MODEL 3525

GENERAL-PURPOSE, PROGRAMMABLE LCR METER

Instruction Manual

PN# 3525-900-01CD
Publication Date: February 2004
REV. C

TEGAM INC.

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LCR METER

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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 description in this manual and the product received.

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

Instrument Description

Model 3525,TEGAM's innovative solution for cost sensitive LCR applications, does not compromise quality or performance. Its flexible design allows a diverse range of testing applications including manual or automated testing of capacitors, inductors, coils, resistors, thermoelectric cooling devices, materials, piezo-electric or other sensors or components possessing AC impedance characteristics.

Up to 9 impedance parameters are easily viewed on each of the 3525's two 4 ½ digit, LED displays. Display A provides accurate and repeatable readings of Inductance (L), Capacitance (C), Resistance (R), and Impedance (|Z|). Display B measures values for Dissipation Factor (D or Tan δ), Quality Factor (Q), Phase Angle (θ), Measurement Voltage (V) and Measurement Current (I). All parameters are easily monitored, selectable from the front panel, and may be measured as Series or Parallel equivalent circuits.

The 3525's compact size is unprecedented and allows side-by-side mounting in standard 19" racks. A built-in comparator function makes the 3525 the ideal choice for manual component checking. Whether you are verifying component values for QA or manufacturing, the built in GO-NO GO comparator reduces test time and increases productivity with an audible beeper that may be set to alarm when a pass or fail state has been measured. A front panel lock feature prevents accidental changes on instruments settings.

Model 3525 is shipped from the factory with standard Kelvin Klips, RS-232C port, and I/O connector. There are a variety of optional accessories available, including GPIB Interface, BCD Output, Kelvin Klip Leads, Kelvin Tweezers, Radial Sorting Fixture, and SMT Chip Test Fixture. See the Accessories Sheet on page 1-4 for complete descriptions.

Feature Overview

The Model 3525 was designed with the right balance of features to keep cost down while providing optimal performance for most basic LCR applications. Below is a summary of the instrument's main features.

0.08% Basic Accuracy with 4.5 digit resolution.
The 3525 is designed to perform basic impedance measurements with up to 0.08% basic accuracy. Measurement accuracies are dependent upon a number of parameters and test conditions. See Performance Specifications to determine the actual measurement accuracies.

High Speed Measurement
With a 1kHz test frequency a reading can be obtained in as little as 15 mS when the instrument is operating in fast mode.

Manual or Remote Operation
The 3525 is equipped for manual or remote operation. Standard interfaces include a RS-232C and I/O port. GPIB and BCD interfaces are available as optional accessories.

Feature Overview cont'd:

Dual High Intensity Displays
The 3525 is equipped with dual LED displays for easy viewing. Display A measures 4½ digits of Inductance (L), Capacitance (C), Resistance (R), or Impedance (|Z|) while Display B indicates Dissipation Factor (D or Tan δ), Quality Factor (Q), Phase Angle (θ), Measurement Voltage (V), or Measurement Current (I).

Programmable GO/NO-GO Comparator with Audible Buzzer
Each unit has an internal comparator function that can be set by the user. Comparator Outputs result from the values of Display A, Display B, or a combination of the two. The comparator outputs may be read from the front panel, buzzer, the I/O connector located on the rear panel, or queried from the remote interfaces.

99 Preset Storage Locations
Panel Settings 01-99 are user-definable and may be programmed manually or via communication interfaces. These settings are stored in non-volatile RAM locations and may be recalled from the front panel or any of the rear interfaces.

Less than ½ Rack Width
Two 3525 units are able to be rack mounted, side-by-side, in a standard 19" rack using a third party rack mount kit, without modifying the instrument cases.

Manual or Auto Ranging
In AUTO range, the instrument automatically selects from 10 different impedance ranges. The selected range is dependent upon the DUT's absolute impedance, |Z|. In the manual range mode, the user may select from any of these ten ranges through the front panel.

Voltage and Current Monitors
Test Voltage (Vx) and Current (Ix) can be measured at the DUT terminals and are viewable on Display B to three significant digits.

Open and Short Circuit Zero Correction
Parasitic impedance of the test cables and/or test fixture may be cancelled out by performing the 3525's auto zero functions.

Front Panel Lock
The 3525 is equipped with a front panel lock-out feature to prevent accidental changes to instrument settings.

Dual Trigger Modes
Trigger instructions may be executed either internally or externally. Internal triggering allows the instrument to run continuously while external triggering requires instruction from the front panel, I/O connector, RS-232C, or GPIB interfaces.

Series or Parallel Equivalent Measurements
AC parameters may be measured as Series or Parallel equivalents.

3525 Accessories Sheet

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 3525. 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 - Chip Test Fixture

Available for performing three terminal measurements on surface mount devices. Connects directly to the front panel of the 3525. 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

CBL-3102-BNC-BNC Cable

BNC to BNC, RG 58/U, coaxial cable for use at the trigger inputs and outputs of the 3525. Cable length is a minimum of 1 meter (3.28 ft) long.

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

3502 – BCD Interface

BCD output for interface to handlers and other automated systems.

3501 – GPIB Interface

GPIB (IEEE-488)-compatible interface card. Field or factory installation.

3525-900-01CD – Instruction Manual

Printed copy of the 3525 users manual.

Performance Specifications

The advertised specifications of the Model 3525 are valid under the following conditions:

1. The instrument's calibration must be verified using the methods and intervals as described in the Service Information 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 Instrument 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. Use only TEGAM-manufactured test leads and sorting fixtures with this device. Modification of existing test cables or fixtures may compromise the accuracy of your readings. Always perform an open and short zero null procedure before taking measurements.

Measurement Ranges

Table 1.1: Absolute Impedance Range Limits Chart

Range No.	|Z| Measurement Range
1	0.0100Ω ~ 0.1999Ω
2	0.1800Ω ~1.9999Ω
3	1.800Ω ~ 19.999Ω
4	20.00Ω ~ 199.99Ω
5	0.2000kΩ ~ 1.9999kΩ
6	2.000kΩ ~ 19.999kΩ
7	20.00kΩ ~ 199.99kΩ
8	0.1800MΩ ~ 1.9999MΩ
9	2.000MΩ ~ 19.999MΩ
10	180.0MΩ ~ 199.99MΩ

The measurement range is determined by the absolute impedance, |Z| of the DUT. The absolute impedance includes the vector sum of L, C, and R values.

Display A & B - Basic Accuracies

Table 1.2: Basic Accuracy for Display A

Range	L	C	R	Z
1	$\pm(0.90+30/fL_1)\%$	$\pm(0.60+1.5fC_1)\%$	$\pm(1.00+0.21/R_1)\%$	$\pm(1.00+0.15/Z_1)\%$
2	±2.10%	±2.10%	±2.10%	±1.80%
3	±0.39%	±0.39%	±0.39%	±0.35%
4	±0.10%	±0.10%	±0.10%	±0.08%
5	±0.09%	±0.09%	±0.09%	±0.08%
6	±0.13%	±0.13%	±0.13%	±0.11%
7	±0.16%	±0.16%	±0.16%	±0.14%
8	±0.34%	±0.34%	±0.34%	±0.30%
9	$\pm(0.17+1.17fL_2)\%$	$\pm(0.17+30/fC_2)\%$	$\pm(0.15+0.20R_2)\%$	$\pm(0.15+0.16Z_2)\%$
10	$\pm(2.00+1.00fL_2)\%$	$\pm(1.7+30/fC_2)\%$	$\pm(2.00+0.16R_2)\%$	$\pm(2.00+0.11Z_2)\%$

Table 1.3: Basic Accuracy for Display B

Range	D	θ
1	$\pm(0.002+0.0015/Z_1)$	$\pm(0.10+0.09/Z_1)°$
2	±0.0179	±1.00°
3	±0.0034	±0.18°
4	±0.0016	±0.08°
5	±0.0011	±0.05°
6	±0.0016	±0.08°
7	±0.0020	±0.10°
8	±0.0036	±0.19°
9	$\pm(0.002+0.0015Z_2)$	$\pm(0.10+0.09Z_2)°$
10	$\pm(0.012+0.0014Z_2)$	$\pm(0.70+0.08Z_2)°$

IMPORTANT ACCURACY NOTES:

Basic Precision Test Conditions:
- Measurement Speed: SLOW
- Measurement Signal Level: 1V
- Open and Closed Circuit Zero Correction Performed

Units:
- Z_1 - DUT absolute impedance [Ω]
- Z_2 - DUT absolute impedance [MΩ]
- C_1 - Capacitance [mF]
- C_2 - Capacitance [pF]
- L_1 - Inductance [μH]
- L_2 - Inductance [kH]
- f - Test Frequency [kHz]

Other Conditions
- Q – Quality factor based on 1/D
- C - Accuracy is for when D≤0.1
- L - Accuracy is for when D≤0.1
- R - Accuracy is for when θ≤6°

The basic accuracy formulas in Tables 1.2 & 1.3 are based on the assumption that the measurement speed is Slow, and the measurement signal level is 1V. The exact accuracies will vary according to the measurement speed and measurement signal level. The formula for calculating the exact measurement accuracy is found in the next section:

Calculating Actual Measurement Accuracies

NOTE: All measurement accuracies assume that open and short circuit zero corrections have been performed.

Measurement Accuracy = Basic Accuracy X Speed Coefficient X Level Coefficient + 2 Counts

Table 1.4: Speed Coefficient

	FAST	NORM	SLOW
Speed Coefficient	3	1.5	1

Table 1.5: Amplitude Coefficient

	1V	500mV	50mV
Amplitude Coefficient	1	1.5	2

NOTE: The 3525 will produce a reading in both range 1 and range 10 using a 50mV test voltage. These readings are for reference use only and are not within any specified accuracy limits.

When measuring C and L, if the condition $D \leq 0.1$ is not satisfied, use Z and θ for accuracy calculations.

See below for an example calculation of this condition:

< Using Z and θ for accuracy calculation >
When C=20nF, D=0.5, Measurement Frequency = 1kHz, Signal Level = 1V, and Measurement Speed is SLOW:

1. Solve for Z and θ (*The |Z| or θ measured values of the 3525 can also be used.*)

   $\theta = \tan^{-1}(1/D) = 63.43°$
   $Z = (1/\omega C) \times (1/\sin\theta) = 8.897k\Omega$

2. Find the accuracy value using the charts for Z and θ

   From Z, the measurement range will be range 6. In range 6, the accuracy of Z =±0.11%, and the accuracy of θ =±0.08°.
   From this accuracy, the maximum and minimum values of Z and θ should be calculated.
   Z_{max}: 8.907kΩ Z_{min}: 8.887kΩ
   θ_{max}: 63.51° θ_{min}: 63.35°

3. From the max and min values, find the range of C and D.

   $C_{max} = 1/(Z_{min} \times \omega \times \sin\theta_{min}) = 2.0036nF$ (+0.18%)
   $C_{min} = 1/(Z_{max} \times \omega \times \sin\theta_{max}) = 1.9964nF$ (-0.18%)
   $D_{max} = 1/\tan\theta_{min} = 0.5017$ (0.0017)
   $D_{min} = 1/\tan\theta_{max} = 0.4983$ (-0.0017)

4. The Accuracy of C =±0.18%, D=±0.0017

Instrument Specifications

Measurement Parameters

- L (Inductance)
- C (Capacitance)
- R (Resistance)
- |Z| (Impedance)
- D (Dissipation Factor / Tan δ)
- Q (Quality Factor)
- θ (Phase Angle in Degrees)
- V (Inter-Terminal Voltage)
- I (Inter-Terminal Current)

Measurement Range

- L 1.6000uH ~ 199.99kH
- C 0.9400pF ~ 199.99mF
- R 0.0100 ~ 199.99MΩ
- |Z| 0.0100 ~ 199.99MΩ
- D 0.0001 ~ 19.999
- Q 0.5 ~ 199.99
- θ −180.00 ~ 180.00°
- V 0.00V ~ 1.00V
- I 0.00mA **~** 10.00mA

Basic Precision

- 0.08% (See *Measurement Range and Precision* for Exact Accuracies)

Measurement Frequency

- 1kHz, 120Hz (Frequency Precision: ±0.01% or less)

Output Impedance

- 100Ω ±10Ω

Measurement Signal Level

- 50mV, 500mV, 1V (Setting Accuracy: ±10%±10mV)

Maximum Short-Circuit Current

- 10mA

Measurement Ranges

- The measurement range is based on the value of |Z|. Parameters other than |Z|, such as L, C, R, D, Q, & θ are calculable values.
- There are ten ranges from 0.1Ω ~ 100MΩ
- Auto or Manual Range Modes

Equivalent Circuit Modes

- Auto or Manually selected Parallel or Series Equivalent Circuit Measurement Modes

Instrument Specifications cont'd:

Displays A & B

- 4½ Digit, High Visibility LED Displays

Measurement & Measurement Speed

- Measured parameter values are determined by the voltage and current amplitudes & phases detected by the instrument's circuitry and/or the average of calculated values.
- Total measurement times are dependent on the measurement frequency, integration speed, comparator settings and correction factor values.
- There are three user-selectable integration speeds to choose from. These are Fast, Normal, and Slow.

Typical Measurement Times:

MODE / MEASUREMENT FREQUENCY	120 Hz	1kHz
FAST	40mS	15mS
NORMAL	90mS	50mS
SLOW	360mS	250mS

Trigger Functions

- Internal Trigger – Instrument runs in continuous mode.
- External Trigger – Executed by the front panel push button, I/O connector TTL input, RS-232C, or GPIB commands

Measurement Terminal

- 5-Terminal (BNC with Guard) Kelvin Configuration

Auto Zero Correction

- Open Circuit Correction ≥1kΩ
- Short Circuit Correction ≤ 1kΩ

Absolute Comparator

Functions
- Display A
- Display B
- Display A & Display B

Outputs
- Front Panel LED
- Audible Buzzer
- External I/O Connector (HI,LO,GO,TOTAL GO,BUSY,END)
- RS-232C or GPIB Interface

Front Panel Settings

- Up to 99 user-definable front panel settings
- System Reset – Initializes the instrument to factory default settings

Instrument Specifications cont'd:

Key Lock Function

- Disables all front panel keys except the manual trigger key.

Audible Buzzer

- User selectable to GO, NO-GO, or OFF operation

Remote Interface

- Control I/O Connector (TTL Open Collector; Optically Isolated) – Standard Accessory
- RS-232C Interface – Standard Accessory
- GPIB Interface – Optional Accessory
- BCD Interface – Optional Accessory

Environmental

- Operating Conditions: from 32° to 104°F (0° to 40°C), <80% RH; (Non-Condensing)
  NOTE: Accuracy errors will double when the unit is operated outside of the specified environmental conditions.

- Storage Conditions: from 14° to 131°F (–10° to 55°C), <80% RH; (Non-Condensing)

AC Power Requirements:

- 100/120/220/240 VAC ± 10%; 50/60 Hz
- 20VA ±10%

Fuse:

- For 100/120 VAC Operation; Use 1A @ 250V, fast acting, TEGAM PN#FU-3102-220
- For 220/240 VAC Operation; Use ½A @ 250V, fast acting, TEGAM PN#49743

3525 Dimensions:

- Depth: 6.69" (17.0 cm)
- Width: 7.87" (20.0 cm)
- Height: 3.94" (10.0 cm)

Weight:

- 5.51 lb (2.5kg)

Standard Accessories:

- Users Manual CD Version – PN# 3525-900-01CD
- Standard AC Power Cord – PN#161006600
- Kelvin Klips - PN#47454

Optional Accessories:

- Radial Lead Adapter – PN#3510
- Chip Tweezers – PN#2005B
- Chip Test Fixture – PN#3511
- BCD Interface – PN#3502
- GPIB (IEEE-488 Interface) – PN#3501

Unpacking & Inspection:

Each 3525 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, them 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 3525 General Purpose, Programmable LCR Meter
Model 3525 User's Manual CD
Kelvin Klips™ PN#47454

⚠ 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 on 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
⏛	Frame or Chassis Terminal
⊥	Earth Ground Terminal
∿	Alternating Current

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 "Instrument Description" or "Service Information" 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 3525 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 Selection:

<u>CAUTION:</u> DO NOT APPLY POWER TO THE INSTRUMENT BEFORE READING THIS SECTION:

Unless otherwise specified, the Model 3525 is delivered from TEGAM with its power supply set for 120V, 60 Hz operation. However, the 3525 design allows it to operate under 100/120/220/240V @ 50/60 operation. It is strongly recommended that the line voltage, frequency setting, and fuse type be verified before powering the unit.

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

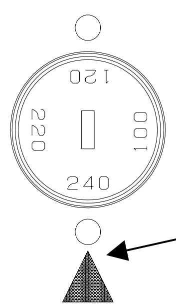
Table 2.1 – Operating Voltage Ranges

Switch Position	Voltage Range
100	90V ~ 110V
120	108V ~ 132V
220	198V ~ 242V
240	216V ~ 250V

The following procedure describes the steps necessary to change the 3525 power settings from factory default settings to a new setting.

1. Verify that there is no power connected to the unit.
2. Change the line selector switch located on the rear panel of the 3525 to the desired operating voltage by using a small screwdriver to turn the voltage selection switch to the desired position.

   Refer to the figure below:



With your screwdriver, turn the desired voltage number to the black arrow. For example, the setting here is for 240V.

3. The fuse size may need to be changed as a result of the increased or decreased voltage operation. Please refer to the “Service Information” section of this manual (page 6-3) for detailed fuse information. The rear panel of the 3525 will also contain information regarding fuse sizes and types.

Proper use of the Model 3525 will maximize measurement accuracy and productivity. The Quick Start section is designed to provide speedy setup for general-purpose applications. It is highly recommended that the user read Chapter 4 for applications involving high accuracy or requiring optimal performance of the instrument.

Power the Unit

⚠

CAUTION
The power supply of the Model 3525 is designed for 50-60 Hz operation and a voltage range of 100-240 VAC. Review the line voltage selection procedure on page 2-5 before proceeding. Make sure that the line voltage setting matches the supply voltage and frequency.

Power the unit and allow at least 30 minutes for the unit to warm up. Make sure that the safety precautions on pages 2-3 and 2-4 have been reviewed and understood. Verify that the environmental conditions, listed on pages 1-10, are met.

Factory Default Settings

The 3525 is shipped from the factory with instrument settings as follows:

Table 3.1 – Factory Default Settings

	Parameter	Setting		Parameter	Setting
1	Range	AUTO	**8**	Communication	*RS232 or GPIB
2	Trigger	Internal	**9**	Key Lock	UN-LOCKED
3	Speed	FAST	**10**	Comparator/Buzzer	OFF
4	Display A	Capacitance	**11**	Frequency	1kHz
5	Display B	Dissipation Factor	**12**	Voltage Level	1V
6	Trigger	Internal	**13**	Circuit Mode	AUTO
7	Range	Auto	**14**	Manual/Remote	Remote

** When a device clear command is sent via communications interface, this value does not change.*

These settings can be recalled by sending a device clear command, *RST via RS232, or GPIB interface.

NOTE: When the 3525's power is cycled, the instrument's settings will return to the state that existed at the time the power was last turned off. You can initialize the 3525 to factory default settings by pressing the [MANU] key while powering the unit.

Instrument Setup

Setup of the Model 3525 for general-purpose use is easy. Once the unit has been allowed to warm up, review the front panel and note the changes that need to be made in order to perform your required measurements. Below are Quick Setup instructions to adjust the main measurement parameters of the 3525. Refer to Chapter IV, Operating Instructions, for a comprehensive description of all the measurement options and instrument settings, including the ones listed below:

Display A

To select L, C, R or |Z| value to be indicated on Display A, make sure that the comparator function is disabled by pressing the [ON] key until all of the LED's in the *JUDGMENT* field are off. In the *FUNCTION* field, press the [A] key until the desired parameter's annunciator is lit.

Display B

To select D, Q, θ, V or I value to be indicated on Display B, make sure that the comparator function is disabled by pressing the [ON] key until all of the LED's in the *JUDGMENT* field are off. In the *FUNCTION* field, press the [B] key until the desired parameter's annunciator is lit.

Measurement Speed

In order to select FAST, NORMAL, OR SLOW mode, press the [SPD] key until the desired measurement rate is illuminated.

Test Frequency

In order to choose a 1kHz or 120 Hz test frequency, press the [FREQ] key until the desired frequency LED is illuminated.

Test Voltage Level

Select either 1V, 500mV, or 50 mV test voltage by pressing the [LEV] key until the desired voltage is selected.

Circuit Mode

The default equivalent circuit mode is AUTO. Refer to Chapter IV for information on series or parallel equivalent circuit measurements.

Range

The default range setting is AUTO. Refer to Chapter IV for more information on manual range selection.

Trigger

Press the [INT] key to select internal (continuous) triggering mode. Press the [MANU] key to select manual or external triggering options. Trigger the unit from the front panel by pressing the [MANU] key.

Performing an Open and Short Circuit Null

Once you have verified that all of the instrument settings are correct, the next step is to perform a zero correction.

1. Assuming that Kelvin Klip™ leads are being used, orient the leads in a similar position that they will be connected to the DUT. Open the leads (refer to page 4-19 for proper lead orientation.)
2. Press the [OPEN] key in the Zero field of the front panel. Allow the unit to step through the open circuit null procedure.
3. Then short the Kelvin Klip™ leads together. Press the [SHORT] key and allow the instrument to step through the short zero adjustment.

You have completed the Zero Correction procedure and are now ready to take basic impedance measurements. Refer to Chapter IV, Operating instructions for additional details or information regarding the use of this instrument.

Measurement Tips

Here are some general tips for users who are relatively new to performing LCR measurements:

- Unless otherwise specified, use 120Hz for capacitance measurements and use 1kHz for testing inductors.

- The 3525 will take the most accurate reading at SLOW measurement speed and 1V test voltage level.

- Orientation of test leads is important for repeatable measurements especially at high frequencies. Try to keep lead orientation the same when making precision measurements.

- Keep metallic or other objects away from test leads including hands when performing zero correction or impedance measurements.

- When measuring components with values that fall to the outer limits or outside of a particular range, put the instrument in manual range to eliminate range switching by locking into one range. This increases repeatability and measurement accuracy.

- When testing capacitors, make sure that the capacitor is completely discharged before connection to the measurement terminals of the 3525.

- Use the Guard Terminal for high impedance measurements to minimize leakage errors and noise.

Please read and understand Chapter III, Quick Start Instructions before proceeding with this section.

Basic Operation

The Model 3525 is a highly versatile product, designed for use in many different applications. There are ideal configurations of the 3525 for each measurement application. These configurations optimize accuracy, measurement speed, and flexibility.

This section is designed to give the user a comprehensive description of the parameters and operating modes available from the Model 3525. The user will be exposed to additional topics that will enhance the integration of the Model 3525 into their application.

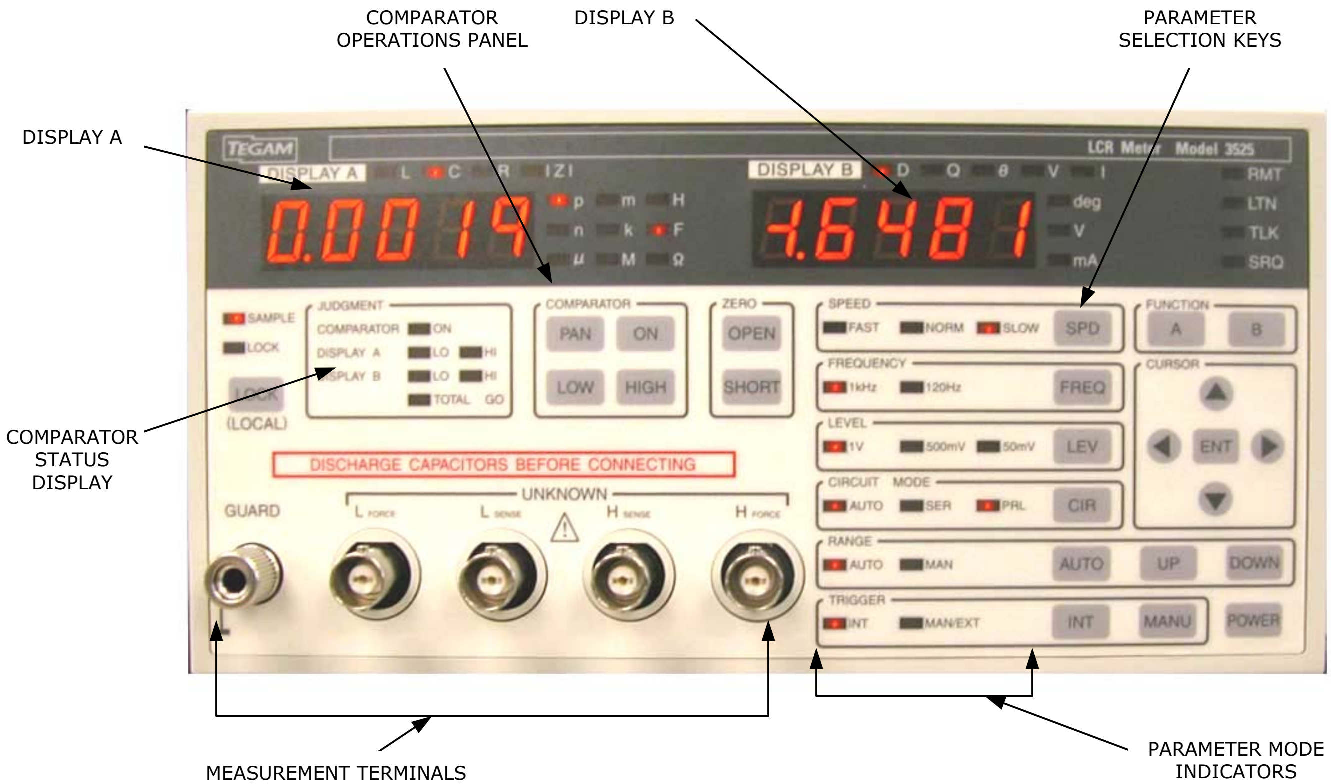
It is highly recommended that the user read this section thoroughly if the intended application requires high precision and maximum throughput.

Default Parameters

Model 3525 is shipped from TEGAM fully calibrated, tested, and preset to factory default settings to accommodate general-purpose manual operation. Chapter III, Quick Start Instructions, contains specific information about factory default settings and some general tips for new users. Please read and understand Chapter III, Quick Start Instructions, before proceeding.

Front Panel Description

Figure 4.1a: Front Panel Layout



DISPLAY A
4-1/2 Digit LED Display indicates measured values for L, C, R, and |Z|.

DISPLAY B
4-1/2 Digit LED Display indicates measured values for D, Q, θ, V, and I.

Parameter Mode Indicators
Displays active parameter modes and settings.

Comparator Status Display
Displays judgment results for display A, Display B or both. Results are based on comparator settings and measurement results.

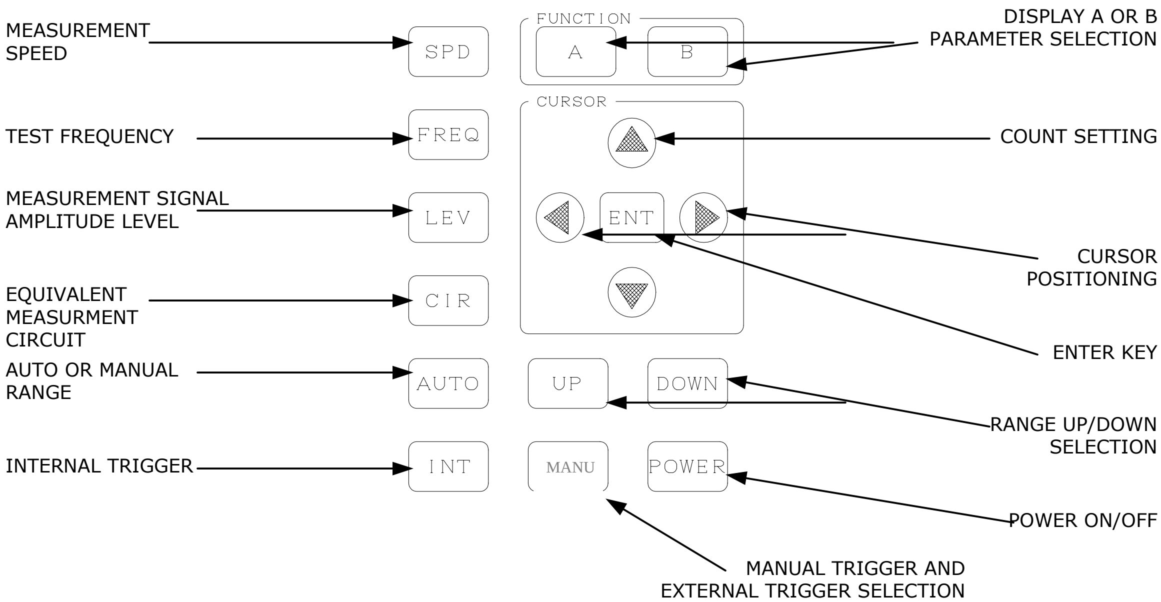
Parameter Selection & Control Keys
Use these keys for selecting measurement modes and parameters.

Comparator Operations Panel
Used for enabling the comparator, programming high and low limits and for preset panel selection.

Measurement Terminals:
A 5-terminal scheme is used:
HFORCE – High potential terminal for sourcing measurement current.
HSENSE - The "high" terminal for voltage sensing.
LSENSE - The "low" terminal for voltage or sensing
LFORCE - Low potential terminal for sourcing measurement current.
GUARD - The guard terminal. Use this connection to cancel any stray capacitance and conductance associated with high impedance measurements.

Front Panel Description cont'd:

Figure 4.1b: Measurement & Parameter Control Area

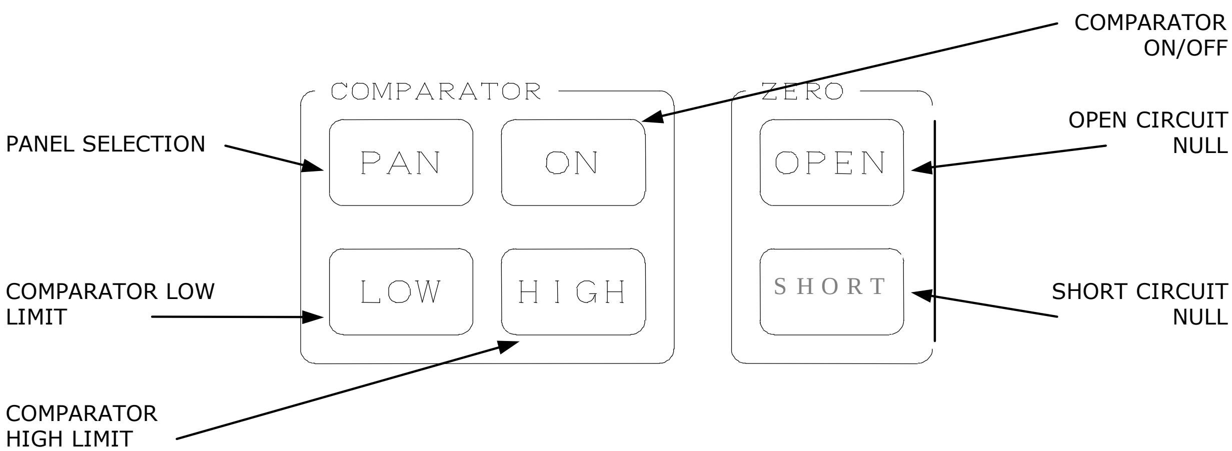


Measurement Speed Key
Use this key to select either FAST, NORMAL, or SLOW measurement speed.
Test Frequency Key
Use this key to select either 120Hz or 1kHz measurement frequency.
Measurement Signal Level Key
Press this key to select 1V, 500mV, or 50mV test signal amplitude.
Equivalent Circuits Mode Key
Press this key to select Series, Parallel, or AUTO equivalent circuit measurements.
Range Mode Key
Press the AUTO key to toggle between AUTO and Manual ranging modes.
Internal Trigger Key
Press this key to select continuous internal triggering of the instrument.
Manual Trigger Key
Press the manual trigger key to select manual or external triggering from the front panel or remote interface. Consequent pressing of the [MANU] key will trigger the instrument.

DISPLAY A Selection Key
Press [A] to select the active measurement parameter for Display A.
DISPLAY B Selection Key
Press [B] to select the active measurement parameter for Display B.
Count Setting Keys
Pressing the [▲] or [▼] keys allows the user to change count, decimal place or units settings during comparator setup.
Cursor Positioning Keys
The [►] or [◄] key allows movement of the display cursor when programming comparator settings.
Enter Key
Enters new parameters or modes into instrument memory.
Range Down key
In manual range mode, this key decrements the active measurement range number.
Range Up Key
In manual range mode, this key increments the active measurement range number.
Power Switch
Toggles the unit power either on or off.

Front Panel Description cont'd:

Figure 4.1c: Comparator Controls Area

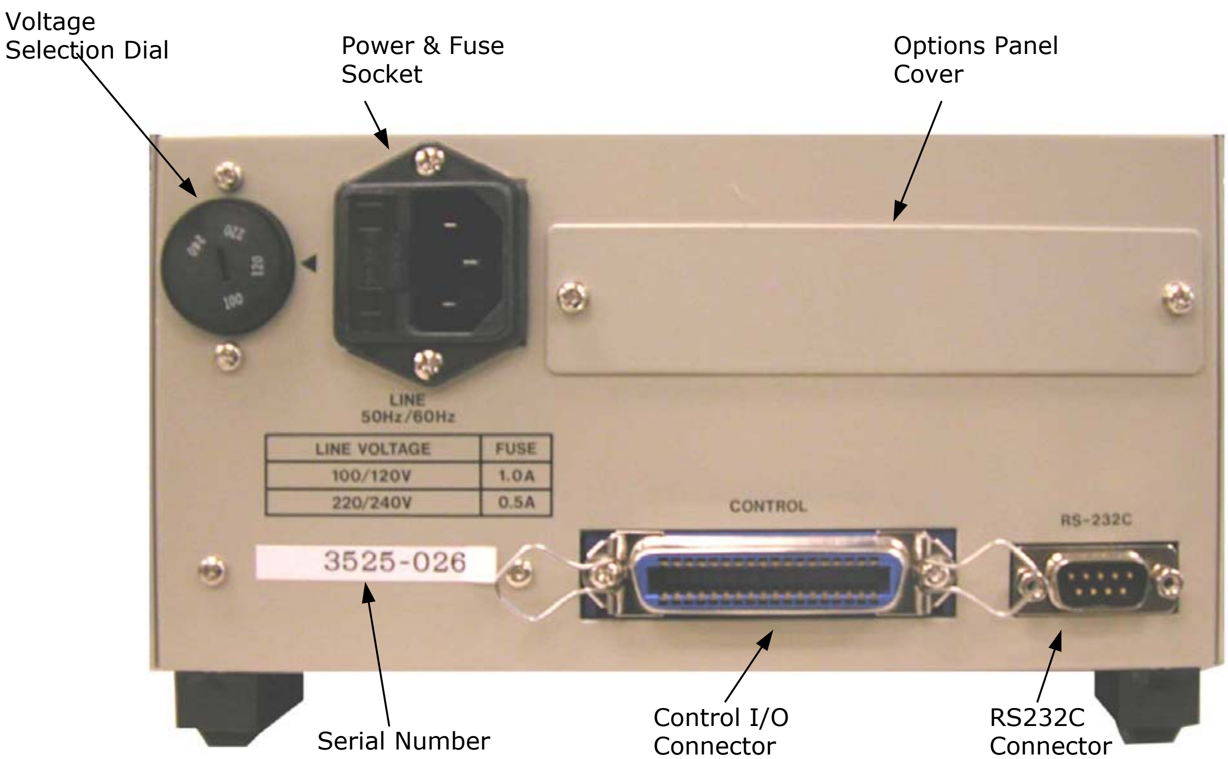


Panel Selection
Use this key to recall panel presets from 00-99
Comparator Low Limit
Press this key to access the comparator low limit programming mode.
Comparator High Limit
Press this key to access the comparator high limit programming mode.

Comparator ON/OFF
Pressing this key will either enable or disable comparator operation.
Open Circuit Null
With the test leads open, pressing this key will initiate the open circuit zeroing process.
Short Circuit Null
With the test leads shorted, pressing this key will initiate the short circuit zeroing process.

Rear Panel Description:

Figure 4.2: Rear Panel



Voltage Selection Dial
For selection of proper operating voltage see Chapter II, Preparation for Use.

Power & Fuse Socket
The three-conductor power cord plugs into this socket. The line fuse is also accessible here.

Serial Number
The Product Serial Number is located here.

Options Panel Cover
Blank cover for Units without GPIB communications or BCD options. This is where the options are installed.

Control I/O Connector
TTL control signal output connector. Photo isolated.

RS232C Connector
RS232C interface connector.

Selecting the Measurement Parameters

On the 3525, you are able to set the measurement parameters on DISPLAY A and DISPLAY B independently. The tables below summarize the measurement options available from DISPLAY A and DISPLAY B.

Table 4.1a: DISPLAY A – Description of Measurement Functions

Item	Description
L	Measures the inductance of the DUT
C	Measures the capacitance of the DUT
R	Measures the resistance of the DUT
|Z|	Measures the absolute value of impedance of the DUT

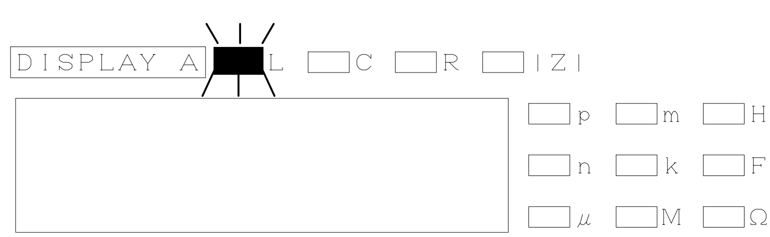
Table 4.1b: DISPLAY B – Description of Measurement Functions

Item	Description
D	Measures the Dissipation Factor, (loss coefficient or tan δ) of the DUT
Q	Measures the quality factor of the DUT
θ	Measures the phase angle of the DUT
V	Measures the test voltage between measurement terminals
I	Measures the test current through measurement terminals

The measurement parameter for display A is selected simply by repeatedly pressing the [A] key until the desired measurement parameter LED lights. The sequence of measurement parameters is as follows:

L→C→R→|Z|→L …

An illuminated LED indicates the active measurement parameter for DISPLAY A:

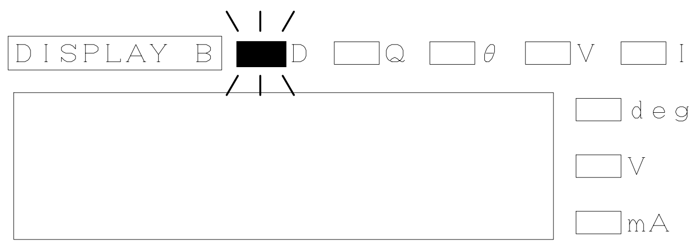


Selecting the Measurement Parameters cont'd:

The measurement parameter on DISPLAY B will change sequentially as the [B] key is pressed:

D→Q→θ→V→I....

Select the desired measurement parameter. Like in DISPLAY A, the active parameter LED will be lit above DISPLAY B.



Setting the Measurement Speed

The 3525 has three measurement speeds to choose from. These are FAST, NORMAL, and SLOW. The most accurate readings are obtained in the SLOW measurement mode.

The measurement frequency and the measurement mode are the key variables, which affect total measurement time. Their typical relationship to measurement speed is indicated in the table below.

Table 4.2: 3525 Typical Measurement Times

Measurement Frequency	FAST	NORMAL	SLOW
1kHz	15ms	50ms	250ms
120Hz	40ms	90ms	360ms

To set the measurement speed, press [SPD] until the desired mode is illuminated. The active mode will change sequentially as the [SPD] key is pressed.

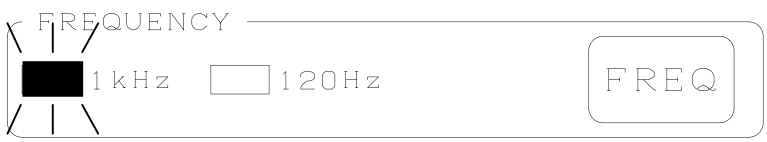
FAST→NORM→SLOW→FAST...

Setting the Measurement Frequency

On the 3525, you can select between two measurement frequencies: 1kHz and 120Hz.
To select the measurement frequency, press the [FREQ] key to scroll through the frequency options:

1kHz→120Hz→1kHz....

When the desired frequency has been selected, you can confirm you selection by inspecting the frequency LED located to the left of the [FREQ] key.

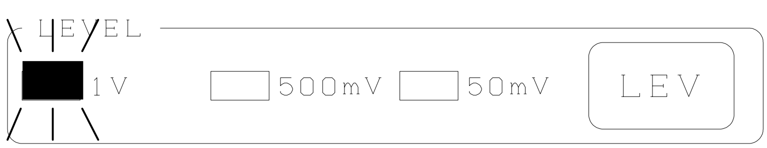


Setting the Measurement Signal Level

The 3525 has three selectable signal amplitudes to choose from: 1V, 500mV and 50mV.
The signal level setting will change each time [LEV] is pressed. The selction sequence is:

1V→500mV→50mV→1V...

Confirm the instrument's setting by observing the Level LEDs located to the left of the [LEV] key.



Setting Equivalent Circuits Mode

There are three equivalent circuit selections to choose from. These are Parallel Equivalent Circuit, Series Equivalent Circuit, and Auto Circuit Equivalent. Generally speaking, if the loss coefficient is small, the equivalent circuits mode will not significantly affect the measurement result. However, as the loss coefficient (D) increases, the difference in readings will increase, so caution is necessary. In typical applications, Parallel Equivalent Mode is used for high impedances while Series Equivalent Circuit measurement is used for low impedance measurement. In AUTO mode, the instrument will choose the appropriate circuit mode. SER equivalent mode will perform a measurement in serial equivalent circuit mode and PRL mode will perform measurements in parallel equivalent circuit mode.

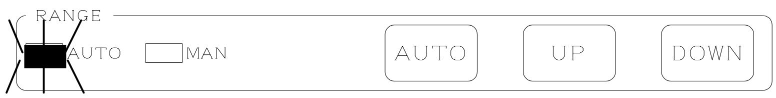
The equivalent circuits mode of the 3525 changes when [CIR] is pressed. The active equivalent circuits mode changes sequentially:

AUTO→SER→PRL→AUTO…

Confirmed the instruments equivalent circuits mode by inspecting the LEDs to the left of the [CIR] key.

Setting the Measurement Range

The 3525 has 10 measurement ranges. The ranges can be set in either AUTO or MANUAL range. Select either AUTO or MANUAL range by depressing the [AUTO] key, which toggles between the two ranges. The active range mode LED will illuminate.



In AUTO range, the instrument selects the measurement range automatically. AUTO range is most suitable for measuring DUTs with unknown levels of impedance.

In MANUAL range, the ranges are selected by pressing the [UP] and [DOWN] keys. The range number will be displayed temporarily on DISPLAY B when the range selection is changed from AUTO to MAN, and whenever the [UP] or [DOWN] keys are pressed.

Use of the MANUAL ranges is best for measuring DUTs with known levels of impedance. It is also recommended that MANUAL ranging be used in production tests where the impedance, |Z| of the DUT lies on the outer limits of a range. Testing in MANUAL mode prevents the instrument from switching between two ranges, thus affecting the accuracy of the measurement. The measurement speed in MANUAL mode is also faster than in AUTO range.

As mentioned, the measurement ranges are determined according to the impedance of the DUT. The relationship between DUT impedance and range is indicated below.

Table 4.3: Measurement Range Characteristics

Range No.	|Z| Measurement Range
1	0.0100Ω ~ 0.1999Ω
2	0.1800Ω ~ 1.9999Ω
3	1.800Ω ~ 19.999Ω
4	20.00Ω ~ 199.99Ω
5	0.2000kΩ ~ 1.9999kΩ
6	2.000kΩ ~ 19.999kΩ
7	20.00kΩ ~ 199.99kΩ
8	0.1800MΩ ~ 1.9999MΩ
9	2.000MΩ ~ 19.999MΩ
10	180.0MΩ ~ 199.99MΩ

Setting the Measurement Range cont'd:

When measuring inductance (L), and capacitance (C), the following formulas are used to find the DUT impedance and select the range.

For measuring inductance (L), and D≈0, impedance, |Z| is as calculated with the following formula:

$$\textbf{For } D\approx 0;\ X_L = |Z| = 2\Pi f L$$

Where:
- D =Dissipation Factor=1/Q
- X_L =Inductive Reactance
- |Z| =Absolute Impedance
- Π = Pi (3.141592654)
- f =Test Frequency
- L =Inductance

When measuring capacitance (C), and D≈0, impedance, |Z| is as calculated with the following formula:

$$\textbf{For } D\approx 0;\ X_C = |Z| = \frac{1}{2\Pi f C}$$

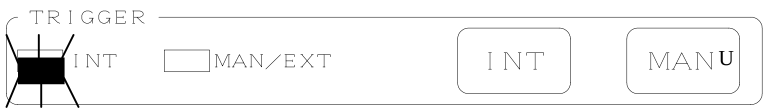
Where:
- D =Dissipation Factor=1/Q
- X_C =Capacitive Reactance
- |Z| =Absolute Impedance
- Π = Pi (3.141592654)
- f =Test Frequency
- C =Capacitance

Setting the Trigger Mode

The Model 3525 may be programmed for INTERNAL or EXTERNAL Trigger Operation.

> **Internal Trigger** [INT]: 3525 triggers automatically for continuous measurement.
> **External Trigger** [MANU]: Measurement starts with RS232, GPIB, Control I/O or front panel trigger.

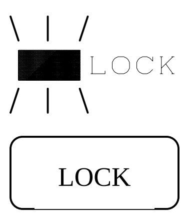
To select INTERNAL trigger, press the [INT] key. To set an EXTERNAL trigger, press the [MANU] key. The active trigger mode can be confirmed by the indicating LED on the left.



Setting the Key Lock

The key lock feature is designed to prevent a user from accidentally changing the instrument settings. This is done by disabling all of the front panel keys except for the [MANU], or manual trigger key and the [LOCK] key.

Enable or disable the LOCK feature by pressing the [LOCK] key. Note the status LED located above the [LOCK] key. The LOCK feature is enabled when this LED is lit.



Using the Comparator Functions

Overview

The 3525 has an internal comparator function that is capable of evaluating the measurements of DISPLAY A, DISPLAY B, or the combination of both. This is achieved by providing the user with the option of disabling or enabling DISPLAY A and/or DISPLAY B. Table 4.4 summarizes comparator operation.

Table 4.4: Operation of GO/NO-GO Comparator

DISPLAY A	DISPLAY B	RESULTING FUNCTION
Enabled	Enabled	Comparator Judgment is based on meeting the GO requirements of both DISPLAY A and DISPLAY B. If the conditions are not met, a NO-GO state will result.
Enabled	Disabled	Comparator Judgment is based on the measurement results of DISPLAY A only.
Disabled	Enabled	Comparator Judgment is based on the measurement results of DISPLAY B only.
Disabled	Disabled	Comparator feature is disabled.

During comparator operation, the measurements of each display are evaluated according to the user-defined HIGH and LOW limits. The end result is indicated by the comparator status LEDs in the Judgment section of the front panel. Respective output conditions can also be obtained from the Control I/O Connector in the instrument's rear panel or heard with the 3525's audible beeper. More information on the audible beeper and Control I/O connector can be found later in this chapter.

Setting the High and Low Limit Values

The following procedure should be followed to set the comparator HI and LOW limits:

1. Define the high or low limit value
2. Enable or disable DISPLAY A (If disabled, go to step 6)
3. Set numerical values for DISPLAY A
4. Set the decimal point for DISPLAY A
5. Set the units of measure for DISPLAY A
6. Enable or disable DISPLAY B (If disabled, go to step 8)
7. Set numerical values and decimal point for DISPLAY B
8. Complete the setting by pressing the [ENTER] key.
9. Enabling the Comparator

The measurement function cannot be changed while the comparator switch is turned ON. In order to change the measurement function, the comparator switch must be turned OFF first.

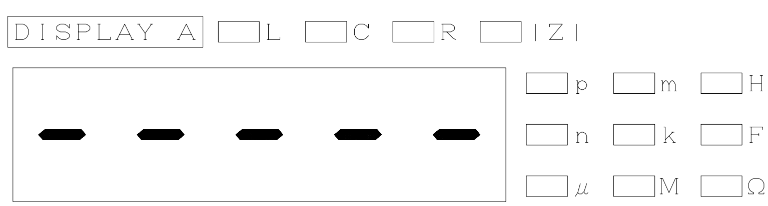
NOTE: Comparator Settings are kept in non-volatile memory and will be retained if the instrument's power is cycled.

1. Define the high or low limit value

To set the high value limit, press [HIGH]
To set the low value limit, press [LOW]

2. Enable or Disable DISPLAY A

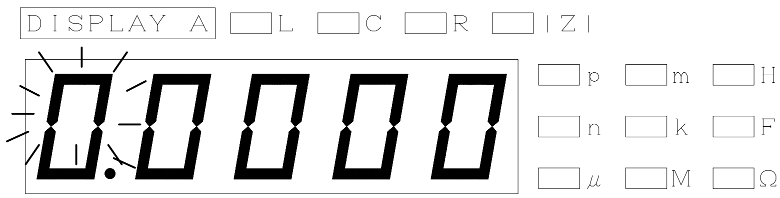
Press the [ON] key to enable or disable DISPLAY A's comparator function. The initial factory default setting is "OFF" If DISPLAY A is disabled, the display will appear as follows:



Setting the High and Low Limit Values cont'd:

2. Enable or Disable DISPLAY A cont'd:

Press the [ON] key until five digits appear across the LED display. This means that DISPLAY A is enabled. The fifth significant digit will blink to indicate that the DISPLAY A comparator is enabled and the instrument is ready to receive numerical data. The numerical data will define either the high or low comparator set point depending on what was selected in step #1.



The illustration above indicates that no previous comparator set points have been entered into the instrument and that the comparator is at factory default values. Normally, you would see the zeros replaced by an actual value.

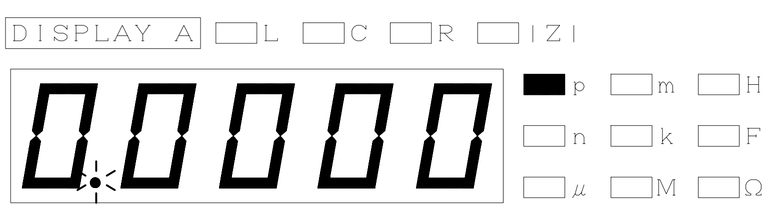
3. Setting Numerical Values for DISPLAY A

If DISPLAY A programming is enabled, a numerical value, a decimal point and unit of measure can be entered. The blinking digit is the active digit that can be changed. In order to select the active digit, move the cursor to the left or the right by using the [►] or [◄] keys. To change the value of an active digit, use the [▲] or [▼] keys to increase or decrease the value.

NOTE: The fifth significant digit can only be programmed with a "0" or "1" value. All others may be programmed from "0"-"9".

4. Setting the Decimal Point for DISPLAY A

Once all of the digit values have been entered, press the [►] key until the cursor reaches the least significant digit of the display. Pressing the [►] key once more will cause the decimal point to blink. Position the decimal point by pressing the [▲] or [▼] keys.



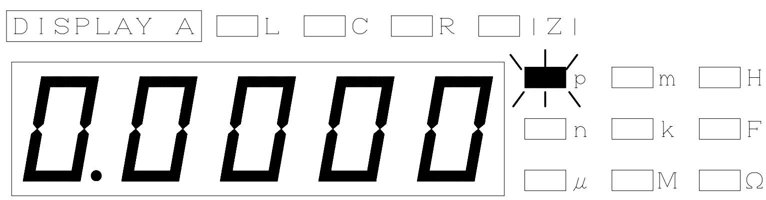
The illustration above shows the display's appearance if the instrument is at factory default settings. The actual appearance and position of the decimal point may differ for each instrument.

Setting the High and Low Limit Values cont'd:

5. Setting the Units of Measure for DISPLAY A

After the decimal point position is set, press the [►] again to define the units of measure for DISPLAY A. Pressing the [▲] or [▼] keys will step through each of the units of measure for DISPLAY A. The active unit will be indicated with an illuminated LED located to the right of the display. The active of units of measure will scroll with each press of the [▲] key as shown below:

p → n → µ → m → (blank) → k → M → p ...



6. Enable or Disable DISPLAY B

After the units of measure have been selected and confirmed, press the [►] key to jump to DISPLAY B setup. Like DISPLAY A, if DISPLAY B is off then the panel will display "- - - - -". If it is ON, a numeric value will be displayed. You can press the [ON] key to toggle between enabling or disabling DISPLAY B.

7. Set Numerical Values and Decimal Point for DISPLAY B

If DISPLAY B is enabled, values and decimal points can be set in the same way as they are for DISPLAY A. For details, refer to steps 3 & 4 of this procedure. This is the last step for setup of the DISPLAY B comparator. There is no need to select units for DISPLAY B, since there is only one unit per measurement parameter.

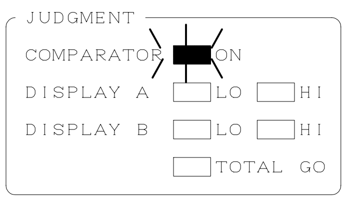
8. Complete the Setup

Press the [ENTER] key to finalize the comparator setup. The instrument will return to normal operating mode. Note that the comparator will not operate until it is enabled.

Setting the High and Low Limit Values cont'd:

9. Enabling the Comparator

The comparator will not function until it is enabled. This is done by simply pressing the [ON] key. The "COMPARATOR ON" LED will indicate the status of comparator operation.



Preset Panel Function

Overview

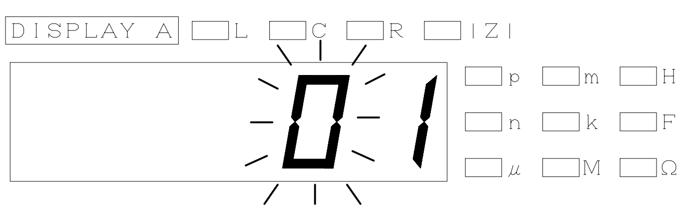
The 3525 is capable of storing up to 99 different measurement settings into memory. A stored measurement setting is referred to as a "panel". Panel numbers 01 through 99 are used to designate each of the 3525 preset panels.

NOTE: Beeper settings are not saved in the panel setting.

Setting Panel Numbers.

First, press [PAN]. The current panel number will be shown on DISPLAY A with the 1st digit flashing. Use the [►] or [◄] keys to select which digit to edit and the [▲] or [▼] keys to increment or decrement the digit value. Once the desired panel number is selected, press the [ENTER] key. This will store the instrument's current settings into this memory location.

You can abort the panel-programming mode by simply shutting the power off before changing the panel number. The instrument will retain the last panel setting prior to editing mode.



Recalling Panel Numbers

The instrument determines whether to save or recall a panel setting based on the user's actions. If no parameter key on the front panel has been pressed and the [PAN] key is pressed, the instrument will recall the selected panel number. If any of the parameter keys have been changed prior to the [PAN] key being pressed, then the instrument will store the current settings into the designated panel location (01-99).

NOTE: If the power is cycled, on power up, the instrument will return to its last setup state before the power was shut off.

Zero Correction

<u>Overview</u>

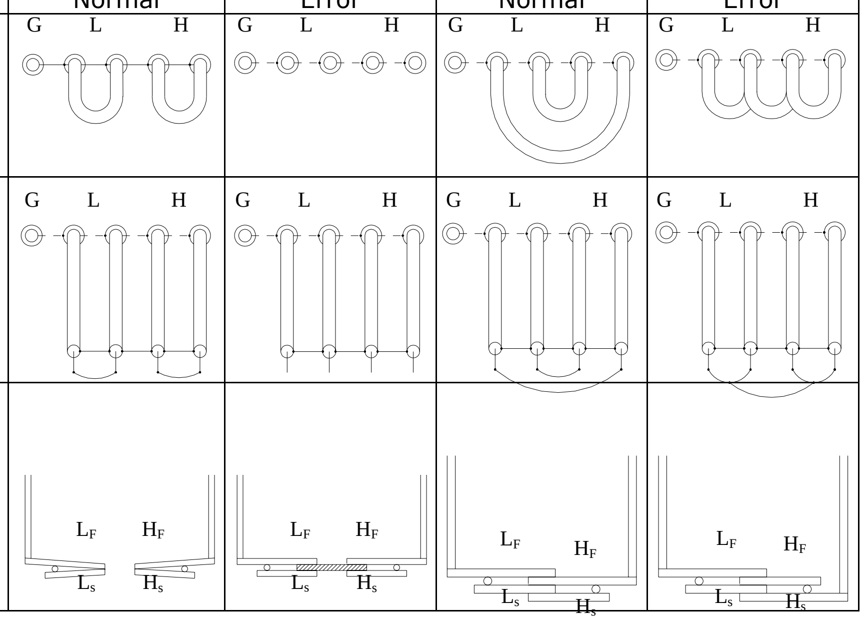
Performing a zero correction procedure compensates for parasitic impedance in test adaptors and measurement cables. There are two types of zero corrections that are performed, open circuit correction and short circuit correction. "Open correction" is used to compensate for leakage capacitance and conductance, while "short correction" is used to compensate for series inductance and resistance.

Compensating for parasitic impedance in the measurement cables and fixtures will increase measurement accuracy and is recommended for all measurements. The 3525 memorizes the zero correction data for each panel. Whenever a panel number is changed, make sure that zero correction is performed again.

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 4.3: Terminal Connections for Zero Correction

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



Use the Figure 4.3 as a reference when performing short circuit and open circuit zero corrections.

Zero Correction cont'd:

Open Circuit Correction

Open circuit correction compensates for capacitance and conductance leakage errors in the measurement cables.

Perform the open-circuit correction procedure as follows:

1. Open the Low (L) and High (H) side measurement terminals.[1]
2. Press [OPEN] to carry out open correction.
3. The correction will be completed when the machine returns to its initial measurement condition.

[1] *"Open" State*
The "open" state of the measurement terminals means that L_{FORCE} and L_{SENSE} are connected, and H_{FORCE} and H_{SENSE} are connected however, there is no connection between the L and H sides. Make the distance between the L side and the H side positions as close to the actual measurement position as possible. This will improve measurement accuracy.

Verify the improvement of an open-circuit correction by taking measurement of a known capacitor before and after the zero correction process. If there is no improvement review your process and check to make sure the cables are connected properly.

Short Circuit Correction

The short circuit correction procedure compensates for the series effect of residual inductance and resistance as found in the test cables.

Perform the short-circuit correction procedure as follows:

1. Short the Low (L) and High (H) side measurement terminals.[2]
2. Press the [SHORT] key to begin short correction.
3. The correction will be completed when the machine returns to measurement mode.

[2]Short "State"
The short state of the measurement terminals is when L_{FORCE}, L_{SENSE}, H_{FORCE}, H_{SENS} are all connected. When connecting the terminals with a cable, make sure to choose one with as low impedance as possible. Cable positioning can affect measurement accuracy. Keep the positioning of the measurement cables as close to the actual measurement conditions as possible. Also be sure to keep hands and metal objects away from the measurement cables as they can affect a measurement's accuracy.

Verify the improvement of a short-circuit correction by taking measurement of a known impedance before and after the zero correction process. If there is no improvement review your process and check to make sure the cables are connected properly.

Audible Beeper

Overview
The 3525 has an audible beeper that may be set to one of three conditions:

1. OFF Condition
2. Indicate on TOTAL-GO
3. Indicate on TOTAL-NO-GO

The factory default setting is for the beeper to sound upon TOTAL-NO-GO.

When there is a power outage, or if the power plug is disconnected, the machine will return to the settings that existed before the POWER switch was last turned off.

Setting the Beep Sound

Beeper Off – Disable the audible beeper by following the instructions below:

1. Push [POWER] to turn off the power.
2. Push and hold the [SPD] key and then depress the [POWER] key. Wait until you hear three short beeps before releasing the [SPD] key. This will disable the audible beeper.

Beeper Indicate TOTAL GO - The beeper will sound when a TOTAL-GO condition is met with the comparator. Follow the steps below to set this function:

1. Push [POWER] to turn off the power.
2. Push and hold the [A] key and then depress the [POWER] key. Wait until you hear three short beeps before releasing the [A] key. The beeper will sound when a TOTAL-GO condition is met.

Beeper Indicate TOTAL NO-GO – The beeper will sound when a NO-GO condition is met by the comparator. Follow the steps below to set this operation:

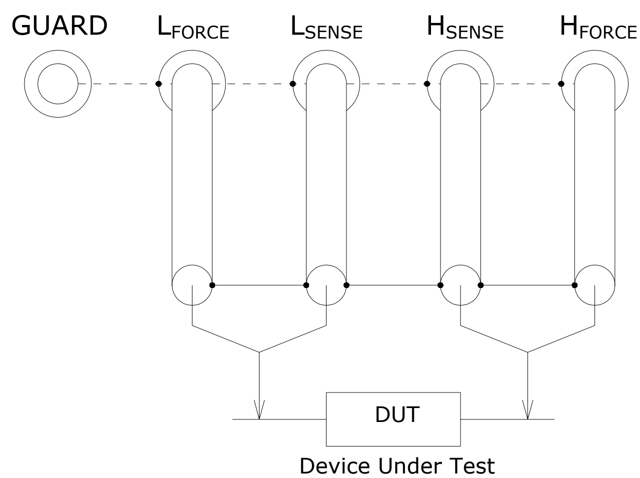
1. Push [POWER] to turn off the power.
2. Push and hold the [B] key and then depress the [POWER] key. Wait until you hear three short beeps before releasing the [B] key. The beeper will sound when a TOTAL NO-GO comparator condition is met.

Connection Methods:

To maintain optimal measurement accuracy, the connection to a DUT (device under test) must be suitable for its impedance. Generally speaking, DUTs with high impedance will use either a 3-terminal or 5-terminal connection. Low impedance DUTs should use a 5-terminal connection.

As a rule of thumb, use 5 terminal connections for measurement ranges 1 through 5. For ranges 6 through 10, use either a 3-terminal or 5-terminal connection.

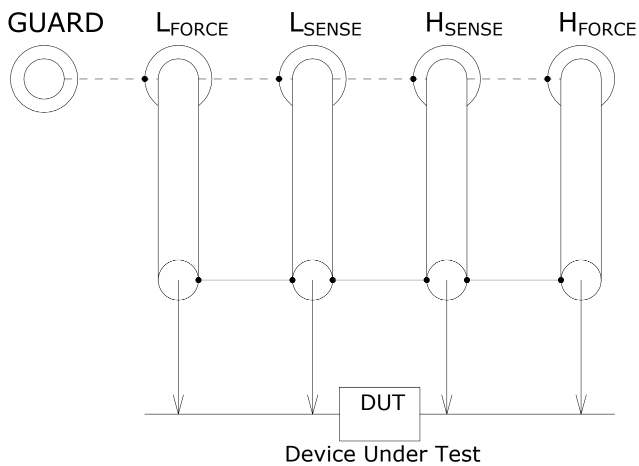
Figure 4.4: 3-Terminal Connection



3-Terminal connections should be used for test pieces with high impedance. The advantage to 3-terminal connections is that stray capacitance and stray conductance between lead cables and other nearby conductors is eliminated.

Connection Methods cont'd:

Figure 4.5: 5-Terminal Connection



The 5-Terminal connection is the best method for low and high impedance measurements and should be used as the default measurement method. It eliminates stray capacitance and conductance between the test cables and other external conductors while bypassing series inductance and resistance of the test leads by placing the source and sense leads directly at the point of measurement.

Adding a GUARD connection to either the 3-Terminal or 5-Terminal connections will improve measurement accuracy and performance by eliminating external noise or stray paths. Use a GUARD connection whenever possible.

Interfacing to the 3525

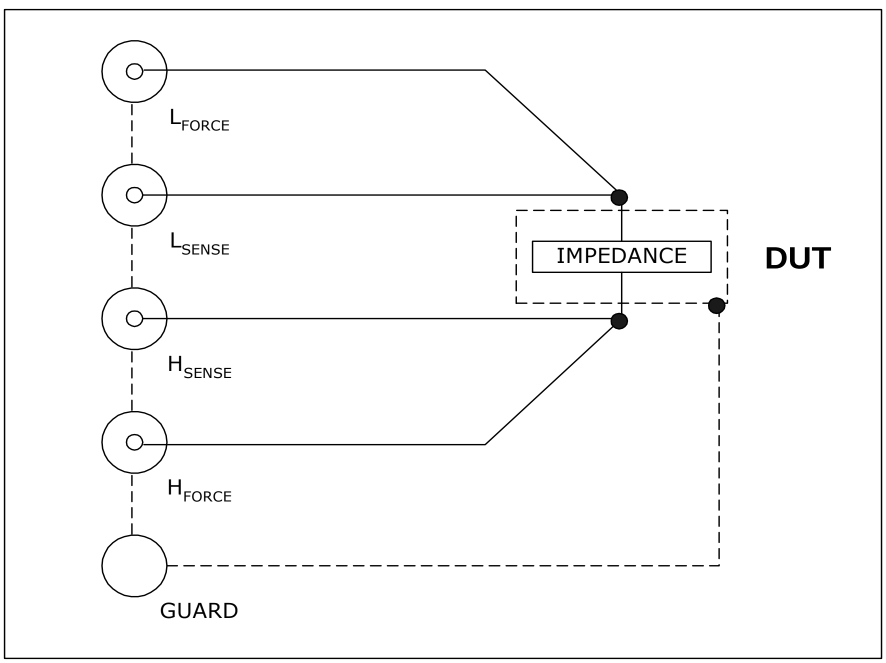
This section provides detailed information about the Model 3525's electrical interfaces and their functionality. It will provide all of the necessary information required to integrate the 3525 easily into a working test stand. The 3525 is shipped from the factory with a standard RS-232C communications port and a Control I/O output. A GPIB (IEEE-488.2) Interface is available and may be purchased as an optional accessory.

Front Panel Connections

The Model 3525 uses four-wire, Kelvin type connections to make impedance measurements. It does this by measuring the phase difference between the measured voltage and current. Secondary parameters such as capacitance, inductance, dissipation factor, etc. are then calculated from these measured values.

Kelvin connections are available from the instrument's front panel as 4 BNC and one GUARD terminal. Two source leads, which send the bipolar test current through the DUT, two voltage sense leads that detect the voltage drop across the DUT, and a shield or guard connection for protection against external electrical interference. The orientation of the front panel BNC connectors is illustrated below:

Figure 5.1: Front Panel Measurement Connections



NOTES:

- For maximum repeatability of measurements take special care in assuring proper contact to the DUT when taking measurements.
- The GUARD terminal is electrically connected to the BNC shield connections.

Rear Panel

RS-232C and the I/O Control Connector are standard interfaces of the Model 3525. Their connectors are located in the rear panel of the unit. If the optional GPIB interface was purchased with the 3525, it will be located in the slot above the RS-232C & I/O Control Connectors.

Figure 5.2: Rear Panel Interfaces

Model 3501 GPIB Interface

Model 3502 BCD Interface

3502 - BCD Board

The BCD board is used when controlling 3525 by a sequencer, I/O of a PC or PLC.
The inputs and outputs of the 3502 are not optically isolated.
Required output voltage is +5V, and input levels can range from +5V~+24V.

The following inputs and outputs are available from the Model 3502, BCD Interface:

Inputs	Outputs
Function A	Measurement Status
Function B	Display A Data
Range	Display B Data
Buzzer	Circuit Mode
Frequency	Range Status
Level	Range Number
Circuit MODE	
Zero OPEN	
Zero SHORT	

I/O Control Connector

The I/O Control Connector provides active-low, TTL interfaces for the following functions:

- Comparator State
- Busy Signal Output
- End of Measurement Output
- External Trigger Input
- Panel Number Inputs

Compatible Connectors

The following connectors are compatible with the TEGAM 3525 I/O Connector. Other compatible connectors may also be used.

Manufacturer	Part Number
TEGAM, Inc.	15738
Honda Tsushin Kogyo	ADS-HC360001-010

I/O Pin Outputs

Figure 5.3: I/O Control Connector Pin Orientation

I/O Pin Outputs cont'd

Table 5.1: Pin Designations

Pin No.	I/O	Signal No.	Pin No.	I/O	Signal No.
1	IN	START	19	IN	PANEL 10^0-2^0
2	IN	PANEL10^0-2^1	20	IN	PANEL 10^0-2^2
3	IN	PANEL10^0-2^3	21	IN	PANEL 10^1-2^0
4	IN	PANEL10^1-2^1	22	IN	PANEL 10^1-2^2
5	IN	PANEL10^1-2^3	23	OUT	DISP-A HI
6	OUT	DISP-A GO	24	OUT	DISP-A LO
7	OUT	DISP-B HI	25	OUT	DISP-B GO
8	OUT	DISP-B LO	26	OUT	TOTAL GO
9	OUT	BUSY	27	OUT	END
10	IN	TRIGGER PANEL/EXT	28	OUT	TOTAL NO-GO
11~14	IN	EXT VCC	29~32	OUT	INT VCC
15~18	IN	EXT GND	33~36	OUT	INT GND

I/O Control Pin Descriptions

The input/output signals through the I/O Control Connector are all "negative logic" (active low) TTL level signals, except for the power source signal.

(PIN 1) START
When the Trigger Mode is MAN/EXT, measurement will be initiated when a high to low pulse is received.

(PINS: 19, 2, 20, & 3) PANEL10^0-2^0, PANEL10^0-2^1, PANEL10^0-2^2, PANEL10^0-2^3
These active low signals determine the one's digit of the panel number to be measured.

(PINS: 21, 4, 22, & 5) PANEL10^1-2^0, PANEL10^1-2^1, PANEL10^1-2^2, PANEL10^1-2^3
These active low, signals determine the ten's digit of the panel number to be measured.

I/O Pin Outputs cont'd

Table 5.2: BCD Panel Settings

BCD	10's digit				1's digit			
	PANEL 10^1-2^3	PANEL 10^1-2^2	PANEL 10^1-2^1	PANEL 10^1-2^0	PANEL 10^1-2^3	PANEL 10^1-2^2	PANEL 10^1-2^1	PANEL 10^1-2^0
0	1	1	1	1	1	1	1	1
1	1	1	1	0	1	1	1	0
2	1	1	0	1	1	1	0	1
3	1	1	0	0	1	1	0	0
4	1	0	1	1	1	0	1	1
5	1	0	1	0	1	0	1	0
6	1	0	0	1	1	0	0	1
7	1	0	0	0	1	0	0	0
8	0	1	1	1	0	1	1	1
9	0	1	1	0	0	1	1	0

Example: To set a panel number of 36, set 1100 1001.
10's 1's

(PINS: 23, 6, & 24) DISP-A HI, DISP-A GO, DISP-A LO
This outputs the Comparator's judgment to Display A. If the range does not match when measuring, both the DISP-A HI and the DISP-A LO signals will be LOW.

(PINS: 7, 25, & 8) DISP-B HI, DISP-B GO, DISP-B LO
This outputs the Comparator's judgment to Display B. If the range does not match when measuring, both the DISP-B HI and the DISP-B LO signals will be LOW.

(PIN: 26) TOTAL GO
The signal will be Low when the results of both DISPLAY A and DISPLAY B produce a GO judgment. If the Comparator is only ON for either DISPLAY A or DISPLAY B, then only the judgment result for the display that is ON will be outputted. If the Comparator is ON with no values in the Comparator, a Low signal will be outputted.
For the relationship between the TOTAL NO-GO and TOTAL GO signal, refer to the TOTAL NO-GO section.

(PIN: 9) BUSY
A Low signal will be outputted if the 3525 is in the process of measuring an analog signal.

(PIN: 27) END
A Low signal is outputted when the measurement is completed and a comparator state has been determined.

I/O Pin Outputs cont'd

(PIN: 10) TRIGGER PANEL/EXT
This input determines whether the front panel or external trigger will be enabled. If the signal is low, then the START signal, PIN 1 will be enabled. When the input is high then triggering can be executed from the front panel.

(PIN: 28) TOTAL NO-GO
The signal will be Low if either DISPLAY A or DISPLAY B produces a NO-GO judgment. If the Comparator is ON for only DISPLAY A or DISPLAY B, then the judgment result for the display that is on will be outputted.
Depending on the measurement condition, the TOTAL GO signal and the TOTAL NO-GO signal will change as follows. If measurement cannot be made due to a wrong measurement range, etc., an ERROR condition will occur.

Table 5.3: TOTAL GO & TOTAL NO-GO Functional Relationships

Output Signal	TOTAL GO Condition	TOTAL NO-GO Condition	ERROR Condition
TOTAL GO Output	0	1	0
TOTAL NO-GO Output	1	0	0

(PINS: 11~14 & 15~18) EXT VCC, EXT GND
These are the terminals for supplying power from an external source. By using these terminals, the 3525 and an external instrument can share a common supply. The power source voltage range is 5~24VDC.

The EXT VCC connections are connected directly to the anodes of each the 3525's optically isolated inputs (PANEL inputs, TRIGGER PANEL/EXT, & START) via a 470Ω resistor. The inputs become true when the PANEL inputs (pins 2~4, 19~22), START (pin 1), or TRIGGER PANEL EXT (pin10), terminals have a low (EXT GND) potential with respect to EXT VCC.

The EXT GND connections (pins 15~18) are tied directly to the emitters of the Comparator Outputs. A pull up resistor is required for each of the Comparator Outputs (pins 6~8, 23~26 & 28), BUSY LINE (pin 9) and END (pin 27). These outputs are low when the output condition is true.

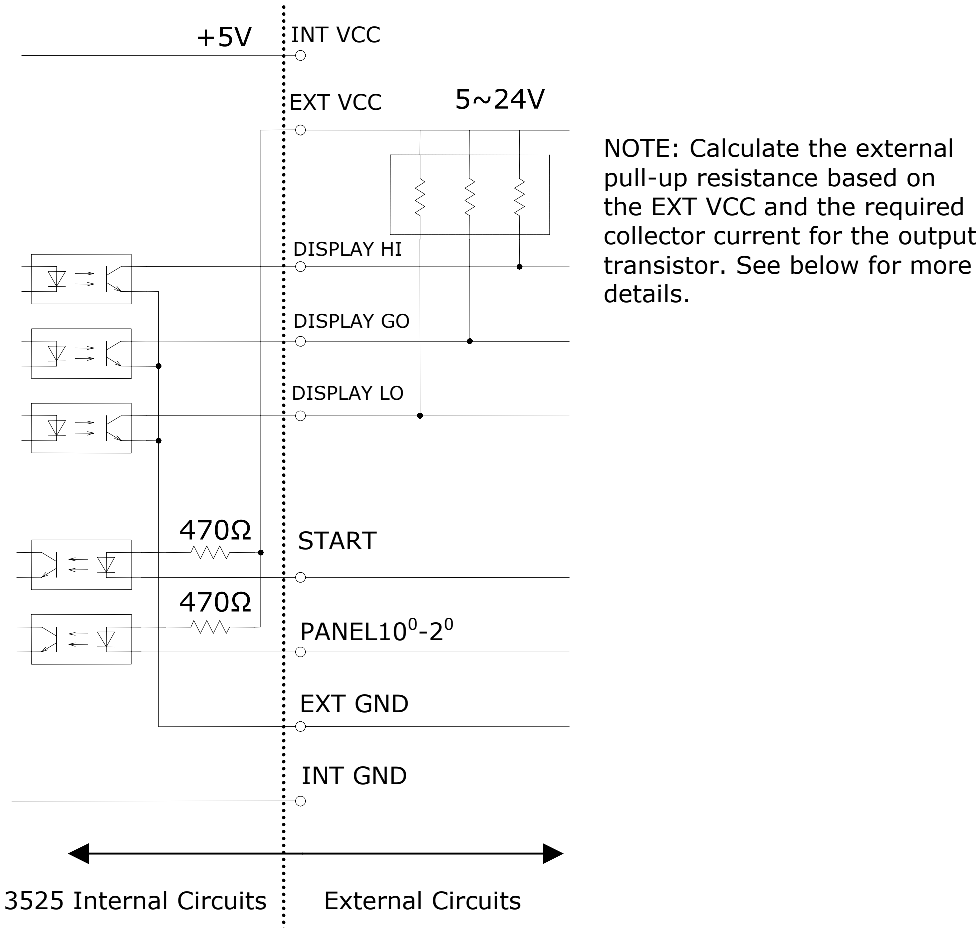
(PINS: 29~32 & 33~36) INT VCC, INT GND
The INT VCC terminal connects to the +5VDC supply of the 3525. The INT GND terminal connects to the GND of the 3525. These may be used for sourcing the I/O signals.

⚠

CAUTION: The maximum output current for INT VCC is 100mA. Do not exceed this limit or instrument damage may result.

I/O Connector Electrical Schematic

Figure 5.4: I/O Control Connector Schematic



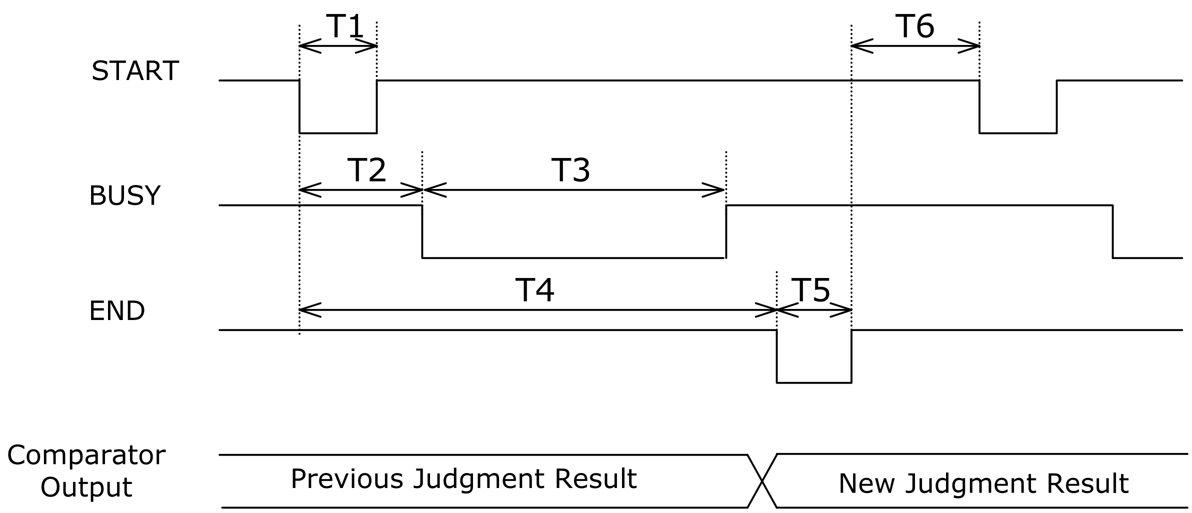
Caution

- The output side (transistor side) of the photo-coupler is of open-collector configuration and requires a pull-up resistor. The user must determine a resistance appropriate for the external (5~24VDC) or internal (5VDC) power source voltage. The acceptable collector current range for the output transistor is 1~10mA(50mA max). For example, if the supply voltage is +5VDC, use a 1kΩ resistor for pull-up to allow 5mA of current to flow through the output transistor.
- The input (photo LED) of the 3525's photo coupler has a 470Ω resistor in series with it. Thus, a source of +5VDC~+24VDC can be used. If a source of +24VDC is used, approximately 51mA of current will flow through the photo LED.
- Between INT VCC and INT GND, there is an output of +5VDC. The maximum output current of this supply is 100mA. Do not exceed this limitation otherwise damage to the equipment will result.
- INT GND is connected to the 3525’s grounded enclosure.
- If a +5VDC external source is being used, EXT VCC and INT VCC can be connected in parallel. EXT GND and INT GND can also be connected together.

I/O Timing Diagrams

Below is a timing diagram, which illustrates the functionality of the I/O Control Connector when the Trigger Mode is MAN/EXT, and the comparator is ON:

Figure 5.5: I/O Control Connector Timing Diagram



Approximate Measurement Times

Table 5.4: Approximate Measurement and Signal Processing Times

Interval	Description	Approximate Time
T1	Minimum Trigger Input Time	200µs
T2	Maximum START to BUSY signal time	350µs
T3	Minimum Analog signal measurement time.	13ms
T4	Minimum Total Measurement Time (Including calculation + comparator time)	15ms
T5	Minimum END signal Time	1.6ms
T6	Minimum time from END to next Trigger	0s

NOTE: T3 and T4 will vary due to measurement speed and frequency.
The times indicated above are for 1kHz test frequency, and the FAST mode.

Approximate Measurement Times cont'd

Analog Signal Measurement Time

The analog signal measurement time will vary according to the measurement frequency and the measurement speed, as indicated below:

Table 5.5a: Analog Signal Measurement Time

	FAST	NORM	SLOW
1kHz	13ms	48ms	248ms
120Hz	38ms	88ms	358ms

Measurement Speed

This is the time taken for an entire measurement cycle. Measurement time varies according to measurement frequency and measurement speed, and includes calculation of the measured value and comparator-processing times as indicated below:

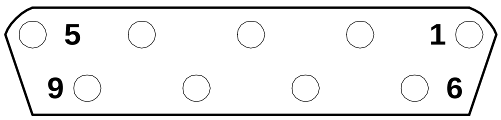
Table 5.5b: Total Measurement Speed

	FAST	NORM	SLOW
1kHz	15ms	50ms	250ms
120Hz	40ms	90ms	360ms

RS-232C Communications

The 3525 is designed with a DTE-type (Data Terminal Equipment) port, so when connecting to a PC etc., a cross cable must be used. The pin numbers and signal designations are as follows:

Figure 5.6: RS-232C Connector



Rear Panel View

Table 5.6: RS-232C DTE Pin Configurations

Pin No.	Signal Name	Name
1		Not used
2	RxD	Receive Data
3	TxD	Transmit Data
4	DTR	Data Terminal Ready
5	SG	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9		Not used

RS-232C Communication cont'd

RS-232C Settings

The Model 3525 comes from the factory preset with the RS-232C protocol. These settings are not user-definable.

Handshake	Hardware
Baud rate	9600 BPS
Data Bits	8
Stop Bits	1
Parity	None
Delimiter	CR+LF

⚠ Caution

- To reduce the risk of electrical shock or damage to the instrument, always turn the power OFF before connecting or disconnecting the RS-232C connector.
- Do not short-circuit the connector or input voltage. This can cause the instrument to malfunction.

Remote Commands

Program Messages

Control commands consist of headers and parameters.

The following example is a command message used to set the measurement frequency to 1kHz:

The header may be typed in abbreviated or non-abbreviated form. The non-abbreviated form makes the program code easier to understand. Using the abbreviated form allows faster execution of the program. In this section, the abbreviated form is displayed in CAPITAL letters, while the remainder of the command is in lower-case letters. The program will accept capitals or lower case.

The Header

There are two types of headers:

- ***Standard Headers*** - One-word headers starting with an alphabet letter (Such as FREQ)
- ***Special Headers*** - Headers that indicate they are shared commands, starting with an asterisk. (Such as *RST)

The Parameter

There are two types of parameters:

- ***Letter Data*** - This data always starts with alphabet letters, and consists of alphabet letters and numbers. The letters can be either capitals or lower-case. However, the response message from the computer will always be in caps.

- ***Numerical Data*** - Numerical data may be typed in three different formats. Integer, Decimal or Scientific Notation. +/- symbols are not required in any of these formats.

Numerical Format	Example
Integer	+15, -65, 52
Decimal	+1.54, -85.32, 1.234
Scientific Notation	+1E+3, -1.25E-6

Remote Commands cont'd:

Rules for Remote Commands

1. Commands are not case-sensitive
   Example) "PAN 10" = "pan 10"

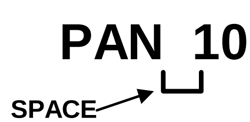
2. Abbreviated commands are valid. The capital letter portion of the command (as seen in the reference chart) is the abbreviation.
   Example) "PANel 10" = "PAN 10"

3. For output request commands, (queries) attach a question mark after the command.
   Example) "PAN?"

4. In order to send several commands in one data string, separate the commands by semi-colons (;).
   Example) "PAN 10;LEV 1"

Rules for Commands and Parameters

1. Put a space in between commands and parameters



2. For commands that use numerical data as their parameter, prefixes can be attached.

Scientific Notation Equivalent	International System Equivalent	Equivalent Program Mnemonic
1E9	G	G
1E6	M	MA
1E3	k	K
1E-3	m	M
1E-6	µ	U
1E-9	n	N
1E-12	p	P

Remote Commands cont'd:

Condition & State Registers

The 3525 has five 8-bit registers. The condition of the 3525 can be determined by reading the state these registers.

The contents of the condition and state registers are reset in the following situations:

- When the "*CLS" command is executed.
- During the initial power ON cycle.

1) The Standard Event Status Register (SESR)

Power on	Not used	Command error	Not used	Device error	Not used	Not used	Operation complete
7	6	5	4	3	2	1	0

Bit	Bit Weight	Description
7	128	Power ON (PON) Bit Becomes "1" when power turns off, then on again
6	64	Not used (always "0")
5	32	Command Error (CME) Bit Becomes "1" when the command changes.
4	16	Not used (Always "0")
3	8	Device Error (DDE) Bit Becomes "1" when a command error occurs.
2	4	Not used (always "0")
1	2	Not used (always "0")
0	1	Operation Complete (OPC) Bit Becomes "1" when processing of a command is complete.

Remote Commands cont'd:

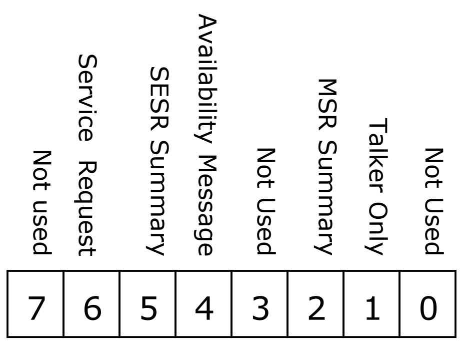
<u>Condition & State Registers:</u>

2) The Standard Event Status Enable Register (SESER)

The purpose of this register is to change Bit 5 of the Status Byte Register (SBR) to "ENABLE".
Bit 5 of the SBR is the logical (OR) of each bit with the logical sum (AND) of SESR and SESER.
As a result of this, the composition of the bit becomes the same as SESR.

For any bit that is set as ”1”, whenever the event designated for that bit occurs, Bit 5 of the SBR becomes "1".
The *ESE command is used to set up the SESER.

3) Status Byte Register (SBR)



Bit	Bit Weight	Description
7	128	Not used (always "0")
6	64	Service Request (RQS) Bit Becomes "1" when the SRQ line is made Low, and is cleared when serial poll is run.
5	32	SESR(Standard Event Status Register)Summary Becomes "1" if any of the valid bits on the SESR becomes "1". When all bits of the SESR become "0", this bit is cleared. (This bit is not cleared during serial poll run)
4	16	Message Available(MAV) Bit Becomes "1" every time an output data is available to the device. This bit is cleared whenever its data is read. (This bit is not cleared during serial poll run)
3	8	Not used (always "0")
2	4	MSR Summary Bit. Becomes "1" when any bit other than the Measurement END bit becomes "1".
1	2	Talker Only Bit: Becomes "1" during Talker Only Mode.
0	1	Not used (always "0")

To read the Status Byte Register, run a serial poll, or read the register using the “*STB” command.

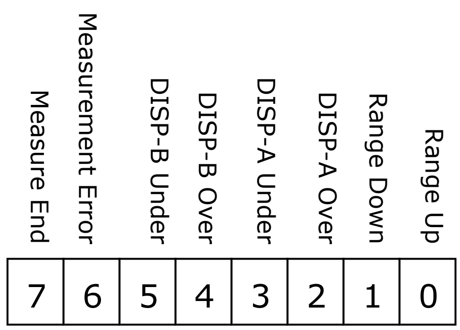
Remote Commands cont'd:

Condition & State Registers:

4) Service Request Enable Register (SRER)

This is a register for setting valid bits on the Status Byte Register (SBR).
Whenever any of the valid bits of the SBR become "1", a service request (SRQ) occurs. Each of the bits of this register corresponds to the bits of the SBR.
If any bit on the SRER is set to "1", then the corresponding bit on the SBR will be able to request service. In order to change the settings of the SRER, use the command "*SRE".

5) Measure Status Register



Bit	Bit Weight	Details
7	128	Measurement End Bit Becomes "1" when 1 measurement ends
6	64	Measurement Error Bit Becomes "1" when a measurement error occurs
5	32	DISP-B Under Bit Becomes "1" when the measured value on Display B becomes smaller than the displayed range.
4	16	DISP-B Over Bit Becomes "1" when the measured value on Display B becomes larger than the displayed range.
3	8	DISP-A Under Bit Becomes "1" when the measured value on Display A becomes smaller than the displayed range.
2	4	DISP-A Over Bit Becomes "1" when the measured value on Display A becomes smaller than the displayed range.
1	2	Range Down Bit Becomes "1" when the measurement range is not suitable and needs to be lowered.
0	1	Range Up Bit Becomes "1" when the measurement range is not suitable and needs to be raised.

Remote Commands cont'd:

Commands List

The commands that can be used on the 3525 are as follows. For detailed explanations of each command, please refer to the command reference list.

Table 5.7: RS-232C & GPIB Command Set

Command	Description
*CLS	Clears the 5 registers
*ESE(?)	Sets or queries the SESER
*ESR?	Queries the SESER
*IDN?	Queries the version and other ID info
*RST	Resets the device
*SRE(?)	Sets or queries the SRER
*STB?	Queries the SBR
*TRG	Triggers one measurement
*WAI	Runs all commands up to the previous command
BEEP(?) <OFF, GO, NG>	Sets the beep
COMParator(?) <ON, OFF>	Sets or queries the On/Off of the Comparator
COMParator:A	Makes Comparator have Display A mode
COMParator:A:HIGH(?) <value>	Sets or queries High limit of Display A
COMParator:A:HIGH:IGNO(?) <ON, OFF>	Sets or invalidates High Limit of Display A
COMParator:A:LOW(?) <value>	Sets or queries Low limit of Display A
COMParator:A:LOW:IGNO(?) <ON, OFF>	Sets or invalidates Low Limit of Display A
COMParator:B:HIGH(?) <value>	Sets or queries High limit of Display B
COMParator:B:HIGH:IGNO(?) <ON, OFF>	Sets or invalidates High Limit of Display B
COMParator:B:LOW(?) <value>	Sets or queries Low limit of Display B
COMParator:B:LOW:IGNO(?) <ON, OFF>	Sets or invalidates Low Limit of Display B
CORR	Starts Correction Mode
CORR:OPEN ON	Runs Open Correction
CORR:SHORt ON	Runs Short Correction
FUNCtion	Starts Measurement Mode
FUNCtion:A	Starts Display A Setting Mode
FUNCtion:A:Type(?) <L, C, R, Z>	Sets or queries Display A measurement items
FUNCtion:B	Starts Display B Setting Mode
FUNCtion:B:Type(?) <D,Q,SE,V,I>	Sets or queries Display B measurement items
FUNCtion:CIRCuit(?) <AUTO, SER, PRL>	Sets or queries equivalent circuits mode
FUNCtion:FREQuency(?) <120Hz, 1000Hz>	Sets or queries Measurement Frequency
FUNCtion:LEVel(?) <1V, 500mV, 50mV>	Sets or queries Measurement Signal Level
FUNCtion:RANGe(?) <AUTO, 1 10>	Sets or queries Measurement Range
MEASure?	Measures 1 time and outputs data
OUTPut(?) <OFF, RS232C, GPIB, ALL>	Designates data output destination.
PANel(?) <1 99>	Sets or queries Panel No.
READ?	Queries previous measurement value
SPEed(?) <FAST, NORM, SLOW>	Sets or queries Measurement Speed
TRS(?) <INT, MAN>	Sets or queries Trigger Mode

Remote Commands cont'd:

Command Reference

*CLS
The CLS command clears the 5 Condition & State registers (SESR, SESER, SRE, SBR, MSR).

Syntax: *CLS

Example: PRINT #1;"*CLS"

This command has no query.

---

*ESE
The ESE command sets up the Standard Event Status Enable Register(SESER). The query returns the current Standard Event Status Enable Register(SESER).

Syntax: *ESE <Format1>
<Format1> → 0~255

Example: PRINT #1,"*ESE 1"

Query Syntax: *ESE?

Output Format: <Format1><END>
<Format1> → 0~255

Example:
```
10 PRINT #1,"*ESE?"
20 INPUT #1,A
30 PRINT A
40 END
```

Remote Commands cont'd:

Command Reference

*ESR

The ESR Query returns the current Standard Event Status Register (SESR) value.
This command is query only.

Query Syntax: *ESR?

Output Format: <Format1><END>
<Format1> → 0~255

Example:

```
10 PRINT #1,"*ESR?"
20 INPUT #1,A
30 PRINT A
40 END
```

---

*IDN

The IDN Query returns the maker, product number, and software version.
This command is query only.

Query Syntax: *IDN?

Output Format: <TEGAM Inc., 3525,Ver.1.00,2000.05.12><END>

The software version may cause this output to vary.

Example:

```
10 PRINT #1,"*IDN?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

*RST

The RST command restores the settings of the 3525 to the ex-factory settings.

Syntax: *RST

Example: PRINT #1;"*RST"

This command has no query.

---

*SRE

The SRE command sets the Service Request Enable Register(SRER). The query returns the current Service Request Enable Register (SRER).

Syntax: *SRE <Format1>
<Format1> → 0~255

Example: PRINT #1,"*SRE 64"

Query Syntax: *ESE?

Output Format: <Format1><END>
<Format1> → 0~255

Example:

```
10 PRINT #1,"*SRE?"
20 INPUT #1,A
30 PRINT A
40 END
```

Remote Commands cont'd:

Command Reference

*STB
The STB query returns the current Status Byte Register (SBR) value.
This command is query only.

Query Syntax: *SBR?

Output Format: <Format1><END>
<Format1> → 0~255

Example:
```
10 PRINT #1,"*STB?"
20 INPUT #1,A
30 PRINT A
40 END
```

---

*TRG
The TRG command triggers one measurement

Syntax: *RST

Example: PRINT #1;"*RST"

This command has no query.

---

*WAI
The WAI command makes the unit wait until the previous command operation has finished.

Syntax: *WAI

Example: PRINT #1;"*TRG;*WAI;READ?"

Outputs the measurement value after one measurement.
This command has no query.

Remote Commands cont'd:

Command Reference

BEEP

The BEEP command sets how the beep will be released based on the Comparator's judgment result. The query returns the current beep setting.

Syntax: BEEP {OFF, GO, NG}
OFF No beep based on Comparator judgment
GO Beep if Comparator gives Total-Go judgment
NG Beep if Comparator gives Total No-Go judgment

Example: PRINT #1,"BEEP GO"

Query Syntax: BEEP?

Output Format: BEEP = {OFF, GO, NG}<END>

Example:10 PRINT #1,"BEEP?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END

COMParator

The COMParator command sets whether the Comparator will be on or off. The query returns the current Comparator switch condition.

Syntax: COMParator {OFF, ON}
OFF No Comparator judgment
ON Comparator judgment is ON

Example: PRINT #1,"COMP ON"

Query Syntax: COMParator

Output Format: Comparator = {OFF, ON}<END>

Example: 10 PRINT #1," COMP?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END

Remote Commands cont'd:

Command Reference

COMParator:A

The COMParator:A command sets the Comparator's Display A condition.

Syntax: COMParator:A

Example: PRINT #1,"COMP:A"
PRINT #1,"HIGH 1.000e3"

This command has no query.

COMParator:A:HIGH

The COMParator:A:HIGH command sets Display A's Comparator High Limit. The query returns the current Display A upper limit value.

Syntax: COMParator:A:HIGH <numerical value>

Example: PRINT #1,"COMP:A:HIGH 1.000E3"

Query Syntax: COMParator:A:HIGH?

Output Format: Comp A High = <numerical value>{UNITS}<END>

<numerical value>→<±0.0000-1.9999>E<±XX>

Example:

```
10 PRINT #1," COMP:A:HIGH?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

COMParator:A:HIGH:IGNO

The COMParator:A:HIGH:IGNO command sets whether the High Limit Comparator of Display A will be valid or invalid (On/Off). The query returns the current Display A High Limit valid condition.

Syntax: COMParator:A:HIGH:IGNO {ON,OFF}

Example: PRINT #1,"COMP:A:HIGH:IGNO ON"

Query Syntax: COMParator:A:HIGH:IGNO?

Output Format: Comp.Ignor A High = {ON, OFF}<END>

Example:

```
10 PRINT #1," COMP:A:HIGH:IGNO?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

COMParator:A:LOW

The COMParator:A:LOWcommand sets Display A's Comparator Low Limit. The query returns the current Display A Lower Limit value.

Syntax: COMParator:A:LOW <numerical value>

Example: PRINT #1,"COMP:A:LOW 1.000E3"

Query Syntax: COMParator:A:LOW?

Output Format: Comp A LOW = <numerical value>{F, H, R, R}<END>
<numerical value>→<±0.0000~1.9999>E<±XX>

Example:

```
10 PRINT #1," COMP:A:LOW?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

COMParator:A:LOW:IGNO

The COMParator:A:LOW:IGNO command sets whether the Display A Low Limit of the Comparator will be on or off (valid or invalid) The query returns the current Display A Low Limit On/Off condition.

Syntax: COMParator:A:LOW:IGNO {ON,OFF}

Example: PRINT #1,"COMP:A:LOW:IGNO ON"

Query Syntax: COMParator:A:LOW:IGNO?

Output Format: Comp.Ignor A Low = {ON, OFF}<END>

Example:

```
10 PRINT #1," COMP:A:LOW:IGNO?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

COMParator:B

The COMParator:B command sets the Comparator for Display B condition.

Syntax: COMParator:B

Example:

```
PRINT #1,"COMP:B"
PRINT #1,"HIGH 1.000e3"
```

This command has no query.

Remote Commands cont'd:

Command Reference

COMParator:B:HIGH

The COMParator:B:HIGH command sets the Display B Comparator High Limit. The query returns the current Display B High Limit value.

Syntax: COMParator:B:HIGH <numerical value>

Example: PRINT #1,"COMP:B:HIGH 1.000E3"

Query Syntax: COMParator:B:HIGH?

Output Format: Comp B High = <numerical value>{deg,V,A}<END>
<numerical value>→<±0.0000~1.9999>E<±XX>

Example:

```
10 PRINT #1," COMP:B:HIGH?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

COMParator:B:HIGH:IGNO

The COMParator:B:HIGH:IGNO command sets whether the Display B High Limit Comparator will be on or Off (valid or invalid). The query returns the current Display B High Limit On/Off condition.

Syntax: COMParator:B:HIGH:IGNO {ON, OFF}

Example: PRINT #1,"COMP:B:HIGH:IGNO ON"

Query Syntax: COMParator:B:HIGH:IGNO?

Output Format: Comp.Ignor B High = {ON, OFF}<END>

Example:

```
10 PRINT #1," COMP:B:HIGH:IGNO?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

COMParator:B:LOW

The COMParator:B:LOW command sets the Low Limit of Display B of the Comparator. The query returns the current Display B Low Limit value.

Syntax: COMParator:B:LOW <numerical value>

Example: PRINT #1,"COMP:B:LOW 1.000E3"

Query Syntax: COMParator:B:LOW?

Output Format: Comp B Low = <numerical value>{ , ,deg,V,A}<END>
<numerical value>→<±0.0000~1.9999>E<±XX>

Example:

```
10 PRINT #1," COMP:B:LOW?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

The COMParator:B:LOW:IGNO

The COMParator:B:LOW:IGNO command sets whether the Display B Low Limit Comparator will be On or Off (valid or invalid). The query returns the current Display B Low Limit On/Off condition.

Syntax: COMParator:B:LOW:IGNO {ON, OFF}

Example: PRINT #1,"COMP:B:LOW:IGNO ON"

Query Syntax: COMParator:B:LOW:IGNO?

Output Format: Comp.Ignor B Low = {ON, OFF}<END>

Example:

```
10 PRINT #1," COMP:B:LOW:IGNO?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

CORRection
The CORRection command starts the Correction Mode.

Syntax: CORRection

Example: PRINT #1,"CORR"
PRINT #1,"OPEN ON"

This command has no query.

CORRection:OPEN
The CORRection:OPEN command runs Open Correction.

Syntax: CORRection:OPEN ON

Example: PRINT #1,"CORR:OPEN ON"

This command has no query.

CORRection:SHORt
The CORRection:SHORt command runs Short Correction.

Syntax: CORRection:SHORt ON

Example: PRINT #1,"CORR:SHOR ON"

This command has no query.

Remote Commands cont'd:

Command Reference

FUNCtion

The FUNCtion command starts the Measurement Parameters mode.

Syntax: FUNCtion

Example: PRINT #1,"FUNC"
PRINT #1,"A:TYPE L"

This command has no query.

FUNCtion:A

The FUNCtion:A command starts the Display A measurement parameters mode.

Syntax: FUNCtion:A

Example: PRINT #1,"FUNC:A"
PRINT #1,"TYPE L"

This command has no query.

Remote Commands cont'd:

Command Reference

FUNCtion:A:TYPE

The FUNCtion:A:TYPE command sets the measurement item for Display A. The query returns the current Display A measurement item.

Syntax: FUNCtion:A:TYPE {L, C, R, Z}

- L: Display A measurement item becomes L.
- C: Display A measurement item becomes C.
- R: Display A measurement item becomes R.
- Z: Display A measurement item becomes |Z|.

Example: PRINT #1,"FUNC:A:TYPE L"

Query Syntax: FUNCtion:A:TYPE?

Output Format: DISP-A = {L, C, R, Z}<END>

Example:

```
10 PRINT #1," FUNC:A:TYPE?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

FUNCtion:B

The FUNCtion:B command starts the Display B measurement parameters mode.

Syntax: FUNCtion:B

Example:

```
PRINT #1,"FUNC:B"
PRINT #1,"TYPE D"
```

This command has no query.

Remote Commands cont'd:

Command Reference

FUNCtion:B:TYPE

The FUNCtion:B:TYPE command sets the measurement item for Display B. The query returns the current Display B measurement item.

Syntax: FUNCtion:B:TYPE {D, Q, SE, V, I}

- D: Display B's measurement becomes D
- Q: Display B's measurement becomes Q
- SE: Display B's measurement becomes θ
- V: Display B's measurement becomes V
- I: Display B's measurement becomes I

Example: PRINT #1,"FUNC:B:TYPE D"

Query Syntax: FUNCtion:B:TYPE?

Output Format: DISP-B = {D, Q, SE, V, I}<END>

Example:

```
10 PRINT #1," FUNC:B:TYPE?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

FUNCtion:CIRCuit

The FUNCtion:CIRCuit command sets the equivalent circuits mode. The query returns the current equivalent circuits mode.

Syntax: FUNCtion:CIRCuit {AUTO, SER, PRL}

- AUTO: The equivalent circuits mode is selected automatically.
- SER: The equivalent circuits mode is serial.
- PRL: The equivalent circuits mode is parallel.

Example: PRINT #1,"FUNC:CIRC AUTO"

Query Syntax: FUNCtion:CIRCuit?

Output Format: Circuit Mode = {AUTO, MAN},{SERIES, PARALLEL}<END>

Example:

```
10 PRINT #1," FUNC:CIRC?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

FUNCtion:FREQuency

The FUNCtion:FREQuency command sets the Measurement Frequency. The query returns the current Measurement Frequency.

Syntax: FUNCtion:FREQuency {120Hz, 1000Hz}

- 120Hz: Sets the Measurement Frequency at 120Hz.
- 1000Hz: Sets the Measurement Frequency at 1 kHz.

Example: PRINT #1,"FUNC:FREQ 1000Hz"

Query Syntax: FUNCtion:FREQuency?

Output Format: Frequency = {120Hz, 1kHz}<END>

Example:

```
10 PRINT #1," FUNC:FREQ?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

FUNCtion:LEVel

The FUNCtion:LEVel command sets the Measurement Signal Level. The query returns the current Measurement Signal Level.

Syntax: FUNCtion:LEVel {1V, 500mV, 50mV}

- 1V: Sets the Measurement Signal Level at 1V
- 500mV: Sets the Measurement Signal Level at 500mV
- 50mV: Sets the Measurement Signal level at 50mV

Example: PRINT #1,"FUNC:LEV 1V"

Query Syntax: FUNCtion:LEVel?

Output Format: Level = {1V, 500mV, 50mV}<END>

Example:

```
10 PRINT #1," FUNC:LEV?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

FUNCtion:RANGe

The FUNCtion:RANGe command sets the Measurement Range. The query returns the current Measurement Range.

Syntax: FUNCtion:RANGe {AUTO, 1~10}

- AUTO: Sets the Measurement Range automatically.
- 1~10: Sets the Measurement Range at 1~10.

Example: PRINT #1,"FUNC:RANG 1"

Query Syntax: FUNCtion:RANGe?

Output Format: Range = {AUTO, MAN},{1~10}<END>

Example:

```
10 PRINT #1," FUNC:LEV?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

MEASure

1 measurement occurs, and the result is outputted.

This command is query only.

Query Syntax: MEASure?

Output Format: <INDEX>,<PANEL>,<FA><D-A>,<JA>,<FB>,<D-B>,<JB>,<JT><END>

- <INDEX1> → Measurement Index No. (Output = 0~9999)
- <PANEL> → Current Panel Number (Output = P{00~99})
- <FA> → Display A Measurement Item (Output = A{L,C,R,Z})
- <D-A> → Display A Meas. Result(Output = X.XXXXEXXX{H,F,R,R})
- <JA> → Display A Judgment Result(Output = {-,L,G,H})
- <FB> → Display A Measurement Item (Output = B{D,Q,S,V,I})
- <D-B> → Display B Meas. Result (Output=X.XXXXEXXX{ , ,deg,V.A})
- <JB> → Display B Judgment Result (Output = {-,L,G,H})
- <JT> → TOTAL Judgment Result {Output = -,N,G}

Example:

```
10 PRINT #1,"MEAS?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

OUTPut

The OUTPut command sets the remote output destination. The query returns the current data output destination.

Syntax: OUTPut {OFF, RS232C, GPIB, ALL}

- OFF: No output
- RS232C: Outputs to RS232C
- GPIB: Outputs to GPIB(option)
- ALL: Outputs to RS-232C and GP-IB(option)

Example: PRINT #1,"OUTP RS-232C"

Query Syntax: OUTPut?

Output Format: OutputMode = {OFF, RS232C, GPIB, GPIB and RS232C}<END>

Example:

```
10 PRINT #1," OUTP?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

PANel

The PANel command sets the Panel Number. The query returns the current Panel No.

Syntax: PANel {1~99}

Example: PRINT #1,"PAN 32"

Query Syntax: PANel?

Output Format: Panel_No = {1~99}<END>

Example:

```
10 PRINT #1," PAN?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

READ

This outputs the measurement result of the immediate previous measurement.

This command is query only.

Query Syntax: READ?

Output Format:<INDEX>,<PANEL>,<FA><D-A>,<JA>,<FB>,<D-B>,<JB>,<JT><END>

- <INDEX1> → Measurement Index No. (Output = 0~9999)
- <PANEL> → Current Panel Number (Output = P{00~99})
- <FA> → Display A Measurement Item (Output = A{L,C,R,Z})
- <D-A> → Display A Meas. Result(Output = X.XXXXEXXX{H,F,R,R})
- <JA> → Display A Judgment Result(Output = {-,L,G,H})
- <FB> → Display A Measurement Item (Output = B{D,Q,S,V,I})
- <D-B> → Display B Meas. Result (Output=X.XXXXEXXX{deg,V.A})
- <JB> → Display B Judgment Result (Output = {-,L,G,H})
- <JT> → TOTAL Judgment Result {Output = -,N,G}

Example:

```
10 PRINT #1,"READ?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Remote Commands cont'd:

Command Reference

SPEed

The SPEed command sets the measurement speed. The query returns the current measurement speed.

Syntax: SPEed {FAST, NORM, SLOW}

- FAST: Sets a measurement speed at FAST
- NORM: Sets a measurement speed at NORM
- SLOW: Sets a measurement speed at SLOW

Example: PRINT #1,"SPE NORM"

Query Syntax: SPEed?

Output Format: Speed = {FAST, NORM, SLOW}<END>

Example:

```
10 PRINT #1," SPE?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

TRS

The TRS command sets the trigger mode. The query returns the current trigger mode.

Syntax: TRS {INT, MAN}

- INT: Sets the trigger mode as INT(internal trigger)
- MAN: Sets the trigger mode as MAN/EXT (manual/external)

Example: PRINT #1,"TRS MAN"

Query Syntax: TRS?

Output Format: Trigger Mode = {INT, MAN}<END>

Example:

```
10 PRINT #1," TRS?"
20 LINE INPUT #1,A$
30 PRINT A$
40 END
```

Warranty:

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of three years 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:

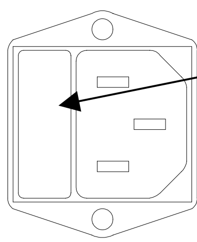
TEGAM, INC.
10 TEGAM WAY
GENEVA, OHIO 44041
PH: 440.466.6100
FX: 440.466.6110
EMAIL: sales@tegam.com

Repair Parts

The Model 3525 has no user replaceable parts.

Changing the Power Fuse

Different fuses must be used for different power voltage settings.
For 100 or 120 volts settings, use a 250V/1A fuse.
For 220 or 240 volts settings, use a 250V/0.5A fuse.



The power fuse is installed in this part of the power inlet. To replace the fuse, open this portion with a screwdriver. There is one reserve fuse shipped with each unit.

Preparation for Repair or Calibration Service:

Once you have verified that the cause for 3525 malfunction 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 address` the particular service you request, which is assigned to that RMA number. Of even more importance is a detailed written description of the problem, which should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or lack of a detailed description of the problem.

The detailed problem description should include information such as measurement range, trigger mode, type of components being tested, is the problem intermittent?, when is the problem most frequent?, has anything 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 to provide detailed symptoms of the instrument's problem.

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.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. Completing 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 3525 Verification Procedure:

Below is the Verification Procedure for the Model 3525. TEGAM recommends that the Verification Procedure be performed on new 3525 units after the initial six months from the date of shipment. After the initial six months, it is recommended that the Verification Procedure be performed once per year. If a measurement is found to be outside of specification, contact TEGAM to obtain Calibration or Repair Service.

REQUIRED EQUIPMENT:

MODEL NUMBER	DESCRIPTION	REQUIREMENTS*
Tegam SR1-1	1Ω STANDARD RESISTOR	Data taken @1KHz, R accuracy ± .4%, Phase ± .25º
Tegam SR1-10	10Ω STANDARD RESISTOR	Data taken @1KHz, R accuracy ± .08%, Phase ± .04º
Tegam SR1-100	100Ω STANDARD RESISTOR	Data taken @120Hz and 1KHz, R accuracy ± 170 PPM, Phase ± .02º
Tegam SR1-1K	1kΩ STANDARD RESISTOR	Data taken @1KHz, R accuracy ± 200 PPM, Phase ± .0125º
Tegam SR1-10K	10kΩ STANDARD RESISTOR	Data taken @120Hz and 1KHz, R accuracy ± 250 PPM, Phase ± .02º
Tegam SR1-100K	100kΩ STANDARD RESISTOR	Data taken @1KHz, R accuracy ± .03%, Phase ± .025º
Tegam SR1-1M	1MΩ STANDARD RESISTOR	Data taken @1KHz, R accuracy ± .07%, Phase ± .048º
Tegam SR1-10M	10MΩ STANDARD RESISTOR	Data taken @1KHz, R accuracy ± .43%, Phase ± .22º
General Radio SC1409L**	10nF STANDARD CAPACITOR	Data taken @1KHz, C accuracy ± .03%, D accuracy ± .0004
General Radio SC1409-Y**	1µF STANDARD CAPACITOR	Data taken @1KHz, C accuracy ± .02%, D accuracy ± .0004
General Radio SC1409-T**	100nF STANDARD CAPACITOR	Data taken @120Hz, C accuracy ± .03%, D accuracy ± .0004
General Radio SC1409-10µF**	10µF STANDARD CAPACITOR	Data taken @120Hz, C accuracy ± .02%, D accuracy ± .0004
General Radio 1482-H**	10mH STANDARD INDUCTOR	Data taken @1KHz, L accuracy ± .02%, D accuracy ± .0004
General Radio 1482-P**	1H STANDARD INDUCTOR	Data taken @1KHz, L accuracy ± .03%, D accuracy ± .0004
General Radio 1482-L**	100mH STANDARD INDUCTOR	Data taken @120Hz, L accuracy ± .02%, D accuracy ± .0004
General Radio 1482-T**	10H STANDARD INDUCTOR	Data taken @120Hz, L accuracy ± .03%, D accuracy ± .0004

* The required calibration accuracies for the standards given are approximately ¼ the accuracy of the unit, for standards that do not meet this specification; the allowable deviation (in counts) must be adjusted.

** Accuracies for these standards: capacitors, .05%; inductors .1%.

Model 3525 Verification Procedure cont'd:

Verification:

1. Set the Speed to SLOW.
2. Set the Level to 1V.
3. Set the Circuit Mode to SER.
4. Set the Range to AUTO.
5. Set the Frequency to 1kHz.
6. Set the Trigger to INT.
7. Connect the test leads to be used with the unit.
8. Perform Open and Short Zero Corrections.
   NOTE: EVERY TIME THE LEADS ARE CHANGED, OPEN AND SHORT CORRECTIONS MUST BE PERFORMED.

9. Perform the following measurements, and record results in the table. Change the Frequency, Mode and Measured Parameters according to the standards specified in the Required Equipment Chart. Verify that the 3525 is within the allowable number of counts from the value of the standard's calibration.

Model 3525 Verification Procedure cont'd:

FREQ. (Hz)	RESISTANCE (Ω)	MODE	ITEM	STANDARD VALUE	MEASURED VALUE	DEVIATION	ALLOWABLE DEVIATION (COUNTS)	PASS/ FAIL
1k	1	SER	|Z|				225	
			θ				125	
1k	10	SER	|Z|				44	
			θ				23	
1k	100	SER	R				13	
			|Z|				10	
			θ				10	
1k	1k	SER	|Z|				10	
			θ				6	
1k	10k	PRL	R				16	
			|Z|				14	
			θ				10	
1k	100k	PRL	|Z|				18	
			θ				13	
1k	1M	PRL	|Z|				38	
			θ				24	
1k	10M	PRL	|Z|				219	
			θ				125	
120	1k	SER	R				11	
			|Z|				10	
			θ				10	
120	10k	PRL	|Z|				14	
			θ				10	
FREQ. (Hz)	**CAPACITANCE (F)**	**MODE**	**ITEM**	**STANDARD VALUE**	**MEASURED VALUE**	**DEVIATION**	**ALLOWABLE DEVIATION (COUNTS)**	**PASS/ FAIL**
1k	10n	PRL	C				16	
			D				20	
1k	1µ	SER	C				13	
			D				20	
120	100n	PRL	C				16	
			D				20	
120	10µ	SER	C				13	
			D				20	
FREQ. (Hz)	**INDUCTANCE (H)**	**MODE**	**ITEM**	**STANDARD VALUE**	**MEASURED VALUE**	**DEVIATION**	**ALLOWABLE DEVIATION (COUNTS)**	**PASS/ FAIL**
1k	10m	SER	L				13	
			D				20	
1k	1	PRL	L				16	
			D				20	
120	100m	SER	L				13	
			D				20	
120	10	PRL	L				16	
			D				20	

NOTE: THE ALLOWABLE DEVIATION IS EQUAL TO THE ACCURACY SPECIFICATION (IN COUNTS) + THE CALIBRATION ACCURACY OF STANDARD.

There is no information contained in the Appendix at this time.