perform a zero correction procedure if the condition of the test leads/fixture has changed. This procedure must be performed before making a measurement. Refer to "How to Perform a Zero Correction" for more details.

2) Press the [A] key and select "L", "C" or "R" on DISPLAY A.

3) Press the [FREQ] key and adjust the frequency using the [UP] or [DOWN] keys or by manually entering a new value for test frequency. See [SHIFT] → [0]: "Frequency Set Mode" for more details on manually setting the test frequency.

4) Press the [V] key, and adjust the measurement voltage using the [UP] or [DOWN] keys or by manually entering a new value for test frequency. See [SHIFT] → [*1*]: "Test Voltage Set Mode" for more details on manually setting the test frequency.

5) Press the [AUTO] key in the RANGE panel and verify that the "AUTO" LED is on. This puts the 3550 in AUTO range.

NOTE: When repeatedly measuring DUTs with similar values selecting the manual mode allows the measurement time to be shortened by eliminating the time needed for switching the ranges. See "RANGE" Selection Panel" for more details.

6) Press the [AUTO] key in the CIRCUIT MODE panel and verify that the "AUTO" LED is on.

7) Press the [INT] key in the TRIGGER panel and verify that the "INT" LED is on. This will continuously trigger the 3550 and update the reading shown on DISPLAY at a rate determined by measurement frequency, delay time, number of averages, and the time taken to auto range. If MAN/EXT trigger mode is selected the reading will not be updated until a new trigger is received from the front panel or remote interface.

8) Connect the DUT to the measurement terminals. The CIRCUIT MODE and RANGE will be automatically selected by the 3550. The L, C, or R reading will be shown on DISPLAY A.

Operating the 3550 cont'd:

Measuring Inductance (L), Capacitance (C) and Resistance (R) cont'd:

Notes of Caution for Inductance (L) Measurement

- For low inductance measurements, 5 Terminal Measurements are required to minimize series resistance and inductance errors. Margins of error for 3 terminal measurements on low inductances will add significant error to the reading.
- When performing measurements on small coils with a core, it is possible that the measured inductance value will vary with a change in test signal level. Take extra caution to match the test signal level of other machines in order to obtain matching results.
- Keep metal objects away from the DUT when performing measurements. The presence of metal objects in close proximity can affect the measured value. Especially in coils with air or other low permeability cores.

Notes of Caution for Capacitance (C) Measurement

- For large capacitance measurements, 5 Terminal Measurements are required to minimize errors caused by series resistance and inductance. Margins of error for 3 terminal measurements on large capacitances will add significant error to the reading.
- ⚠ Always make sure that capacitors are completely discharged before connecting to the 3550 measurement terminals otherwise erroneous readings or damage to equipment could result.

Notes of Caution for Resistance (R) Measurement

- For low resistance measurements, 5 Terminal Measurements are required to minimize series resistance and inductance errors. Margins of error for 3 terminal measurements on low resistance will add significant error to the reading.

Operating the 3550 cont'd:

Measuring Impedance (|Z|) and Admittance (|Y|)

1) Always perform a zero correction procedure if the condition of the test leads/fixture has changed. This procedure must be performed before making a measurement. Refer to "How to Perform a Zero Correction" for more details.

2) Press the [A] key in the "DISPLAY A-B panel to select "|Z|" or "|Y|".

3) Press the [FREQ] key and adjust the frequency using the [UP] or [DOWN] keys or by manually entering a new value for test frequency. See [SHIFT] → [0]: "Frequency Set Mode" for more details on manually setting the test frequency. The measurement frequency will be displayed on DISPLAY C.

4) Press the [V] key, and adjust the measurement voltage using the [UP] or [DOWN] keys or by manually entering a new value for test frequency. See [SHIFT] → [*1*]: "Test Voltage Set Mode" for more details on manually setting the test frequency. The measurement voltage will be displayed on DISPLAY C.

5) Press the [AUTO] key in the RANGE panel and verify that the "AUTO" LED is on. This puts the 3550 in AUTO range.

NOTE: When repeatedly measuring DUTs with similar values selecting the manual mode allows the measurement time to be reduced by eliminating the time needed for switching the ranges. See "RANGE" Selection Panel" for more details.

6) Press the [INT] key in the TRIGGER panel and verify that the "INT" LED is on. This will continuously trigger the 3550 and update the reading shown on DISPLAY A at a rate determined by measurement frequency, delay time, number of averages, and the time taken to auto range. If MAN/EXT trigger mode is selected the reading will not be updated until a new trigger is received from the front panel or remote interface.

7) Connect the DUT to the measurement terminals. The RANGE will be automatically selected by the 3550. The |Z| or |Y| reading will be shown on DISPLAY A.

Operating the 3550 cont'd:

Measuring: Loss Coefficient (D), Quality (Q), Equivalent Series Resistance (R_S), Equivalent Parallel Resistance (R_P), Conductance (G), Reactance (X), Susceptance (B), and Phase Angle (θ)

1) Always perform a zero correction procedure if the condition of the test leads/fixture has changed. This procedure must be performed before making a measurement. Refer to "How to Perform a Zero Correction" for more details.

2) Press the [B] key in the "DISPLAY A-B panel to select D, Q, R_S, R_P, G, X, B, or θ.

3) Press the [FREQ] key and adjust the frequency using the [UP] or [DOWN] keys or by manually entering a new value for test frequency. See [SHIFT] → [0]: "Frequency Set Mode" for more details on manually setting the test frequency. Frequency will be displayed on DISPLAY C.

4) Press the [V] key, and adjust the voltage using the [UP] or [DOWN] keys. See [SHIFT] → [*1*]: "Test Voltage Set Mode" for more details on manually setting the test frequency. The measurement voltage will be displayed on DISPLAY C.

5) Press the [AUTO] key in the RANGE panel and verify that the "AUTO" LED is on. This puts the 3550 in AUTO range.

NOTE: Selecting the manual mode allows the measurement time to be reduced by eliminating the time needed for switching the ranges. See "RANGE" Selection Panel" for more details.

6) Press the [INT] key in the TRIGGER panel and verify that the "INT" LED is on. This will continuously trigger the 3550 and update the reading shown on DISPLAY A at a rate determined by measurement frequency, delay time, number of averages, and the time taken to auto range. If MAN/EXT trigger mode is selected the reading will not be updated until a new trigger is received from the front panel or remote interface.

8) Connect the DUT to the measurement terminals. The CIRCUIT MODE and RANGE will be automatically selected by the 3550. The D, Q, R_S, R_P, G, X, B, or θ reading will be shown on DISPLAY B.

Notes for Measuring Reactance & θ

- On occasion a "-" sign will be observed occupying the same display as the most significant digit "1". The minus sign indicates a negative phase angle from a capacitive reactance, X_C. This is normal functionality in order to maximize the number of significant digits for an upper-range measurement.

Display B indicating 16.775Ω X_C Value

Display B indicating 16.775Ω X_L Value

The Comparator

Important Notes for the Absolute and Percent Comparator Functions

Comparator settings can only be defined and stored into panels 1-9. Before a comparator setting can be defined, a panel, 1-9 must be recalled.
This is done by pressing the [0-9] key until the desired panel is active while the 3550 is in the measurement mode.

Settings for DISPLAY A, DISPLAY B and CIRCUIT MODE must be finalized in the panel setting, [1-9] before defining comparator upper and lower limits. This is because these values cannot be changed after the comparator high and low limits have been set.

If any of the DISPLAY A, DISPLAY B, or CIRCUIT MODE keys, ([A][B][AUTO][SER][PRL]) are pressed after the comparator limits have been set, the [LOW] and [HIGH] LEDs of the comparator will start flashing to indicate an illegal operation. If either the [LOW] or [HIGH] keys are pressed afterwards then all of the comparator settings will be cleared. This will be indicated by "_____" appearing on the display. Pressing any other keys on the front panel will return the instrument to measurement mode without affecting the comparator settings.

The 3550 offers a dual-function comparator meaning that for each BIN there are two comparator settings that may be defined. The DISPLAY A setting allows a high and low limit to be defined for L, C, R, |Z|, and |Y| measurements while DISPLAY B allows limits to be set for D, Q, RS, RP, G, X, B, or θ. The comparator is equipped to offer an output based on the measurement results of DISPLAY A only, DISPLAY B only or the combined measurement results of both DISPLAY A and DISPLAY B.

The comparator may be used in absolute or percent mode. In the absolute mode, the comparator high and low limits are defined by entering absolute value high or low limits. This means that the high and low limits are entered as actual magnitudes and units of measure. The percent mode requires that the high and low limits are defined in terms of a percentage of a nominal value. The following sections provide instruction for setting the high and low limits in the Absolute or Percent Comparator modes.

During high and low limit setup, if a numeric key is pressed that will create a limit value, which falls outside of the measured parameter's range, the instrument will disable the functionality of that key.

Refer to the following sections for additional information regarding the 3550 comparator functions.

[SHIFT]→ [5] –Setting the comparator buzzer function.
[SHIFT]→ [7] – Absolute or Percentage Comparator Function
8 - Comparator Limit Set Panel
18 – Comparator ON/OFF Switch

The Comparator cont'd:

Absolute Value Settings

NOTE: A condensed version of this procedure can be found in the "Quick Start Section"

1) Make sure that panel 1~9 is selected. Do this by pressing the [0~9] key until the desired panel # appears on the Panel LED. Press [SHIFT] → [7] to access the Comparator Functions Mode. Either a flashing "0" or a "1" will appear on DISPLAY B. The meaning of the numbers is as follows:

0: Absolute Value Comparator Function
1: Percent Comparator Function

To change the flashing digit, press [*0*] → [ENTER] to call the absolute comparator mode and return to the measurement mode.

2) In the measurement mode, press the [LOW] key in the Comparator Limit Set Panel. *Make sure that a panel number from 1~9 is selected otherwise the comparator [HIGH] and [LOW] keys will be disabled.* The [LOW] LED will light. The BIN segment LED will flash the numeral "1". Press a numeric key [1]~[9] to define the bin number.

3) Press the [CURSOR ►] once. This will cause the 5th digit if DISPLAY A to flash. Type in the comparator low limit value using the [*0-9*] keys and the [CURSOR ►] or [CURSOR ◄] keys to navigate between the 1st and 5th digits.After digits 1 through digit 5 has been set, press the [CURSOR ►] key until the decimal point begins to flash. Press the [DP] key until the decimal point is in the desired position. Then press the [CURSOR ►] key once again to set the units of measure. Units are defined by pressing the [UNITS] key until the desired annunciator illuminates.

6) After the units for the low limit (DISPLAY A) have been selected, press the [CURSOR ►] key. The 5th digit of DISPLAY B will begin to blink indicating that a value can be entered for the high comparator limit.

7) Enter the values for the DISPLAY B low comparator limit in the same manner as performed for the DISPLAY A low limit.

NOTE: If the comparator function for DISPLAY A or DISPLAY B is not required, press the [IGNORE] key while the display is active and the comparator for that display will be disabled. A disabled display will show a "-----" in place of a numerical value.

8) To set the high value limit for the comparator press the [HIGH] key located in the Comparator Limit Set panel. The comparator high limit set mode is indicated when the [HIGH] LED lights. Repeat steps 3-7 to set the comparator's high limit values.

9) This completes setting the values for BIN #1. To set the high and low limits of the remaining BINs return to step #2. When the BIN LED is flashing select a BIN number from 1-9 by pressing the [1]-[9] keys and continue with the procedure.

NOTE: The BIN functionality is expressed as:

LOW≤BIN≤HIGH

The Comparator cont'd:

Percent Value Settings

NOTE: A condensed version of this procedure can be found in the "Quick Start Section"

Set the Nominal Value
1) Make sure that panel 1~9 is selected. Do this by pressing the [0~9] key until the desired panel # appears on the Panel LED. Press [SHIFT] → [*7*] to access the Comparator Functions Mode. Either a flashing "0" or a "1" will appear on DISPLAY B. The meaning of the numbers is as follows:

0: Absolute Value Comparator Function
1: Percent Comparator Function

To change the flashing digit, press [*1*] → [ENTER] to call the percent comparator mode and return to the measurement mode.

2) In the measurement mode, press the [LOW] key in the Comparator Limit Set Panel. *Make sure that a panel number from 1~9 is active otherwise the comparator [HIGH] and [LOW] keys will be disabled.* The [LOW] LED will light. This will cause the 4th digit if DISPLAY C to flash either a "1" or a "0". A flashing "0" indicates the Nominal Value Set Mode. This is where the nominal value of the measured value will be entered. High and low limits are calculated as a percent of this value. A flashing "1" indicates the High and Low Percent Limits Set Mode. The High and Low Percent Limits Mode requires a [HIGH] and [LOW] comparator setting. The Nominal Value Set Mode requires only one setting. Press the [*0*] key to set the instrument to Nominal Value Set Mode.

3) Press the [CURSOR ►] once. The BIN LED in the Comparator Panel will flash a numeral "1". Press a numeric key [1]~[9] to set the active bin number. *BIN 0 cannot be used with the comparator function.* Then press the [CURSOR ►] key once again so that the 5th digit of DISPLAY A starts to flash.

4) Enter the nominal digit value of the % comparator setting. After a value has been assigned for each digit the decimal point will start to blink. Use the [DP] key to position the decimal point and then press the [CURSOR ►] key to set the unit prefix of measure. Press the [UNITS] key to select the desired prefix for the DISPLAY A, nominal value setting.

NOTE: *Units of measure in DISPLAY A or DISPLAY B cannot be changed once the comparator has been enabled. The [IGNORE] function and the equivalent circuit mode setting are also locked out.*

5) After the prefix units for the nominal value have been selected, press the [CURSOR ►] key. The 5th digit of DISPLAY B will begin to blink indicating that a value can be entered for the DISPLAY B measurement. Enter a nominal value setting for DISPLAY B then press the [CURSOR ►] key.

6) The 4th digit of DISPLAY C will display a blinking "0". Press the [*1*] key to enter the High and Low Percent Limits Mode.

The Comparator cont'd:

Percent Value Settings cont'd

7) To input an upper limit threshold value, press the [HIGH] key. Press the [LOW] key to set the lower limit threshold value. Then, highlight the first digit of DISPLAY C and press [1].

8) After selecting the threshold value input mode, use the cursor key, [►] to highlight the bin LED, and then press [1]~[9] to select the desired bin.

9) After entering the bin number, use the cursor key [►] to highlight DISPLAY A. Enter the 5-digit threshold value for DISPLAY A using keys [0]~[9]. (The setting range is from 000.00%~199.99%)

10) Enter the 5-digit threshold value for DISPLAY B using keys [0]~[9]. (The setting range is 000.00%~199.99%)

11) To finalize an upper limit, press [HIGH] or press [LOW] to finalize a low limit setting.

NOTE: Step 7 determines whether a high or low limit %comparator setting is defined be sure that both a low and high limit have been defined.
To input settings for other bins, return to Step 1 and repeat the process.

12. To invalidate the settings, for threshold values, simply enter the Threshold Percent Comparator Set Mode and move the cursor to any segment in DISPLAY A or DISPLAY B. Then press [IGNORE] to invalidate the % comparator settings for that DISPLAY.

NOTES:

- The comparator can only be set using panels 1~9. 0 cannot be used.
- This procedure is only for the percent comparator setting. Note that the procedure for the absolute value comparator is different.
- Make sure the comparator mode is set for "Percent Mode" otherwise the procedure will not work correctly.
- After setting the limit values for the comparator, the measurement parameters for DISPLAY A and DISPLAY B cannot be changed. This means that the measurement parameters must be defined before the comparator settings.
- For DISPLAY B, there are no units for D,Q, or θ.

NOTE: The BIN functionality is expressed as:

LOW≤BIN≤HIGH

Refer to Figures 4.5 and 4.6 for an illustration of BIN operation.

The Comparator cont'd:

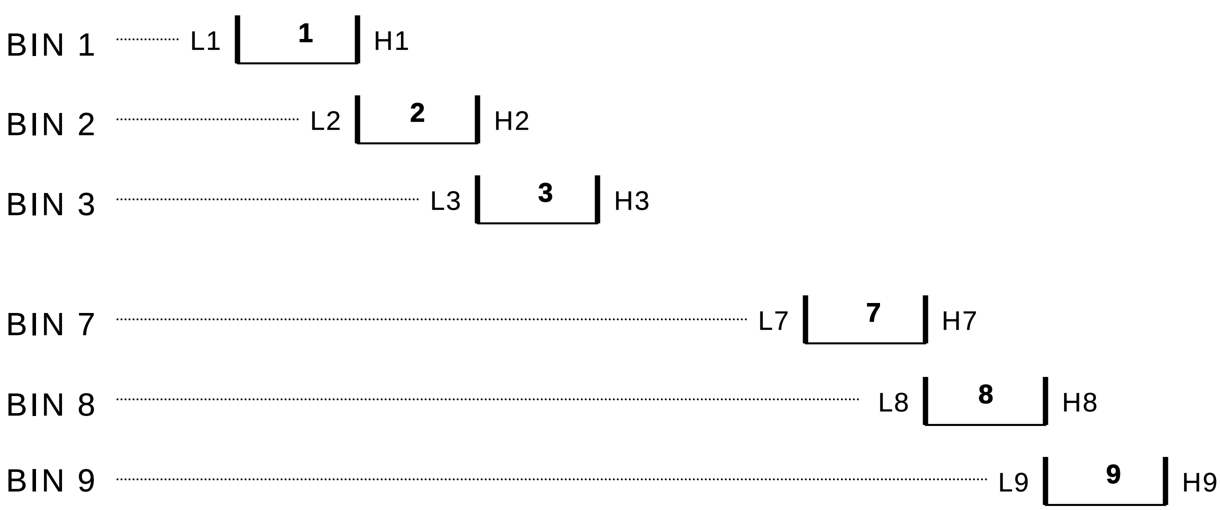
BIN Operation

Comparator operation may be disabled for DISPLAY A or DISPLAY B by pressing the [IGNORE] key while in the high or low limit set mode. A disabled DISPLAY is indicated by "-----" in place of the limit value being shown on the display.

Sequenced Sorting Configuration

There are two common multi category BIN settings for sorting components. The first is Sequenced Sorting as illustrated in Figure 4-5. In this setting, the 3550 comparator will sort components based on their limit values where each BIN# will define a unique range of measured values. Any number of bins may be used for Sequenced Sorting. If there is no matching BIN found for the component value to fall under, then the component will be placed in BIN 0.

Figure 4.5 Sequenced BIN Sorting
LOW≤BIN≤HIGH



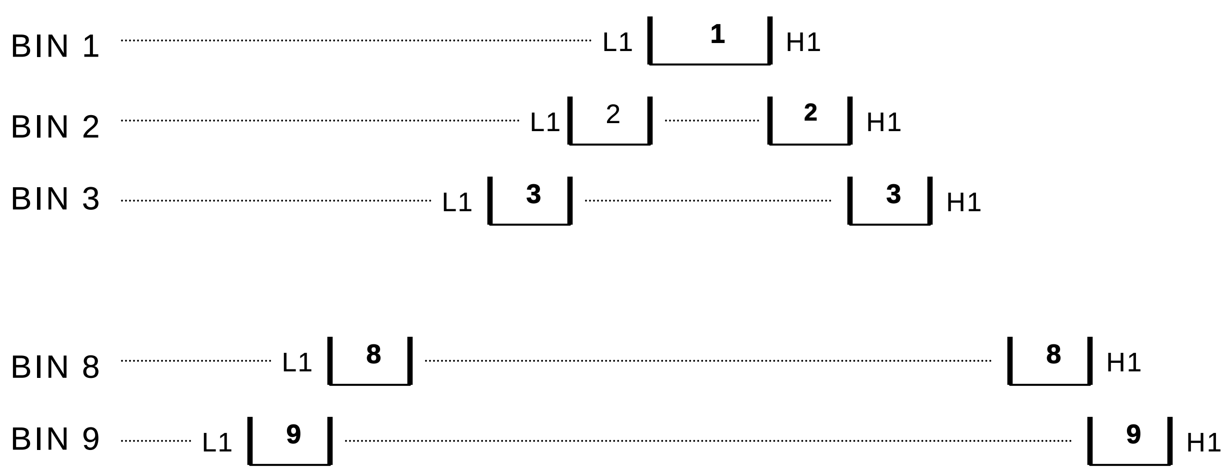
The Comparator cont'd:

BIN Operation cont'd

Nested Sorting Configuration

Nested sorting is typically used for tolerance-based sorting where an acceptable % or value range is defined for each BIN #. First, the 3550 evaluates the measured value according to the defined range of BIN 1. If the measured falls within the range of BIN 1 then the component is sorted into BIN 1. If the measured value falls outside of the BIN 1 range then it is evaluated for BIN 2. If the component value falls within the BIN 2 range then it is sorted into BIN 2. If not, then the 3550 proceeds the evaluation to BIN 3 and so on. If the measured value does not fall within any defined ranges then the component will be sorted into BIN 0, the reject BIN.

Figure 4.6 Nested BIN Sorting
LOW≤BIN≤HIGH



The Comparator cont'd:

Outputting the Comparator's Results

There are two ways to determine the state of the comparator. The LEDs of the Comparator Panel, and the optically isolated, open collector outputs of the Control I/O Connector on the rear of the instrument.

Comparator values may be entered and sorted into BINs 1~9. When a measured value falls within ant of the ranges of BINs 1~9, the TOTAL-GO LED will light. When a measured value falls outside of the defined 1~9 BIN ranges, then either the "LO" or "HI" LEDs on the Comparator Panel will illuminate (depending on whether the measured value is higher or lower than the BIN settings). Measured values outside of the comparator range will be sorted to BIN 0.

For instructions regarding the pin connections of the Control I/O Connector, refer to "Programming and Interfacing"

Audible Buzzer Operation

When the [SHIFT] → [*5*]: Comparator Buzzer Function is set to "1", the buzzer will sound with a "TOTAL GO" condition. If it is set as "2", the buzzer will sound with "TOTAL NO-GO" condition. If the buzzer function is set to "0", then the buzzer will be disabled. See [SHIFT] → [*5*]: Comparator Buzzer Function for more information on setting the comparator-state buzzer function.

Interfacing to the 3550

This section provides detailed information about the 3550 electrical interfaces and their functionality. It will provide all of the necessary information required to integrate the 3550 easily into a working test application. A Control I/O connector is available for optically coupled TTL interface to PLCs and other control hardware. The 3550 has a standard RS232 communications port and an optional GPIB interface for software-based applications.

Control I/O Connector

Located on the rear panel, the Control I/O Connector offers an optically isolated, TTL-level interface for integration into PLC and other hardware controlled applications.
These terminals require a positive 5V~24V signal across the 3~8 Pins (*these are the anode connections for external trigger, panel enable/disable, and the four panel BCD inputs*) and a common potential across pins 28~33. A constant current diode is in series with the 5~24V supply to limit the current flowing through the photo diode. There is no need for a current limiting resistor for the inputs or outputs of the Control I/O Connector.

Inputs

There are 3 groups of inputs available from the Control I/O Connector:

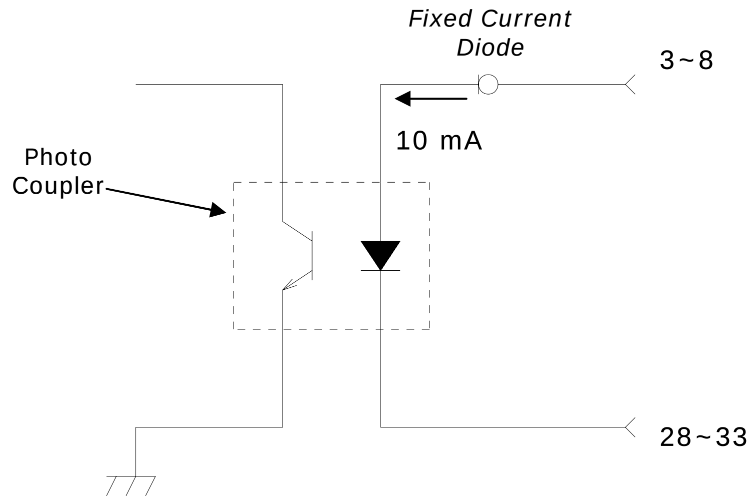
- CONTROL PANEL/EXT (Pins 3 & 28) – This input works in conjunction with the front panel trigger or the rear panel External Trigger Input. When this input is true (current flows through pins 3 & 28) the rear panel External Trigger is enabled. If the Control PANEL/EXT input is false, then the triggering must be performed from the front panel.

- External Trigger (Pins 4 & 29) – Used with the CONTROL PANEL/EXT input. The 3550 will take measurements when the CONTROL PANEL/EXT input <u>AND</u> External Trigger are true.

- Panel BCD Inputs, [Pins 5~8 (Anode) and Pins 30~33 (Cathode)]. - A BCD setting of 0~9 is required. Settings other than 0~9 will automatically default to panel 9.

The inputs of the Control I/O Connector are optically Isolated. The figure below is a representation of a typical input.

Figure 5.1 – Input Schematic

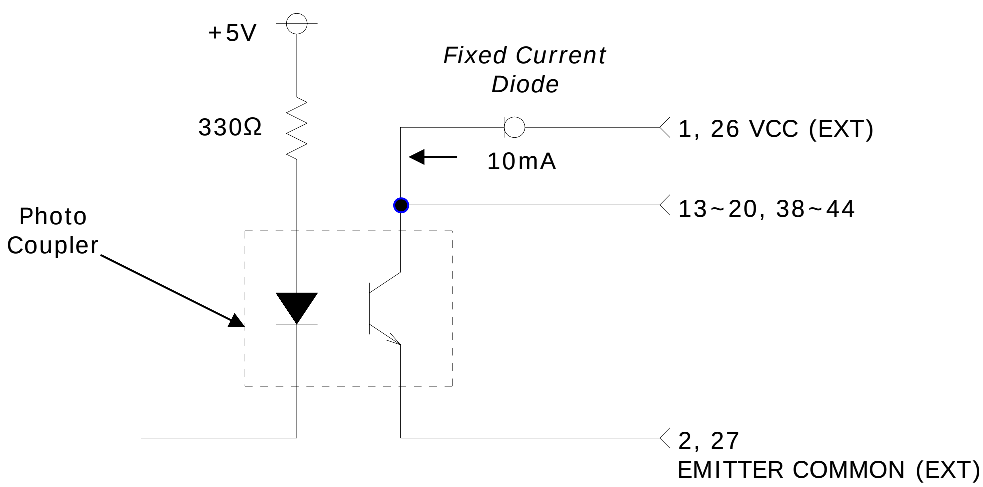


Control I / O Connector cont'd:

Outputs

The 3550 has 5 data output lines available for external monitoring. Each of the data outputs are optically isolated and current limited through the use of a constant current diode as shown in the illustration below:

Figure 5.2 – Output Schematic



Control I / O Connector cont'd:

Timing Diagrams

Figure 5.3a – Test Busy Operation

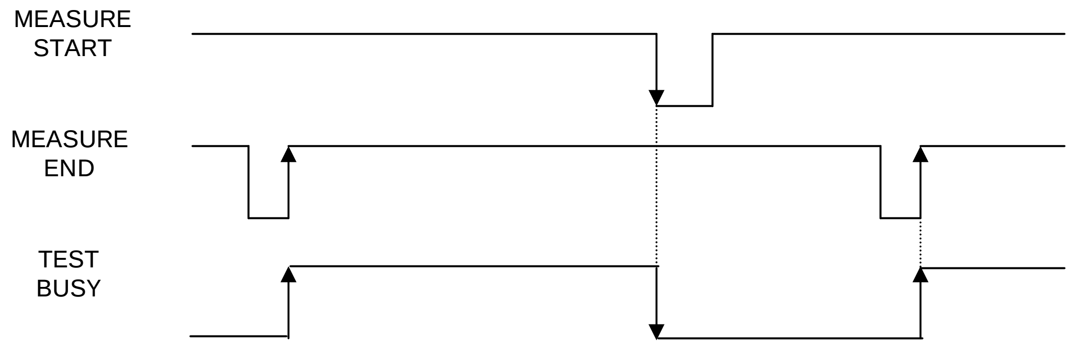


Figure 5.3b – Measure End Operation

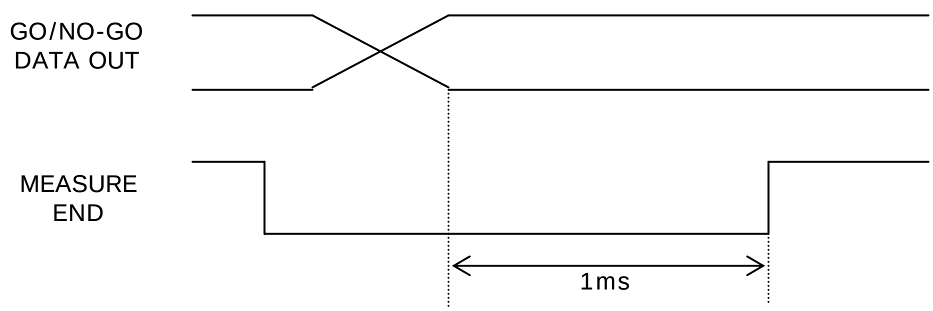
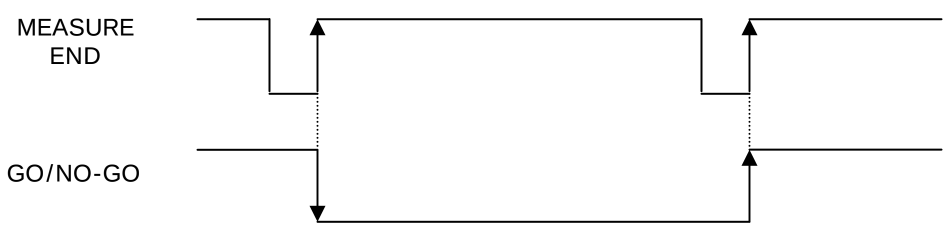


Figure 5.3c - GO / NO-GO Operation



Control I/O Connector cont'd:

Table 5.1 - Connector Pin Designations

PIN NO.	Signal Name	PIN NO.	Signal Name
1	EXT POWER	26	EXT POWER
2	EMITTER COMMON	27	EMITTER COMMON
3*	CONTROL PANEL/EXT (A)	28*	CONTROL PANEL/EXT (K)
4*	EXTERNAL TRIGGER (A)	29*	EXTERNAL TRIGGER (K)
5*	PANEL 2^3 (A)	30*	PANEL 2^3 (K)
6*	PANEL 2^2 (A)	31*	PANEL 2^2 (K)
7*	PANEL 2^1 (A)	32*	PANEL 2^1 (K)
8*	PANEL 2^0 (A)	33*	PANEL 2^0 (K)
9		34	
10		35	
11		36	
12		37	
13	DISPLAY A HNG	38	DISPLAY B HNG
14	DISPLAY A LNG	39	DISPLAY B LNG
15	DISPLAY A GO	40	DISPLAY B GO
16	TOTAL GO	41	TOTAL NG
17	BIN 2^3	42	BIN 2^2
18	BIN 2^1	43	BIN 2^0
19	TEST BUSY	44	MEASURE END
20	ERROR	45	
21		46	
22		47	
23		48	
24		49	
25		50	

* : Input Pin
(A) and (K) are the Anode(A) and Cathode(K) of the photo coupler LED
Output is the Open Collector of the transistor of the photo coupler

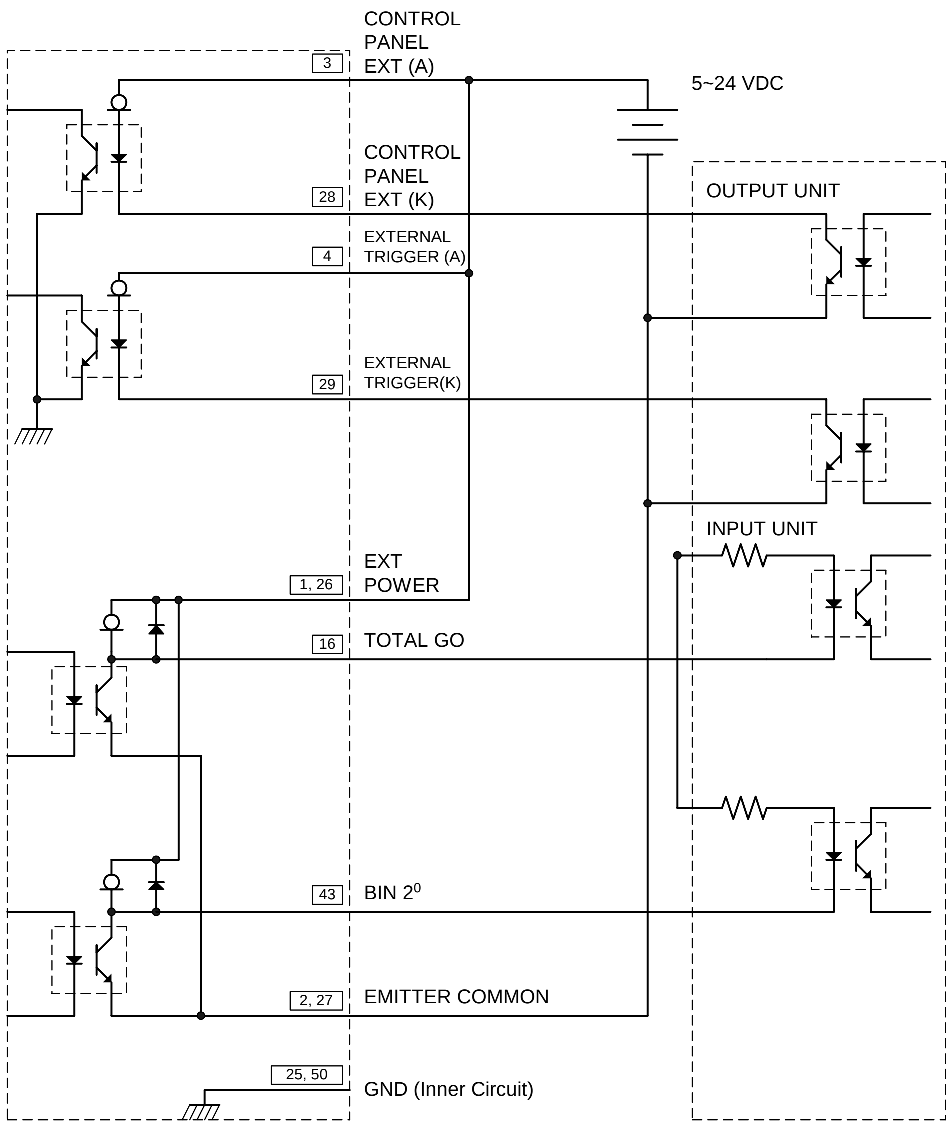
Control I/O Connector cont'd:

Table 5.2 - Control I/O Function Summary

<table>
<tr><th>Item</th><th>PIN No.</th><th colspan="10">Functions</th></tr>
<tr><td rowspan="5">*PANEL</td><td></td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>5, 30</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>6, 31</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>7, 32</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>8, 33</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td rowspan="2">*CONTROL
PANEL/EXT</td><td></td><td colspan="5">EXT</td><td colspan="5">PANEL</td></tr>
<tr><td>3, 28</td><td colspan="5">ON</td><td colspan="5">OFF</td></tr>
<tr><td>*EXTERNAL TRIGGER</td><td>4, 29</td><td colspan="10">OFF | ON (5~15ms) | OFF</td></tr>
<tr><td rowspan="4">DISPLAY A
GO/NO-GO</td><td></td><td colspan="3">Low NG</td><td colspan="4">High NG</td><td colspan="3">GO</td></tr>
<tr><td>14</td><td colspan="3">0</td><td colspan="4">1</td><td colspan="3">1</td></tr>
<tr><td>13</td><td colspan="3">1</td><td colspan="4">0</td><td colspan="3">1</td></tr>
<tr><td>15</td><td colspan="3">1</td><td colspan="4">1</td><td colspan="3">0</td></tr>
<tr><td rowspan="4">DISPLAY B
GO/NO-GO</td><td></td><td colspan="3">Low NG</td><td colspan="4">High NG</td><td colspan="3">GO</td></tr>
<tr><td>39</td><td colspan="3">0</td><td colspan="4">1</td><td colspan="3">1</td></tr>
<tr><td>38</td><td colspan="3">1</td><td colspan="4">0</td><td colspan="3">1</td></tr>
<tr><td>40</td><td colspan="3">1</td><td colspan="4">1</td><td colspan="3">0</td></tr>
<tr><td rowspan="3">TOTAL
GO/NO-GO</td><td></td><td colspan="5">GO</td><td colspan="5">NO-GO</td></tr>
<tr><td>16</td><td colspan="5">0</td><td colspan="5">1</td></tr>
<tr><td>41</td><td colspan="5">1</td><td colspan="5">0</td></tr>
<tr><td rowspan="5">BIN No.</td><td></td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>17</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>42</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>18</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>43</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>TEST BUSY</td><td>19</td><td colspan="10">READY (OFF) | BUSY (ON) |</td></tr>
<tr><td>MEASURE
END</td><td>44</td><td colspan="10">Test End → | ON (1ms) |</td></tr>
<tr><td rowspan="2">**ERROR</td><td rowspan="2">20</td><td colspan="5">ON</td><td colspan="5">OFF</td></tr>
<tr><td colspan="5">0</td><td colspan="5">1</td></tr>
<tr><td colspan="12">*: Input Pin
**: The ERROR signal indicates a GO/NO-GO decision error. When the range is wrong, or the fixed current/voltage setting value has not been reached, "0" is outputted.
"1" for the Output Pins = C-E Open, "0" = C-E Short</td></tr>
</table>

Control I / O Connector cont'd:

Figure 5.4 - Sample Diagram of External Connections to Sequencer



Note: The diagram above provides examples of typical input and output connections as required for interface to a sequencer. Similar connections apply to the remaining terminals of the I/O Connector.

RS-232C

Interface Cable

The interface is based on RS-232C. The 3550 is designed to act as the DTE side, so please use a cross cable when connecting with a personal computer or other controller unit.

Input Format

Remote In-Commands

To activate the RS-232C, send the "REN" command. This will change the 3550 from Panel Mode to Remote Mode.

Entering Program Codes

Program codes will be sent from the controller unit to the 3550 as a string of ASCII characters. To change the panel number, "PAN*" should be sent. (If a Panel Number is not relayed, then the currently displayed panel will be re-set by the command)

e.g.) "PAN0 FA0 R0 M0 S0 E0"

Notice that a space is necessary between each of the commands. If a space does not precede a command, then the subsequent command/s will be ignored.

Setting Limit Values

Below is an example of how the high and low limits of a BIN are set for DISPLAY A and DISPLAY B.

e.g.) "BIN1 CAL+1.0000e-06 CAH+1.5000E-06"
"BIN1 CBL+0.0100e00 CBL+0.1000e00"

The order of LOW and HIGH values may be reversed. Programming LOW or HIGH alone is also permitted.

e.g.) "BIN1 CAH+1.5000e-06 CAH+1.0000e-06"
"BIN1 CAL+1.0000e00"

To invalidate a specific BIN's high or low limit value replace the polarity and numerical data with a series of nine dashes as expressed below:

e.g.) "BIN1 CAL---------"

This command will invalidate the comparator's DISPLAY A, low limit value.

RS-232C

Input Format cont'd

Setting the Measurement Voltage

The voltage setting range is from 0.01V through 5.00V, in 0.01V increments. However, for frequencies between 1.00MHz~5.00MHz, the range is limited to 0.01V~1.00V.

Units: Volts
Resolution: 3 digits

e.g.)	"LEV1.00E0"	(Set the Measurement Voltage to 1.00V)
	"LEV1.52E0"	(Set the Measurement Voltage to 1.52V)

Values, which are less than the 0.01V steps, will be automatically truncated.

e.g.) "LEV1.248E00" (Set the Measurement Voltage to 1.24V)

The 3550 will automatically reassign voltage levels if the absolute maximum levels are exceeded. As shown above, any voltage defined with less than 0.01V resolution will automatically be truncated to 0.01V resolution. Voltage levels exceeding 5.00V will automatically become 5.00V. If the test frequency is greater than 1.00MHz, voltages defined that exceed 1.00V will become 1.00V.

Setting Measurement Currents

For frequencies from 42.0Hz to 1.00MHz, the test current setting ranges from 0.01mA~99.99mA in 0.01mA steps. If the test frequency is between 1.01MHz~5.00MHz, the current setting are limited to 0.01mA~20.00mA.

Unit: mA
Significant Digits: 3 digits

e.g.)	"LEI1.00E0"	(Set the Measurement Current to 1.00mA)
	"LEI15.20E0"	(Set the Measurement Current to 15.20mA)

Like the voltage settings, any values less than the 0.01mA resolution will be automatically truncated.

e.g.) "LEV1.549E00" (Set the Measurement Current to 1.54mA)

The 3550 will automatically reassign test current levels if the absolute minimum or maximum levels are exceeded. As shown above, any current level defined with less than 0.01mA resolution will automatically be truncated to a value with 0.01mA resolution. Defined current levels exceeding 99.99mA will automatically become 99.99mA. If the test frequency is greater than 1.00MHz, test current will be limited to 20.00mA.

RS-232C

Input Format cont'd

Setting the Measurement Frequency

The setting range for Measurement Frequency is between 42.0Hz~5.00MHz.

Unit: Hz
Significant Digits: 3 digits.

e.g.)	"FRE42.0E0" ~ "FRE99.9E0"	42.0Hz ~ 99.9Hz
	"FRE100E0" ~ "FRE999E0"	100Hz ~ 999Hz
	"FRE1.00E3" ~ "FRE9.99E3"	1.00kHz ~ 9.99kHz
	"FRE10.0E3" ~ "FRE99.9E3"	10.0kHz ~ 99.9kHz
	"FRE100E3" ~ "FRE999E3"	100kHz ~ 999kHz
	"FRE1.00E6" ~ "FRE5.00E6"	1.00MHz ~ 5.00MHz

Because the 3550 uses exponential number formatting for the test frequency, variations of the above format may be used. To set 100kHz, the following methods are also valid:

e.g.) "FRE1.00E5" –**OR-** "FRE10.0E4"
(Set the test frequency to 100kHz)

Setting the Number of Averages per Reading

To change the number of measurements to be averaged use the "V*" command.
* can be replaced by values between 1~100

e.g.) "V55" (Set the number of averages to 55 samples)

Errors in defining the number of samples to be averaged for a reading are addressed as follows:

Settings outside the range of 1~100, are considered program errors.

e.g.) The values 0 or 101 would be considered invalid values for the average parameter.

RS-232C

Table 5.3a – Command Summary

Function	Program Code	Content	Remarks
Panel	*PAN0 ~ PAN9	Panel Number	
DISPLAY A Measurement Function	FA0 *FA1 FA2 FA3 FA4	DISPLAY A Measurement Item Change	Measurement Item "L" Measurement Item "C" Measurement Item "R" Measurement Item "|Z|" Measurement Item "|Y|"
DISPLAY B Measurement Function	*FB0 FB1 FB2 FB3 FB4 FB5 FB6 FB7	DISPLAY B Measurement Item Change	Measurement Item "D" Measurement Item "Q" Measurement Item "R_S" Measurement Item "R_P" Measurement Item "G" Measurement Item "X" Measurement Item "B" Measurement Item "θ"
Measurement Range	*R0 R1 R2 R3 R4 R5 R6 R7 R8 R9	Auto Range Settings Range1 Range2 Range3 Range4 Range5 Range6 Range7 Range8 Range9	AUTO RANGE 100mΩRange 1ΩRange 10ΩRange 100ΩRange 1kΩRange 10kΩRange 100kΩRange 1MΩRange 10MΩRange 100MΩRange
Measurement Mode	*M0 M1 M2	Auto Mode Settings Series Mode Settings Parallel Mode Setting	AUTO MODE SER MODE PRL MODE
Measurement Frequency	FRE	Measurement Frequency Settings	"42.0E0"~"5.00E6"
Measurement Mode Change	*JV JCV JCC	Voltage Measurement Fixed Voltage Measurement Fixed Current Measurement	Open Terminal Voltage Measurement Mode Fixed Voltage Measurement Mode Fixed Current Measurement Mode
Measurement Signal Voltage	LEV	Measurement Signal Voltage Settings	"0.01E0"~"5.00E0"
Measurement Signal Current	LEI	Fixed Current Mode Current Settings	"0.01"~"99.99"

RS-232C

Table 5.3b – Command Summary cont'd

Function	Program Code	Content	Remarks
Service Request	*S0 S1	OFF ON	SRQ Settings for GPIB
Measurement Start-Up Trigger	*E0 E1 E2 E3	Internal Trigger External Trigger TRIGGER EXT "T0"Trigger	Address Command GET Start Start by "MAN" Listener-Address Designation Start
Trigger	T0	Trigger Command	Only Valid for "E3"
Initial Settings	I0 I1	Clear Panel Clear All Panels	
Zero Offset	Z0	Offset Clear	Clear Correction Value
	Z1	ZERO OPEN	Measurement Terminal OPEN -ZERO Correction
	Z2	ZERO SHORT	Measurement Terminal SHORT-ZERO Correction
	Z3	Spot OPEN	OPEN-ZERO Spot Correction
	Z4	Spot SHORT	SHORT-ZERO Spot Correction
	Z5	Spot Correction Clear	Correction Value Spot Clear
Command Lock	*L0 L1	Lock OFF Lock ON	
Measurement Conditions Monitor	MON	Measurement Conditions Monitor	
Measurement Data Averaging	V	Averaging Times	Set 1~100
Data Output	REN	Measurement Data Output	Set so that data output will be through GPIB/RS-232C
Correction Frequency Limit	WCLI0	Invalid Low Frequency limit	
	WCLI1	Effectively Low Frequency limit	
	WCHI0	Invalid High Frequency limit	
	WCHI1	Effectively Low Frequency limit	
	WCL	Low Frequency limit setting	"WCL42.0E0" ~ "WCL5.00E6"
	WCH	High Frequency limit setting	"WCH42.0E0" ~ "WCH5.00E6"
Data Output Destination Selection	O0	Output OFF	GPIB only valid with Installed Option
	O1	RS232C Only	
	O2	GPIB Only	
	O3	RS232C/GPIB	

RS-232C

Table 5.3c – Command Summary cont'd

Function	Program Code	Content	Remarks
Soft Version	VER	Information on the Software Version	
Spot Correction Input Number	SPX	Spot Correction Select from 1 to 3	"SP1"
Spot Correction Frequency Limit	SPFXXX	Set Spot Frequency	"SPF42.0E0" ~ "SPF5.00E6"

*1) * indicates initial setting
*2) If a non-program code is entered, it will be considered invalid, and no setting will be made. In this case, the previous setting will be unchanged.

NOTE 1: After receiving "L1", only "L0", "T0" and GET can be received.
NOTE 2: As soon as "MON" is sent, make sure that the system is ready to receive.
NOTE 3: Settings will vary according to the measurement range and measurement frequency. Please refer to the range charts.
NOTE 4: After the termination of zero offset, the following indications are shown on the computer.
"Correct OK" - Zero correction has executed properly
"Correct Error Impedance Under" – The open circuit impedance is less than 1kΩ, which is beyond correction limits.
"Correct Error Impedance Over" The short circuit impedance has exceeded 1kΩ, which is beyond correction limits.

RS-232C

Table 5.4 - Comparator Instructions

Function	Program Code	Content	Remarks
Comparator	*C0	Comparator OFF	
	C1	Comparator ON	
Comparator Mode	CP0	Absolute Value Setting	Absolute Value Setting Comparator
	CP1	% Setting	% Setting Comparator
Bin Number	BIN		Sorting Category BIN No.(1 9)
Absolute Value Setting Limit Values	CALXXXX CAHXXXX CBLXXXX CBHXXXX	DISPLAY A LOW DISPLAY A HIGH DISPLAY B LOW DISPLAY B HIGH	XXXX: ±0.0000e00 ~ ±1.9999e08 Disabled Setting = "---------"
% Setting Limit Values	CAPXXXX CBPXXXX PALXXXX PBLXXXX PAHXXXX PBHXXXX	DISPLAY A Std. Value DISPLAY B Std. Value DISPLAY A Min. % DISPLAY B Min. % DISPLAY A Max. % DISPLAY B Max. %	XXXX: ±0.0000e00 ~ ±1.9999e08XXXX: ±0.0000e00 ~ ±2.000e02 Disabled Setting = "---------"

*1) * indicates a initial setting

NOTE 1: As soon as "LIM" is sent, make sure that the system is ready to receive signals.

RS-232C

Data Output Format for Measurement Settings

Output Format Sample

```
 0000 _ P1 _ 1.00 E03 Hz _ OV _ +1.0795 E00 V _ +1.0771 E-03 A,
 [1]    [2]  [3]  [4] [5]  [6]  [7]     [8] [9]   [10]    [11] [12]

N   R   P _ +1.0022 E03   R  GO,  N _ A0 _ -1.1874 E03  R, GO, BIN1, GO
[13][14][15] [16]   [17] [18] [19] [20] [21]  [22]   [23][24] [25] [26] [27] [28]
```

1	Indexing Number	15	Circuit Mode There is no circuit mode on Z and Y, alternatively, "-" is outputted.
2	Panel Number	16	Data Temp. Value (A)
3	Measurement Frequency Temp. Value	17	Data Exponent (A)
4	Measurement Frequency Exponent	18	Data Unit (A)
5	Measurement Frequency Unit	19	Comparator Result (A)
6	Measurement Mode	20	Status (B)
7	Test Piece Voltage Temp. Value	21	Function (B)
8	Test Piece Voltage Exponent	22	Data Temp. Value (B)
9	Test Piece Voltage Unit	23	Data Exponent (B)
10	Test Piece Current Temp. Value	24	Data Unit (B)
11	Test Piece Current Exponent	25	Comparator Result (B)
12	Test Piece Current Unit	26	Bin Number
13	Status (A)	27	Comparator Result (TOTAL)
14	Function (A)	28	Delimiter

NOTES:

- For the Comparator Result, if the Comparator is OFF, 2 "_" symbols (ASCII Code 2Dh) will be outputted instead of a result.
- For the Bin No., if the Comparator is OFF, 4 "_" symbols (ASCII Code 2Dh) will be outputted.
- In the Format Sample, the "_" denotes a "space" (ASCII code 20h).

RS-232C

Table 5.5a - Data Output Code Functions

<table>
<tr><th>Number</th><th>Output Code</th><th colspan="2">Content</th></tr>
<tr><td>1</td><td>****</td><td colspan="2">Index Number (0001~9999)</td></tr>
<tr><td>2</td><td>P*</td><td colspan="2">Panel Number (0~9)</td></tr>
<tr><td>3</td><td>**.*
*.**
***.</td><td colspan="2">Measurement Frequency Temp. Value
e.g.) 42.0Hz → "42.0": 100Hz → "100.": 1.00kHz → "1.00"</td></tr>
<tr><td>4</td><td>E**</td><td colspan="2">Measurement Frequency Exponent
e.g.) "E+00" → Hz: "E+03" → kHz: "E+06" → MHz</td></tr>
<tr><td>5</td><td>Hz</td><td colspan="2">Measurement Frequency Unit</td></tr>
<tr><td rowspan="3">6</td><td>OV</td><td colspan="2">Open Voltage Mode</td></tr>
<tr><td>CV</td><td colspan="2">Fixed Voltage Mode</td></tr>
<tr><td>CC</td><td colspan="2">Fixed Current Mode</td></tr>
<tr><td>7
8</td><td>+*.****E±**</td><td colspan="2">Test Piece Voltage Temp. Value Exponent
e.g.) 1.00V → "1.0000E+00"
0.10V → "100.00E-03"</td></tr>
<tr><td>9</td><td>V</td><td colspan="2">Test Piece Voltage Unit</td></tr>
<tr><td>10
11</td><td>+*.****E-**</td><td colspan="2">Test Piece Voltage Temp. Value Exponent
e.g.) 10.00mA → "10.000E-03"
0.01mA →"10.000E-06"</td></tr>
<tr><td>12</td><td>A</td><td colspan="2">Test Piece Current Unit</td></tr>
<tr><td rowspan="4">13</td><td>O</td><td colspan="2">Over Range</td></tr>
<tr><td>N</td><td colspan="2">Measurement Data Normal</td></tr>
<tr><td>U</td><td colspan="2">Under Range</td></tr>
<tr><td>E</td><td colspan="2">Error</td></tr>
<tr><td rowspan="5">14</td><td>L</td><td colspan="2">Inductance Measurement (L)</td></tr>
<tr><td>C</td><td colspan="2">Capacity Measurement (C)</td></tr>
<tr><td>R</td><td colspan="2">Resistance Measurement (R)</td></tr>
<tr><td>Z</td><td colspan="2">Impedance Measurement (|Z|)</td></tr>
<tr><td>Y</td><td colspan="2">Admittance Measurement (|Y|)</td></tr>
<tr><td>15</td><td>S
P</td><td colspan="2">Series Mode Measurement
Parallel Mode Measurement –|Z|, |Y| ”-“symbols (ASCII Code 2Dh)</td></tr>
<tr><td rowspan="2">16</td><td>+1.9999</td><td colspan="2">Over Range, Measurement Data Abnormal</td></tr>
<tr><td>±*.****</td><td colspan="2">Under Range, Measurement Data Normal</td></tr>
<tr><td rowspan="8">17</td><td></td><td colspan="2">Measurement Data Exponent</td></tr>
<tr><td>E-12</td><td>p</td><td>(10^{-12})</td></tr>
<tr><td>E-09</td><td>n</td><td>(10^{-9})</td></tr>
<tr><td>E-06</td><td>M</td><td>(10^{-6})</td></tr>
<tr><td>E-03</td><td>m</td><td>(10^{-3})</td></tr>
<tr><td>E+00</td><td></td><td>(10^{0})</td></tr>
<tr><td>E+03</td><td>k</td><td>(10^{3})</td></tr>
<tr><td>E+06</td><td>M</td><td>(10^{6})</td></tr>
</table>

RS-232C

Table 5.5b - Data Output Code Functions cont'd:

Number	Output Code	Content	
18		DISPLAY A Display Unit	
	H	For Inductance Measurement	
	F	For Capacity Measurement	
	R	For Resistance, Impedance Measurement	
	S	For Admittance Measurement	
19	LO	LOW NO-GO	
	GO	GO	
	HI	HIGH NO-GO	
	__	Comparator OFF (ASCII Code 2Dh, outputted 2 times)	
20	O N	Over Range Measurement Data Normal	
21	D0	Loss Coefficient Measurement (D)	
	Q0	Quality Measurement (Q)	
	RS	Equivalent Series Resistance Measurement(R_S)	
	RP	Equivalent Parallel Resistance Measurement (R_P)	
	G0	Conductance Measurement (G)	
	X0	Reactance Measurement (X)	
	B0	Susceptance Measurement (B)	
	A0	Phase Angle Measurement (θ)	
22	+1.9999	Over Range, Measurement Data Abnormal	
	±*.****	Under Range, Measurement Data Normal	
23		Measurement Data Exponent	
	E-09	n	(10^{-9})
	E-06	µ	(10^{-6})
	E-03	m	(10^{-3})
	E+00		(10^{0})
	E+03	k	(10^{3})
	E+06	M	(10^{6})
24	R	For Equivalent Parallel + Series Resistance Measurement, and also Reactance Measurement	
	S	For Conductance and Susceptance Measurement	
	_	For Loss Coefficient, Quality Measurement, Phase Angle Measurement (ASCII Code 5Fh)	
25	LO	LOW NO-GO	
	GO	GO	
	HI	HIGH NO-GO	
	__	Comparator OFF (ASCII Code 2Dh, outputted 2 times)	
26	BIN*	BIN Number Decision Result (*:0 9) If Comparator is OFF, then "____"(ASCII Code 2Dh, 4times)	
27	GO	TOTAL GO	
	NG	TOTAL NO-GO	
	__	Comparator OFF (ASCII Code 2Dh, 2times)	
28	C_R+L_F	Delimiter. For RS-232C, only C_R+L_F	

RS-232C

Monitor Output Format

Output in Relation to Monitor Command "MON"

For all 10 panels, (0~9) the PANEL No., DISPLAY A Function, DISPLAY B Function, CIRCUIT MODE, RANGE, Measurement Signal Frequency and Measurement Signal Voltage will be outputted and divided by spaces. At the end, whether or not there is a Limit Value will be indicated as well.

Output Format Sample:

```
P0 _ L _ D0 _ R0 _ A _ 1.00E+03 _ OV _ 1.0000E+00V _ V1 _ -
P1 _ L _ D0 _ R0 _ S _ 1.00E+03 _ OV _ 1.0000E+00V _ V1 _ -
P2 _ L _ Q0 _ R1 _ S _ 1.00E+03 _ OV _ 1.0000E+00V _ V1 _ -
P3 _ L _ Q0 _ R2 _ S _ 10.0E+03 _ OV _ 1.0000E+00V _ V1 _ *
P4 _ L _ D0 _ R3 _ S _ 10.0E+03 _ OV _ 1.0000E+00V _ V1 _ *
P5 _ L _ D0 _ R4 _ S _ 10.0E+03 _ CV _ 5.0000E-01V _ V1 _ -
P6 _ L _ D0 _ R5 _ S _ 100.E+03 _ OV _ 1.0000E+00V _ V1 _ -
P7 _ L _ D0 _ R6 _ S _ 100.E+03 _ CC _ 1.0000E+00V _ V1 _ -
P8 _ L _ D0 _ R7 _ S _ 5.00E+06 _ OV _ 1.0000E+00V _ V1 _ -
P9 _ L _ D0 _ R7 _ S _ 2.21E+06 _ OV _ 1.0000E+00V _ V1 _ -
1  2   3   4    5   6   7         8      9      10         11  12 13
```

1 - Panel Number
2 - DISPLAY A Function
3 - DISPLAY B Function
4 - Range Number
5 - Measurement Circuit Mode
6 - Measurement Signal Frequency Temp. Value
7 - Measurement Signal Frequency Exponent
8 - Measurement Mode
9 - Measurement Signal Voltage Temp. Value
10 - Measurement Signal Voltage Exponent
11 - Measurement Data Averaging
12 - Comparator (*:ON -:OFF)
13 - Delimiter

NOTE: In the Output Format Sample, the "_" denotes a space (ASCII Code 20h).

RS-232C

Monitor Output Format

Output in Relation to Limit Monitor Command "LIM"

<u>Absolute Value Settings Mode</u>

This will output the PANEL No., BIN No., LOW LIMIT, and HIGH LIMIT for BIN No.1   No.9 in the order of DISPLAY A and then DISPLAY B.
However, if "LIM" is sent when the Panel Number is"0", the system will announce an error.

Output Format Sample

```
P1_BIN1_CP0_+9.9000E-03H/+10.100E-03H_+1.0000E+00R/+10.000E+00R
P1_BIN2_CP0_+9.8000E-03H/+10.200E-03H_+10.000E+00R/+100.00E+00R
P1_BIN3_CP0_+9.7000E-03H/+10.300E-03H_+100.00E+00R/+1.0000E+03R
P1_BIN4_CP0_------------/------------_------------/------------
P1_BIN5_CP0_------------/------------_------------/------------
P1_BIN6_CP0_------------/------------_------------/------------
P1_BIN7_CP0_------------/------------_------------/------------
P1_BIN8_CP0_------------/------------_------------/------------
P1_BIN9_CP0_------------/------------_------------/------------
1  14   18        15     16   17   15          16   17     13
```

1 - Panel Number
13 - Delimiter
14 - BIN Number
15 - Low Limit Setting Value
16 - Divider for High/Low Settings (2Fh)
17 - High Limit Setting Value
18 - Comparator Mode

NOTES:

- ❖ Places with no setting will be filled with "------------" (ASCII Code 2Dh×12)
- ❖ D, Q, and θ will have a "_"(ASCII Code 5Fh) for their "Unit"
- ❖ In Output Format Sample, the "_" denotes a space (ASCII Code 20h)

RS-232C

Monitor Output Format

Output in Relation to Limit Monitor Command "LIM"

<u>% Setting Mode</u>

Output Format Sample

```
P1_BIN1_CP1_+10.000E-03H_005.00%/006.00%_+1.0000E00R_010.00%/010.00%
P1_BIN2_CP1_+10.000E-03H_010.00%/010.00%_+1.0000E00R_020.00%/020.00%
P1_BIN3_CP1_+10.000E-03H_020.00%/020.00%_+1.0000E00R_030.00%/030.00%
P1_BIN4_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
P1_BIN5_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
P1_BIN6_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
P1_BIN7_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
P1_BIN8_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
P1_BIN9_CP1_+0.0000E-00H_-------/-------_+0.0000E00R_-------/-------
1  14  18  19  20  16 21  19  20  16 21  13
```

1 - Panel Number
13 - Delimiter
14 - BIN Number
16 - Divider for High and Low Settings (2Fh)
18 - Comparator Mode
19 - Standard (Std.) Value
20 - Low Limit Value Setting
21 - High Limit Value Setting

NOTES:

- Places with no setting will be filled with "-------" (ASCII Code 2Dh×7)
- D, Q, and θ will have a "_"(ASCII Code 5Fh) for their "Unit"
- In Output Format Sample, the "_" denotes a space (ASCII Code 20h)

RS-232C

Table 5.6a - Monitor Output Code Functions

Number	Output Code	Content
1	P*	Panel Number(* :1~9)
2	L	Inductance Measurement (L)
	C	Capacity Measurement (C)
	R	Resistance Measurement (R)
	|Z|	Impedance Measurement (|Z|)
	|Y|	Admittance Measurement (|Y|)
3	D0	Loss Coefficient Measurement (D)
	Q0	Quality Measurement (Q)
	RS	Equivalent Series Resistance Measurement (R_S)
	RP	Equivalent Parallel Resistance Measurement (R_P)
	G0	Conductance Measurement (G)
	X0	Reactance Measurement (X)
	B0	Susceptance Measurement (B)
	A0	Phase Angle Measurement (θ)
4	A	Auto Circuit Mode
	S	Series Equivalent Circuit Mode
	P	Parallel Equivalent Circuit Mode
5	R0	Auto Range
	R1	100mΩRange
	R2	1ΩRange
	R3	10ΩRange
	R4	100ΩRange
	R5	1kΩRange
	R6	10kΩRange
	R7	100kΩRange
	R8	1MΩRange
	R9	10MΩRange
6	**.* *.** ***.	Measurement Frequency Temp. Value e.g.) 42.0Hz ~"42.0": 100Hz~"100.": 1.00kHz~"1.00"
7	E+**	Measurement Frequency Exponent e.g.) "E+00" → Hz: "E+03" → kHz: "E+06" → MHz
8	OV	Open Terminal Voltage Measurement Mode
	CV	Fixed Voltage Measurement Mode
	CC	Fixed Current Measurement Mode
9 10	+*.****E±**	Test Piece Voltage Temp. Value Exponent e.g.) 1.00V→"1.0000E+00": 0.10V → "100.00E-03"
11		
12	*	Comparator ON
	-	Comparator OFF
13	C_R+L_F	Delimiter, for RS-232C is C_R+L_F only
14	BIN*	BIN Number (* :0~9)

RS-232C

Table 5.6b - Monitor Output Code Functions cont'd

Number	Output Code	Content		
15 17	±**.***E+**XX	Limit Values(15 Minimum, 16 Maximum)		
		XX:	H	(Inductance Measurement)
			F	(Capacity Measurement)
			R	(Resistance, Serial Equivalent Resistance, Parallel Equivalent Resistance, Reactance)
			S	(Admittance, Conductance, Susceptance)
			_	(Loss Coefficient, Quality, Phase Angle Measurement)
16	/	Divider for High and Low Limit Values (ASCII Code 2Fh)		
18	CP0	Absolute Value Setting Mode		
	CP1	Percent Settings Mode		
19	±**.***E+**XX	Percent Settings Standard Values		
		XX:	H	(Inductance Measurement)
			F	(Capacity Measurement)
			R	(Resistance, Serial Equivalent Resistance, Parallel Equivalent Resistance, Reactance)
			S	(Admittance, Conductance, Susceptance
			_	(Loss Coefficient, Quality, Phase Angle Measurement)
20 21	***.**%	Limit Values(20 Low Value, 21 High Value) ***.**% has a setting range of 000.00%~200.00%		

RS-232C

RS-232C Hardware and Computer Settings

Set the settings as indicated below. These are the default settings of the RS-232C interface.

Baud rate	9600 bps
Data length	8 bit
Parity	NONE
Stop Bit	1 bit

Sample programs for RS-232C

Explanation of SAMPLE.BAS

The following is a sample program establishing basic initial settings and data
Display conditions for the purpose of controlling the 3550 through the RS-232C.

- 1000-1070 are initial settings
- 1010 is the setting for the RS232C environment on the computer side.
- 1030 is the setting for the "break-in" (interruption) action by the computer.

When the power for the 3550 is turned on, the 3550 sends the text signal "3550" to the computer in order to determine whether a control device exists on the computer. The computer receives the signal, and then sends signals to establish the necessary basic settings within the 3550 main unit.

If the textual signal "3550" is received by the computer prior to line "1260" of sample.bas, the computer will send the command line "E3 REN O1" to the 3550, LCR meter.

For more details regarding "E3 REN O1" and other commands, refer to the command summary, Tables 5.3a & 5.3b on pages 5-11 and 5-12. Basically, the RS-232C will use the external trigger and output the measurement data to an external device. The textual signal that the computer receives at this point will be displayed on the CRT.
The "VER" in 1110 is the output command of the ROM version. The wait times indicated in 1120 and 1125 allow time for the computer to read the data. When the display is finished, the program will end.

RS-232C

Sample programs for RS-232C

SAMPLE.BAS

```
1000 REM sample.bas
1010 OPEN "COM:N81" AS #1 : CLS
1030 ON COM GOSUB *RECIEVE
1040 COM ON:KAN = 0
1050 '
1055 *LABEL
1060 GOSUB *WAIT10
1070 IF KAN = 0 THEN GOTO *LABEL
1080 '
1100 *LABEL2
1110 PRINT#1,"VER"
1115 F = 0
1120 GOSUB *WAIT10
1125 IF F = 0 THEN GOTO 1120
1130 PRINT "end"
1140 COM OFF
1150 END
1160 '
1170 *RECIEVE
1180 IF LOC(1) <> 0 THEN GOTO 1200
1190 GOTO 1290
1200 GOSUB *WAIT10
1210 W$ = INPUT$(LOC(1),#1)
1220 D$ = LEFT$(W$,6):F = 1
1230 IF(D$ = "3550" AND KAN = 0)THEN GOTO 1260
1240 PRINT LEFT$(W$,LEN(W$)-3)
1250 GOTO 1290
1260 PRINT#1,"E3 REN O1"
1270 PRINT D$
1280 KAN = 1:GOSUB *WAIT10
1290 RETURN
1299 '
1300 *WAIT10
1310 FOR I=0 TO 1000:NEXT I
1320 RETURN
```

RS-232C

Sample programs for RS-232C

Explanation of SAMPLE2.BAS

This sample program changes frequencies from 100Hz to 10 kHz in 100Hz increments, and calculates the capacitor value and phase angle in relation to the changes.

- Lines 1000 to 1070 are basic settings for the main unit of the 3550.
- In Line 1130, PRINT #1, "PAN2 E3 O1, FA1 FB7" indicates settings for measurement conditions that will calculate the condenser value and phase angle, and output with RS-232C, panel 2, TO trigger 01.

The 3550 can store 10 pages of settings. However, the initial setting of the trigger is the internal trigger for EO, so it is necessary to change the trigger mode to the mode of the external TO command immediately after changing the panel number. Note that each command is separated by a space. Also, single commands like: PRINT #1 "TO" are also possible, but when the panels need to be changed, complex commands such as below are necessary:

PRINT #1 "PAN2 E3"

- Lines 1150 to 1220 are where measurements are made while the frequency is changing.
- Line 1180 is "FRExxxxxx TO", where xxxxxx is the frequency value setting and TO is the measurement trigger.
- The wait times of 1200 and 1210 are used to wait for data reception and end of display.
- The program will cycle through 1150 to 1220 until the measurement frequency reaches 10kHz. and then it will terminate.

RS-232C

Sample programs for RS-232C

SAMPLE2.BAS

```
1000 REM sample2.bas
1010 OPEN "COM:N81" AS #1 : CLS
1020 KAN = 0
1030 ON COM GOSUB *RECIEVE
1040 COM ON
1050 *LABEL
1060 GOSUB *WAIT10
1070 IF KAN = 0 THEN GOTO *LABEL
1080 '
1090 GOSUB *WAIT10
1110 *LABEL2
1120 GOSUB *WAIT10
1130 PRINT#1,"PAN2 E3 O1 FA1 FB7"
1140 GOSUB *WAIT10
1150 FOR J=100 TO 10000 STEP 100
1160   K= LEN(STR$(J))
1170   A$=MID$(STR$(J),2,K-1)
1180   PRINT#1,"FRE"+A$+" T0"
1190   F = 1
1200   GOSUB *WAIT10
1210   IF F=1 THEN GOTO 1200
1220 NEXT J
1230 PRINT "end"
1235 COM OFF
1240 END
1250 '
1260 *RECIEVE
1280 IF LOC(1) <> 0 THEN GOTO 1300
1290 GOTO 1390
1300 GOSUB *WAIT10
1320 D$ =INPUT$(LOC(1),#1):PRINT D$
1330 D$=LEFT$(D$,6):F = 0
1340 IF D$ = "3550" THEN GOTO 1360
1350 GOTO 1390
1360 PRINT#1,"E3 REN O1"
1380 KAN = 1:GOSUB *WAIT10
1390 COM ON: RETURN
1400 *WAIT10
1410 FOR I=0 TO 1000:NEXT I
1420 RETURN
```

RS-232C

Sample programs for RS-232C

SAMPLE2.BAS cont'd:

Note 1: In Line 1400, WAIT10 may need be adjusted according to the speed of the computer. This program was tested on a Epson PC 486 Note AU DX4. Make adjustments for your computer if necessary.

The settings format and weight adjustments are the same even if Visual Basic 6 is used, so there should be no problem using the above sample as reference.

Note 2: When running this program, please start-up the program first. Then, after the program is started, power the 3550.

The GPIB Interface (Optional)

General Description of GPIB

Part #3505, is the optional GPIB communications board offered with the 3550 LCR Meter. Installing the board onto the main unit of the 3550 LCR Meter makes remote control and data output possible. After the 3505 has been installed into the 3550, it will have the capability to perform both "talker" and "listener" functions.

Primary Specifications of GPIB

The GPIB connector is a standard 24-pin connector. The pin arrangement and signal protocol conform to the IEEE-488 standard (1978). The GPIB interface functions are listed in the table below:

Table 5.7 – GPIB Functions

NAME	Code	FUNCTION
Source Handshake	SH1	All source handshake functions
Acceptor Handshake	AH1	All accepting handshake functions
Talker	T5	Basic Talker functions Serial poll Talker deactivation using MLA Talk only-function
Listener	L4	Basic listener functions Listener deactivation using MTA
Service Request	SR1	Send message during serial poll
Remote/Local	RL1	Remote/Local switching function
Device Clear	DC1	Machine initialization function
Device Trigger	DT1	4 types of DT1 commands; "E0","E1","E2",E3"

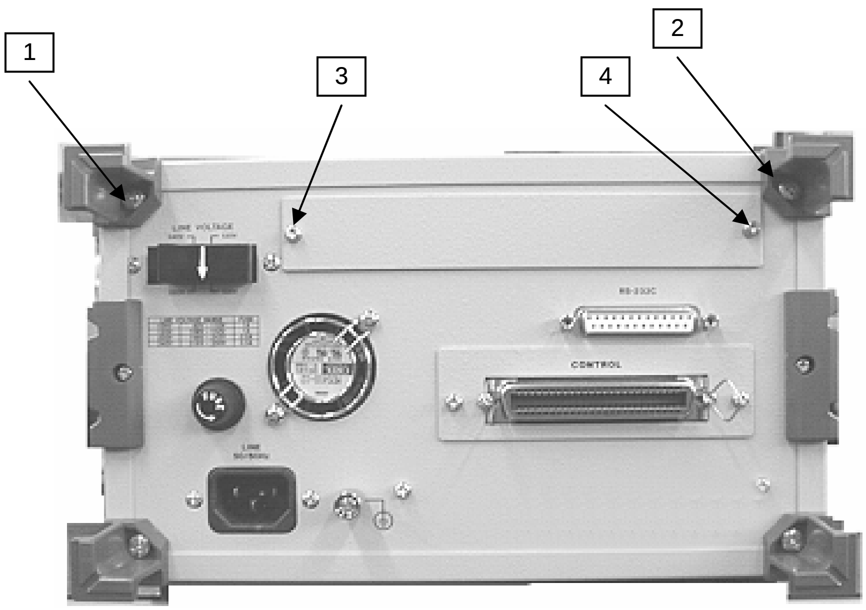
The GPIB Interface

Installation of the GPIB Board, Option #3505

When installing this option board onto the main unit, follow the following directions:

1. Turn OFF the power of the 3550 and remove the AC line cord. Remove screws “1” and “2” of the cord hook on the upper part of the rear side, and proceed to remove the top cover by pulling it rearward.

Figure 5.4a – Rear View

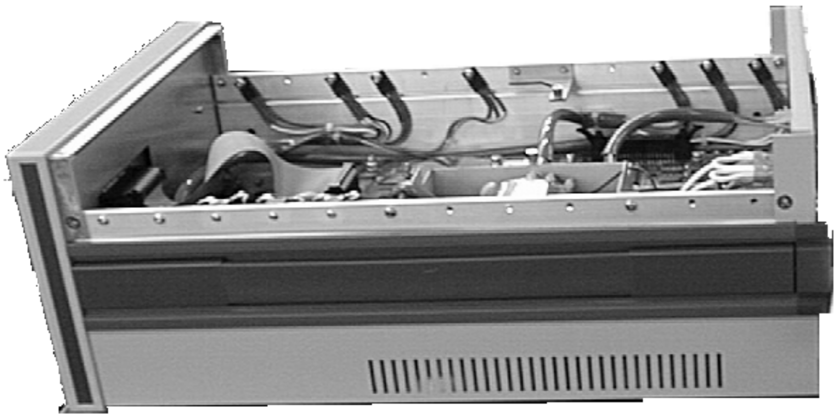


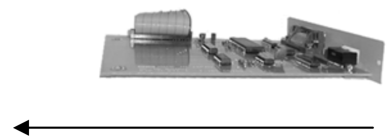
2. Remove screws “3” and “4” from the “blank panel”, and then remove the “blank panel”.
3. Next, install the GPIB board. Insert the GPIB board into the main unit through the place in the rear where the “blank panel” came off. Then tighten screws “3” and “4’’.

The GPIB Interface

Installation of the GPIB Board, Option #3505 cont'd:

Figure 5.4b – Side View



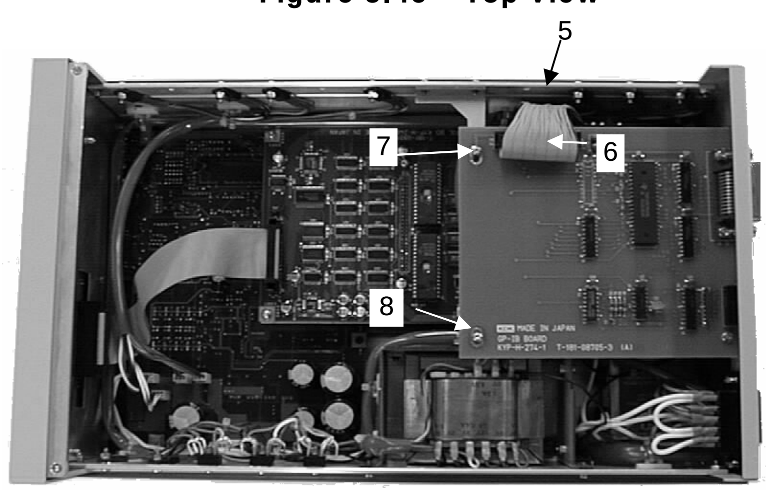


Slide the GPIB card into the slot and tighten screws "3" and "4" .

4. Then, connect the cable "6" of the GPIB board with the connector of the Control Board "5".

5. Match the 2 holes ("7" and "8") to the "pillars" on the Control Board, and tighten the screws.

Figure 5.4c – Top View



6. Replace the top cover.

NOTE: The input and output commands & formats for GPIB are the same as they are for RS232C. Refer to the previous section on RS-232C communications for details regarding specific commands and formats.

The GPIB Interface

Front Panel Status Display LEDs

On the front of the main unit, there are 4 LED's displaying the interface status of GPIB. They light up under the following circumstances:

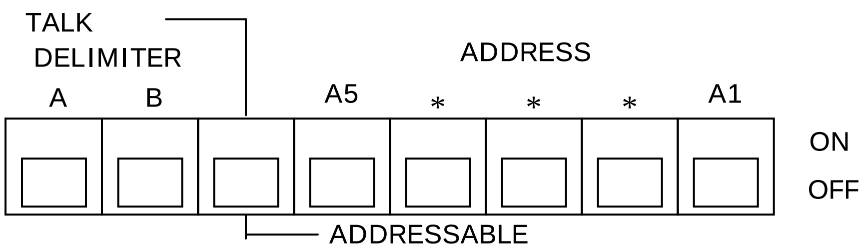
[SRQ]: An SRQ (service request) is being sent from the 3550 to the GPIB bus line.
[LTN]: The 3550 is set to be the Listener
[TLK]: The 3550 is set to be the Talker
[RMT]: The 3550 is being controlled remotely. When the GPIB bus line receives the commands REN, MLA "REN", and enters remote mode.

LOCAL Key Switch

Pushing the LOCAL key-switch changes the machine to front panel operation.

GPIB Switches (Delimiter, Talk-Only, Address Switch)

The optional GPIB board has switches for setting the Delimiter and Address.



When setting the GPIB address exercise caution not use the same address as other GPIB devices on the same bus. Please set the "TALK ONLY/ADDRESSABLE" switch to the "ADDRESSABLE" side, and establish different addresses for each device. On the "TALK ONLY" side, a GPIB interface may be installed, or the Listen-only Mode Printer may be used.

Delimiter Output Format

Four output format choices are available using switches A & B of the “DELIMITER", as shown below in chart 9-4.

DELIMITER		Content (Added to last line of data)	Output Code
A	B		
0	0	Return+New Line(also EOI)	CR+LF
0	1	Return only	CR
1	0	New Line only	LF
1	1	EOI line is LOW	

The Address switches (A5 through A1) can be set within the binary range of (00000~11110) and decimal range of (0~30). In binary “11111” and in decimal ‘31’ cannot be set.

The GPIB Interface

Output Status Bits for Service Requests

After the power is turned ON, sending the command, "S1" allows "Service Requests" to be used. The status bits for the 3550 are positioned as indicated below.

Figure 5.5 – GPIB Status Bits

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	SRQ	0	Command Error	0	Data Continue	Hand Shake Error	Data Ready
(DIO8)	(DIO7)	(DIO6)	(DIO5)	(DIO4)	(DIO3)	(DIO2)	(DIO1)

Bit6: If a Service Request occurs under program code "S1", this will become "1" and the SRQ Line will be "True".
Bit4: When improper program codes or numerical data are received, this will become "1".
Bit2: While data flow is continuing, this will be "1".
Bit1: If a GPIB Handshake Error, or an unknown command is received, this will become "1".
Bit0: When data to be output is ready to go, this will become "1".

Additional Notes for Using the GPIB Interface

1) Almost all of the switches on the front and rear panel of the 3550 can be controlled remotely through an external controller.

2) The 3550 should be designated as the Listener, and the necessary measurement parameter program codes should be sent from the controller. The program codes for GPIB are the same as the program codes for the RS-232C.

3) By setting "E1" within the program code, measurement using a "GET" message is possible. If "E2" is set; measurements will be made every time the "MAN/EXT" key on the panel is pressed.

4) The controller will then designate the 3550 as the Talker, and read the data.

5) If you would like to issue Service Requests from the serial poll, make sure that the controller reads the status bit related to the request.

The GPIB Interface

Programming Examples

Below is a sample program for remotely controlling the 3550 using the GPIB controller. In this program, measurement is carried out while changing the frequency.
The example here is based on the commonly used PC-9801(NEC).

TO Trigger (without SRQ)

```
110 ON HELP GOSUB *TESTEND
120 CLS
130 HELP ON
140 ISET IFC
150 FOR I=0 TO 100000! : NEXT I
160 ISET REN
170 CMD DELIM = 0
180 PRINT @5;"ren"@
190 PRINT @5;"s0 e3 o2"@
200 FOR J=100 TO 10000!  STEP 100
210 K = LEN(STR$(J))
220 A$ = MID$(STR$(J),2,K-1)
230 PRINT @5;"fre"+A$+" T0"@
240 LINE INPUT @5;A$
250 LOCATE 0,10 : PRINT A$
260 NEXT J
270 GOTO 200
280 *TESTEND
290 END
```

TO Trigger (with SRQ)

```
110 ON HELP GOSUB *TESTEND
120 CLS
130 HELP ON
160 ISET IFC
170 FOR I=0 TO 100000! : NEXT I
180 ISET REN
190 CMD DELIM = 0
200 PRINT @5;"ren"@
210 PRINT @5;"s1 e3 o2"@
220 FOR J=100 TO 10000!  STEP 100
230 K = LEN(STR$(J))
240 A$ = MID$(STR$(J),2,K-1)
250 PRINT @5;"fre"+A$+" T0"@
260 FOR I = 0 TO  30 : NEXT I
270 POLL 5,SB
280 IF SB < 64 THEN GOTO 260
290 LINE INPUT @5;A$
300 LOCATE 0,10 : PRINT A$
310 NEXT J
320 GOTO 220
330 *TESTEND
340 END
```

The GPIB Interface

Programming Examples

GET Trigger

```
110 CLS
120 ISET IFC
130 FOR I=0 TO 100000! : NEXT I
140 ISET REN
150 CMD DELIM = 0
160 PRINT @5;"ren"@
170 PRINT @5;"s0 e1 o2"@
180 FOR J=100 TO 10000!  STEP 100
190 K = LEN(STR$(J))
200 A$ = MID$(STR$(J),2,K-1)
210 PRINT @5;"fre"+A$ @
220 WBYTE &H2F,&H8;
230 LINE INPUT @5;A$
240 LOCATE 0,10 : PRINT A$
250 NEXT J
260 GOTO 180
270*TESTEND
280 END
```

INSTRUMENT DESCRIPTION
PREPARATION FOR USE
QUICK START INSTRUCTIONS
OPERATING INSTRUCTIONS
PROGRAMMING & INTERFACING
SERVICE INFORMATION
APPENDIX

Warranty:

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of one year from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of 6 months from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations:

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration:

This instrument has been inspected and tested in accordance with specifications published by TEGAM Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM Inc.

Contact Information:

TEGAM INC.
10 TEGAM WAY
GENEVA, OHIO 44041
PH: 440.466.6100
FX: 440466.6110
EMAIL: sales@tegam.com

Repair Parts

The Model 3550 has no user replaceable parts. Available accessories are listed in Section I.

Troubleshooting:
The TEGAM Model 3550 has been designed to provide many years of trouble free performance. However, there are some instances where harsh operating environments or excessive physical strain may cause premature failure. Should a malfunction of the 3550 be observed, it is recommended that certain steps be taken in order to assist our service department in identifying the cause of the malfunction and to provide the quickest possible turn around time for the repair cycle.

Below is a summary of some commonly observed symptoms and some possible remedies for ruling out the possibilities of user error or environmentally-related problems.

No Display – The display is completely blank.

- Check the power supply. Make sure that the AC line is operational and is supplying power to the unit.
- Check the fuse located in the rear panel. If a blown fuse is identified there is usually a reason for the fuse blowing, so the probability of another related problem is high.

Unstable Reading – The reading bounces erratically with no apparent pattern.

Be sure that the Operating Instructions have been reviewed and thoroughly understood. Constant voltage or constant current modes, sample averages, frequency and other settings can affect the stability of the reading. Readings that bounce out of the specification ranges can also indicate a problem with noise.

- Make sure that the test leads or fixtures are manufactured by TEGAM. All accessories for the 3550 are specially designed to minimize the effects of external noise to the measurement signal.
- Verify that there are no sources of noise in close proximity to the 3550, test leads, power leads, or test fixture. Sources of noise such as CRTs, relays, and other switching devices are primary causes for erratic readings.

Inaccurate Reading **–** Measurements do not fall within expected or known values or accuracies.

- Perform Open and Closed Circuit Zero Correction procedures as instructed in this manual.
- Make sure that the Range is appropriate for the measurement.
- Verify that four or five-wire Kelvin measurement leads are being used and that they are not defective.
- Measured component values can sometimes vary with the test voltage or current being applied. Make sure that the manufacturer’s recommended test settings are followed in order to duplicate measurement results. Sometimes constant current or constant voltage modes may be required to stabilize readings.
- Verify that the test fixture or leads is appropriate for the measurement to be performed. Not all fixtures and leads are designed for the entire range of 3550 test frequencies and measurement accuracies.

Preparation for Repair or Calibration Service:

Once you have verified that the cause for 3550 problem cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA, (Returned Material Authorization), number. You can contact TEGAM customer service via the TEGAM website, www.tegam.com or by calling 440.466.6100 OR 800.666.1010.

The RMA number is unique to your instrument and will help us identify your instrument and to address the particular service request by you which is assigned to that RMA number. Of even importance, a detailed written description of the problem should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or of a detailed description of the problem.

This description should include information such as measurement settings, type of components being tested, whether the problem intermittent or constant?, when is the problem most frequent?, has the test changed since the last time the instrument was used?, Etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use the Expedite Repair & Calibration form provided on the next page.

Once this information is prepared and sent with the instrument and RMA number to our service department, we will do our part in making sure that you receive the best possible customer service and turnaround time possible.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The completion of this form and including it with your instrument will expedite the processing and repair process.

RMA#:		Instrument Model #:	
Serial Number:		Company:	
Technical Contact:		Phone Number:	
Additional Contact Info:			

Repair Instructions:

☐ Evaluation ☐ Calibration Only ☐ Repair Only ☐ Repair & Calibration ☐ Z540 (Extra Charge)

Detailed Symptoms:

Include information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent?, Has anything changed with the application since the last time the instrument was used?, etc.

Model 3550 Verification Procedure:

EQUIPMENT NEEDED

MODEL NUMBER	DESCRIPTION	REQUIREMENTS
Agilent 42033A	100mΩ STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42034A	1Ω STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42035A	10Ω STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42036A	100Ω STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42037A	1kΩ STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42038A	10kΩ STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Agilent 42039A	100kΩ STANDARD RESISTOR	Four terminal BNC male connectors. .863in centers
Process Instruments 106	1MΩ STANDARD RESISTOR	Capable of measurement at 1KHz
Process Instruments 107	10MΩ STANDARD RESISTOR	Capable of measurement at 1KHz
Process Instruments 108	100MΩ STANDARD RESISTOR	Capable of measurement at 1KHz
Agilent 16089B	Kelvin Clip Leads	Capable of measuring at 1KHz, Through 100M ohms
Agilent 4284A	Precision LCR Meter	Frequency Range: 20Hz to 1MHz Four Terminal Pair *
Agilent 4285A	Precision LCR Meter	Freq. Range: 75kHz to 30MHz Four Terminal Pair *
Agilent 42090A	Open Termination	Four terminal BNC male connectors. .863in centers
Agilent 42091A	Short Termination	Four terminal BNC male connectors. .863in centers
Agilent 16385A	.01 µF Standard Capacitor	Four terminal BNC male connectors. .863in centers
Agilent 16386A	.1 µF Standard Capacitor	Four terminal BNC male connectors. .863in centers
Agilent 16387A	1 µF Standard Capacitor	Four terminal BNC male connectors. .863in centers

***NOTE: All required accuracy specifications and features of the Agilent equipment are not listed.**

Model 3550 Verification Procedure cont'd:

PREPARATION FOR TEST:

A. SET UP THE TEGAM 3550:

1. Cycle power on the 3550 and depress MANUAL to obtain manufacturer's default.
2. Set Display A to |Z|.
3. Set Display B to θ
4. Verify that the frequency is set to 1KHz.
5. Verify that the level is set to 1V.
6. Set the averaging to 100 as follows:

SHIFT	CV/CC	1	0	0	ENTER

7. Allow the unit thirty minutes (minimum) to warm up.
8. Connect the Open Termination, Model 42090A, to the UNKNOWN BNC connectors on the 3550.
9. In the ZERO Section, press OPEN.
10. Wait for the open correction to complete.

Note: If a problem with the open correction was detected, a series of beeps will be heard.

11. Replace the Open Termination with the Short Termination, Model 42091A.
12. In the ZERO Section, press SHORT.
13. Wait for the short correction to complete.

Note: If a problem with the short correction was detected, a series of beeps will be heard.

14. Press the Manual button.

B. SET UP THE AGILENT 4284A:

1. Cycle power on the 4284A to obtain manufacturer's default.
2. Use the cursor keys and the soft-keys to set the function to **Z-θ deg.**
3. Verify that the frequency is set to 1KHz.
4. Verify that the level is set to 1V.
5. Press the MEAS SETUP key.
6. Set the Hi-Pw Mode to OFF.
7. Set TRIG to MAN.
8. Set the AVG to 32.
9. Allow the unit thirty minutes (minimum) to warm up.
10. Connect the Open Termination, Model 42090A, to the UNKNOWN BNC connectors on the 4284A.
11. Press the MEAS SETUP key.

Model 3550 Verification Procedure cont'd:

SET UP THE AGILENT 4284A cont'd:

12. Press the soft key labeled CORRECTION.
13. Set the CABLE to 0m.
14. Use the cursor keys to select OPEN. Press the soft key labeled ON.
15. Press the soft key labeled MEAS OPEN.
16. Wait for the open correction to complete.

Note: When the measurement is complete, the unit will indicate "Open Measurement Complete."

17. Replace the Open Termination with the Short Termination, Model 42091A.
18. Use the cursor keys to select SHORT. Press the soft key labeled ON.
19. Press the soft key labeled MEAS SHORT.
20. Wait for the short correction to complete.

Note: When the measurement is complete, the unit will indicate "Short Measurement Complete."

C. Measure Standards as follows:

1. Select the first Resistance Standard Model 42033A, connect to the UNKNOWN terminals of the 4284A.
2. Press TRIGGER, when the measurement changes, record the values for impedance and phase in the 4284A column.
3. Move the standard to the 3550, and press MAN/EXT. Wait for the reading to display and press MAN/EXT again. Record the values for impedance and phase in the 3550 column.
4. Repeat for each step in the 4284A table.
5. Calculate the difference in counts (3550) between the units.
6. Verify that each step is within tolerance.

Note: The last few steps require that the leads be changed to incorporate Kelvin Klip leads to measure the higher value resistance standards. Open and Short corrections must be completed using the Kelvin Klip leads.

7. Set up the 4285A using the same steps as for the 4284A with the exception of Hi-Pw mode.
8. Measure and record each standard in the 4285 Table.
9. Calculate the difference in counts (3550) between the units.
10. Verify that each step is within tolerance.

Note: For instances where the 4284A or 4285A does not meet a 4:1 calibration ratio with the 3550, for verification purposes, the allowable number of counts may need to be adjusted to reflect the added error of the Agilent meters.

Model 3550 Verification Procedure cont'd:

TEGAM 3550 AND AGILENT 4284A MEASUREMENTS

				A	B	A-B	
STANDARD VALUE	FREQ (Hz)	LEVEL (V)	PARAMETER	4284A	3550	ERROR	TOL. (CTS)
100mΩ	1k	1	Z			=(1000A-B)*100	1400
100mΩ	1k	1	θ			=(A-B) *100	101
1Ω	1k	1	Z			=(A-B) *10k	340
1Ω	1k	1	θ			=(A-B) *100	20
10Ω	1k	1	Z			=(A-B) *1k	94
10Ω	1k	1	θ			=(A-B) *100	10
100Ω	1k	1	Z			=(A-B) *100	22
100Ω	1k	1	θ			=(A-B) *100	10
1kΩ	1k	1	Z			=(A-B) *10k	21
1kΩ	1k	1	θ			=(A-B) *100	10
10kΩ	1k	1	Z			=(A-B) *1k	21
10kΩ	1k	1	θ			=(A-B) *100	10
100kΩ	1k	1	Z			=(A-B) *100	21
100kΩ	1k	1	θ			=(A-B) *100	10
100Ω	42	1	Z			=(A-B) *100	27
100Ω	42	1	θ			=(A-B) *100	10
1kΩ	42	1	Z			=(A-B) *10k	26
1kΩ	42	1	θ			=(A-B) *100	10
100Ω	10k	1	Z			=(A-B) *100	27
100Ω	10k	1	θ			=(A-B) *100	10
1kΩ	10k	1	Z			=(A-B) *10k	27
1kΩ	10k	1	θ			=(A-B) *100	10
100Ω	100k	1	Z			=(A-B) *100	85
100Ω	100k	1	θ			=(A-B) *100	40
1kΩ	100k	1	Z			=(A-B) *10k	85
1kΩ	100k	1	θ			=(A-B) *100	40
10Ω	1M	1	Z			=(A-B) *1k	204
10Ω	1M	1	θ			=(A-B) *100	50
100Ω	1M	1	Z			=(A-B) *100	115
100Ω	1M	1	θ			=(A-B) *100	40
1kΩ	1M	1	Z			=(A-B) *10k	115
1kΩ	1M	1	θ			=(A-B) *100	40
.01µF	1k	1	Z			=(A-B) *1k	22
.01µF	1k	1	θ			=(A-B) *100	20
.1µF	1k	1	Z			=(A-B) *10k	22
.1µF	1k	1	θ			=(A-B) *100	20
1µF	1k	1	Z			=(A-B) *100	21
1µF	1k	1	θ			=(A-B) *100	20

Model 3550 Verification Procedure cont'd:

TEGAM 3550 AND AGILENT 4284A MEASUREMENTS

				A	B	A-B	
STANDARD VALUE	**FREQ (Hz)**	**LEVEL (V)**	**PARAMETER**	**4284A**	**3550**	**ERROR**	**TOL. (CTS)**
.1µF	100k	1	θ			=(A-B) *100	187
.01µF	10k	1	Z			=(A-B) *10k	33
.01µF	10k	1	θ			=(A-B) *100	28
.1µF	10k	1	Z			=(A-B) *100	26
.1µF	10k	1	θ			=(A-B) *100	20
1µF	10k	1	Z			=(A-B) *1k	96
1µF	10k	1	θ			=(A-B) *100	86
.01µF	100k	1	Z			=(A-B) *100	83
.01µF	100k	1	θ			=(A-B) *100	78
.1µF	100k	1	Z			=(A-B) *1k	203
1µF	100k	1	Z			=(A-B) *10k	425
1µF	100k	1	θ			=(A-B) *100	341
.01µF	1M	1	Z			=(A-B) *1k	203
.01µF	1M	1	θ			=(A-B) *100	187
.1µF	1M	1	Z			=(A-B) *10k	525
.1µF	1M	1	θ			=(A-B) *100	531
1MΩ	1k	1	θ			=(A-B) *10k	180
1MΩ	1k	1	Z			=(A-B) *100	23
10MΩ	1k	1	θ			=(A-B) *1k	235
10MΩ	1k	1	Z			=(A-B) *100	44
100MΩ	1k	1	θ			=(A-B) *100	1015
100MΩ	1k	1	Z			=(A-B) *100	426

NOTE: Phase values are dependent on the phase of the device under test. If the Standard is beyond .1 degree in phase for resistance values the tolerance must be recalculated. Exceptions are 1M ohm and 10M ohm, which should be within 2 degrees and 100M ohm, which should be within 5degrees.

TEGAM 3550 AND AGILENT 4284A MEASUREMENTS

				A	B	A-B	
STANDARD VALUE	**FREQ (Hz)**	**LEVEL (V)**	**PARAMETER**	**4284A**	**3550**	**ERROR**	**TOL. (CTS)**
10kΩ	1M	1	Z			=(A-B) *1k	205
10kΩ	1M	1	θ			=(A-B) *100	71
100kΩ	1M	1	Z			=(A-B) *100	605
100kΩ	1M	1	θ			=(A-B) *100	183
100Ω	5M	1	Z			=(A-B) *100	355
100Ω	5M	1	θ			=(A-B) *100	153
1kΩ	5M	1	Z			=(A-B) *10k	655
1kΩ	5M	1	θ			=(A-B) *100	353

NOTE: Phase values are dependent on the phase of the device under test. If the Standard is beyond 1 degree in phase for resistance values the tolerance must be recalculated.

Model 3550 Calibration Adjustment Procedure:

Please contact TEGAM in order to obtain Calibration or Repair Service for your Instrument.

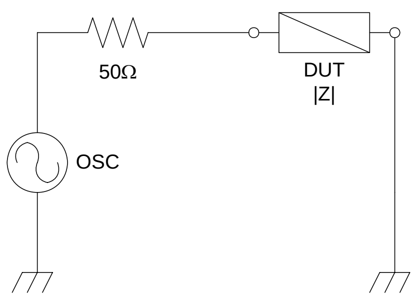
Setting the Constant Voltage Mode

To Enable the Constant Voltage Mode

1. Check and confirm that the [CV/CC] button is not illuminated.
2. Press the [V] button until Display C indicates voltage.
3. Press the [CV/CC] button.
4. Check and confirm that both the [CV/CC] and [V] button are illuminated.
   The 3550 is now operating in Constant Voltage Mode.

Calculating the Maximum Allowable Constant Voltage Setting

The figure bellow is an equivalent circuit of the Output Oscillator of the 3550. When connected to a DUT of a known impedance, |Z| and known phase angle, theta; the constant voltage maximum limit for a defined impedance and theta may be determined by using formula 1.
NOTE: The absolute maximum allowable constant voltage setting (regardless of DUT impedance) is limited by instrument capability. This maximum amount is 3.58V.



$$CV \leq \left| \frac{Z\cos\theta + jZ\sin\theta}{50 + (Z\cos\theta + jZ\sin\theta)} xV \right|$$

Formula 1

Where:
CV = Constant Voltage Setting Limit
V = Maximum Oscillator Voltage Setting

Sample Calculation:
For a test frequency of 1 kHz, |Z| = 100Ω, and theta (θ) =45º, the maximum constant voltage setting is calculated as follows:

$$CV \leq \left| \frac{Z\cos\theta + jZ\sin\theta}{50 + (Z\cos\theta + jZ\sin\theta)} x5 \right|$$

$$CV \leq \left| \frac{100\cos 45^{o} + j100\sin 45^{o}}{50 + (100\cos 45^{o} + j100\sin 45^{o})} x5 \right|$$

$$CV \leq \left| 3.458 + j0.903 \right|$$

$$CV \leq 3.574V$$

Setting the Constant Current Mode

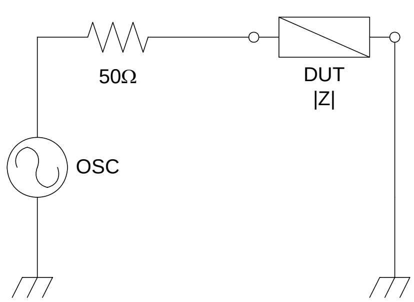
To Enable the Constant Current Mode

1. Check and confirm that the [CV/CC] button is not illuminated.
2. Push the [I] button until Display C indicates current.
3. Press the [CV/CC] button.
4. Check and confirm that both the [CV/CC] and [I] button are illuminated.
   The 3550 is now operating in Constant Current Mode.

Calculating the Maximum Allowable Constant Current Setting

The figure bellow is an equivalent circuit of the Output Oscillator of the 3550. When connected to a DUT of a known impedance, |Z| and known phase angle, theta; the constant current maximum limit may be determined by using formula 2.

NOTE: The absolute maximum allowable constant current setting (regardless of DUT impedance) is limited by the instruments sourcing capability. This maximum amount is 35.74mA.



$$CC \leq \left| \frac{V}{50+(Z\,cos\theta + j\,sin\theta)} \right|$$

Formula 2

Where:
CC = Constant Current Setting Limit
V = Maximum Oscillator Voltage Setting

Sample Calculation:

For a test frequency of 1 kHz, |Z| = 100Ω, and theta (θ) =45º, the maximum constant current setting is calculated as follows:

$$CC \leq \left| \frac{5}{50+(Z\,cos\theta + j\,Zsin\theta)} \right|$$

$$CC \leq \left| \frac{5}{50+(100cos45^o + j\,100sin45^o)} \right|$$

$$CC \leq \left| 0.03083 \;- j\; 0.01806 \right|$$

$$CC \leq 0.03573\,A$$

Table A.1: Basic Accuracy Table

Range	Impedance	Measurement Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ	(5+4β)%+500	(5+4β)%+500	(5+4β)%+500	(5+4β)%+500	(10+4β)%+500		
		(5+2β)%+100	(5+2β)%+100	(5+2β)%+100	(5+2β)%+250	(10+4β)%+500		
1Ω	0.1800Ω~ 1.9999Ω	(2+0.4β)%+200	(1+0.4β)%+200	(1.5+0.4β)%+200	(1.5+0.4β)%+200	(2+0.4β)%+200	(3+0.4β)%+200	
		(2+0.3β)%+20	(1+0.2β)%+20	(1.5+0.2β)%+20	(1.5+0.2β)%+60	(2+0.2β)%+150	(3+0.2β)%+250	
10Ω	1.800Ω~ 19.999Ω	(1+0.4β)%+200	(0.8+0.04β)%+10	(0.8+0.04β)%+10	(0.8+0.04β)%+10	(1.5+0.04β)%+50	(1.5+0.04β)%+50	(5+0.4β)%+200
		(1+0.2β)%+20	(0.8+0.03β)%+10	(0.8+0.03β)%+10	(0.8+0.03β)%+10	(1.5+0.03β)%+50	(1.5+0.03β)%+50	(5+0.3β)%+200
100Ω	18.00Ω~ 199.99Ω	(0.15+0.02β)%+10	(0.1+0.02β)%+10	(0.15+0.02β)%+10	(0.15+0.02β)%+10	(0.4+0.05β)%+40	(0.6+0.05β)%+50	(3+0.05β)%+50
		(0.15+0.01β)%+10	(0.1+0.01β)%+10	(0.1+0.01β)%+10	(0.1+0.01β)%+10	(0.4+0.03β)%+40	(0.6+0.03β)%+40	(3+0.03β)%+150
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.15+0.05α)%+10	(0.4+0.05α)%+40	(0.6+0.05β)%+50	(3+0.05β)%+350
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.1+0.03α)%+10	(0.4+0.03α)%+40	(0.6+0.03β)%+40	(3+0.05β)%+350
10kΩ	1.800kΩ~ 19.999kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.15+0.05α)%+10	(0.4+0.05α)%+40	(1+0.05α)%+100	(3+0.05α)%+400
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.1+0.03α)%+10	(0.4+0.03α)%+40	(1+0.03α)%+70	(3+0.05α)%+300
100kΩ	18.00kΩ~ 199.99kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.8+0.05α)%+50	(1+0.05α)%+50	(3+0.05α)%+300	(20+0.5α)%+700
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.8+0.05α)%+180	(2+0.05α)%+180	(3+0.05α)%+180	(20+0.5α)%+500
1MΩ	0.1800MΩ~ 1.9999MΩ	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(2+0.1α)%+70	(2+0.1α)%+70	(20+0.1α)%+700	
		(1.5+0.1α)%+20	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(2+0.1α)%+200	(2+0.1α)%+250	(20+0.1α)%+200	
10MΩ	1.800MΩ~ 19.999MΩ	(2+0.15α)%+20	(2+0.15α)%+20	(2+0.15α)%+20	(2+0.15α)%+70	(20+0.15α)%+500		
		(2+0.1α)%+40	(2+0.1α)%+40	(2+0.1α)%+40	(2+0.1α)%+200	(20+0.1α)%+700		
10MΩ	18.00MΩ~ 199.99MΩ	(5+0.15α)%+500	(5+0.15α)%+500	(5+0.15α)%+500	(5+0.15α)%+500	(50+0.15α)%+500		
		(5+0.1α)%+400	(5+0.1α)%+400	(5+0.1α)%+400	(5+0.1α)%+400	(50+0.1α)%+700		

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\frac{\left[\begin{array}{c}\text{Accuracy Limit from}\\ \text{Measurement Limit Chart}\end{array}\right] \times \left[\begin{array}{c}\text{Maximum Voltage}\\ \text{Limit for Chart}\end{array}\right]}{\text{The Set Measurement Voltage}}$$

$$\alpha = \frac{Zx}{10{,}000} \quad \beta = \frac{10{,}000}{Zx}$$

Zx = the number of counts for |Z|

Table A.2: Basic Accuracy Table [.01V to .04V]

Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ							
1Ω	0.1800Ω~ 1.9999Ω							
10Ω	1.800Ω~ 19.999Ω	(6+2.4β)%+1200	(4.8+0.24β)%+60	(4.8+0.24β)%+60	(4.8+0.24β)%+60	(9+0.24β)%+300		
		(6+1.2β)%+120	(4.8+0.18β)%+60	(4.8+0.18β)%+60	(4.8+0.18β)%+250	(9+0.18β)%+300		
100Ω	18.00Ω~ 199.99Ω	(0.9+0.12β)%+60	(0.6+0.12β)%+60	(0.9+0.12β)%+60	(0.9+0.12β)%+60	(2.4+0.3β)%+240	(3.6+0.3β)%+300	
		(0.9+0.06β)%+60	(0.6+0.06β)%+60	(0.6+0.06β)%+60	(0.6+0.06β)%+120	(2.4+0.18β)%+240	(3.6+0.18β)%+240	
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.9+0.06α)%+60	(0.6+0.06α)%+60	(0.9+0.3α)%+60	(0.9+0.3α)%+60	(2.4+0.3α)%+240	(3.6+0.3β)%+300	
		(0.6+0.03α)%+60	(0.6+0.03α)%+60	(0.6+0.18α)%+60	(0.6+0.18α)%+120	(2.4+0.18α)%+240	(3.6+0.18β)%+240	
10kΩ	1.800kΩ~ 19.999kΩ	(0.9+0.06α)%+60	(0.6+0.06α)%+60	(0.9+0.3α)%+60	(0.9+0.3α)%+60	(2.4+0.3α)%+240	(6+0.3α)%+600	
		(0.6+0.03α)%+60	(0.6+0.03α)%+60	(0.6+0.18α)%+60	(0.6+0.18α)%+120	(2.4+0.18α)%+240	(6+0.18α)%+420	
100kΩ	18.00kΩ~ 199.99kΩ	(0.9+0.06α)%+60	(0.6+0.06α)%+60	(0.9+0.3α)%+60	(4.8+0.3α)%+300	(6+0.3α)%+300		
		(0.6+0.03α)%+60	(0.6+0.03α)%+60	(0.6+0.18α)%+60	(4.8+0.3α)%+1080	(12+0.3α)%+1080		
1MΩ	0.1800MΩ~ 1.9999MΩ							
10MΩ	1.800MΩ~ 19.999MΩ							
100MΩ	18.00MΩ~ 199.99MΩ							

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\frac{\left[\text{Accuracy Limit from Measurement Limit Chart}\right] \times \left[\text{Maximum Voltage Limit for Chart}\right]}{\text{The Set Measurement Voltage}}$$

$$\alpha = \frac{Zx}{10,000} \qquad \beta = \frac{10,000}{Zx}$$

Zx = the number of counts for |Z|

Table A.3: Basic Accuracy Table [.05V to .10V]

Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ							
1Ω	0.1800Ω~ 1.9999Ω							
10Ω	1.800Ω~ 19.999Ω	(4+1.6β)%+800	(3.2+0.16β)%+40	(3.2+0.16β)%+40	(3.2+0.16β)%+40	(6+0.16β)%+200	(6+0.16β)%+200	(20+1.6β)%+800
		(4+0.8β)%+80	(3.2+0.12β)%+40	(3.2+0.12β)%+40	(3.2+0.12β)%+40	(6+0.12β)%+200	(6+0.12β)%+200	(20+1.2β)%+800
100Ω	18.00Ω~ 199.99Ω	(0.6+0.08β)%+40	(0.4+0.08β)%+40	(0.6+0.08β)%+40	(0.6+0.08β)%+40	(1.6+0.2β)%+160	(2.4+0.2β)%+200	(12+0.2β)%+200
		(0.6+0.04β)%+40	(0.4+0.04β)%+40	(0.4+0.04β)%+40	(0.4+0.04β)%+40	(1.6+0.12β)%+160	(2.4+0.12β)%+160	(12+0.12β)%+600
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.6+0.04α)%+40	(0.4+0.04α)%+40	(0.6+0.2α)%+40	(0.6+0.2α)%+40	(1.6+0.2α)%+160	(2.4+0.2α)%+200	(12+0.2β)%+1400
		(0.4+0.02α)%+40	(0.4+0.02α)%+40	(0.4+0.12α)%+40	(0.4+0.12α)%+40	(1.6+0.12α)%+160	(2.4+0.12α)%+160	(12+0.2β)%+1400
10kΩ	1.800kΩ~ 19.999kΩ	(0.6+0.04α)%+40	(0.4+0.04α)%+40	(0.6+0.2α)%+40	(0.6+0.2α)%+40		(4+0.2α)%+400	(12+0.2α)%+1600
		(0.4+0.02α)%+40	(0.4+0.02α)%+40	(0.4+0.12α)%+40	(0.4+0.12α)%+40	(1.6+0.12α)%+160	(4+0.12α)%+280	(12+0.2α)%+1200
100kΩ	18.00kΩ~ 199.99kΩ	(0.6+0.04α)%+40	(0.4+0.04α)%+40	(0.6+0.2α)%+40	(3.2+0.2α)%+200	(4+0.2α)%+200	(12+0.2α)%+1200	
		(0.4+0.02α)%+40	(0.4+0.02α)%+40	(0.4+0.12α)%+40	(3.2+0.2α)%+720	(8+0.2α)%+720	(12+0.2α)%+720	
1MΩ	0.1800MΩ~ 1.9999MΩ							
10MΩ	1.800MΩ~ 19.999MΩ							
100MΩ	18.00MΩ~ 199.99MΩ							

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\alpha = \frac{Zx}{10{,}000} \quad \beta = \frac{10{,}000}{Zx}$$

Zx = the number of counts for |Z|

$$\frac{\left[\begin{array}{c}\text{Accuracy Limit from}\\ \text{Measurement Limit Chart}\end{array}\right] \times \left[\begin{array}{c}\text{Maximum Voltage}\\ \text{Limit for Chart}\end{array}\right]}{\text{The Set Measurement Voltage}}$$

Table A.4: Basic Accuracy Table [.11V to .20V]

Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ							
1Ω	0.1800Ω~ 1.9999Ω	(4+0.8β)%+400	(2+0.8β)%+400	(3+0.8β)%+400	(3+0.8β)%+400	(4+0.8β)%+400	(6+0.8β)%+400	
		(4+0.6β)%+80	(2+0.4β)%+80	(3+0.4β)%+80	(3+0.4β)%+120	(4+0.4β)%+300	(6+0.4β)%+500	
10Ω	1.800Ω~ 19.999Ω	(2+0.8β)%+400	(1.6+0.08β)%+20	(1.6+0.08β)%+20	(1.6+0.08β)%+20	(3+0.08β)%+100	(3+0.08β)%+100	(10+0.8β)%+400
		(2+0.4β)%+40	(1.6+0.06β)%+20	(1.6+0.06β)%+20	(1.6+0.06β)%+20	(3+0.06β)%+100	(3+0.06β)%+100	(10+0.6β)%+400
100Ω	18.00Ω~ 199.99Ω	(0.3+0.04β)%+20	(0.2+0.04β)%+20	(0.3+0.04β)%+20	(0.3+0.04β)%+20	(0.8+0.1β)%+80	(1.2+0.1β)%+100	(6+0.1β)%+100
		(0.3+0.02β)%+20	(0.2+0.02β)%+20	(0.2+0.02β)%+20	(0.2+0.02β)%+20	(0.8+0.06β)%+80	(1.2+0.06β)%+80	(6+0.06β)%+300
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.3+0.02α)%+20	(0.2+0.02α)%+20	(0.3+0.1α)%+20	(0.3+0.1α)%+20	(0.8+0.1α)%+80	(1.2+0.1β)%+100	(6+0.1β)%+700
		(0.2+0.01α)%+20	(0.2+0.01α)%+20	(0.2+0.06α)%+20	(0.2+0.06α)%+20	(0.8+0.06α)%+80	(1.2+0.06β)%+80	(6+0.1β)%+700
10kΩ	1.800kΩ~ 19.999kΩ	(0.3+0.02α)%+20	(0.2+0.02α)%+20	(0.3+0.1α)%+20	(0.3+0.1α)%+20	(0.8+0.1α)%+80	(2+0.1α)%+200	(6+0.1α)%+800
		(0.2+0.01α)%+20	(0.2+0.01α)%+20	(0.2+0.06α)%+20	(0.2+0.06α)%+20	(0.8+0.06α)%+80	(2+0.06α)%+140	(6+0.1α)%+600
100kΩ	18.00kΩ~ 199.99kΩ	(0.3+0.02α)%+20	(0.2+0.02α)%+20	(0.3+0.1α)%+20	(1.6+0.1α)%+100	(2+0.1α)%+100	(6+0.1α)%+600	
		(0.2+0.01α)%+20	(0.2+0.01α)%+20	(0.2+0.06α)%+20	(1.6+0.1α)%+360	(4+0.1α)%+360	(6+0.1α)%+360	
1MΩ	0.1800MΩ~ 1.9999MΩ	(3+0.2α)%+40	(3+0.2α)%+40	(3+0.2α)%+40	(4+0.2α)%+140	(4+0.2α)%+140		
		(3+0.2α)%+40	(3+0.2α)%+40	(3+0.2α)%+40	(4+0.2α)%+400	(4+0.2α)%+500		
10MΩ	1.800MΩ~ 19.999MΩ	(4+0.3α)%+40	(4+0.3α)%+40	(4+0.3α)%+40				
		(4+0.2α)%+80	(4+0.2α)%+80	(4+0.2α)%+80				
100MΩ	18.00MΩ~ 199.99MΩ	(10+0.3α)%+1000	(10+0.3α)%+1000	(10+0.3α)%+1000				
		(10+0.2α)%+800	(10+0.2α)%+800	(10+0.2α)%+800				

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\alpha = \frac{Zx}{10{,}000} \quad \beta = \frac{10{,}000}{Zx}$$

Zx = the number of counts for |Z|

$$\frac{\left[\begin{array}{c}\text{Accuracy Limit from}\\ \text{Measurement Limit Chart}\end{array}\right] \times \left[\begin{array}{c}\text{Maximum Voltage}\\ \text{Limit for Chart}\end{array}\right]}{\text{The Set Measurement Voltage}}$$

Table A.5: Basic Accuracy Table [.21V to .45V]

Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ							
1Ω	0.1800Ω~ 1.9999Ω	(3+0.6β)%+300	(1.5+0.6β)%+300	(2.25+0.6β)%+300	(2.25+0.6β)%+300	(3+0.6β)%+300	(4.5+0.6β)%+300	
		(3+0.45β)%+30	(1.5+0.3β)%+30	(2.25+0.3β)%+30	(2.25+0.3β)%+90	(3+0.3β)%+225	(4.5+0.3β)%+375	
10Ω	1.800Ω~ 19.999Ω	(1.5+0.6β)%+300	(1.2+0.06β)%+15	(1.2+0.06β)%+15	(1.2+0.06β)%+15	(2.25+0.06β)%+75	(2.25+0.06β)%+75	(7.5+0.6β)%+300
		(1.5+0.3β)%+30	(1.2+0.045β)%+15	(1.2+0.045β)%+15	(1.2+0.045β)%+15	(2.25+0.045β)%+75	(2.25+0.045β)%+75	(7.5+0.45β)%+300
100Ω	18.00Ω~ 199.99Ω	(0.225+0.03β)%+15	(0.15+0.03β)%+15	(0.225+0.03β)%+15	(0.225+0.03β)%+15	(0.6+0.075β)%+60	(0.9+0.075β)%+75	(4.5+0.075β)%+75
		(0.225+0.015β)%+15	(0.15+0.015β)%+15	(0.15+0.015β)%+15	(0.15+0.015β)%+15	(0.6+0.045β)%+60	(0.9+0.045β)%+60	(4.5+0.045β)%+225
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(0.225+0.075α)%+15	(0.6+0.075α)%+60	(0.9+0.075β)%+75	(4.5+0.075β)%+525
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(0.15+0.045α)%+15	(0.6+0.045α)%+60	(0.9+0.045β)%+60	(4.5+0.075β)%+525
10kΩ	1.800kΩ~ 19.999kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(0.225+0.075α)%+15	(0.6+0.075α)%+60	(1.5+0.075α)%+150	(4.5+0.075α)%+600
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(0.15+0.045α)%+15	(0.6+0.045α)%+60	(1.5+0.045α)%+105	(4.5+0.075α)%+450
100kΩ	18.00kΩ~ 199.99kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(1.2+0.075α)%+75	(1.5+0.075α)%+75	(4.5+0.075α)%+450	(30+0.75α)%+1050
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(1.2+0.075α)%+270	(3+0.075α)%+270	(4.5+0.075α)%+270	(30+0.75α)%+750
1MΩ	0.1800MΩ~ 1.9999MΩ	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(3+0.15α)%+105	(3+0.15α)%+105		
		(2.25+0.15α)%+30	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(3+0.15α)%+300	(3+0.15α)%+375		
10MΩ	1.800MΩ~ 19.999MΩ	(3+0.225α)%+30	(3+0.225α)%+30	(3+0.225α)%+30	(3+0.225α)%+105	(30+0.225α)%+750		
		(3+0.15α)%+60	(3+0.15α)%+60	(3+0.15α)%+60	(3+0.15α)%+300	(30+0.15α)%+1050		
100MΩ	18.00MΩ~ 199.99MΩ	(7.5+0.225α)%+750	(7.5+0.225α)%+750	(7.5+0.225α)%+750	(7.5+0.225α)%+750			
		(7.5+0.15α)%+600	(7.5+0.15α)%+600	(7.5+0.15α)%+600	(7.5+0.15α)%+2250			

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\frac{\left[\text{Accuracy Limit from Measurement Limit Chart}\right] \times \left[\text{Maximum Voltage Limit for Chart}\right]}{\text{The Set Measurement Voltage}}$$

$$\alpha = \frac{Zx}{10{,}000} \quad \beta = \frac{10{,}000}{Zx}$$

Zx = the number of counts for |Z|

Table A.6: Basic Accuracy Table [.46V to 1.00V]

Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ	(5+4β)%+500	(5+4β)%+500	(5+4β)%+500	(5+4β)%+500	(10+4β)%+500		
		(5+2β)%+100	(5+2β)%+100	(5+2β)%+100	(5+2β)%+500	(10+4β)%+1500		
1Ω	0.1800Ω~ 1.9999Ω	(2+0.4β)%+200	(1+0.4β)%+200	(1.5+0.4β)%+200	(1.5+0.4β)%+200	(2+0.4β)%+200	(3+0.4β)%+200	
		(2+0.3β)%+20	(1+0.2β)%+20	(1.5+0.2β)%+20	(1.5+0.2β)%+60	(2+0.2β)%+150	(3+0.2β)%+250	
10Ω	1.800Ω~ 19.999Ω	(1+0.4β)%+200	(0.8+0.04β)%+10	(0.8+0.04β)%+10	(0.8+0.04β)%+10	(1.5+0.04β)%+50	(1.5+0.04β)%+50	(5+0.4β)%+200
		(1+0.2β)%+20	(0.8+0.03β)%+10	(0.8+0.03β)%+10	(0.8+0.03β)%+10	(1.5+0.03β)%+50	(1.5+0.03β)%+50	(5+0.3β)%+200
100Ω	18.00Ω~ 199.99Ω	(0.15+0.02β)%+10	(0.1+0.02β)%+10	(0.15+0.02β)%+10	(0.15+0.02β)%+10	(0.4+0.05β)%+40	(0.6+0.05β)%+50	(3+0.05β)%+50
		(0.15+0.01β)%+10	(0.1+0.01β)%+10	(0.1+0.01β)%+10	(0.1+0.01β)%+10	(0.4+0.03β)%+40	(0.6+0.03β)%+40	(3+0.03β)%+150
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.15+0.05α)%+10	(0.4+0.05α)%+40	(0.6+0.05β)%+50	(3+0.05β)%+350
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.1+0.03α)%+10	(0.4+0.03α)%+40	(0.6+0.03β)%+40	(3+0.05β)%+350
10kΩ	1.800kΩ~ 19.999kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.15+0.05α)%+10	(0.4+0.05α)%+40	(1+0.05α)%+100	(3+0.05α)%+400
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.1+0.03α)%+10	(0.4+0.03α)%+40	(1+0.03α)%+70	(3+0.05α)%+300
100kΩ	18.00kΩ~ 199.99kΩ	(0.15+0.01α)%+10	(0.1+0.01α)%+10	(0.15+0.05α)%+10	(0.8+0.05α)%+50	(1+0.05α)%+50	(3+0.05α)%+300	(20+0.5α)%+700
		(0.1+0.005α)%+10	(0.1+0.005α)%+10	(0.1+0.03α)%+10	(0.8+0.05α)%+180	(2+0.05α)%+180	(3+0.05α)%+180	(20+0.5α)%+500
1MΩ	0.1800MΩ~ 1.9999MΩ	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(2+0.1α)%+70	(2+0.1α)%+70	(20+0.1α)%+700	
		(1.5+0.1α)%+20	(1.5+0.1α)%+20	(1.5+0.1α)%+20	(2+0.1α)%+200	(2+0.1α)%+250	(20+0.1α)%+200	
10MΩ	1.800MΩ~ 19.999MΩ	(2+0.15α)%+20	(2+0.15α)%+20	(2+0.15α)%+20	(2+0.15α)%+70	(20+0.15α)%+500		
		(2+0.1α)%+40	(2+0.1α)%+40	(2+0.1α)%+40	(2+0.1α)%+200	(20+0.1α)%+700		
100MΩ	18.00MΩ~ 199.99MΩ	(5+0.15α)%+500	(5+0.15α)%+500	(5+0.15α)%+500	(5+0.15α)%+500	(50+0.15α)%+500		
		(5+0.1α)%+400	(5+0.1α)%+400	(5+0.1α)%+400	(5+0.1α)%+1500	(50+0.1α)%+1500		

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\alpha = \frac{Zx}{10,000} \quad \beta = \frac{10,000}{Zx}$$

Zx = the number of counts for |Z|

$$\frac{\left[\text{Accuracy Limit from Measurement Limit Chart}\right] \times \left[\text{Maximum Voltage Limit for Chart}\right]}{\text{The Set Measurement Voltage}}$$

Table A.7: Basic Accuracy Table [1.01V to 5.00V]

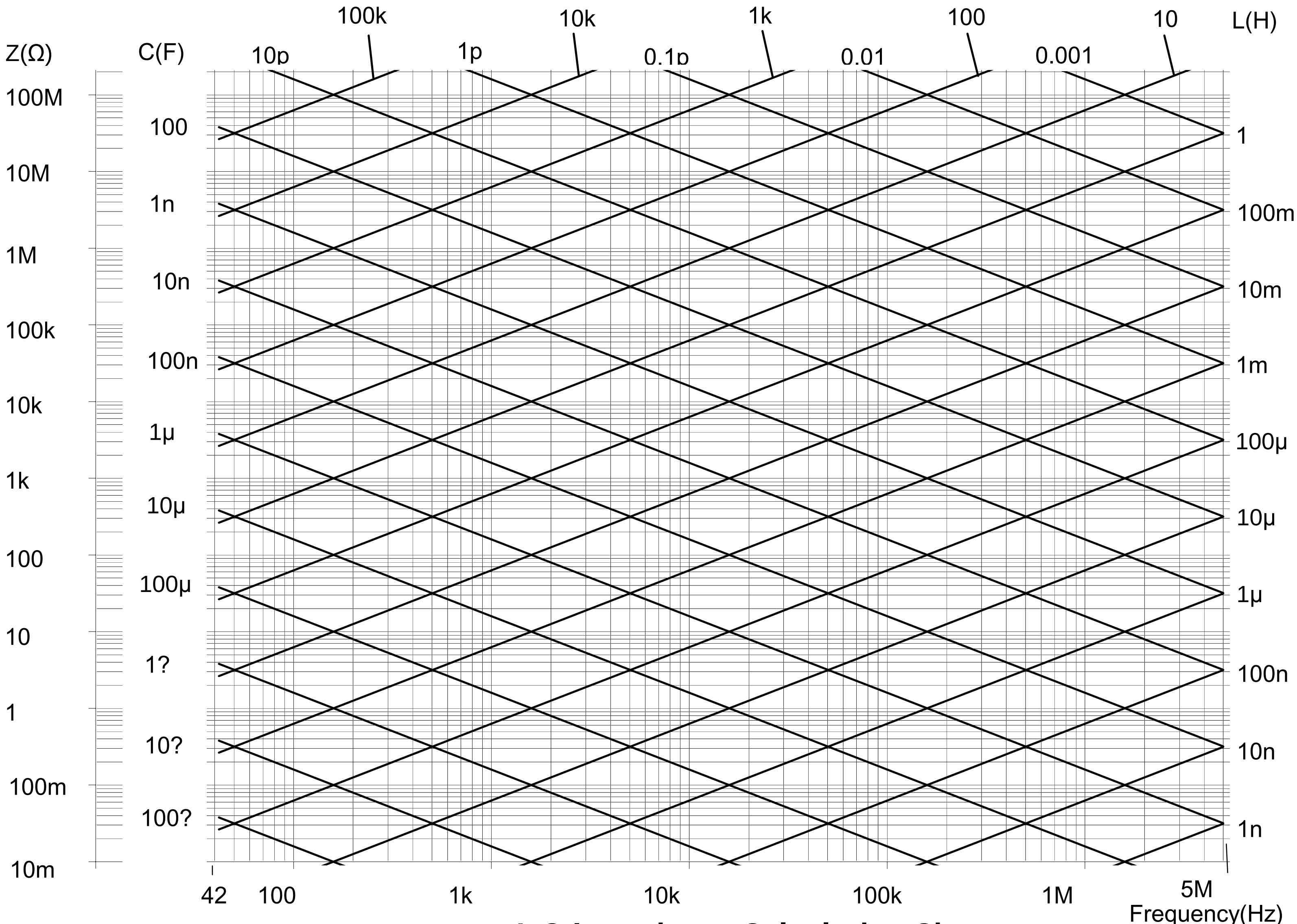
Range	Impedance	Measure Frequency						
		42Hz~99.9Hz	100Hz~1kHz	1.01kHz~10.0kHz	10.1kHz~30.0kHz	30.1kHz~100kHz	101kHz~1.00MHz	1.01MHz~5.00MHz
100mΩ	10.00mΩ~ 199.99mΩ	(7.5+6β)%+750	(7.5+6β)%+750	(7.5+6β)%+750	(7.5+6β)%+750	(15+6β)%+750		
		(7.5+3β)%+150	(7.5+3β)%+150	(7.5+3β)%+150	(7.5+3β)%+750	(15+6β)%+2250		
1Ω	0.1800Ω~ 1.9999Ω	(3+0.6β)%+300	(1.5+0.6β)%+300	(2.25+0.6β)%+300	(2.25+0.6β)%+300	(3+0.6β)%+300	(4.5+0.6β)%+300	
		(3+0.45β)%+30	(1.5+0.3β)%+30	(2.25+0.3β)%+30	(2.25+0.3β)%+90	(3+0.3β)%+225	(4.5+0.3β)%+375	
10Ω	1.800Ω~ 19.999Ω	(1.5+0.6β)%+300	(1.2+0.06β)%+15	(1.2+0.06β)%+15	(1.2+0.06β)%+15	(2.25+0.06β)%+75	(2.25+0.06β)%+75	
		(1.5+0.3β)%+30	(1.2+0.045β)%+15	(1.2+0.045β)%+15	(1.2+0.045β)%+15	(2.25+0.045β)%+75	(2.25+0.045β)%+75	
100Ω	18.00Ω~ 199.99Ω	(0.225+0.03β)%+15	(0.15+0.03β)%+15	(0.225+0.03β)%+15	(0.225+0.03β)%+15	(0.6+0.075β)%+60	(0.9+0.075β)%+75	
		(0.225+0.015β)%+15	(0.15+0.015β)%+15	(0.15+0.015β)%+15	(0.15+0.015β)%+15	(0.6+0.045β)%+60	(0.9+0.045β)%+60	
1kΩ	0.1800kΩ~ 1.9999kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(0.225+0.075α)%+15	(0.6+0.075α)%+60	(0.9+0.075β)%+75	
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(0.15+0.045α)%+15	(0.6+0.045α)%+60	(0.9+0.045β)%+60	
10kΩ	1.800kΩ~ 19.999kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(0.225+0.075α)%+15	(0.6+0.075α)%+60	(1.5+0.075α)%+150	
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(0.15+0.045α)%+15	(0.6+0.045α)%+60	(1.5+0.045α)%+105	
100kΩ	18.00kΩ~ 199.99kΩ	(0.225+0.015α)%+15	(0.15+0.015α)%+15	(0.225+0.075α)%+15	(1.2+0.075α)%+75	(1.5+0.075α)%+75	(4.5+0.075α)%+450	
		(0.15+0.0075α)%+15	(0.15+0.0075α)%+15	(0.15+0.045α)%+15	(1.2+0.075α)%+270	(3+0.075α)%+270	(4.5+0.075α)%+270	
1MΩ	0.1800MΩ~ 1.9999MΩ	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(3+0.15α)%+105	(3+0.15α)%+105	(30+0.15α)%+1050	
		(2.25+0.15α)%+30	(2.25+0.15α)%+30	(2.25+0.15α)%+30	(3+0.15α)%+300	(3+0.15α)%+375	(30+0.15α)%+300	
10MΩ	1.800MΩ~ 19.999MΩ	(3+0.225α)%+30	(3+0.225α)%+30	(3+0.225α)%+30	(3+0.225α)%+105	(30+0.225α)%+750		
		(3+0.15α)%+60	(3+0.15α)%+60	(3+0.15α)%+60	(3+0.15α)%+300	(30+0.15α)%+1050		
100MΩ	18.00MΩ~ 199.99MΩ	(7.5+0.225α)%+750	(7.5+0.225α)%+750	(7.5+0.225α)%+750	(7.5+0.225α)%+750	(75+0.225α)%+750		
		(7.5+0.15α)%+600	(7.5+0.15α)%+600	(7.5+0.15α)%+600	(7.5+0.15α)%+2250	(75+0.15α)%+1950		

Upper Specification: Accuracy of |Z| ± (Nominal% + Counts)
Lower Specification: Accuracy of θ ± (Nominal% + Counts)
The count coefficient should be calculated as follows:

$$\frac{\left[\text{Accuracy Limit from Measurement Limit Chart}\right] \times \left[\text{Maximum Voltage Limit for Chart}\right]}{\text{The Set Measurement Voltage}}$$

$$\alpha = \frac{Zx}{10{,}000} \quad \beta = \frac{10{,}000}{Zx}$$

Zx = the number of counts for |Z|



L C Impedance Calculation Chart

Error Codes

DISPLAY CODE	ERROR TITLE	ERROR CONDITION
601	PRINTER BUSY	When becoming timeout causing from printer output
1102	COMPARATOR RELATION SETTING ERROR	Input miss of character code following C through program code
1103	TRIGGER ERROR	Input miss of character code following E through program code
1104	FUNCTION ERROR	Input miss of character code following F through program code
1105	INITIAL SETTING RELATION ERROR	Input miss of character code following I through program code
1106	MEASUREMENT SIGNAL・ COMMAND LOCK ERROR	Input miss of character code following L through program code
1107	MEASUREMENT MODE・ MONITOR ERROR	Input miss of character code for M0*~M2*・ MON through program code
1108	SELECT ERROR TO DATA OUTPUT	Input miss of character code for OO*~O3* through program code
1109	COMPARATOR RELATION SETTING ERROR	Input miss of character code following P through program code
1111	SERVICE REQUEST・ SPOT CORRECTION ERROR	Input miss of character code following S0*,S1*,SP1*~SP3* through program code
1112	TRIGGER ERROR	Input miss of character code following TO*,TO* through program code
1114	ZERO OFFSET ERROR	Input miss of character code for Z0*~Z5* through program code
1115	MEASUREMENT MODE ERROR	Input miss of character code for JV, JVC, JCC through program code
1120	CORRECTION FREQUENCY CONTORL RELATION ERROR	Input miss of character code following W through program code
1121	COMPARATOR RELATION SETTING ERROR	Input miss of character code following PALXXXX through program code
1122	COMPARATOR RELATION SETTING ERROR	Input miss of character code following PAHXXXX through program code
1123	COMPARATOR RELATION SETTING ERROR	Input miss of character code following PBLXXXX through program code
1124	COMPARATOR RELATION SETTING ERROR	Input miss of character code following PBHXXXX through program code
1128	CORRECTION FREQUENCY CONTROL RELATION ERROR	Input miss of character code following WCH through program code
1129	CORRECTION FREQUENCY CONTROL RELATION ERROR	Input miss of character code following WCL through program code
1201	FREQUENCY SETTING RETATION ERROR	Input miss of character code following FRE· SPF through program code
1202	Ver COMMUNICATION ERROR	Miss-communication when sending Ver Command through program code
1603	COMPARATOR SW SETTING ERROR	When turning on program code C1 (comparator ON) in panel O
1604	FUNCTION A ERROR	Input miss of character code for FA0*~FA4* through program code
1605	FUNCTION B・ RANGE・ DATA OUTPUT ERROR	Input miss of character code for FB0*~FB7*, R0*~R9*· REN through program code
1606	VOLTAGE SETTING MEASUREMENT AVERAGE VERSION ERROR	Input miss of character code for· V001*~V101*· Ver* which is out of LEV setting range through program code
1607	PANELNUMBER SETTING ERROR	Input miss of character code for FAN0*~FAN9* through program code